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# REPORT

FACT

ON BEHALF OF THE COMMISSION OF INQUIRY

to establish the reasons for the loss of
sovereignty and energy independence of France

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VOLUME
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See numbers: **218** and **287**.

*The Commission of Inquiry aimed at establishing* the *reasons* for the *loss of sovereignty and energy independence* of *France*, *is composed of:* Mr. Raphaël Schellenberger, *President*; Mr Antoine Armand, *rapporteur*; Mr. Henri Alfandari; Mrs. Anne-Laure Babault; Mrs. Marie-Noëlle Battistel; Mrs. Véronique Besse;
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# SUMMARY

# FOREWORD BY THE PRESIDENT

## INTRODUCTION

This winter 2022/2023, it is thanks to an effort to reduce industrial production, a decline in the level of production of companies and a significant renunciation of the comfort of citizens, that France has not been plunged into darkness. Not since the end of the Second World War had such a step backwards been asked of the French.

How did we get here? What are the successive choices that have led to this loss of energy sovereignty?

All French people have asked themselves these questions. The creation of our Committee of Inquiry to establish the reasons for the loss of France's energy sovereignty and independence has attempted to provide answers. Its audience in the public, the media and on social networks, rather rare for a parliamentary Commission of Inquiry, demonstrates how much the questions we raised were shared. Even the energy industry is coming to ask itself these questions. How did we manage to transform what was a French success, with an unmatched level of electricity exports in Europe and world-class companies in oil and gas, into a "Headless duck" as described by Yves Brechet, High Commissioner for Atomic Energy from 2012 to 2018?

From October 2022 to March 2023, when every French household was invited to lower the temperature of its heating;

while the French economy had drastically reduced its production;

while the European electricity markets had lost their minds and made trading prices imply irrational ;

while a quarter of our nuclear power plant was shut down due to the detection of a generic defect;

while the war in Ukraine had permanently cut Europe off from what had become its primary source of supply;

while the IPCC produced its annual report warning once again of the need to accelerate our fight for decarbonisation;

while many craftsmen were facing a wall with the explosion of their energy charges;

while our hydroelectric park and the level of "Lake France " were constantly scrutinised to pass the possible peak of electricity consumption;

while an "electric weather" was set up by RTE;

We heard, before our Committee of Inquiry, for 150 hours, 88 personalities who have contributed to defining and implementing French energy policy over the last thirty years.

This report describes how the energy sovereignty strategy, conceived after the Second World War and whose implementation was accelerated after the first oil shock, was a success. This report recounts above all how this success has gradually led to the comfort of abundance making us forget the strategic nature of the mother of industries: energy. This report tells how the anti-nuclear dogma of political ecology has gradually established itself as the key to reading energy choices rather than sovereignty and the urgency of decarbonisation.

This story is one of political choices and truncated societal debates. It is the desire to impose an opinion, without sharing or even measuring the consequences. This story is that of the falling asleep of a nation that has forgotten to think about its power and its global role, cowering in its domestic market and electoral strategies, forgetting national interest and ambition.

Is there a culprit or culprits? Or are we collectively responsible for dozing off in opulence?

(1) In this story, precise, substantiated and serious, I nevertheless wish to give a glimpse of a note of hope. Not all of the consequences for our energy system are the result of decisions. The most serious come simply from a discourse, from a course which, shared by the whole of society, leads to induced choices. It also means that our nation can recover through collective awareness and re-engagement in the reconstruction of an industrial energy sector.

This story is therefore also one of a form of generational responsibility. Restore confidence in France, its genius and its ability to do!

Our energy model will have to change profoundly in the coming decade to face the challenges of climate change. With a note of optimism, let us hope that this report will contribute to the turning point of awareness and the birth of a French energy renewal.

## I. SOVEREIGNTY OR INDEPENDENCE: MASTERY OR AUTARKY?

In the course of our work, we have wondered at length about the intersecting notions of independence and sovereignty. These two notions, although similar, are nevertheless very different. In a world where value creation is a function of energy consumption, it is up to us to be precise in their definition and especially in the choice of the goal pursued.

At the end of our work, energy independence seems to be a mirage. The fight against climate change should lead us to rapidly reduce our consumption of fossil fuels. Nevertheless, it remains the majority in our energy mix and France has almost no fossil energy source on its territory. We also do not have a uranium ore resource. As for so-called renewable energies, they are excessively consuming precious ore, which are also not present in the French subsoil.

While political strategies have been guided by the choice to pacify relations between nations through trade, it seems to me questionable to seek to pursue this goal of independence. We do not live on an island but at the crossroads of a Europe that has become a daily living space for many of our fellow citizens.

The essential concept is therefore that of sovereignty. This ability, which is crucial for a democracy, to make choices, to control them from start to finish and to secure their vulnerabilities. From this point of view, the French electricity strategy has been remarkable. It is not only the choice of nuclear power generation that France made with the "Messmer plan", but that of building a complete industrial sector. From the extraction of uranium ore to the operation of nuclear power plants through their design, the control of the different phases of fuel production and reprocessing. It is the control of this entire industrial chain that makes nuclear power an element of national sovereignty.

Let us regret here that, for the first time in forty-three years, France was, this winter, a net importer of electricity. It is this observation that leads, beyond the loss of independence, to observe an obvious loss of energy sovereignty.

Through the succession of destructive choices of our electricity sectors, both nuclear and hydroelectric, we have gradually put our strategic interests in the hands of other political powers.

If energy independence does not seem accessible to us, it remains to choose, sovereignly, with whom we wish to link.

It was therefore a major strategic choice to have positioned, from the beginning of European integration, the energy issue as a common interest. The founders of the European Coal and Steel Community (ECSC) immediately grasped the strategic interest of energy for peace on our continent.

This strategy has not aged a bit. Even if national interests may diverge - we will come back to this - we are bound by the European continent. This winter, although we regret having had to import a large part of our electricity, it is European cooperation that has enabled us to have the electrical energy we needed. It is this same European network that allows us to export in normal times and stabilise the network on a relevant scale. Like any cooperation, it requires constant work and commitment. It is certainly at this level that we have given up far too much in recent years.

This abandonment of the European terrain is now leading to a difficult catch-up: taxonomy, rules applicable to the atypical regime of hydroelectric concessions, perimeter of the technologies supported for the production of hydrogen: these are all European arbitrations badly engaged for French economic and industrial interests. These are all subjects on which we must remobilise. What may appear from afar as anti-nuclear ideology at the European level looks more like, on closer inspection, the national interests of states that do not have the excellence of the French nuclear industry and that have better defended their interests.

The strategic nature of energy and the historic and unavoidable role of the European Union make energy a sovereign subject. This is what the conduct of our hearings has shown. It is at the highest level of the State, that is to say at the level of the President of the French Republic, that this subject must be treated.

**Proposal A: Evaluate the strategic proposals of the next multiannual energy programming with regard to the ability to set up complete industrial sectors on a French or European scale.**

## II. NUCLEAR POWER, THE KEYSTONE OF SOVEREIGNTY, SPOILED BY IDEOLOGY

Without being reduced to the nuclear issue alone, it has largely occupied the work of our Committee of Inquiry. Given the issue of sovereignty, this makes perfect sense. Indeed, as mentioned above, nuclear power is THE French success story in terms of mastering a complete sector: in research, development, skills, implementation of nuclear power. works and in the establishment of industrial units on the national territory.

If nuclear power is the flagship of the sovereign industrial sector, it is also proof of the substitution of the notion of sovereignty by ideology and anti-nuclear dogma in the implementation of electoral strategies. The report goes back at length to this story, and I would like to highlight a few salient points.

### A. SUPERPHÉNIX: BEHIND THE SYMBOL, A STRATEGY TO WEAKEN THE SECTOR

The first victory of anti-nuclear ideology over "scientific coherence" dates back to December 31, 1998, when Mr. Lionel Jospin, then Prime Minister, decided to put an end to the Superphénix reactor. It is the original sin, the one that crystallised the action of the opponents of nuclear power, their first great victory. It was the first time that political power had yielded to an ideological minority. Unfortunately, once reason is yielded to ideology, a totem is created, a precedent.

Since then, anti-nuclear action has not ceased to mobilise on different sites erected as symbols which nevertheless each aim to be essential links in an industry conceived as a whole:

- Superphénix: the hoped-for end of the closure of the cycle, the colossal reduction of the problem of nuclear waste and the almost unlimited availability of fuel present on national soil

- Fessenheim: the definition of an expiry date for the French nuclear power plant

- Bure: deadlock for the treatment of final waste

- Marcoule and La Hague: targeted in the 2011 agreement between the PS and the Greens; the closure of the reprocessing and production plant necessarily leads to the asphyxiation of the sector.

By concentrating action on a few sites rather than on the system as a whole, the whole edifice is weakened.

The political decision to abandon Superphénix is the result of an electoral agreement concluded between the Socialist Party and the Greens in 1997 but did not result from any recommendation of the Safety Authority at the time.

The Directorate for the Safety of Nuclear Installations (DSIN), had always authorised the restart of the reactor and had even declared that it had a degree of safety equivalent to that of similar reactors in the French nuclear fleet.

It was not surprising that a prototype like Superphénix experienced technical problems during the first years of commissioning, not yet being fully completed. However, this was not a sufficient reason to scuttle an avant-garde sector.

The shutdown of the breeder reactor had a profound impact on research on fast neutron reactors (RNRs), an area in which France enjoyed a considerable lead and control over its foreign partners.

It was not until 2006, under the presidency of Jacques Chirac, that the CEA (Commissariat à l'Énergie Atomique) relaunched the design of a prototype (Astrid) with commissioning then scheduled for 2020.

We can deplore the fact that at present France has still not equipped itself with a new demonstrator, allowing it to recover its delay in the field of RNR (Fast Neutron Reactors). This sector is of a of paramount importance for the notion of

French independence and sovereignty. In the long term, it could enable the industrial sector to sustainably address the reprocessing of materials currently leaving the fuel cycle and would drastically reduce our dependence on natural uranium.

### B. GERMAN INFLUENCE ON FRENCH ENERGY POLICY:

In the early 2000s, Germany, led by Gérard Schröder, decided to abandon nuclear power and opted for an orderly exit in agreement with the country's 4 major energy companies.

With this decision, Germany is partly ceding its energy policy to anti-nuclear ideologues. By choosing to replace nuclear power in its energy mix with gas and coal – renewable energies being inherently intermittent – it undermines the credibility of scientific discourse and creates a precedent that will have repercussions on our energy policy.

The generation of EPRs will have partly borne the brunt of the withdrawal of our German partner. The result of increased cooperation between France and Germany, the pressurised water reactor project was launched in the late 1980s with the initial support of AREVA NP and SIEMENS, later joined by German electricians. Part of the design of the EPR reactor was based on plans for the German Konvoi reactor.

With the Germans abruptly withdrawing from nuclear power and ongoing projects, French engineers faced a major problem, largely delaying the EPR project already caught up in the complexities of the accumulation of standards of two states, sometimes contradictory.

At this point, it is worth remembering that it is up to each Member State of the European Union to determine its energy mix sovereignly. *(Article 194(2) of the Treaty on the Functioning of the EU).*

It is therefore regrettable to note that a European partner which has made different choices in terms of energy policy has allowed itself to interfere with the in our energy policy through its representatives. Because, by leading its country on the road to phasing out nuclear power, Germany has also repeatedly called for the shutdown of the French reactors at Fessenheim and Cattenom, as well as the firm exclusion of nuclear power from the European Plan "*Net zero industry act*". thus preventing an entire industrial sector from being able to benefit from coordinated European funding mechanisms.

Nevertheless, it should be stressed that the trend has recently been reversing timidly in Germany. Nuclear power loses its taboo character and returns to the front of the stage, even calling into question the nuclear phase-out advocated in the aftermath of Fukushima.

Indeed, the crisis in Ukraine has shown the limits of a system that has largely developed renewable energies, while remaining dependent on Russian gas to compensate for the peak in consumption. When gas supply becomes scarce, renewable energies do not produce enough electricity and France is prevented from exporting carbon-free electricity, the limits of the virtues of the German electricity model are reached.

The Government has been forced to turn back the clock by turning to coal-fired power plants.

## C. 2012-2022: A DECADE OF DECISIONS AND EVENTS PERMANENTLY WEAKENING THE NUCLEAR INDUSTRY AND DELAYING THE DEVELOPMENT OF RENEWABLE ENERGIES

### 1. 2012-2017: the years of energy recklessness

In terms of energy, France has lived on its achievements for a very long time since we had electricity in abundance. Indeed, France was in excess of production capacity from the end of the 1990s (consumption forecasts made in the 1980s were higher than real consumption growth). In the early 2010s, France was still largely overcapacity and therefore exported a large part of its production.

It is during the decade 2010-2020 that our country will close nearly 10 gigawatts of thermal generation means (coal and fuel). While we can only strongly encourage the exit from fossil fuels, it is imperative to think about alternative means. President François Hollande wanted to go even further in the pursuit of these objectives of reducing production since in his "*60 commitments for France*", he aimed at a considerable decrease in the production of electricity from the nuclear sector.

This objective was and remains aberrant on at least two points:

- it starts from the premise that electricity consumption would decrease (despite the increasing electrification of our uses),
- It chooses to tackle the nuclear sector (carbon-free, abundant and cheap energy), rather than seeking carbon neutrality.

This choice led in particular to the launch of the process of closing the Fessenheim nuclear power plant, although this closure was made impossible – during the five-year period 2012-2017 – in particular because of EDF's status as a private company. This effectively obliged the State – broadly – to respect the right to property.

This position sends a lasting negative signal to the sector, which has difficulty considering the future and making itself attractive. On the occasion of his hearing, we heard the explanations of the former President of the Republic François Hollande. The positions taken in his presidential program are less excessive with regard to the nuclear industry than those present in the agreement concluded by Martine Aubry on behalf of the Socialist Party and Ms. Cécile Duflot for Europe Ecology the Greens. Nevertheless, they are a very negative signal for the sector, which is entering into crisis.

To explain *a posteriori* that this choice (not to take over the entire PS-Greens agreement) made it possible to save the French nuclear industry looks more like internal concerns within the Socialist Party than an acute awareness of the signal sent to the sector.

At this stage, it falls to me to point out that the institutional framework in which a parliamentary Committee of Inquiry takes place may have influenced the completeness of certain hearings. Indeed, the separation of powers - which is intrinsic to the rule of law - distances the incumbent President of the Republic from Parliament.

However, Mr. Emmanuel Macron was successively economic advisor to the President of the Republic and Minister of the Economy between 2012 and 2016. Several meetings held during this period and which proved essential for the French nuclear industry have been described to us without its role being really specified. It is a question of the proper functioning of our institutions that we have not sought to know more. However, this remains a less informed part of the precise narrative in the report.

**2. Since 2017: depending on the circumstances**

In line with his predecessor, candidate Emmanuel Macron included in his program in 2017 the maintenance of the objective of reducing to 50% the electricity from the nuclear sector by 2025. This objective, which was already known to be untenable at the time and which was not the result of any impact study, was in fact a signal sent to the ecologist and socialist electorate. Shortly after the election of Mr. Emmanuel Macron, his Prime Minister, Mr. Edouard Philippe decides to postpone the objective of 50% of nuclear share in the electricity mix to 2035.

Nuclear offender, Mr. Emmanuel Macron will appoint to the Ministry of Ecological Transition – in charge of energy – throughout his first five-year term only personalities who are hostile to the atom: Mr. Nicolas Hulot, Mr. François de Rugy, Ms. Elisabeth Borne, Ms. Barbara Pompili.

It is also in its Multiannual Energy Programming, adopted in 2019, that binding objectives will be included such as the reduction of the share of nuclear power in the energy mix, the closure of 14 reactors the decrease in final energy consumption of 7.6% in 2023 and 16.5% in 2028 compared to 2012.

All these measures are in fact very restrictive since they de *facto* force us to drastically reduce our energy consumption (industrial and daily) in a short time. During the first five-year period of Mr. Emmanuel Macron, the ministers of the environment bet on a decrease in energy consumption, which justified according to them the closure of capacities production and plans to shut down an additional 14 nuclear reactors. It is a declinist vision of our economy today that is difficult to reconcile with a reindustrialisation plan - even if it is green.

That is why Prime Minister M. Édouard Philippe and the Minister of Ecological Transition, Elisabeth Borne, signed the decree to close the Fessenheim power plant in 2019. However, all energy forecasts already show an increase in our electricity needs.

I would like to highlight here the clarifications made in the report on the possibility of making another choice in 2017 for Fessenheim and gladly refer the reader to report No. 4515 of the National Assembly tabled on October 6, 2021 by the mission of information and follow-up of the closure of the Fessenheim nuclear power plant.

Another major error characterising the inconsistency of the first years of Mr. Emmanuel Macron: the abandonment of ASTRID for reasons that I still cannot explain, even after 150 hours of hearings, if not a declinist vision of France, seen as a middle power that no longer has the means to innovate on an industrial scale.

The beginning of the first five-year term of Mr. Emmanuel Macron is punctuated by a succession of decisions heavy with consequences on which the President of the Republic will deny himself.

### 3. The Duplicity of the Current Government

On February 10, 2022, the President of the Republic Emmanuel Macron, future candidate for re-election, delivers a speech in Belfort in which he develops a plan to revive French nuclear power. This plan incorporates all the proposals of the "D'Escatha-Billon report" which had been submitted to M. Nicolas Hulot in July 2018 and immediately classified defense secret. This report recommended that these decisions be taken as early as 2019, three years before the effective date of their announcement.

A turning point in the energy strategy then seems to be emerging.

However, on the occasion of the hearing of Mrs Élisabeth Borne, Prime Minister, by our parliamentary Committee of Inquiry, a form of duplicity appeared to us and many apparent contradictions remain unresolved, suggesting that the formidable stability of the ministerial advisers in charge of energy over the last ten years, energy has continued to produce effects slowing down the implementation of real national energy industrial sectors:

- For more than a year and the announcement of the plan on new nuclear, we have not yet seen any statement on the financing strategy;
- The extension of the life of the historic nuclear power plant is approached solely from the angle of the search for the reactors to be shut down, instead of a proactive approach of safely extending the fleet;
- France's commitment to build a European alliance to bring nuclear power to decarbonisation plans is timid, to say the least;
- ARENH remains credible in the eyes of the government solely through the prism of the price charged to the consumer, while creating difficulties in financing renovation and extension projects of historic power plants;
- The *energy consumption scenarios* on which the government's energy strategy is built seem to us to be largely underestimating the transfers of use towards carbon-free electricity and betting on risky societal changes (sobriety).

## III. RECOVERING THE PERSPECTIVE OF THE LONG TERM

Is it the candidates in the elections who have lost the sense of the long term and strategic interests? Or was it the choice of voters that confirmed the change in priorities? It is not for this report to decide that question. The strong conviction resulting from these six months of work nevertheless lies in the need to bring the perspective of the long term back into the public debate. Not all decisions have immediate effect. The biggest decisions are revealed well after their investigators.

Our Committee of Inquiry has thus extensively questioned the relationship between science, industry and political decision-making.

The report goes into detail on concrete proposals. Nevertheless, it seems important to me to stress that the issue of the relationship to science does not cross the political class alone but the whole of society. The speed at which information circulates is undoubtedly the greatest opportunity of our century. It is also its greatest challenge because approximate, incomplete or even false information circulates at the same speed.

The increase in scientific knowledge also creates a major public policy challenge. Knowledge deepens and becomes clearer very quickly. What can the citizen cling to to build his thought, his reasoning and his decision when the state of knowledge advances faster than what everyone can apprehend?

The communication society in which we find ourselves leads to certain excesses in the interpretation of the word of scientists. This is how our Committee of Inquiry had to deal with it directly, and this from its first hearing. Thus, in order to draw up an overview of society's relationship to energy, we invited an energy anthropologist, an official of the Ministry of Ecological Transition.

Far from sharing with us her analyses on her subject of expertise and research, she preferred to take advantage of the media exposure time allowed by her hearing to assert an opinion, calling for supposed studies in the service of her reasoning and playing on her authority of scientist. At the end of the hearing and after an exchange of letters recalling the very formal framework of a Commission of Inquiry, the anthropologist told us to withdraw his remarks, which were based on his opinion and conviction and were indeed unsubstantiated scientifically. Yet she had used her status as a scientist to give authority to her subject.

This demonstrates a mechanism that has become common in public debate where the scientist is sometimes instrumentalised and where his statement actually becomes an opinion when he moves away from his discipline. Let us also admit that communication and participation in the media debate are not the skills for which we want to hear from a scientist. This therefore questions the contextualisation of the remarks by mediation intermediaries which are increasingly absent, especially on social networks.

In this context, it is the relationship to science that becomes more easily instrumentalized. Because more than scientific knowledge in itself, it is the scientific approach that must be shared. A better knowledge of the history of science is an absolutely necessary prerequisite for a public debate in a society totally dominated by technology and technology.

From this point of view, the eruption into the public debate of Non-Governmental Organisations (NGOs) can, at times, contribute to the apparent misunderstanding of certain technical contradictions. If the presence in the public debate of expertise from civil society is necessary, it must also be part of the framework of transparency that is that of the political field.

Thus, in 2007, the launch of the Grenelle Environment Forum was an opportunity, for the first time, to set up a number of NGOs around the table. The hearing of Mrs Nathalie Kosciusko-Morizet, then Secretary of State, enabled us to return to the need for this development. Since then, their participation in public decisions has become largely institutionalised, although the choice of the round table remains composed without real transparency. This contradiction was widely pointed out during the exchange between the Committee of Inquiryand the energy branches of the representative trade union organisations. They rightly pointed to the discrepancy between the demonstration of representativeness for trade unions and the discrimination that leads to the choice of NGOs. I think it is important to correct this imbalance.

**PROPOSAL B: Imagine a system guaranteeing the representativeness of Non-Governmental Organisations called upon to participate in the development of public policies on the model of the rules of representativeness set up for trade unions from 2010 and implement the transparency of their funding on the model of political party financing.**

This phenomenon of instrumentalisation of science has not spared the political world. The energy policy of recent years is, like any other policy, deeply rooted in its time. There are many examples of the presentation of partial facts to justify decision-making. This is the case of Mrs Dominique Voynet who, during her hearing, had a partial and erroneous explanation to justify the operation and closure of Superphénix.

In relation to science and technology, we have also seen an attitude that seems to me to be even more serious when trying to develop long-term policies: casualness and disregard for facts and physical and technical constraints. For Ms. Ségolène Royal, the energy issue during the 2007 campaign was at the time "*not a high priority*" while it will nevertheless carry objectives with serious consequences for the nuclear industry and our energy needs.

Ms. Élisabeth Borne had a hard time justifying on a technical and scientific level the closure of the two reactors of the Fessenheim power plant in 2020 (Closure decree signed in 2019 by the Prime Minister at the time, Mr. Édouard Philippe, and Ms. Élisabeth Borne, then Minister of Ecological and Solidarity Transition). It will justify this decision to the members of the committee according to a somewhat arbitrary criterion of seniority; at least without a technical and rational basis.

The problem in this case lies in the mobilisation of scientific arguments to justify what is only a political choice. It would be to restore nobility to politics to avoid hiding behind technical arguments when it is only a political choice.

Finally, this Committee of Inquiry has largely led us to question the relationship between the advisers to the ministers and decision-making. Thus, Mr. Nicolas Hulot did not remember having in his possession the report of MM Laurent Collet-Billon and Yannick D'Escatha classified "secret defense", and which recommended in particular:

- to announce by 2021 at the latest the decision to launch a series of three pairs of 3rd generation EPR2 reactors
- to announce in 2019 the maintenance of a nuclear base;
- to strengthen the role of the State and give back to politics the steering of France's nuclear policy;

- to set up a nuclear programme;
- improve the performance of nuclear engineering, its methods and its organisations.

When I asked him about this, Mr. Nicolas Hulot was frank enough to admit that it was unlikely that he had read this report and that he had no memory of the report that had been commissioned under his responsibility.

What is the point of ordering reports in this case?

Alas, the dozens of hours of hearings have demonstrated quite implacably the disrepute for science. Indeed, the former High Commissioners for Atomic Energy have confirmed to us that they have been sidelined. Those who followed the hearings were also able to note that this Commission of Inquiry had also been an opportunity for experts and professionals from the nuclear industry to restore their image, well tarnished after more than fifteen years of anti-nuclear speech. Because it is the entire sector that has suffered from what has been called "shameful nuclear power", even though they conscientiously ensure our daily electricity needs, without which our lives would be very different. In this respect, the Committee of Inquiry has therefore enabled certain experts, trade unions and other professionals to finally be heard and listened to.

The problem is more acute at the level of ministerial advisers. We have received several former members of ministerial cabinets since October 2022. Thus, in terms of energy, we have been able to observe two phenomena:

- the continuity of the personalities who advise in this area between 2012 and today, which would rather be reassuring,
- the fact that this advice seems to have reversed. In terms of energy, rather than being a belt of interpretation and understanding of constraints for ministers, ministerial advisors have positioned themselves as prescribers for the administration.

I note in general the extent to which the majority of the political figures we have received (ministers and members of cabinets) have shown before our Committee of Inquiry some restraint as to the consequences of decisions taken under their responsibility. Finally, I note that, with hindsight, many former politicians are now timidly assuming the main principles they claimed.

**The limit of symbols in politics**

So why such a decorrelation between the political and the scientific?

Because we wanted to compose governments as political "symbols". Generally speaking, the more leaders give up politics in the prospective sense of the term, the more they spread ideological postures that they illustrate with symbols. Energy policy is surely the most tangible and revealing example of this.

In an era where everything is accelerating, where the only constancy is change, where technology is constantly changing our lifestyles, our relationship to time evolves accordingly. Citizens are asking us to provide them with rapid, almost instantaneous political responses to current challenges. But the time of technical and industrial implementation is not the media time that runs continuously. The rigour to which we must submit to carry out our decisions requires time, discussion and reflection.

Energy policy can only be built in industrial time, that is to say in the long term. And that is what we are talking about here. No, we cannot implement promises as radical as those made by François Hollande or Emmanuel Macron in terms of energy unless we pay the social, societal and economic cost.

The "flagship measures" and other "shock proposals" presented in the programmes - such as the reduction to 50% of the share of nuclear power in the electricity mix before 2025 - are certainly attractive to capture part of the electorate, because they are symbolic and, let us add, simplistic, but they are nevertheless unrealistic.

Emmanuel Macron's energy program of 2022 is a denial of candidate Emmanuel Macron's energy program of 2017; the principle of reality has gone through this. Moreover, the binding measures present in the 2019 PPE and enshrined in the law are now obsolete. One of the big losers of these reversals is the public discourse, which is greatly weakened. Being elected on promises and not implementing them fuels distrust of politics, politics and democracy. At a time when abstention rates are breaking records, it is time to put seriousness and pragmatism back into the measures taken by the candidates.

In the report, we make proposals to take better account of scientific advice - and therefore the long term - in public decisions. Unfortunately, bodies of this type already exist and have sometimes been deliberately forgotten during periods when political choices have been contrary to the clarifications of specialists as to their capacity for implementation. This is the case with the Atomic Energy Committee, which must meet at least once a year and which, between 2012 and 2018, met only twice. There is therefore a need for personal ministerial responsibility for those who do not convene the collegiate legal advisory bodies.

**PROPOSAL C: Create personal accountability for ministers who do not convene the collegial scientific advisory bodies created by law.**

If we insist so much on the question of the relationship to science, it is because it is the only one able to assess the impact of political decisions over the long term and the correctness of technical choices as to the objectives pursued.

It is not a question of considering that the societal choices we have to make must be dictated by science, quite the contrary, but that they must be illuminated with regard to their impact over time. What has therefore been lacking in the choices and reversals made over the last ten years is the evaluation of the long-term impact in favour of symbolic visibility in the short term.

Unfortunately, reality always catches up with us! And the circumstances of this winter 2022/2023 have cruelly reminded us that politics does not live next to physical rules.

**About ARENH**

Ace most of our work has focused on the electricity exit - and for good reason - and therefore on the situation of EDF, the question of ARENH has largely found itself at the heart of our debates. I wholeheartedly endorse the rapporteur's proposal to abandon this mechanism, which has become toxic, very quickly.

However, electricity transactions will continue to exist. It therefore seems important to me to draw up some conditions for these new rules for the sale of electricity from EDF to third-party distributors:

– Obligation forum the Third-party Distributor to have their own means of production

– Setting a transaction price at the real cost of production of historical nuclear energy taking into account actual production

– Limitation of the volume sold at this price to a share of production based on the production forecast at N+1 rather than in volume

## IV. THEUNCERTAINTY OF THE LONG TERM AND THE TECHNICAL NEUTRALITY OF POLITICAL OBJECTIVES

A long-term energy strategy - which we are calling for in this report - necessarily involves some uncertainty. This part of uncertainty, today, lies either in a technological bet or in a behavioral bet.

During our Committee of Inquiry, we were able to hear divergent views on the credibility of this confidence in ruptures. But in all long-term *scenarios*, there is one constant in the assumption of a major change:

- The *scenarios* that rely on the only available technologies all involve a significant part of societal disruption, even if it is not necessarily put forward,
- While *scenarios* that rely on stable behavior mobilise technologies that are not necessarily available.

Confidence in technical progress does not in itself seem to me to be a problem in the development of a long-term scenario. Nevertheless, we must be transparent about the need for this progress for the realisation of the scenario.

Beyond the traditional bets of availability of a production technology (e.g. RNR) and the industrial capacity to implement it (e.g. construction of nuclear power plants) and its social acceptability (e.g., wind farms), I wanted to highlight some additional challenges that will need to be addressed.

The first, for electricity, is that of networks. The multiplication of production and injection points requires that the network is ever more complex. Although this appears to be a matter of known technology, the scale of the challenge remains significant and can face many challenges.

Intuitively, the promoters of a diffuse production system consider that the multiplication of production points contributes to the resilience of the network. This sometimes seems to me to have to be qualified given the complexity of the network to be implemented. Resilience also comes from simplicity.

Beyond the challenge of decarbonisation through electrification, there is still the challenge of decarbonisation of liquid and gaseous energies. This format, whose advantage is the simplicity of storage and the high concentration in small volumes, will survive in many uses. An important part of their decarbonisation is based on the mobilisation of biomass. However, in this case, we quickly find ourselves in a situation of conflict of use between mobilisation of biomass for food, energy or material production.

During our hearings, this question was raised several times, but it appeared to us that there is not yet a global vision of the distribution of biomass uses. This reflection will have to be put in place quickly.

**PROPOSAL D: Conduct a study on the availability of biomass and the possible distribution of its additional uses between food, energy and material manufacturing.**

At this point, I think it is important to issue an alert. The mobilisation of biomass in the service of the decarbonisation of energy or materials, is based first and foremost on an increase in its production. If we formulate this in terms understandable to all, it means agricultural intensification: by mobilising co-products that until then had returned to the soil, by adding a harvested intermediate crop, or by optimising the choice of crop according to its yield. This constraint nevertheless seems contrary to certain societal choices that are being built and which push, for example, to favor extensive agriculture with lower yields, rather than intensive agriculture as described.

What attitude should the political decision adopt in the face of these uncertainties?

First, transparency. If there are conditions of rupture in the *scenarios*, these must be explained in a clear way. Whether these conditions lie in technical and technological breakthroughs or in major societal changes.

It is then necessary to place the right constraint in the right place. The law has never shown what is the best way to innovate. In terms of carbon-free energy production, the challenge for the coming decades is such that it is necessary to position the legal constraint in the right place, in order to allow innovation, including that which we do not think about.

This means that as far as possible, the positioning of political discourse and its transcription into law or norm should be formalised in a technically neutral way.

Environmental, social and economic objectives must be set ...:

- Carbon-neutral energy
- Available energy
- Accessible energy

...and set constraints, necessarily numerous :

- Acceptability of production sites
- Risk Management
- Transparency of induced effects
- Possibility of having a sovereign industrial sector

It is then up to researchers, industrialists and engineers to implement these objectives. The challenge is such and the need for disruptions so colossal that the solution can only lie in innovation and intellectual ferment enabled by freedom. History has taught us that the administration of the economy has never been the best way to innovate.

## V. BEHIND THE ISSUE OF ENERGY: A SOCIETAL CHOICE

One of the fundamental difficulties in the energy debate of the last decade lies in the unspoken social consequences. Not because they have not been thought out, but essentially because these individual and collective consequences are not acceptable to the greatest number.

Because energy is at the heart of any model of society. Our Western society has been built on a logic of growth: its comfort, its goods, its services that some do not hesitate to question. But its social model and solidarity are also based on our energy model and our ability to create added value. Without energy, there is no value creation that allows the financing of our formidable tools of solidarity such as social security.

The difficulty of producing technical *scenarios* therefore lies in societal unthinking. Should the society we share be the consequence of the means of energy production available? Or should we first think about our society, our solidarity and our level of demand and then implement the energy strategy to meet them?

Thus, depending on the approach, all *scenarios* are feasible. The demonstration of Mrs. Barbara Pompili, Minister of Ecological Transition from 2020 to 2022 is thus surprising: "*We commissioned a 100% renewable scenario to finally silence those who said that it was not not possible*". *A priori* all *scenarios* are always possible, the political question is that of their environmental, social and economic acceptability.

The problem then remains in the unspoken of certain scenarios. The political debate has focused on technology (the choice of mode of production) and sometimes only the environmental prism.

This once again raises the question of the place of political discourse. Rather than defending a technology, wouldn't its role be to carry the project of society? Clarification of the technical consequences would be very different and may be more acceptable than taking the problem in the current sense that the technical proposal is seen as a means of constraining the choice of society.

To inform the public debate, it is therefore necessary to produce prospective scenarios. Today these are mainly established by sectoral bodies. Thus, the reference energy scenarios in the public debate are currently taken from the TEN report "Energy Futures 2050". We will note here the surprising nature tending to be based, for the energy strategy, on a study drawn up by the operator of the electricity network alone. This choice demonstrates once again the weight of the technological prism in the energy policy debate in France.

**PROPOSAL E: Formulate energy *scenarios* within the Ministry of Energy that consider environmental, economic and social conditions as a starting point and decline technical hypotheses according to this.**

## CONCLUSION – A USEFUL COMMISSION AND WORK TO BE CONTINUED

At the end of the six months of work of the Committee of Inquiry charged with establishing the reasons for the loss of sovereignty and energy independence of the France, I would first like to welcome the hearing and the attention it has generated. Everywhere in France, the hearings were followed, proof if any were necessary that the French are particularly attentive to the preservation of the strategic interests of our nation.

This popular attention allowed the work of our Committee of Inquiry to be useful and to move the lines even before the report was submitted. I would like to note several happy coincidences:

- the announcement of the *Bill on the acceleration of procedures related to the construction of new nuclear facilities near existing nuclear sites and the operation of existing facilities* was made two weeks after the announcement of the group Les Républicains to create our Commission of Inquiry;
- The discussion of this text was concluded two weeks before the presentation of the report of the Committee of Inquiry;
- A few days after the hearing of Éric Besson, Minister of Industry from 2010 to 2012, whom we widely questioned about his European strategy, the current Minister of Energy announced the establishment of a "*task force*" for nuclear power in Europe, modelled on the description made at the hearing;
- While our first hearings largely focused on the issue of continuing research around the "closure of the cycle" and regret at the abandonment of the "ASTRID" research program of the French Atomic Energy Commission (CEA), welcome announcements in terms of funding for start-ups working on the implementation of Fast Neutron Reactors (RNR) modeled on ASTRID technology have been made;
- While the absence of a meeting of the Atomic Energy Committee or the Nuclear Policy Council was loudly denounced before our Commission by Yves Bréchet in November 2022, the President of the Republic convened his first Nuclear Policy Council on February 3, 2023.

This list is not exhaustive. Its establishment is not the result of any investigation or scientific approach. These are simply happy coincidences that allow me to think that the work of control and evaluation carried out seriously by the national representation can concretely move the lines.

At the end of our work, I am pleased that we and the rapporteur have reached conclusions on which there is consensus. Apart from the reservations expressed on the proposal on societal change (proposal 10), I agree with all the recommendations made in the report. I am also pleased that everyone has made the effort to try to objectify the decisions taken, regardless of the political majorities in charge.

Above all, our work should lead us to reflect on the proper position of the political decision and its legislative transcription for its implementation. It is up to elected officials to deliberate on major societal issues and to set the constraints that researchers, engineers and technicians will have to take into account. It seems to me that the law must reserve a form of technical and technological neutrality. The political course and its ambition will be all the clearer, understandable and mobilising.

Finally, and by way of conclusion, I took a lot of time to express the need to think of our collective decisions from a long-term perspective and therefore of broad consensus. However, when it comes to energy, we must also face the urgency of taking decisions. Too much time has been wasted and takes us away from the objectives of decarbonisation and the temporality of the technical implementation that will allow its societal acceptance. Successful decarbonisation cannot be achieved through degrowth. It must go through progress. This is only possible thanks to the mobilisation of industrial sectors that need time to structure themselves. It has therefore become urgent to act. Decide - what is emerging - but also implement, which is always more complicated!

The alert that this report raises must be taken seriously in all strategic areas for State sovereignty. We could change the words to talk about the pharmaceutical industry, there would certainly not be many details to correct. We must also take the greatest care to avoid finding ourselves in the same situation in a few years' time. This is the case with agriculture. Yes, in all these sectors we need strategic support from the State, investment in infrastructure and confidence in Man and his intelligence, in short, progress!

After the reconstruction of the France that followed the Second World War and laid the foundations for our nation's power, it is up to our generation, born in the comfort and abundance of goods and services, to meet this challenge while respecting the resources of our planet and our environment. We owe it to those who will follow us!

**SUMMARY OF COMPLEMENTARY PROPOSALS:**

In addition to the proposals made by the facilitator which the Chair supported (with the exception of proposal 10), the Chair wished to make several additional proposals:

**PROPOSAL A: Evaluate** the **strategic proposals of** the **next multiannual energy programming with regard to the capacity to set up complete industrial sectors on a French or European scale.**

**PROPOSAL B: Imagine a system guaranteeing** the representativeness of **Non-Governmental Organizations called upon to participate in** the **development** of **public policies on the model** of the **rules of representativeness set up for trade unions from 2010 and implement the transparency** of **their funding on the model of political party** financing **.**

**PROPOSAL C : Create personal accountability for ministers who do not convene the collegial scientific advisory bodies created by law.**

**PROPOSAL D: Conduct a study on** the **availability** of biomass and **the possible distribution of its additional uses between food, energy and** material **manufacturing.**

**PROPOSAL E: Formulate** energy ***scenarios*** **within the Ministry of Energy that consider environmental, economic and social conditions as a starting point and decline technical hypotheses according to this.**

## RAPPORTEUR'S SUMMARY

### *The Commission of Inquiry on Energy Sovereignty and Independence*

A few weeks before a winter on which there were threats of power cuts, due to the lack of availability of the nuclear fleet in particular, the Commission of Inquiry to establish the reasons for the loss of sovereignty and energy independence of France was created by the Conference of Presidents on October 11, 2022 pursuant to Article 141 of the Rules of Procedure of the National Assembly and under the drawing right attributed to the group Les Républicains.

Admittedly, the initial title seemed questionable as energy independence is an illusion and sovereignty only an objective; Admittedly, the original intention could give the impression that this commission would have an essentially polemical aim.

However, after nearly 150 hours of hearings and 5 000 pages of written contributions collected, after a dozen trips by the rapporteur to energy sites and about fifty additional technical hearings, in the light of the statements made and the elements established, the initiative of this Committee of Inquiry can only be unanimously welcomed – just as much as the rigour must be, the intellectual honesty and variety of questions and debates moderated by the Chairman of the Committee and made possible by the assiduous presence of many Member Members.

In order to deal with the long-term issue of energy policies, the rapporteur hoped that the work of the Committee of Inquiry would cover the widest possible spectrum and that the hearings would be able to date back to the mid-1990s: experts and scientists, leaders of the energy sector and regulatory bodies, senior officials in charge of energy issues, former ministers, former prime ministers and even – unprecedented in the history of parliamentary commissions of inquiry – former presidents of the Republic.

**Let's face it : often, we have gone from incomprehension to surprise, to the point of dismay.**

We have, of course, heard many leaders and scientists of very high level, who have courageously and without hesitation affirmed the causes for which they have consistently advocated, and who have honestly specified the limits of their knowledge, their action and their success.

We heard from leaders who took responsibility, acknowledged errors in analysis, judgment and decision-making, while placing their actions in the context of their time – which is necessary.

We also heard public officials who seemed, sometimes at the very moment of their hearing, to realize the magnitude of the consequences of what appeared to them at the time only a "signal", a "message", of political "voluntarism" – thus attesting to a form of unconsciousness of physical, technical and industrial realities.

But we heard from other public officials, who seemed to have always been aware of the impact of their decisions, who sometimes assumed them with vague and detached words; public officials who led a political fight above all against nuclear energy rather than for decarbonisation, a fight of remarkable hypocrisy, which went and still clearly goes against the vital interests of the country.

**The narrative that has been reconstituted before us is indeed the story of a slow drift, of a political rambling, often unconscious and inconsistent, which has distanced us from both the ecological transition and our energy sovereignty.**

**It is the story of the often defective, sometimes even non-existent, link between scientific and technical expertise, investigation of files and political**

**decision**; the story of reports that should have been read, reread or sometimes simply thought of ordering. They have been drawn up by scientific experts, by committees of experts appointed *ad hoc,* by the administrations of the ministries and associated institutions or by the Parliament itself: High Commission for atomic energy, academies of science and technology, OPECST, RTE, ASN...

At every key moment in our energy history over the past thirty years, there have been many, many contributions to the North. Whether it's the impact of our choices on the electricity grid, our inability to get out of fossil fuels quickly, the low efficiency of our energy saving policies, the importance of conducting cutting-edge research in nuclear energy, the need for skills in our energy industry. They targeted precisely, lucidly, cruelly, the delay we were taking.

**As a result, it is also the story of decisions that are often partial or delayed, even contradictory, for reasons that are sometimes understandable when we look back at the climate of the time, but which have led to costly delays.**

**Finally , unfortunately, it is the story of decisions taken backwards, without method, without foresight, with serious consequences, and which seemed to find their source only in deep evils: recklessness and electoralism.**

**After three decades of energy divestation and while sobriety, the revival of nuclear energy and the acceleration of renewable energies are all finally on the table of our policies, this report therefore calls for turn the page on our mistakes and learn all the lessons to face the energy emergency with eyes wide open.**

* * *

***Three decades of energy wandering***

In the hundreds of pages that follow, the rapporteur presents our state of energy health as it emerges from the hearings and the documents consulted; It attempts to trace the narrative of 30 years of energy policies.

**In three decades, it is clear that France has fallen considerably behind in terms of energy sovereignty (Chapter 1).**

The hearings conducted made it possible to dismiss the utopian notion of energy independence in the sense of autonomy and complete control of its energy production. On the contrary, the notion of energy **sovereignty** has shown all its meaning and interest, understood as the freedom to define one's policy and choose one's energy options, the reduction of our dependencies, the resilience of our energy system in the face of crises.

**Over the last thirty years, our energy mix has finally changed little and its fragilities have increased: multiple dependencies on imported fossil fuels that are becoming scarce and will be exhausted within a few decades; very little development of the means of controlling demand as well as renewable thermal energies yet more likely to replace certain fossil fuels**.

In particular, our electricity mix, which is almost entirely domestic, controllable and already decarbonised, has weakened from within. The need for maintenance was poorly anticipated and delays were taken on the renewal of our nuclear fleet; the installation of renewable energy production capacities, intermittent and with major industrial dependencies, remains limited.

**This delay has its roots in a gradual drift of thirty years, in which everyone bears a share of responsibility (Chapter 2).**

**The period from the late 1990s to the early 2010s is like a lost decade.**

The completion of the Messmer plan and the surplus of electricity production, *via* nuclear energy, compared to the consumption of the time (which resulted for years in a carbon-free export of electricity and constituted a margin against the vagaries of production) gave the leaders a form of illusion of

**overcapacity** – illusion in view of the anticipable but unanticipated need, for succeeding in the ecological transition, to have more electricity; illusion in view of the challenge that would constitute the renewal of the nuclear fleet.

**Despite announcements favorable to nuclear energy in the 2000s, the** stewardship **does not follow**: the fratricidal guerrilla war between EDF and AREVA within the sector is not stopped by the public authorities, in a context an explosion in the debt of EDF, which has nevertheless been asked by the State to pay significant dividends; the decision to build an EPR recorded in 2005 appears both hasty and not included in an overall industrial plan; The anticipation of the maintenance and renewal of the fleet is not very present.

**Moreover, the emergence of new energy objectives – energy efficiency, phasing out of fossil fuels, development of renewable energies – has only been very partially accompanied by an industrial ambition,** which constantly involves research, sector support and investment in skills.

**Finally, the end of the 2000s and the beginning of the 2010s will remain irremediably the years of the conception of a European framework harmful to the French model.** The idea of consolidating export opportunities for our electricity has led to weakening EDF in France and Europe, to installing a sword of Damocles on our hydroelectric concessions, and to creating a market for electricity responds to concerns about margin allocation rather than industrial success and security of supply at reasonable cost.

**After these years of latency, the years 2012-2017 have greatly aggravated the situation.**

Paradoxically, even though planning tools are put in place such as the multiannual energy programming, these tools are little or poorly used.

**Thus, the electricity consumption forecasts requested from RTE only cover the short or medium term, unrelated to the well-known climate objectives or to the long time required by the energy sector** industry. In 2015, for example, three out of five trajectories predict a decline or near stagnation in electricity consumption in the following years. At the same time, the integration of European trade leads us to think of the country's security of supply on a continental scale, and no longer only on the French one: we rely on imports in the event of a crisis.

**In this sense, the 2015 law, its quantified objectives including the "50%" and the capping of nuclear production capacity, a logical consequence of the political commitment made in 2012, constitute a counter-example of energy** policy. The assumed absence of impact study and prior in-depth reflection, for such a structuring law on our energy model and our electricity network with regard to the intermittency of certain energies, will have marked the Commission of

Inquiry. **The choice to develop renewable energies** without adding the necessary industrial resources, and necessarily in competition with the nuclear fleet, has obviously been done above all to the detriment of the exit from fossil fuels.

**If this law cannot bear sole responsibility for the weakening of the nuclear industry, it has undoubtedly sent a destructive signal at a crucial time... without triggering sufficient acceleration of renewable energies** – further increasing the energy wall. Mirroringly, the delay taken and not followed on the EPR site made it all the more difficult to envisage the renewal of a fleet whose post-40-year maintenance was just beginning.

**After these years of energy inconsistency, since 2017, the course of energy policy has been mixed: after the pursuit of damaging decisions, largely stemming from the recent past, the country has had for the first time global energy forecasting tools and structuring decisions have been announced.**

The shutdown of the Fessenheim power plant – which was not inevitable even in 2017 –, the suspension of the $^{4th}$ generation nuclear project ASTRID without an industrial or experimental alternative to the height, the only partial revision of the PPE have *de facto* continued to weaken the nuclear industry.

However, at the same time, industrial and electrical rationality was at work with feedback from the EPR site, the commissioning of an energy forecast based on climate and industrial objectives and the instruction of the decision to launch new reactors with a simplified *design*.

**It is these elements, objective and detailed, which have led, albeit belatedly, to an unprecedented revival of the nuclear project finally concomitant, and not rival, with the acceleration of renewable energies.** The creation of a programming law, the choice to project oneself into a world where electricity is more in demand, the announcement of the desire to build 6 EPRs and to think about the construction of 8 others, the projections of *offshore* wind farms are all strong markers that reverse a strong trend in the French energy policy for 30 years – **all these markers remain to be concretised in the coming months and years.**

***Six mistakes, six lessons, six projects for the next thirty years***

From these three decades, the rapporteur deduces six major energy errors, six general lessons to be drawn from them and six operational projects to be implemented tomorrow for the decades to come (Chapter 3).

**The six mistakes of our energy policy**

1. **Energy** forecasts: having underestimated our electricity needs in relation to our ecological objectives and the necessary exit from fossil fuels, without long-term reflection on our industrial and climate ambitions.

2. **Opposition from renewable electric energies and nuclear power**: having **focused** on the electricity mix, **when it is already controllable** and **decarbonised, and having done so necessarily to the detriment of the exit from fossil fuels**, which entails immense challenges such as the electrification of uses and the impact on the network, the ability to assume a share of energy sobriety, etc.

3. **Nuclear fleet**: not having anticipated the extension of the life of nuclear power plants as well as their renewal in industrial series and not in an isolated site, which has weakened both the nuclear industry, its skills and the country's ability to relaunch a major project.

4. **Renewable energy**: not having built industrial renewable energy chains to replace fossil fuels more quickly, as targets were set.

5. **European** market: having allowed a framework to be built over the past 20 years that has weakened the French and EDF energy model, through the NOME law, the ARENH system, the status of hydroelectric concessions and electricity trading rules.

6. **Research**: having shut down the Superphénix reactor in 1997 and not having preserved our lead in the research and development of the 4th generation post-2019.

From these decades, the rapporteur also tries to draw six general lessons that deserve to be highlighted and which, if they appear more evident in 2023 than in the past, could again be neglected or set aside, against the elementary laws of physics and industry, in the more or less near future.

**Six energy lessons for the next 30 years**

**1. The long term counts:** we must make consistent (*via* RTE and other public bodies) our climate (reduction of emissions), industrial (reindustrialisation) and energy (ability to produce this or that energy in France) ambitions on a compatible time scale, i.e. several decades.

**2. Energy, *via*** electricity, **is not a good like any other:** within the European Union, each country first defends its energy mix, France must also defend its controllable and carbon-free electricity mix.

**3. Energy is an industry, the 3rd largest French industry:** we need to continue to master the entire value chain of an energy sector and to have the skills, but also to choose renewable energy technologies and sources, of which hydraulics are the most important and the only controllable, the most profitable and the most able to ensure our security of supply.

**4. Electricity is not everything:** we must not focus solely on electricity when its production is already almost entirely carbon-free in France, but also, for example, accelerate the development of heating networks, thermal renewable energies to replace fossil fuels.

**5. The control of demand is being prepared: the** achievable energy efficiency in the residential stock must be better evaluated and equipped with the necessary skills; sobriety is prepared upstream, in mentalities.

**6. Without research, we are doomed to be late:** Research needs visibility and means to anticipate the next 5 decades: closure of the cycle in the nuclear industry; massive storage of electricity for the grid; recycling of critical materials, etc.

We are therefore now facing an unprecedented energy wall that will only be solved by sobriety and energy efficiency and by increasing our carbon-free energy production, first and foremost our electricity production. While our electricity mix is fragile, our energy will have to come from controllable, carbon-free and less vulnerable sources.

**The rapporteur deduces six operational projects, broken down into 30 proposals, to give back to France an energy destiny.**

**1. Adopt an energy ambition for at least the next 30 years, which is reflected in a scientifically and industrially supported programming law on this horizon and which fully integrates the considerable increase in electricity consumption compatible with our climate and industrial ambitions.**

France needs a programming law compatible with the requirements of industry and climate; a law with objectives supported by the lessons of scientific and technical institutions, which spans several decades and is subject to preparation and monitoring by Parliament (proposals 1, 2 and 3). This horizon will have to assume that our industrial and climate objectives require a considerable increase in electricity production, and that this electricity gap (between our current capacities and our needs from the next decade) can only be bridged by the simultaneous use of sobriety, the development of renewable energies and a massive revival of the nuclear industry.

This new course must be accompanied by adequate steering based on the reintegration of the Directorate-General for Energy within the Ministry in charge of industry, the monitoring by the administrations of our vulnerabilities and the revision of our doctrine of security of electricity supply (proposals 4 and 5).

**2. European framework: reform, within the year and in depth, the European market, in line with our national industrial choices, and suspend or review the rules that threaten our industry: ARENH, the status of hydroelectric concessions; demand compliance with the Treaty of Lisbon and give new impetus to the Euratom Treaty.**

The rapporteur, who is profoundly pro-European, insists on the urgent need to reform the entire European framework for energy policies: France must stop being subjected to economic rules that weaken its industry in defiance of the principle subsidiarity and get out of the ARENH mechanism while the reform is negotiated; our country must in any case defend its hydroelectric and nuclear power heritage and give impetus to the Treaty Euratom of 1957, which already provides for scientific and technical cooperation between States in the nuclear field (proposals 6 to 9).

**3. Decarbonise our energy mix by accelerating sobriety and efficiency efforts and relying on thermal renewable energies**

In the last thirty years, debates have tended to focus on the French electricity mix, which is almost entirely decarbonised, to the detriment of our much stronger and problematic dependence on imported fossil fuels.

The reduction of this dependence requires the continued reduction of our energy consumption and the sustainability of the sobriety plan, the decarbonisation of all our sectors including transport, and energy renovation whose devices must be made more efficient – as well as by the development of thermal renewable energies, largely underexploited in their potential in recent decades, while they can be a direct substitute for fossil fuels (proposals 10 to 13).

**4. Strengthen our sovereignty over the entire value chain and meet the skills needs of the energy sector and in particular electricity**

Because it is an industry, energy production requires a long-term vision and support throughout its value chain, from the supply of resources (and in particular critical materials essential to the electrification of uses) to industrial outlets, with a central stake: the ability to bring out the necessary skills, in quantity and quality, in the coming years, both in terms of energy renovation and the nuclear industry (proposals 14, 15 and 30).

**5. Nuclear fleet: Remaking the nuclear industry the great French strength, and in particular establishing an evolutionary plan to close our plants as and when ASN decides and preparing accordingly the complete renewal of the fleet, as well as the strengthening of the fuel cycle; after scientific evaluation, arbitrate between accelerating research on multi-recycling in EPR and changing scale on 4th generation research (without technological pre-choice)**

The challenges facing our nuclear fleet are immense: they must be fully identified, measured, made transparent and dealt with one by one, whether it concerns uranium supply and our (re)enrichment capacities, the need to adapt to climate change, the impact of ageing on the operation of the reactors, and of course the pace and extent of fleet renewal (proposals 16 to 23 and 27).

Beyond this renewal, which has become urgent because it was insufficiently anticipated, France must catch up with the delay in research and actively relaunch large-scale programs on the 4th generation, the only one able to change scale our needs for imported uranium and to significantly reduce, but not resolve it at this stage, the issue of waste (proposals 24-26).

**6. Renewable energies: on the basis of energy profitability and full cost studies, launch a binding installation plan for certain renewable energy sources in the territory**

Faced with the energy wall that presents itself in the short term, even before new nuclear reactors can be built, even intermittent, renewable electric energies will be essential and complementary to controllable electricity production.

The rapporteur therefore proposes, in addition to reinvestment in hydropower plants, to continue to accelerate the deployment of renewable electricity sources deemed to be the most energy-efficient, after a in-depth study of RTE, taking into account in particular the load factor, the minimisation of intermittency, social acceptability, land consumption, etc. Finally, it stresses, in particular, that the desire to build 50 offshore wind farms must be concretized by the launch of calls for tenders taking into account the European and French industrial dimension, and by continuing to simplify procedures and deliberations that will not make it possible to respond to the energy emergency (proposals 28 and 29).

**These 30 recommendations have a chance to be developed, adopted, implemented seriously and sustainably only under two conditions that may have been lacking in the past:**

Scientifically, technologically and industrially instruct the options that are proposed;

To bring out a national, republican consensus around the energy emergency and the need to combine lines often wrongly opposed: sobriety and production, development of nuclear energy as efficient renewable energies.

**This report is therefore above all a challenge to the governments and parliaments of today and tomorrow, which share the responsibility of giving an energy destiny, that is to say an ambition that is both ecological and sovereign, to France.**

## PROPOSALS: 30 PROPOSALS FOR THE NEXT 30 YEARS

Proposal 1: in line with our climate and industrial objectives, assume a growing need for electricity by the end of the decade, by 2050 and beyond, and note the production gap that separates us from energy sovereignty

Proposal 2: adopt a 30-year energy-climate programming law with climate, energy and industrial objectives and related resources, which will be closely and regularly monitored by Parliament and Expert institutions

Proposal 3: strengthen the consultation of Parliament, and in particular OPECST, on energy policies and their control over their implementation

Proposal 4: Put the Directorate-General for Energy back within the Ministry of Industry and provide it with the means to identify, monitor and reduce our industrial vulnerabilities

Proposal 5: ask RTE to change its security of supply criterion in the short term, and launch an overhaul of our global security of supply doctrine under its responsibility

Proposal 6 : adopt a common and sustainable European position to define nuclear energy as a decarbonised and strategic energy, which should be supported in the same way as renewable energies

Proposal 7: link the reform of the electricity market to the negotiations on the EU's overall energy policy by carrying out a profound reform of the European electricity market to protect French specificity, uncorrelate the price of gas from that of carbon-free electricity; in the meantime, suspend without delay and compensate ARENH

Proposal 8 : Following the recent announcement by the Minister for Energy Transition, demand compliance with the Lisbon Treaty and give new impetus to the Euratom Treaty

Proposal 9: Keep hydroelectric concessions in the public domain, for example by applying a quasi-governance mechanism to avoid competition and boost the necessary investments

Proposal 10 : Perpetuate and increase the ambition of the winter 2022-2023 sobriety plan, and extend it to all individuals, public services, and businesses without ignoring the financial and industrial cost of erasure

Proposal 11 : Strengthen the decarbonisation efforts of all emitting sectors, particularly in transport with the acceleration of public transport and rail freight projects and with the reduction of vehicle weights through incentive schemes

Proposal 12 : evaluate energy renovation schemes to prioritise the most effective, set measurable consumption reduction objectives and break them down by department; launch a sector plan to develop training

Proposal 13 : revise our renewable heat targets, which according to several institutes could be at least doubled by 2030, and strengthen the associated Heat Fund

Proposal 14 : launch a new mining inventory on French soil, accelerate the identification of critical imports and the creation of rare earth processing and recycling channels

Proposal 15: deepen the forecasting of investment needs on the network, in particular in the case of the strong reindustrialisation trajectory

Proposal 16 : on all major short-term challenges (stress corrosion, thermal fatigue) and medium-term challenges (impact of climate change), ask EDF to produce and present to the Government, OPECST and the general public, a precise and prospective inventory of the measures taken to ensure the operation of the nuclear fleet, dams and all energy installations

Proposal 17: conduct the preliminary studies necessary for the extension of all reactors that can be extended under different scenarios, and anticipate today and within the framework of the EPML the needs, impacts and consequences of the closure and dismantling of the existing fleet, regardless of the effective shutdown date of the reactors

Proposal 18: increase as much as necessary the resources allocated to the delegation to new nuclear power in the monitoring of the project for the construction of new EPRs and obtain regular and public monitoring reports on the progress of the project; consolidate EDF as a single, nationalised operator

Proposal 19: anticipate the need for renewal and development of the entire existing fleet, in number of reactors (including SMR) or installed capacity, in the coming decades and on existing or new sites

Proposal 20 : ask EDF for greater transparency on its supplies of natural and enriched uranium, at least one geographical grid per country

Proposal 21: Support the strengthening of enrichment capacities on French territory

Proposal 22: study the industrial feasibility and economic options for installing a new re-enrichment plant on French soil in the short term

Proposal 23: Provide all necessary financial and administrative support for the expansion of spent fuel storage capacity in The Hague

Proposal 24 : validate the final steps and ensure State support for the financing of the Jules Horowitz reactor while controlling deadlines and costs

Proposal 25 : relaunch the construction of an ASTRID-type demonstrator, of potentially more modest power, to make up for the delay accumulated for 30 years, and continue to develop associated research on the fuel cycle

Proposal 26: increase support for technologies related to the 4th nuclear generation, giving priority to companies that are able to present experimental and/or industrial results, and not only numerical simulations

Proposal 27: ensure an increase in the number of employees in nuclear safety, by optimising the administrative organisation and questioning the existing relations to date between the various nuclear safety organisations, in order to assume the new burden linked to the revival of nuclear power

Proposal 28 : ask RTE for an in-depth analysis, based on renewable energy, integrating their potential, their energy and economic profitability (calculations of average, minimized intermittency, acceptability, land consumption, longevity)

Proposal 29: launch calls for tenders for the 50 offshore wind farms as soon as possible, make their installation binding and secure the financing and commitment of the project owner

Proposal 30: create an "energy apprentices" label to enable young people to identify the training of the future, associated with financial aid, mobility and housing facilities

# CHAPTER I[ER] : IN THREE DECADES, FRANCE HAS ACCUMULATED A CONSIDERABLE DELAY IN TERMS OF ENERGY SOVEREIGNTY

Invited to question the "loss of independence and energy sovereignty of France", the Commission of Inquiry began its work with an inventory of the concepts in question in order to deconstruct certain myths (I). The Committee of Inquiry then carried out a precise assessment of the current situation of the French energy mix. The rapporteur draws a very worrying conclusion from this: the country's energy mix is currently subject to strong and numerous dependencies, which will worsen (II).

## I. IF ENERGY INDEPENDENCE IS A RED HERRING, ENERGY SOVEREIGNTY MUST BE A MAJOR OBJECTIVE OF OUR POLICY.

At the end of the work carried out on the concepts of energy sovereignty and independence, the rapporteur stresses that while the challenge of energy policy is to meet energy needs while decarbonising its production (A), energy independence, in the sense of production autonomy, is meanwhile a mirage (B). On the other hand, energy sovereignty, in the sense of freedom of choice underpinning the French energy system, constitutes a legitimate and necessary aspiration (C).

### A. A CENTRAL CHALLENGE: HAVING THE ENERGY WE NEED WHILE DECARBONIZING ITS PRODUCTION

Present everywhere around us, **energy** – the force in action(1) – is the essential element for the existence of our environment, our system and our society. It is the "***determinant of what makes our world***"(2). This singular good, "*indispensable to all human activity*"(3) to use the terms of Mr. Jacques Percebois, professor and director of the Centre de recherche en économie et droit de l'énergie, allows us to move, heat, produce, light, refrigerate or power the electrical equipment that makes the comfort of modern life, and more simply, it allows us to live.

**Yet the main sources of energy we use are limited. The current energy crisis and the warnings issued by the French electricity transmission system (RTE)** before winter about a risk high voltages on the French electricity grid in January 2023 have put **energy back at the heart of concerns** and recalled, if it were necessary, how energy is an essential resource for the proper functioning of society.

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*(1) The word* "*energy"* from the *Latin energia comes from the ancient Greek enéergeia which means the force in action.*

*(2) Hearing of Mr Jean-Marc Jancovici, professor at Mines ParisTech, November 2, 2022.*

*(3) Hearing of Mr Jacques Percebois, November 9, 2022.*

Because energy is vital and the energy we use is limited, it is necessary **to organise and plan its management** – this is the goal of **energy policies.**

Meeting these needs may involve the use of energy in various forms and from various sources (1), the aim being to balance energy supply and demand (2) which, in the case of electricity, requires specific constraints to be taken into account (3).

### 1. Meeting energy needs is based on various sources and forms of energy

**Energy refers to an ability to act, to provide work,** whatever the modes: to set a mass in motion, to generate a change in temperature, a change in the state of matter, to transmit information, etc. It is qualified as primary energy when it is considered gross, as derived or extracted from the environment, and secondary or final energy when it is considered as transformed and used by its consumer, after possible losses.

#### *a. Energy takes different forms depending on its use*

**Energy takes different forms**: it can be mechanical, thermal, chemical, light or nuclear.

**Mechanical energy** is defined as the sum of the kinetic energy (that of motion) and the potential energy of gravity. Mechanical energy is a form of energy that can **be used to perform work by using moving objects or changing their position**. The applications of mechanical energy are vast and varied: transportation (motor vehicles: internal combustion converts the chemical energy of the fuel into mechanical energy that moves the vehicle; planes and trains that use turbines to convert mechanical energy into kinetic energy); machine tools; buildings and infrastructure (heating and cooling, lighting, ventilation, lifts, etc.); household appliances (blades, wheels, other parts); activities of all types (leisure and sports, amusement parks, ski lifts, etc.).

Mechanical energy is therefore omnipresent. It can be **stored hydraulically** , by compression or by flywheels and can be converted into electrical energy.

**Thermal energy is the** expression of energy in the form of **heat**. It is caused by kinetic energy from the agitation of atoms and molecules in a solid, liquid or gaseous body. Thermal energy is used in many areas, such as power **generation**: combustion power plants burn fuel (coal, natural gas, oil) to heat water and produce steam. This steam is then used to turn a turbine that generates electricity, cooking, heating and cooling buildings, manufacturing industrial products (many industrial products require heat for their manufacture: for example, Glass, metal and ceramic production plants all use thermal energy to melt and shape materials).

It can also be used to produce mechanical power and mechanical energy (example of the combustion engine). **It can also be stored** in insulating materials such as glass wool, polyurethane foam or expanded polystyrene.

**Chemical** energy is stored in molecules until it is released during a chemical reaction. The atoms of molecules are held together by chemical bonds that contain potential energy. When a chemical reaction occurs, these bonds can be broken and the energy stored in the bonds can be released as **kinetic, thermal or electrical** energy.

**Light energy** is the energy created and transported by light waves. It is used both to **produce electricity**, **heat**, to allow the growth of living organisms, to illuminate, to transmit information (optical fiber), to treat (treatment of skin diseases, laser medicine ...).

**Nuclear energy** is a form of energy released by an atomic nucleus. Nuclear energy is not a form of chemical energy: unlike chemical reactions, which only change the electrons around the nucleus, nuclear reactions directly modify the atomic nucleus. Nuclear energy can be caused in two ways:

By **nuclear fission**: energy is released when an atomic nucleus splits into two (sometimes three) smaller nuclei. This is only possible if the nucleus is said to be "fissile", i.e. susceptible to fission, regardless of the energy of the neutrons that hit them. This phenomenon is caused when a neutron collides with a fissile nucleus (the case for isotopes 233 and 235, or even 238 of uranium and isotopes 239 and 241 of plutonium), which releases a large amount of energy. Most of the energy is carried away as kinetic energy by fission products, which jostle other atoms. The fission products then lose speed and generate heat. Kinetic energy is transformed into thermal energy. Each fission produces between two and three neutrons of high kinetic energy. The latter then interact with another fissile nucleus, which cause new fission: this is the chain reaction.

By **nuclear fusion**: two light, positively charged nuclei fuse to create a heavy atom. This releases a very large amount of energy. The reaction most accessible by man is the fusion of adeuterium atom and a tritium atom, which gives rise to a helium atom. Melting is caused when two positively charged nuclei come closer together, a phenomenon that is possible only at very high temperatures (100 million °C).

Nuclear energy is mainly used for the **purpose of generating electricity, *through* the exploitation of the heat** produced during a reaction in a nuclear power plant. Fission reactions produce heat, which is transformed into steam that feeds a turbine connected to an alternator. The mechanical power of the moving steam is thus transformed into electricity. The nuclear reaction is also used for the manufacture of atomic weapons, for naval propulsion or for medicine, radiotherapy and cancer treatment.

### *b. Energy production depends on the energy sources present on our territory or available for import*

**These different forms of energy come from various sources,** non-renewable sources, present in limited quantities on Earth, or renewable sources, considered inexhaustible on the scale of human time.

The subsoil of the Earth is composed of elements that can be exploited by Man to produce energy. So-called **fossil** energy **sources** are raw materials available below the **Earth's** surface and resulting from the decomposition of plant and organic matter. These residues are called hydrocarbons, because of their composition consisting solely of carbon and hydrogen.

**Fossil sources** come from deposits of material called sediments, rich in organic matter, which sink and solidify in the Earth's crust over millions of years: this is the mother rock. From a certain pressure and depth, the source rock is transformed into kerogen (intermediate state between organic matter and hydrocarbons). It begins to generate hydrocarbons (oil, natural gas and shale, coal...) from 2,000 metres deep, burial distance where the subsoil temperature reaches 100°C. If fossil fuels are an accessible energy since Man controls its extraction and exploitation, its transport and storage, these energies have two major disadvantages: they participate, during their combustion, in **the emission of greenhouse gases** (GHGs) and they are **said to** be **limited since they are not renewable on a human time scale**.

**Petroleum:** kerogen processed between 2,000 and 3,800 meters. This interval is called the "oil window". Oil is used as an energy source for the production of heat, electricity, to power gasoline vehicles, for the production of chemicals, as a raw material for the manufacture of plastics, synthetic rubber, medicines, cosmetics, paints, varnishes.

According to IFP Énergies nouvelles (IFPEN)(1), proven oil reserves are estimated at 1732 Gb worldwide at the end of 2020, i.e. **53 years of production at the rate of 2021.** Including all oil resources excluding extra heavy oils and oil shale, this ratio reaches about 189 years. Despite the depletion of reserves, oil was still the **most consumed energy in 2019 for 31% of global primary energy consumption(2)**.

**A gaseous mixture of hydrocarbons**: gas (natural and shale). When the burial of the source rock continues betwee3,800 and 5,000 meters, the production of liquid hydrocarbons reaches a peak. The liquids produced become lighter and lighter and pass into the gaseous state. This depth interval is called the gas window. The gas is composed mainly of methane, but can also contain varying amounts of ethane, propane, butane and other organic compounds. It is produced from the decomposition of organic matter under conditions of high temperature and pressure. Gas is used as an energy source for the production of heat, electricity and to power gas vehicles.

According to IFPEN[3], proven natural gas reserves are estimated at 4,036 $Gm^3$ worldwide at the end of 2020, i.e. **47 years of production at the rate of 2021**. This ratio calculated by integrating all gas resources reaches about 200 years. However, in 2019, natural gas was the **third most consumed energy – 23% of global primary energy consumption**[4].

Shale gas is a special type of natural gas that is found in so-called shale rock formations. It is produced from source rock formations or unconventional bedrock, which contain significant amounts of gas trapped in their pores. In 2016, the world's reserves of technically recoverable shale gas reached 214.5 trillion cubic meters, or **61 years of production at the rate of 2016**[5] – the environmental consequences of the extraction process, however, lead some countries, including France[6], to stop the exploitation of its resources.

**Coal: combustible sedimentary rock**. Coal is a solid rock formed from organic matter, dead animals and vegetation, which has been compressed and recrystallised over millions of years. Coal is mostly composed of carbon, but also contains varying amounts of hydrogen, nitrogen, sulfur, and oxygen. It is generally classified into three types: anthracite coal, bituminous coal and lignite coal, depending on its degree of maturation and energy quality. It is a fossil source that has been used as an energy source for millennia, mainly for the production of heat and electricity. It is also used in steel production and in some chemical industries.

According to IFPEN[1], proven coal reserves are estimated at 1,074 Gt worldwide at the end of 2020, i.e. **131 years of production at the rate of 2021**. In 2019, coal remained the **second most consumed energy – 27%** [2].

**The rapporteur can therefore only recall this alarming observation: at this rate of production and the current degree of knowledge of reserves, energy sources, which account for nearly 80 % of world energy consumption, will be exhausted in about fifty years' time.**

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(1) *Based on IFPEN's responses to the rapporteur's additional requests, based on data from the International Energy Agency (IEA).*

(2) *MTE, Key Energy Data* – 2022 *edition*, *November 2022, p. 46.*

(3) *Based on IFPEN's responses to the rapporteur's additional requests, based on data from the International Energy Agency (IEA).*

(4) *MTE, Key Energy Data* – 2022 *edition*, *November 2022, p. 46.*

(5) *United Nations* Conference on *Trade and Development, Commodities* at *a Glance* – Special *Edition on* Shale *Gas*, *2018, p. 12.* https://unctad.org/system/files/official-document/suc2017d10_fr.pdf

(6) *Law No.* 2011-835 of *13 July 2011 prohibiting* the exploration and exploitation of *liquid or gaseous hydrocarbon* mines *by hydraulic fracturing and repealing the exclusive permits of research involving projects using this technique.*

**Nuclear sources** are elements that can be used as fuel. Only atomic isotopes can be mobilised to release energy. An isotope is an atom that has, in its atomic structure, the same number of electrons as protons to remain neutral, but which, in its nucleus, has a different number of neutrons. The chemical properties are unchanged while the physical properties are different (the atom is stable or radioactive).

According to the International Atomic Energy Agency, there are about 8.1 million tons of natural uranium on the planet, or about 130 years of reserves from current mines at current production rates and double the time when including estimated reserves[(3)]. In 2021, nuclear energy accounted for about **5% of global primary energy consumption**.

| | **Type** | **Characteristic** | **Presence in natural uranium** | **Usage** |
|---|---|---|---|---|
| Uranium-235 | Natural isotope of uranium | Fissile | 0.7 % | Light water reactors<br>Molten salt reactors<br>Fast neutron reactors (RNR)<br>Natural uranium graphite gas (UNGG) reactors |
| Uranium-238 | Natural isotope of uranium | Fertile | 99.3 % | RNR reactors UNGG reactors |
| Uranium-233 | Produced from thorium-232 | Fissile | - | Light water reactors<br>Molten salt reactors RNR reactors |
| Plutonium-239 | Produced from uranium-238 | Fissile | - | RNR reactors |
| Plutonium-241 | Produced from plutonium-240 | Fissile | - | RNR reactors |

*Source: Rapporteur.*

*(1) Based on IFPEN's replies to the rapporteur's additional requests.*

*(2) MTE, Key Energy Data – 2022 edition, November 2022, p. 46.*

*(3) https://www.iaea.org/fr/themes/la-production-duranium*

In addition to geological sources, other natural energy sources are mobilisable and considered inexhaustible on the scale of human time: **renewable energy sources** such as the sun, air masses, water, biomass and heat from the earth's subsoil.

The Earth draws all its energy from a single source: **the sun.** It emits photons, elementary particles that carry energy in an electromagnetic field, have no charge or mass and interact with matter by creating free electrons or exciting atoms and molecules. For example, this happens when light hits a photocell. Solar radiation, through the photons it emits, makes it possible to produce energy according to three different technologies:

**Solar photovoltaic technology** is the only one that can directly produce electricity. It is within the photovoltaic cells, which make up the panels, that the particles of sunlight transfer their energy to the electrons of a semiconductor material. These electrons then set in motion and create an electric current collected by a very fine metal grid. Assembled in series and in parallel, then protected by different layers of materials to form a photovoltaic module, these cells provide voltage and electric current.

**Energy in thermal form** can be extracted from the Sun, by solar thermal collectors, again in the form of panels. Unlike photovoltaic technology, no electricity is produced. The captured heat is transmitted into metal absorbers and then heats a heat transfer fluid which circulates in a pipe network, to supply central heating or produce domestic hot water.

**Thermodynamic technology makes it possible to produce electricity indirectly**: solar radiation is transformed into heat, then this heat makes it possible to produce electricity. The principle of thermodynamic solar is to concentrate the photon fluxes of solar radiation using an optical device (composed of mirrors) so that the energy they contain can heat a heat transfer fluid to a high temperature of 400° C to 1,000° C, allowing subsequently to produce electricity through steam or gas turbines. The main advantages of this technology are the partial storage of energy in thermal form and the production of electricity on a larger scale(1).

**The wind** comes from the primary energy of the sun. The sun heats the Earth unevenly and the continents heat the air in this way. Warm air increases in volume, is lighter and encounters cold air at altitude. It is from the pressure difference between masses of warm and cold air that the wind is born. The movement of air masses can be exploited: the kinetic energy of the wind is converted by a **system into mechanical energy** that drives an electricity generator.

The movement of **water** is historically used by humans for energy purposes. The first water mills date back to antiquity. Hydropower is produced by using the power of water to generate electricity. This can be done in several ways.

The **hydraulic dam** is the most common method of transforming water energy into electricity. In the upper part, water and by extension its potential energy is stored. When it falls, its potential gravity energy is converted into kinetic energy (in the movement of water, with speed and acceleration) that drives turbines connected to an alternator generating electricity.

In the case of **tides,** the ebb and flow of water makes it possible to produce electricity. At rising tide, water is stored in a reservoir and then released when the difference in height between sea level and basin level is large enough. Tidal energy is then captured and converted either into mechanical energy (water mill) or electricity using turbines and generators .

In the case of **ocean currents**, the kinetic energy of water flows can be captured to create mechanical energy and then transformed into electricity: this is the tidal turbine.

Finally, the movements of the **swell**, i.e. waves that propagate in the water in contact with the wind, form wave energy. Several technologies are being studied to recover wave energy and transform it into electricity, such as oscillating water columns (the oscillation of water acts as a piston that compresses air to drive an electricity-producing turbine), or breaking systems (water fills a raised basin and then the water is released through an electricity-producing turbine).

The sun's radiation energy acts directly on organic matter of plant, animal, bacterial or fungal origin. **Biomass** refers to all these materials that can be transformed into chemical potential energy. Materials make it possible to produce electricity and/or heat by three main methods:

– by **combustion** : wood, waste, plants, etc. are directly burned and produce heat, which can be transformed into electricity;

– by **gasification**: it is a thermochemical transformation in order to obtain a combustible gas mixture. Gasification is used as a source of heat production, electricity (gas on turbines) or hydrogen;

– by **methanisation**: the materials are transformed into biogas by the action of microorganisms. This method creates two products. The first is biogas with methane as its main component. It is an energy source that can be injected directly into the natural gas network and used to produce electricity (cogeneration). The second is a residue, the "digestate", used as fertiliser.

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*(2) The only solar power plant based on this technology in France is located in Llo in Occitania and was commissioned in 2019. If this plant is unique on our territory, it is because in France, except in a few very restricted areas, direct sunshine is not sufficient to consider economically viable projects.*

Earth's energy is the energy continuously generated by the heat of the Earth's depths. **Geothermal** energy consists of exploiting the natural heat stored underground to produce energy. Hot water or steam stored in an underground tank is used as is or converted into electricity. Geothermal energy can be used to produce **heat:**

– geothermal energy for buildings, swimming pools, greenhouses, fish farms. The reservoirs are located in a shallow layer (a few tens of meters deep). Thermal energy is used to heat small installations using heat pumps or to produce domestic hot water;

– heating networks: the reservoirs are located in a medium-deep layer (a few hundred meters). The energy captured can produce hot and cold.

Geothermal energy can also be used to produce **cold**, with or without the use of heat pumps. The basement then becomes a source of cold when its temperature is low enough to cool a building; this is the case in the summer. Heat from the basement can also be cooled using reversible heat pumps and then injected into a building.

Finally, deep geothermal energy, between 2,000 and 3,000 meters, can be used to produce **electricity**, through two methods:

– **by turbinating steam** hot pressurised water rising from a production well gradually loses its heat and arrives in the form of water and steam due to the loss of pressure. The steam is used to drive an electricity-producing turbine;

– **By transfer of thermal energy to one fluid**: when the water is less hot, it is kept under pressure to dissipate its heat to a second fluid that vaporises at low pressure and low temperature. The steam produced drives an electricity-producing turbine.

The energy sources are therefore varied and allow, after recovery and transformation, to obtain an energy that can take different forms.

## 2. Needs met by adjusting supply and demand

**In particular, French energy policy** seeks to establish a balance between supply and demand. It must make it possible to continuously forecast the forms of energy that consumers need in order to adapt the supply according to the available **energy sources** – those available on the territory (solar, wind, water, heat) and those to be imported (gas, oil, uranium) – and according not only to the possibility and the capacities to **be imported. transform these energy sources into** energy (electricity, heat, hydrocarbons), **but also the capacity to store and transport energy.**

To ensure that France has the energy it needs, at all times, and despite the **variability** of national supply and demand, it can act to both on energy production and on consumption.

***a. Development of supply through the deployment of production capacity and imports***

On the supply side, it is first of all a question of having sufficient **production capacity** and anticipating a possible volume **of additional imports.** A country's **means of production** vary according to the resources at its disposal and the technologies it develops according to the energy mix it chooses. **Having domestic production capacity requires:**

– to have deployed energy production facilities – which requires sufficient **mastery of the technologies** underlying these production facilities, with the patents, know-how and skills necessary for their operation and maintenance – and to have organised the good **availability of raw** materials and materials essential for the construction and operation of the means of production (for example critical materials for certain renewable energies or uranium supply for nuclear energy);

– **to maintain** these production facilities **in functional condition**: nuclear generation fleet, electricity production facilities from renewable energy (hydro, wind, solar, bioenergy), thermal installations fossil fuel (combined cycle gas power plants, coal-fired power plants, oil-fired power plants, oil- or gas-fired combustion turbines, decentralised thermal generation means);

– **organise the transport of energy from the** producer to the consumer, whether residential or professional, *via* an energy transmission and distribution network which can take different forms (e.g. power lines and transformer stations for electricity, pipelines for gas, refining, storage and transmission for oil). When, as is usually the case, domestic production capacity is not sufficient to meet demand, a country's energy supply can still rely on energy **imports.**

Imports thus enable a State to benefit from forms of energy which it does not have on its territory, to supplement national production, or to compensate for the occasional unavailability of production capacity. However, this requires the **necessary infrastructure for** the transport of energy**:** as in the context of the transport of national production from the producer to the consumer, it is a question of organising interconnections by means of a well-sized transmission and distribution network.

**Box 1: Energy transmission and distribution networks**

The distribution of the various energies from their places of production, extraction or storage to their place of consumption is carried out by transmission and distribution networks.

Hydrocarbons, such as oil and natural gas, are transported by pipeline, tankers and tanker trucks to supply refineries and thermal power plants. Petroleum products, such as petrol and diesel, are then distributed by petrol stations and used for road, sea and air transport.

**Heat** is based on a heat distribution system that includes one or more heat production units, a distribution network in which a heat transfer fluid transports heat to exchange substations feeding a secondary distribution network that serves buildings. Heat distribution networks are small since heat cannot be transported over long distances.

**Electricity and gas** benefit from large-scale (international) developed transmission and distribution networks.

The gas is transported from the place of extraction to the place of consumption by onshore or subsea pipelines - pipelines allowing the transport of gas under pressure over long distances - or by its transformation into liquefied natural gas (LNG) - in particular for transport by LNG carrier to the LNG terminal. The gas transmission network for transporting gas to final consumers consists of a main network connecting it to neighbouring networks, storage facilities and LNG terminals and a regional network to supply the distribution networks and consumers connected to the network.

The electricity grid makes it possible to transport electricity from the places of production – power plants, renewable energies – to the place of consumption.

### *b. The possibility of reducing energy demand through incentives*

On **the demand** side, it is also possible to act to reduce energy consumption and control energy consumption.

These can be actions with both immediate and lasting effects, as part of an approach of energy **sobriety,** a concept that refers to all actions and changes in behavior and lifestyles to reduce energy consumption.

In the longer term and beyond sobriety, which refers to a decrease in energy consumption, which translates into a reduction or evolution of uses, **energy efficiency** makes it possible to consume less by improving the performance of appliances and installations.

In addition to these different levers of action to balance supply and demand, it is also necessary to take into account the physical constraints on electricity management.

## 3. The specificities of electricity: the need for an adapted network and the permanent intervention of the operator

**Electricity** takes the form of a continuous flow of electrons moving through an electrical circuit – from production facilities to consumption sites. By construction, it is therefore not transported like other energies and is difficult to store.

> **ELECTRICITY BASICS**
>
> **Electric current**: it matches to the movement of electric load carriers (electrons) in a conductive material.
>
> **Electric voltage**: it corresponds to the force of the electric current that circulates in a circuit. It is expressed in volt (V).
>
> **Electrical intensity**: it corresponds to the speed and quantity of electric current, i.e. the flow of electrons in a conductor. It is expressed in ampere (A).
>
> **Electrical power**: this matches to the speed at which energy is delivered. It is the result of the voltage multiplied by the intensity and is measured in watts (W or joule – J – per second).
>
> **Energy production or consumption**: it is defined by the electrical power over a given time (watt-hour – Wh; kilowatt-hour – kWh; etc.).
>
> **Load factor**: is the ratio between the number of hours of actual operation at full power and the number of hours of theoretical operation in the year. For renewable energies, this load factor is constantly changing according to the strength of winds, heat, radiation, etc.

**Current technologies do not allow for the massive storage of electricity** as such. However, electricity storage is carried out by converting the electric current into a storable energy which makes it possible to store it from a few minutes to a long time. For this, storage can be mechanical thanks to pumping stations (pumped energy transfer stations – WWTPs, representing 99% of electricity storage capacities worldwide), compressed air or inertia (flywheel). Storage can also be chemical (hydrogen, *see* Box 10: current hydrogen and future prospects) or electrochemical (battery, most often lithium-ion or stationary storage)(1).

Electricity **storage becomes strategic on a large scale** when intermittent energies such as renewable energies are developed, which produce little or no electricity during certain periods. In the absence of sufficient storage capacity to meet electricity demand continuously, the obligation to:

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*(1) Cf. . EDF, Electricity storage, 25 May 2020.*

– to have a **nationwide transmission and distribution network** capable of withstanding strong constraints related to the variation in electricity demand – and therefore supply. It must be able to ensure an adequate and continuous electricity supply;

– maintain the **balance of the network** at all times: the amount of electricity produced and injected into the grid must be equal, at all times, to the amount of electricity consumed.

**Electricity transmission and distribution networks** are sets of physical infrastructure consisting of overhead lines, underground cables and transformers. They are divided into three levels [(1)]:

**– the large-scale transmission and interconnection network** ("energy highways") supports a large electrical voltage (225 or 400 kV) over long distances. In France, it is managed by RTE (electricity transmission system) and at European level by the Organisation of Transmission System Operators for Electricity (ENTSO-E) (*cf.* Box 2: Management of the European network).

**– regional networks support an average voltage** (63, 90, 225 kV) on a regional scale. They are managed by municipalities which have the possibility to delegate the management of their networks to a distribution system operator (DSO) (ENEDIS or local distribution companies or companies (LDCs));

**– medium and low voltage networks** (400V or 20kV) serve end consumers.

Any **change within this network** – adding or removing a generation, storage or consumption facility – **affects its balance** and may require a connection or adaptation of it. **An imbalance in the network can affect connected equipment or lead to power cuts.** The failure to adapt the network infrastructure leads to the maximum transit capacity of the lines concerned (known as network congestion) being exceeded, on certain axes and at certain times, the occurrence of which could multiply as electricity production intensifies[(2)].

**To respond to the increase in electricity** production (development of the nuclear fleet, deployment of renewable energies) the **network must be extended according to the location of future production facilities**.

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*(1) Commission de régulation de l'énergie (CRE), Presentation of electricity networks, 26.01.2023. https://www.cre.fr/Electricite/Reseaux-d-electricite/presentation-des-reseaux-d-electricite*

*(2) In its report "Energy Futures 2050" (pp. 485 et seq.), RTE identifies the areas of network fragility* to *be covered as a priority according to the scenarios selected. Thus, scenarios of homogeneous deployment of renewable energies and self-consumption on the territory generate less significant constraints on the network than a scenario of new nuclear reactors.*

**Box 2: Managing Director the European Network**

At European level, electricity system management is ensured and coordinated by the **Organisation of Transmission System Operators for Electricity (ENTSO-E),** which brings together 39 transmission system operators (TSOs) from 35 countries.

To enhance network coordination, the third energy package of 2009 (1) creates the European *Association for the Cooperation of Transmission System Operators* (ENTSO-E) for one for gas and one for electricity (*ENTSO-E).*

The objective of the ENTSO shall be **to ensure the permanent electricity supply**, **security and reliability of the European grid**. To this end, the association works with national energy regulatory authorities and the European Commission(2).

In collaboration with the Agency for the Cooperation of Energy Regulators (ACER), the ENTSO defines technical rules and codes for access to the network; it coordinates its operation through the exchange of information and the establishment of shared safety and emergency standards and procedures. It shall publish, every two years, a ten-year network investment plan, revised by ACER.

### *a. Market mechanisms to balance the grid*

In France, **RTE (Réseau de transport d'électricité),** owner and operator of the electricity network, is responsible for ensuring a balance between supply and demand in real time by monitoring the network, controlling flows between regions and between countries and anticipating variations in electricity consumption at different time steps.

**Box 3: TEN (Network from transport electricity)**

Created In 2000 with the aim of preparing forum the opening of the electricity market, TEN is responsible for managing the electricity transmission network. TEN generated arrival of €4.7 billion in 2020 and has 9,438 employees.

RTE's activities consist of managing, operating and developing the electricity transmission network in France, ensuring continuity and security of electricity supply. This includes planning and building new infrastructure, maintaining existing equipment, managing electricity flows and integrating renewable energy.

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*(1) The 3rd energy package harmonises the conditions of competition within the Union with a view to completing the internal energy market. It consists of two Directives on the electricity and gas markets (2009/72/EC and 2009/73/EC), two Regulations on conditions for access to the network for cross-border exchanges in electricity (Regulation (EC) No 714/2009) on the one hand, and the conditions for access to natural gas networks (Regulation (EC) No 715/2009) on the other hand, as well as Regulation (EC) No 713-2009 establishing the Agency for the Cooperation of Energy Regulators (ACER).*

*(2) Entsoe, Mission Statement, accessed March 14, 2023.* https://www.entsoe.eu/about/inside- entsoe/objectives/

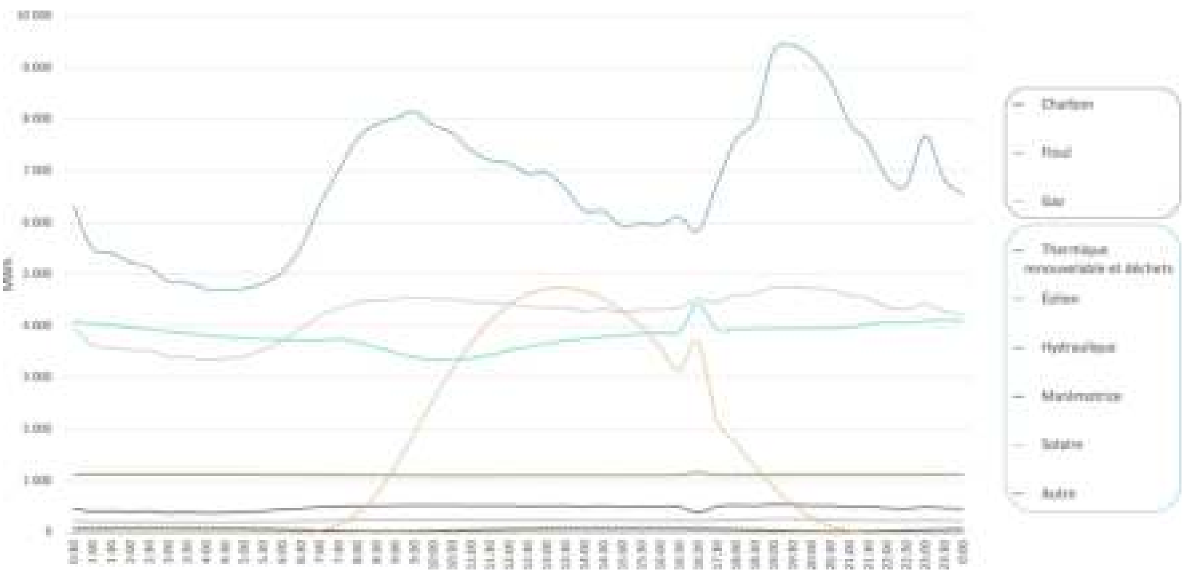
The **monitoring and forecasting** approach provided by RTE is calibrated **from the very short** term (real time), to the long term (3 years) or even to the **very long term** with regard to prospective reports over several decades (e.g. energy futures 2050) and requires:

– **forecast consumption trajectories** – presented in its annual forecast balance sheets;

– to **take into account** the **vagaries** of the weather **and the availability of the generation** fleet, in particular affected by maintenance operations for the nuclear fleet or by the intermittency of energy for renewable installations.

Renewable energies are said to be intermittent, i.e. their availability varies. The inconstancy of natural elements (wind, sun) leads to variations in energy production. This variability in production, or intermittency, creates a challenge for the balance of **grids** that must absorb peaks in production whose importance increases as renewables, some of which such as wind do not produce electricity for a long period of time in the day, are deployed.

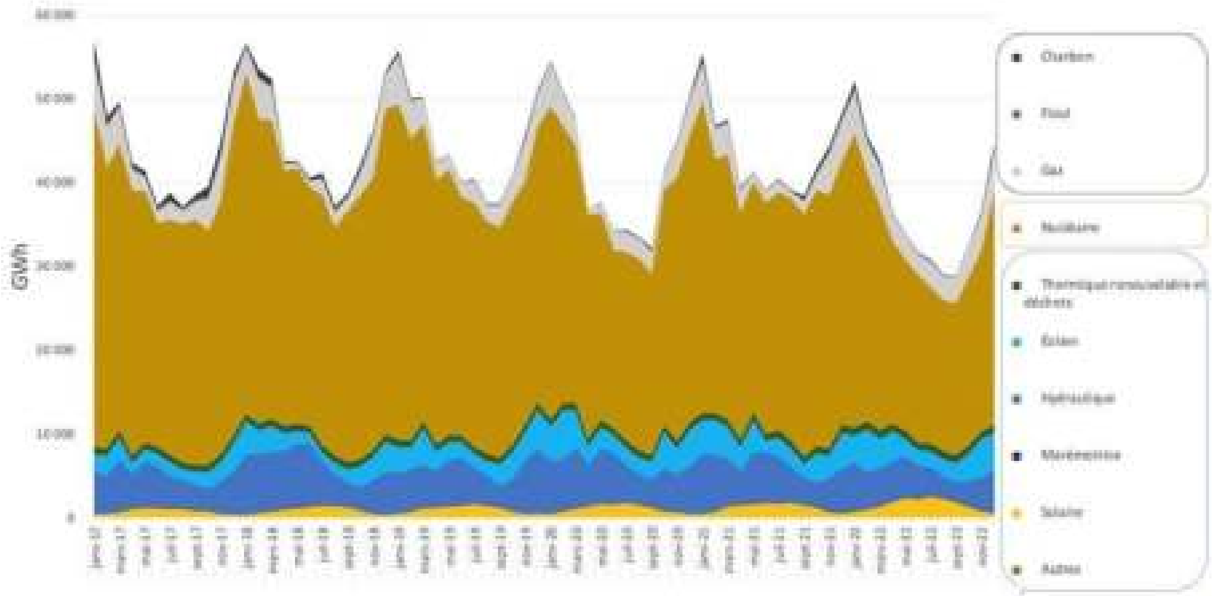
**Figure 1: average evolution of electricity production in France by sector** and **per hour between 2017 and 2022 (excluding nuclear energy)**




*Source : rapporteur, based on data provided by RTE.*

*Reading : average of electricity production in France, by sector and per hour, between 2017 and 2022 - the contribution of different sectors to daily electricity production varies over the course of a day.*

**Figure 2: evolution of monthly** energy **production per energy since 2017 (in GWh)**



*Source : rapporteur, based on data provided by RTE*

*Reading: evolution* of *monthly energy* production *by sector since 2017* - the *contribution of* the *different sectors to annual electricity production varies during the year (seasonality).*

RTE forecasts electricity supply and demand in order to coordinate the strategy of the various actors – electricity producers, distributors, consumers – and anticipates the production surplus or deficit that it balances by means of **market mechanisms**[(1)]:

• **wholesale markets allow large** quantities of electricity to be exchanged for large-scale supply at European level at a price set according to the marginal cost of producing the last MWh produced. However, when demand is high, fossil fuel thermal power plants are in demand and the latter MWh is almost systematically produced from gas or coal whose marginal costs are much higher[(2)]. They are declined according to the products exchanged and the horizons considered:

– **the "spot" market** (*EPEX* Spot *and Nord Pool Spot exchanges*) on which volumes of electricity are traded in the very short term *(*same day or the next day) at an hourly or half-hourly step with maturities up to H-1;

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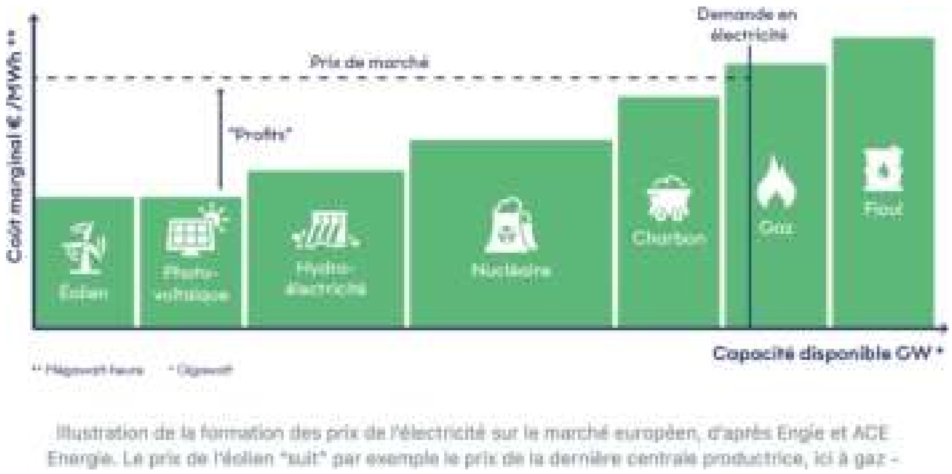
*(1) Court of Auditors, The organisation of electricity markets, July 2022.*

*(2) Since the beginning of the conflict in Ukraine, wholesale market prices have been particularly volatile. Thus, while* the Court of Auditors *estimates that* the *cost* of *producing one MWh by* the *French nuclear fleet is between €43.8 and €64.8 (cf. Court* of *Auditors*, *Report on the analysis of the costs of the* electricity production system *in France, 13 December 2021), a peak was recorded on 26 August* 2022 on electricity prices for the winter of 2022-2023 *: the price* per *MWh amounted to* €1,840 for the *first quarter* of 2023 and *€* 1,115 for *the year 2023 (cf. Commission de régulation de l'énergie,* Rapport sur *les prix futures de electricity for winter 2022-2023 and year* 2022, *December 2022).*

– **futures markets (***EEX exchange)* on which volumes are traded in the short and medium term (beyond the next day and up to three years at advance) and over a given period of time (one year, one semester, one month, one weekend, one day);

**Figure 3: Electricity spot price formation**




*Source : All of Europe*

• **the retail electricity market**[(1)] on which electricity suppliers sell quantities of electricity to final consumers (households, businesses, etc.). In France, two offers are offered to consumers: market offers (fixed price or indexed price) and regulated sales tariffs (TRV) determined by the public authorities.

### *b. The different power purchase agreements (PPAs)*

The electricity purchased by suppliers in these different markets is then resold to consumers at different prices depending on the contract concerned.Since 1 July 2009, the French electricity and natural gas markets have been open to competition. Each consumer is therefore free to choose his supplier to conclude the contract he wishes.The sale and purchase of electricity is governed by ***power purchase agreements (PPAs***). In the retail electricity market, customers can subscribe to two distinct types of contracts.

In France, **contracts with regulated sales tariffs (TRV)** are only offered by incumbent suppliers (EDF and about 100 local distribution companies (LDCs)). Covering 98 % of national electricity consumption[(2)], they allow consumers with a contract with a capacity of 36kVA or less to buy their energy at a price set by the public authorities.

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*(1) Commission de régulation de l'énergie (CRE), Retail electricity market, 1 August 2022.* [https://www.cre.fr/Electricite/marche-de-detail-de-l-electricite](https://www.cre.fr/Electricite/marche-de-detail-de-l-electricite) .

*(2) CRE - Observatory, The retail markets of electricity and natural gas – 2nd quarter 2021.*

The BDCs were marked by the creation of the Regulated Access to Historic Nuclear Electricity (ARENH) by the NOME law[(1)] of 7 December 2010 establishing a right for suppliers to purchase nuclear electricity at a regulated price from EDF to supply end customers located in metropolitan France.

**Contract offer** contracts are offered by historical suppliers and alternative suppliers, these contracts vary according to suppliers. Offers can be variable price indexed to TRVs or other products (*spot* price, ARENH, etc.) or **fixed** price according to the contractual terms chosen (constant energy price but evolving subscription; energy price and constant subscription; etc.). They can also distinguish themselves by their products, on the model of green offers that offer only renewable electricity.

The selling prices of energy offered by suppliers include costs identical to all suppliers (access to networks whose tariffs are set by the Commission de régulation de l'énergie (CRE)) and **variable costs** (production and commercial costs, margin, etc.). In addition to these costs, there are also contributions and taxes borne by the client:

– the transport tariff contribution (CTA) to finance the old-age insurance rights of persons in the electricity and gas industries scheme;

– the contribution to the public electricity service (CSPE), also known as the domestic tax on final consumption of electricity (TICFE);

– taxes on final electricity consumption (TCFE) defined by each municipality and applied to contracts less than or equal to a power of 250kVa. Since 1 January 2021, these taxes are restricted to the municipal tax on final electricity consumption (TCCGE);

– value added tax (VAT) amounting to 5.5% or 20% depending on the subscribed power.

### *c. Network balancing mechanisms*

The precise work of forecasting electricity supply and demand carried out by RTE does not erase a **residual part of the uncertainty** induced by:

– **variability in supply,** i.e. electricity production (intermittency);

– **variability in demand**, a function of many factors: consumer activity; changes in seasons and the resulting variations in weather conditions, which have an impact that is verified by the French thermo-sensitivity[(1)]; the calendar

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*(1) Law No. 2010-1488 of 7 December 2010 on the new organisation of the electricity market.*

(weekends, holidays, public holidays) which also has an impact on electricity consumption, as well as the time of day (daily consumption peaks are observed in the evening and morning).

If it finds a gap between production and consumption, RTE can **act on electricity** production, by requesting the increase or decrease of a production unit. This raises the question of the size of the national production fleet, which, if interconnections are disregarded, must make it possible to cover both the base and the peak consumption. It is therefore useful to have controllable production capacities, mobilised to cope with the peak.

Since 2017, the **capacity mechanism**[(2)] requires suppliers prove that they have sufficient availability to cope with peaks, through contracts with operators.

Players exchange capacity guarantees[(3)] *via* organised market sessions or over-the-counter. Details of transactions shall be published in the register of capacity guarantees. For auctions, the volumes traded and the prices (€/guarantee) are published, in complete transparency, on the EPEX Spot website.

In the year of delivery, RTE reports the peak days during which the actors must fulfil their respective commitments (PP1 days for suppliers, PP2 days for producers and other capacity operators). After the year of delivery, RTE notifies suppliers of their final level of obligation and calculates the actual availability of capacity. Discrepancies give rise to financial settlements.

On the demand side, **grid balancing mechanisms** have also been put in place by RTE such as **market-based** measures. In non-interconnected areas, these are the normal operation measures of the network. In continental France, it is essentially "*redispatching*[(4)]" or *counterparties*[(5)]. According to the risk preparedness plan, primary **and secondary reserves** are activated automatically to contain the frequency deviation, restore the frequency to 50 Hz and bring energy

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*(1) Due in particular to electric heating, there is a link between the outside temperature and the peaks of electricity consumption.*

*(2) The mechanism was established by Law No. 2010-1488 of 7 December 2010 on the new organisation of the electricity market (NOME law). After a consultation phase, it was conditionally approved by the European Commission on 8 November 2016, and has therefore only been operational for energy market players since 2017. This system complements the energy market with a view to achieving the objective of securing the French electricity supply in the medium term by covering the risk during winter peaks.*

*(3) Replies of the Directorate-General for Energy and Climate (DGEC) to the questionnaire sent by the rapporteur.*

*(4) The above-mentioned risk preparedness plan defines redispatching as "a measure, including reduction, that is activated by one or more transmission system operators or distribution system operators and consists of modifying the model of generation, load, or both, so as to modify the physical flows on the electricity system and thus relieve physical congestion or otherwise ensure the safety of the system" (cf. DGEC's replies to the questionnaire sent by the rapporteur).*

*(5) The above plan defines counterparty exchange as a cross-zonal exchange undertaken by network operators between two bidding zones to relieve physical congestion."*

exchanges at the borders back to their predicted value.

The **adjustment mechanism**, or **"tertiary reserve",** set up in 2003, makes it possible to balance the network by activating a production or **demand response** capacity. The tertiary reserve is activated manually by a RTE dispatcher to supplement the secondary reserve, replace it, or to solve constraints on the transmission network resulting from an excess or a local lack of production.

**Demand response** consists of a **total or partial one-off reduction**, upon solicitation, and against remuneration, of the consumption of electricity withdrawal sites. Because of the benefit it brings to the electrical system (it reduces the tension on the supply-demand balance) demand response is valued on the market: remuneration compensates for the discomfort caused to the consumer accepting it. The demand response supply volume for 2023 is 2,702 MW, up for the third consecutive year (+36% compared to 2022).

When the normal operation of the network is seriously and immediately threatened, the electricity system operator, RTE, can trigger the **interruptibility mechanism** in a few seconds, which allows it to instantly interrupt the supply of a profile consumer interruptible consumption, such as an industrialist, against financial compensation. The interruption is carried out over a very short period of time: RTE can interrupt one or more industrial consumers in less than 5 seconds. Five sites have been selected for 531 MW contracted *via* a call for tenders for the year 2023.

The organisation of a **load shedding**, which consists of making temporary power cuts of short duration (2 consecutive hours maximum), can also be considered, even if this type of measure is rarer thanks to the use of increased interconnections with networks in neighbouring countries. Load shedding is activated as a last resort by the Network Manager in the event of a network backup procedure, and does not give rise to remuneration.

The means of electricity production generally begin to produce according to their order of economic precedence, by increasing marginal cost of installations until demand is met. The more or less polluting nature of the various electricity production systems is another criterion that can lead to activating certain production capacities only as a last resort.

**Ensuring the country's energy supply while pursuing the objective of decarbonisation therefore requires both the control of energy demand, the national production of carbon-free energy including renewable energies and nuclear, and the diversification of supplies for the necessary imports.**

However, security of energy supply should not be confused with energy independence, which is a mirage.

## B. A MIRAGE: ENERGY INDEPENDENCE, IN THE SENSE OF PRODUCTION AUTONOMY

All the personalities heard by the Committee, whether independent experts, heads of research institutes or administrations in charge of energy issues, shared a clear observation: energy independence, in the sense of complete autonomy of production, does not exist (1).

Admittedly, the measurement of the "energy independence rate", which is an imperfect statistical tool, can give an idea of the energy dependence of States; from this point of view, France appears in a position above the European average (2).

But the analysis of the energy model of the countries with the lowest dependency rates confirms the fact that the pursuit of energy independence in France is illusory: the countries deemed to be the least dependent on energy have specific geographical characteristics or base their energy supply on a mix that does not meet the objective of decarbonising energy. the energy pursued by France (3).

### 1. The concept of energy independence based on the notion of autonomy is in practice unattainable

Energy independence has been defined as "*the ability to autonomously ensure the supply and production of energy that citizens need*"[(1)] by Mr. Daniel Verwaerde, General Administrator of the French Atomic Energy Commission (CEA) from 2015 to 2018, or as the "*capacity of a country to meet energy needs autonomously, thus maximising the local production of energy necessary for the population and industrial activities*"[(2)], by Mr. Pascal Colombani who held the same position fifteen years earlier (1999-2002).

Despite these nuances, a consensus quickly emerged among the various actors and analysts of French energy policy that historically, **France has never been totally independent in terms of energy.** This is an idea that Mr. Jean-Marc Jancovici, professor at Mines Paris, advanced in the preamble to his hearing: schematically, "*France has never been energy independent since it left the era of renewable energies. We were energy independent at the time when we used exclusively stones and wood from French soil to build windmills and water mills as well as French wood and grass to advance draught animals*"[(3)].

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*(1) Hearing of Mr Daniel Verwaerde, December 6, 2022.*

*(2) Hearing of Mr Pascal Colombani, November 30, 2022.*

*(3) Hearing of Mr Jean-Marc Jancovici, November 2, 2022.*

Professor Yves Bouvier confirmed that "***France has never really known*** energy independence**",** but that "the *quest for energy independence represents a political horizon*"[(1)], whose origin can be found at the end of the First World War, when "*emerges the idea of a coordination of energy policies by sector, carried in particular by Henry Bérenger*[(2)]".

Beyond the historical analysis, consensus has also emerged about the mirage of total energy independence. For Mr Jean-Marc Jancovici thus declares that "*independence does not exist* stricto sensu"[(3)]. For Mr. Cédric Lewandovski, Executive Director of the EDF Group in charge of the management of the nuclear and thermal fleet, "*absolute energy independence is impossible to achieve*"[(4)]. For Jean-Bernard Lévy, former Chairman and Chief Executive Officer (CEO) of EDF, "*total independence is not realistic, even in the Community context*"[(5)].

**This objective appears all the more illusory in view of the current French situation.** Such independence would imply having all the raw materials and components essential for the construction of the production facilities, having complete control of the technology and the industrial chain, as well as of course having the possible fuel to be used. necessary.

**Without even entering into the debate of whether total energy independence is desirable**[(6)], **it is therefore, from the point of view of the experts interviewed, unattainable.**

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*(1) Mr. Yves Bouvier also recalls that during the first oil shock, the observation that France imports about three-quarters of the energy it consumes, "justifies to the public opinion on the nuclear programme in the Messmer plan, which allowed France to achieve a rate of independence of around 50% from the mid-1980s, knowing that all uranium was imported"; Hearing of Mr. Yves Bouvier, University Professor, History Research Group (GRHis), University of Rouen, November 2, 2022.*

*(2) Senator of Guadeloupe from 1912 to 1945, President of the French delegation to the Inter-Allied Oil Conferences of 1918; diplomat, France ambassador to the United States from 1925 to 1926; writer, author of the book Le Pétrole et la France, 1920, published by Flammarion.*

*(3) During his hearing, Jean-Marc Jancovici stressed that real energy independence is only achievable if "a country masters on its soil all the energies currently used in the world and exploits on its territory all the metal mines necessary to provide the devices for extracting energy and transforming vectors energy to power our machines."*

*(4) Hearing of Mr Cédric Lewandovski, January 19, 2023.*

*(5) Hearing of Mr Jean-Bernard Lévy, December 14, 2022.*

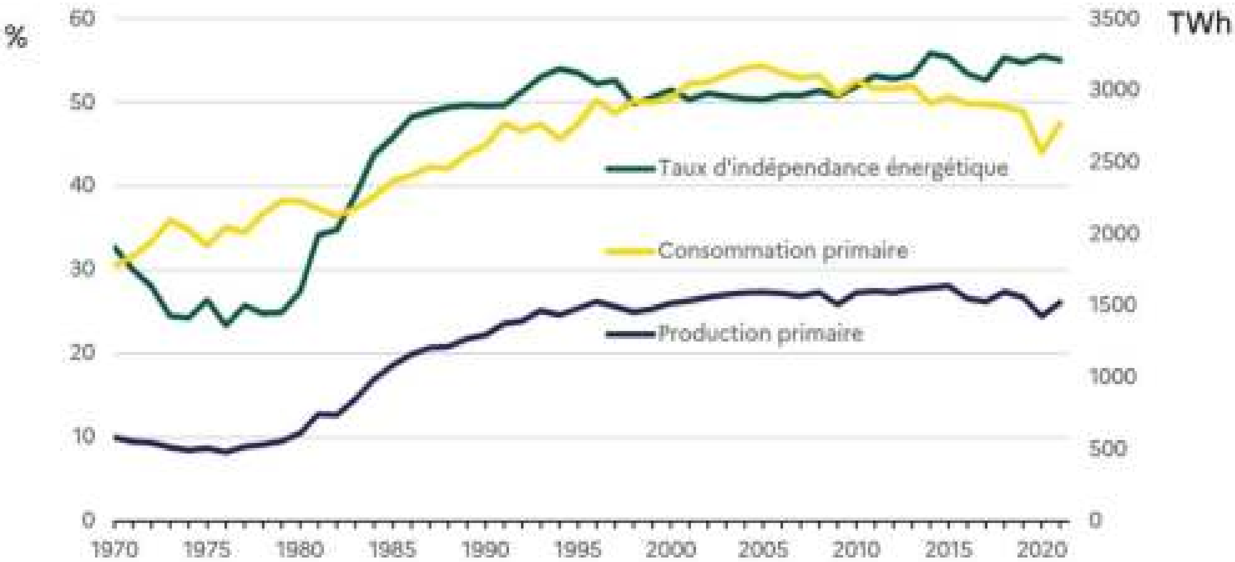
*(6) During his hearing, Mr Marc-Antoine Eyl Mazzega, Director of the Energy and Climate Centre of the French Institute of International Relations (IFRI), for example, considered that the quest for energy independence did not make sense because of its technical and economic nature unattainable, extremely high costs that it would involve, and the gain to be interdependent. It therefore considers energy independence to be neither possible nor desirable. Hearing of 24 November 2022.*

### 2. Imperfect statistical measurement of energy independence puts France at a relatively high and increasing level

Statistical tools propose to measure the rate of independence or energy dependence of States. Despite the methodological reservations that can be opposed, the observation of the results they arrive at shows that **France is among the most energy-independent European countries.**

In France, energy independence is apprehended using the statistical indicator defined by the National Institute of Statistics and Economic Studies (INSEE) of the rate of energy independence. It measures, for a given year, the ratio between national primary energy production (coal, oil, natural gas, nuclear, hydro, renewable energies) and primary energy consumption[(1)]. This rate rises, for France, to 55% in 2021, compared to 25% in the mid-1970s, before the implementation of the Messmer plan for the construction of the nuclear fleet. Over the period 2005-2021, France's energy independence rate has risen steadily.

**Figure 4: evolution of the energy independence rate of France**




*<u>Source</u>: SDES, provisional energy balance 2021 transmitted by the SDES to the Commission of Inquiry.*

*Reading: the energy independence rate measures the ratio between primary production and primary consumption.*

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*(1) According to INSEE, primary energy is all energy products that are not processed, exploited directly or imported. These are mainly crude oil, oil shale, natural gas, solid mineral fuels, biomass, solar radiation, hydropower, wind energy, geothermal energy and energy from uranium fission. Primary energy production means any type of extraction, in a directly usable form, of energy products from natural sources. This may include the exploitation of natural sources (e.g. in coal mines, crude oil fields and hydroelectric power plants) or manufacturing biofuels. Primary energy consumption is equal to all energy consumption in the economy in primary form (i.e. not transformed after extraction), and marginally in the form of non-energy derivatives (tar, bitumen, lubricants, etc.). In other words, higher primary energy consumption than primary energy production reflects the use of imports. The lower the ratio, the higher the use of imports.*

**This first indicator is the subject of criticism** [(1)] on the grounds that it **includes, in primary production, primary steam from nuclear fuels.** This primary steam, three times greater than the amount of electricity produced, is therefore considered French even though it comes from the combustion of imported fuels.

This method of calculating independence, including imports, contradicts "*the international conventions on energy statistics (which) consider as primary energy* the *heat resulting from* the *reaction and not the nuclear fuel itself",* says the Ministry of Ecological Transition[(2)].

**However, this calculation method has a certain consistency with regard to the composition of the French energy mix.** Mr. Pascal Colombani, former general administrator of the CEA, points out that the inclusion of **uranium rather than heat from the nuclear reaction in the calculation of primary energy would reduce this rate to 12%**[(3)]. Admittedly, access to nuclear fuel is "*out of all proportion to our dependence on oil and gas*" (see II, D, 2, d), which may justify retaining nuclear energy and not imported uranium to apprehend French energy independence, but the objection remains important.

For M. David Marchal[(4)], final energy consumption – i.e. primary consumption minus the volumes linked to losses in transport, the use of a certain quantity in the transformation of these energies or in non-energy uses, but also the part of energy not used – "*shows well at what level **France depends on these imports**, both of fossil fuels but also of fuels for our nuclear power plants*."

To overcome these limits, Mr. David Marchal proposes an alternative calculation: develop a measurement indicator including the question of materials and resources necessary for the operation of different energy sources, which present certain vulnerabilities in terms of renewable energies (see I, D, 3, d, i). According to him, the notion of energy sovereignty should in fact be conceived **by including all imported fuels**, including nuclear fuels – contrary to the international nomenclature which considers them as ore.

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*(1) Hearing of Mr David Marchal, Deputy Executive Director for Expertise and Programmes of the French Environment Agency for Energy Management (ADEME), 17 November 2022.*

*(2) Ministry of Ecological Transition, Energy balance of France for 2020, January 2022, https://www.statistiques.developpement-durable.gouv.fr/edition-numerique/bilan-energetique-2020/pdf/bilan-energetique-de-la-france-pour-2020.pdf*

*(3) According to the same energy balance, p. 28: "In the case of France, which uses entirely imported fuels (used directly or after recycling), the rate of energy independence would lose about 40 percentage points, to around 12% in 2019, if we considered nuclear fuel rather than the heat from its reaction as primary energy.»*

*(4) Hearing of David Marchal, Deputy Executive Director for Expertise and Programs at ADEME, 17 November 2022.*

Thus, of the French final energy consumption, of about 1,600 TWh in 2020[1], energy entirely produced in France – mainly composed of renewable energies – represents about 19%: 1 **81% of France's final energy consumption would then depend on imported fuels[2]**.

To this analysis we can answer that the **share of added value linked to the import of uranium is low – it represented only between 5 and 7% of the cost of production[3]** – which makes it possible to consider the bulk of nuclear power generation as French.

According to Mr. David Marchal, it would also be necessary to integrate into this new indicator the dependence on strategic materials **of the industrial sectors** that make up our energy mix even if "*this dependence on materials is strategic in the medium term but does not is not as urgent as fuel dependence*." "*If we wanted to make a real calculation, it would probably be appropriate to include **intermediate consumption and the materials used** in the different energy production sectors as well as their origin*"[4].

**In any case, the very small variation in France's energy independence rate over the last thirty years (the rate was 55% in** 1995, fell to 50% over the decade 2000-2010, before rising to 55% in 2015) **does not allow to fully measure the evolution of the mix energy** for 30 years, and the evolution of vulnerabilities it presents.

These reservations being made, **the international comparison of the dependency rates of the various States can make it possible to better appreciate the situation of France**, in particular thanks to the rate of "dependence on energy imports"[5] produced by Eurostat and which measures the relationship between the

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*(1) SDES, Key Energy Figures– 2021 Edition, p. 25.*

*(2) According to the same reasoning, primary energy production would be only 14% independent.*

*(3) Until 2021. Prices have been rising since then with the prospect of global nuclear development .*

*(4) According to the information provided by ADEME, the indicator leads to three different results according to three calculation methods based on the consideration of primary energy sources (fossil fuels, uranium and renewable energies) and their imported nature. If it is justified, in primary energy, by considering that all the steam of nuclear origin used to make electricity is imported: the rate is 14%. If it is justified, in final energy, by considering that the share of final energy consumption covered by uranium (20% in 2020) is imported, it is 19%; If, still in final energy, it is considered that the share of final energy consumption covered by uranium is French (with the argument that the share of value added linked to the import of the ore is low), it reaches 39%. Hearing David Marchal, Deputy Executive Director for Expertise and Programs at ADEME, 17 November 2022.*

*(5) This indicator is defined by the ratio of net imports to gross energy available. Net imports correspond to imports minus exports. The gross energy available corresponds to the total energy for all activities on the territory of a country: it includes the transformation of energy, losses and the use of fossil materials for non-energy uses.*

net imports (imports minus exports) and gross energy available[(1)].

This rate indicates that the dependence of the European Union (EU-27) on energy imports has fluctuated between 40 % and 60 % since the 1990s - from a rate of 50 % in 1990 to 55,5 % in 2021[(2)]. A comparison of European rates shows that, since 2013, **all Member States have been net importers of energy[(3)]** but are very unevenly[(4)]. Indeed, in 2021, EU states would have a very wide variety of situations, from a dependency ratio of almost 100% for some (97% for Malta, 89.5% for Cyprus, and 92.5% for Luxembourg) to 1% for others (Estonia).[(5)]

The data used for 2021 show that **France is among the least energy-dependent European states** with a rate of 44.2%. It would be the 9th most energy-independent country in the European Union, with a gap of more than 13 points compared to the European average (*cf*. Figure 5: Energy dependency rate of EU Member States in 2021)

**Seven countries have rates lower than that of France,** it being pointed out that Poland, Finland, the Czech Republic and Bulgaria, which precede France in the ranking, have a rate close to the French rate, around 40% of dependency.

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*(1) Eurostat uses total energy for all activities on the territory of a country as gross energy available: it includes energy transformation, losses and the use of fossil materials for non-energy uses.*

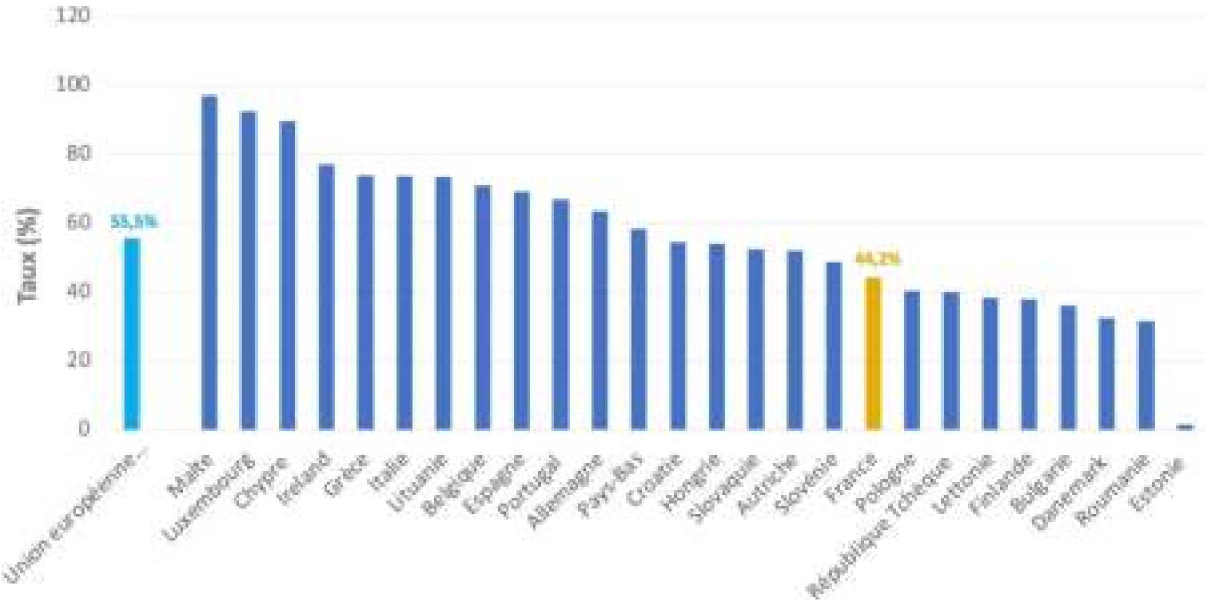
*(2) Based on Eurostat data, 2023.*

*(3) Eurostat's written replies to the rapporteur's questionnaire.*

*(4) In 2020, three states were almost entirely dependent on external energy: the islands of Malta and Cyprus, as well as Luxembourg, with percentages between 92.5% and 97.6%. The France has an energy import dependency ratio of 44.5%, behind Italy (73.5%), Spain (67.9%) and Germany (63.7%), and just ahead of Poland (42.8%). The lowest energy import dependency rates were observed in Estonia (10.5 %), Romania (28.2 %) and Sweden (33.5 %). Eurostat's written replies to the rapporteur's questionnaire.*

*(5) based on Eurostat data, 2023.*

**Figure 5: Energy dependency rate by EU Member States in 2021**

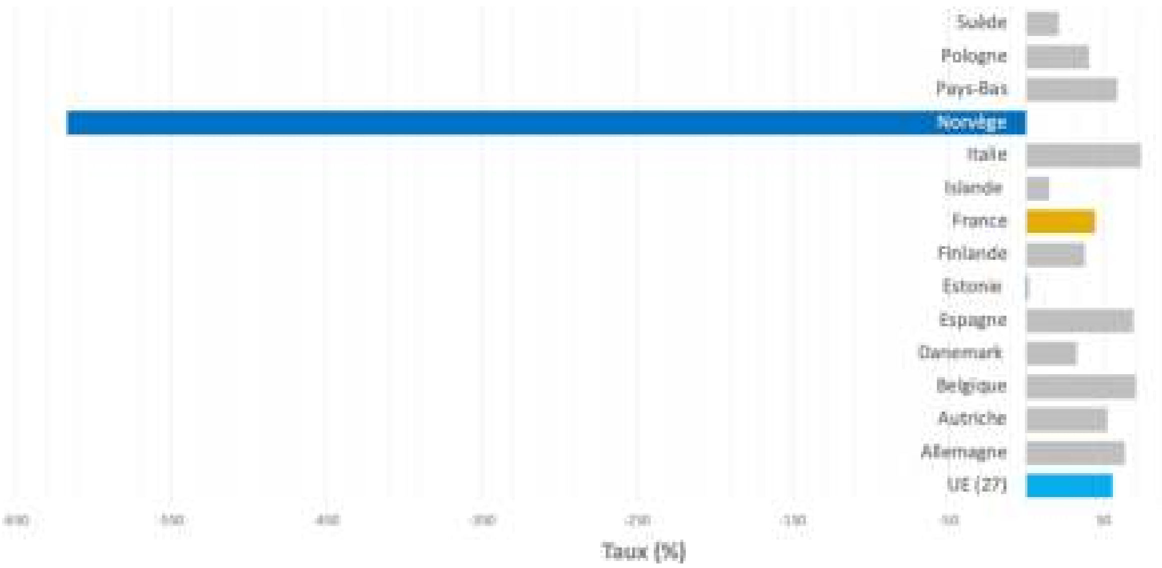



*Source: Rapporteur, based on Eurostat data.*

*Interpretation : the import dependency ratio measures the ratio between net imports (imports net of exports) and available raw energy.*

This relatively better position of France is all the clearer when compared with countries with similar demographic and economic characteristics. The graph below provides a closer look at the comparison of selected European countries.

**Figure 6: Energy import dependency rate in Europe in 2021**




*Source: Rapporteur, based on Eurostat data.*

*Interpretation: the import dependency ratio measures the ratio between net imports (imports net of exports) and available raw energy. As Norway exports more energy than it consumes, its energy dependence rate is negative.*

Germany, Spain and Italy have dependency ratios above France rate by at least twenty points. Excluding countries with moderate populations and high concentrations of energy resources, including fossil fuels, such as Estonia, Romania or Sweden, France has a rate of dependence lower than that of its neighbors of comparable size(1).

### 3. Countries with the highest level of energy independence have geographical singularities or have a very carbon-intensive mix

**An examination of the countries with the highest level of independence reveals that France cannot rise to their level, because they have singularities** (geographical or geological in particular) **that are not reproducible** and energy mixes are very carbon-intensive.

These singularities allow some countries such as the United States, Russia and Norway to come very close to energy independence. However, observation of both the energy production choices of these countries and the resources at their disposal shows that **France is in a very different situation and that it could not, in any event and considering its geography, geology and the ambitious environmental and climatic standards it wished to set itself, continue the same model in order to approach their rates of energy independence**.

In fact, the degree of possible independence for a country is conditioned, in the first place, by ***"the initial endowment of factors***"(2) to quote Mr. Jacques Percebois, that is to say that he is conditioned to the **importance of the energy resources present on his territory**.

Following this observation, it is logically the countries with the largest gas and oil resources that are among the champions of energy independence. According to statistics from the US Energy Information Agency (EIA), the five largest oil producers in the world were, in 2021 and in order of priority, the United States, Saudi Arabia, Russia, Canada, China (3). These five countries are also among the nine largest producers of natural gas (4). This wealth of resources facilitates the achievement of greater energy independence.

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*(1) Hearing of Béatrice Sédillot, Head of the Data and Statistical Studies Department (SDES) at the General Commission for Sustainable Development (CGDD), 15 November 2022; Hearing of Madeleine Mahovsky, Head of Eurostat's Energy Unit, 15 November 2022.*

*(2) Mr. Jacques Percebois, ProfessorEmeritus at the University of Montpellier, Director of the Center for Research in Energy Economics and Law (CREDEN), November 9, 2022.*

*(3) "What countries are the top producers and consumers of oil?", 8 December 2022, https://www.eia.gov/tools/faqs/faq.php?id=709&t=6.*

*(4) According to statistics collected on the US Energy Information Administration (EIA) website in 2021: https://www.eia.gov/international/rankings/world?pa=291&u=2&f=A&v=mapbubble&y=01%2F01%2F2021&ev=false*

On the European continent, two countries stand out in particular: Norway and Estonia.

### *a. The Norwegian system: a very large surplus offossil fuels*

Norway is quite unique because of the amount of resources available on its territory. According to the 2022 International Energy Agency (IEA) report on Norway's energy policy[(1)], the country exported 87% of its energy production in 2020.

By being a **major producer of gas for a domestic consumption of this energy almost non-existent**, this country exported, in 2020, 98% of its gas production, placing it in third place in the world of exporters of this energy. Norway is also endowed with significant water resources. 92% of Norway's electricity mix is based on hydropower, even though the electrification of the Norwegian energy mix is very advanced[(2)]. Norway also produced 2.3% of the world's oil in 2020.

Its energy surplus is therefore significant: in 2020, Norway produced 10 times more oil and 21 times more gas than its domestic consumption requires. This country therefore has certain advantages to ensure its energy independence while pursuing the objectives of reducing polluting emissions.

### *b. The Estonian system: independence at the expense of the environment*

Estonia has **the lowest energy dependency rate among EU Member States**, but its energy model is based on a **high dependence on oil shale** from which it can produce heat, electricity and hydrocarbons.

According to the latest analysis report on the Estonian energy mix produced by the IEA[(3)], in 2018, oil shale accounted for 72 % of Estonia's total domestic energy production, and 73 % of primary energy supply. While the use of this energy source provides Estonia with a high degree of energy self-sufficiency, it is a major obstacle to meeting climate commitments to reduce greenhouse gas emissions.

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*(1) IEA, Norway 2022 Energy Policy Review, http://www.iea.org/reports/norway-2022*

*(2) Almost half of the country's final energy consumption is electric.*

*(3) IEA,Estonia 2019 Review, Energy policies of IEA countries, https://www.connaissancedesenergies.org/sites/default/files/pdf-actualites/Estonia_2019_Review.pdf*

### *c. The US system: energy production at all costs*

Other countries have the particularity of combining the presence on their territory of varied natural resources in large quantities, but also the **desire to exploit certain energy sources independently of the environmental issues they pose**.

This is particularly the case for the United States, which in 2020 became **a net exporter of energy** for the first time since 1953. This evolution is the result of a strong increase in its energy production, which is based on technical innovations in **hydraulic fracturing and horizontal drilling.**

The choice made by the United States to implement these processes has led, in 20 years, to a significant increase in the energy production of the country, which has become the world's leading producer of oil and gas. In the first half of 2022, the country became the world's leading exporter of liquefied natural gas(1) and had record exports of petroleum products over the same half-year(2). In 2020, 34% of U.S. energy production came from natural gas(3) – 88% of which was based on shale gas development(4).

While the U.S. energy sector remains largely dominated by fossil fuels and is expected to remain so(5), **coal production and consumption are declining(6)**. This decrease was made possible by the increase in natural gas, but also by the development of renewable energies.

Thus, the **very high level of energy independence of the United States is based on many assets**, which are not limited to the mere presence of energy sources on the territory. Geographically, first, as pointed out by Mr. Philippe Sauquet(7), former Managing Director Gas Renewables & Power at TotalEnergies, the organisation of space, because of its density, is much more conducive to the

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*(1) EIA, The US became the world's largest LNG exporter in the first half of 2022, 27 December 2022, https://www.eia.gov/todayinenergy/detail.php?id=55025*

*(2) According to the EIA's Annual Energy Outlook 2023, in the first half of 2022, U.S. exports of petroleum products averaged nearly 6 million barrels per day (b/d), the largest first-half exports since the production of monthly oil supply data began in 1973.*

*(3) EIA, U.S. energy consumption in 2020 increased for renewables, fell for all other fuels, June 4, 2021. https://www.eia.gov/todayinenergy/detail.php?id=48236*

*(4) Based on the rapporteur's calculations based on EIA data, Natural gas explained, 28 February 2023, https://www.eia.gov/energyexplained/natural-gas/where-our-natural-gas-comes-from.php*

*(5) The "Annual Energy Outlook 2022" published by the US Energy Information Administration (EIA) predicts that oil and natural gas will remain the most consumed energy sources in the country until 2050.*

*(6) The share of coal energy in total primary energy consumption in the United States fell below the share of natural gas in 2008, and since 2020 has been slightly higher than the share of nuclear electricity. Coal production halved between 1998 and 2020, with the decline in coal production in the United States being -25% in 2020 alone. All data on both the production and consumption of each type of energy are available on the EIA website: https://www.eia.gov/*

*(7) Hearing of Mr Philippe Sauquet, December 1, 2022.*

installation of renewable energy infrastructure than the French territory. Secondly, from an economic point of view, the situation in the United States is also, as Mr Bruno Bensasson[1], CEO of EDF Renewables, pointed out, totally different from ours because this country benefits from the rise in the price of oil and gas when France suffers and subsidises tariff shields.

**The development of such a model in France is therefore neither possible** – due to the geological and geographical situation of France – **nor desired** – France banned the use of hydraulic fracturing in 2011[2].

The reference to these few foreign examples confirms the importance of the initial allocation of resources to achieve energy independence, which can only be approached by very few countries. In this sense, **the energy independence of France appears to be a myth from which we must detach**, unlike the quest for energy sovereignty which, according to Mr. Daniel Verwaerde, "*can integrate a part of dependence if it is chosen*".

## C. AN OBJECTIVE THAT MUST GUIDE PUBLIC ACTION: ENERGY SOVEREIGNTY, IN THE SENSE OF FREEDOM OF CHOICE

As much as the hearings of the Committee of Inquiry and the data studied lead to the rejection of the idea of energy independence, they also show the meaning and importance of aiming for energy sovereignty, in the sense of a freedom to have energy options that reduce the country's dependence. This quest for sovereignty, and therefore freedom, at the energy level must be pursued by means of various levers (1). It must be in "normal" times, but also in times of crisis: the concept of sovereignty is then declined into the concept of resilience (2). In both cases, in an energy world made up of interdependencies, the European scale appears to be, for France, a major strategic element (3).

### 1. Energy sovereignty, freedom of choice in the face of different energy options

#### *a. Energy sovereignty implies having production and adaptation capacities under a dual economic and environmental constraint*

The realisation of energy sovereignty requires a State to have different options to ensure its security of supply. It is a question of being able to **guarantee maximum domestic production**, as well as **having the capacity** to **adapt to any shortcomings of this production.** This implies as much to think carefully about

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*(1) Hearing of Mr Bruno Bensasson, January 12, 2023.*

*(2) Law No. 2011-835 of 13 July 2011 prohibiting the exploration and exploitation of liquid or gaseous hydrocarbon mines by hydraulic fracturing and repealing the exclusive permits of research involving projects using this technique.*

the import strategy, as to optimise its domestic production by giving it sufficient calibration to meet both basic and peak needs.

For M. Yves Bréchet[(1)], former High Commissioner for Atomic Energy, energy sovereignty corresponds to the "*ability to provide the country, both its citizens and its industrialists, with the necessary quantities and powers, by mastering the technologies to do so and by depending only, in terms of resources, on allied and diversified countries*".

Mr. Pierre-Marie Abadie[(2)], Director General of the National Agency for Radioactive Waste Management (ANDRA) shares this reading of energy sovereignty which, according to him, involves "*technological and economic mastery or diversification of sources of supply as well as control of strategic stocks*".

The centrality of technology makes Mr. Jean-Bernard Lévy[(3)] that by mastering most nuclear technologies, EDF contributes to French energy sovereignty. This energy sovereignty which must be, according to Mr. Alexandre Grillat, National Secretary for Public and European Affairs at the CFE-CGC Energies Federation, as much " *industrial, technological, scientific, economic as digital* ".

According to Mr. Pierre-Marie Abadie, "*the fact that France controls the entire chain from upstream to downstream, including the management of radioactive waste from the sector*" also contributes to this sovereignty and the control of the entire cycle.

However, the organisation of the best possible national energy production is not enough, since, as Jean-Baptiste Fressoz points out[(4)], "*energy systems are based on such a diversity of materials and technologies that guarantee a form of sovereignty implies a lot of dependencies and an industrial presence dispersed in huge value chains*."

This is why Mr. Patrick Landais[(5)], High Commissioner for Atomic Energy, stresses that, in addition to the location in France of key industrial sectors, it is important, in order to support this sovereignty, to ensure "*the absence of critical dependence*" as well as the "*ability to control essential supplies*".

This refers to the words of Mr Jean-Marc Jancovici who considered before the Committee of Inquiry that "*the right questions seem to be to know from whom*

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*(1) Hearing of Mr Yves Bréchet, November 29, 2022.*

*(2) Hearing of Mr Pierre-Marie Abadie, January 10, 2023.*

*(3) Hearing of Mr Jean-Bernard Lévy, December 14, 2022.*

*(4) J.-B. Fressoz, "The myth of energy sovereignty", Le Monde, 14 December 2022.*

*(5) Hearing of Mr Patrick Landais, December 15, 2022.*

*we depend, in what proportions and with what abilities to turn around in case of problems*."

Energy sovereignty is thus based on a multitude of levers that a state must be able to mobilise, while responding optimally not only to the **objective of decarbonising the energy system**, but also to economic constraints, particularly industrial performance. Ensuring optimal national production cannot therefore be achieved through investment based on unlimited debt aimed at having national production capacities, if it appears possible and more economically coherent to prefer the import of energy to domestic production.

### *b. Energy sovereignty as a search for freedom of choice*

Despite the low level of use of this concept in the literature and in positive law, the numerous hearings conducted have highlighted the meaning of the concept of energy sovereignty through the question of the s**tate's freedom of choice to make its decisions in energy matters**.

Of course, energy sovereignty is first and foremost a political objective, which is why it is envisaged by M. Yves Bouvier as ***"the ability to make trade-offs in the energy field"*** or by M. Laurent Michel[(1)] as the ***"ability to define and conduct one's policy".*** In this, this objective can be achieved by simultaneously activating many levers, themselves more or less quantifiable:

– the **ability to secure supply despite dependencies on critical materials;** Mr. Bernard Fontana[(2)], President of Framatome, understood sovereignty as "*the ability of France to meet its* energy *needs, through national solutions or cooperation chosen and mastered, and freedom of action internationally on these subjects*";

**– the mastery of the associated technologies and know-how**, through the possession of a patent or concrete ability to operate or maintain effectively and quickly any equipment based on this technology;

**– the ability to build production facilities to** achieve the power needed to meet national needs;

**– the resilience of the entire energy model**, i.e. its adaptability in the event of a crisis and its ability to evolve in response to various shocks external,

*(1) Hearing of Mr Laurent Michel, December 13, 2022.*

*(2) Hearing of Mr Bernard Fontana, December 8, 2022.*

geopolitical or climatic, which could have consequences for security of supply[1].

In short, a "***sovereign France in energy policy must be able to define and decide alone, for its own interests, its*** *energy policy and to have the means to achieve the objectives defined by this policy*" (Daniel Verwaerde).

**Under this sense, energy sovereignty lies both in a capacity to do, to act in a desired direction, and in an ability to resist or adapt to decisions** that could be imposed by others. A loss of sovereignty would then manifest itself in a voluntary or involuntary limitation, internal or external, of these possibilities of action.

### 2. Sovereignty in times of crisis: reducing vulnerabilities through a resilience strategy

One of the dimensions of energy sovereignty is the ability to meet the country's needs even in times of crisis.

This capacity is measured through the **concept of resilience**, which, according to Mr. Daniel Verwaerde, "assumes***that an incident has come to call into question the normal supply*** **process**" and corresponds to "the ability to continue the *mission of providing the French with the energy they need while the nominal process in place has proved defective*".

As Professor Xavier Jaravel[2] pointed out, "*in a globalised world, where everyone depends on several value chains, sovereignty is less about pure autonomy* ***than about resilience, defined as the ability to withstand internal*** shocks, such as the *unavailability of the nuclear fleet*, and ***external shocks****, such as a war that makes difficult to supply energy*." The central issue is that of measuring vulnerabilities since, in the words of Mr. Jacques Percebois, "*one can be dependent without being vulnerable, and independent while being so*".

To control dependencies, it is a question of anticipating vulnerabilities, trying to reduce them, and having, in the event of a shock, solutions allowing the continuity of energy security. Have a resilience strategy therefore involves intervening in two stages: **first, identifying vulnerabilities**; next, define responses that can reduce those vulnerabilities.

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*(1) It is also the concepts of supply and independence of the Nation that the Constitutional Council confronts to assess the constitutionality of legislative provisions taken in energy matters derogating from the Environmental Code. It was thus able to consider that such measures are constitutional when they aim to "respond to difficulties in energy supply of gas by increasing national liquefied natural gas processing capacity" and to "limit the risk of failure of the national electricity system", and, in so doing, "implement the constitutional requirements inherent in safeguarding the fundamental interests of the Nation, These include the independence of the nation and the essential elements of its economic potential."*

*(2) Hearing of Mr Xavier Jaravel, round table of November 9 , 2022.*

Mr. Xavier Jaravel, author with Ms. Isabelle Mejean of a study on the resilience strategy(1), explained this approach:

*"It is important to* ***make a very detailed diagnosis of value chains****. We have come to the conclusion that* ***4% of all French imports constitute vulnerabilities****, i.e. reflect dependence on a small number of non-European countries. This requires a more detailed analysis of the value chains needed for energy production,* ***through mapping to identify and anticipate vulnerabilities in value chains****. This diagnostic work is necessarily long-term, particularly with regard to metals and strategic minerals extracted from rare earths. Such targeting makes it possible to reduce the costs of resilience, provided that a range of tools are forged, such as the relocation of production and, if possible, the diversification of sources of supply or the use of storage. We must also check whether our European partners share our vulnerabilities or not, and finally* ***identify reciprocal dependencies****, a weakness on part of the value chain that can be compensated by a force on the another, so that the situation is not asymmetric and may be tolerable from a geopolitical point of view."*

However, this mapping work is proving difficult to implement.

**The France does not yet have a statistical follow-up on this subject. According to Jean-Luc Tavernier**, Director General of INSEE, the **assessment of value chain dependence and resilience is a new subject for the statistical** system, and it is not obvious to him to know how or with what types of instruments to shed statistical light on things, especially since it is a qualitative work that supposes, to identify a dependency, to know the range of suppliers of companies, and the fragility of their subcontractors of different ranks.

Ms. Ketty Attal-Toubert(2), Head of the Department of Statistics and Foreign Trade Studies (DSECE) also said that the DSECE had not yet carried out a study on the subject in the energy sector. On the other hand, it conducted an initial study based on the notion of vulnerability according to a methodology defined by the International Monetary Fund (IMF) in order to analyse the vulnerabilities of supplies originating in China(3). As part of this work, the vulnerability was defined according to two criteria. The first is the degree of concentration of the countries supplying imports of the product, since

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*(1) X. Jaravel and I. Méjean, "What strategy of resilience in globalization? ", Les notes du conseil d'analyse économique, n° 64, April 2021,* [https://www.cae-eco.fr/staticfiles/pdf/cae-note064.pdf](https://www.cae-eco.fr/staticfiles/pdf/cae-note064.pdf)

*(2) Hearing of Ms Ketty Attal-Toubert, 15 November 2022.*

*(3) DSCE, Increasing vulnerability of supplies originating in China, Studies and insights n° 93, July 2022,* [https://lekiosque.finances.gouv.fr/fichiers/etudes/tableaux/ee_93.pdf](https://lekiosque.finances.gouv.fr/fichiers/etudes/tableaux/ee_93.pdf)

The importation of a product by a small number of supplier countries may represent a risk, unless a transfer to other suppliers is possible. The second criterion is that of the potential for short-term diversification of the product : the number of world exporters for a product is analysed.

In addition, according to Mr Sylvain Moreau(1), Director of Business Statistics at INSEE, an experimental European survey being carried out by Eurostat on the value chain, covering the period 2018-2020, should soon make it possible to analyse the evolution of the organisation of European enterprises before the covid-19 crisis and how they were planning to relocate part of their productive apparatus. It would be desirable for the French statistical services to draw lessons from this study and then apply it to the French energy sector.

In any event, Mr. Jaravel has made the proposal, which your rapporteur endorses it, to **instruct a body to reflect on this issue in the long term and to draw up this mapping.** It could work in a transdisciplinary framework bringing together the Centre for Analysis, Forecasting and Strategy of the Quai d'Orsay, energy economists, value chain economists and specialists in geopolitics.

In the immediate future, despite the lack of detailed and exhaustive mapping, a number of vulnerabilities have nevertheless already been identified and addressed, in particular by the Ministry of Economy and Finance. The Directorate-General for Enterprise (DGE) is already working to implement the second component of the resilience strategy, which consists of managing them by providing them with an answer.

The Director General of Enterprises, Mr. Thomas Courbe(2), reported on work to **structure the vulnerability response policy** undertaken since 2019, and which has accelerated since the covid-19 crisis. He stated that strategic sectors and associated value chains are now better identified, particularly in the six strategic sectors defined at the Versailles Summit of March 2022(3) for which the European Union wished to equip itself with production facilities in Europe. These six sectors include the means of energy production(4).

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*(1) Hearing of Mr Moreau, round table of November 9 , 2022.*

*(2) Hearing of Mr Thomas Courbe, November 24, 2022.*

*(3) During this Summit held under the French Presidency of the Council of the European Union, the Heads of State and Government of the European Union, the President of the European Commission and the President of the European Council exchanged views on possible solutions to strengthen European defence capabilities and reduce our strategic dependencies.*

*(4) The six priority areas identified concern the strengthening of European defence (investing in defence capabilities (1) and preparing for emerging challenges (2)), reducing our strategic dependencies (reducing the use of fossil fuels, diversifying supplies and accelerating renewable energies (3) ; optimise gas storage management (4); improving energy efficiency in Europe (5)) and building a more resilient economy (6).*

Mr. Thomas Courbe indicated that "*in these sectors, where critical products are clearly identified, we deploy* ***actions to act on the reduction of vulnerabilities*** throughout the value chain, both to ***produce in Europe and in France part of these products and*** *to control the entire value chain,* ***up to inputs****, which are either energy or of another nature. These* ***critical inputs are now better identified****, both at European and French level*." In particular, he indicated that, with regard to strategic metals, France and the European Union are deploying vulnerability reduction actions on a list of 30 particularly critical metals[1].

In their above-mentioned study on resilience strategy in globalisation[2], M. Xavier Jaravel and Isabelle Méjean identify the three axes underlying any resilience strategy. They indicate that depending on the technological level of vulnerable inputs, it is necessary to act in three directions: "*encourage* ***diversification of supplies and strategic alliances*** *where other trading partners can be mobilised, in particular at European level; if diversification of sources is not possible,* ***facilitate or subsidise storage****, particularly on low value-added products; for vulnerable inputs at the technological frontier,* ***foster innovation to produce on the national territory in a competitive manner*** ".

Securing supplies of uranium, thermal energies but also metals necessary for the energy transition was indeed presented as essential during numerous hearings, as was the issue of storage. Technological innovation was also discussed, for example by Mr Piechaczyk[3] who stressed the fundamental nature of the "**notion of technological diversification**, *within the nuclear family, but also between nuclear and other sources of energy production*".

Conversely, a recent feature of the French energy system has been presented as a weak point as part of the resilience strategy: the lack of excess production capacity, which would facilitate the remediation of systemic shocks on the energy system.

Concretely, **several preventive devices or to be activated in the event of a crisis exist in France**, for oil, gas, and electricity.

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*(1) Communication from the European Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - resilience of critical raw materials: the way forward for greater security and sustainability.*

*(2) Op. Cit. p. 5.*

*(3) Hearing of Mr Xavier Piechaczyk, Chairman of the Management Board of RTE, 15 December 2022.*

**For oil**, we find:

**– a storage obligation**[(1)]: aimed at constituting and maintaining for twelve months quantities of petroleum product corresponding to a volume of strategic stock, fixed by regulation, so that France permanently has strategic stocks equivalent to 90 days of net imports;

**– a hydrocarbon emergency plan**: it allows the public authorities to enact crisis measures (increase in the availability of products, limitations on use, access restrictions – for example when a Prefect requisitions a service station for the benefit of activities essential to the functioning of the State) and the Directorate-General for Energy and Climate to activate various means depending on the extent of the crisis (release of strategic stocks at the request of operators, derogations and exemptions from certain obligations relating to the composition and transport of fuels, requires operators to activate and accelerate the establishment of alternative supplies.

**For gas**, the following devices have been put in place:

**– the strategy of sizing the gas system,** storage sites and interconnections, makes it possible to cope with a cold peak for three successive days such that statistically one occurs every fifty years, i.e. a demand of 4,100 GWh/d;

**– A storage obligation**[(2)]**:** according to the Energy Code, the Minister for Energy sets each spring, the minimum stocks of natural gas necessary by 1 November to guarantee the security of natural gas supply for the coming winter. Suppliers must then fill their storage capacity to at least 85%[(3)];

**– the gas emergency plan**: in the event of a gas crisis, this plan allows the implementation of **preventive measures** (provision of last resort, provision of relief, obligation to place natural gas stocks on the market, interruptibility of the

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*(1) Articles L. 642-2, L. 642-4, L. 651-1 of the Energy Code. The International Energy Agency (IEA), created in 1974 following the first oil shock to ensure its members of energy supply, also includes, among its membership criteria, an obligation to store crude oil or equivalent products corresponding to 90 days of net imports, the Government having immediate access to these reserves in case of decision by the IEA to use it to deal with disruptions in global oil supply. The France has been a member of the IEA since 1992. This device was first activated only in 1991 during the first war in Iraq, then in 2005 to deal with the consequences of the destruction caused to oil facilities in the Gulf of Mexico by Hurricane Katrina. It was appealed again in 2022 following the Russian invasion of Ukraine.*

*(2) Articles L 421-4 and 421-7 of the Energy Code.*

*(3) Gas storage: Since the adoption of Law No. 2022-1158 of 16 August 2022 on emergency measures for the protection of purchasing power, Article L. 421-7-2 of the same code provides that the Minister responsible for energy sets, by an order taken after consultation with the Energy Regulatory Commission, a trajectory of filling for each operator of storage infrastructures, which includes intermediate filling targets.*

consumption of natural gas[1]), **measures relating** to consumption (recommendations to moderate energy consumption, strict application of the temperature limitation in the premises of certain establishments open to the public and of the heating temperature in the event of vacancy (Construction and Housing Code)), measures to relax **public service obligations** (relaxation of the obligation of continuity of supply, relaxation of the obligation to fill storage capacity subscribed in essential infrastructures), and **measures of last resort** (offloading of certain large industrial consumers in order to avoid the collapse of the natural gas network[2]).

For electricity, the following may be mentioned :

**– a strategy for storing and diversifying uranium supply**: historically led by EDF, this diversification strategy concerns both suppliers and countries of supply. The storage strategy is led by the Government and classified. It is implemented by EDF to allow the storage of the equivalent of several years of fuel[3];

– the electricity **sector** risk **preparedness plan**[4]: it identifies the different possible electricity crisis scenarios, the competent authorities and the procedures to be followed in the event of an **electricity** crisis. In addition to monitoring and operational planning for crisis management, measures are identified **to mitigate or absorb electricity crises when they occur** (activation of a production or demand response capacity, reduction of the level of voltage on the distribution network, interruptibility, load shedding, call for consumption reduction, activation of mutual assistance offers between transmission system operators, requisition and deployment of generators).

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*(1) Established by Law No. 2015-992 of 17 August 2015 on the energy transition for green growth and extended by Law No. 2022-1158 of 16 August 2022 on emergency measures for the protection of purchasing power, this mechanism is enshrined in Articles L. 431-6-2 and L. 431-6-3 of the Energy Code.*

*(2) This mechanism is provided for in Articles L. 434 1 to L. 434 4 of the Energy Code. It concerns the largest gas transport customers, whose consumption in year n-1 exceeded 5 GWh.*

*(3) EDF's policy on securing its supplies is the subject of presentations to its Board of Directors, and the Government may, on the basis of Article L. 143-1 of the Energy Code and Decree No. 92-1466 of 31 December 1992, take control measures and distribution, including uranium.*

*(4) Developed by the DGEC and adopted in January 2022, it implements Regulation (EU) No 2019/941 on risk preparedness in the electricity sector.*

**Box 4: Crisis measures activated in 2022**

Among the devices mentioned above, several were activated during the year 2022:

– During the " fuel crisis" in October 2022, the DGEC communicated daily to the public authorities information on the state of service stations and fuel availability with regional and departmental focus and on the availability of stocks at operators in order to guide large consumers, and was able to disseminate updated contact lists of oil operators, to facilitate local contact with key consumers in difficulty.

– **exceptional crisis management at European level**: while hydrocarbon-related crises are generally mainly local, Russia's invasion of Ukraine has led to stronger European coordination to ensure security energetic. Thus, the European Union has decided on an **embargo on products from Russia**[(1)] and has set up a ***task force*** **responsible for coordinating and facilitating joint calls for tender, optimising the use of infrastructure and work with Member States** to address potential bottlenecks in regional groups.

– **in France, the management of this crisis led to the creation of a *task force* within the DGEC.** In addition to the publication of Decree No. 2022-495 of 7 April 2022 on the load shedding of natural gas consumption and amending the Energy Code, specifying the conditions for implementing the **load shedding procedure**, the **storage system** has been strengthened by the legal consecration of the filling trajectory for each operator. The filling target was reached in mid-November 2022. On the issue of **infrastructure sizing**, steps have been taken to increase LNG import capacity with the optimisation and increase from 2022 of the unloading capacities of the Fos Cavaou and Dunkirk LNG terminals, and the government has taken the decision to set up a new floating terminal in Le Havre.

– **additional electrical safeguard measures have been taken for winter 2022/2023**: obligation to switch off illuminated advertisements in the event of an Ecowatt signal, obligation to make available to RTE, in the event of a red Ecowatt signal, emergency means with a power greater than 1 MW, all demand response, production and storage capacities recovered by adjustment operators on the adjustment mechanism, possible requisition of gas-fired power plants when there is a serious and concomitant threat to the security of gas and electricity supply.

The implementation of all the measures taken has effectively enabled the France to cope with the crisis, and to get through the winter of 2022. In the 2022 electricity report, RTE has also judged the "*Resilient electricity system in the face of an energy crisis not seen since the 1970s*". He points out that despite the addition of three independent but simultaneous crises (the soaring gas prices resulting from Russia's war on Ukraine, the French nuclear production crisis, and the prolonged drought that reduced hydropower production in France to its lowest level. since 1976), there has been no disruption of supply, thanks to "*the structural decrease in demand for electricity and in neighbouring countries as well as the operation of gas and electricity exchanges in accordance with European rules*".

However, beyond the crisis measures already in place and the French strategy that should be implemented to increase the resilience of our energy system, it is essential to take into account the European framework in which our energy system is inscribed, and which is of a strategic nature.

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*(1) Starting December 5, 2022 for crude oil and February 5, 2023 for refined products*

### 3. The strategic nature of the European scale to conduct a policy of sovereignty and energy resilience

The criticism levelled at the European energy market, which will feed into reflections on the changes that should be made to it, must not obscure the strategic nature of the European scale in the quest for energy sovereignty.

**Since France cannot be energy independent, its energy sovereignty cannot be thought of in a strictly national framework**. Mr Jean-Luc Tavernier[(1)] observed that "*since we live in a European area of solidarity and geopolitical stability, it is at this level that we must apprehend the issues related to our energy independence*", while Mr. Philippe de Ladoucette[(2)], former President of the Commission de régulation de l'énergie (CRE) considered that "*sovereignty, if it can exist, can only be European*".

It seems useful to stress the strategic nature of the European level for at least two fundamental aspects of energy sovereignty: the **contribution of interconnections** to security of **supply**, and the relevance of this scale of reflection to conduct a real industrial policy.

#### *a. European interconnections and the European market*

Firstly, European **energy interconnections**, which make it possible to activate European solidarity, **constitute a real force** whose value must be measured.

As recalled by André Merlin[(3)], Honorary President of RTE, the European network of **electricity interconnections** is **one** of the **largest** in the world, to which only the Chinese network can be compared. Mr François Brottes[(4)], Senior Adviser at the Court of Auditors, former Chairman of the Executive Board of RTE, confirmed that in Europe, "electrons know no borders", but transit permanently through an electricity transmission network that covers the whole of continental Europe, covers thirty-seven countries recently joined by Ukraine and Moldova and relies on nearly 430 interconnections, 50 of which are located in France. According to him, it is a "European success story and a fine example of solidarity" that encourages collective resilience.

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*(1) Hearing of Mr Jean-Luc Tavernier, round table of November 9 , 2022.*

*(2) Hearing of Mr Philippe de Ladoucette, January 19, 2023.*

*(3) Hearing of Mr André Merlin, February 1, 2023.*

*(4) Hearing of Mr François Brottes, December 14, 2022.*

**Box 5: European interconnections**

An interconnector is a ***'transmission line which crosses or spans a border*** *between* Member *States and which connects the national transmission networks of the Member States of the European* Union'[1]. RTE has 305 000 kilometres of lines for more than 400 interconnections throughout Europe[2].

Developed with the opening of the European gas and electricity market, these interconnections make it possible to compete on national markets, secure supply to Member States, contain and harmonise electricity prices and encourage the deployment of carbon-free energies – the grid makes it possible to transport electricity that is by nature intermittent and non-storable produced by renewable sources.

The **geographic position of France** favors the development of interconnections: it now has 50. RTE is currently building new interconnections and aims to double its capacity by 2035[3]. The French network is connected to six neighbouring countries – Germany, Belgium, Spain, Italy, the United Kingdom and Switzerland. The France is the main exporter of electricity in Europe.

**Figure 7: Map of European electricity and gas interconnectors**

*Source: CRE, report on electricity and gas interconnections in France, 2018*

**Figure 8: Trade flows at the French borders in 2020**

*Source : CRE, interconnections*

The interconnections that France will develop are included in the ten-year development plan drawn up by RTE. In 2015, the opening of the **France-Spain** interconnector east of the Pyrenees almost doubled the interconnection capacity with the country. In October 2022, a new interconnection with **Italy** was set up. In advanced development or under construction are also the Bay of Biscay project, a submarine interconnection between France and Spain (commissioning targeted in 2027) and the Celtic project linking France and Ireland (commissioning in 2026)[4].

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*(1) CRE, Glossary "interconnection", https://www.cre.fr/Pages-annexes/Glossary/INTERCONNECTION.*

*(2) RTE, Interconnections for a Europe of electricity solidarity. https://www.rte- france.com/acteur-majeur-europe-electricite/les-interconnexions-service-europe-electricite-solidaire*

*(3) RTE, Interconnections for a Europe of electricity solidarity. https://www.rte- france.com/acteur-majeur-europe-electricite/les-interconnexions-service-europe-electricite-solidaire*

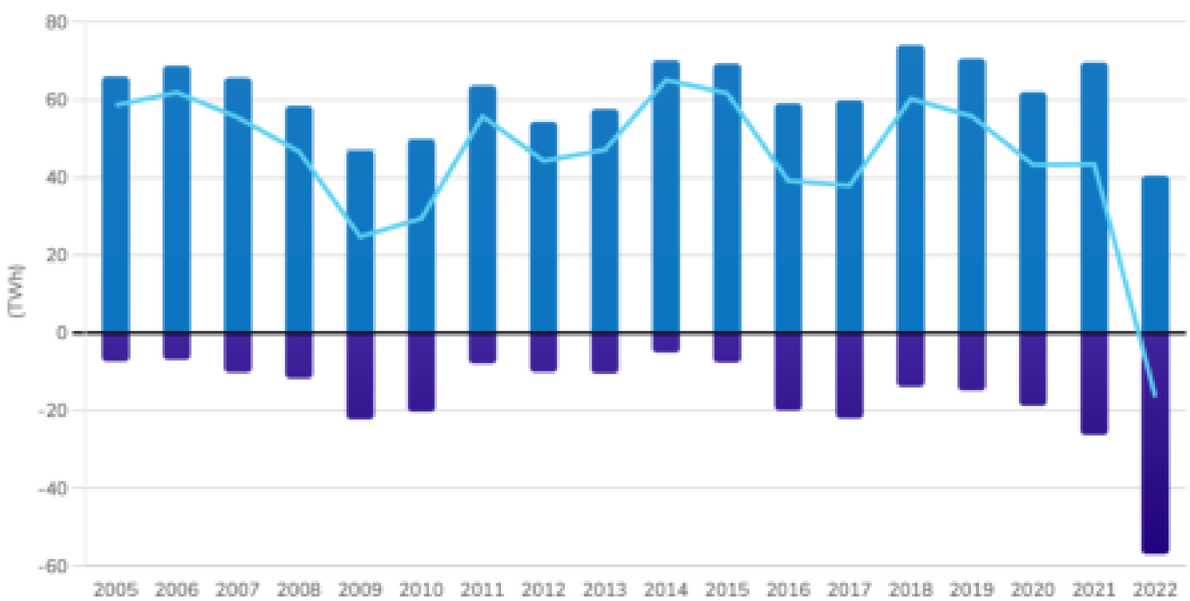
*(4) DGEC replies to the questionnaire sent by your rapporteur.*

However, these interconnections, which make it possible to export energy when production is greater than consumption, and to import energy when it is insufficient, constitute a major element of French **security of supply**. According to M. Pierre-Marie Abadie, "***Electricity interconnections remain the most efficient contribution to security of supply*** *and the integration of the intermittency of renewables*".

They thus made it possible to avoid a blackout in Europe, when, in 2006, load shedding carried out on the network of several European countries, including France, made it possible to prevent the spread to the entire network of an incident that occurred in Germany.

Much more recently, **these interconnections have enabled France to mitigate the consequences of the unavailability of the French nuclear fleet** due in particular to the discovery of the phenomenon of stress corrosion**.** The fact that France, a net exporter of around 20 TWh in the third quarter of 2021, became a **net importer of 10 TWh in the third quarter of 2022 illustrates the importance of these energy transfers**.

**Figure 9: Electricity trade balance between France and its neighbours**




*Source : RTE, [Bilan électrique 2022]*

*Reading : France imported energy over the entire period studied. In 2022, its imports surpassed its exports making its balance negative.*

In the absence of such interconnections, the risk of blackout increases, or the need to keep more thermal power plants necessary to pass the peak consumption.

European legislation currently encourages the development of these electricity and gas interconnections[1]. To facilitate the achievement of the objectives contained in development plans for these interconnections, the European Commission finances interconnections recognised as being of common European interest.

According to RTE, in 2050, the security of France's electricity supply would depend on its neighbours 5% of the time, compared to about 1% in recent years. At the same time, the scenario foresees a disappearance of France's dependence on oil and fossil gas producing countries**: carbon neutrality scenarios are indeed scenarios of very strong strengthening of energy sovereignty, taken as a whole**[2].

Secondly, **the European level is also strategic in terms of developing a genuine energy industrial policy**.

**The deployment of renewable energies should therefore be** based on a European **industrial fabric**, where national initiatives struggle to compete with external competition, particularly from China.

France has advocated at European level for a genuine European industrial policy, notably by publishing a manifesto on this theme with Germany in 2019[3]. The Director-General of Enterprise M. Thomas Courbe believes that the efforts made in this direction are beginning to bear fruit. According to him, the favourable European context of recent years has allowed the evolution of the legal framework and the transformation of European industrial policy through the Important Programmes of European Common Interest (IPCEI), which allow the Member States to finance production capacity in Europe. For example, a genuine European industrial strategy for electric vehicle batteries was initiated in 2019.

***b. Rare metals supply***

As an underlying issue of industrial sovereignty, the subject of **mining** in order to ensure the supply of land and metals necessary for the energy transition was also presented by the administrations in charge of the subject, but also by the

*(1) Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action , amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council , Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council. The objective is for each member country to have reached 15% interconnection at its borders by 2030.*

*(2) RTE's replies to the supplementary questionnaire sent by your rapporteur.*

*(3) Franco-German manifesto for a European industrial policy adapted to the twenty-first century, published on 19 February 2019.*

Academy of Technology[1], as an element to be treated also at European level.

The Director General of Enterprises, Mr. Thomas Courbe, indicated that the **issue of securing mineral resources for Europe was a matter** of European **concern**, and that, during the French Presidency of the Council of the European Union (PFUE), an informal competitiveness council had been devoted to it. The Director General for Planning, Housing and Nature (DGALN), Ms Stéphanie Dupuy-Lyon[2], confirmed that **resource diplomacy** was conducted with the support of the Ministry for Europe and Foreign Affairs in order to carry out the French strategy in line with that of the EU, in particular with a view to the development of the **European Raw Materials Alliance**[3]. The Deputy Director General and Scientific Director of the Bureau of Geological and Mining Research (BRGM), Mr. Christophe Poinssot[4] stressed that many European countries had pursued mining activity and that France had every interest in benefiting from its proximity with the countries of the European Union to develop this activity.

Apart from the definition of a common industrial strategy, Mr Xavier Jaravel and Ms Isabelle Mejean[5] also established, as part of their study on the resilience strategy, that the definition of such a policy should be carried out at European level, because "*The single market is the relevant scale for the analysis of the organisation of the production chains in which French companies are inserted*".

**The France's accumulated backlog in terms of energy sovereignty is expected to increase** as our electricity needs increase and new dependencies grow. **The French electricity mix is already weakened** and, while the development of production capacity should be a priority, it is progressing at too low a speed.

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*(1) Academy of Technologies, Contribution: energy sobriety or new technologies?, November 2022, https://www.academie-technologies.fr/wp-content/uploads/2023/03/Cahier-d-acteur-AT-Concertation-national-mix-energetique.pdf*

*(2) Hearing of Ms Stéphanie Dupuy-Lyon, 7 December 2022.*

*(3) The European Alliance for Raw Materials (ERMA) was launched by the European Commission in 2020, in response to the European desire to secure supplies of critical materials, in particular for the energy transition.*

*(4) Hearing of Mr Christophe Poinssot, round table of 22 November 2022.*

*(5) Op. cit., p. 7.*

# II. THE FRENCH ENERGY MIX IS TODAY SUBJECT TO STRONG AND NUMEROUS DEPENDENCIES THAT WILL WORSEN

## A. THE OVERALL FRENCH ENERGY MIX HAS CHANGED LITTLE AND REMAINS LARGELY DEPENDENT ON IMPORTS

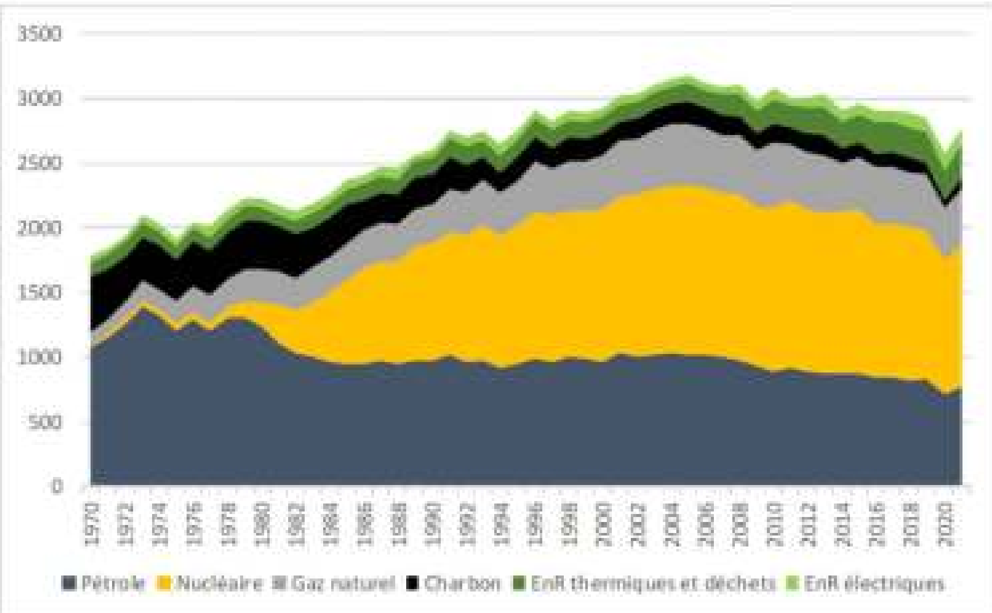
### 1. Energy consumption has decreased slightly since the 2000s, due to energy gains but also probably to the weakening of the industrial sector

Data from the statistical service of the Ministry in charge of the Ecological Transition show **a clear shift in energy consumption in the mid-2000s (*Fig 10*).**

French primary consumption, i.e. all energy consumption in primary form (not transformed after extraction), increased until 2005(1), reaching a peak of 3,155 terawatt hours (TWh or 271 megatonnes of oil equivalent or Mtoe), following the deployment of nuclear energy and, to a lesser extent, that of natural gas(2). Primary consumption then decreased to 245 Mtoe in 2019 (excluding post-Covid rebound).

The trend is less clear for final consumption (by end users) after counting losses during processing and transport, but the trend is similar. Final consumption reached its highest level in 2001, at 150 Mtoe, and decreased to 142 Mtoe in 2019.

**Figure 10: primary consumption in France (TWh)**




*<u>Source</u>: SDES, provisional energy balance 2021 transmitted by the SDES.*

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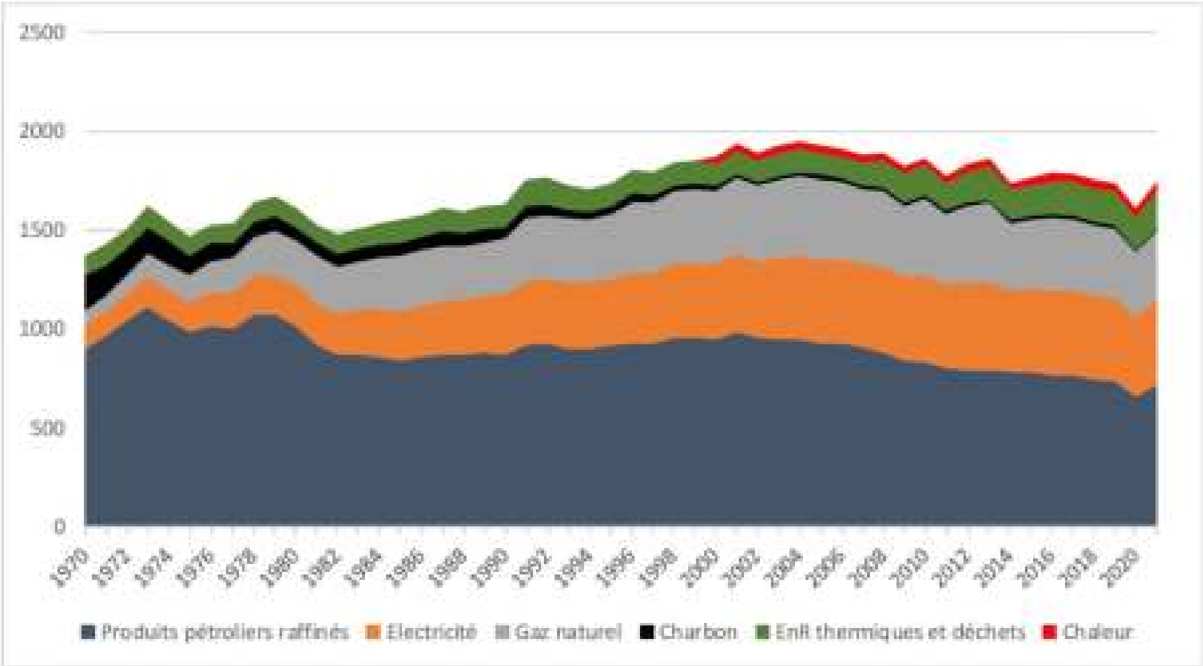
*(1) Data Lab, Key Energy Figures . 2020 and 2022 editions.*

*(2) Note that this is the last year before the health and geopolitical crises, the 2019 figures give a good idea of the energy situation of our country in ordinary times.*

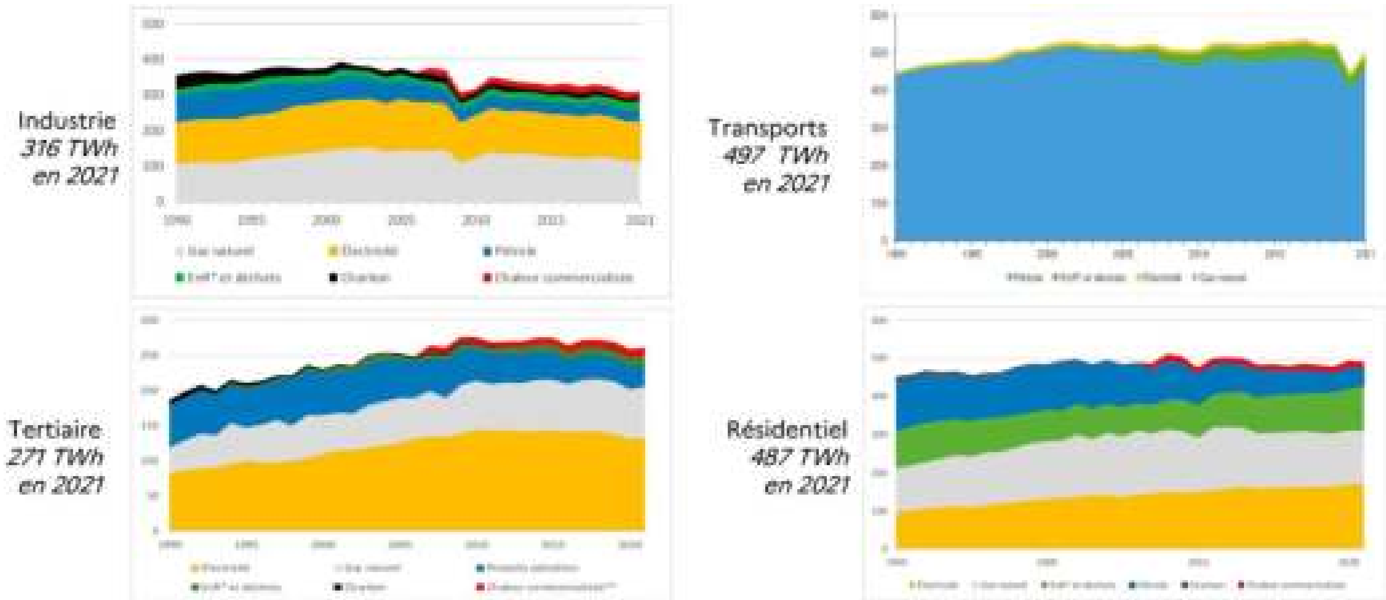
**This slight decline in consumption from the beginning of the 21st century is mainly reflected in the decline in consumption in the industrial sector**. Indeed, while the overall consumption of all other sectors is stable – as is the mix that composes it – the industrial sector has experienced a marked decline in consumption since the early 2000s, without the composition of its mix changing.

**Figure 11: final consumption in France (TWh)**




*Source: SDES, provisional energy balance 2021 transmitted by the SDES.*

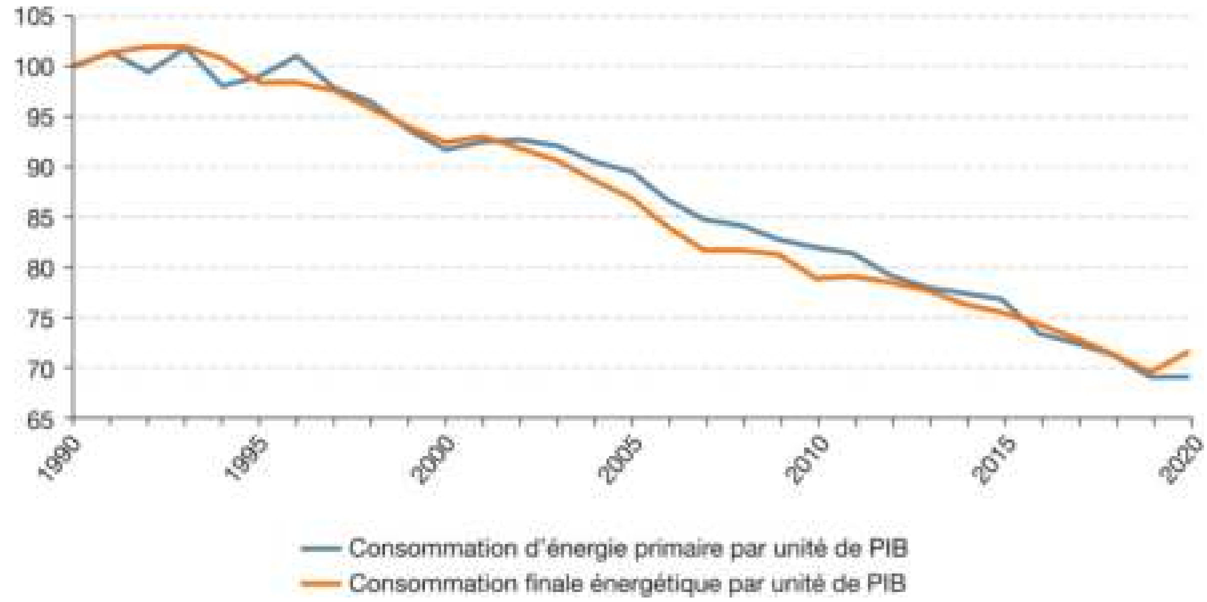
**Figure 12: Final energy consumption by sector in France (TWh)**




*Source:* SDES, *provisional energy balance 2021 transmitted by the SDES.*

Mr. Jean-Luc Tavernier, Director General of INSEE, highlights the steady and gradual decline in overall consumption in relation to GDP growth, whether primary energy or final energy, "*so that* we are ***30% more economical than we are*. *were in the 1990s."*** This translates into an improvement in the energy intensity index, or energy consumption per unit of GDP.

**Figure 13: Energy intensity relative to GDP of France from 1990 to 2020 – in base 100 index in 1990 (climatically adjusted)**




*Coverage: up to and including 2010, the geographical perimeter is the metropolitan France. As of 2011, it also includes the five DROMs.*

*<u>Sources</u>: SDES, energy balance of France; Insee.*

*Reading: Energy intensity measures energy consumption per unit of GDP. Over the period, the energy intensity of France improves.*

However, the hearings held in this committee have made it possible to **qualify the correlation between lower consumption and an improvement in the energy intensity index.**

**Indeed, if the same activity, producing the same wealth, is carried out thanks to a reduced volume of energy, the energy intensity index improves**: this is what Mr. Tavernier quoted above reminds us.

But **if the industrial sector has undeniably gained in energy efficiency over the last thirty years, this decline in consumption also seems to be linked to the deindustrialisation of our country.** Mr. Tavernier cites French deindustrialisation as one of the causes of the decline in energy consumption. Moreover, as highlighted by the work of the Shift Project[1], among others, **certain energy-intensive industrial activities have been abandoned on French territory**, in favour of the development of other, more energy-efficient sectors, which contribute as much, sometimes more, to GDP.

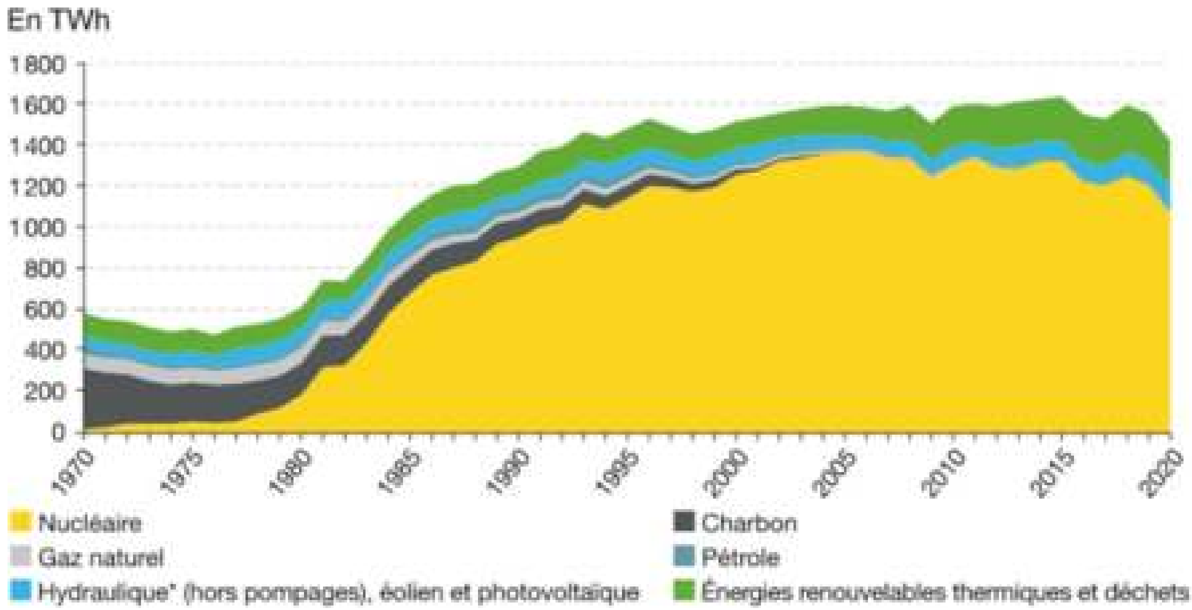
**2. But domestic energy production, much lower than our consumption, stagnated and then decreased over the same period due to a downward trend in nuclear production.**

With the development of the French nuclear fleet, then renewable energies, **primary energy production has grown sharply since the** 1970s (from 44 Mtoe in 1973 to 134 Mtoe in 2019, 77% of which is nuclear), **especially in electricity**.

**However, national primary energy production (1,522 TWh in 2021) has never been enough to cover the country's needs. The France has always been a net importer** of energy, amounting to 1 247 TWh in 2021, equivalent to 45 % of its primary consumption and 71% of its final energy consumption (*see*: volumes of energy imports in relation to primary energy consumed (in metropolitan France)).

However, it can be seen that after a peak in 2005, corresponding to the commissioning of the last nuclear power plant, national electricity production rather stagnated in the following years, despite the arrival on the market of new renewable generation capacity, and even began to decline sharply from 2015, with the gradual decline in nuclear production.

**Figure 14: Primary energy production by energy**




*Source: SDES, energy balance of France in 2020. Primary energy production of 1,423 TWh in 2020.*
** Including marine energies.*
*Coverage: up to and including 2010, the geographical perimeter is the metropolitan France. As of 2011, it also includes the 5 DRAOM.*

(1) PTEF, Decarbonizing industry without undermining it, January 2022

3. **The gap between consumption and production is reflected in imports and, above all, in a considerable trade deficit, which has become exceptional in the crisis situation.**

***a. Imports rather stable in volume in our energy consumption for 40 years***

Data published by the SDES show that after having decreased with the development of nuclear electricity production in the 1970s and 1980s, the **share of imported energy has remained stable in relation to energy consumed in France, at about 60%, since the maturity of the nuclear fleet**, and had even decreased slightly in 2021, last year considered.

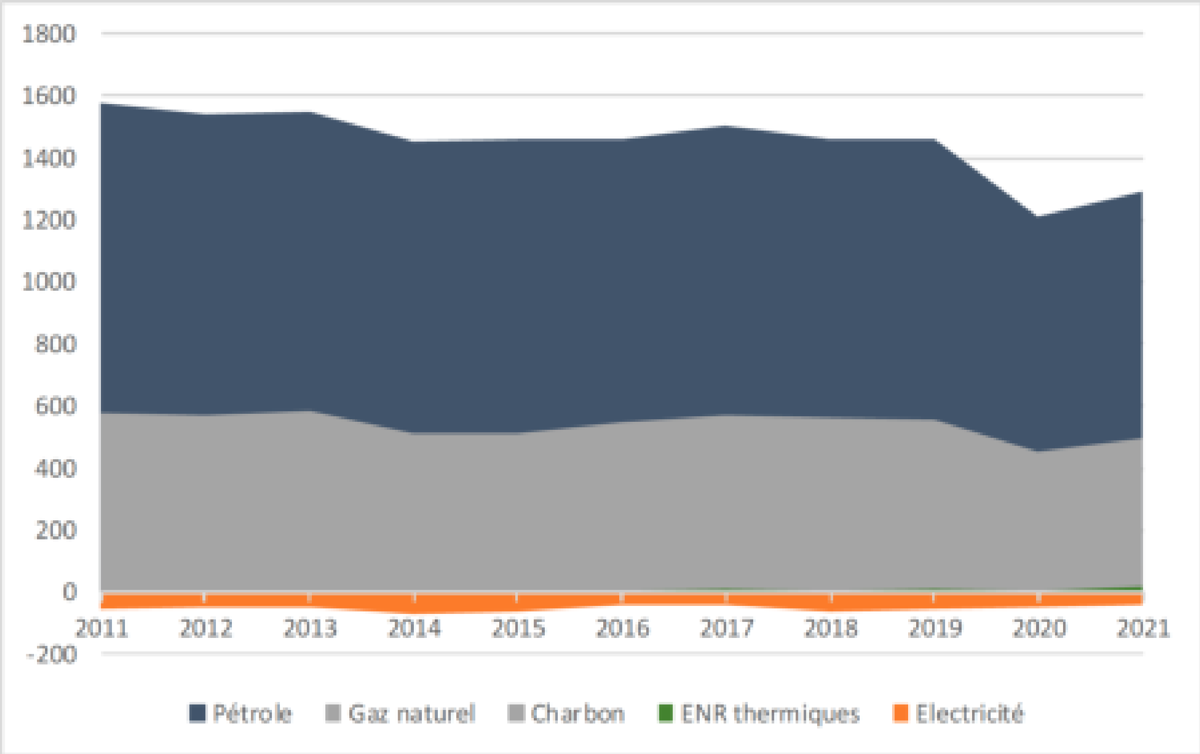
**Figure 15: Volumes of energy imports in relation to primary energy consumed (in metropolitan France)**


Source: SDES, provisional energy balance 2021 transmitted by the SDES.

Reading: since the development of the French nuclear fleet, France imports about two-thirds of the primary energy it consumes.

**In gross quantities, the volumes of energy imports have even shown a downward trend, following the decline in energy** consumption observed over the last twenty years, in a context of relative stability in primary energy production.

**Figure 16: France net energy imports (TWh)**




*Source:* SDES, *provisional energy balance 2021 transmitted by the SDES.*

*Reading: The chart estimates the balance of imports minus exports. Over the period, France is therefore an importer of fossil fuels but an exporter of electricity.*

### *b. But a cost very sensitive to the volatility of hydrocarbon prices*

The industrial revolution and the technological transformation of our daily lives were essentially based on fossil fuels, which our country had little to endowed with. Since their deployment, France has therefore borne a negative balance of foreign trade in energy products, known as the energy bill, which weighs heavily on its economic and financial margins.

This amount is, by construction, dependent on the volatile prices of hydrocarbons, which weigh massively in French imports in recent years, between the highest point in 2012, with a bill of €94 billion, and the lowest point in 2016, at €46 billion.

**Figure 17: Energy imports in France by major components (€ billion)**

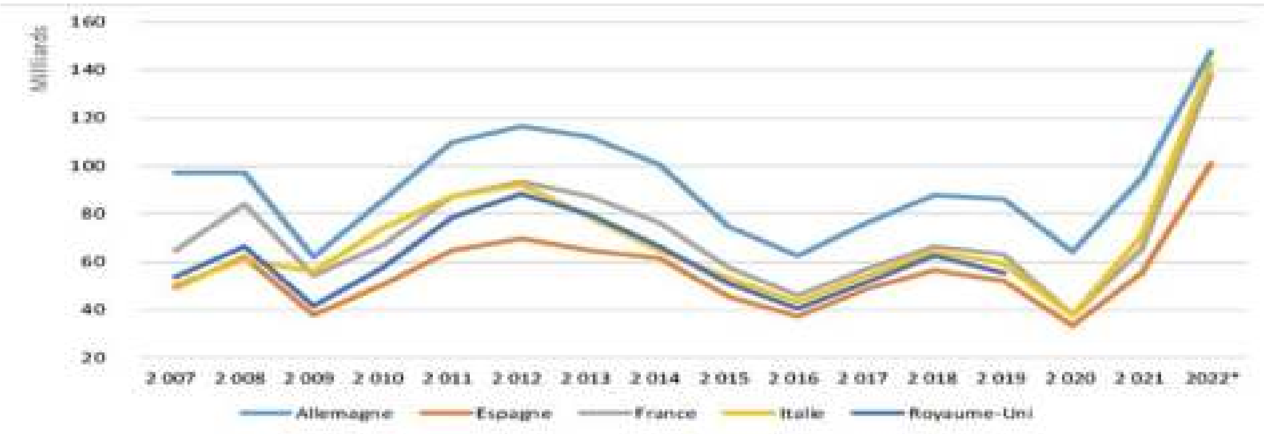
*Source: DSECE, document transmitted to the rapporteur by the DSECE.*

*Reading: the monitoring of France's energy imports by component makes it possible to see the economic weight of its energy dependencies. Hydrocarbons are an important source of dependence, reduced in 2020 due to the measures taken as part of the management of the covid-19 pandemic.*

The Department of Statistics and Foreign Trade Studies (DSECE) of the Directorate General of Customs and Indirect Taxes (DGDDI) points out, that the amount of energy imports of France is the average of its main European neighbors.

**Figure 18: comparison of France's energy import amounts with its main neighbours**

*(EUR billion )*



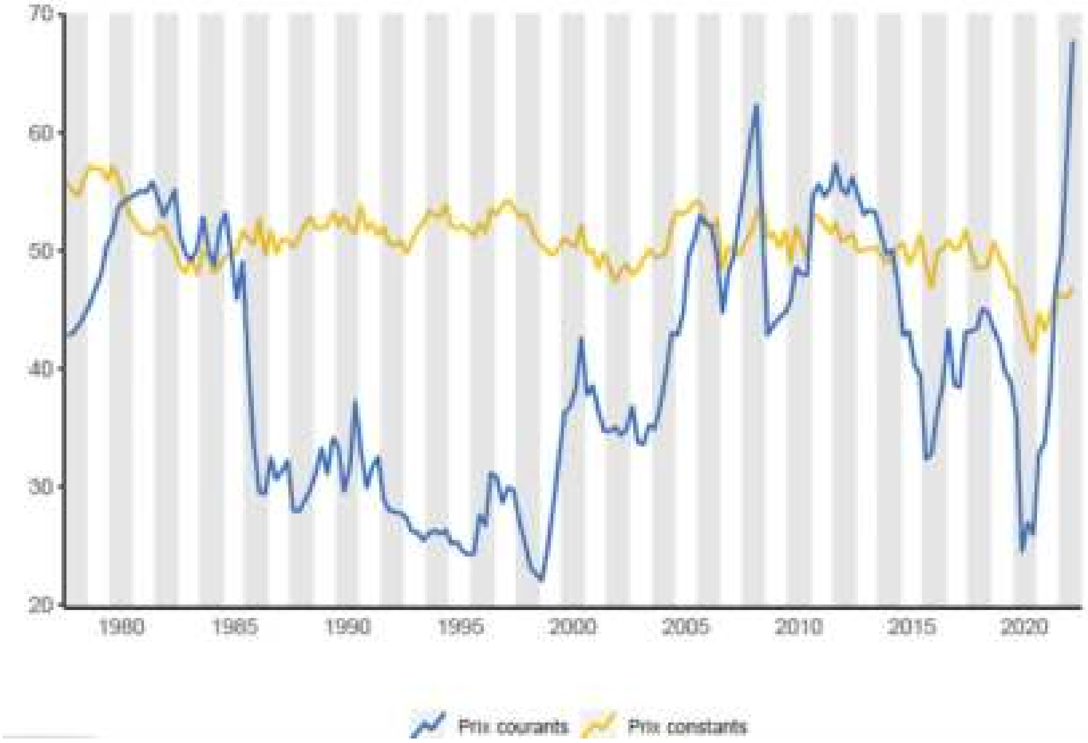

Source : Eurostat
* 2022 a été calculée en multipliant les données disponibles de janvier à juillet par 12/7.
** Compte tenu de la sortie du Royaume-Uni de l'Union européenne, les données du Royaume-Uni ne sont plus disponibles dans Eurostat depuis 2020.

In any case, if the economic impact of our energy bill is undeniable(1), this must be read with caution as it is particularly sensitive to fluctuating energy prices.

(1) INSEE macroeconomic models according to the Mésange model (economic model for simulation and general analysis of the economy) show that a $10 increase in the price of a barrel of oil leads to a loss of activity of a quarter of a point of GDP in the second year.

On this point, INSEE stresses that the **variation in the share of imports in domestic expenditure on energy depends mainly on prices**. This share increases when the prices of hydrocarbons (oil, refined products and now gas) on international markets rise faster than the prices of electricity production in the territory – as happened in particular between the oil shocks – and falls in the opposite situation – as in the counter-shock of 1986.

**Figure 19: Share of imports in domestic energy expenditure**




*Source: INSEE, national accounts, document sent to the rapporteur by INSEE.*

**These fluctuations do not detract from the observation of a chronic trade deficit, which translates into a negative balance of between €10 and €20 billion for France** (excluding the 2022 crisis).

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*The direct impact of a gas price increase equivalent to billions of euros amounts to about the same. INSEE points out, however, that this extrapolation does not take into account the influence of the price of gas on that of electricity on the European market, gas supplying the last power station called, nor the choices of certain companies which prefer to cease their activity rather than sell at a loss, as they cannot pass on the prices of inputs and intermediate energy consumption to their selling prices.*

**Figure 20: trade balance, including energy, of France in value (€ billion)**

*(EUR billion )*


*Source: INSEE, national accounts, document sent to the rapporteur by INSEE.*

*Reading: the trade balance of the France has been deteriorating since 2020, mainly due to the increase in the weight of energy in it.*

### c. *The crisis in French electricity production has massively accentuated this trade deficit*

Recent crises have led to a crisis in electricity production, which has resulted in an increase in our imports in volume and an increase in the energy bill, while highlighting the new fragilities of the French nuclear fleet.

While **France has been a net exporter of electricity since 1980**(1), **it was a net importer of electricity in 2022**, with a balance of 16.5 TWh – representing just under 4% of national electricity consumption(2) (*See* Figure 9: balance of electricity trade between France and its neighbours). The France not only imported more electricity in volumes in 2022, but also had to acquire it at an extremely high price.

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*(1) It should be noted that at certain times of the year, especially in winter, France imports electricity to meet its consumption peaks. The total is smoothed over the year.*

*(2) To have an order of comparison, this represents approximately* the *average annual production of the Belleville Nuclear Generating Station (2 x 1310 MW, step P'4).*

**The increase in electricity imports has aggravated the weight of the "energy bill", adding to the shock of increases in fossil fuel and electricity prices: while it amounted to €19.1 billion in 2020, €44.3 billion in 2021, it reached €115 billion in 2022,** an increase of 187% in one year, according to figures from the SDES to the General Commission for Sustainable Development (CGDD). According to INSEE, the energy bill, in GDP points, in the last quarter of 2022 was no longer very far from that of the early 1980s, when it was at its maximum after the second oil shock.

**The deterioration in the electricity trade balance is due in particular to a fall in total electricity production, which is at its lowest level since 1992, due to low nuclear and hydro production.** In fact, our electricity production has declined significantly since 2020. And even if it rebounds in 2021, at the end of the health crisis, it remains below its 2019 level.

**At 1,150 TWh,** nuclear **primary generation in 2021 is indeed at one of its lowest levels since the late 1990s**. It is 15 per cent below its peak in 2005. The covid-19 crisis has indeed shifted the maintenance schedules of nuclear power plants.

**With stress corrosion problems**(1) discovered in several reactors from the end of 2021, which led to their shutdown, **these difficulties continued and even accentuated in 2022**. Between maintenance requirements and these structural problems, up to 32 reactors were shut down in August, out of the 56 in operation in the French fleet. They were still 15 at the end of December(2).

While it reached 452 TWh in 2005, it was still at 335 TWh in 2020, in the midst of the covid-19 crisis, and 361 TWh in 2021, **nuclear electricity production has fallen to 279 TWh in 2022.**

At the same time, **hydropower production also declined** in 2021 due to low rainfall and fairly low hydro stocks, not reaching the 2019 level. However, this problem persisted in 2022 – losing up to 22% of production to reach only 32 TWh – and continues at the beginning of 2023.

**Fortunately, part of this fall in production appears to be cyclical, unlike the new weaknesses in historical electricity production capacities that the period revealed** (see II. D. 2.b.).

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*(1) These are cracks detected in the elbow welds of the safety injection pipes, the "RIS" circuit designed to inject bored water into the main primary circuit of the reactor in order to cool it in the event of an incident, as well as on the shutdown cooling circuit (SRA) which allows the circulation and a minimum water level in the primary circuit to evacuate waste heat from radioactive fuels when the reactor is shut down.*

*(2) Seven others remain closed for "modulation", the low consumption of the French does not require their recovery.*

## B. FRANCE IS FIRST AND FOREMOST DEPENDENT ON FOSSIL FUELS, THE EXIT OF WHICH WILL BE DIFFICULT AND EXPENSIVE

### 1. Almost total dependence on hydrocarbon imports

The still very important weight of fossil fuels in the energy consumption of France is also one of **its first vulnerabilities in terms of sovereignty, since it must import** 99% of the oil and gas it consumes[(1)].

The France consumes around 70 Mtoe (excluding 2020-2021) and produces only 0.8 Mtoe each year[(2)]. After producing nearly 100 million tons of oil and 300 billion cubic meters of gas in 60 years, France has reduced and virtually stopped production. **In 2015, France had only 64 oil and gas fields in operation** (reserves of 7.7 and 0.12 Mtoe respectively in 2019), put into production in the 1980s and mainly located in the Aquitaine basin and the Paris basin.

**Box 6: France's renunciation of shale gas**

Unlike several countries, including the United States, France has given up exploring its potential shale oil gold gas deposits since Law No. 2017-1839 of 30 December 2017 putting an end to the exploration and exploitation of hydrocarbons and containing various provisions relating to energy and the environment. Although since the war in Ukraine, our country has been importing American unconventional gas, France has not reversed this principle.

Indeed, such an option would run counter to the necessary trajectory of decarbonisation of our uses, not to mention the damage that these operations can cause to the environment and that should be avoided as much as possible.

Moreover, the current imports of American gas meet immediate needs, without an adequate alternative solution today; but European and French officials are betting on a fall in gas demand by 2040-2050. Not only will France not be able to replace these imports for several years, but the trajectory targeted is incompatible with the commitment new explorations then exploitations of hydrocarbons which require several decades of activity to amortise their investments.

Although coal consumption is not zero, it has fallen sharply, to around 7.3 Mtoe in primary consumption and 1.9 Mtoe in final consumption in 2019[(3)], its lowest level in decades. In fact, in accordance with the environmental requirements of the European directive on greenhouse gas emissions from large combustion,

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*(1) Data Lab, key figures on energy, 2020 and 2022 editions.*

*(2) Orders of magnitude of the 2010 decade, crude oil, excluding the years 2020-2021-2022 which were very specific, particularly because of the covid-19 crisis. Ministry of Energy Transition, 2023.*

*(3) SDES, Energy balance of the France for 2019,https://www.statistiques.developpement-durable.gouv.fr/edition-numerique/bilan-energetique-2019/20-44-la-consommation-de-charbon.*

almost all coal-fired thermal units were shut down and activity was reduced to a minimum. Some have nevertheless been kept in reserve in the event of a threat to electricity supply in the current crisis[(1)]. In view of the share, which has become very minority, of coal in energy consumption, the Committee of Inquiry chose not to study this energy source in more detail.

**This large share of imported fossil fuels in our energy consumption is the very first energy vulnerability of France.**

**The risk is of course geopolitical**: on supplies, it is not new and we can mention the sanctions against Iran or Venezuela that have affected the supply of oil, as well as the risks of internal destabilisation from certain producing countries, such as Libya. These risks have recently been exacerbated by the crisis in Ukraine, as Russia was one of Europe's largest suppliers of oil and gas. Both Western sanctions and Russian retaliatory measures[(2)] have weighed on prices and destabilised the European Union's security of supply. This episode challenges the belief that mutual trade dependence avoids supply disruptions.

Fossil fuels therefore represent major challenges for our country, in terms of decarbonisation of the energy *mix*, in economic terms linked to rising prices, in geopolitical terms, whose importance has been recalled by the crisis in Ukraine, and even in **terms of the level of supply**.

Because resource depletion is less a risk than a certainty. If the debates on the date of peak oil persist, and in particular if the total production of hydrocarbons (conventional and unconventional oil[(3)]) has not yet reached its peak and is the subject of widely different estimates, on whether known or undiscovered deposits

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*(1) Cf. in particular Law No. 2022-1158 of 16 August 2022 on emergency measures for the protection of purchasing power.*

*(2) According to Europa.eu, the official website of the European Councils and the European Union, the EU has adopted nine packages of sanctions against Russia, including several energy measures, including: the application of a price cap linked to the maritime transport of crude oil and petroleum products, the ban on coal imports from Russia, the ban on oil imports from Russia, with some exceptions, the ban on exports to Russia of goods and technology in the oil refining sector, the ban on new investments in the Russian mining and energy sector, and the ban on the supply of oil refining capacity. gas storage (excluding the part of LNG facilities) to Russian nationals.*

*(3) The "unconventional" character does not distinguish the process of formation of oil, but the composition of the rock in which it is found and thus the techniques used for its extraction. The same applies to gas.*

*– In the case of conventional oil, hydrocarbons formed at the bedrock migrate to a porous and permeable rock (called a reservoir). They accumulate there and form deposits that are exploited by simple drilling.*

*– For unconventional oil, hydrocarbons remain dispersed in the low porous and permeable layers of the sedimentary basin. They can even be trapped in bedrock (oil shale and shale oil). In other cases (tar sands and heavy oils), the physical characteristics of the oil, very viscous or even solid, do not allow conventional exploitation.*

are taken into account, conventional oil production declines and this phenomenon, whose reasons are geological, will accelerate in the coming decades. The production of Europe's top sixteen suppliers is expected to halve by 2050, meaning that **their exports to Europe could be between two and twenty times lower**.

Moreover, on 6 December, ***The Shift Project*** **published a similar study on gas according to which the world peak production** is in 2030, but that it took place as early as 2005 for the North Sea fields.

**Europe, including France, would therefore be exposed to an inevitable decline in its hydrocarbon supplies (and their inflation**), **which international competition will not fail to accentuate when rationing is felt.** This poses a serious threat of loss of sovereignty, Mr. Jancovici: "*On fossil fuels, which are the primary engine of the civilization in which we live, the question of the loss of sovereignty has already been at work for a long time. This loss will accelerate and translate directly into a contraction of flows of all kinds, which we are used to classically summarising from the point of view of gross domestic product (GDP).”*

The France has developed a comprehensive strategy to cover its oil and gas consumption, according to three main axes: control of consumption, diversification of suppliers and crisis measures. But **in view of the challenges ahead, these measures will not be enough**.

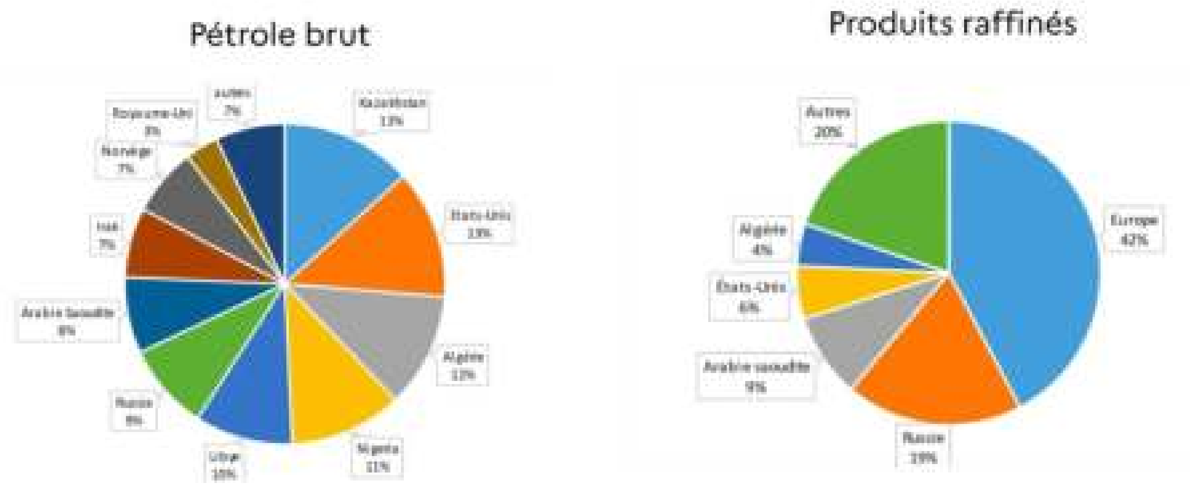
The IFRI (French Institute of International Relations) considers that "we have underinvested in the subject of the security of hydrocarbon supplies in recent years and [that] we have not entered the era of low-carbon technologies quickly and strongly enough", even if France is less behind than its neighbors thanks to the development of nuclear power which has made it possible to electrify various uses.

### 2. For oil, the diversification of supply sources does not prevent a strong dependence with major consequences

#### *a. Historically extensive diversification of supply sources*

The crude oil supply of French refineries has always been highly diversified. This was already the case before the Ukrainian crisis, as shown in the following graphs, based on 2021 data.

**Figure 21: French oil supply**




*<u>Source</u>: SDES, transmitted by SDES.*

*Reading: Refined products are derivatives of crude oil, including fuels .*

While the EU's main suppliers of petroleum products were Russia, Norway, Kazakhstan, the United States and Saudi Arabia, Russia accounted for only 9% of France's crude oil imports – but 19% of its refined product imports.(1)

The French Institute of Petroleum and New Energies (IFP-EN) highlights France's dependence on Russian diesel. In fact, European refineries mainly produce gasoline, which forces Europe to import mainly its diesel.

However, after stopping the import of crude oil at the beginning of December 2022, in retaliation for the war in Ukraine, the EU banned the import into its territory of Russian refined petroleum products(2) (diesel, kerosene, fuel oil and fuel oil). Importing these products over a longer distance represents a higher cost but it should not have a major impact on European supply, according to Olivier Appert, advisor to the IFRI energy centre and member of the Academy of Technologies(3): "*Operators and markets have anticipated the implementation of this decision (...) Diesel consumption is relatively stable during the year. And (...) we have 90 days of stocks in France, which can be mobilised if necessary*."

*(1) Refining consists of transforming crude oil into various products, both energy (fuels, fuels) and non-energy products (lubricants, bitumen and petrochemical products).*

*Russia is the state with the largest refining capacity on European territory, equivalent to 6 million barrels per day on average over the last decade. capacities three times higher than the second European country (Germany – 2M barrels / day).*

*(2) https://www.consilium.europa.eu/fr/policies/sanctions/restrictive-measures-against-russia-over-Ukraine/sanctions-against-russia-explained/*

*(3) "La Dépêche" on February 7, 2023.*

As IRIS (Institute of International and Strategic Relations) points out, this decision of the EU forces it to turn to other suppliers, and pushes Russia to look for other markets for its crude. **One global oil flow redirection is underway with more Russian oil exports to Asia and more European oil imports from the United States, the Middle East or Africa**. Thus, this diversification of supplies does not entail increased risks of oil shortages resulting from this European embargo. The EU is therefore not expected to run out of crude oil in the coming months.

**On the other hand, the common strategy for diversifying sources of supply is still in its infancy at European level,** this policy remaining the prerogative of the States, whose interests and energy history are not necessarily convergent. The first elements have been incorporated into the European Commission's *"REPowerEU"* package approved by the Council of the European Union on 18 May 2022. With the aim of organising the exit from dependence on Russian fossil fuels from 2027, it plans in particular to encourage strategic energy partnerships with certain supplier states. Since the beginning of 2022, this has resulted in political actions or prospections and sometimes agreements by the EU, for example on **gas and hydrogen**, with Norway and the United States, as well as Algeria, Egypt, or Azerbaijan.

#### *b. French fossil fuel consumption*

Primary consumption of petroleum products fell sharply in France: from 87 Mtoe in 1990, it was about 70 Mtoe in 2019.

But petroleum products remain essential to some sectors. They thus account for **almost all** of the energy **consumption** of **the transport sector** (497 TWh in 2021, 38.6 Mtoe in 2019), which alone uses 58% of refined products. While the share of oil in industry has fallen sharply, it remains significant in energy expenditure in the tertiary and residential sectors[1]. **The road to decarbonising these uses is therefore still long and uncertain.**

The development of biofuels is one of the ways to improve the carbon weight of mobility.

In France, IFPEN researchers are also working on reducing the need for oil as a component in the manufacture of plastics – which accounts for 4% of global oil consumption. IFPEN is studying bioplastics – as detailed by M. Pierre-Franck Chevet, Chairman and CEO of the institute, during his hearing: "*We are working with Michelin to manufacture biopneumatics at the Bassens site in Nouvelle-Aquitaine – and chemical recycling of plastics*."*These processes are mature and represent an improvement over the mechanical recycling currently used. (...) Chemical recycling makes it possible to obtain the same quality as that of the*

*(1) See graphs in A of this II.*

*original product. Industrial demonstrators are already experimenting with these technologies. A company will soon carry out tests of this type in Japan, for the manufacture of clothing*."

### c. *Alternative solutions to reduce greenhouse gas emissions from fossil fuels, such as biofuels or hydrogen*

Biofuels and biofuels cover all liquid, solid or gaseous fuels produced from biomass and intended for energy recovery in transport and heating. Biofuels are mainly used as additives or as a complement to fossil fuels. The objective of biofuels is to reduce the carbon intensity of the energy supplied [(1)].

> **Box 7: The Challenges and Limitations of biomass**
>
> Biomass was the subject of year in-depth study of France Strategy in 2021[(2)] with look to its potential, challenges and limitations. While the National Low-Carbon Strategy (SNBC) forecasts year energy potential forum the production of biomass resources reaching 430 TWh in 2050, including 250 TWh for agricultural biomass (against currently about 40 TWh), this study highlights the many conditions necessary to achieve such an objective, particularly on the evolution of agriculture.
>
> Some experts interviewed, such as Jean-Marc Jancovici, point out, however, that **biomass is not necessarily carbon neutral**. "*For biomass to be considered carbon neutral*, *you have* to *take from a stock that*, *yew we didn't use it, would be in balance, with some of the trees dying and young trees growing back every year."*
>
> In any case, **if the biomass used to produce energy is associated with deforestation, its balance sheet is worse than that of fossils.**

**There are three generations of biofuels** according to the origin of the biomass used and the associated transformation processes[(3)]. Today, the first generation has reached the industrial stage and the second generation is in the development phase.

The regulation of biofuels is also carried out according to the nature of the feedstock used: conventional biofuels, developed from a feedstock produced in

---

*(1) See c of 1 of D of this II on the carbon cycle and carbon weight of the various forms of energy.*

*(2) https://www.strategie.gouv.fr/publications/biomasse-agricole-ressources-potentiel-energetique*

*(3) The three generations of biofuels :*

*– 1st generation: use plants rich in sugar (such as beetroot) or starch (such as potatoes) or rich in oil (such as rapeseed or sunflower);*

*– 2nd generation: non-food parts of plants, i.e. forest remnants (parts of trees not used by the wood industry), agricultural residues (such as corn stalks), rapid growth (such as poplar and eucalyptus), or organic waste (e.g. sludge from sewage treatment plants);*

*– 3rd generation: photosynthetic microorganisms (cyanobacteria, microalgae).*

in competition with food crops, and advanced biofuels, made from other feedstocks.

The first generation of biofuels typically uses agricultural and food resources. To **avoid competition between the uses of these resources and the mobilisation of land needed for their production**, the EU caps the rate of incorporation into conventional fuels. The average rate on engines of all types in France is 7%.

IFPEN's research focuses on second-generation biofuels, based solely on forest or agricultural waste " *which have no other use* ".

**Box 8: State of French research on biofuels**

For more than a decade, IF-EN and its partners have been trying to demonstrate the value of biodiesel and biokerosene production technologies, particularly for the production of sustainable aviation fuels, by **reducing greenhouse gas (GHG)** emissions by **more than 90%.** In 2022, this technology **entered an industrial phase**: Elyse Energy launched the BioTjet project, in partnership with IFPEN, Avril and BioNext, with the aim of building and operating the first French **industrial** unit in the advanced biokerosene production from sustainable biomass.

IFPEN, along with ten French partners, has also developed a technology for the production of ethanol from agricultural and forestry residues. To make it a reality on French territory, IFPEN and Axens have brought together various partners to carry out a project to set up a first industrial production unit: the NACRE project. It aims to produce 30,000 t/year of ethanol from corn residues and forest residues and will be located on an industrial site to be converted. Such a project will also make it possible to produce biomethane in large quantities (4,000 t/year) as a co-product. Ethanol is a platform molecule that can be used as a road fuel but can also be transformed into biokerosene for aircraft using industrial technologies developed by IFPEN. It can also be used to make bio-based chemical molecules such as ethylene or butadiene. Maize residues are not yet collected and recycled.

Finally, IFPEN is working on technologies for the production of e-biofuels, synthetic fuels made from "green" electricity that bring together different products. The institute is working on this process and the associated catalysts, in particular for the production of advanced e-biofuels. The BioTjet project mentioned above provides for feasibility and basic design studies for the production of e-biofuels. In addition, IFPEN is developing a complementary brick to convert carbon dioxide ($CO_2$) into carbon monoxide (CO) in the presence of hydrogen (H2 reaction of gas to reverse water), which will enable it to offer a complete $CO_2$ recovery chain into e-fuels or e-chemicals; exchanges are underway with European industrialists for a demonstration project.

IFPEN's work highlights the **many advantages of these biofuels**: reducing transport's dependence on oil, reducing transport-related GHG emissions, encouraging them to create or maintain them an agricultural or forestry activity, an industrial activity and thus jobs, and no need to adapt the electricity distribution network or vehicles, unlike the electrification of transport.

Initially, **biofuels may appear to be an interesting solution for the decarbonisation of certain sectors for which it is difficult to envisage other solutions in the short term**, **particularly in aviation**, even if their contribution will remain limited: France thus aims for a share of 5% for aviation in 2030, and 50% at most in 2050[(1)].

The France is the world's fourth largest producer of biofuels (5% of world production) after the United States, Brazil and Germany, with more than two million tonnes of biofuels produced in the territory[(2)]. According to IFPEN, in 2022, global energy consumption in road transport amounted to 2 093.9 Mtoe, of which 91 Mtoe was covered by biofuels, or about 4%[(3)]. In the previous year, France recorded energy consumption in transport of 501 TWh, 7% of which was provided by biofuels[(4)].

The hearings conducted by the committee highlighted numerous projects for the deployment of the sector[(5)], in particular in terms of increasing the percentage of incorporation of biofuels into conventional fuels.

On the other hand, the technologies developed by the sector ensure uneven yields. For example, while municipal waste has an attractive economic advantage for operators, going so far as to encourage TotalÉnergies to convert refineries into biorefineries for processing, the technology for exploiting wood waste[(6)] is developed but does not offer sufficient efficiency for companies.

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*(1) French roadmap for the deployment of sustainable aviation biofuels, https://www.ecologie.gouv.fr/sites/default/files/Feuille%20de%20route%20française%20pour%20le%20deployment%20des%20biofuels%20aéronautiques%20durable.pdf*

*(2) Data from the Ministry of Energy Transition.*

*(3) IFPEN, 2022 Biofuels Scoreboard, 2 January 2023.*

*(4) SDES, Key Energy Data – 2022 edition, p. 33.*

*(5) In particular, IFPEN and TotalÉnergies.*

*(6) Woody green waste is waste from plants that have the consistency or appearance of wood such as trees, shrubs, bushes and shrubs.*

**Box 9: Use of waste for biofuel production**

As part of the exploitation of municipal waste for the production of biofuels, two sites are privileged in France by TotalÉnergies.

Commissioned in July 2019, the La Mède biorefinery has technology to use all types of oils to transform them into biofuels, mainly road. Its production capacity is 500,000 tons per year.

The Grandpuits site, scheduled to start up in 2025, is being transformed into a zero-oil platform including a biorefinery, a bioplastics plant and a plastics recycling plant. This will include producing 210,000 tonnes per year of aerial biofuels, 50,000 tonnes per year of renewable diesel and more than 70,000 tonnes per year of bio naphtha/LPG. This new unit should thus contribute to the French Roadmap for the Deployment of Sustainable Aviation biofuels, which includes an incorporation target of 2% in 2025 and 5% in 2030.

In addition, the development of *Coprocessing* offers new avenues. It consists of producing renewable diesel or sustainable aviation fuel (SAF) in the same units that currently produce distillates by adding oils from the circular economy. The Normandy unit started in 2022 the production of SAF by *Coprocessing* to meet the French mandate of 1% incorporation in 2022.

Finally, in view of the volumes of material to be mobilised, the development potential of these biofuels cannot be at the level of current transport needs. **Electrification therefore still appears to be one of the most suitable and accessible solutions for land mobility.**

In any case, the **decarbonisation of transport and industry still requires significant investment**, whether for research, the creation of national industrial sectors and the adaptation or renewal of air, sea and land fleets.

*(1) CEA, Hydrogen, 10 May 2022.*

**Box 10: Current hydrogen and future prospects**

**Hydrogen (H), a molecule very abundant in the environment**, is always bound to other chemical elements. **As an energy carrier** whose combustion releases four times more energy than gasoline[1], hydrogen has the advantage of being able to be stored (gas, liquid, solid storage).

Of the **70 million tons of hydrogen produced worldwide**, **48% comes from natural gas, 28% from oil, 23% from coal and 1% from water electrolysis**. In France, 40% of hydrogen production comes from methane vapor reforming, 40% from hydrocarbon oxidation, 15% from coal gasification and 5% from electrolysis.

The production of energy from hydrogen could therefore be almost inexhaustible if it is produced in sufficient quantities and at competitive cost. However, **the extraction of hydrogen from the primary resources in which it is present requires energy input**.

**The dependence is very strong on fossil sources and thermal energy**. Consequently, STIs production is highly carbon-intensive: World average of 15 $kgCO_2$ / kg $H_2$ (in comparison, the same amount of energy in the form of coal represents 13 $kgCO_2e$, 11 $kgCO_2e$ for fuel oil and 8 $kgCO_2e$ for natural gas). In 2018, global hydrogen production emitted 830 MT of $CO_2$.

According to the CEA, 95% of hydrogen is produced by hydrocarbons. We speak **of grey hydrogen** if it is manufactured by thermochemical processes from fossil raw materials (coal / natural gas). We speak of **blue** hydrogen if it is manufactured in the same way as gray hydrogen with the difference that the $CO_2$ emitted is captured for use gold storage. Finally, it CAN be produced from water (electrolysis) thanks to renewable carbon-free electricity, we then speak **of green** hydrogen gold- **yellow** hydrogen if the hydrogen is produced from electricity from nuclear sources.

**Research is underway to optimise STIs cost and** performance to make its performance interesting. The production of hydrogen from biomass (wood, straw, etc.) is also a line of research. Finally, it would be possible to extract hydrogen from existing underwater Deposits goal, to date, unattainable – it is called **white hydrogen.**

The hydrogen produced by electrolysis costs around €4 / kg to €6 / kg forum has duration of use of the order of 4,000 to 5,000 hours per year and **has cost of electricity around of €50 /MWh.**

## 3. For gas, diversification of supply limited by logistical constraints in Europe

### *a. Consumption on the rise, whose supply has diversified*

The energy historian, Mr. Yves Bouvier, explained at the hearing that in France, nuclear energy and natural gas developed in parallel, and not in competition as in other countries. Natural gas supply agreements with Algeria in 1971 and with the Soviet Union in 1980 ensured a form of reduction in oil dependence.

This consumption continued to increase. Total natural gas consumption in 2020 was 494 TWh GCV[(1)], but this was the first year of the pandemic. Consumption reached 600 TWh PCS in 2019 while it was only 100 in 1979.

Gas accounts for an important share of energy consumption in industry and the residential sector. Mainly used for its calorific value, some (19% in 2019) is also used for electricity production (Figure 12: final energy consumption by sector in France (in TWh)).

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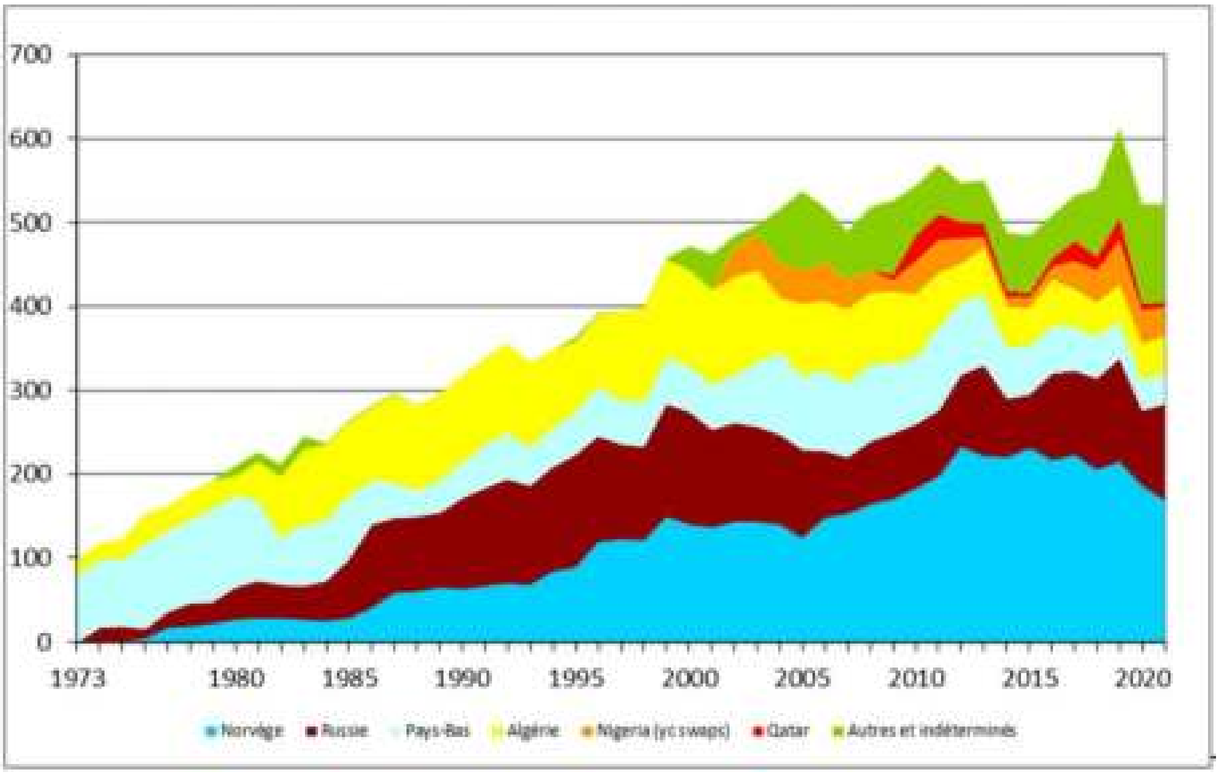
*(1) Higher calorific value.*

Not only has the share of purchases on the market increased in recent years, but SDES also notes that **supply has diversified with the increase in liquefied natural gas** (LNG) trade[1].

This trend has accelerated since the Ukrainian crisis: in the third quarter of 2022, gaseous natural gas inflows decreased by nearly 80% year-on-year while net LNG inflows increased by 170%. This comes from the United States and Qatar, which diversifies our gas supply, even if 30% of our imports still come from Norway; and from August there are no more imports of Russian gas, whereas previously they represented 17% of French consumption.

**Figure 22: External gas trade in 2021 (in TWh)**




*Source:* SDES, *transmitted by SDES.*

### *b. Supply constraints, particularly logistics,*

As production has not peaked, global resources are now sufficient to meet demand. However, the main obstacle to the development of the sector is the constraints on the gas supply chain.

The barriers identified to the delivery of natural gas to France are in the LNG supply chain. The pressure observed on gas prices is thus partly explained by:

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*(1) LNG refers to natural gas transformed into liquid form. To do this, it is cooled to a temperature of about -160 °. In this condition, it is 600 times less bulky and can thus be easily stored and transported by boat. It can be used as is or need to be regasified (reheated).*

– **insufficient liquefaction capacity,** linked to limited investments in previous years;

– **the demand shock** created by the Russian gas deficit in Europe;

– **the LNG carrier fleet limited to 700 vessels (GIIGNL) can also be a** bottleneck (by comparison, there are 8,000 tankers);

– finally, there has been a **new need to invest** in regasification in Europe, especially in Germany.

In addition, gas storage is an essential element for the gas supply of a non-producing country such as France. By injecting gas into storage during the summer and extracting it during the winter, suppliers can meet their customers' consumption, which is highly dependent on the climate for most of them. **The storage capacities cover nearly 40% of the volumes of gas consumed in France during the winter and are essential during cold peaks.**

However, French LNG terminals do not appear sufficiently sized to import all the gas needed for cold peaks, as demonstrated by the analysis of the physical balance – which presents the coverage of the needs of French consumers during a cold peak – carried out by the Ministry of Energy Transition.

Beyond the LNG chain and the design of French terminals, the inadequacies of gas interconnections between European countries are also a brake. Moreover, the projected decline in gas consumption does not encourage European states to invest more in this infrastructure.

***c. The slow progress of biogas***

The transformation of biomass into energy can also be a way of regaining sovereignty. Currently, the biogas sector can be broken down into three sub-sectors, segmented according to the origin and treatment of the waste:

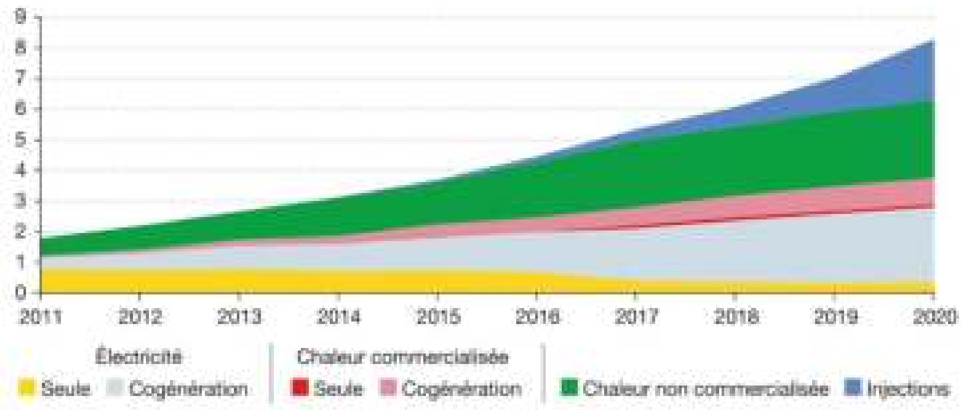
– methanisation of non-hazardous waste or raw plant matter;

– methanisation of sludge from wastewater treatment plants (WWTPs);

– biogas from non-hazardous waste storage facilities (ISDND).

Mainly produced in metropolitan France, up to 9 TWh in 2020, biogas is mainly used to produce electricity (34% of the energy produced from biogas) and heat (42%), mainly not marketed (therefore consumed directly by the end users of biogas). The purification of biogas into biomethane, in order to then be injected into natural gas networks, has also been a new outlet for a few years (24% in 2020). Between 2019 and 2020, overall energy production from biogas increased by 18%.

**Figure 23: evolution of energy production from biogas (in TWh)**




*Note : l'énergie est comptabilisée ici sous sa forme finale lorsqu'il s'agit d'électricité ou, lorsqu'elle est vendue, de chaleur, mais sous sa forme primaire avant conversion (énergie contenue dans le biogaz) lorsque l'énergie finale produite correspond à de la chaleur non commercialisée ou à des injections dans le réseau de gaz.*

***Sources** : SDES, enquête sur la production d'électricité ; Ademe, Itom ; GRTgaz*

The potential deposits of substrates that can be used in anaerobic digestion were estimated as part of a study carried out by SOLAGRO and INDIGGO on behalf of ADEME[1]. **The global deposit that can be mobilised in 2030 for methanization has been estimated at 130 million tons of raw material, or 56 TWh of primary energy in biogas production.** It is composed of 90% agricultural materials.

The hearings of the Committee of Inquiry highlighted nuanced points of view: for TotalÉnergies, ready to invest massively in this energy, France has the second largest potential at European level after Germany. Biogas is a completely local energy, the production of which is expensive, but creates jobs that cannot be relocated and can offer opportunities for farmers.

On the other hand, for Jean-Marc Jancovici, it is not appropriate to follow the German strategy, which consists of installing dedicated crops to produce biogas in large quantities. The expert rather believes in a use of niches: "*Making biogas with agricultural waste or intermediate blankets and using it primarily to replace the fossil fuels of agricultural mechanisation seems to me quite appropriate*."

In any case, like biofuels, there is a balance to be preserved between energy production and food production and the need to remain vigilant about the carbon footprint of this biogas. This is one of the reasons why the 2023-2028 multiannual energy program (PPE) only plans to support, through national aid, an additional volume of 22 TWh.

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*(1) Study "Estimation* of *potential deposits of substrates usable* in *methanization in France", SOLAGRO and INDIGGO, 2013*

In addition, for a farmer, the initial investment is significant and the operation of a biogas plant requires qualified personnel to manage anaerobic digestion. A biogas plant would be profitable for a farm with a minimum of 100 cows after about ten years. Thus, this type of production is aimed more at intensive livestock farming than at small farms.

**The dependencies and vulnerabilities of the excessive share of fossil fuels in the French energy mix encourage the strengthening of carbon-free energy** production based on energy sources available on the territory: this is the objective of electricity production provided mainly by nuclear and hydro.

## C. THERMAL ENERGY PRODUCTION FROM RENEWABLE SOURCES CAN BE A SUBSTITUTE FOR FOSSIL FUELS

The production of renewable thermal energy is a particularly relevant alternative to fossil fuels. Indeed, heat **production accounts for half of energy consumption in France and is still mainly based on fossil fuels** (and now on gas for a large part).

In addition to biogas and biofuels mentioned above(1), the main modes of heat production are wood, geothermal energy, solar water heaters and heat pumps.

In practice, renewable heat has developed mainly in countries with significant potential, such as the Nordic countries, whose forest deposits are very important in relation to the population. France has nevertheless set up a public financial support scheme for the development of renewable heat (or cooling) production, the Heat Fund, as part of the Grenelle Environment Forum. In 2021, 212 TWh of renewable thermal energy was produced in France(2), and 180 TWh were consumed(3). Between 2005 and 2021, gross final consumption of renewable energy increased by 160 TWh, mainly thanks to the development of biofuels, heat pumps, and solid biomass. While heat pumps have exceeded their production target under the PPE by 2021(4), this is not the case for other modes of thermal energy production. renewable(5).

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*(1) Cf. II-B.*

*(2) Primary production – 125 TWh wood energy, 14 TWh waste, 43 TWh heat pumps .*

*(3) Gross final consumption - including 123.8 TWh solid biomass and waste, 42.1 TWh heat pumps, 7.2 TWh biogas, 2.4 TWh solar thermal, 2.3 TWh geothermal thermal, 3.2 TWh biofuels.*

*(4) 2023 target for heat pumps: 39.6 TWh / 2021 production: 43 TWh.*

*(5) SDES, Key Figures on Renewable Energy - 2022 Edition.*

**Box 11: The heat fund**

Managed by ADEME, it helps all the sectors concerned (biomass, geothermal, solar thermal, etc.) goal is reserved for collective housing, communities and businesses. It also supports the creation of heating networks.

Over the period 2009-2021, it was endowed with €2.9 trillion and supported 6,600 projects representing a total production of renewable heat and recovery of 39 TWh per year. The Court of Auditors has also stressed its effectiveness. **Its budget has been steadily increased since 2017**: from €200 million it rose to €260 million in 2018, €300 million in 2019, €350 million in 2020 and again in 2021, to jump to €520 million in 2022.

ADEME believes that These renewable Productions are overwhelmingly substituted forum gas. It estimated the savings they represent for the French trade balance at €1.6 billion per year based on the average gas price in 2021, and around €4 billion per year based on the average price in 2022.

### *a. The growing use of wood resources, coveted by many sectors*

Of all renewable sources, the most used in the world and in our country remains **biomass produced with wood,** which is transformed into heat or biofuel. Wood energy consumption thus reached 132 TWh in 2021, of which 60% for the residential stock, 22% for energy and 13% for industry [(1)].

This sector has been very successful, reinforced since the development of pellet stoves: about 400,000 wood-burning appliances are sold each year for residential housing (mainly stoves)[(2)].

However, this sector has limitations: not only is global warming harming the forest[(3)], but there is now a **real risk of competition between all the energy uses of wood envisaged,** given the development of the sectors concerned (residential and transport in particular)[(4)].

### *b. Increasing exploitation of geothermal potential*

Geothermal energy can be drawn from small or medium depths. **Medium-depth – or medium-temperature – geothermal energy**, which pumps less hot water to a depth of about a thousand meters to supply heating networks. This process is being developed in the Paris Basin, where 500,000 to 600,000 homes benefit from it, and which represents the world's largest geothermal district heating hub.

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*(1) SDES, ibid.*

*(2) Observ'ER, data 2003-2021 , metropolitan France.*

*(3) According to Jancovici, provided climate stabilised — that is, if warming stopped — 10 % of French forests would still die. In a world warming by two degrees, we are closer to 40 or 50% of current species, according to simulations carried out with all the reserves we can have.*

*(4) SDES, Key Figures on Renewable Energy - 2022 Edition.*

The potential lies in the 800 to 900 existing district heating networks, only a small part of which works thanks to geothermal energy; the others are gas-powered.

**Geothermal energy of very close surface** is based, on the other hand, on a heat exchanger. The Bureau de recherches géologiques et minières (BRGM) and IFP-EN indicated during their hearings that the development of this technology on a larger scale will not be possible without the emergence of an industrial sector, but there are significant obstacles to this. The drilling profession, in particular, is experiencing significant tension and requires expertise that is not guaranteed today.

The BRGM also stresses, in its work and in the hearing, that once drilling has been carried out, it is possible to draw different uses from it. For example, water pumped underground may contain lithium to be recovered.

***c. Other modes of heat production***

Another renewable heat technique is **solar water heaters**, which have been promoted in overseas territories where this technology makes sense. According to the SDES, in 2021, production primary solar thermal represents 0.7% of renewable energy production in France. It produces 2.4 TWh and is mainly developed in the overseas departments and regions (notably Reunion).

Finally, there are **heat pumps**, which exploit the transfer of energy between the environment and the interior of a home or factory, with a very advantageous thermodynamic efficiency since for one kilowatt hour of electricity injected into the machine, several kilowatt hours of heat are transferred between the outside and inside of a home.

With the installation of heat pumps receiving significant financial support, their contribution is beginning to become visible in the residential sector. But their heat production needs electricity to be implemented, which minimises their balance.

**Cogeneration** is also a heat production technique. It consists in producing in the same installation and from the same primary energy (gas, waste, oil, etc.) thermal energy and mechanical energy; by extension it refers to the fact of recovering the waste heat, generally released into the environment, from the production of mechanical energy – electrical the most often – to use it for thermal demand (heating, domestic hot water, sanitary process, etc.). It thus increases the efficiency of the installation, but the profitability of this solution presupposes, in particular, to be as close as possible to the places of consumption due to losses during heat transport. The France would have 860 cogeneration plants.

Given the size of the French nuclear fleet, the use of the significant waste heat produced by nuclear fission is an avenue that deserves to be studied and the rapporteur regrets that he did not have the material time to examine it.

## D. ALMOST ENTIRELY CARBON-FREE ELECTRICITY PRODUCTION, WHICH WILL HAVE TO GROW MASSIVELY, STILL MAINLY PROVIDED TODAY BY NUCLEAR AND HYDROPOWER

### 1. Electricity consumption in France, which concerns many uses and is expected to grow, is currently covered by domestic and carbon-free production.

#### *a. Electrification of final energy consumption*

According to the energy balance established by the SDES for 2021, the final electricity consumption of France amounted to 434,3 TWh, or 24,4 % of the total final consumption of France[(1)] and the net production rose to 532 TWh[(2)]. Our country was able to export 42 TWh[(3)].

Electricity is the energy used by many sectors in France for domestic, industrial or utility needs (lighting and heating, household appliances, industry, transportation).

It is **consumed** primarily by the **residential sector** (39% of final electricity consumption in 2021), **the tertiary sector** (31%) and **industry** (26 %)[(4)]. Although electricity still accounts for just over a quarter of final energy consumption in France[(5)], it is the **leading energy item in the tertiary sector** (133.7 TWh or 50.8% of the sector's consumption in 2021[(6)]), **industrial** (113 TWh or 39% in 2021) and **residential** (170 TWh or 34 % in 2021).

With 492 TWh of electricity consumed in 2021, the **residential sector** ranks first among the sectors that **consume the most electricity.** The items that consume the most electricity concern heating, domestic hot water and specific needs (household appliances, etc.).

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(1) *SDES, Key Energy Figures - 2022 edition, November 2022, p. 80.*

(2) *SDES, Key Energy Figures - 2022 edition, November 2022, p. 80.*

(3) *SDES, Key Energy Figures - 2022 edition, November 2022, p. 33.*

(4) *SDES, Key Energy Figures – 2022 edition, p. 70. https://www.statistiques.developpement-durable.gouv.fr/edition-numerique/chiffres-cles-energie-2022/pdf/chiffres-cles-de-lenergie-2022-signets.pdf*

(5) *According to SDES, final electricity consumption in 2021 and France was 434.3TWh out of an overall final energy consumption of 1626.8TWh, or a share of 26.7%. SDES, Key Energy Figures – 2022 edition, p. 80. https://www.statistiques.developpement-durable.gouv.fr/edition- digital/key-figures-energy-2022/pdf/key-figures-of-energy-2022-bookmarks.pdf*

(6) *SDES, Key Energy Figures – 2022 edition, p. 80. https://www.statistiques.developpement-durable.gouv.fr/edition-numerique/chiffres-cles-energie-2022/pdf/chiffres-cles-de-lenergie-2022-signets.pdf*

Electricity accounts for more than half of the energy consumption of the tertiary sector, which has remained **relatively stable in value** since the 2010s, while the **sector's** energy consumption is gradually declining, with the help of energy sobriety and efficiency measures. The electricity consumption of the sector results mainly from the electrical needs of heating and air conditioning(1). Since 2017, electricity consumption related to heating has been steadily decreasing, while that dedicated to air conditioning has risen sharply – it has doubled across the entire residential stock between 2016 and 2020(2).

In addition, it accounts for a significant share of **intermediate consumption** – i.e. electricity consumed during the production process – of certain industrial branches, notably metallurgy, the agri-food industry and chemicals.

Particularly energy-intensive, the **metallurgy and metal products** branch is responsible for **23.6%** of the electricity consumed by the industrial sector, or 26.3% of the total energy **consumed by** the branch(3), dedicated to primary processing, foundry and Constructions (mechanical, electrical, electronic, naval, aeronautical and armaments). The **agri-food industry** sector ranks second among the industrial branches that consume the most electricity (18.2% of the sector's consumption in 2021, i.e. more than a third(4) of the energy consumed by the industry), especially for food processing and processing, storage and preservation, but also process automation. Finally, the **chemical branch** comes in third place by representing **20% of the total electricity consumption of the industrial sector**, an energy that it uses for the operation of these tools (motors, pumps, compressors) and as raw material necessary for the production of chlorine or the reduction of certain metals(5).

The **industrial sector tends to structurally reduce its** energy consumption by improving processes (energy efficiency), reducing consumption (sobriety) and electrifying processes, while maintaining relatively stable electricity consumption(6) In other words, while the **share of electricity** in the energy **consumption of the sector is increasing,** the fact remains **that it remains stable in value**. The

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*(1) SDES,Energy consumption by tertiary use,24 December 2021. https://www.statistiques.developpement-durable.gouv.fr/consommation-denergie-par-usage-du-tertiaire*

*(2) SDES,Energy consumption by residential use,24 December2021, https://www.statistiques.developpement-durable.gouv.fr/consommation-denergie-par-usage-du-residentiel*

*(3) INSEE,Energy consumption in industry,1 December 2021. https://www.insee.fr/fr/statistiques/5758772?sommaire=5759063*

*(4) According to INSEE, in 2021, the electricity consumption of the agri-food industry branch represents 34.6% of the sector's energy consumption. INSEE, Energy consumption in industry, 1 December 2021. https://www.insee.fr/fr/statistiques/5758772?sommaire=5759063*

*(5) France Chemistry, Energy, https://www.francechimie.fr/positions-expertises/energie-logistique/energie.*

*(6) SDES, Key Energy Figures – 2022 Edition, p. 35. https://www.statistiques.developpement-durable.gouv.fr/edition-numerique/chiffres-cles-energie-2022/pdf/chiffres-cles-de-lenergie-2022-signets.pdf*

Recent economic conditions, and in particular the increase in energy prices and in particular electricity, is certainly at the origin of a reduction in electricity consumption in the sector, but it cannot, for the moment, reflect a long-term dynamic.

### *b. This consumption is expected to grow massively in the coming years*

The need to rapidly decarbonise our energy model, coupled with the desire shown by successive governments to strengthen the country's industrial apparatus, and therefore its energy consumption, leads us to anticipate a significant increase in electricity demand.

Faced with uncertainties about the extent of this increase, and at the request of the Government, the electricity transmission system operator, RTE, has developed several electricity consumption trajectories, which integrate the different scenarios of energy efficiency, reindustrialisation, electrification of uses.

In its so-called "reference" trajectory of its *Futur énergétique 2050* study, RTE anticipates, by 2050, consumption of around 645 TWh, an increase of nearly 150 TWh compared to current consumption. But the scenarios, plausible and desirable at the national level – and moreover consistent with the first prospective exercises of the 2010s (*cf.* Chapter 2, II) – of a reindustrialisation and/or electrification of uses lead to much higher expectations, up to 750 TWh – insofar as the ambitious energy efficiency objectives are also met.

**Figure 24: Scenarios studied by RTE in the *Energy Futures 2050* report**

## LES TRAJECTOIRES DE CONSOMMATION
## À L'HORIZON 2050

Consommation finale d'électricité par secteur : Industrie, Résidentiel, Tertiaire, Transport, Hydrogène

### SCÉNARIOS

| | HYPOTHÈSES | NIVEAU 2050 | PRINCIPALES ÉVOLUTIONS |
|---|---|---|---|
| Référence | Électrification progressive (en substitution aux énergies fossiles) et ambition forte sur l'efficacité énergétique (hypothèse SNBC). Hypothèse de poursuite de la croissance économique (+1,3% à partir de 2030) et démographique (scénario fécondité basse de l'INSEE). La trajectoire de référence suppose un bon degré d'efficacité des politiques publiques et des plans (relance, hydrogène, industrie). L'industrie manufacturière croît et sa part dans le PIB cesse de se contracter. Prise en compte de la rénovation des bâtiments mais aussi de l'effet rebond associé. | 645 TWh | 180 TWh<br>134 TWh<br>113 TWh<br>99 TWh<br>50 TWh |

| | HYPOTHÈSES | NIVEAU 2050 (par rapport à la référence) | PRINCIPALES ÉVOLUTIONS (± écart par rapport à la référence) |
|---|---|---|---|
| Sobriété | Les habitudes de vie évoluent dans le sens d'une plus grande sobriété des usages et des consommations (moins de déplacements individuels au profit des mobilités douces et des transports en commun, moindre consommation de biens manufacturés, économie du partage, baisse de la température de consigne de chauffage, recours à davantage de télétravail, sobriété numérique, etc.), occasionnant une diminution générale des besoins énergétiques, et donc également électriques. | 555 TWh (-90 TWh) | 160 TWh (-20 TWh)<br>111 TWh (-23 TWh)<br>95 TWh (-18 TWh)<br>77 TWh (-22 TWh)<br>47 TWh (-3 TWh) |
| Réindustrialisation profonde | Sans revenir à son niveau du début des années 1990, la part de l'industrie manufacturière dans le PIB s'infléchit de manière forte pour atteindre 12-13% en 2050. Le scénario modélise un investissement dans les secteurs technologiques de pointe et stratégiques, ainsi que la prise en compte de relocalisations de productions fortement émettrices à l'étranger dans l'optique de réduire l'empreinte carbone de la consommation française. | 752 TWh (+107 TWh) | 239 TWh (+59 TWh)<br>134 TWh (0 TWh)<br>115 TWh (+2 TWh)<br>99 TWh (0 TWh)<br>87 TWh (+37 TWh) |

### VARIANTES

| | HYPOTHÈSES | NIVEAU 2050 (par rapport à la référence) | PRINCIPALES ÉVOLUTIONS (± écart par rapport à la référence) |
|---|---|---|---|
| Électrification + | La part de l'électricité dans la consommation finale s'accroît de manière plus forte que dans la SNBC. Certains usages basculent plus rapidement ou fortement vers l'électricité. C'est particulièrement le cas dans le secteur des transports, dans lequel l'adoption du véhicule électrique et l'électrification de certaines catégories de poids lourds est beaucoup plus rapide. Le transfert vers le chauffage électrique se fait également plus rapidement et de manière plus volontariste. | 700 TWh (+55 TWh) | 192 TWh (+12 TWh)<br>139 TWh (+5 TWh)<br>120 TWh (+7 TWh)<br>125 TWh (+27 TWh)<br>50 TWh (0 TWh) |
| Moindre électrification | La part de l'électricité dans la consommation finale augmente de manière moins forte et moins rapide que dans la SNBC. Dans l'industrie, par exemple, l'électricité ne parvient pas à être compétitive et la bascule vers l'électrification se fait moins rapidement. Il en est de même pour le transfert vers la mobilité électrique (véhicules légers et lourds) et vers les dispositifs de chauffage électrique dans les secteurs résidentiel et tertiaire. | 578 TWh (-67 TWh) | 150 TWh (-30 TWh)<br>126 TWh (-8 TWh)<br>107 TWh (-6 TWh)<br>81 TWh (-18 TWh)<br>50 TWh (0 TWh) |
| Efficacité énergétique réduite | Les hypothèses de progrès de l'efficacité énergétique des équipements électriques généralement retenues ne se matérialisent pas, ou s'accompagnent de phénomènes de surconsommation au-delà de ce qui est prévu dans la trajectoire de référence. Dans le secteur du bâtiment, les objectifs de rénovation et la conversion aux pompes à chaleur ne sont pas atteints, et le taux d'atteinte des gisements d'efficacité énergétique ne dépasse pas 50% en 2050 (contre 70% dans la trajectoire de référence). | 714 TWh (+69 TWh) | 191 TWh (+11 TWh)<br>156 TWh (+22 TWh)<br>135 TWh (+22 TWh)<br>105 TWh (+6 TWh)<br>50 TWh (0 TWh) |
| Hydrogène + | Le développement de la production d'hydrogène décarboné connaît une forte accélération conduisant à une demande finale d'hydrogène nettement plus élevée que dans la trajectoire de référence. L'hydrogène se substitue à l'électrification directe dans certains secteurs difficiles à électrifier (sidérurgie...) ainsi qu'à l'utilisation de biomasse (transport lourd, chaleur industrielle). | 754 TWh (+109 TWh) | 164 TWh (-16 TWh)<br>134 TWh (0 TWh)<br>113 TWh (0 TWh)<br>93 TWh (-6 TWh)<br>171 TWh (+121 TWh) |

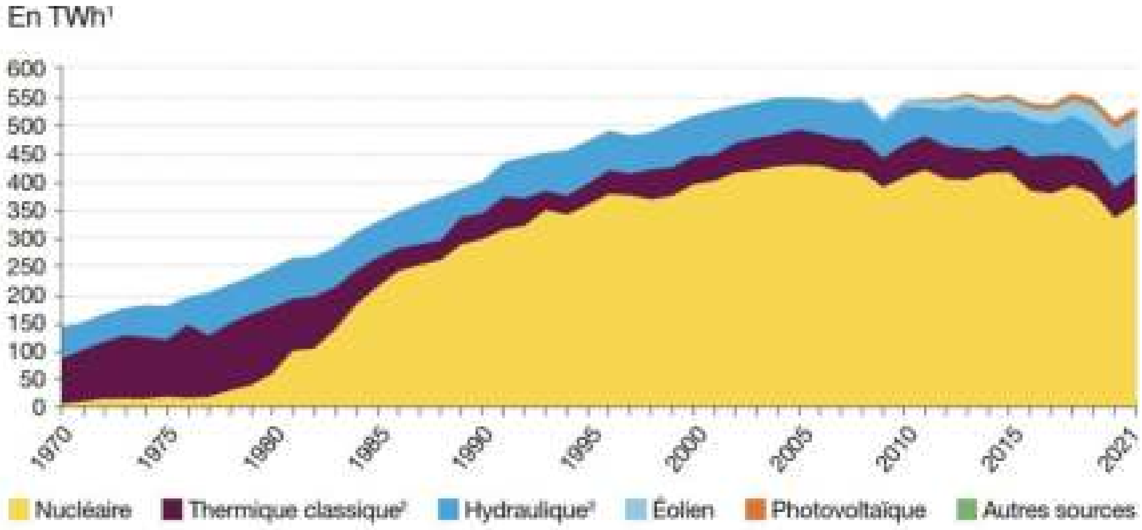
*Source : RTE, Energy Futures 2050.*

### c. *Domestic and carbon-free production, which until now covered consumption*

Unlike the overall French energy mix, since 2011, **gross electricity production** in France – i.e. production measured at the terminals of power plants, including consumption of ancillary services and losses in transformers(1) – **has always covered consumption interior electricity.**

According to the SDES, in 2021, total electricity production amounted to 532 TWh for a final consumption of 422 TWh(2).

**Figure 25: Net Electricity Production by Stream**




¹ TWh = 1 milliard de kWh.
² Thermique à combustibles fossiles (charbon, fioul, gaz naturel), biomasse ou déchets.
³ Y compris énergie marémotrice.
Champ : jusqu'à l'année 2010 incluse, le périmètre géographique est la France métropolitaine. À partir de 2011, il inclut en outre les cinq DROM.

*Source:* SDES *provisional energy balance 2021 transmitted by the SDES.*

**This production of electricity in France contributes greatly to our sovereignty.**

At the end of 2022, installed capacity represented 140.2 GW, consisting of 61.4 GW of nuclear facilities, 17.1 GW of fossil fuel thermal units (12.8 GW for gas, 2.5 GW for fuel oil, 1.8 GW for coal) and **61 GW of renewable electricity generation capacity** (25.7 GW for hydro, 19.8 GW for onshore wind and maritime, 13.3 GW for solar and 2.2 GW for generation from renewable thermal power plants and waste).

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*(1) Definition of SDES, https://www.statistiques.developpement-durable.gouv.fr/edition-numerique/chiffres-cles-energies-renewables-2021 /22-definitions-and-methods*

*(2) SDES, Key Energy Data – 2022 edition, p. 80. https://www.statistiques.developpement-durable.gouv.fr/edition-numerique/chiffres-cles-energie-2022/pdf/chiffres-cles-de-lenergie-2022-signets.pdf*

It should be noted that **installed** capacity refers to the maximum power that can be generated by a die if it is operating at full capacity. It **does not reflect actual production**, which varies according to different parameters such as the level of needs, maintenance operations, precipitation for hydroelectricity, wind intensity for wind or sunshine for photovoltaics. Nevertheless, the increase in this power leads to an increase in production.

Thus, in 2021, the 532 TWh produced were composed of 361 TWh of nuclear electricity, 56 TWh of conventional thermal production (gas, coal, petroleum products, etc.) and the rest of renewable electricity[(1)]. If the latter use foreign fuels, the "green" electricity comes from local sources; finally, nuclear production can be considered domestic insofar as the imports of uranium necessary for its process are negligible in its production costs – according to Jean-Marc Jancovici, it represents less than one euro per MWh of electricity produced[(2)].

On the other hand, even if there is a quasi-equivalence between fossil production and the volume of exports, **this fossil share** could not have been more easily reduced because it **corresponds to the adjustment of national supply to demand** in periods of foreseeable tension – European interconnections ensuring very short-term adjustments. Indeed, **these means of production can be started or stopped very quickly** according to needs. While petroleum products and coal predominated in conventional thermal power plants in the 1970s, gas now represents the most frequent use (61.5% in 2019).

More generally, this quasi- "autonomy " of French electricity production is the result of a rapid and **strong development of nuclear production capacity in response to the oil shocks of the 1970s**, prolonged by an **acceleration in the deployment of renewable energies from 2005** (Figure 25: net electricity production by sector).

The deployment of nuclear power plants and renewable energies has not only enabled France to ensure all of its electricity consumption but also to ensure part of the consumption of its neighbours: France was a net exporter from 1980 to 2021**.**

In 2022, RTE recorded the **first French net importer of electricity**. It states that the balance of trade has been importing 70% of the time but that **France has been dependent on these imports to ensure its security of supply** "***only a small part of the time***"[(3)].

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*(1) SDES, Key Energy Data – 2022 edition, p. 80. https://www.statistiques.developpement-durable.gouv.fr/edition-numerique/chiffres-cles-energie-2022/pdf/chiffres-cles-de-lenergie-2022-signets.pdf*

*(2) Hearing of Mr Jean-Marc Jancovici, professor at Mines Paris, November 2, 2022.*

*(3) RTE, Bilan électrique 2022 – Main results, p. 17. https://assets.rte-france.com/prod/public/2023- 02/Bilan-electrique-2022-synthese.pdf*

While **France's strong electricity production capacity contributes to national energy sovereignty, it has weakened, despite new capacity installed in renewable sectors. This is due to the decline in nuclear production**, **which can be seen since 2006,** and which the increase in renewable sources has not been sufficient to compensate.

| *In TWh (or Mtoe)* | **2005** | **2008** | **2010** | **2012** | **2014** | **2017** | **2019** | **2021** |
|---|---|---|---|---|---|---|---|---|
| (a) Nuclear electricity | 452 (117,7) | 439 (114,5) | 429 (111,7) | nc (110.9) | 436 (113,7) | 379,1 (103,8) | 379,5 (103,85) | 361 Nc |
| (b) Renewable electricity | 58 (5) | 75 (6,4) | 78 (6,7) | nc (7.1) | nc (7.8) | nc (7.1) | nc (8.95) | Nc |
| Differential (a+b) | – | + 4 | – 7 | (– 0.4) | (+3,5) | (– 1.6) | (+1,9) | Nc |
| **Gross electricity** generation (including conventional thermal) | **576 (122,7)** | **575 (120,9)** | **569 (118,4)** | **nc (117.9)** | **nc (121.6)** | **530,4 (132)** | **547** Nc | **532** Nc |

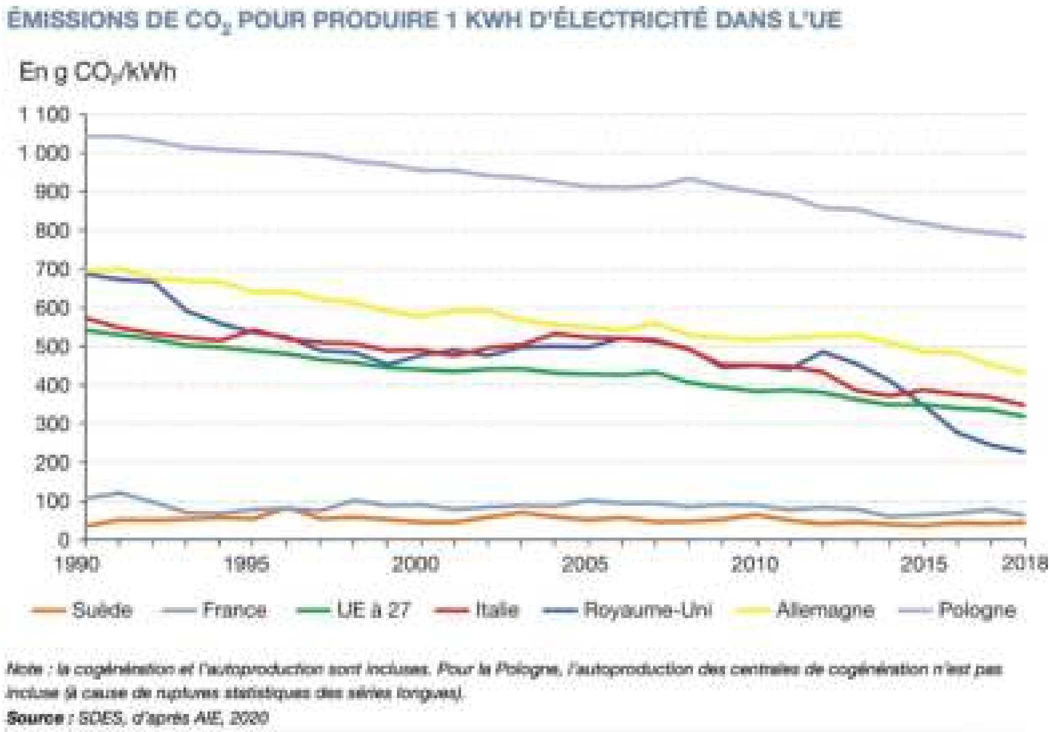
*Source: data from SDES energy balances*.

Our electricity *mix* is, in any case, largely decarbonised. According to data published by RTE for 2021[(1)], **91.4% of electricity production is carbon-free**[(2)] – i.e. from renewable or nuclear sources.

**This decarbonisation distinguishes France in Europe**: **the country emits nearly 3 times less $CO_2$ to produce 1 kWh than in the United Kingdom, 4 times less than in Italy and 5 times less than in Germany, which has one of the most carbon-intensive electricity mixes in Europe.**

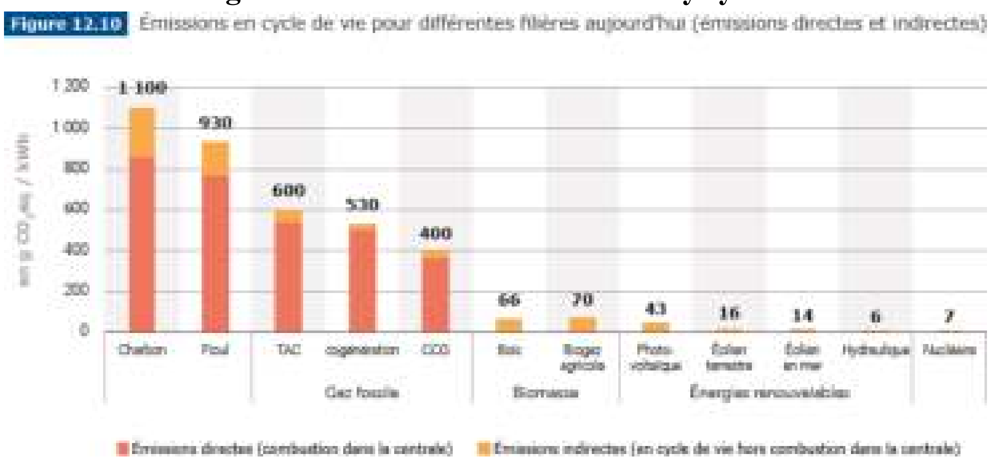
*(1) RTE's electricity production data shows a difference of 10TWh over 2021 compared to those transmitted by the SDES.*

*(2) RTE, Bilan électrique 2022, p. 7. https://assets.rte-france.com/prod/public/2023-02/Bilan-electrique-2022-synthesis.pdf*




**This virtuous balance sheet is due to the place taken by the nuclear and renewable sectors,** given the carbon impact, emission and life cycle, of fossil fuels – but also, to a lesser extent, of certain renewable electric energies.

**Figure 26: Emissions from electricity systems**




*Source : RTE.*

While most of the progress in terms of GHG emissions has been achieved as new nuclear capacity is commissioned, SDES data confirm their continuation: -2.2% per year between 2006 and 2019.

## 2. Nuclear power, a pillar of our production and electricity sovereignty

**Figure 27: Overview of the French nuclear industry**

| Summary table : French nuclear fleet | |
|---|---|
| **Installed capacity** | 61.4 GW |
| **Average production over the period 2006-2021** | 404 TWh / year |
| **Production 2022** | 360.7 TWh |
| **Park** | 56 nuclear reactors for an average capacity available in 2022 of 34.8 GW[1] (54%) |
| **Cost** | Between 42 and 62 €/MWh [2] |
| **$CO_2$ emissions** | 6g$CO_2$ kWh [3] |
| **Number of employees** | More than 220,000 jobs and 3,000 businesses |

### *a. The many advantages of the current nuclear industry: energy density, controllability, material savings, controlled full cost*

French civil nuclear power occupies a special place because of its weight in the world and in our country. The France is the **world's third largest producer of nuclear energy and the largest producer in Europe**[4]. Of the 126 reactors in the European Union, 56 are French.

Since the closure of the two Fessenheim reactors in June 2020, the civil nuclear fleet has only **56 reactors in operation,** all of which are pressurised water reactors (*cf.* annex), organised into 18 national power plants and representing an installed capacity of 61.4 GW, divided between **32** reactors of 900 MW, **20 reactors of 1 300 MW and 4** 1,450 MW. While domestic production has declined since its peak in 2005 (*cf.* II-A-2), it still represents **more than 69% of French electricity production** (except for 2022), while in Europe, its share is around 25% (down by more than 25% since 2006) and 10% globally (up from 17% in 1996).

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*(1) RTE, Bilan électrique 2022. https://assets.rte-france.com/prod/public/2023-02/Bilan-electrique-2022-synthesis.pdf*

*(2) Court of Auditors, The analysis of the costs of the electricity production system in France, 13 December 2021. https://www.ccomptes.fr/fr/publications/lanalyse-des-couts-du-systeme-electrique-en-france*

*(3) EDF has made a contribution to update the emission factor for nuclear to 4g/kWh. This contribution was presented by EDF to the carbon base governance committee on 13/12/2022. This contribution is currently under investigation, ADEME having received EDF's answers to the questions asked in March 2023. For electricity production, the data are derived from life cycle assessments, and therefore include emissions related to the manufacture of the means of production, as well as those related to their use and end-of-life. The calculation is related to the kWh produced by considering an average load rate representative of the French context. Based on data provided by ADEME to the rapporteur.*

*(4) Half of the EU countries use this kind of energy. 14 European countries have no nuclear production capacity (Italy and Poland in particular).*

This situation is the result of a **proactive policy**, first of all on the part of post-war governments which, in addition to military concerns in a Cold War context, noted that France did not have many raw materials – practically no gas and little coal compared to its neighbours – and that it was, therefore, dependent on its energy imports, then in reaction to the oil shocks of the 1970s. This strategy has contributed to the development of most of the **current civil nuclear fleet but also to the creation of a complete French industrial sector** – which today brings together 220,000 employees in France, distributed in about 3,200 companies, 80% of which are VSE-SMEs.

**Box 12: The constitution of the nuclear industry**

**1945-1970**

In 1945, Charles De Gaulle, convinced of the need to create an organisation devoted to nuclear energy, signed the ordinance of 18 October 1945 and created the CEA to supply the future nuclear program. Law Issue 46-628 of 8 April 1946 on the nationalisation of electricity and gas created the public establishment Électricité de France (EDF) acting, among other things, a quasi-monopoly on national electricity production.

The first five-year plan forum atomic energy of July 1952 set France one the path of industrial achievements in nuclear power generation.

While the country does not have sufficient uranium enrichment facilities, the **Natural Uranium Graphite Gas** (**UNGG** (1)) **sector** is preferred. The accessibility of raw materials, including the fact that it does not require fuel enriched in Uranium-235, ensures the energy independence of the technology. The first reactors of the first generation were built at Marcoule (30) in 1955-1956. At the same time, to control the entire nuclear cycle, a first isotopic separation plant to obtain enriched uranium for armaments and naval propulsion, was created in Pierrelatte in 1958.

Before 1971, six reactors with UNGG technology, operated by EDF, were commissioned in Chinon, Saint Laurent Les Eaux and Bugey. At the initiative of EDF, a first **pressurised water reactor (PWR)**, a technology of American origin that uses enriched uranium(2), Made STIs beginning in Chooz in 1967. This was the beginning of **second generation reactors**.

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(1) ***The principle of nuclear energy** generation is based on the splitting of a natural fissile radioactive element into two fragments which, by emitting two to three electrons, can fission other atoms. A **chain reaction** ensued. In the process part of the atomic masses is transformed into energy, mainly heat. This heats a heat transfer fluid which, by producing steam, turns turbines that produce electricity. The quantity of neutrons emitted by the fission of uranium, called fast neutrons, must be controlled, by the "control rods", and slowed down in order to have the right energy to maintain the chain reaction. This is the moderator's goal: neutrons are slowed down when they pass through a material that does not absorb them. **In a UNGG reactor**, it is graphite blocks surrounding the fuel (uranium) that intervene. The chain reaction is used to heat carbon dioxide (CO2) in the reactor core. This gas is the coolant.*

(2) ***In a pressurised water reactor**, neutrons are slowed down by liquid water, which allows a greater probability of fission when they encounter a uranium-235 or Plutonium-239 (fissile isotopes of uranium and plutonium). But for the chain reaction to continue, it is necessary to increase the amount of fissile nuclei per unit volume of natural uranium, i.e. to "enrich" uranium. Water also serves as a coolant.*

For its part, the CEA continues to develop other technologies such as **"fast neutrons**", which show the advantage of using plutonium from UNGG plants and producing more plutonium than it consumes (breeder reactor). The first experimental reactor, RAPSODIE, was commissioned in 1967.Before 1969, the presidential veto was categorical: national independence took precedence over economic profitability. The UNGG stream is maintained. After the election of President Georges Pompidou, the choice is decided, the American sector wins because of its lower cost, its ease of construction, loading and unloading.

**1973-1982**

The first oil shock of 1973, caused by the embargo of the Organisation of Arab Petroleum Exporting Countries (OAPEC) against Western Europe marks a real take-off of PWR technology in France. In the electricity sector, the PEON Commission (Programming of Electricity of Nuclear Origin) proposed in April 1973 a nuclear target of 13,000 MW to be commissioned over the period 1978-1982. The Messmer Plan in 1974 made the **choice** of **all nuclear** to limit dependence on oil and ensure "the energy independence *of the country*". The objectives are the standardisation of nuclear technology on French territory as well as the construction of a nuclear fleet to benefit from the "*series effect*" (same technical references, codes and standards for the design) and thus optimise costs. The technology comes from the American company Westinghouse, but Framatome will be the only manufacturer. It will remain the sole supplier of PWR reactors in France. Framatome is carrying out the series construction of two types of PWR reactors: 900 MW and then 1,300 MW, of which EDF orders an average of 5 reactors per year. This is **the third generation of reactors.**

**1983-2002**

This was followed by a period of slowdown in orders since 1983 (two, then a 1,400 MW reactor every three years between 1984 and 1992). The need to curb the development of the power plant fleet takes into account the expected slowdown in the growth of consumption, and the fact that over-equipment in nuclear energy can be a source of costly waste (*cf.* the preparatory work of the IXth Plan). The slowdown in orders also marks the transition to a **new generation of reactors (N4) of** 1,450 MW. The last PWR-type nuclear power plant to be commissioned was the Civaux nuclear power plant, launched in 1997 and 1999 and commercially operated from 2002.

The French nuclear fleet has thus brought together up to 60 power generation reactors in operation, with a total capacity exceeding 63 GW. In parallel with these achievements, the French manufacturer (CEA-EDF-Framatome) asserted itself as a serious export competitor by obtaining between 1975 and 1995 40 % of orders on the world market. Moreover, because uranium enrichment and reprocessing are important aspects of French development, the major fuel cycle infrastructures are installed by Cogema, created in 1976 – which will be integrated into TOPCO, which became Areva in 2006, taking the name of Areva NC.

The CEA, for its part, is working in particular on future solutions for waste management and controlled fusion. As an extension of the Rapsodie project, **Superphénix** was designed and reached the industrial stage in 1985 under the **"Fast Neutron Reactor" (RNR**) technology – the evolution of this track will be studied more precisely in the second part of this report.[(1)]

(1) ***In a fast neutron reactor****, there is no need for a moderator to avoid slowing down the neutrons in order to fission more nuclei. Water is also given up as a coolant; necessary to transport the heat which, transformed into steam, feeds the generator turbine, this role is provided by liquid sodium (in the case of Superphénix).*

The nuclear industry has **important advantages.** If we cannot speak of energy independence strictly speaking – in the current state of technology – and, unlike fossil fuels, the **energy density** of nuclear fuel makes it possible to store "*years of operation*" of uranium according to Jean-Marc Jancovici[(1)]. For comparison, when 1 kg of natural uranium provides 100,000 kWh of heat, 1 kg of coal provides 8 kWh[(2)].

In addition, this technology produces **non-intermittent and controllable electricity**, unlike energy produced from natural flows. It can provide electricity continuously throughout the year but also adapt production to variations in demand from one season to another, or during the day.

Unlike nuclear reactors in other countries, French nuclear power plants were **designed to operate in a flexible regime**, i.e. at a level of power that is not constant. This flexibility makes it possible to balance the frequency of the network, to ensure the balance between electricity supply and demand (absorption of the increase in renewable energy production for example) and to optimise production over the year[(3)].

*(1) "We are not dependent in the same way (...) compared to hydrocarbons," observes Mr. Jean-Marc Jancovici. "The France has three months' stock of hydrocarbons. When it comes to uranium, we can store years of operation on the ground, which gives a little more time to adapt if we have a problem with a supplier. By switching from hydrocarbons to nuclear, which is the decision taken in electricity production in the 1970s, we cannot say that we have gained independence stricto sensu but we have gained in comfort and share of added value realized on French soil", Hearing of Mr Jean-Marc Jancovici, 2 November 2022.*

*(2) ECA,Energy Dossier,*

*https:// www.cea.fr/comprendre/Pages/energies/energie.aspx?Type=Chapitre&numero=3*

*(3) Based on the replies provided by Mr. Cédric Lewandowski to the questionnaire sent by your rapporteur.*

**Box 13: The controllability of nuclear reactors**

Production is adjusted for consumption over **different temporalities** (daily and seasonal consumption) and great variability in electricity demand can be observed between day and night, winter and summer as well as working days and weekends. The nuclear fleet is flexible on its scale. French nuclear power plants have been designed to operate in a flexible regime, i.e. at a level of power that is not constant. To meet the variation in electricity demand, the nuclear fleet adapts its production level using load **monitoring.**

The **power of a nuclear reactor is controlled by adjusting the amount of nuclear fuel** in the reactor core and changing the **amount/flow rate of water** used to cool the core. This can also be done by using "control rods" boron rods that regulate the neutron population by absorbing them to keep the reactor power at the desired level. These rods are mobile in the reactor core: they can be introduced or extracted depending on the number of neutrons to be absorbed. They thus make it possible to control the reactor(1).

Variable load **schedules are predefined** and allow to reduce or increase the power delivered. These programs **are agreed in advance with the network operator and allow for initial balancing**. **Large variations in rated power are possible(2)**. For example, a 1,300 MW reactor can increase or decrease its output by 900 MW in 30 minutes.

Electricity consumption cannot be determined in advance with exact precision: **nuclear power plants must immediately adapt their production** to maintain the stability of the grid frequency (50 Hz**). Two mechanisms** are **in place** to **readjust frequency fluctuations**, which are activated according to network demand(3):

– **the primary frequency setting**, which allows the power to be modulated by the order of ± 2% of the rated power with an adjustment to the electricity demand every 2 to 30 seconds;

– the **secondary** frequency setting, which allows the power to be modulated by the order of ± 5% of the rated power in addition to the primary frequency setting. This adjustment takes anywhere from a few seconds to several minutes.

This controllability has limitations: **the capacity to vary power in 30 seconds is lower** for **nuclear** (up to 5%) than for gas-fired (5-10%) and coal-fired (20-30%) thermal power plant(4). And **the restart time is also longer, between** two hours and **two days** (compared to 1-10 **hours** for coal-fired power plants and 10-20 minutes for gas-fired plants) on French territory).

However, this flexibility reduces the productivity of plants compared to those that operate on base (i.e. continuously) and leads to **premature wear of the plants**. **EDF thus states that variations in the power delivered result in variations** in the temperature of certain parts of the primary circuit affecting in particular the secondary circuit(5).

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*(1) CEA,The operation of a nuclear generator reactor,29 January 2015. https:/ /www.cea.fr/comprendre/Pages/energies/nucleaire/essentiel-sur-fonctionnement-reacteur-nucleaire-electrogene.aspx*

*(2) EDF. 50 climate solutions. November 2015*

*(3) Nuclear Energy Agency. Load monitoring in nuclear power plants. 2011*

*(4) Ibid.*

*(5) Based on the replies provided by Mr. Cédric Lewandowski to the questionnaire sent by your rapporteur.*

In 2018, the International Atomic Energy Agency (IAEA) published a study on the flexibility of nuclear power plants[(1)] and specifies its potential consequences on facilities:

– **The large variations in temperature lead to fatigue of the metallic materials which reduces the** margins of the cyclic loads taken during the design of the installations – in other words, each modification of the activity of a plant[(2)] (stopping, restart, variations in power) leads to temperature variations experienced by the metallic materials which reduces their mechanical strength and can lead, eventually, to the appearance of failures. The recurrence of these variations is anticipated during the design of a power plant but, the more numerous they are, the faster the wear of the systems will be[(3)];

– **variations in flow rates, especially local, increase corrosion and erosion** – in the fluid system of a nuclear power plant, the reduction of flow rates may be necessary for the flexibility of production resulting in increase in erosion / corrosion (flow-accelerated corrosion – CAE)[(4)]. The phenomenon mainly concerns operational systems (valves of the main feed water system, extraction steam pipes, etc.);

– **Variability in the use of active components increases their wear** – the mechanisms used (control valves, pumps)[(5)] – the cooling conditions of the reactor can affect the safety limits of the fuel in PWRs – these are power density redistributions in the reactor core caused by the rapid movement of the control rods necessary for the flexibility of the plant's energy production[(6)];

**– fluctuations in the physical parameters of the reactor cooling system affect certain components –** variations in pressure, temperature and flow rate increase chemical impurities (aluminum, calcium, magnesium, silica, etc.), which

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*(1) IAEA, Non-baseload operation in nuclear power plants: load following and frequency control modes of flexible operation, 2018, p. 45.*

*(2) The operating temperatures of a nuclear power plant are as follows: water temperature at the reactor vessel inlet 292°C; water temperature at the outlet of the reactor vessel 329°C; average water temperature in the reactor 310°C. IRSN, Nuclear safety elements – pressurised water reactors, part 2 – Safety by design, https://www.irsn.fr/sites/default/files/documents/larecherche/publications-documentation/collection- works-irsn/Element%20sécurité%20REP%20chapter%205.pdf.*

*(3) IAEA, Non-baseload operation in nuclear power plants: load following and frequency control modes of flexible operation, 2018, pp. 50-51, https://www-pub.iaea.org/MTCD/Publications/PDF/P1756_web.pdf; Société française d'énergie nucléaire, Conference: fatigue damage to nuclear installations, 23 November 2000, https://inis.iaea.org/collection/NCLCollectionStore/_Public/32/048/32048976.pdf;*

*(4) Ibid., p. 52, https://www-pub.iaea.org/MTCD/Publications/PDF/P1756_web.pdf*

*(5) Ibid., p. 54, https://www-pub.iaea.org/MTCD/Publications/PDF/P1756_web.pdf*

*(6) Ibid., p. 52, https://www-pub.iaea.org/MTCD/Publications/PDF/P1756_web.pdf*

has already been observed in French nuclear power plants[(1)];

– **continuous operation at low power affects fuel performance**[(2)];

– Overall, the modulation of nuclear production **increases maintenance requirements**.

**The known and anticipated effects of the modularity of the nuclear fleet are subject to safety measures and controls**. Cédric Lewandowski, Executive Director of the EDF Group in charge of the nuclear and thermal fleet management, stresses, however, that the **consequences** of the **modularity of the nuclear fleet "are quite minor"[(3)]** because it is little used. At his hearing, Mr Lewandowski points out that the technical debate on the effects of modularity on the acceleration of ageing of installations concerns the secondary circuit and that **EDF has initiated reflections on this point.**

In addition, the **production of electricity** by the nuclear fleet also has the advantage of being economically attractive. The report on work on new nuclear power (PPE 2019-2028), commissioned by the Government and delivered in February 2022 projecting the production of three pairs of EPR2, show competitive full costs, particularly in a low cost of capital scenario[(4)] (Box 14: Analysis of production costs of the production system French electricity by the Court of Auditors), even though all costs are taken into account (including the impact on the public transport network).

This question of costs is even more sensitive for the existing fleet, the depreciation of which has made it possible to moderate the cost of supply and **to** charge, **on the bulk of final electricity consumption in France, a domestic price not only stable and predictable but also lower than in Western European countries**, whether in regulated tariffs or in offers on the French market, *via* the Regulated Access to Historic Nuclear Electricity (ARENH) system.

For French households, despite taxes representing a third of their bill, the price of electricity in France was 38% lower than the EU average in 2008; the gap was still 17% in 2021 (latest consolidated data from SDES) and more compared to its neighbours – with an average price including VAT of €193/MWh against €260 for Italy, €289 for Spain, €327 for Germany – thanks to the safeguard measures taken by the Government.

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*(1) IAEA, Non-baseload operation in nuclear power plants: load following and frequency control modes of flexible operation, 2018, p. 60, https://www-pub.iaea.org/MTCD/Publications/PDF/P1756_web.pdf*

*(2) IAEA, Non-baseload operation in nuclear power plants: load following and frequency control modes of flexible operation, 2018, p. 59, https://www-pub.iaea.org/MTCD/Publications/PDF/P1756_web.pdf*

*(3) Hearing Mr Cédric Lewandowski, Executive Director of the EDF Group in charge of the nuclear and thermal fleet management, 19 January 2023.*

*(4) Report Work on New Nuclear, PPE 2019-2028, February 2022, p.9.*

For French companies, the average price[1] excluding VAT reached €106 /MWh in 2021. However, it is still well below the prices recorded in other Member States of the European Union (excluding four countries). French companies benefit from prices 21% lower than those charged, on average, in the European Union. Electricity consumed for business purposes is particularly cheaper in France (€106/MWh) than in Spain (€127/MWh), Germany (€168/MWh) and Italy (€174/MWh).[2]

Thanks to the strategic choice to develop nuclear energy, our economy had until now a very competitive – and already low-carbon – electricity.

**Box 14: The Court of Auditors' analysis of the production costs of the French electricity production system**

In a report adopted on 15 September 2021, the Court of Auditors focused on updating the average production costs of the main electricity sectors. The " accounting" approach takes into account, over a given year, depreciation and amortisation and remuneration of the net book value of fixed assets. The economic approach, used to make investment decisions, calculates an average annual cost of investments over the life of the production asset.

According to the latter, the average full cost of the nuclear fleet over the period 2011-2020 hovers around €42/MWh, but in 2019 alone, it stands at €43.80 /MWh. According to the economic method, the values rise to €60 for 2011-2020 and €64.80 for 2019. These results concern only the "historic" park. In another 2020 report, the Court of Auditors estimated that the estimated cost of producing electricity supplied by Flamanville could be between €110 and €120 $_{\text{in 2015}}$/MWh.

On the basis of the data used by ADEME and CRE and the results of their calculations, using different methods, or its own calculations, the Court of Auditors notes the following figures:

– onshore wind: between €50 and €70 2020/MWh;

– *offshore* wind: €98 to €117 $_{2020}$/MWh;

– photovoltaic: costs vary in particular according to the size of the installations, between 61 and €104 in the category large roofs and shades and between €88 and €223 in the residential sector;

– Similarly in hydroelectricity, costs vary between €34 and €150 depending on the size and the possibility or not of extending the operation of the installations.

Finally, the Court of Auditors observes that it is not enough to compare the average costs of each sector but that it is necessary to look at the cost of the electricity system as a whole, taking into account also the cost of the means of storage, flexibility of demand, those of the transmission and distribution network, interconnections, etc.

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*(1) In detail, the more electricity a company consumes, the lower the price per MWh. Electro-intensive companies, especially those exposed to international competition, or companies in certain sectors, large consumers of electricity, benefit from exemption or reduced rate on various taxes as well as on the transmission tariff (known as TURPE).*

*(2) See Ministry of Energy Transition, Data-Lab, Electricity prices in France and in the European Union in 2021, October 2022.*

**Finally, the consumption of fuel and rare materials by nuclear** energy **is particularly low.** As indicated in *d* below, the world's reserves of **uranium** used for nuclear power plant fuel and accessible would provide 130 to 135 years of operation in the current state of the reactors.

In addition, the Observatory for the Safety of Energy Flows and Materials(1) estimates that the three **minerals most consumed by the sector by 2050** will be **zirconium (Zr), whose geological criticality is presented as low** – current reserves would ensure 55 years of consumption at 2021 level –, **boron** – used for the production of control rods, abundant but spatially concentrated(2), its reserves would ensure more than two centuries of consumption at the current rate, and **niobium (N)** – particularly used to respond to the deterioration of the fuel cladding of pressurised water reactors (PWR); relatively rare and whose supply is ensured by a single player (CBMM) and almost exclusively from Brazil (more than 91% of world production in 2019), it would present reserves to ensure a century of current consumption(3).

Finally, the nuclear industry consumes **little of the most threatened metals.** This is the case of copper – from which nearly 90% of known resources would be extracted by 2050, in a 2°C scenario(4) and will be subject to very high tensions from 2027(5) – since its consumption by thermal power plants (nuclear or fossil) is 5 to 10 times lower than by renewable energies(6).

### *b. A cyclical situation that has led to a historically low nuclear production*

**However, nuclear power generation reached a historically low ceiling in 2022, with 279 TWh produced**, resulting from **both repairs and preventive research related to stress corrosion** found in several reactors from the end of **2021**, as well as scheduled stops and ten-year visits(1). This decrease in productibility

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*(1) Observatory of the safety of energy flows and materials, Critical raw materials of the nuclear industry, March 2022, https://www.defense.gouv.fr/sites/default/files/tronc_commun/OSFME_R11_Les%20matières%20premières%20de%20la%20filière%20nuclear.pdf*

*(2) Turkey has almost all estimated borate reserves (87% of the world total) but accounts for only 43% of global production in 2019.*

*(3) Observatory of the safety of energy flows and materials, Critical raw materials of the nuclear industry, March 2022, https://www.defense.gouv.fr/sites/default/files/tronc_commun/OSFME_R11_Les%20matières%20premières%20de%20la%20filière%20nuclear.pdf*

*(4) IFPEN, Metals in the energy transition, https://www.ifpenergiesnouvelles.fr/enjeux-et-prospective/decryptages/climate-environment-and-circular-economy/metals-energy-transition.*

*(5) Hearing of Mr Christophe Poinssot Deputy Director General and Scientific Director of the Bureau de recherche géologique et minière (BRGM), 22 November 2022.*

*(6) According to Olivier Vidal, director of research at the CNRS quoted in SFEN, Copper: nerve of war, November 2, 2021. https://www.sfen.org/rgn/5-9-cuivre-nerf-guerre/*

largely contributed to the negative net result of €17 billion in 2022 and to the increase in EDF's debt from €43 billion to €64 billion, ahead of ARENH (see part 2).

Following new detections of stress corrosion and thermal fatigue, EDF has updated its maintenance and monitoring schedule. Although the energy company is still targeting production of between 300 TWh and 330 TWh in 2023, this level would remain historically low, also due to the accumulation of planned ten-year visits and scheduled shutdowns.

The last few months have generated legitimate concern, since the chain of problems, delays following lockdowns, shutdowns of reactors hit by stress corrosion phenomena, has shown the **narrowness of the margin of adaptation of the fleet in its current state.**

In particular, stress corrosion problems, which were judged by the Nuclear Safety Authority (ASN) last June as "*a serious and unprecedented event whose complete treatment will take several years*" and which were first revealed on recent reactor models, of 1,500 or 1,300 MW, raise **unprecedented questions about the ability of these facilities to operate well sustainably** and the real costs of their upgrade. These questions not only relate to the plants in operation but, in addition to the technical difficulties encountered by the construction of the Flamanville EPR, also feed doubts about the relevance of this technology – at least on the relevance of betting on a single technology whose vulnerabilities, when they appear, may affect the entire series.

Last but not least, the continuation of planned shutdowns and ten-year visits planned for the coming months and years will continue to put pressure on the industrial room for manoeuvre and the availability of the nuclear fleet.


<u>Source :</u> *RTE, Energy Futures 2050.*

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*(1) Seven others remain closed for "modulation", the low consumption of the French does not require their recovery.*

### c. *The challenge of water management anticipated by the sector*

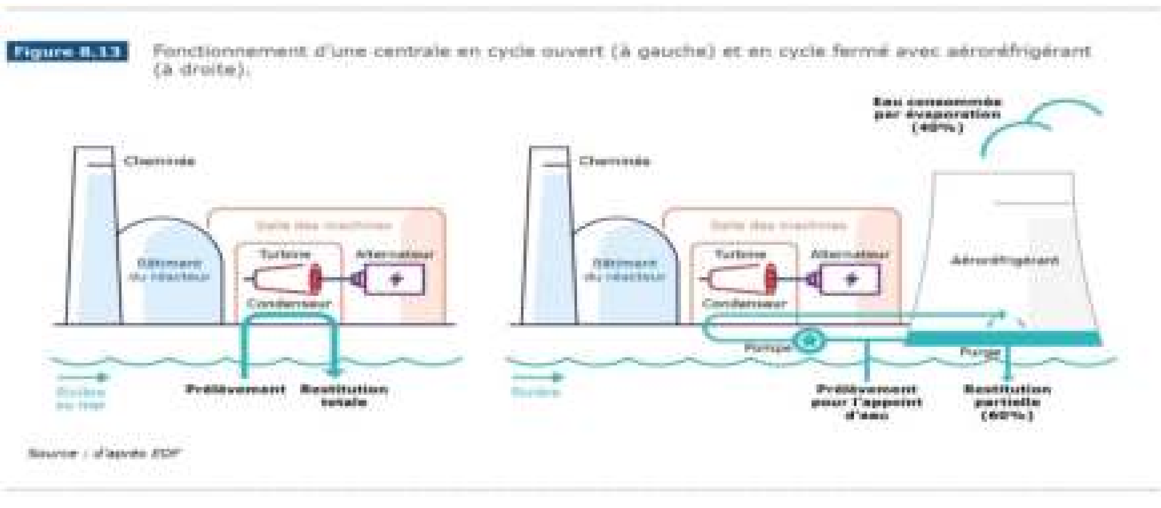
Among the challenges of the coming years for the existing fleet, adaptation to climate change is an important point**. The availability of water resources can affect the operation of nuclear reactors**. All the cooling systems of the reactors of the French nuclear fleet require water to be taken nearby, before returning it partially or completely.

Two reactor configurations are present on the French fleet which counts:

– **26 open-circuit reactors** ( 14 reactors by the sea and 12 by rivers): cold water is taken from a nearby water reserve (river or sea). It serves the **secondary (non-radioactive)** circuit – i.e. the circuit that converts thermal energy into electrical energy – through the condenser, before being **fully discharged into the water source** at a higher temperature;

– **30 reactors in closed circuit** (along the river): on the same system, cold water, in much smaller quantities, is taken is injected into the secondary circuit (non-radioactive) through the condenser but joins, at the end of the circuit, an air cooler to be cooled – cooling leads to evaporation of around 40% of the abstraction – before being returned to the river[1]. This second system makes it possible to limit the withdrawal of water and to lower the temperature of the water discharged into the river.

**Figure 28: Nuclear Power Plant Configuration**




This second system makes it possible to limit the withdrawal of water and to lower the temperature of the water discharged into the river.

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*(1) RTE, Energy Futures* 2050, *February 2022, p. 411.*

EDF estimates that its 13 riverside sites consumed 400 million cubic meters of water in 2021[1].

Data published by the Ministry of Ecological Transition on March 30, 2023, indicate that power plants took 15.3 billion m$^3$ of water in 2019, but consumed only about 490 million m$^3$ on average between 2010 and 2019, or 12% of national consumption.[2]

**Figure 29: Technical Bearings and Cooling Source for Nuclear Power Plants**

*Source : RTE, Energy Futures 2050.*

**The parameters of the water** (temperature, quantity) **returned**, after its use for the cooling system of the power plants, **are regulated and regularly controlled**. **In exceptional circumstances** (heat wave or drought) **affecting the watercourse** (flow, initial water temperature), **reactor production is revised downwards** in order to comply with the regulatory constraints set for the purpose of preserving fauna and flora.

The risk of unavailability of nuclear production resulting from heat waves or droughts weighs mainly on 4 of the 18 French nuclear sites, which accounted for **90% of production losses due to their unavailability over the period 2007-2021**[3]. But according to RTE's forecasts for 2050, the risk could increase by a factor of two to three[4].

(1) *Le Monde*, *Water consumption of French nuclear power plants in debate,* 23 *March 2023.*

(2) https://www.statistiques.developpement-durable.gouv.fr/leau-en-france-ressource-et-utilisation-synthese-Knowledge-in-2022

(3) *RTE, Energy Futures 2050 – full report*, *24 June 2022, p.412.*

(4) *Ibid., p. 377.*

Consequently, and despite the **improvements made by EDF**, **following the heat wave of 2003, to these installations on the occasion of periodic safety** reviews (new equipment adapted to higher temperatures, increased performance of heat exchangers, etc.)(1), RTE recommends "***finding levers to minimise the sensitivity of the nuclear reactor fleet to*** *climate change, in particular by studying the positioning of future reactors on rivers with little flow constraints*"(2).

During the summer of 2022 (between 15 July and 5 August), several temporary derogations(3) from the parameters in force were granted by decree, with the prior agreement of ASN, to certain power plants in order to allow them to discharge water at temperature levels higher than those accepted (+3°C at the daily average value).

On 21 March, the Court of Auditors also published a report on the impact of climate change on the existing nuclear fleet but also on future EPRs. Climate change can affect facilities and their immediate external environment. Added to this are peripheral phenomena, such as the risk of an imminent fire, and the rise of conflicts over water use. The Court of Auditors therefore insists on the "*need for an integrated and territorialised approach*".

There are, however, alternatives for installing nuclear power plants away from bodies of water. The Palo Verde power plant (United States) works with wastewater from the city of Phoenix (4).

**In any case, drought does not pose a nuclear safety problem.** In the event of water scarcity, the only risk involved is lack of production, a risk common to all water-dependent modes, such as thermal power plants and hydroelectricity. The seaside sites have no supply difficulties.

* * *

The fleet of nuclear reactors is only one link in the nuclear industrial chain; it depends in particular on a complete nuclear fuel cycle to be supplied, to operate properly and to comply with the rules of the European Union spent fuel and ultimate waste management.

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*(1) IRSN, Information note: effects of the heat wave on the production and safety of nuclear power plants, 27 June 2019. https://www.irsn.fr/sites/default/files/documents/actualites_presse/actualites/IRSN_NI-canicule-and-central-nucleaires_27062019.pdf*

*(2) RTE, Energy Futures 2050 – full report, 24 June 2022, p.415.*

*(3) Derogations granted to the nuclear power plants of Golfech (Tarn-et-Garonne), Blayais (Gironde), Saint-Alban (Isère) and Bugey (Ain).*

*(4) Framatome, Framatome successfully replaces a drinking water heater at the Palo Verde power plant in the United States, September 23, 2019. https://www.framatome.com/medias/framatome-remplace-avec- success-a-food-water-heater-of-the-palo-verde-plant-in-the-united states/*

### *d. The fuel cycle in the nuclear industry*

**Nuclear fuel –** uranium – provides energy by fission, not combustion. It has the particularity of **being able to be reprocessed after use in order to remove certain recyclable materials**: we therefore use the term fuel cycle.

This cycle consists of **five successive stages:** uranium mining in mines; fuel fabrication; fuel use in the reactor; reprocessing of fuel discharged from the reactor; and waste treatment and storage (i.e. the residual part of spent fuel which is, for the moment, not reusable).

– The **nuclear fuel cycle** begins with **the extraction** of uranium from uranium ore, in underground or open-pit deposits.

Containing 1 to 200 kg of uranium per tonne – a kilo of uranium produces 10,000 times more energy than a kilo of coal or oil in a thermal power plant – the ore is dissolved and then processed to obtain a yellow powder: yellow cake (99.27% uranium 238 and 0.7% uranium 235). After several refining and conversion steps, it is finally converted to uranium tetrafluoride (UF4). These operations are carried out by Orano in its Malvési and Tricastin plants.

Only the isotope 235 of uranium is fissile by slow neutrons (generating energy when its nucleus is broken by a neutron) and is present in very small proportions in natural uranium (0.7%). For the chain reaction to occur in a pressurised water reactor (PWR), it is necessary to enrich the natural uranium so that the proportion of uranium-235 reaches 3 and 5%.

All natural uranium is imported. Globally, the main producers are Kazakhstan at 45%, Namibia at 12% and Canada at 10%. The work of the Organisation for Economic Co-operation and Development (OECD)(1) and the IEA(2) indicates a relatively homogeneous distribution of uranium deposits between geographical areas, with in particular a low geopolitical risk for two of the three most important resource countries (Australia and Canada). Until recently, their resource estimates amounted to about 8 Mt, for a global annual consumption of about 50,000 to 60,000 tons, or a hundred years of operation. It goes without saying that these reserves will be more quickly exploited with the revival that nuclear energy is experiencing in the world.

For its part, Orano owns mining companies in several countries (including Canada, Kazakhstan and Niger, with projects under development in several other countries, including Mongolia for example), which allows it diversified and long-

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*(1) OECD, Uranium* 2020 *– Resources, Production and Demand, 11 January 2021.*

*(2) IEA, Nuclear power in a clean energy system, May 2019.*

term access to predictable volumes of natural uranium, while being active in the uranium market.

**Uranium enrichment** can be carried out through two processes developed by industry: **gaseous diffusion** or **ultracentrifugation.** The first is to convert uranium tetrafluoride ($UF_4$) into uranium hexafluoride ($UF_6$). The gas obtained is then "filtered" to keep only the lightest molecules, uranium hexafluoride 235. The process is extremely progressive: used by the Orano plants in Tricastin (Georges-Besse II), it requires 1,400 repetitions to obtain uranium sufficiently enriched in uranium-235 to be used in French nuclear power plants. Enrichment can also be done, again very gradually, through a centrifuge. This process is used by the Urenco Group (United Kingdom, Netherlands, Germany, United States). The manufacture of one tonne of enriched uranium generates about 8 tonnes of depleted uranium which, until now, has no use *(cf. storage).*

– The second stage of the cycle is **the fabrication of the fuel:** enriched UF6 gas is converted into uranium oxide powder (UOX**).**

The UOX is then compressed into 7 g pellets that can release energy equivalent to one tonne of coal. These pellets are fed into metal tubes 4 meters long, constituting the fuel "rods " that make up a fuel assembly (264 rods in an assembly). 157 assemblies, or 11 million pellets, are needed to power a 900 MW reactor.

– Third, nuclear fuel is fed into the reactor and the **reaction is initiated.**

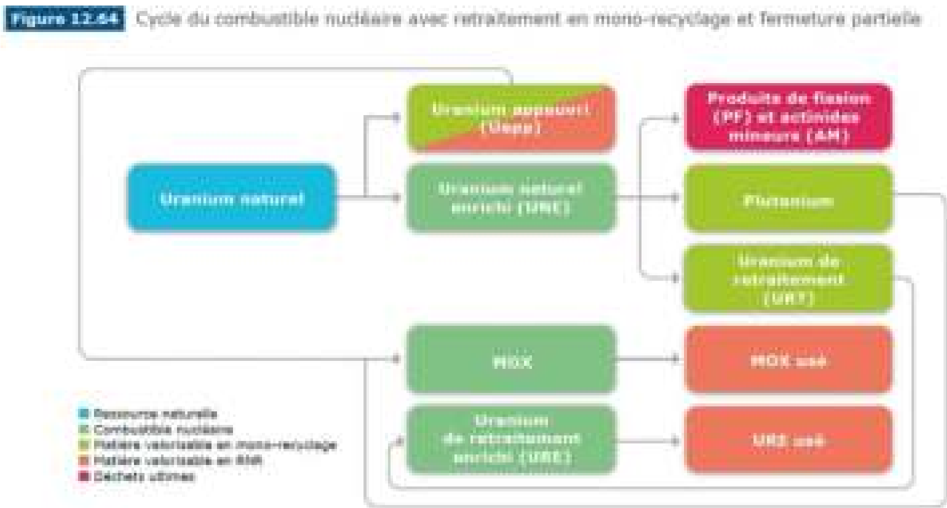
About 900 tonnes of uranium enriched to 4% are introduced into EDF's fleet each year and will remain in the reactor for three or four years. **This means having about 7,000 tonnes of uranium available each year**. During the reaction, some U238 nuclei capture a neutron and transform into plutonium-239. The reaction gradually degrades the fuel (consumption of U235 and appearance of fission products disrupting the chain reaction). The spent and highly radioactive fuel is then removed from the reactor and stored in a cooling pool located near the reactor for three years – the time necessary to reduce its activity before being transported to the Orano reprocessing plant in La Hague.

– The fourth stage of the cycle is the **reprocessing of spent fuel**, which consists of **recovering recyclable material** (plutonium and uranium) and **sorting non-recoverable radioactive waste.** Spent fuel consists of 96% of highly energetic waste (1% plutonium and 95% uranium, including less than 1% of 235U) and 5% of final waste which has since 1976, retired by Orano. For this, the elements of the spent fuel are separated in order to recover uranium and plutonium.

The spent fuel is first stored in the pools of the Orano plant in La Hague, before being reprocessed for one part and transformed into ultimate waste for another. Since the commissioning of this plant, 38,000 tonnes of spent fuel have been processed, including 900 tonnes in 2022[(1)].

The recovered materials are recycled, **respectively into MOX fuels** (mixed oxide U and Pu) and **Reprocessed Uranium (URT).**

**Figure 30: Nuclear fuel cycle with reprocessing**




*Source : RTE, Energy Futures 2050.*

**MOX fuels can be used by 24 of the current 56 French reactors**[(2)] and by 44 reactors worldwide, i.e. 10% of the **world's feet**[(3)]. Manufactured in Cadarache from 1989to 1995, MOX production was then taken over by the Orano Melox plant in Marcoule. Since it began operations in 1995, nearly 3,000 tonnes of MOX have been produced.

The Melox plant is currently facing major industrial difficulties, reaching a historic low of production[(4)] but has set itself the objective of reaching a stable production level of 100 tonnes of MOX per year in 2025 (50 tonnes in 2021, 60 in 2022).

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*(1) Orano's replies to the questionnaire sent by the rapporteur.*

*(2) Of the 24 reactors licensed to use MOX, only 22 actually use it.*

*(3) Replies by Mr. Philippe Knoche, Director of Orano, to the questionnaire sent by your rapporteur.*

*(4) This plant has recently encountered difficulties related to the change in the nature of the OU2 powder used to dilute plutonium. But a multi-year action plan has been put in place to solve them and the plant has started to turn around its production capacity since April 2022. In his reply to the rapporteur's questionnaire, Mr. Philippe Knoche indicates that "Orano is investing more than 80 million euros by 2025 to improve production, maintenance and training of teams at Melox".*

**Uranium from spent fuel reprocessing (URT)** can, after being enriched (ERU), be used as fuel for power plants. ERU fuel is used by two French reactors at the Cruas-Meysse power plant[(1)]. To date, the world's only plant for converting URT to ERU is located in Russia (Rosatom).

**Box 15: Prospects for the enrichment of URT in France**

It should be noted that with look to enriched uranium, EDF received, until last December, from Russia enriched **reprocessed uranium (URT)** – called ERU, more precisely from uranium itself from spent fuel from STIs reactors after reprocessing at The Hague. Still recoverable (because it contains about 0.9% uranium-235), this material can be converted and enriched again to be recycled in our reactors, which saves **mineral resources, up to 15% potentially**. With a stock of around 25,000 tons of URT, which is increasing by 1,045 tonnes per year, EDF decided in 2018 to restart their operations and signed a contract, following a call for tenders, with the Russian company Rosatom to convert and enrich its URT. But this uranium is still the property of EDF.

The challenge was not to access a technology that Orano would not have, but to strengthen the circular economy of nuclear fuel, avoiding devoting a workshop exclusively to the conversion of URT, to the detriment of the enrichment of natural uranium.

Unlike other European countries, these were not imports of natural uranium from Russia to France; these have collapsed since 2016-2017. Moreover, our country can do without this source. At the same time, Orano has signalled its plan to increase STIs uranium Enrichment capacity at Tricastin by 2028 to replace part of Russian imports into Europe. Orano also considers that it has the capacity to re-enrich the URT in STIs Georges Besse II seedling subject to certain investments; it also claims to be able to build a conversion workshop for the preliminary phase.

The French company Orano has the technological capabilities and technical skills to "re-enrich" the URT in its Georges Besse II (GBII) plant located in Tricastin but specifies that the development of such an activity requires significant investments for additional adaptations that the company conditions to "*long-term commercial commitments and associated financing*" [(2)].

*(1) ASN, The safety of the " fuel cycle ". https://www.asn.fr/l-asn-informe/dossiers-pedagogiques/la- Fuel-cycle-safety*

*(2) Orano's replies to the questionnaire sent by your rapporteur.*

**Box 16: Security of fuel supply**

The **supply of French** nuclear power plants and fuel research activities can be carried out using different types of fuel: **enriched uranium** used by **nuclear power plants** whose manufacturing requires a supply of natural uranium or reprocessed uranium; **high or medium enriched uranium** used in research reactors, **MOX** fuel and **URT fuel.**

The French nuclear fleet consumes about **8,000 tons** of **natural uranium** per year, or 13% of world consumption (62,000 tons)(1). The world's conventional resources are estimated at around 8 million tonnes(2) – which would make it possible to supply the **world's nuclear fleet for a period of 120 to 135 years** under current conditions(3). To strengthen the security of supply of its nuclear fleet, France follows a policy of diversification of its sources and subjects EDF to an obligation to **hold long-term** stocks. of nuclear materials, under the control of government authorities – EDF has interim stocks of several years and has concluded contracts to cover around 90% of its reference needs until 2030(4).

For **raw uranium alone**, our country has, in the current state of the needs of its fleet, **several** years of reserves – "*two to three years of stocks are generally available in the world, and in particular in France, under the control of EDF*" according to Philippe Knoche(5) (classified data). To this stock is added the 25 000 t of reprocessed uranium (URT)(6). An annual production of 400 TWh corresponds to a need of 7,000 t of uranium before its conversion and enrichment.

In addition to conventional sources, the use of highly enriched uranium from the dismantlement of nuclear weapons provides 10,000 t of natural uranium per year in France.

The **treatment and recycling of spent** fuel makes it possible in particular to produce **MOX fuel**, which provides around 10% of our needs, saving an additional 2,000 tonnes.

The monitoring of stocks and volumes of radioactive materials and waste present on French soil is carried out by the National Agency for Radioactive Waste Management (ANDRA), which is responsible for drawing up the **National Inventory of Radioactive Materials and Waste** every five years (see annex).

Be that as it may, since each sector has its own fuel, we cannot think separately of a reactor sector and a fuel manufacturing sector. However, one of the great strengths of France is that it controls all the activities of the nuclear fuel cycle present on the national territory (conversion and enrichment of natural uranium, manufacture of fuel assemblies, reprocessing of spent fuel).

In accordance with the Strategic Contract for the French Nuclear Industry 2019-2022 and its amendment, the actors of the nuclear sector – CEA, EDF, Framatome and Orano – have organised themselves to establish a research program to study the interest of **multi-recycling in PWR (MRREP**) of materials (Pu and U) in terms of competitiveness and management of materials and nuclear waste and its feasibility and performance in reactors (safety and operation) and in the fuel cycle (processing, fabrication, transport, storage)(7).

The solution of multi-recycling plutonium via the use of MOX2 fuels to recover the Pu resulting from the treatment of spent MOX assemblies in PWRs could make it possible to stabilise plutonium stocks as well as spent fuel stocks.

**Pending the completion of this research, ERU and MOX fuels reprocessed for the first time are stored in a pool, with a view to possible reclamation (MRREP**).

**In any event, by 2040, Orano[(8)] estimates that storage needs will reach 10,500 to 12,000** tonnes of spent fuel (excluding volumes stored for three years in EDF's pools adjacent to the reactors) for spent fuel processing needs of between 700 and 1,150 tonnes/year. The volume stored could be significantly reduced (-1,000 tonnes) thanks to the early non-closure of moxed units – i.e. reactors using MOX – provided for in the 2019-2023 multiannual energy programming (PPE), would reduce by more than 1,000 tonnes the inventories of spent fuel to be stored by 2040.

As the first commissioning of the new EPRs is projected for 2035 at the earliest, it would have little impact on projections to 2040. The cooling pools will be sufficient for the first unloading. The reference solution for

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*(1) The estimates of the Ministry of Energy Transition confirm a reserve of 120 years on the basis of an annual global consumption of 62,000 t; MTE, Uranium supply and the nuclear fuel cycle, https://www.ecologie.gouv.fr/approvisionnement-en-uranium-et-cycle-du-combustible- nuclear At the rapporteur's request, the BRGM provided an estimate of reserves amounting to 135 years on the basis of an annual consumption of 60 000 t. In any case, the BRGM states that "proven and probable uranium reserves are now estimated at 135 years of autonomy, assuming constant consumption of around 60,000 t/year. These resources are estimated at 6.1 million tonnes of uranium metal available at a cost of less than $130/kg, and 8 million tonnes of uranium metal available at. A cost of less than $260/kg. Nevertheless, it is estimated that the development of nuclear power could lead to an increase in consumption of about 60% to about 100,000 t/year by the middle of the century would obviously reduce the autonomy of proven and probable reserves in a proportion that will depend on the rate of growth and the type of reactor."*

*(2) Like any chemical element, uranium is omnipresent, on the other hand, geological processes have allowed it throughout geological history to concentrate in certain areas with particular properties (very low oxygen environment, known as reducing medium). The search for uranium deposits therefore consists in looking for deposits whose exploitation is economically profitable. In other words, the higher the price of uranium, the more profitable it will be to look for areas where it is less concentrated. Uranium reserves therefore increase with the price of uranium. The figures provided are therefore indicative and based on known resources only.*

*(3) MTE, Uranium Supply and the Nuclear Fuel Cycle, https://www.ecologie.gouv.fr/approvisionnement-en-uranium-et-cycle-du-combustible-nucleaire*

*(4) DGEC replies to the questionnaire sent by the rapporteur.*

*(5) Hearing of Philippe Knoche, 12 January 2023.*

*(6) Replies by Mr. Luc Rémont (EDF) to the questionnaire sent by the rapporteur.*

*(7) Orano's replies to the questionnaire sent by the rapporteur; the CEA's replies to the questionnaire sent by your rapporteur.*

*(8) Orano's replies to the questionnaire sent by the rapporteur.*

securing the storage of spent fuel in the medium and long term is **EDF's centralised storage pool,** whose commissioning is targeted by 2034. It will be dedicated to the storage of spent MOX and ERU fuels(1).

Indeed, in addition, other solutions are proposed by Orano to guard against the risk of saturation of existing storage capacities until the implementation of the centralized storage pool: first, a Orano swimming pool densification project in La Hague – in compliance with the limits defined by the ministerial decrees governing basic nuclear facilities 116 and 117, reducing the size of the current storage baskets with the aim of gaining up to 30% of places additional(2). Finally, temporary dry storage of sufficiently cooled spent fuel in TN Eagle new generation packaging is being studied. This solution is reversible and temporary(3).

**In its 2021 report, ASN stresses, however, that a series of events are currently weakening the fuel chain, putting the electrical system under tension** and points out in particular:

– the risk that the unanticipated accumulation of radioactive material or waste will lead to "*unsafe*" storage conditions. ASN reviews the above-mentioned projects and states that the need for a centralised storage pool, the project for which EDF is projecting, had been identified as early as 2010 and that the late start of the project"*requires the installation of parades to increase existing storage capacity*"(4).

– the Hague swimming pool densification project led by Orano is "a *parade*" that "*cannot constitute a sustainable solution given the necessary storage periods, of the order of a hundred years, and the most recent safety standards*"(3);

– the difficulties encountered by the Mélox plant in Orano "induce a *saturation*, *from 2022*, *of* the *storage capacities* of *plutonium materials*, *due to the production* of *a large quantity of manufacturing waste*" and "*could induce saturation* at a *time closer than 2028-2029 of the spent fuel storage pools of the Hague plant*"(3);

– the discovery of faster than expected corrosion on the evaporators of the Orano Hague plant reduces reprocessing capacities until the equipment changes,

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*(1) EDF, EDF swimming pool in La Hague, project to build a wet storage facility for spent fuel in La Hague, 7 October 2022. https://www.debatpublic.fr/sites/default/files/2022- 10/EDF%20Piscine%20-%20Enseignements%20de%20la%20concertation%20préalable%20-%20071022.pdf*

*(2) Orano,Swimming pool densification project C-D-E Orano La Hague, March 8, 2022. http://www.hctisn.fr/IMG/pdf/05_2022_03_08_hctisn_projet_de_densification_des_piscines_de_la_hague.pdf*

*(3) Orano's replies to the questionnaire sent by your rapporteur.*

*(4) ASN , ASN report on the state of nuclear safety and radiation protection in France in 2021, p. 4.*

which could degrade the saturation margin of the Hague swimming pools[3].

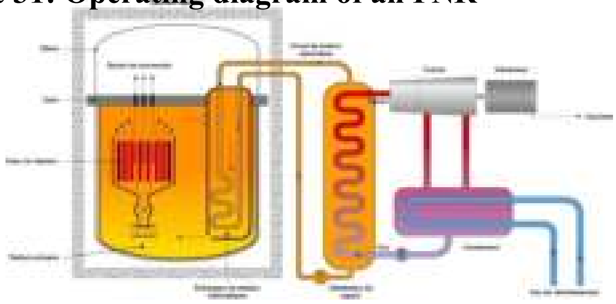
**The rapporteur wishes to reiterate ASN's conclusions on the "lack of *anticipation and precaution due to the lack of margin*" which weakens the fuel cycle and consequently the operation of the nuclear fleet (3).**

***Box 17: A technological breakthrough for the fuel cycle, fast neutron reactors (FNR)***

Since the 1960s, nuclear research has focused on fast neutron reactors (FNRs). In an FNR, neutrons have the ability to fission more isotopes because they have greater kinetic energy. This technology therefore does not require **a moderator** (water) so as not to slow down the neutrons in order to fission more nuclei. Only a coolant is needed to transport heat (sodium), transformed into steam that feeds an electricity-producing turbine.

The interest of fast neutrons is that they are the only ones capable of **extracting all the fission energy contained in the fuel** they consume (U238 + Pu). The main interest is to be able to generate under certain conditions more fissile material than is consumed. Such a reactor is called a " **breeder reactor** ".

**Figure 31: Operating diagram of an FNR**



*Source : Energy Knowledge*

Fast reactor fuel consists of reprocessed plutonium and depleted uranium or natural uranium. The stocks of depleted uranium (which still contains less U235 and U234 than natural uranium) kept by the French industry during the enrichment phases carried out in France, and plutonium from spent fuel, **would allow these reactors to operate for a long time several thousand years without natural uranium mining completely[1]**.

Different types of FNR cooling are being researched: **FNRs cooled with sodium**, lead, lead-bismuth and gas are being developed in several countries[2]. Research is also focused on a concept of a **fast molten salt reactor (RSF).**

French research has focused on sodium-cooled nuclear reactors (FNR-Na), first with the **Rapsodie** reactor (1967-1982), then with **Phénix** (1973-2009) and with **Superphénix** (1986-1998)[3]. In 2010, the ASTRID (*Advanced sodium technological reactor for*

*(1) CEA, Sodium-cooled nuclear reactors , p. 90.*

*(2) IAEA, Fast Neutron Reactors, https://www.iaea.org/fr/themes/reacteurs-a-neutrons-fast*

*(3) CEA, Sodium-cooled nuclear reactors , p. 140.*

*industrial demonstration*) aimed to resume this research with the design of has Technology Demonstrator of an RNR-Na. However, this track was abandoned in October 2019 (see report, part 2, III).

The main consequence of the complete closure of the cycle is the possibility of producing electricity at the current level for thousands of years from existing reserves, in addition to significantly reducing the lifespan of the most radiotoxic waste and eliminating stages of the current cycle (mining in particular).

The final stage of the fuel cycle is the **conditioning of the final waste.** The final waste is trapped in a glass matrix: this is the vitrification process, which is developed at the CEA and implemented in the Hague factories.

### *e. The challenge of waste management*

Of the 900 tonnes of radioactive material introduced each year into French nuclear power plants, **864 tonnes are recovered** – because their composition is 1% plutonium and 99% depleted uranium – and reused to make a new fuel and **36 tons are not removable:** it is **ultimate waste.**

Since 1976, the Hague plant, owned by Orano, **has been reprocessing spent fuel** and conditioning final waste by trapping it in a glass matrix. Vitrified, they are then poured into stainless steel containers and stored in wells while waiting to be stored in a deep geological layer (Cigeo project).

Of the **36 tonnes of waste per year**, ANDRA distinguishes:

– long-lived intermediate-level waste (**LL-LL)** and high-level waste (**HLW**), mainly from the reprocessing of spent fuel, which is stored at waste producers' sites pending the commissioning of the **Cigeo project**, a deep reversible geological disposal, conducted by ANDRA by 2027, for an estimated industrial commissioning by 2040, with a capacity of 10,000 m$^3$ for HA waste and 73,000 m$^3$ for MA-VL;

– Long-lived low-level waste (**LL-LL),** which consists mostly of old waste, such as from UNGG reactors or from remediation of radium-polluted sites. This waste is stored on the sites of their producers pending storage solutions currently being studied by ANDRA;

– low- and intermediate-level waste mainly short-lived **(FMA-VC),** which was taken over between 1969 and 1994 at the Channel Storage Centre, now in the closure phase, and is stored since 1992 on the Aube Storage Centre (CSA), which has a maximum authorised capacity of one million m$^3$. Thanks to optimisations and volume reductions carried out by waste producers and the creation of the Very Low-Level Waste Management (VLLW) sector in 2003, **the CSA's occupancy rate was 36.3 % at the end of 2021. The CSA's authorised capacity would be reached around 2060**(1);

– Finally, very low-level waste (**VLLW**) has been stored at the Industrial Centre for Grouping, Storage and Storage (CIRES) since 2003. The report on the work on the new nuclear energy states that by the end of 2021, **the Centre had reached approximately 66.1% of its authorised storage capacity** of 650 000 $m^3$(2).

**In its current configuration, Waxes will not be sufficient to store the volumes of TFA waste from future dismantling in the coming years.** Complementary management solutions are therefore currently being studied. The medium-term solution is to **increase** the authorised storage capacity of the Cires, without changing the current footprint of the storage area and while maintaining its level of safety (Acaci project – Increase in the capacity of the Cires) to bring it to around 900,000 at 950,000 $m^3$. The volume of TFA waste from the dismantling of existing nuclear fleet facilities makes it possible to anticipate the **need for new storage around 2045**. The creation of a new TFA waste storage site should therefore be considered.

Thus, even before the announcement of the new nuclear project, the future needs for new storage capacity were anticipated. However, ANDRA stresses that the existing storage centres and the projects undertaken make France one of the **most advanced countries in terms of the final management of radioactive** waste (PNGMDR) created in 2006, is regularly reviewed, in particular by the IAEA (the last in July 2022), which highlights its strengths and has not identified any sensitive points or vigilance(3).

At the end of 2020, the total volumes of waste stored in France reached 1.7 million $m^3$, distributed according to the following table:

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*(1) The forecast of the achievement of the authorised capacity of the CSA remains relatively similar whether the French nuclear fleet is developed or not, according to the report - work on new nuclear, February 2022, p. 60.*
*"Regarding FMA-VC waste, we note that delivery chronicles remain more or less of the same order of magnitude with the consideration of new reactors. On this basis, the achievement of the authorised capacity of the CSA would occur around 2060, a deadline little different from that envisaged today on the perimeter of the current fleet and with a gap of about 12 months between the two scenarios".*

*(2) The report - work on new nuclear, February 2022, p. 58.*

*(3) See, inter alia, IAEA, Integrated review service for radioactive waste and spent fuel management, decommissioning and remediation (Artemis), Mission to France, January 2018. https://www.iaea.org/sites/default/files/documents/review-missions/final_artemis_france_report_.pdf ; IAEA, Nuclear and Radiation Safety, 2022, https://www.iaea.org/sites/default/files/gc/gc66-10_fr.pdf*

**Table 1: Balance of volumes (in m$^3$) of radioactive waste at the end of 2020**

BILAN DES VOLUMES (m³) DE DÉCHETS PRÉSENTS SUR LES SITES DES PRODUCTEURS/DÉTENTEURS ET STOCKÉS DANS LES CENTRES DE L'ANDRA À FIN 20

| Catégories de déchets radioactifs | Total | Sur sites producteurs/ détenteurs | Stockés dans les centres de l'An |
|---|---|---|---|
| HA | **4 190** | 4 190 | |
| MA-VL | **42 900** | 42 900 | |
| FA-VL | **93 800** | | |
| FMA-VC | **971 000** | | |
| TFA | | | |
| DSF | | | |
| Total | | | |

*Source : ANDRA.*

In 2019, the Court of Auditors published a thematic public report on "*The downstream of the nuclear fuel cycle. Radioactive materials and waste, from reactor exit to storage*." According to this report, the average operating costs of storage and warehousing facilities are €137.7 million on average per year. Cumulative investments in these facilities between 2014 and 2017 amounted to €255 million. But the cost of the Cigeo project was set by decree at €25 billion (under the economic conditions of December 2011).

Deciding on the construction of new reactors will eventually generate new waste, the management of which can be financed by the sale of electricity, as and when it is produced. The Court of Auditors had estimated that waste management costs represented between 1 and 2% of the production cost per kWh.

At the request of the Government, ANDRA carried out a preliminary technical assessment of the possible impact of six new EPR reactors on operational or planned radioactive waste storage systems. The volumes vary depending on the reprocessing strategy chosen (multi-recycling, mono-recycling or no recycling) between 3 951 and 2 574 m 3 for MA-VL waste and between 1 872 m$^3$ and none for HA waste.

Several methods are implemented to manage waste from the sector. The most common is to bury them, permanently or reversibly pending possible future use. It is also possible to reprocess part of it. This reduces both fuel requirements and storage requirements at the end of the process.

### *f. Security and safety unanimously recognised*

The specificities of the nuclear industry – the risk of external or internal contamination and irradiation – require **special safety and security** measures.

The **security of nuclear installations** against malicious acts is organized both by the operators themselves and at the governmental level. This mission is part of the Directorate of State Protection and Security, at the General Secretariat of Defence and National Security (SGDSN) and is part of the concept of "security of activities of vital importance" (SAIV) and the planning of the government response to major crises.

**Nuclear safety**, on the other hand, aims to prevent nuclear accidents, or to limit their effects, by means of a set of technical provisions or organisational measures relating to the design, construction, operation, decommissioning and dismantling of basic nuclear installations and the transport of radioactive substances(1).

The presence of radioactive material on nuclear power plants and on installations constitutes a potential danger for the immediate environment of the site, or even far away in the event of dispersion of radioactive substances into the atmosphere. To protect the environment from nuclear risks, nuclear safety has developed on the concept of"defence **in depth"** organised around five successive levels(2) of defence and making it possible to prevent incidents, detect them and implement actions so that they do not lead to accidents and manage accident situations(3).

**A nuclear accident is an event that can lead to an abnormal** release of radioactive elements into the environment, in other words it is the significant release of toxic elements, especially radioactive, or a strong irradiation. Such an accident can lead to **contamination** – so-called external when it comes to the deposit of a radioactive substance on the skin, or internal when it comes to the penetration of a radioactive substance into the body (respiratory, digestive, cutaneous tract). It can also lead to **irradiation**, i.e. exposure of the body to radiation from a radioactive source, which can also be external or internal.

**Nuclear accidents have already occurred and have marked populations, their environment and regulatory authorities.** Three Mile Island in 1979, Chernobyl in 1986 and Fukushima in 2011 have revived fears about nuclear energy for years. **The Chernobyl** accident **had a very heavy toll but often insidiously amplified** – nearly 200 people died of acute radiation syndrome or its sequelae between the accident and 2006 (and which has changed little since then),

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*(1) Article 1 of Law No. 2006-686 of 13 June 2006 on transparency and safety in nuclear matters, repealed by Article 6 of Ordinance No. 2012-6 of 5 January 2012.*

*(2) Level 1: prevention of operational anomalies and system failures; Level 2: detection of failures and control of operating anomalies; Level 3: accident control (up to"design basis accidents"; Level 4: control of severe accidents; Level 5: limitation of radiological consequences in the event of releases of radioactive substances. V. not. IRSN, core meltdown accidents at nuclear power reactors, 2018.*

*(3) Article 3.1 of the decree of 7 February 2012 laying down the general rules relating to basic nuclear installations .*

to which in addition, there are deaths linked to the increase in the frequency of certain cancers (although it is not possible to accurately assess the number of cancers[1] linked to the accident). According to IRSN, *" it is impossible to draw up an exhaustive health assessment*".

Fortunately, these **nuclear accidents** are the result of exceptional circumstances linked to a succession of serious human errors resulting from unpreparedness and lack of anticipation. Having learned from these accidents, the regulatory authorities, in particular the French authorities, have adapted their approach to nuclear safety and taken action accordingly[2].

The method chosen by **the French safety authorities of "defense in depth"** is a **deterministic method that allows, for each event, to provide provisions and actions to be implemented**. It is complemented by **probabilistic safety assessments (PSAs) to examine the possibilities of cumulation and chaining of events.** Following the Fukushima accident, French nuclear installations were subject to complementary safety assessments (CSA), extended by the Institute for Radiological Protection and Nuclear Safety (IRSN), which broadens the scope of EPS[3].

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*(1) The organisation s that have followed the health consequences of the Chernobyl accident have observed in particular the multiplication of the risk of leukaemia (between 3 and 6), the increase in thyroid cancers a studied, but unproven, increase in the frequency of solid cancers. IRSN, Consequences on the health of the population of the Chernobyl accident, 15 April 2018. https://www.irsn.fr/savoir-understand/crisis/consequences-over-health-the-Chernobyl-accident*

*(2) Academies of Technology, Science and Chinese Academy of Engineering, Nuclear Energy and the Environment, May 2019, pp. 63 et seq. https://www.academie-technologies.fr/wp-content/uploads/2021/10/NuclearEnergy_REPORT-0514.pdf*

*(3) IRSN, core meltdown accidents at nuclear power reactors, 2018.*

**Figure 32: The nuclear safety principle "defence in depth"**


*Source :* ASN

**The majority of players in the nuclear production chain are involved in its safety.** The first concerned are the operators of the installations, IRSN, the Nuclear Safety Authority (ASN), the local information commissions (CLI) and the High Committee for Transparency and Information on Nuclear Safety (HCTSIN).

As a public body for research and expertise, IRSN evaluates, researches and anticipates nuclear and radiological risks. **IRSN is particularly involved in the fields of nuclear safety, transport of radioactive and fissile materials** the protection of man against ionising radiation, the protection and control of nuclear materials and the protection of nuclear installations[1].

**ASN is responsible for regulatory monitoring and information tasks**. In particular, it verifies compliance with regulations and obligations in terms of radiation protection or safety and carries out around 850 inspections each year in nuclear installations and the transport of radioactive materials.

**ASN and IRSN draw conclusions from nuclear** incidents and accidents in order to adopt safety rules for French nuclear fleets.

**ASN is also responsible for stating its position on the ability of a reactor to continue its operation during the ten-year visit** to which it has been subject by law since 2006. This is a unit shutdown – that is, a shutdown of production to change

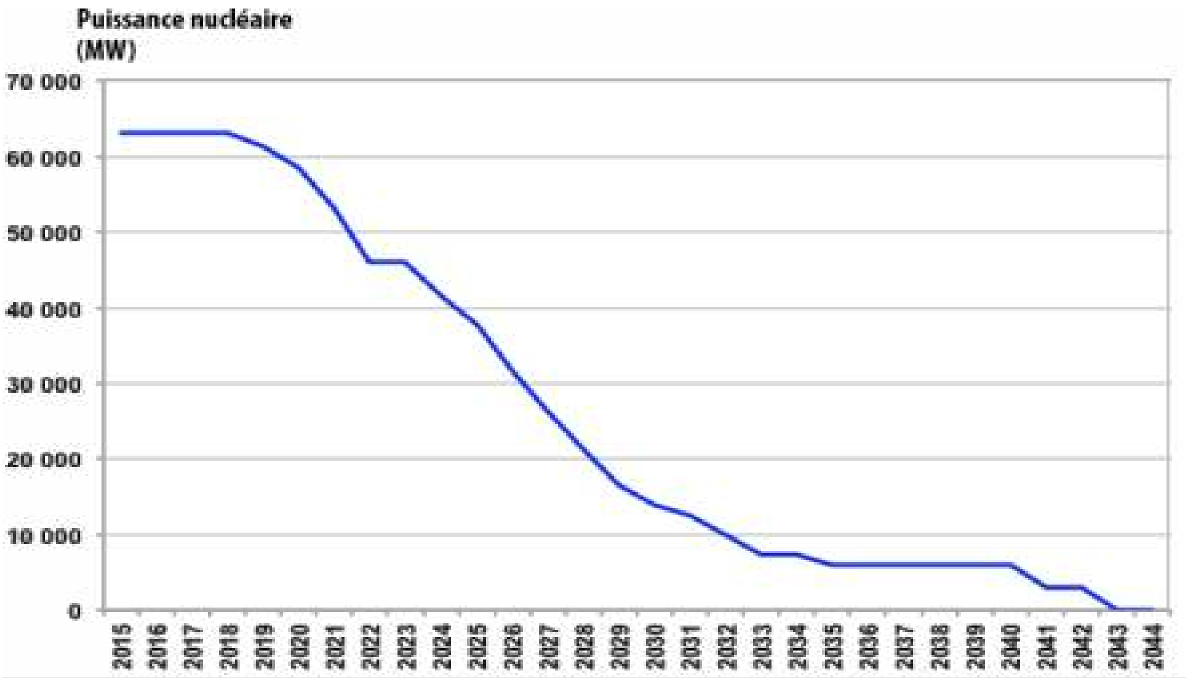
(1) *Decree No.* 2016-283 *of 10 March 2016 on the Institute for Radiation Protection and* Nuclear Safety.

part of the nuclear fuel, equipment maintenance and modifications – combined with larger-scale testing and testing. It is also an opportunity to carry out a safety review verifying compliance with the new standards enacted since the last ten-year visit. According to EDF, the ten-year visits last a hundred days, about twice as long as a stop for simple refueling.

### *g. Anticipation of the cliff effect*

The cliff effect refers to the very rapid decrease in our production capacities if we decided to decommission them at a fixed and identical age. Indeed, most of the park was commissioned in a relatively short time, between the late 1970s and early 1990s.

**Figure 33: evolution of installed nuclear capacity (evolution of the nuclear fleet until 2044, without new construction and assuming a shutdown of the plants after 40 years of operation) according to Jean-Marc Jancovici**




*Source: Blog Jean-Marc Jancovici, 2012 - nuclear power installed in France without additional construction and assuming a shutdown of existing plants (in MW) at 40 years.*

Installed capacity, which was 63 GW in 2012, would have declined rapidly from 2018 to less than 10 GW in 2032. In 2025, the residual installed capacity would have been 40% lower than in 2012.

In this hypothesis of relatively simultaneous closure, **without an alternative, France would find itself in great difficulty.** Even if desirable, controlling our electricity consumption cannot counterbalance such a fall. The France would therefore have to substantially increase its imports of electricity and/or oil and gas, if it had the means to do so.

This challenge for the electricity supply of our country is not ignored by political and industrial leaders (see part 2), and the aging of American nuclear reactors , which operate by being much older and which could be extended beyond the age of 80, opens up a more distant perspective; But the discovery of a generic fault that cannot be repaired or the impact of aging on power plants could pose a major difficulty for our electricity supply.

This challenge is all the more important as the current nuclear fleet, like the possible new nuclear power, is supported by EDF, which is facing a colossal need for investment in maintenance and new nuclear while it reached a debt level of €64.5 billion at the end of 2022 (see part 2).

## 3. Electricity production from renewable energy sources

### *a. Production capacity and actual production of renewable energy*

According to the SDES(1), in 2021, the primary production of electric renewable energies (hydro, tidal, wind, photovoltaic) amounted to 111.5TWh.

For a long time, French renewable electricity was limited to the hydraulic sector, developed in parallel with the nuclear sector. However, since 2005, the production of renewable energies (RE), in general, and renewable electricity, in particular, have been increasing, even if their share in total production remains modest(2).

RTE's data on gross inland consumption (excluding electricity imports and exports) by sector since 2000 also illustrate these increases – while showing some variation in hydropower production, which depends on hydrological conditions.

*(1) SDES, Key Energy Figures- 2022 edition, November 2022, p. 80.*

*(2) Cf. Chapter 1-II-A.*

### GROSS DOMESTIC CONSUMPTION BY SECTOR

| *In TWh* | **2000** | **2005** | **2006** | **2008** | **2010** | **2012** | **2014** | **2017** | **2019** | **2021** |
|---|---|---|---|---|---|---|---|---|---|---|
| Hydraulics | 71,6 | 56,2 | 61 | 68 | 67,6 | 63,79 | 67,43 | 52,27 | 58,84 | 61,3 |
| Onshore a nd offshore wind | 0 | 0,98 | 2,26 | 5,56 | 9,73 | 14,93 | 16,97 | 23.98 | 33,77 | 36,88 |
| Solar | 0 | 0 | 0,06 | 0,25 | 0,55 | 4,07 | 5,94 | 9,15 | 12 | 14,23 |
| Tidal | 0 | 0,5 | 0,51 | 0,5 | 0,52 | 0,49 | 0,51 | 0,55 | 0,53 | 0,54 |
| Renewable thermal and waste | 0 | 3,3 | 3,34 | 4,12 | 4,85 | 5,77 | 7,1 | 9,32 | 9,48 | 10 |
| **Addition of channels** | **71,6** | **61** | **67,09** | **78,2** | **83,24** | **89,05** | **97,96** | **95,28** | **114,64** | **122.94** |

*Source: RTE data. Note that there is a gap between the total renewable energies displayed by RTE (117.5 in 2021) and the sum of consumption by sector. These figures only indicate the volumes of electricity that have passed through the public transmission network. They therefore do not take into account self-consumption production that is not injected into this network.*

**This increase in renewable energies has been made possible by public incentives. Indeed, the development** of renewable energies benefits from State support either upstream in the field of research and development, or in the industrialisation phase in support of demand and commercial deployment (for example through feed-in tariffs, calls for tenders or tax schemes) ([1]. Initially highly subsidized and accompanied by buy-back guarantees, these technologies have seen their costs fall dramatically[2].

This progress is significant, but still far from the objectives of the multiannual energy programming (PPE). For example, those for 2023, of 24 GW of wind and more than 20 GW of photovoltaics, will probably not be reached.

In order to transform renewable energy sources into electricity and then distribute it to consumers, renewable equipment requires many critical metals, which France does not have on its territory[3] and for which it has launched a specific strategy (cf. *infra*).

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*(1) As summarised by the CRE, the most important devices are:*

*– Obligation to purchase: all the energy produced injected into the network is purchased by an obligated buyer or an approved body at a tariff defined in advance in the purchase contract;*

*– Additional remuneration: the producer sells the energy produced directly on the market. It then receives from the obligated buyer EDF Obligation d'Achat a premium per MWh injected into the network which is equal to the difference between a reference tariff. fixed in the remuneration supplement contract and the reference market price.*

*(2) Cf. section on nuclear energy – Chapter 1-II–D.*

*(3) Cf. Chapter II-C-4-c-i.*

**However, dependence on these critical metals is not of the same nature as French dependence on fossil fuels**. Without oil, the vast majority of our vehicles would end up immobilised. Without the necessary resources to deploy renewable energies, we would not be able to continue our country's energy transition; But the existing means of production would continue to function.

Finally, as the Court of Auditors has been able to establish, the costs of producing electricity from these energy sources are very diverse and potentially very important when they include the costs related to the network and the management of the intermittency of energies such as solar or wind that require significant flexibility and storage capacities (*cf.* Box 14: the analysis of the production costs of the French electricity production system by the Court of Auditors).

**Table 2: Full costs of renewable electricity generation in €/MWh**

| Equipment | Full cost of production in €/MWh Min-max range |
|---|---|
| Aeolian | 68-108 |
| Offshore wind | 130-329 |
| Residential photovoltaics | 223-407 |
| Commercial photovoltaics | 139-246 |
| Ground-mounted photovoltaics | 92-167 |
| Thermodynamic solar | 113-249 |
| Geothermal energy | 51-301 |
| Hydro: large run-of-river installations | 30-50 |
| Hydro: high-power installations and high-head operators | 70-90 |
| Hydraulic: low-power installations | 70-160 |

*Source: Court of Auditors report, Support for renewable energies, March 2018 / Court of Auditors report, Cost analysis of the electricity production system in France, 2021.*

i. The major participation of hydropower in the French electricity mix

In France, with nearly26 GW of installed capacity – including some 14 GW totally flexible (with so-called lake structures and pumped energy transfer stations, known as WWTPs) and 4 GW modular (with so-called lock structures), hydropower represents 12 to 14% of electricity production (and nearly 20% of the peak mix).

Among the various hydropower operators, EDF's fleet in metropolitan France brings together nearly 500 hydroelectric power plants, including nearly 300 concessions, and constitutes 80% of the hydroelectric capacity installed in France, including 5 GW of WWTP, and 66% of French hydroelectric production.

The hydroelectric sector provides both base electricity (continuously, through so-called run-of-river installations) and at the peak (lock and lake power plants that benefit from a stock of water controllable on demand, which is filled in spring and turbine in winter). Its average annual producibility is 67 TWh. **Hydropower now provides 50% of the energy adjustment** (for grid balancing and operational security) **in France thanks to its large dams, which can provide large powers very quickly, and almost all electrical storage, thanks to WWTPs.**

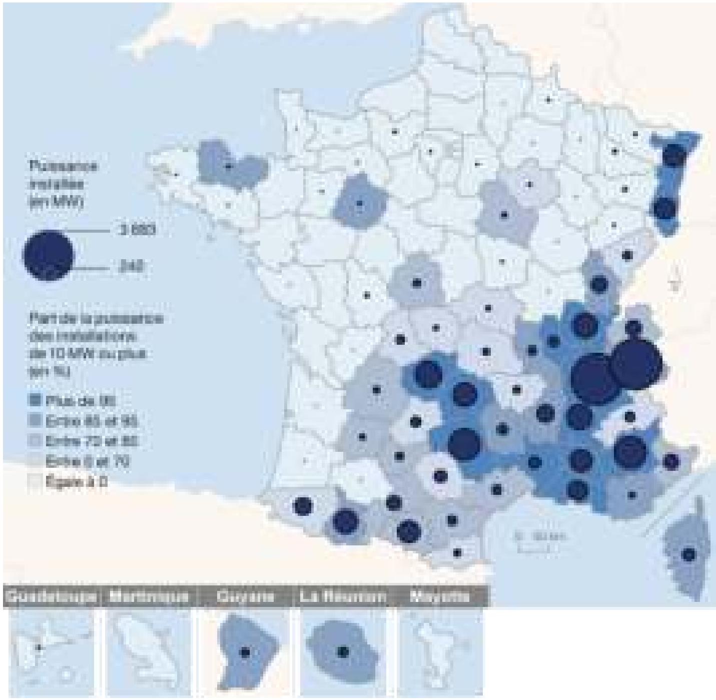
The hydropower value chain is 90% European and overwhelmingly French.

| **Summary table: French hydroelectric fleet** (1) | |
|---|---|
| **Installed capacity** | 25.7 GW |
| **Average production over the period 2000-2022** | 63.2 TWh / year |
| **Production 2022** | 48.9 TWh (40% lake power stations 16% locks<br>26% run-of-river power plants<br>18 % STEP) |
| **Park** | +2,600 installations |
| **$CO_2$ emissions** | 6 gCO2/kWh |
| **Number of employees** | 20,000+jobs |
| **Number of enterprises** | 1,000+ |

The geographical distribution of hydroelectric installations, on metropolitan French territory and overseas, is obviously dependent on the resources present in each department and very unequal. These facilities are mainly concentrated in the Alps and the Massif Central.

*(1) Figures from RTE, SDES and SER data*

**Map 1: Power of hydroelectric installations by department at the end of 2021**




*Source: SDES, Key Figures on Renewable Energy - 2022 edition.*

ii. The progressive development of onshore and offshore wind

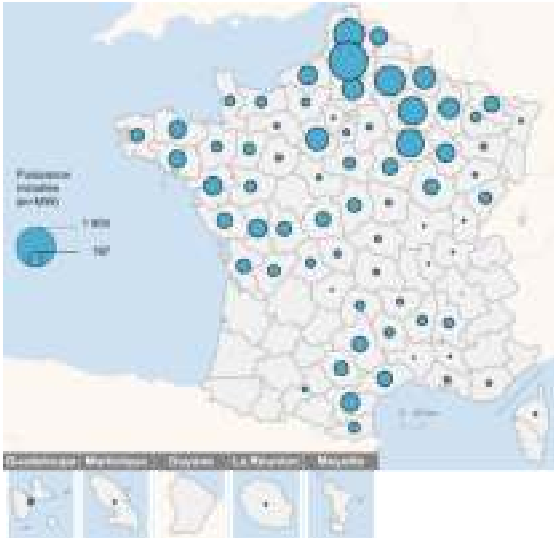
Wind capacity stood at 19 GW in 2021 and reached 20.5 GW at the end of 2022, including the first GW of offshore wind.

| **Summary table: French wind farm** (1) | |
|---|---|
| **Installed capacity** | 20.5 GW |
| **Average production over the period 2001-2021** | 15.2 TWh / year |
| **Production 2022** | 38.1 TWh |
| **Park** | 1,829 onshore wind farms 1 offshore wind farm |
| **$CO_2$ emissions** | Onshore wind: 14.1 gCO2/kWh<br>Offshore wind: 15.6 gCO2/kWh |
| **Number of employees** | + 25,000 jobs |
| **Number of enterprises** | 1,000+ |

Like all renewable energies, wind installations are distributed of unequal materials across the territory, with a high concentration in the north of France.

*(1) Figures from RTE, SDES and SER data*

**Map 2: capacity of wind installations by department at the end of 2021**



*Source: SDES, Key Figures on Renewable Energy - 2022 edition.*

Over the past 15 years, offshore wind energy has undergone considerable development in Europe, which has led to a very sharp reduction in the costs of the sector, which has currently become among the most competitive on the market.

The France's assets in offshore wind power are particularly strong (vast maritime space, industrial and energy know-how, maritime know-how, port capacity) and, on the basis of the first projects undertaken in France since 2012, an industrial sector has been structured and established in our territories to produce and install components of future offshore wind farms (production of blades, nacelles, foundations, electrical substations, etc.).

iii. The very gradual deployment of solar photovoltaic

According to SDES, in 2021, primary solar photovoltaic production represents 4 % of renewable energy production. But self-consumption is growing and would have reached, in 2021, 520 GW. Installed solar capacity reached 15.8 GW in France in 2022.

Solar energy has benefited from a significant reduction in costs, mainly due to a change in industrial scale. The spin-offs of the photovoltaic sector are essentially local, with an activity that cannot be partially relocated, such as connection works, roads, development studies and maintenance and maintenance activities. Local authorities also benefit from the revenue from taxes related to the operation of photovoltaic installations. Finally, several industrial players are active on French territory, driven by the dynamics of the national market.

If the deployment of photovoltaic parks requires considerable land[1], this electricity production activity can be combined with other economic activities such as crops or livestock. Thus, a photovoltaic installation is qualified as agrivoltaic when it is located on the same plot area as an agricultural production and that it directly provides a service to it (adaptation to climate change, access to protection against weather hazards, improvement of animal welfare, agronomy for crop needs).

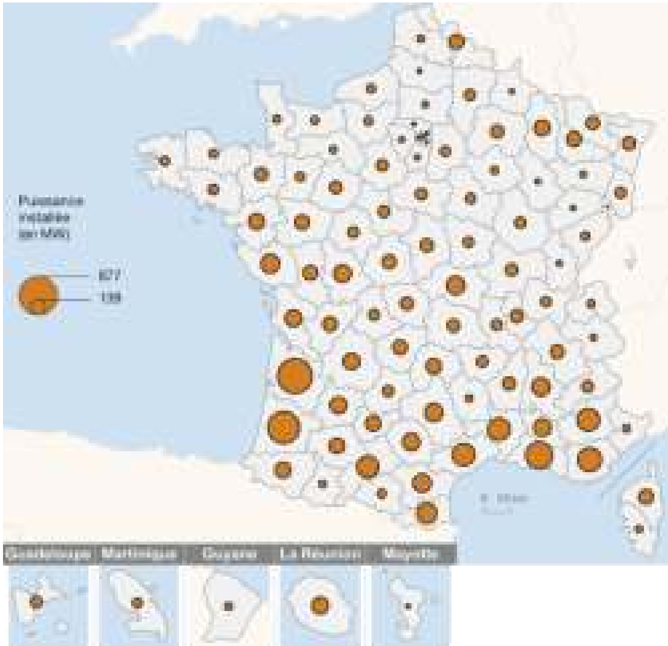
| **Summary table: French photovoltaic park [2]** | |
|---|---|
| **Installed capacity** | 15.8 GW |
| **Average production over the period 2006-2021** | 6.5 TWh / year |
| **Production 2022** | 18.6 Twh |
| **Park** | 600,000 photovoltaic installations connected to the grid, including 208,000 for individual self-consumption |
| **$CO_2$ emissions** | Manufacturing in France: 25.2 gCO2/kWh<br>Manufactured in Europe: 32.3 gCO2/kWh<br>Made in China: 49.9 gCO2/kWh |
| **Number of employees** | 8,000+ jobs |

The France has the fifth largest solar field in Europe. Photovoltaic installations are very present on the French territory, which enjoys strong sunshine, especially in the south of metropolitan France and overseas. However, unlike hydro and wind power, each French department has photovoltaic electricity production facilities.

*(1) According to the Academies of Technology, Science and the Chinese Academy of Engineering, on average solar PV requires the use of 10,000 to 60,000m$^2$ per MW. Nuclear Energy and the Environment, May 2019, p. 25. https://www.academie-technologies.fr/wp-content/uploads/2021/10/NuclearEnergy_REPORT-0514.pdf*

*(2) Figures from RTE, SDES and SER data.*

**Map 3: Power of photovoltaic solar installations by department at the end of 2021**



*Source: SDES, Key Figures on* Renewable *Energy - 2022 edition*.

iv. Other residual sources of renewable electricity generation

At the margin, geothermal energy and tidal energy make it possible to produce electricity.

**Geothermal generator** involves pumping water hot enough to power a turbine and produce electricity. However, it is only relevant in territories where thermal anomalies give access to very hot water, such as in the Rhine ditch or in volcanic overseas territories.

**The production of electricity from so-called "deep" geothermal energy** (0.1 TWh of electricity injected into the networks) is mainly concentrated in Guadeloupe: the Bouillante geothermal power plant thus exploits the heat of volcanic origin from the La Soufrière massif. Deep geothermal energy also concerns the Alsatian site of Soultz-sous-Forêts, which served as a research and experimentation laboratory until its industrial production in June 2016.

According to the SDES, in 2021, primary production of marine **energy** represents 0.1 % of renewable energy production. Tidal energy is produced in tidal power plants. It has a dam equipped with turbines that capture the kinetic energy of the sea during tidal movements. The electricity produced on site is not immediately distributed to consumers but passes through a transformer that will reduce its voltage so that it can be used in home networks.

The France has only one tidal power plant: that of La Rance which is located in an estuary with the highest tidal coefficients in the world. Operational since 1966, with a capacity of 240 MW and an annual production of around 500 GWh, it meets 17% of Brittany's electricity needs. It is also formed by a 750-metre-long dam that connects the cities of Saint-Malo and Dinard.

### *b. The production of electricity from renewable sources has economic and strategic advantages, and allows the reduction of French GHG emissions*

The development of renewable energies in France already has a significant positive balance sheet, in terms of reducing strategic dependencies on fossil fuels, and consequently in terms of reducing GHG emissions, and reducing energy bills. If these qualities are also attributed to nuclear energy, renewable energies can be installed and commissioned much faster than nuclear energy.

In 2022, ADEME published an assessment of energy imports avoided by the increase in the volume of energy produced thanks to renewable energies (during peak periods, nuclear and hydro capacities are not enough). Its main findings are:

– the additional development of renewable energies for heat and power production in France between 2000 and 2019 has avoided the consumption of 1,468 TWhep of fossil fuels in France and Europe, equivalent to more than 910 million barrels of oil cumulatively. In 2019 alone, this represents 178 TWhep of fossil fuels avoided in Europe, including 63 TWhep in France, or 5% of its energy consumption. Fossil. On average, each additional TWh of renewable energy avoided 1.17 TWh of fossils over the period 2000-2019;

– if we follow the objectives of the PPE, between 2021 and 2028, the development of renewable energies in France should make it possible to avoid in France and Europe the consumption of 685 TWhep of fossil fuels, or about 1.5 times the current annual consumption of our country or the equivalent of more than 420 million barrels of oil cumulatively;

– finally, according to the same study, the development of renewable energies in France should save €6.4 billion on our cumulative energy bill between 2021 and 2028.

In addition, the carbon footprint of their operation is much lower than that of fossil fuel sectors and, for wind power, equivalent to that of nuclear.

Finally, their construction and amortization times are much faster than those of large nuclear projects (excluding administrative delays, construction takes itself: 6 to 9 months for a wind farm, 8 to 10 months for a photovoltaic park, compared to a minimum of 5 years for a nuclear power plant). However, there is a need to rapidly increase electricity production to support the ramp-up of electrification of uses, especially industrial uses. The challenge of having new production capacities that can replac nuclear reactors that would not pass the 4th or 5th ten-year visit in the coming years is also central.

Without renouncing the nuclear option, the prospects for an increase in the nuclear fleet in the short term can besummed up in the commissioning of the Flamanville EPR, announced for mid-2024. In the longer term, the construction of new nuclear reactors could only be commissioned from 2035 at the earliest.

**Under these conditions, in view of the trajectories of electricity demands, the imperative of rapid decarbonisation and given the risks associated with the ageing of the nuclear fleet, whatever the balance of the electricity mix sought in the long term, the acceleration of the deployment of renewable, electrical and thermal energies presents benefits for the continuation of our country's decarbonisation effort, and contributes to the energy security of France – and Europe – by 2035**.

c. ***But the hydroelectric sector, the main source of renewable electricity production, faces new constraints.***

i. The impact of climate change

The variation in hydroelectric production according to the evolution of the volumes of water used is an ordinary seasonal phenomenon. Lower river or reservoir flows slow down turbines. And in periods of lower low water, dams can be used to preserve other uses (irrigation, biodiversity, industry, tourism, etc.).

But the magnitude and duration of these declines are expected to increase. Simulations about global warming show a drying up around the Mediterranean basin, and especially in the Alps in the broad sense. This drying up could even extend northwards, knowing that in 2022, dam reservoirs have filled very badly in Norway to the point that it has reduced its exports.

Not only will this trend weigh durably – and significantly, as we have seen over the last two years – on the productive performance of the French fleet, but it will reinforce tensions between the different uses of water.

### ii. The legal issue of the status of hydroelectric concessions

Hydroelectricity has been regulated by the State since the law of 16 October 1919 on the use of hydropower, which stipulates that " *no one may dispose of the energy of tides, lakes and rivers [...] without a concession or authorisation from the State* " (Article L.511-1 of the Energy Code). Installations of less than 4.5 MW are subject to the authorisation and concession regime above this threshold.

The first category represents an installed capacity of about 2.5 GW for an energy produced of the order of 4.5 TWh per year.

The 340 existing concessions provide more than 90% of installed hydropower capacity (25.4 GW and production of 62.5 TWh in 2021) and constitute the largest hydropower park in the European Union. The concessionaires are responsible for the investments, construction and operation of the hydroelectric facility and are remunerated from the profit from its operation throughout the duration of the concession. In return, the concessionaire country a fee, grants water and energy reservations and must, at the end of the concession, make a free return of the goods necessary for the operation of the concession to the State, which may then decide to renew the concession.

These Concessions are mainly Managed by EDF, which supplies 70% of the national hydroelectric production, by the Compagnie Nationale du Rhône (CNR), which contributes 25%, and by the Société hydro-électrique du Midi (SHEM), for 3%.

The French hydroelectric park is characterized by a wide variety of equipment, with disparate profitability, which nevertheless fall under the same concession regime. This does not favour the development of new pumped energy transfer stations (WWTPs), a type of high-power equipment that requires considerable investment.

These hydroelectric concessions have expired or are gradually expiring according to a timetable extending between 2003 and 2080. Years of uncertainty regarding the terms of their renewal have weakened concessions. Between the desire of Brussels to obtain a liberalisation of the energy market and that of the French government to study "alternative scenarios", the French hydraulic sector remains plunged into vagueness. Failure to choose a renewal modality at the beginning of this period and to stick to it, 38 concessions have so far expired and have not been renewed. As the award period is at least three years, it is already possible to consider that there will be 61 of them on 31 December 2025 and will continue to increase rapidly thereafter.

The continued operation of expired concessions is authorised by law under the so-called "rolling deadlines" regime[(1)]. However, this interim solution has many disadvantages, in particular as regards the investments necessary for the proper functioning or improvement of these works whose programming is disrupted and

*(1) Article L. 521-16 of the Energy Code.*

and funding more uncertain.

This situation has also led the European Commission to give formal notice to France of applying the Directive on the award of concession contracts[1] twice since 2015 by reopening competition between expired concessions or to expire, at least to choose its approach for their renewal. Because the national and European legal framework allows the contracting authority to award a public concession in two ways, either by putting it in competition or by awarding it discretionarily to a public operator over which it exercises control similar to that over its own services, a so-called "quasi-governance" device.

The 2022-1979 summary of the Court of Auditors of 2 December 2022 recalls the elements of this complex and sensitive file, pending for several years.

Various concerns complicate this choice: on the terms of the fee, the first legal criterion for competition, with the grantor's wish to be able to properly capture the rent in the event of a significant increase in wholesale electricity prices, and on the duration of the concession – the terms of the contract being binding until the end of the term; but a permanent renewal cycle is cumbersome to manage...

In addition, the intervention of several concessionaires in areas with many works hitherto managed by a single concessionaire would have two negative effects: the first would be a risk of disruption of the operation of hydraulic chains and a negative effect on production; the second would be to increase the operating costs of concessions that do not would benefit more from the pooling of field staff.

Reopening competition would not be tantamount to privatising dams; these would remain the entire property of the French State. But the opening to other actors, especially foreign, worries French operators.

Not only will it become more complex to coordinate the use of reservoirs for other uses of water, the flexibility of the electricity system, through the storage it allows, or security, particularly in terms of floods and cooling of nuclear power plants, but entrusting foreign operators with a strategic tool for the production of national electricity raises fears of ceding part of our energy sovereignty.

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*(1) See Directive 2014/23/EU of the European Parliament and of the Council of 26 February 2014 on the award of concession contracts, which unifies the common rules for different public procurement contracts that are concession contracts within the meaning of EU law. A distinction is thus made between a public contract, where an operator receives a lump sum to provide a service requested, and a concession, where an operator derives his remuneration from the right to exploit the work.*

iii. The potential for hydroelectric development

The potential of hydroelectricity has been the subject of various works, still incomplete depending on the capacity of the installations considered.

In its Energy Futures 2050, RTE integrates identical developments regardless of future *mix* scenarios.

RTE considers it possible for national operators to **develop an additional 5 GW**, **including 3 GW of WWTP,** in view of the major challenge for the security of electricity systems represented by mixes integrating more and more variable renewable energies and increased use of electricity.

For their part, the state services and producers had published in 2013 a "convergence" study on the hydroelectric potential, estimating that the creation of new structures could represent a power of 2.45 GW and a production of 8,950 GWh per year; and the equipment of existing thresholds, a power of 962 MW and a producible of 922 GWh annually. This study is due to be revised in 2023.

With regard to RTE's recommendations, EDF Renewables considers that the objectives of 5 GW, including 3 GW of STEP, are both necessary and achievable, with new developments but above all thanks to the development of existing facilities.

EDF Hydro has already identified development projects on existing infrastructure. But they are suspended pending the resolution of legal issues: that of the renewal of expiring concessions but also the fact that a substantial modification of the concession requires to terminate it and to put it back in competition. EDF has also proposed five projects for non-substantial increases in power, which are achievable very quickly and without significant environmental impact. These cases are currently being investigated by the state. As for new installations, it is mainly a question of further improving the sites operated. It will hardly be possible to find a completely new site.

Finally, the potential of "small" hydro in France, i.e. installations with a capacity of less than 10 MW, remains unknown and is the subject of little study.

A mapping work was nevertheless carried out between 2013 and 2015 at the request of the defenders of the mills. According to this census, France would have **a small hydropower potential** of 6.8 TWh. This potential should not be overlooked. But its development would require equipment, sometimes the renovation of tens of thousands of structures and the multiplication of connections to distribution networks. It could be interesting locally for self-consumption, but would have **little impact on French electricity production and consumption, with a significant cost for the community that finances connections, and no use for energy storage.**

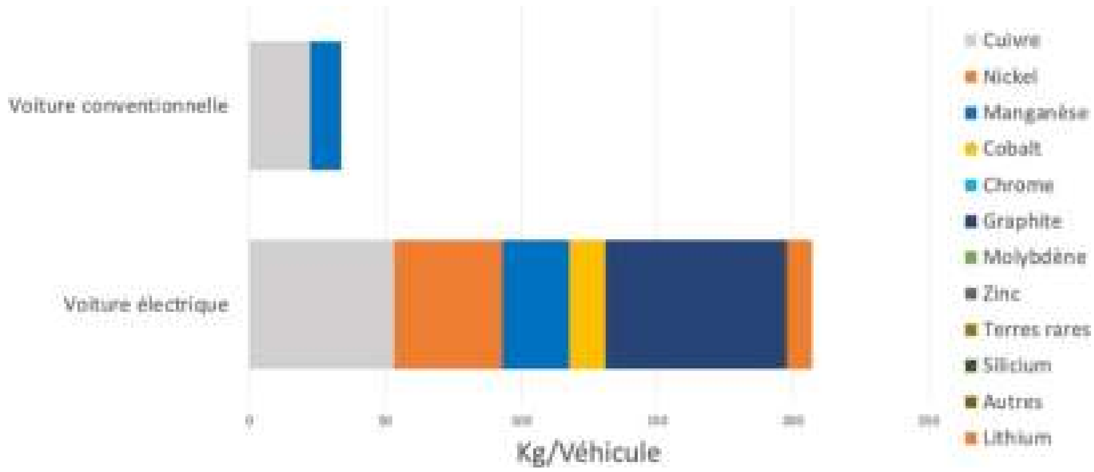
### d. *All renewable electricity production sectors must take into account vulnerabilities to be anticipated*

i. Growing needs for strategic minerals and metals, which France must import

Energy transition technologies consumer mineral resources in particular.

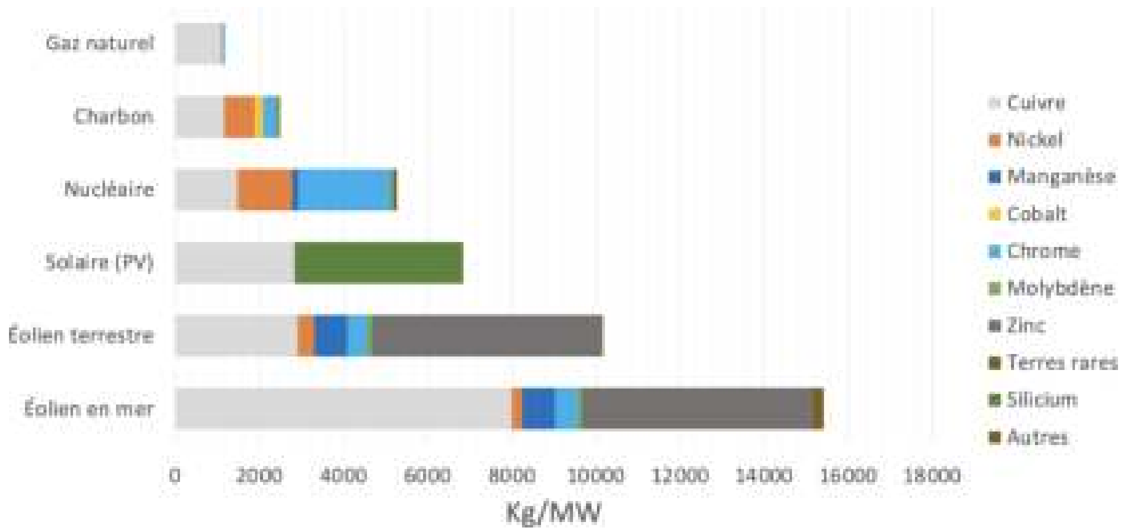
The Bureau de Recherches Géologiques et Minières (BRGM) indicates, for example, that an offshore wind turbine requires six times more mineral resources than a coal-fired electricity production facility per megawatt hour installed. Similarly, an electric vehicle contains six times more metals than a combustion vehicle.

**Figure 34: material intensity (kg per vehicle) for electric versus thermal mobility**




*Source: Rapporteur, based on IAEA data, [the Role of Critical Minerals in Clean Energy Transitions]*

**Figure 35: Material intensity (kg per MW installed) for different power generation technologies**




*Source: Rapporteur, based on IAEA data, [the Role of Critical Minerals in Clean Energy Transitions]*

The IEA estimates that by 2040, forty times more lithium, twenty times more nickel or cobalt and seven times more rare earths, with constant functions, will be needed. The requirements for metals and chemical elements are also very varied beyond these three items (boron, niobium, gallium, indium, germanium, titanium).

In addition, these needs compete for their supply with the sectors of the digital transition. This risk was clearly identified by the **"Varin report" submitted on 10 January 2022** as a strategic fragility that must call for proactive action at national and European level.

"*More mineral resources will have to be produced by 2050 than since the beginning of humanity* ," comments the BRGM. We mainly find:

– lithium, nickel, cobalt and graphite as essential elements for the electrodes of Li-ion batteries, now used in electric vehicles;

– rare earths needed to manufacture high-power permanent magnets used in offshore wind turbines or the most efficient electric motors;

– and the silicon essential for the manufacture of photovoltaic panel plates.

That said, EDF Renewables specifies that rare **earths** are not rare in absolute terms; their criticality is mainly linked to China's hegemonic position in their extraction and transformation because their modes extractions are laborious and polluting(1). Other supply chains can develop, particularly in Australia, which is the world's second largest producer, and in the United States in particular. Moreover, new generations of wind turbines and the latest solar technologies no longer use them. Finally, among the commonly used batteries, only one uses it and its use should remain marginal.

For its part, TotalEnergies indicates that the most sensitive minerals are neither silicon nor lithium, both abundant, nor even cobalt, substitutable, but **nickel** for batteries and **copper** for all power grids.

Regarding the latter, whose production has been multiplied by 7 between 1960 and 2019, the first producer remains Chile but the foundries are located in China. On the other hand, there is a general downward trend in the metal content of mines worldwide: for example, at the beginning of mining of the first copper mines in the world, and particularly in the Rio Tinto's mine, copper accounted for between 15 and 20% by weight in the ore.

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*(1) China controls almost all of this market. Of the 170,000 tons of rare earths produced last year, 71% (120,000 tons) were produced by the latter, according to the US Geological Survey. The other producers – Australia (20,000 tonnes) and the United States (15,000) – are far behind.*

Today, in ore from mines operated around the world, the average copper content is 0.4% by weight. Information was recently published by the IEA saying that copper mines in operation and under development around the world would peak between now and in two years. However, for new mining projects to see the light of day, it takes between ten and fifteen years. As a result, between the pressure of growing global demand and greater difficulties in accessing the metal, prices are rising sharply.

More generally, **many of the mineral resources needed**, **such as lithium**, **cobalt and rare earths, are fully imported**. Europe has no or no longer mines to extract these resources, nor industries to refine them. The latter have been transferred to third countries for several decades, due to low labour costs and less consideration of the environmental impacts they induce in these countries. **This results in a strong dependence for access to these resources**, as well as ethical questions.

In addition, **the extraction and production of certain critical minerals is highly concentrated in a few countries**: for cobalt, nickel or rare earths, the share of the top three producing countries is between 60 and 90% of global trade. Similarly, 75% of solar-grade silicon is produced in China; 78% of the lithium used in Europe comes from Chile, more than 70% from PGMs from South Africa, and more than 70% of cobalt from the Democratic Republic of Congo.

**Map 4: Main suppliers of critical raw materials to the EU**

*Source: European Commission Criticality Assessment Report, 2020.*

ii. China-dominated value chains

The development of solar energy was quickly accompanied by the emergence of a dominant position of China in the manufacture of photovoltaic panels. In 2020, it held 70% of this production, compared to 16% in 2006. The share of the United States had declined. And the European sector, which had 300,000 employees, now has 100,000, concentrated in Germany, the United Kingdom, France and Italy. Various measures had been taken to facilitate the development of this sector and protect it, but the financial crisis of 2008 weakened it: Germany lost its place as world leader, which it held until 2005, and the European Union disappeared from the list of the top ten manufacturers. Europe is now active mainly downstream of the sector (installation and maintenance) and in the research sector.

China also accounts for 50% of global electric vehicle production. And if Germany is the leading European hub for battery production, it is with Chinese and American investments.

For wind, however, 5 of the 10 largest turbine manufacturers are based in the European Union in 2020. According to IFRI, the European Union has technological advantages on solar panel inverters, potential on fourth-generation solid state batteries or flow batteries and the possibility of making breakthroughs in new generations of photovoltaic cells, or recycling. It also has strong capabilities in civil nuclear, energy efficiency and hydrogen, as well as cyber capabilities. These assets must be used to build strategic industrial sectors, create jobs and added value on European territory and avoid a situation of technological dependence.

However, if investment decisions have recently been taken at French and European level to bring out in Europe important production links for the energy transition (such as *battery gigafactories*), these plants will have to be powered, initially, by some semi-finished components (active cathode materials) from abroad (and China in particular) before integrating upstream technologies. They will thus have to secure their supplies of constituents, or even mineral resources, in a tense global market where all major countries seek to secure these same resources in the long term.

iii. Mining on French territory and on a European scale

The France still has a mining sector with Orano and Eramet, but having gradually stopped mining activities on its soil, knowledge of its subsoil is fragmented and partly obsolete. However, in the state of knowledge, even if it imports almost all of its mineral and metal needs[(1)], our country is not without resources.

According to the average of global projects carried out over the past fifteen years and the figures put forward by the IEA, seventeen years are needed between the decision and the opening of a mine. This work must be done taking into account the life cycle of materials, environmental constraints, and involving local populations.

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*(1) Today, only about fifteen mines remain in metropolitan France in operation, most of which concern only non-metallic substances (salt, bauxite, bituminous limestone) with the notable exception of the Echassières site (Allier) which extracts tin, tantalum and niobium as a co-product of kaolinite.*

*To this must be added the gold production of French Guiana and the particular case of New Caledonia, which has large reserves of nickel and cobalt but has autonomy over their exploitation.*

**Box 18: Subsurface geology**

The geology of the metropolitan subsoil is relatively well known on the surface. The first 100 to 200 meters deep are also relatively well known in terms of mining. All this data is now capitalised by the BRGM in the Subsurface Database (BSS), which now gathers data from nearly one million underground structures.

One the other hand, knowledge of deeper levels remains largely fragmented to date. The last national mining inventory was conducted between 1975 and 1992. It was made with less efficient technologies than those available today and covers overall only the first 300 meters deep. On the other hand, it was focused one the elements of economic interest at the time, which were much less numerous than today (lithium for example was not looked at). Finally, it concerned only two-thirds of the so-called "base" areas corresponding to the oldest massifs (Massive Central and Massive Armorican), areas that a priori have the most potential.

Nevertheless, it has made it possible to identify significant potential deposits (tungsten, antimony, gold, molybdenum, fluorite, lead, zinc, germanium, tin, tantalum, niobium), some of world rank. And since the 2010s, predictive metallogeny studies (capitalized on an open information website developed by the BRGM: MINERALINFO) have confirmed the significant mining potential of France, particularly for lithium.

An investment fund is being set up to help secure long-term investments in mining projects.

Finally, it is certain that neither the circular economy nor the French and European subsoil will be sufficient to ensure the supply of all resources necessary. To secure imports in the long term, mineral resources diplomacy is currently being structured under the aegis of the Ministry of Foreign Affairs, as well as at European level (Box 19 below).

In any case, the vision of sourcing and securing value chains in relation to these critical materials must be thought out at European level, given the extent of current dependencies and Future.

**Box 19: EU measures on raw materials**

On 16 March 2023, in response to the expected increase in demand for critical raw materials and the EU's dependence on imports, the European Commission proposed a European **regulation on *critical raw materials*** (Communication COM, 2008, 699).

This initiative sets out a strategy to reduce dependence on non-energy raw materials for industrial value chains and societal well-being by diversifying sources of primary raw materials from third countries, strengthening domestic and supporting the supply of secondary raw materials.

It materialised in 2010 with the launch of the European *innovation partnership on raw materials* (EIP-RM) which mobilised the various *European* actors around the development of innovative solutions to strengthen European autonomy. This work has notably accompanied an investment of €600 million by the European Commission on these issues in the Horizon 2020 research framework programme (2014-2020).

More recently in 2020, the European Commission adopted the Action Plan for Critical Raw Materials. The first action was the launch of the *European raw materials alliance* (ERMA) in September 2020. ERMA's first mission was to contribute to the development of a resilient value chain of rare earths and permanent magnets of electric motors.

The European Parliament then adopted, on 24 November 2021, a Resolution on a European Strategy for Critical Raw Materials to strengthen the resilience of supply chains and reduce Europe's dependence on foreign suppliers such as China. Finally, in a recent State of the Union address, the President of the European Commission announced a plan to secure the supply of critical raw materials. This "*Critical Raw Materials Act*" is currently being consulted at Member State level.

It would allow the EU to extract at least 10 % of its annual consumption, produce at least 40 % of its annual consumption, recycle 15 % and limit the import of the same strategic raw material from a single third country supplier to 65 %(1).

In parallel and on the same day, the European Commission proposed the ***Net Zero Industry Act***(2) to support European Industry, including carbon-free technologies. It aims forum the overall production capacity of decarbonised technologies to reach at least 40% of the annual technology needs needed to meet the objectives of *RepowerEU* and the EU Green Deal by 2030. It could include nuclear technologies in the list.

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*(1) European Commission, press release: Critical raw materials: ensuring safe and sustainable supply chains for the EU's green and digital future, 16 March 2023.*
*https://ec.europa.eu/commission/presscorner/detail/fr/ip_23_1661*

*(2) European Commission, press release: Net Zero Regulation to make the EU the epicentre of clean technology production and green jobs, 16 March 2023.*
*https://ec.europa.eu/commission/presscorner/detail/fr/IP_23_1665*

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**Through the prism of energy sovereignty, i.e. the ability to have various options to ensure a decarbonised energy supply, including in the event of a crisis, it is clear that France has accumulated a double delay.**

A delay in the decarbonisation of its global energy mix, in a world where fossil fuels – nearly two-thirds of the energy consumed – represent the major contribution to greenhouse gas emissions and are imported from countries that present an undeniable geopolitical risk and are now experienced.

A delay, too, in the face of the need to massively electrify our economic and industrial fabric and our transport sector. While France has a key asset, a large electricity mix, decarbonised and relatively undependent, it faces a triple challenge: the maintenance and renewal of its nuclear power plant on the one hand, the construction of renewable energy sectors on the other hand, and the overall increase in its electricity production capacity.

This accumulated double delay has some of its roots in the energy policies pursued, or not, in the last three decades.

# CHAPTER II :
# FROM THE LATE 1990S TO THE 2020S: THREE DECADES TO BECOME AWARE OF THE ENERGY WALL

To understand the roots of the current weakening of France's energy sovereignty, and to identify in particular the choices that may have weighed, it is necessary to trace the thread of strategies, decisions and actions developed and implemented since the last years of the installation of our nuclear power plant. That is the purpose of this Part.

First of all, the rapporteur points out that, in order to avoid any anachronism, these acts should be judged in their time, restoring them to their context.

## I. FROM THE LATE 1990S TO THE EARLY 2010S, A LOST DECADE FOR OUR ENERGY MODEL

### A. ANESTHETIZED BY THE ILLUSION OF OVERCAPACITY, DECISION-MAKERS NEGLECT ENERGY STRATEGY

#### 1. At the end of the 1990s, the illusion of overcapacity and independent energy model

##### *a. After forty years of nuclear voluntarism, the years 1990-2000 believe themselves durably oversized in electricity*

The voluntarism of the Messmer Plan, which allowed the construction in just two decades of the entire existing French nuclear fleet, reached its conclusion at the end of the century.

In fact, the 1990s reaped the results of past investments. **By the time their construction was completed, most of the new nuclear power capacity was commissioned between 1981 and 1995**, i.e. 44 reactors with a combined capacity of 48.34 GW. They will be completed in 2000 by the 3 GW of Chooz-B 1 and 2, then in 2002 by the 2.99 GW of Civaux 1 and 2. (*see* Annex Schedule of nuclear power plants)

**CUMULATIVE INSTALLED NUCLEAR POWER**

| *In GW* | **1970** | **1980** | **1990** | **1995** | **2000** | **2005** | **2010** |
|---|---|---|---|---|---|---|---|
| Total net power (of electricity production) | 1,69 | 12,76 | 59,72 | 59,2 | 61 | 63,99 | 63,83 |
| Number of reactors in service | 8 | 23 | 55 | 56 | 58 | 60 | 59 |

**2005 marks the peak of the expansion of the French nuclear power plant**, despite the gradual closure of the very first generations and the shutdown of the Superphénix fast neutron reactor in 1998 (1,200 MW), with 60 reactors in operation and **a net installed capacity of 64 GW.** Cumulative nuclear power then declined with the shutdown of the Phoenix fast neutron reactor in 2010 – and the subsequent closure of Fessenheim.

However, if in October 1981 François Mitterrand's Prime Minister, Pierre Mauroy, still spoke of continuing nuclear power, at the rate of seven tranches of "*1990 to 2010 at least*" in order to avoid "*excessive dependence*"[(1)], electricity demand has begun to slow since the early 1980s. As a result, as new nuclear power capacity enters the market, **electricity supply appears to be increasingly in excess of domestic demand**.

Former Director General of Energy and Raw Materials at the Ministry of Industry from 1998 to 2007, then Chairman of the Executive Board of the Electricity Transmission Network (RTE) until 2015, Mr. Dominique Maillard[(2)] was able to note that the park had been calibrated for an evolution in demand that had not materialised in the early 2000s. Yannick d'Escatha, Chief Executive Officer of the French Atomic Energy Commission (CEA) from 1995 to 1999, confirms that there was talk of overproduction of electricity at the time. And Mr Pierre Gadonneix[(4)] points out that, when he became Chairman of EDF in 2004, the excess capacity was estimated at around 20%.

Energy historian Yves Bouvier explains that **this oversizing to date is also linked to a decline in industrial consumption after 2005 and especially after 2008**, resulting in particular from deindustrialisation in the electro-intensive business sector (cf. table below). At the global level, however, final electricity consumption will only start to decline from the 2010s onwards.

*(1) See the Government's statement to Parliament on its energy policy of 7 October 1981.*

*(2) Hearing of Mr Dominique Maillard, January 26, 2023.*

*(3) Hearing of Mr Yannick d'Escatha, November 29, 2022.*

*(4) Hearing of Mr Pierre Gadonneix, December 8, 2022.*

**DOMESTIC ELECTRICITY CONSUMPTION AND PRODUCTION**

| *In TWh or Mtoe* | 1985 | 1990 | 2000 | 2005 | 2007 | 2008 | 2009 | 2010 | 2012 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total final consumption * | 248 | 305 | 391 | 423 | 433 | 440 | 425 | 442 | 437 | 442 |
| *of which steel industry* | *10* | *11* | *11* | *12* | *12* | *12* | *9* | *10* | *11* | *Nc* |
| *of which industry (excluding iron and steel)* | *87* | *105* | *127* | *128* | *124* | *121* | *108* | *111* | *107* | *Nc* |
| Gross consumption ** | 303 | 350 | 441 | 482 | 480 | 495 | 496 | 506 | Nc | Nc |
| Gross output | 344<br>63,9 | 420<br>86,8 | 540<br>114,4 | 576<br>122 7 | 570 | 575 | 539<br>118,4 | 569 | -<br>117.9 | 530,4 |
| Imports | 6 | 7 | 4 | 8 | 11 | 11 | 19 | 19 | Nc | Net balance<br>- 40.1 |
| Exports | - 29 | - 52 | - 73 | - 68 | - 68 | - 59 | - 45 | - 50 | Nc | |

*Source: Key Energy Figures, SDES, 2009 to 2018 editions. * climate-adjusted ** not climate-adjusted.*

In addition, on the supply side, overcapacity to date is maintained (but not aggravated, *see* Part One) by the arrival of new renewable electricity production capacity, the development of which begins to be visible from 2005.

**The expected outcome of the Messmer Plan, investment in new nuclear capacity gradually stopped in the second half of the 1990s**. It was not until the programming law setting the guidelines for energy production, known as POPE, of 2005 that the principle of building a new reactor, that of Flamanville 3, was recorded.

Knowing that electricity cannot be stored, **one of the challenges was rather to find outlets**. Contracts were then signed between the State and EDF making the export of electricity an objective for the company, in order to ensure profitability for its investments. In fact, **surplus electricity is sold on the European market**, offering the company additional cash flows, not framed by regulated sales tariffs, for several decades.

**GROSS ELECTRICITY EXPORTS AND IMPORTS**

| *In TWh* | 2000 | 2002 | 2004 | 2006 | 2008 | 2010 | 2012 | 2014 | 2016 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Exports | 73,2 | 79,7 | 67,6 | 71,2 | 57,9 | 50,1 | 56,4 | 74,7 | 61 | 76,1 | 72,9 |
| Imports | 3,7 | 2,7 | 5,7 | 7,6 | 9,5 | 19,5 | 11,3 | 7,2 | 19,2 | 12,8 | 14,9 |

*Source : RTE. N.B. Domestic imports respond to peaks in consumption not covered by domestic production, even with the reinforcement of thermal capacities.*

According to some officials, this apparent overcapacity has led to "drifts". Ms Corinne Lepage[1], Minister of the Environment of M. Jacques Chirac in the government of M. Alain Juppé, between 1995 and 1997, as Mrs Dominique Voynet [2], Minister for Regional Planning and the Environment from 1997 to 2001, **accuse EDF** of **having excessively encouraged the development in France of electric heating**, **whose performance was questionable at the time**, in order to sell larger volumes of its production. Ms. Lepage says: "*Since it could not be stored, this electricity had to be consumed [in France (since) the European electricity market did not exist or at least in another form at the time when it was in government]. With the agreement of the State, EDF has implemented a policy of very low prices to consume electricity. This is the reason why electric heating has increased in France*."

**The rapporteur points out that the criticisms levelled at the State were not substantiated by factual evidence before the Committee of Inquiry**. Mr. Yves Bouvier, specifies that the development of electric heating was recommended more precisely from the beginning of the 1970s, and only for new well-insulated housing. According to Mr. Bouvier in the 1980s, more than 60% of new homes were already equipped with them; They naturally absorbed some of the electricity from nuclear power plants, which replaced electricity produced from fuel oil.

However, the insulation of the dwellings in question was not always ensured and, encouraged by preferential tariffs, old dwellings were gradually equipped with electric heating without their energy performance being improved. The thermal efficiency of electric heating being much lower than that of fossil systems (around 30%, compared to 80% for oil), residents lost comfort, while being encouraged to consume more to compensate. M. Dominique Maillard recalls that heated debates on the lack of efficiency of electric heating took place from 1974 to 1980.

It confirms that, despite this, "*overcapacity [in electricity] has undeniably led to the development of new uses for electricity. EDF has initiated research into the development of electric heating, which has not always been encouraged by the public authorities. The electric vehicle was not considered as a sector, because of the storage capacities, which were perceived as the main obstacle. EDF's areas of commercial development therefore included electric heating and the development of electricity uses in industry*."

Mr. Jean-Bernard Levy, Chairman and Chief Executive Officer of EDF from 2014 to 2022, **today highlights the carbon-free nature of this heating method; But the combination of poor performance of old equipment and lack of insulation pose various problems to the stock of buildings concerned**, and in particular to a large part of the 9 million homes thus heated.

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*(1) Hearing of Ms Corinne Lepage, 10 January 2023.*

*(2) Hearing of Ms Dominique Voynet, 7 February 2023.*

It is also the cause of **the great thermosensitivity of our electrical system**[1]. One degree less in winter corresponds to an additional demand of 2,400 megawatt hours (MWh) of demand[2] – which our country fortunately manages to cover thanks to European interconnections. Indeed, the development of electric heating in France being unparalleled in neighbouring countries, when Europe suffers a cold wave, the electricity demand is high in France, but increases much less in other countries, which allows us to import.

**The rapporteur stresses that this overcapacity, which seems a fact when one examines the data statistically, has all the illusion when one places oneself in a dynamic perspective: the political will for reindustrialisation, the need already known at the time to gradually phase out the consumption of fossil fuels, necessarily imply to think of a production apparatus. of major and growing electricity.**

***b. Encouraged by "sufficient" electricity production, governments do not anticipate future challenges or timidly tackle them***

In any case, the **security of electricity supply was not a concern** for politicians **in the late 1990s**, such as Dominique Voynet, Minister of Regional Planning and the Environment in the "plural" government of Mr. Lionel Jospin, from 1997 to 2001, confirms this: "*At that time, I was more concerned about the fact that EDF was encouraging new uses of electricity (...) than by securing supplies. The question would not arise until several years later. Extending the life of power plants was also not a topic of reflection in the late 1990s. Power plants had come online in 2000 and 2002 and there was no fear of running out of electricity*."

At least the question did not arise in volumes. Mr. Jospin says he was nevertheless concerned, from that time, about **two difficulties** :

–The first, technical, stemming from the fact that nuclear power plants are more adapted to (constant) baseload consumption and less to peaks in consumption, for which it is better to use more flexible production facilities, such as hydropower or gas – We saw in the first part that the production adjustments, which French nuclear power plants allow, effectively lead to faster wear and lower average efficiency of installed capacity.

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*(1) The supply-demand balance of the electricity system is disturbed in particular by consumption peaks that appear in the coldest (or hottest) periods.*

*(2) Cf. Website of the Ministry of Energy Transition, Security of electricity supply.*

In fact, only fossil heat capacities have such flexibility of controllability. For this reason, it is still necessary, in the current state of technical solutions, to retain some of these installations. For 30 years, the use of these fossil capacities has oscillated around 11% of national production.

**ELECTRICITY PRODUCTION OF CONVENTIONAL THERMAL CAPACITIES**

| *In TWh* | 1985 | 1990 | 2000 | 2005 | 2007 | 2008 | 2009 | 2010 | 2011 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|
| Total production | 344 | 420 | 540 | 576 | 570 | 574 | 539 | 569 | Nc | 530,4 |
| Conventional thermal production | 56 | 48 | 53 | 67 | 60 | 60 | 59 | 63 | 56,2 | 63,1 |
| % of total | 16,3 | 11,4 | 10,2 | 11,6 | 10,5 | 10,5 | 10,9 | 11,1 | - | 11,9 |

But while coal and fuel oil accounted for more than 85% of thermal capacity in 1973, political and industrial leaders have focused on reducing their contribution: they accounted for just over half in 2010 and then about 30% in 2017, gradually replaced by natural gas;

–The other relates to **the excessive dependence on a single source of carbon-free electrical energy, without substantiated evidence explaining this fear having been provided to the committee**.

This concern to diversify carbon-free energy sources will also be reflected in the programming laws relating to energy adopted in 2005 under the government of Jean-Pierre Raffarin, then in 2009 under the impetus of the Minister of Ecology, Energy, Development sustainable and sea, M. Jean-Louis Borloo, and Nathalie Kosciusko-Morizet, Secretary of State for Ecology who will succeed Mr Borloo in 2010.

On the other hand, **successive governments have done little to address the high dependence of France on fossil fuels**, which still accounted for more than 50% of primary energy consumption and more than three-quarters of final energy consumption **other than by encouraging energy savings and by phasing out the oldest and most polluting fossil thermal power plants**.

The measures taken to free themselves from coal and fuel oil are substantial, and their results are quickly noticeable. "*We have reduced the consumption of coal, the largest source of carbon emissions into the atmosphere, we have closed the mines of Carmaux, Alès and Gardanne, while organising the redevelopment of sites and the training of miners' children in new trades. We have also closed the Penchot coal-fired power plant*," recalls Mr. Jospin.

Closures of coal and oil-fired power plants will continue and accelerate with the implementation of binding environmental standards on air pollutants resulting from European directives applicable from 2005, without the need for the State to intervene. Almost all oil-fired power plants will be closed from the 2010s, as well as about fifteen coal-fired power plants. This movement is offset by the commissioning of gas-fired power plants, at a time when gas is cheap and its carbon footprint considered more acceptable. But fossil electricity production capacity is still declining significantly.

So much so that **in the early 2010s a new concern for the security of electricity supply appeared** on which RTE is watching. The final electricity production-consumption balance is still largely in surplus. But **peak consumption increased rapidly** in the 2000s with the development of electrical appliances in homes. A record peak of 102 GW, never equalled, will be recorded during the cold wave of February 2012. With less controllable thermal capacity, which was not replaced by other carbon-free controllable energy sources, France must be able to call on other adjustment devices, in order to minimise the need for imports – and remain within volumes manageable by public transport networks.

In addition to the network of volunteers for demand response, the capacity mechanism created by Law No. 2010-1488 of 7 December 2010 on the organisation of the electricity market, known as the NOME law, meets this objective. Developed between 2011 and 2015, it provides in particular to remunerate the capacities necessary for the balance of the system, such as gas-fired power plants.

RTE specifies that if this new risk of disruption appeared, it remained until 2016 at a perfectly acceptable level compared to the security of supply criterion chosen by the public authorities: the 3-hour criterion.

Apart from heating and part of industry, **for a long time the decarbonisation of energy uses, particularly in transport, does not really seem envisaged, or seems inaccessible in the** state of technology. Moreover, the still bearable costs of oil and gas and the lower awareness of climate change clearly do not encourage us to explore these paths and to consider the alternative that electricity or renewable fuels can represent today.

The governments of the period focused above all on securing supplies, through agreements with producer countries, the creation of new transport routes and the strengthening of national actors. Mr Borloo[1] recalls in particular the challenge of independence that gas from Russia already posed. The pipeline through Ukraine had been the subject of litigation and had virtually ceased to be used in January 1999. " *This tension, which, if it lasted for a short time, occurred for the fourth time in five years, led to support for France's third largest LNG port at Dunkirk.*"

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*(1) Hearing of Mr Jean-Louis Borloo, January 26, 2022.*

Finally, the renewal of the nuclear fleet remains totally unimpeded. Admittedly, it is considered in a shared way that the reactors, authorised for 30 years will be extended to 40 years or even 60 years, subject to the validation of the Nuclear Safety Authority. **But reactors are beginning to exceed 20 years and the cliff effect – the fact that near-simultaneous construction risks leading to near-simultaneous shutdowns – are well-known points. 9 reactors had passed their 20th anniversary in 2001, 23 were expected to reach them by 2005 and another 16 by 2010.** Not only was their extension not guaranteed, but their replacement, if it were to be decided, takes time: such projects require several years of preparation and the last construction sites took more than ten years to complete, even based on a widely mastered technology.

**However, until the mid-2000s, no decision was made, on the contrary.**

Before the Commission of Inquiry, Mr. Lionel Jospin affirms that his intention was to continue the development of nuclear power: "*we thought that the EPR would take over, even if it was at the stage of studies*".

In fact, on 21 November 2000, the Prime Minister replied to the National Assembly that "*the Government recognises the benefits that France currently derives from the existence of a large fleet of nuclear power plants".*

*"The evolution of the place of nuclear power will, when the time comes, - and as I have already said - be the subject of a scientific and democratic debate that will make it possible to examine all the consequences of possible choices and to weigh all the arguments. The modalities of the renewal of the park will obviously be central to this debate. EDF, the German electricians as well as Framatome and Siemens are conducting studies and research on a new generation of pressurised water nuclear power reactors – the EPR reactor – with technical and safety features further improved. (...) These studies must continue and are currently continuing, but they are not sufficiently advanced today for a debate on the advisability of the industrial launch of a prototype of the EPR reactor to be raised.*[1]

**The fact remains that the common program of the Socialist Party and the Greens explicitly provided for a moratorium: "We will reorient France's energy policy by establishing a moratorium on the construction of nuclear**

(1) *Cf.* *http://www.premier-ministre.gouv.fr*

**reactors",** affirmed, in the spring, the program of the Socialist Party and the Greens[(1)]. Moreover, Mr. Jospin explained it, in this same declaration of November 2000, by the observation that "the current demand for electrical energy and (…) the lifespan of our current power stations do not [justify] such a order immediately.

The Prime Minister of the time even endorsed, as soon as he took office in 1997, the abandonment of the Carnet nuclear power plant project downstream of Nantes. Admittedly, this decision closes a file blocked since 1974, which no subsequent government will reopen. But Mr Jospin then refrained from explicitly deciding the question of the future of nuclear power, choosing to refer this choice to a democratic debate without ever engaging in this debate – which will contribute to the waste of time that we see today. Mr. Jospin never explicitly mentioned the possibility of phasing out nuclear power or actively reducing its share in the French electricity mix, as he reaffirmed at the hearing: "*Several governments, before and after mine, considered that France had sufficient capacity. Some governments, before and after mine, have even mentioned the need to reduce the percentage of nuclear power in French electricity production. (...) I have never made a statement saying that nuclear power should be reduced to this or that percentage, I have never spoken on this subject*."

It is always easier to judge the relevance of a political strategy with the benefit of hindsight. On the EPR file, the sequel will show that its *design* was not yet completed when it was decided to authorise the construction of a prototype in 2004. On the other hand, the period of uncertainty that the nuclear industry was going through since the end of the national projects and the rise of anti-nuclear protests, and that the rather vague position of the Jospin government has undoubtedly has made the sector fear that it will miss an opportunity to restore prospects to its value chain, reports Ms Kosciusko-Morizet[(2)], and a little hasty the process. Be that as it may, and despite Ms Voynet's statements to the contrary in the press, Mr Jospin disputes that a threat of resignation by his Minister of Regional Planning and the Environment in the event of authorisation of an EPR project would have convinced him to bury such a project. On the contrary, he said he had taken several decisions that did not meet the expectations of the Green group, such as maintaining and even strengthening the MOX sector. Far from stopping the reprocessing, his government "moxé" ten new nuclear units.

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*(1) It planned to "reorient energy policy by establishing a moratorium on the construction of nuclear reactors and on the manufacture of MOX fuel (mixture of oxides) until 2010, while sharply increasing credits for energy saving and renewable energies. This policy includes the closure of Superphénix, the reversibility of nuclear waste storage by rebalancing research credits by real application of the Bataille law. The reprocessing at La Hague will be reviewed, which implies increased monitoring of the site and a new research effort. In addition, no new reprocessing contracts will be undertaken. The vote on an energy law will take place no later than 2005. »*

*(2) Hearing of Ms Nathalie Kosciusko-Morizet, 2 February 2023.*

And when Cogema and the French enrichment and reprocessing sector were for a moment weakened by the refusal of the German government to resume the waste of his nuclear industry reprocessed in La Hague, Mr Jospin personally intervened with the German Chancellor allowing the resumption of shipments of waste from France to Germany, which restored margins for the storage of French waste and restored the visibility to manufacturers.

Ms Anne Lauvergeon[1] recalls that Cogema was at the time the point of crystallisation of anti-nuclear drugs, in particular its plant in The Hague, which recycles spent fuel, although this technology greatly reduces radioactive waste. "*At the same time, it was well seen, since the closure of The Hague would have immediately had the effect of embolising the entire French nuclear system. These attacks were very serious*."

Defending himself from having harmed the strength of the nuclear industry, Mr. Jospin stresses having stabilised Framatome's shareholding after the withdrawal of Siemens, by achieving an opening of the market limited to the largest industrial consumers ("Pierret Law" of 10 February 2000), and by studying solutions to the very sensitive subjects of safety and radioactive waste (see *below*). These actions had seemed to him more essential for the future of the nuclear industry than the premature and non-urgent launch of a new reactor, he said.

**However, this is not for lack of studies calling attention to these issues of reactor lifetime and replacement.** The Energy Commission of the General Planning Commission had explored the "*paths of sober growth and the challenges of the long term*" as early as 1998.The annex to its report, "*Energy scenarios for* France 2010-2020", recalls precisely that with the assumption of a 40-year duration of existing nuclear power plants, only a small part of the existing fleet would have to be replaced (about 10 GW) before 2020, whereas with the thirty-year hypothesis almost the entire existing fleet would have to be replaced (43 GW).

Similarly, the report "*Prospective economic study* of the *nuclear electricity sector*" by Jean-Michel Charpin, Planning Commissioner, Benjamin Dessus, Director of the Ecodev-CNRS programme, and René Pellat, High Commissioner for Atomic Energy [2], submitted to the Prime Minister in July 2000, addresses the lifetime of power plants, this time by 2050. A high scenario assumed a consumption of 720 TWh by this horizon, while the low scenario assumed a consumption of 535 TWh, nuclear capacity in 2050 being estimated, depending on the scenario, between 33 and 85 GW – compared to the 63 GW available in 2000. The report looked at both electricity demand management and power generation technologies, from upstream to downstream of the cycle.

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*(1) Hearing of Ms Anne Lauvergeon, 15 December 2022.*

*(2) Including Ms. Nicole Jestin-Fleury and Mr. Jacques Percebois were rapporteurs.*

**The rapporteur also notes that, as early as the end of 1991, a report by the Parliamentary Office for Scientific and Technological Choices (OPECST) alerted the political leaders of the problems caused by the announced shutdown of nuclear sites, whether it is the need to anticipate the renewal of the French fleet so that industrialists do not have to manage too many sites at the same time (a form of cliff effect) that would exceed their capacities, or the impact of a prolonged pause in the nuclear program will weigh on industrialists such as Framatome, etc.**[(1)]

In this case, despite the 1991 alert, for a long time, **political leaders do not seem to have been concerned about the impact that the suspension of the nuclear industry**, between the completion of the Civaux reactors in 1997-1999 and the relaunch of a construction site in 2007, **will have on the preservation of its** competences.

Indeed, once the construction of power plants stopped in France, to survive, industrial players in the sector turned to external markets or tried to refocus on maintenance, but sometimes had to stop their activities. Mr. Bernard Fontana, Chairman and CEO of Framatome, testifies to the harshness of the transition: "*The first victims were industrial activities. (...) Integrated industrial platforms have been cut. With a lot of effort, some activities have been preserved, but, from my point of view, with subcritical sizes to carry out industrial construction programs. Skills have been lost with retirements. The engineering worked in a vacuum...*"

For his part, Mr. Pascal Colombani, general administrator of the CEA from 1999 to 2002, saw the teams "*dissolve*", especially those of EDF. However, these skills are crucial to remain in the international competition against old and new competitors Russian, Japanese, Korean, American, ready to invest in the markets that were opening up in many countries, and to prepare the eventual replacement of the national park.

Finally, **we have to wait for the government of M. Jean-Pierre Raffarin** (2002-2005) **to restore prospects to the nuclear industry**.

**Its Law No. 2005-781 of 13 July 2005 on programming laying** down the guidelines for energy policy lays down, on the one hand, the principle of a "*support for the national nuclear industry for the development and improvement of the third generation EPR reactor and for the development of innovative nuclear fuels*" and "*development of future nuclear reactor technologies (fission or fusion), in particular with the support of the ITER programme, and also of the technologies necessary for sustainable management of nuclear waste*" (Article 5).

*(1) Cf. Report n°2417 National Assembly - n°155 Senate of 6 December 1991 on the control of the safety and security of nuclear installations by Mr. Claude Birraux, deputy.*

These provisions thus strengthen research on the sustainable management of nuclear waste and on the reactors of the future (in fission, with the reactivation of a fast neutron reactor project in 2006, and in fusion, as part of the ITER international programme scheduled to be implemented in France, in Cadarache). They will be supplemented by **Law No**. 2006-739 of 28 June 2006 on the **sustainable management of radioactive materials and waste**, which confirms in particular the establishment of a fast neutron reactor demonstrator " *before 31 December 2020*" (Article 3). The **ASTRID project** is launched in the aftermath, with a first financing of 600 million euros (M€) from the Great Loan. This project to test a fourth-generation reactor fills the gap left by the closure of Superphénix in 1998 – discussed later – in the exploration of nuclear waste recycling technologies. It therefore aims to respond to two problems posed by the nuclear industry: the management of waste from thermonuclear combustion and the reduction of French dependence on uranium imports.

On the other hand, Article 4 of the 2005 Law specifies that "*the State shall ensure* that a significant proportion of nuclear production is ***retained in French electricity production, which contributes to security of supply and energy*** *independence, competitiveness, the fight against the greenhouse effect and the promotion of an industrial sector of excellence, even if, in the future, it will base electricity production alongside nuclear power on a growing share of renewable energies and, in order to meet peaks in consumption, on maintaining hydroelectric production potential and on thermal power stations' and fixed thermal power stations, as such, the priority for the State to "maintain the nuclear option open by 2020 by having, around 2015, a new generation nuclear reactor operational to opt for the replacement of the current generation*".

The law thus provides a legal framework for the Flamanville 3 project, which has been under debate since 2002-2003. The political message is strong.

The fact remains that, even if they are expressly invoked, the main motivations for this revival of nuclear power capacity are not necessarily security of supply or the strengthening of France's energy independence.

The current Chairman and CEO of EDF Renewables, Mr. Bruno Bensasson, remembers that the park was said to be "*overcapacity*", hovering around 420 terawatt hours (TWh) per year, and prices were quite low in the 1990s and 2000s, at 20 or 30 euros per MWh; the proposal made to EDF to build an EPR could then be surprising, but this project was presented as "*a way to keep the nuclear option open. We felt that if we waited for tensions, we would lose even more skills*." According to him, it was a question of "*retaining skills beyond security of supply*".

Former Director-General for Energy and Raw Materials, Mr. Dominique Maillard, also underlines the challenge of demonstrating the capacity of the French sector to build an EPR to remain in international competition and export its technology and services beyond Finland, where Areva NP has been building the Olkiluoto EPR since 2004.

Of course, the vitality of skills is an important issue for the sovereignty of France. But these approaches, far removed from the question of the cliff effect or the decarbonisation of the energy mix, reveal that future needs are still largely underestimated by public officials.

In fact, **concretely**, **it was decided to start construction of only one European pressurised water reactor or EPR**.

When asked about the reason for limiting themselves to a single project, the interviewees put forward several explanations.

Mr. Maillard said he considered that given the EPR's unit size of 1,650 megawatts, a single prototype was sufficient, especially since similar constructions were undertaken internationally and that trade was expected to be carried out. experiences between the Finnish and French teams of Areva NP, which operated in Olkiluoto.

In addition, the lifespan of the nuclear fleet was already under discussion. In the early 2000s, a longevity of forty years may have seemed high, but the United States was already granting licenses for sixty years. For Mr. Cédric Lewandowski, Executive Director of the EDF Group in charge of the management of the nuclear and thermal fleet, the managers of the fleet were more focused on extending its life. The question of the renewal of the existing thus seemed distant.

**However, many former EDF and CEA officials deplored this choice to launch only one reactor, because the** construction of units in parallel is important in terms of capacity and flexibility of the site, because it facilitates the sending of engineers from one site to another when needed or the use of a part available on one site for another site.

In addition, insofar as it allows for the sharing of experiences, a double project might also have made it possible to manage more quickly the various technical problems encountered by the Flamanville 3 project. Because, in retrospect, the decision to build this new reactor model appeared precipitate, the design not yet being fully finalised, as will be revealed later (see the point on the EPR of Flamanville in the b of 1 of A of this Part).

**The subsequent decision to build a second reactor at Penly, which the President of the Republic, Nicolas Sarkozy, announced on 29 January 2009, was therefore welcome from this point of view, even if it did not concern itself with these conditions of efficiency.**

It would have been a response to the double concern expressed by EDF's managers to retain their competences but also, and above all, to be able to replace in the long term plants likely to close in the event of a negative decision on the part of ASN, explains the Minister for Industry, Energy and the Digital Economy between 2010 and 2012, Mr. Eric Besson [(1)].

Moreover, Mr. Jean-Louis Borloo specifies that if "*we were already aware of the problems related to the demography of skills, I would not say (...) that the EPR was launched so as not to lose skills. On the other hand, two candidates had volunteered for the construction of Penly: a consortium led by GDF Suez, and EDF. The only argument justifying entrusting the project to EDF was indeed that, faced with the risk of loss of competences, it was not desirable to develop two separate competence entities*."

Mr Nicolas Sarkozy[(2)] explained during his hearing before the Committee of Inquiry that **he also wanted to rely on the French nuclear industry to revive the national economy, shaken by the 2008 crisis**. Shortly after the Fukushima disaster, the President of the Republic reaffirmed his conviction of the importance of pursuing the nuclear path. In this regard, the officials of the time, starting with Mr Sarkozy himself, confirm that nuclear issues were dealt with and arbitrated at the highest level of the State.

**Box 20: Nuclear Policy Council (NPC)**

A Nuclear Policy Council was established under the President of the Republic by Decree No. 2008-378 of 21 April 2008 (which at the same time repealed the Decree of 1 September 1976 one the Foreign Nuclear Policy Council). It was set up on 21 April 2009.

The New Council is responsible forum defining the Guidelines for nuclear policy and ensuring their implementation, particularly regarding exports and international cooperation, industrial policy, energy policy, research, safety, security and environmental protection.

Meetings held between 2009 and early 2012 included:

– The **Nuclear Policy Council** of 21 February 2011, which is followed by the government's announcement of a programme to "rationalise the civil nuclear industry". The State asked EDF and GDF-Suez to cooperate in the development of the Atmea medium-power reactor, developed by Areva with Japan's Mitsubishi Heavy Industries; to Areva to transform its uranium mining activity into a subsidiary, and to conclude a long-term uranium supply agreement with EDF.

Finally, the Strategic Committee for the Nuclear Industry (CSFN) is created within the framework of the National Conference for the Industry, to strengthen relations between the various players in the industry.

*(1) Hearing of Mr Éric Besson, February 9, 2023.*

*(2) Hearing of Mr Nicolas Sarkozy, March 16, 2023.*

– The **Nuclear Policy Council** of 8 February 2012, which reacts to the report of the Court of Auditors one the costs of the nuclear power sector submitted to the Premium Minister on 31 January, noting that nuclear power remains the most competitive energy with hydroelectricity.

It also confirms the need to continue the process to prepare for the validation of an extension of the plants beyond 40 years. It also confirms the continuation of the EPR project in Penly.

Ms. Catherine Cesarsky[(1)], High Commissioner for Atomic Energy from 2009 to 2012, explained that President M. Nicolas Sarkozy was present at all the meetings of the Nuclear Policy Council she attended. There were seven between 2009 and 2010.

The very first session was devoted to extending the life of power plants beyond 40 years, "*on the understanding that it had already been decided to extend them*". "*We discussed the need to extend the life of the plants to 50 or 60 years, whether we would have enough energy, and considered that the operation was feasible provided that the plants operate long enough each year." "We understood that if we couldn't extend them, we should start building others right away, and if we could instead extend them, we could wait until 2026-2027to build more, with a maximum between 2033 and 2035. The intention was therefore to build EPRs*."

Mr. Borloo observes, however, that *"the nuclear future did not depend solely on the EPR*", its size, acceptability and price were not without some concerns, "*even if it was not then the subject of a real questioning*". Smaller reactors were also being studied with a view to foreign sales.

**As for the state of electricity production capacity, the general feeling remained that there was no urgency**, recalls Ms. Kosciusko-Morizet. "*During the Grenelle, the first concern was energy efficiency, far ahead of production-related considerations. This situation continued for a few years*. The development of renewable energies was also a strong desire. Finally, to secure supply, the government was also working on a capacity mechanism, aimed at making the controllability of the means of production more flexible, which was successful after its departure from the ministry.

**It thus appears that the decisions taken are not yet up to the challenge; the fundamental choices on the future of the nuclear fleet remain to be decided, even if the announcements and declarations made between 2005 and 2012 are perceived by the sector as a form of renaissance.**

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*(1) Hearing of Ms Catherine Cesarsky, 12 January 2023.*

The decree authorising EDF to create the EPR Flamanville 3 basic nuclear installation was signed on 11 April 2007 for 10 years and construction began in December 2007, in the middle of the Grenelle Environment Forum, on the proposed design by EDF in 2004, with a reactor supplied by Areva NP, commissioning scheduled for 2012 and an announced price of €3.5 billion.

On the other hand, the Penly 3 project will not ultimately be supported by any government: from 2010, it is the subject of strong opposition that delays the process; after the Fukushima disaster, its public inquiry was postponed for the first time in November 2011, then again in 2012 in the run-up to the presidential elections. The new Minister of Ecology, Delphine Batho, finally announced that the project was abandoned in July 2012.

***c. Two reports drawn up at the beginning of the 2010s, however, identify issues that are still largely topical***

In 2010, after the failure of the French nuclear industry in the United Arab Emirates, the President of the Republic Nicolas Sarkozy asked **Mr**. **François Roussely**, former president of EDF, to lead a mission devoted to the future of civil nuclear energy and to propose concrete orientations as well as "*to inform the decisions that the State should take vis-à-vis the sector*".[1]

After more than 200 hearings, the final report was submitted to the President of the Republic in May 2010. It was finally classified, but a summary of the fifteen main recommendations was made public in June 2010.[2]

In particular, it states that "*the French sector – namely EDF, AREVA and Alstom, but also Bouygues and Vinci, as well as a whole network of SMEs, including about 200 specialised in the sector – faces a double challenge by 2030. On a national level, it will have to complete the construction of the few new plants, ensure the perfect functioning of the fleet and prepare the extension of the life of the current plants beyond 40 years*", or even beyond the age of 50. And internationally, it will have to conquer a significant share of the market for new power plants, then in full renaissance, in a very competitive context. It recommends that the State continue to assume a central role in organising the sector, but also that it correct certain weaknesses that have emerged with the international turn taken by companies in the sector: "*problems of overall organisation of "Team France", competitiveness of the offer, financing capacity, availability of human resources, mobilisation of R&D, etc …"*

(1) *Cf. Mission letter of the President* of the *French Republic of 27 October 2009.*

(2) *This report was finally declassified at the request of the Commission of Inquiry on March* 23, *2023.*

It notes in particular the difficulties encountered on the two EPR sites, which undermine the credibility of the reactor model and the ability of French industry to succeed in new plant constructions, but also the sharp decrease in the availability of national power plants. He therefore calls for urgent measures to redress the situation.

Beyond that, it recommends more structural measures in the organisation and operation of the French sector, in which EDF would play a role of architect as an interior designer, as in its technological offer. In particular, it is necessary to continue optimising the EPR based on feedback from reactors under construction and to complete the French offer by having several product families, such as the ATMEA designed by AREVA and Mitsubishi, with a lower power.

Securing fuel supplies and solving waste management problems are also imperative. As well as the maintenance of a high safety requirement, considering, however, that "*the only reasonable logic cannot be a continuous growth of safety requirements. In this context, it is proposed to launch, under the responsibility of the State, a working group whose mission would be to formulate proposals with a view to combining security requirements and economic constraints as closely as possible, including an international vision, at least European*".

The report also focuses on the conditions necessary for the competitiveness of French civil nuclear power: they obviously depend on the control of construction costs, but also on the conditions of its financing. On this point, the report recommends several strengthening measures:

– continue to implement $CO_2$ pricing;

– support the extension of plant operation to 60 years, with constant safety;

– plan a moderate but steady increase in electricity tariffs (in constant euros) in order to prepare the financing of the renewal of the fleet in the long term;

– ensure that the price of sale of electricity by EDF provided for by the Nome law covers the full cost of renewing the fleet in the long term;

– and pursue resolute political action to ensure that all multilateral financing for renewable energy is also open to nuclear.

Finally, the synthesis concludes with the challenge of renewing skills in all fields, "*from boilermakers to specialised engineers*". "*The generations of technicians, engineers and researchers recruited during the major construction programs of the 1970s and 1980s are retiring and need to be replaced. The sector is therefore now faced, in a short time, with the dual obligation to preserve the knowledge and know-how acquired, and to train a new generation of staff, in order to support international development and guarantee the performance of the existing fleet.*"

The findings are strong; yet few measures were taken after 2010. The Cigeo project has certainly progressed and the strategic committee of the sector has undertaken actions to relaunch training. But in the meantime, the Fukushima disaster has occurred, less than a year after the publication of the report, upsetting global plans for nuclear development. **It does not invalidate the findings, but has created a new state of mind that will freeze or delay several strategic decisions for the future of the sector over the 2010s.**

Ten years later, these remarks appear even more glaringly topical. A second report, commissioned in 2011 by the Minister for Industry, of Energy and the Digital Economy, M. Éric Besson, at the Energy Commission and entrusted to Jacques Percebois and Claude Mandil[(1)], former Executive Director of the International Energy Agency (IEA) focused on analysing various possible energy policy scenarios for France up to 2050.

**The Energy 2050 report** was submitted in February 2012. In particular, it demonstrates that domestic electricity demand is expected to grow strongly in the coming decades.

"***Everyone knew that to reduce greenhouse gas emissions, it would be necessary to increase the share of electricity in many areas****. We were already working on electric vehicles at the time. When I was Secretary of State (between 2007 and* 2009), notably in charge of *foresight*, *I had led an exercise called France 2025, some conclusions of which were clear in this respect. In 2009-2010, we already knew that electricity consumption was going to increase in trend*," comments Mr. Besson.

With regard to nuclear energy, the report examined four different developments in electricity in France: the extension of the current nuclear fleet, the acceleration of the transition to the third generation (or even fourth generation), a gradual reduction of nuclear power and, finally, its complete abandonment in electricity production in France. This last hypothesis is a first in our country. It shows the psychological and political impact of the Fukushima disaster. The Energy 2050 report shows that there are several possibilities provided we give ourselves the means and the time.

*(1) Whose rapporteurs were Domique Auverlot and Richard Lavergne.*

*Cf. Centre for Strategic Analysis, Synthesis Note* "Energies 2050 " *n° 263 of February 2012.*

**While stressing the need to "*make energy sobriety and efficiency a major national cause*", it concludes, however, that "**the ***optimal trajectory for our country [consists] in extending the life of existing plants as long as ASN allows, in providing for a small number of third-generation*** *nuclear reactors. (EPR) to smooth production at the time of the closure of the oldest power stations*, ***and to prepare for the future by pursuing, alongside*** *the development of renewable energies, the* ***development of generation 4****, while leaving open the question of the share of nuclear power in 2050 and even in 2030". "This will depend on several factors: success of demand control lower costs of renewable energies, technological breakthroughs, feedback on the operation of French and foreign EPRs,* natural *gas prices*" says his introduction.

**In particular, the Energy 2050 report advises against any administrative closure of a nuclear power plant that has not been decided by the operator following the injunctions of the Safety Authority.**

**The rapporteur can only note here the lack of continuity of the State and of consideration for scientific and technical work.** Although it comes from recognized specialists, published by a reference centre of expertise **and available to government teams that came to power in 2012, it seems to have been "forgotten" when examining the Draft law on energy transition for green growth, which will have a lasting impact on the dynamics of the French nuclear power sector.**

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In the context that has just been recalled, the European market, which the Member States of the European Union want to open up more in the 1990s, seems to offer answers to the limits of the French model, opportunities for the all-powerful EDF, at least manageable constraints.

### 2. This illusion of overcapacity leads to the opening up of the electricity market to competition

Europe was built around energy issues, first with the creation, in 1952, of the common market for coal and steel within the European Coal and Steel Community (ECSC), and the creation, in 1957, of the European Atomic Energy Community (Euratom).

Mr Yves Bouvier also recalled that in the 1960s and 1970s, there were many sketches of a genuine European energy policy, modelled on the common agricultural policy. There were even plans to build European nuclear power plants within a Europe-wide network to rationalise energy production. These projects have been abandoned, one of the reasons being that European countries follow different, even divergent, energy strategies. The United Kingdom and the Netherlands have favoured natural gas, while Germany has long opted for coal. And in times of economic crisis, each country relies on its fundamentals.

Article 194 of the Treaty on the Functioning of the European Union (TFEU) preserves "*the right of a Member State to determine the conditions the exploitation of its energy resources, its choice between different energy sources and the general structure of its energy supply*".(1)

The same article gives the European Union the responsibility to: a) ensure the functioning of the energy market; (b) ensuring security of energy supply in the Union; (c) promoting energy efficiency and energy saving and the development of new and renewable energies; and (d) promoting the interconnection of energy networks, "*taking into account the need to preserve and improve the environment*" in addition.

For a long time, however, energy was considered to be part **of the so-called "excluded" sectors** alongside transport and water supply, given its strategic nature for national economies and vital for citizens, i.e. the rules governing competition were not fully applied.

But in the 1990s, when most national electricity and natural gas markets were still regulated monopolies, the European Union and the Member States decided to gradually open these markets to competition.

According to the privileged observer, Mr. Dominique Maillard, the European Commission was already convinced of the benefits of competition. Mr. Maillard says that it is supported on the subject by the two states that occupied a prominent place within the European Union, Great Britain and Germany. According to Maillard, Britain had an organisation comparable to France with the Central Electric Generation Board (CEGB), but it did not show much efficiency. The British dismantled it early on and liberalised production. Having done it at home, the English will then have pleaded in favor of the dismantling of EDF. As for Germany, the federal system is already organized around five, then four major operators; It therefore seemed natural to them that more operators coexist. Mr. Yves Bouvier even argues that EDF was erected as a scarecrow figure by German industrialists and politicians.

In Europe, the Italians had a system comparable to EDF, with Enel, as did the Spanish, but the latter followed the movement more than sought to constitute with France a pole of defense of the *status quo*.

*(1) Explicitly recalled in the TFEU by the Treaty of Lisbon signed on 13 December 2007.*

The first liberalisation directives (**first energy package**) were adopted in 1996 for electricity and 1998 for gas. These and subsequent texts aim to build an "internal energy market" at European Union level. This involves moving from several national markets operating independently of each other to a single integrated European market.

**Box 21: Creation of the European energy market**

**Directive 96/92**/EC of the European Parliament and of the Council concerning common rules for the internal market in electricity and **Directive 98/30/EC** of the European Parliament and of the Council concerning common market rules were to be transposed into the legal systems of the Member States by the respective deadlines of 1998 and 2000.

They were eventually replaced by **the second energy package** adopted in 2003.

At **the Lisbon Summit of 23 and 24 March 2000**, the Heads of State and Government affirmed their determination to speed up liberalisation in sectors such as gas and electricity, noting that most European countries had gone well beyond the liberalisation steps set (in particular the thresholds of 30% of the electricity and 28% of the gas market in 2000). In fact, as early as 2000, the average threshold for opening up the European electricity market was around 66% and 79% for gas or even 100% in the UK and Germany.

The Council of the European Union of 25 November 2002 finally concluded an agreement providing for the liberalisation of these markets for non-household customers by 1 July 2004 at the latest, followed by full opening for all customers no later than July 1, 2007.

These agreements are reflected in several texts adopted in June 2003, including Regulation (EC) No 1228/2003 on conditions for access to the network for cross-border exchanges in electricity, Directive 2003/ 54/EC concerning common rules for the internal market in electricity and Directive 2003/55/EC on common rules for the internal market in natural gas, which repeal the previous ones. They were in turn replaced on 13 July 2009 by the **third energy package**, which still forms the basis for the implementation of the internal energy market, with the following texts:

– Regulation (EC) No 713/2009 establishing an Agency for the Cooperation of Energy Regulators;

– Regulation (EC) No 714/2009 on conditions for access to the network for cross-border exchanges in electricity (repealing Regulation (EC) No 1228/2003);

– Regulation (EC) No 715/2009 on conditions for access to the natural gas transmission networks (repealing Regulation (EC) No 1775/2005);

– Directive 2009/72/EC concerning common rules for the internal market in electricity (repealing Directive 2003/54/EC);

– Directive 2009/73/EC concerning common rules for the internal market in natural gas (repealing Directive 2003/55/EC).

The first series provides for the separation of transmission (on high-voltage lines or by high-pressure pipelines) and distribution networks, on the one hand, and storage, supply and generation activities, on the other. This separation should allow better competition by preventing one operator from taking control of the entire production and distribution chain.

It also provides for the establishment of energy market regulatory agencies in each Member State, which provide regulatory oversight of national markets in order to promote their interconnection. These interconnections should make it possible to increase security of supply in the event of an overload or incident in a national market.

Cooperation between regulators is organised with the creation of an agency for the cooperation of energy regulators.

The opening up to competition is mainly recorded by the second series of texts, which establishes the principle that industrial and private consumers are Henceforth free to choose their own gas and electricity implore from has whole range of competitors, and affirms freedom of establishment for producers.

If they remain monopolies, national energy transmission and distribution networks must guarantee the right of access under objective, transparent and non-discriminatory conditions for all users.

Nevertheless, States may still impose certain technical limits on injections into networks and impose public service obligations on new market operators.

These provisions are based on the premise that European energy policy must be based on three pillars: security of supply, preservation of the environment and implementation of competition – without always ensuring compatibility between these three objectives. Mr. Maillard notes that competition does not necessarily guarantee security of supply. Indeed, instead of seeking to diversify their sources, the various actors have tended to rush together to the least expensive countries of origin at a given time, even if it means finding themselves faced with a rise in the unilateral price or an abrupt cessation of supply.

In any case, the proponents of the directives also believe that competition will have beneficial effects on prices and innovations.

**The construction of the Europe of energy therefore openly questions the large state structures**, even if, in principle, the ownership of companies does not fall within the competences conferred on the European Union by the Treaties.

The monopolistic organisation chosen in France is particularly concerned. Admittedly, the 1946 law on the nationalisation of energy left a small private sector, especially in small hydro, where independent producers were subject to a megawatt limit; and energy distribution can be operated by local authorities, which often emanate from local authorities. But transport is in a monopoly situation, and electricity production is largely owned by EDF.

The France strives to defend its organisation , with more or less resistance depending on the government.

President Jacques Chirac had accepted the 1996 directive on which the opening of the electricity market was based, but his first governments did not rush to transpose it. And when the first transcription text in domestic law, **Law No. 2000-108 of 10 February 2000** on the modernisation and development of the public electricity service, known as the "Pierret law", intervenes, the opening is limited to large consumers only, protecting the public electricity service which ensures a single tariff throughout the national territory(1).

**Mr Lionel Jospin recalled that in March 2001, at the Stockholm Summit, France blocked for the first time the setting of a timetable for the complete liberalisation of the energy markets**. It reaffirms its opposition and defends "controlled" liberalisation at the Barcelona Summit in March 2002. But France is in the hot seat. The summit concludes with an agreement on the opening up of the gas and electricity markets to competition by 2004 for professional users. This timetable will be completed by the Council of the European Union in November 2002 – after the arrival of a new political majority – which sets 2007 as the opening of markets for all consumers, including households.

French officials at the time no longer seemed so worried about the prospect.

Mr. Pierre Gadonneix, Chairman of EDF from 2004 to 2009, acknowledges that **they were confident about the opening of the market**: "*We were convinced that EDF would come out a winner, with the best tariffs in Europe.* They were about 30 percent lower than Germany's, he recalls.

The fact that the development of the European market offers **greater prospects for exporting its surpluses** is probably not unrelated to this feeling of confidence either.

In addition, faced with the growing problem of peak consumption, the strengthening of interconnections appears to be a consolidation of security of supply.

Finally, **Jean-Louis Borloo also saw the arrival of new entrants to the French market as a response to the need foradditional capacity**.

However, the European Commission and the countries that have opened their markets most widely **consider that the persistence of monopolies causes distortions of competition**, especially since the liberalisation of the markets has mainly accelerated the concentration of the sector in the hands of a few groups, including EDF, in the first half of the 2000s. The fact that an undertaking has captive customers in a Member State, and thus the assurance of income, facilitates its

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*(1) The 1998 Directive, which deals with the gas market, is transposed into national law by Law No. 2003-8 of 3 January 2003 on gas markets. and electricity and the energy utility.*

development in other national markets through acquisitions.

The annoyance of a foreign champion entering its domestic market and the reciprocal difficulties in entering a market dominated by quasi-monopoly firms have probably played into the pressures placed on States less advanced in opening up. This particularly concerns EDF, which is Europe's leading electricity producer. Mr Philippe de Ladoucette, President of the Commission de régulation de l'énergie (CRE) from 2006 to 2017, recalls that between 1995 and 2000, many European conferences reflected a form of annoyance vis-à-vis its extension and the fact that it was impossible to penetrate the French market.

In fact, in France on 1 June 2005, although 70 % of the national markets had theoretically been open to competition for almost a year, Gaz de France still held 82 % of the gas market and EDF 86 % of the electricity market.

Moreover, the French choice of an electricity mix where nuclear power largely prevails is not shared by the majority of European countries[(1)], in particular by Germany, which the SPD-Green coalition that came to power in October. 1998 committed to a gradual phase-out of nuclear power. As for the United Kingdom, it has just discovered major oil deposits and its privatisation of the energy sector has led to the de facto abandonment of all construction projects from the late 1990s to the early 2010s. Suspicion of nuclear power is also quite widespread in European public opinion, which is still marked by the Chernobyl nuclear accident in 1986. We can therefore think that the fate of the French nuclear champion does not move much, especially since the decarbonisation of electricity production is not yet a priority subject at the time.

The France is thus strongly encouraged to change the organisation of its energy sector throughout the 2000s.

### *a. The opening of the capital of EDF and GDF*

**Law No. 2004-803 of 9 August 2004** on the public service of electricity and gas and electricity and gas companies aims first and foremost to adapt in French law, two principles stemming from European directives:

– the management independence of transmission and distribution network operators, by creating dedicated subsidiaries. To maintain the integrated character of EDF and GDF (Gaz de France) groups, these subsidiaries are wholly owned by EDF and GDF or by the State or any other public sector company;

*(1) At the end of 1999, of the 25 Member States, only 12 had nuclear power plants: Belgium, Finland, France, Germany, the Netherlands, Spain, Sweden, the United Kingdom, Hungary, the Czech Republic, Slovakia and Lithuania.*

– and transparent and non-discriminatory third-party access to transmission and distribution networks.

This reorganisation of network operators does not seem to have posed any problems other than political. Especially the law reaffirms the preservation of public electricity and gas services and the principle of tariff equalisation in electricity.

The 2004 law focuses more fundamentally on transforming the public industrial and commercial establishments EDF and Gaz de France into companies whose capital can be opened up to 30% to shareholders other than the State (Article 24).

This development is intended to repeal the principle of speciality which confined the activities of the two companies to the supply of energy and prohibited them from marketing associated services. It should allow, according to the initial presentation of the Minister of Economy, Finance and Industry, Thierry Breton, the two companies to "*compete on equal terms with their European competitors"* and "*to develop and diversify their marketing activities both on French territory and abroad and especially on the market European interior*". The public service missions incumbent on EDF and Gaz de France will be the subject of a contract signed with the State.

While recalling the strengths of the two companies and the great attachment of the French to their champions, MP Jean-Claude Lenoir, rapporteur of the text, explains that: "*the notion of a single European market is not (...)* ***not compatible with the maintenance of the State monopolies hitherto constituted by EDF and GDF****. The status quo is therefore impossible. (...) Adaptations are needed to open up our market to competition. But these adaptations do not require us to question the values to which we are legitimately attached and which have forged the success of our electricity and gas system*." "*Drawing lessons [from deregulation in Britain or the United States, the European Commission] is now very keen to ensure that the opening up to competition is regulated and is not guided exclusively by market imperatives. The latest directives (...) of 26 June 2003 - which must now be transposed into French law - thus require Member States to lay down precise rules on regulation, public service obligations, consumer protection, security of supply and safety of the electricity system*'.[1]

This reform is presented as an industrial opportunity: *"it is a question of making EDF and GDF, French champions of today, the European champions of tomorrow*". However, "***these companies are now audiences operating in competitive markets.***

*(1) Cf. National Assembly, Report No. 1659 registered on 8 June 2004.*

**This situation makes investments necessary and constrains their financing**. [In addition to its own financing needs] this new context makes (...) investments necessary because it requires companies to develop or decline. It must be understood that incumbent operators faced with the opening up to competition of their markets, on which they were by definition in a monopoly situation, can only lose market share on these. In relatively sluggish markets (unlike, for example, the telecommunications sector), this loss of market share automatically leads to a decline in turnover. On the other hand, their status as public institutions only allows them to finance themselves, to receive State grants, insofar as they are not reclassified as State aid, or to go into debt, but EDF is already with a debt - net representing 1.3 times its own funds.

EDF therefore became a public limited company on 19 November 2004. On 21 November 2005, it listed 15% of its capital on the Paris Stock Exchange. Two years later, the state sold 2.5% of its capital. At 31 December 2020, 83.68% of the capital was still held by the State, 14.94% by the public (institutional for 12.97% and individuals for 1.97%), 1.36% by EDF employees and 0.02% by EDF.

The process will go further with regard to SFM. On April 7, 2004, before the National Assembly, Mr. Nicolas Sarkozy, then Minister of the Economy in the government of Mr. Jean-Pierre Raffarin, assured that "*EDF-GDF will not be privatised, neither today nor tomorrow. The government of France wants the state to retain a majority stake in this large company. We will debate it because the law will set a minimum threshold*." This threshold was set at 70% by the law of 9 August 2004 and the company was floated on the stock exchange on 6 July 2005. But on February 25, 2006, officially to counter the threat of a hostile takeover bid by the Italian Enel on the private group Suez, the government of the new Prime Minister Dominique de Villepin announced the merger of GDF with Suez. After eighteen months of opposition from the unions and many elected representatives, who see in this merger a privatisation of the gas group, **Law No. 2006-1537 of 7 December 2006** on the energy sector authorises this operation (Article 39), accompanied by various provisions continuing the transposition of European directives and securing the gas tariff system.(1)

*(1) The merger was formalised on September 3, 2007; in 2015, the group became Engie. Finally, Law No . 2019-481 of 22 May 2019 on the growth and transformation of companies, known as the PACTE law, authorises the State to sell its entire stake in Engie (just over 24% in 2019). It retains only a specific action giving it the right to oppose the most strategic decisions. The law also authorises the operator of the public transmission networks, GRTgaz, to open its capital to private investors; it will henceforth impose only a "majority holding" – and no longer total – of the capital by Engie or public entities.*

EDF therefore remains the great national champion of electricity. But **its new status as a private law marked a clear international turning point from 2005.**

However, if this evolution is in line with the 2004 reform, observers are led to worry about a **persistence** in **undersizing** its **investments in maintenance** – without sacrificing safety, however, – **despite the contribution of capital that its opening of capital has brought it**, until it was asked to rebalance its investments in the late 2000s.

**Box 22: EDF's IPO**

**On the eve of the 2010s, there was a relative underinvestment in French production**[1]
Heard by the Committee on Economic Affairs, the Environment and Territory of the National Assembly, the Chairman and Chief Executive Officer of EDF, Mr. Pierre Gadonneix declared on 10 December 2008: "*It has become urgent for EDF to quickly and massively relaunch investments. For* ***ten or fifteen years, the latter experienced a very significant slowdown****, accompanied by a tariff reduction. This was only possible – I am not saying* it *was desirable – because we had excess production capacity. They are no longer and even became problematic in 2005.*"

However, EDF's IPO in 2005 did not mark an immediate return on its national investments. It was only from 2007 that EDF began to mobilise resources to catch up, very gradually.

During its examination of EDF's accounts and management from 2003 to 2008[2], the Court of Auditors had come to question certain strategic and financial group of the industrial group that will have weighed at the time on the company's ability to meet its internal responsibilities.

**From 2005**, **the group's priorities took a clearly international turn**, with the result that in a few years, the company achieved almost half of its turnover of business out of France. The conquest of these world market shares seemed necessary to counter the threat for EDF to lose share in its historic French market with its opening to Community competition will complete from 2007. The company also highlighted the need to maintain and enhance the experience of its teams in nuclear matters and their know-how as an architect and operator of 3rd generation power plants, while most of the French fleet is already built. This search for growth drivers and external synergies has notably involved the takeover of energy companies from other countries or development projects – with varying degrees of success.

EDF's international ambitions are legitimate, as are its concerns about financial profitability, but the 2012 rapporteurs recalled that "the group, *84% owned by the State, carries out an activity in a quasi-sovereign domain since it affects energy independence and the protection of populations against an industrial risk that could potentially be large-scale. (...) It must therefore ensure a public service in the best conditions for the national population, but also to accompany the necessary changes in an optimal timetable*. »

*(1) On this issue, we can usefully refer to the information report n ° 4463 of 7 March 2012 of the deputies Marc Goua and Camille de Rocca Serra on the financial situation and the prospects for Electricité de France and Areva.*

*(2) Special report RB 56-409 of 21 October 2009.*

Because this slowdown in heavy maintenance expenses, when the plants began to reach year operating life of fifteen gold twenty years, was has **source of damage and had an impact on the group's production capacities**. The availability rate of nuclear power plants fell by 10 points between 2006 and 2010. **At the beginning of 2011, the New Chairman and CEO of EDF still acknowledged that:**

***"The majority of the cut will soon cross the Decisive Milestone of thirty years, which, in a heavy industry like ours, corresponds to the renewal of large components. [...] We have fallen behind in this area. This has no impact one safety but causes severe damage and affects our performance."***

The subject was all the more strategic as there was already talk of the hypothesis of year extension of the life of power plants.

In any case, today, the Directorate General for Energy and Climate (DGEC) of the Ministry of Energy Transition notes that "***EDF exercises its responsibilities*** *as operator* of the French *nuclear fleet, including in the field of nuclear safety and radiation protection, by carrying out large-scale maintenance and safety improvement operations, which have been taking place in particular for more than ten years"*. Beyond the issue of maintaining the level of performance of the facilities that these arbitrations between the international and the national seem to have allowed to deteriorate, Ms. Corinne Lepage also denounces the fact that these massive investments abroad have resulted in "*little*" and that they have not prevented the company from losing skills.

For his part, Mr Philippe Page Le Mérour, Secretary of EDF's Central Social and Economic Committee[1], criticises the reform for having encouraged EDF to favour a logic of profitability rather than continuing its investments in networks, hydropower and nuclear power. "*Particularly worrying*", the current debt of the group would result, according to him, for a third "*from the sometimes foolish bets of EDF executives internationally*" and for another third from the system of regulated access to historic nuclear electricity (ARENH, see below).

**The evolution of the EDF group's debt,** recalled in Appendix 4, **shows that it had risen sharply well before the introduction of ARENH in 2011. It even reached €42.5 billion in 2009. It had fallen back to €34.4 billion in 2010 and then varied, never returning to its 2009 level until 2020.**

However, it is impossible to distinguish between EDF's indebtedness and its changes attributable to its international investments, its investments in the French fleet and the operation of ARENH. **EDF indicated to the rapporteur that it was not in a position to calculate the amount of its debt linked to ARENH.**

*(1) Hearing of Mr Philippe Page Le Mérour as part of the round table on January 17, 2023.*

### *b. The emergence of the hydroelectric concession issue*

The first part of this report takes stock of the outstanding issue between France and the European Commission of the conditions for the renewal of hydroelectric concessions (reopening of competition or quasi-governance). In the absence of a decision, a number of concessions that have expired since 2003 have not yet been renewed. The continuation of their operation remains authorised under the regime of "rolling deadlines", but **the uncertainty about their future leads their operators to minimise their investments** in these concessions, as in all those whose deadline is approaching, to what is strictly necessary.

This situation limits in particular investments in the optimisation of production capacities in the hydro sector. However, there is a strong concern among elected officials, local and national, and our compatriots to lose part of the country's electric autonomy (the sector provides 14% of the *mix*) if foreign companies win these concessions on the occasion of their re-competition.

Even if the concession regime preserves State ownership of dams and their operation is carried out within the framework given by the latter, it is particularly difficult to impose coordinated management of the different uses of water on different operators who would intervene in an area, *a fortiori* the same watershed.

However, if the European Commission did not put France formal notice to settle the file until 2015, the **government of Mr. François Fillon had envisaged the reopening of competition of these concessions in July 2008.**

When asked, **Mr Jean-Louis Borloo replied that by being part of the European market, we had to leave room for competition**. Even under French law, there is no perpetual concession, especially when it comes to a private company.

In addition, a first battle had taken place with the Compagnie Nationale du Rhône (CNR). "*We wanted to comply. The pressure from the European Commission was real, just as it is today. We therefore prepared a decree, **preparing the competitive tendering procedure, but without triggering any**. The construction site remained as it was. **To be honest, it was a way to save time**.*" In fact, no decision was made one way or the other to settle this issue.

Mr. Jacques Percebois notes that the European Commission would have used the disagreement on hydraulic concessions as a pretext to prevent the publication of the decree on the application of the ARENH in 2015.

**The rapporteur considers that such a lack of decision, and the establishment of this situation, have permanently weakened the hydroelectric park and its investments, on which a sword of Damocles weighed, which has only increased with time and formal notices of the European Commission.**

### c. *The challenge to EDF's dominant position by the NOME law of 2010 and the establishment of ARENH*

The choices that will be made in Law No. 2010-1488 of 7 December 2010 on the new organisation of the electricity market, known as the NOME law, were strongly determined by the context of the preceding years.

First, the European Commission opened two infringement procedures against France. The first, for failure to transpose the 2003 directive, was supported by the Constitutional Council in a 2006 decision.

The second considered that the regulated electricity purchase tariffs enjoyed by companies with large or medium consumption (yellow and green tariffs) constituted State aid contrary to European law. Confirmation of that procedure would have involved the repayment by the beneficiaries of all the 'aid' received. At the time, we were talking about billions of euros for French industry.

The Government therefore had to combine sometimes divergent interests, Mr. Borloo recalls, between the desire to protect electro-intensive companies from this threat, and that of continuing to benefit French consumers; the competitiveness of the nuclear fleet – which produces electricity that is cheaper than market prices(1); – the interest in promoting the development of interconnections through further integration of the European market and that of seeing the arrival of new entrants to our market to cover peak consumption.

The integrity of the EDF group was also at stake in France's willingness to respect competition. However, the French market did not seem to evolve fast enough for the taste of its competitors. Heard by the Economic Affairs Committee of the National Assembly on 12 May 2010, three years after the full opening of the electricity market, Mr. Philippe de Ladoucette noted that out of 35 million consumption sites (for 449 TWh annually), about 1.5 million residential sites had switched to competition (for a consumption of 7 TWh) and 750,000 non-residential sites (representing a consumption of about 140 TWh) were in market offer, but more than half of this consumption was sold at the transitional regulated market adjustment tariff (TaRTAM), of which about 60% by EDF.

A period of very high market prices had indeed led the Government, before 2007, to return urgently – and all the more temporarily as this had been done without consultation with the European Commission – to a form of regulated tariff, the TaRTAM, to protect industrial consumers. It was due to expire in 2010.

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*(1) We also speak of nuclear rent or infra-marginal rent, i.e. the economic advantage provided by production capacities that are less expensive than marginal capacities that set the market price.*

All these events led the Government to set up in 2008 **the "Champsaur Commission",** made up of two parliamentarians and three economists, to consider how to respond to this situation.

The Champsaur Commission studied several avenues. It ruled out the avenues represented by the exit from the European market, the dismantling of EDF and the direct sale on the market associated with a taxation of the rent to redistribute it.

To the extent that several players (GDF-Suez, ENEL, EON, etc.) announced at the time that they were considering investing in nuclear power, the choice was made for a temporary arrangement of fifteen years to sell EDF competitors volumes of electricity at the full cost of the nuclear fleet. The Commission proposed that this volume be capped at a total of 100 TWh per year, which represented about 20% of the production at that time.

**Box 23: The Champsaur Commission**

The Champsaur Commission also studied **different models for calculating the selling price**:

– The long-term renewal cost made the most sense in a renewal process. But this possibility was ruled out because the renewal was distant and the regulatory device transitory;

– The base remuneration model for assets could be considered. It's about taking an asset base and paying for it. But this approach was difficult to implement because the park had been largely reimbursed in the nineties. A conventional revaluation of the asset base was necessary, but it was difficult to justify;

– The third method, which was chosen, was that of **economic current costs**.

The idea was to cover all of EDF's costs during the regulation period (operation, depreciation, dismantling as well as major repairs, investments in life extension, i.e. the major refit, and investments made after Fukushima). This model was quite comfortable for EDF because, in principle, everything had to be paid for over the regulation period, even though the extension of the life was going to be spread over 10 or 20 years.

**On the other hand, ARENH was not to deal with new nuclear power.** Mr. Pierre-Marie Abadie, who was director of energy at the Ministry of Ecology, Sustainable Development and Energy from 2008 to 2014, explains that the mechanism for covering future reactors was still being studied. One of the avenues considered was in particular that of "*contracts for difference*" chosen by the United Kingdom for Hinkley point.

The law also provided for the possibility of signing long-term contracts that would share the risks between EDF and the signatories, in order to obtain a price cheaper than the regulated price that does not bear any risk.

Finally, access to nuclear power is determined according to the national market shares of EDF's competitors. This approach ensures that the electricity obtained at an ARENH price is intended for French consumers. Otherwise, a correction, called price supplement, makes it possible to recover the transferred benefit.

Thus, in the initial design of the device:

– the "infra-marginal rent" is not transferred from EDF to its competitors, but to French consumers;

– EDF's costs were to be fully covered by ARENH's price calculation method;

– But the renewal of the park, whose prospect was still distant, had to be financed by other devices still to be defined.

**In any case, this device, which will become the Regulated Access to Historic Nuclear Electricity, or ARENH, is a French initiative, which its approval by the European Commission – on the express condition that it is provisional – has made it possible to lift the ongoing procedures**.

The **NOME law of 7 December 2010** is a direct result of this work. It reorganizes the French electricity market to allow its effective opening and encourage the arrival of alternative suppliers by ensuring them access to historic nuclear electricity (ARENH) on economic terms equivalent to those enjoyed by EDF, while aiming to preserve competitive prices in France for final consumers and the present and future financing of the existing nuclear power plant.

With this in mind, the NOME law requires EDF to sell part of its nuclear production to competition at a price defined by decree, known as the ARENH tariff. **The system is framed at different levels** :

– the electricity concerned is the '*share of electricity supplied corresponding to the production of power plants operating continuously with the exception of maintenance shutdown periods*' and the volume to be divested is capped at 100 TWh per year.

The Commission de régulation de l'énergie (CRE) is responsible for controlling the sharing of electricity volumes between the different suppliers. This is done according to their forecasts at first, then on the volumes actually sold to residential customers. To avoid deadweight effects, they are asked for an additional price if the volumes received prove to be higher than the reality of their needs;

– The law does not fix a tariff, but a method of fixing prices. This is supposed to represent the full cost of production. **It must** "***ensure fair remuneration for Électricité de France***" taking into account the addition, in particular, operating costs, costs of maintenance investments or those necessary for the extension of the duration of the operating licence, and estimated costs related to the sustainable management of radioactive materials and waste and decommissioning operations.

The Champsaur commission had initially suggested a price of 32 or 34 euros per megawatt hour. The Commission de Régulation de l'Énergie (CRE) proposed a tariff of 36 or 38 euros. Following the parliamentary debate, this tariff was set at 40 euros – the floor price for EDF, according to Eric Besson – increased to 42 euros in 2012, after the Fukushima incident, to take into account the costs induced by safety requirements. Mr. Besson remembers the critics of the time who saw it as a "gift" to EDF.

The CRE itself does not set the price: it gives an opinion.

In addition**, the law provided that three years after its promulgation, a decree would define the calculation method used by the CRE for the annual evolutions of the ARENH**;

– To strengthen the security of supply of France, "each electricity ***supplier must have direct or indirect guarantees of demand response*** capacity[(1)] and ***electricity*** *production that can be implemented to satisfy the balance between production and consumption on the continental metropolitan territory*" (Article 6, NOME Act). Otherwise, the supplier risks a financial penalty or even the immediate suspension of its authorisation to resell electricity in France.

The rapporteur notes that the requirement laid down in Article 6 of the NOME Law has **left a very comfortable choice for alternative suppliers**, **who have been able to content themselves with providing demand response guarantees**, **without developing new production** capacity. This was systematically the case for a long time. It is only very recently that large groups such as Total (now TotalÉnergies) have begun to invest in new production facilities. **The rapporteur regrets that the law that created the ARENH system did not define a minimum of productive obligations in return for a very advantageous and otherwise not very restrictive system** (see the following sections on the problems posed by this device).

More generally, the law provides for the sanction of any abuse of ARENH's rights;

– Implemented from 1 July 2011, the system ends on 21 December 2025, but can also be suspended "*in the event of exceptional circumstances affecting the plants*";

– Finally, the scheme had to be re-evaluated before 31 December 2015 and every five years thereafter.

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*(1) By not consuming electricity for a certain period of time or postponing this consumption.*

In parallel with the definition of the ARENH framework, the NOME law includes provisions relating to the security of energy supply, regulated tariffs and the composition and missions of the CRE.

In particular, it reaffirms that all consumers can choose offers from different suppliers, while reinforcing regulated sales tariffs for small consumers (which only EDF can offer since it has signed a public service contract with the State). On the other hand, yellow and green tariffs must be abolished by 2015 and make way for market offers.

When the Court of Auditors evaluated the ARENH mechanism in 2017, it described it as a "*compromise mechanism*", which Borloo and Besson fully acknowledge.

**Mr Borloo rightly points out that for several years the scheme did not really give rise to debate, because alternative suppliers made little use of it because of lower electricity prices on the wholesale market**. **The situation was complicated later, revealing a regulation of the device more chaotic than expected**.

As for EDF, the political leaders were primarily concerned with protecting its monopoly on the existing nuclear fleet while meeting the Community obligations to which France had subscribed.

They also considered that they had treated the company well by setting the tariff at €42/MWh. Besson recalls that, moreover, many experts thought that EDF, thanks to its installed capacity and the competitive marginal price of the nuclear fleet, could be one of the big winners of the development of interconnections favored by the opening of markets. "*None of us would have accepted a device that would have aimed to weaken EDF*."

This did not prevent the successive directors of EDF from denouncing what they saw as "*a subsidy to its competitors*" (Mr Pierre Gadonneix during his hearing by the committee survey), a gift made "*to traders and not industrialists*" (Mr. Henri Proglio[1]).

*(1) Hearing of Mr Henri Proglio, December 13, 2022.*

Heard by the Economic Affairs Committee of the National Assembly on the occasion of the examination of the bill, Mr. Proglio had stressed the **need to take into account industrial issues** and alerted elected officials that "*only the prospect of a programmed reduction (of the volumes of electricity to which will have access alternative suppliers) may* ***encourage them to develop their own supply****, either through direct investment or through industrial agreements with other suppliers. If this were not to happen, the entire electricity system would be at an impasse – no operator would have an interest in investing – and our country's security of supply would be at risk.*"

#### *d. Market* **design** *unsuited to nuclear power*

Pierre-Marie Abadie explains that at the time, the construction of the European electricity market was seen as competition between thermal producers – operating coal or gas power plants – which have a relatively similar relationship between CAPEX and OPEX.

Market *design* aims to set up the best mechanism for allocating means of production in the short term. The latter on which the process of integrating European markets was based logically referred to marginal cost pricing (the market operating at the **marginal cost** of the last unit called), which is an efficient way to select the best unit to call in a system requiring little CAPEX. The investment is made in thermal power plants that are relatively easy to develop.

If renewables were still off the market, because financed by predetermined tariffs or calls for tenders, nuclear, which mobilises a lot of CAPEX but few OPEX, constituted, in the words of Mr. Abadie, a "*strange piece*" in this context: its specificities were not all things considered, neither does its competitive price.

Nevertheless, it worked for a few years. But the context has changed since then. Renewable capacities, which are essentially CAPEX, without OPEX, have taken a significant place in the European electricity system. **The price signals returned by the market no longer have the same relevance**, **at least not the same meaning, and no longer make it possible to remunerate investments at their fair value**.

## B. NEW OBJECTIVES EMERGE, WITHOUT INDUSTRIAL LEVERS

### 1. The first energy efficiency and renewable energy targets appear

French governments began to implement energy-saving policies in the 1970s. After the first oil shock, controlling demand and reducing imports of fossil fuels, which had been the engine of our economies and comfort since the industrial revolution, was indeed an issue of sovereignty.

The French Agency for Energy Management (AFME) – which became the Environment and Energy Management Agency (ADEME) in 1991 – was created in 1982. It provides important communication around everyday gestures, with slogans that we still remember: “We don't have oil but we have ideas”; we also proposed to “drive out waste”.

But prices then returned to bearable levels and the development of nuclear power brought a more virtuous alternative solution from the point of view of air pollution, and abundant. The efforts were quickly forgotten because the environmental dimension was little perceived. Electricity was not rationed, fossil energy resources seemed immense, and the consequences of their consumption on the climate were still invisible to the population.

The impacts of certain forms of energy on the air were not ignored but these topics were not yet a priority. As for the phenomenon of greenhouse gases (GHG), it was known to physicists since the late nineteenth century, but the possibility that emissions related to energy and human activity The climate was understood very late and remained controversial.

The creation of the IPCC(1) in 1988, the first international conference on climate change in The Hague in 1989, the Rio Earth Summit and the adoption of the United Nations Framework Convention on Climate Change (UNFCCC), which aims to stabilise the concentration of greenhouse gases in the United States the atmosphere at a level preventing any dangerous disruption of the climate system for humans, then the Kyoto Protocol signed in 1997 (which entered into force only in 2005) gradually changed the paradigm of public policies.

These commitments will underpin the implementation of new climate policies in Europe and France. But the evolution of priorities is more general. Mr. Yves Bouvier observes that the 1990s and 2000s marked the emergence of a form of environmental preponderance in energy debates. Consumption and its carbon emissions, rather than its economic utility, have even become the measure of energy according to him.

The secondment of energy from the Ministry of Industry or the Economy to be attached to the Ministry of the Environment from 2007 would illustrate this evolution of opinions.

### *a. The adoption of the European Climate and Energy Package*

The Kyoto Protocol was ratified by the European Union in 2002. **It has a collective target of an 8% reduction in greenhouse gases**.

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*(1) Intergovernmental Panel on Climate Change*

Even after the Kyoto Summit, the European authorities are committed to setting up a European market in emission rights, which corresponds to one of the three "flexibility" mechanisms allowed by the Kyoto Protocol and is today the main instrument of its climate policy.

The EU Emissions Trading Scheme (EU ETS)(1) is established by Directive 2003/87/EC of 13 October 2003 in order to '*promote reduction of greenhouse gas emissions in economically efficient and efficient conditions*" (Article I). It sets up a limit on the gases to be emitted by sectors of activity and a carbon market – a trading exchange – where each company can buy or sell emission allowances. In the first period (2005-2007) the system is limited to the most polluting industrial plants, but this also includes combustion plants such as coal-fired power plants, which increases their operating costs.

This mechanism is complemented by the adoption, on 12 December 2008, of the European Union Action Plan for a common energy policy and the fight against climate change. The aim is to achieve the "20-20-20" (or "3x20") objective, i.e. increasing the share of renewable energies in the European energy *mix* **to** 20%, reducing $CO_2$ emissions from EU countries by 20% and increasing energy efficiency by 20% by 2020.

In 2017, the European Court of Auditors carried out an initial assessment of Community policies in the fields of energy and climate, noting in particular the obstacles encountered in their implementation. Nevertheless, it has observed rapid growth of renewable energy industries in Europe and a significant decline in costs. And in fact, Eurostat notes that the European Union has achieved its objective of achieving at least 20% renewable energy in its final energy consumption in 2020, with an average rate of 22.1%.

In terms of energy efficiency, on the other hand, the European Court of Auditors noted significant delays in achieving the objectives, in particular due to a lack of constraints. For example, 75% of buildings in the European Union were not energy efficient in 2017.

### *b. The affirmation of France's first ambitions in terms of energy performance and renewable energies*

In France, in 1989, an interministerial technical group was set up to consider an action programme against the greenhouse effect. It was replaced in 1992 by the Interministerial Mission on the Greenhouse Effect (MIES). Our country is thus building a reflection on the problem and is in a position to present in 1993 to the

(1) *Also known as the European* Union Emissions Trading System *(EU ETS).*

European Commission the first elements of a French programme to combat the greenhouse effect which is already based on energy saving, a tax on fuel, the awareness of energy saving and efficiency, as well as the development of a nuclear fleet.

However, they have not yet been followed by concrete measures. The new government of Mr. Alain Juppé nevertheless adopted **Law No. 96-1236 of 30 December 1996 on air and the rational use of energy, known as the "LAURE** law" or "Lepage law" named after its Minister of the Environment, which is part of a certain continuity even if it targets air quality rather than GHG emissions.

In fact, this law is the starting point for air quality protection in France. Enshrineding the right of everyone "to *breathe air that is not harmful to his health*" (Article I), it set out a policy to prevent, reduce and eliminate air pollution, including that which may affect climate change. And to do this, it subordinated the economy and rational use of energy to this goal. Even if they were not the heart of the law, a series of measures were planned to reduce energy consumption, indirectly, by promoting cycle paths in the city, or directly, *via* technical rules and tax incentives. In particular, the tax regime applicable to fossil fuels and renewable energies had to take into account the effects of their use on the competitiveness of the economy, public health, the environment and security of supply.

Deploring the fact that this law has been generally poorly applied, Ms. Corinne Lepage observes that the implementation of some of its provisions would nevertheless have "*saves time*" with regard to natural gas for vehicles, energy consumption control, energy performance diagnosis, renewable energy development, etc.

Mrs. Dominique Voynet, who took over her portfolio in the government of Mr. Jospin, assures that many tools have been implemented, but in terms of energy saving, the LAURE law was only a guiding law, without very restrictive provisions.

Instead, Voynet has sought to incorporate it into **the first national programme to combat climate change**. Presented **in December 2000**, **it is ambitious**, sweeping all major fields of human activity and providing for various measures to reduce emissions, particularly at the territorial level within the framework of State-regional contracts. These measures are almost exclusively focused on energy: energy management in buildings and electrical uses, piggyback transport, improvement of public transport, etc. And we see for the first time a carbon tax project.

This programme also announced the mobilisation of €1.5 billion in 2001 to support the production of renewable energies. It thus complemented the establishment, by **Law No. 2000-108 of 10 February 2000** on the modernisation and development of the public electricity and gas service, of **a support mechanism**

**for renewable energies which will become one of the fundamental instruments of energy policies in France**.

Both the **obligation to purchase** by **EDF** (essentially) renewable electricity production (Article 10), which guarantees an economically profitable outlet for installations whose capacity does not exceed 12 MW, and the principle of full compensation for renewable electricity costs, and the **principle of full compensation for renewable electricity costs. public service** (including purchase obligations) incumbent on **electricity producers** – known as the CSPE, initially in the form of a tax on final consumption, today through a reimbursement of the State budget – (Article 5), which protects obligated buyers, as well as the right to be able to inject its production into public networks transmission or distribution, under certain conditions, to sell it in particular.

In any case, the climate change programme has not been followed up much more than the LAURE law, according to Ms Voynet. Not all regions would have played the game and the climate threat is perceived as a distant prospect, if not denied.

In November 2002, during the second annual review of the implementation of the national programme, it became clear that its implementation had been insufficient so far to ensure that French GHG emissions were maintained, below the Kyoto objective by 2010. In response, President Jacques Chirac evoked, at the opening of the 20th session of the IPCC, on February 19, 2003, the need to halve global GHG emissions, which for France could mean a division by four or five of its emissions.

A Climate Plan was drawn up in 2004. A bonus-malus on passenger cars is announced, which will ultimately not see the light of day, and, in the building sector, the generalisation of the energy performance diagnosis (DPE) and the introduction of thermal regulations, mandatory in certain cases of renovation-rehabilitation operations.

But **the decisive step was taken** under the government of M. Jean-Pierre Raffarin **with Law No. 2005-781 of 13 July 2005** on programming setting the guidelines for energy policy, known as the **POPE law**.

First, among its multiple objectives (among others, contributing to national energy independence and guaranteeing security of supply, ensuring a competitive price of energy), the law formalises the fight against climate change as a priority of energy policy.

Secondly, **it puts in place the major energy efficiency systems**, starting with the thermal regulations for buildings (RT 2012) and the energy saving certificates (EEC) which attest to the completion of renovation work. energy and oblige energy suppliers to finance part of the work of private individuals through energy saving bonuses.

And finally, for **the first time, it gives quantified objectives**:

– reduce greenhouse gas emissions from France by an average of 3% per year to four or five times by 2050;

– reduce final energy intensity by % per year from 2015 and by 2.5% per year by 2030. Energy intensity refers to the ratio between a country's energy consumption and gross domestic product (GDP), it thus draws the desired trend for the control of energy demand;

– Covering 10% of energy needs by renewable energies by 2010 – with the "*indicative*" target of 21% of domestic electricity consumption covered by renewable energy sources, while electricity production by thermal power plants was still significant. This includes increasing the production of heat from renewable sources by 50% and increasing the share of biofuels.

The nuclear option is maintained with the authorization to construct a new generation nuclear reactor (see A of this I), but it is important to diversify energy supply sources.

Barely elected to the presidency of the Republic in 2007, less than two years after the POPE law, Mr. Nicolas Sarkozy asks his ministers in charge of ecology and sustainable development, Mr. Alain Juppé then M. Jean-Louis Borloo, to organize meetings between representatives of the State, local authorities, social partners, companies and non-governmental organisations (NGOs) involved in environmental issues to make long-term decisions on the environment and sustainable development. Responding to a commitment by candidate Nicolas Sarkozy, who had signed Nicolas Hulot's Ecological Pact, the **Grenelle Environment Forum** takes place between 6 July and 25 October 2007 and addresses various environmental themes, including climate change, waste and energy, but excluding the issue of nuclear power.

Ms. Nathalie Kosciusko-Morizet, who had conceived the project as environmental officer in the campaign of Mr. Nicolas Sarkozy, then in charge of the negotiations as Secretary of State, explains that the Grenelle aimed to bring together all the actors, whose views were sometimes diametrically opposed, to agree on cooperative policies that would go beyond historical quarrels. "*This is one of the reasons why topics such as nuclear, hunting and GMOs were excluded*. She is convinced that this innovative approach has "*made it possible to tear some of the corsets where public policies were trapped*".

Energy issues were dealt with in particular by the first working group, in which all the colleges participated. Title – "*fight against climate change and control energy demand*" – shows "the *preponderant role played by energy efficiency and* *consumption control in the work of the Grenelle, relegating to a secondary place issues related to production*".

At the end of the Grenelle, 263 commitments were made by the Government, including the study of the creation of a tax based on the energy consumption of Goods and services (carbon tax) – track that will finally be abandoned between the 2009 law and that of 2010.

This work led to Law **No**. 2009-967 of **3 August 2009** on programming relating to the implementation of the Grenelle Environment Forum (known as Grenelle **I**), adopted almost unanimously by the National Assembly. It is supplemented by **Law No**. 2010-788 **of 12 July 2010** on the national commitment to the environment (known as **Grenelle II),** which specifies the practical modalities.

The objectives are a little more ambitious, and above all more detailed and more binding than those of the POPE law.

The central objective relates to climate and specifically aims to reduce greenhouse gas emissions by four **between 1990 and 2050 "***by reducing* greenhouse gas emissions into the atmosphere by an average of *3*% per year, in order to **reduce** its annual **greenhouse gas emissions** to *less than 140 million tonnes of carbon dioxide equivalent per year.*" (Article I). The sectors most affected by this challenge are buildings and transport, which together account for 40% of total emissions. But the programming law also devotes a **whole section to the reduction** of energy consumption, which presupposes the implementation by the State of various instruments including the adaptation **of consumption standards**, the implementation of incentive mechanisms, including of a fiscal nature, in favour of the most energy-efficient products, the extension of the energy labelling, strengthening the EWC system, but also incentive mechanisms to promote the production of renewable energies, particularly by small and medium-sized enterprises, etc.

It is also stressed that "*the objectives of energy efficiency and sobriety require the establishment of mechanisms for adjustment and demand response of peak energy consumption*" and that *"the implementation of these mechanisms will include the installation of smart meters for individuals*."

In order to achieve the overall GHG emission reduction target, the Act provides in particular:

– for energy and climate, the primary objective is to **increase the share of renewable energies (RE) to at least 23% of final energy consumption by 2020** – "*a doubling compared to 2005* – with the setting of intermediate targets for each sector in 2009.

This increase, equivalent to 20 Mtoe, is **not intended to replace nuclear**

**energy, which is not mentioned.** Other objectives of the Act, however, are "*diversify energy sources*" and *"reduce the use* of *fossil fuels*".

The law also announces the regional planning of the development of renewable energies, *via* regional renewable energy schemes, and the encouragement of development of pumped energy transfer stations (STEP), which are still the only real energy storage solutions;

– for buildings and housing, the fivefold division of energy consumption in new buildings in 2012, the rehabilitation of 800,000 social housing units to halve their energy consumption by 2020 and the amendment of the urban planning code to promote renewable energies.

It is also recalled that "*controlling energy demand is the sustainable solution to the problem of rising energy costs for consumers*";

– for transport, the overall reduction of GHG emissions from the sector by 20% by 2020, bringing them back to the level they reached in 1990. The programming law also breaks down this axis into objectives differentiated by area, in particular by promoting the development of urban public transport, rail motorways and alternative modes to road freight freight;

– finally, the creation of regional climate, air and energy plans (SRCAE) which must set out the main orientations of the Grenelle laws in terms of reducing consumption energy and GHG emission prevention.

Various measures have been adopted, such as the bonus-malus on individual vehicles, the new thermal renovation of buildings (the "Low Consumption Building" standard and the " positive energy" standard from 2020) or the eco-loan on social housing.

The Grenelle I and II laws are also followed by the creation of various programming instruments, such as the energy renovation plan for housing and the programming of investments in the production and supply of energy in France by 2020.

Concretised in particular by the decree of 15 December 2009 on the multiannual programming of investments in electricity production, this reflects the objectives set by the government in 2008, when Ms. Kosciusko-Morizet stated: "*Our responsibility is to prepare and support France in this energy transition. To do this, France must undertake a vast carbon-free energy equipment programme. In particular, we must* ***massively intensify*** the development of renewable energies and ***establish*** **the *timetable* for the *implementation* of the *third-generation nuclear power plant program launched by the President of the Republic*"** by defining a development schedule for each renewable energy sector and by confirming that "*the target for the production of electricity commissioned from nuclear energy is a first* *third-generation reactor by 2012 and a second third-generation reactor by 2017, on existing nuclear sites*.”

Finally, it should be noted that to reduce the environmental impacts of electricity production from fossil fuels, the decree announces the reduction of the coal-fired generation fleet and the **concomitant development of the centralised fleet of electricity production from natural gas**.

### 2. But the adjoining industrial sectors are only poorly developed and the results are still too modest

#### *a. Uneven progress in energy sobriety and efficiency*

As noted in the first part of the report, the curve of French energy consumption shows a **visible bending, after a peak reached in 2005.**

This decline is marked in primary consumption, marking the decline of coal and fuel oil, which have been replaced by nuclear and renewable electricity and gas over time.(1)

The decline in petroleum products was particularly rapid from the late 1970s to the mid-1980s, in obvious parallel with the rise of nuclear production. It then slowed down and even tended to rise slightly in the 2000s, until the financial crisis of 2008, from which the decline is no longer denied.

Coal consumption decreased from the 1980s onwards, but this trend stagnated in the 2000s. We can think that the problem of peak consumption, which appeared at that time, prompted managers to slow down the closure of coal-fired power plants, which are very controllable. Nevertheless, the decline of coal resumed from the end of the 2000s.

Meanwhile, gas consumption has risen sharply since the 1980s and more markedly in the 1990s. Gas consumption then remained at the level reached until the end of the 2010s.

As for nuclear power, consumption peaked in 2005 at the peak of the commissioning of new production capacity. It will then slowly decline with the decrease in the yields of French power plants .

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*(1) See the graphs in the first chapter.*

These developments are less noticeable for final consumption of France, but they follow the same trends. The curve thus reached its highest level in 2001, at 150 Mtoe, before falling back to 142 Mtoe in 2019.

While the overall balance is going in the right direction, **it does not present a reduction in fossil fuel consumption that would significantly reduce our GHG emissions**. This is still true today; it was even more glaring in the 1990s and 2000s.

In addition, the decline in consumption (all energies) is mainly due to the industrial sector, whose final consumption has fallen markedly since the 1990s. On the other hand, we note that those of transport and residential continued to grow in the 1990s and then stabilised from the mid-2000s.

The good results of the industrial sector are undoubtedly explained in large part by the closures of oil and coal-fired power plants, desired by political leaders or decided by their managers who no longer found the same profitability, in particular with the increase in prices generated by European carbon quotas. For the rest, the Committee of Inquiry was unable to distinguish between what resulted from the economic downturn following the crisis of 2008 and the efforts actually made by industrialists during the two decades 1990 and 2000.

As for the other sectors of activity, it **is clear that the ambitions displayed by the measures that have been successively put in place have been followed by little or no effect at the national level**. At best, they have stabilised their consumption levels.

The actors interviewed put forward several explanations for these relative failures:

– Several former politicians of the time recalled the **intrinsic weakness of non-binding operational objectives**. This was in particular the defect of the provisions relating to territorial planning of the LAURE law according to Ms Voynet. Conversely, the EWC scheme quickly yielded results – even if they were still insufficient – because energy suppliers had to justify their actions in favour of energy saving.

– Mr Bouvier and Mr Bensasson pointed out that energy prices were relatively low in the 1990s and 2000s (between 20 and 30 euros per MWh for electricity) and abundant energy.

As a result, consumers were **not sufficiently encouraged** to make the necessary investments. Indeed, thermal renovation projects for buildings represent a particularly heavy financial burden for households. As for electric mobility, it was still in its infancy. The law of 2009 provided for a strengthening of research into renewable or economical technologies.

Ms. Voynet also accuses the "*single*" price of electricity of having deprived any prospect of profitability from alternative production solutions for years.

– To the question: "*Why hadn't France adopted a culture of cycling and public transport as other European countries have done?* Nathalie Ortar, research director at the National School of Public Works of the State, observed that the Netherlands does not have an automotive industry, unlike France, it has been easier for governments to respond to the pressure of their population.

In fact, the economic and industrial structure of a country inevitably weighs on certain political trade-offs, such as on the level of public resources to be mobilised.

– **The importance of public support was itself decisive.**

Measures had been taken: ADEME's resources had been significantly increased, to the tune of an additional €1 billion for the new heat fund; The Finance Act for 2009 of 27 December 2008 had put in place tax measures to encourage energy renovation (tax credits, zero-interest loans, etc.) and the amending finance law for 2008 of 30 December 2008 a tax incentive (extension of eligibility for reduced VAT) for the heat from renewable energy, as well as an ecological penalty. Finally, the investment program for the future (PIA), resulting from the Great Loan, promoted energy savings through the circular economy, *smart grids*, batteries, or less polluting industrial processes – and announced €12 billion for offshore wind (Law No. 2010-237 of 9 March 2010 amending finance for 2010 on investments for the future).

But, heard by the Finance Committee of the National Assembly on 18 January 2012, the First President of the Court of Auditors, Mr. Didier Migaud, pointed out that the taxes that were to finance part of the actions of the Grenelle had not been collected in time, which had hindered its implementation. Four years after the start of the implementation of the Grenelle, the State budget for the period 2009–2011 for the Grenelle reached only €3.5 billion instead of the €4.5 billion planned.

– **Technical difficulties** were not absent either. Mr Borloo recalls the complexity of energy performance contracts, which are essential to guarantee a global treatment, and to use the economy to finance investment.

– **Neither do bad apps**. In terms of energy renovation of housing in particular, some actors have seized on the virtuous label of the Grenelle to deceive consumers, observes Ms. Kosciusko-Morizet. The Ministry of the Environment has therefore quickly launched training policies in this field and policies for the certification of actors to counter these abuses.

Mr. Jean-Louis Borloo defends the power of the plans launched by the Government in the late 2000s: many eco-loans were contracted by individuals; the

HLM park has carried out its thermal renovation; a massive plan aimed at transport. The ecological bonus-malus on cars has had a considerable effect on $CO_2$ emissions from new cars. And as part of the "Clean Site" plan, the Grenelle proposed to finance 20 to 30% of local authorities' investments; the Seine-Nord canal, launched at this time, aimed to divert 500,000 trucks from motorways; the Grenelle also provided for the launch of three TGV lines to free up train paths for freight; the reconfiguration of port governance aimed to create a rail hinterland, as 88% of the tonnage of our ports is handled by trucks, etc.

But the former Minister of Ecology, Energy, Sustainable Development and the Sea, in charge of green technologies and climate negotiations, recalls that *"public action requires monitoring, consistency, evaluations and correction of gaps constantly. (...) All the measures that had been decided in the context of the Grenelle have been put in place. The problem is that of their follow-up.* A follow-up committee was provided for by law. He worked for a year and then fell into disuse. "*Some measures should probably have been corrected, re-evaluated!* ***Our tragedy is the steering and monitoring***."

### *b. A development of renewable energies that has lacked industrial bases*

The rapporteur observes at the outset that, in order to assess the results of the policies pursued in the 1990s and 2000s, he only had at his disposal graphs on the evolution of energy production communicated by the SDES and data on RTE's gross electricity consumption. The analyses carried out in Chapter I, like those that follow, therefore remain partly empirical.

* * *

Nevertheless, these graphs clearly show that **renewable energy production did not really take off until 2005**. The electricity consumption recorded by RTE confirms the phenomenon. Non-hydro renewable electricity production started in 2005 but **continued to grow**, as shown in the following table:

**GROSS DOMESTIC ELECTRICITY consumption BY SECTOR**

| *In TWh* | **2000** | **2005** | **2006** | **2008** | **2010** | **2012** | **2014** |
|---|---|---|---|---|---|---|---|
| Hydraulics | 71,6 | 56,2 | 61 | 68 | 67,6 | 63,79 | 67,43 |
| Onshore and offshore wind | 0 | 0,98 | 2,26 | 5,56 | 9,73 | 14,93 | 16,97 |
| Solar | 0 | 0 | 0,06 | 0,25 | 0,55 | 4,07 | 5,94 |
| Tidal | 0 | 0,5 | 0,51 | 0,5 | 0,52 | 0,49 | 0,51 |
| Renewable thermal and waste | 0 | 3,3 | 3,34 | 4,12 | 4,85 | 5,77 | 7,1 |
| **Addition of channels** | **71,6** | **61** | **67,09** | **78,2** | **83,24** | **89,05** | **97,96** |

*Source: use of RTE data.*

Adding the years required to deploy the corresponding capabilities, we can date this start-up back to the second half of the 1990s.

It is easy to understand that the massive development of nuclear power that continued in the 1990s left little room for other sectors of electricity production – apart from the hydropower park, which had been built for the most part before the launch of the nuclear program. France then had rapidly growing generating capacity, which already exceeded the country's supply needs.

A certain strength of conviction was needed to support the development of renewable energies (RE) at the end of the decade. The alliance of Mr Jospin's government with the ecologists has probably strengthened this political choice; but it is at least as much the Prime **Minister's concern to diversify energy sources** that underpinned the €1.5 billion of investments planned for this purpose in his national programme to combat climate change in December 2000.

And even if this Government had envisaged the end of nuclear power – which Mr Jospin disputes – it would have been very gradual. During the Government's statement on energy policy held on 20 January 1997 in the National Assembly, Mr. Christian Pierret, Secretary of State for Industry, had set the principle of "neither everything, nor *everything*" – "*neither all electric*, nor any *gas or fossil fuels, nor any new energies*". And for Mrs. Dominique Voynet, who does not deny her criticism of nuclear power, the idea was to *"gradually loosen the constraint as technical progress progresses, efforts, including funding and research that we had to grant, to be ready when the first plants would expire*".

In any case, the question of the intermittency of non-carbon-free means of production was little raised, says Ms. Voynet. " *It must be placed in the technical context of the time*."

The first of the renewable energies targeted was hydropower. The Government of M. Jospin organised the transformation of the Compagnie Nationale du Rhône into a full-service hydropower producer, in partnership with another French energy company, Suez, to secure the sector.

The second resource was wind. It was beginning to develop in Denmark and Germany, but was embryonic in France. In 2001, the Government issued a decree requiring EDF to purchase wind power at a pre-secured price of €0.55 per kWh for five years, then at a decreasing remuneration over 10 years – while setting a target of 3,000 MW of wind electricity in its national programme to combat the greenhouse effect.

Solar energy was not yet defined as an axis of national policy. We were mainly discussing solar thermal, with the idea of producing hot water and facilitating a form of energy independence in the overseas departments (DOM) – bagasse was not yet exploited, everything ran on oil. Moreover, EDF's statutory monopoly prohibited a particular user from producing its own electricity. The law had to evolve.

In the end, despite the stated ambitions, the results appear modest if it is possible to judge by the renewable energy production capacities observed a few years later (see the table *Gross domestic electricity consumption by sector*). However, this step has been fundamental in the construction of our country's energy policies by introducing the mechanism of obligation to purchase renewable electricity production (for installations with a capacity of less than 12 MW). Not only does it guarantee an outlet, but its price defined in advance by the regulatory authority and maintained for 20 years, ensures the economic viability of productions whose cost was much higher than coal or nuclear production. The system will evolve, but will never be called into question thereafter. **It participates in its own way in the energy sovereignty of France.**

The systems that have succeeded do not seem to have given more convincing results, but have nevertheless made it possible to **continue the progression of renewable energies** in France.

Nevertheless, there has been an acceleration in the growth of consumption recorded by RTE from 2014, which it is reasonable to consider as largely attributable to the development of renewable energies during the Grenelle years. We could also link to their balance sheet the 480 MW of the offshore wind farm of Saint-Nazaire which was inaugurated last September but had been initiated under the mandate of Mr. Sarkozy.

In fact, the **ambitions of Nicolas Sarkozy's governments were high with regard to renewable energies**: the Grenelle I law aimed to double the share of renewable energies in electricity production by 2020.

More than 77% of the electricity mix was produced from nuclear energy, 10.9% from fossil fuels and 11.9% from renewable energies (more than 87% of which came from hydro). To the extent that this included hydroelectricity, whose potential could not be significantly increased, it implied a real acceleration of other sectors, or even a tenfold increase in wind and solar. Nathalie Kosciusko-Morizet points out that, in their calculations, this doubling was based in particular on the doubling of wood energy, measures related to heating networks and an acceleration of photovoltaics.

The heat fund, which encourages companies to develop renewable heat, heating networks and biomass recovery, was supposed to cover a quarter of these actions. It was launched with an investment of one billion euros for the period 2009-2011. The waste fund, which until then had been mainly devoted to supporting incinerators, has been revived and redirected towards projects with more emphasis on recycling. In addition, the financial supplements provided for in the State-regional plan contracts have been multiplied by five and the feed-in tariff for renewable energies has been extended to all local authorities, in order to encourage middle and high schools to develop their own production facilities.

However, the most innovative in the strategy adopted by the government of the day was its desire to **link environmental objectives** and energy policy with employment policy **and industrial policy**.

"*Energy policies must be coupled with economic, social and industrial meaning*," Kosciusko-Morizet said.

"*So we were not advocating a simple set of environmental measures, but a **global policy** that linked to other dimensions. We have had success in this area: the heat fund has created 10,000 jobs. As such, I am proud of the offshore wind policy I launched in 2011*. In particular, local production criteria have been integrated into the tender specifications in order to develop a real local production industry.

***On the other hand*, the lack of coupling with industrial policy has undoubtedly been a factor of slowdown**, according to her.

According to Kosciusko-Morizet, on onshore wind, for example, France had fallen behind industrially. The volumes produced by the French value chain would have remained low compared to the Danes and Germans, who would have been the real industrial beneficiaries of the rise of European wind power. In this context, it appeared difficult to launch a national industrial base. This may have played on the lack of appetite of local populations.

The national solar industry was also in its infancy, despite the fact that the photovoltaic panel technology was of French origin. In addition, China had undertaken to conquer the world market, putting all its weight to discourage its competitors. Germany had paid the price itself and was seeing its value chain decline in the face of Chinese competition.

This distortion of competition is one of the causes of the **moratorium decided in December 2010 on aid to photovoltaics**. The former Secretary of State for Ecology recalls the context of this episode: "The *policy in favor of solar was mainly based on long-term subsidies weighing largely on future generations and benefiting only installation and maintenance jobs, **without developing an industrial base**. The panels were mostly imported. We have therefore launched calls for tenders with low-carbon criteria to promote local production. A carbon footprint criterion, which took into account the impact of transporting the panels, was established in an attempt to circumvent World Trade Organisation (WTO) rules and limit imports from China. However, we have not had the same success as we have with offshore wind. Over the years, tenders have abandoned low-carbon criteria. This time, the European Commission has been tougher on the subject*."

As a result, the financing of solar fields benefited only very occasionally local employment – through installation and maintenance activities – and little European employment, which struggled to maintain itself.

At the same time, buoyed by very high feed-in tariffs at that time (especially since Prime Minister M. Dominique de Villepin had doubled them in 2006) and all the more advantageous as Chinese solar panels were cheaper, photovoltaic installation projects have multiplied, representing **a disproportionate annual cost** for the energy gain they brought – in a report published on 18 April 2018(1), the Court of Auditors estimated that the guarantees granted before 2011 for solar photovoltaic will still represent €2 billion per year until 2030, for production equivalent to 0.7% of the electricity *mix*...

**The moratorium was not retroactive and lasted only three months, but it will long be blamed for having broken the dynamics of the solar sector.** It is in reality, and *a posteriori* even more, difficult to judge because the sector was almost non-existent at the time. SDES statistics do not start counting photovoltaic production until 2008, with 0.2 TWh. In 2010, it reached 0.6 TW.h, 2.1 TWh in 2011 and 4.1 TWh in 2012.

**In any case, it did not seem absurd to revise the methods of support for the sector as it existed, in view of the amounts committed.**

Finally, as Ms. Kosciusko-Morizet noted, a strong link between renewable energy installations and local economic development or national competitiveness promotes their social acceptance, even their appropriation. Conversely, “environmental objectives that did not directly bring jobs or competitiveness benefits – at least not commensurate with the investment they required – were more dependent on macroeconomic conditions: we could start these measures when we had enough money, but they were stopped when we did not spend any more on them.”

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*(1) Support for* renewable *energy. Communication to the* Senate *Finance Committee.*

### c. *Nuclear power, which has become a very divisive political object, misses important industrial meetings for the future*

i. The closure of Superphénix is a major strategic mistake and opens a vague decade on the future of the French nuclear industry

It would be an exaggeration to attribute too much responsibility to the political actors in power in the mid-1990s and late 2000s for the deteriorating situation that our nuclear fleet is currently experiencing, and consequently our energy sovereignty.

By that time, the first generations of reactors had already been replaced; and governments, managers and experts all noted that the projects under way would be sustainably sufficient for the country's needs and should even generate a substantial surplus of production. This belief of being able to benefit from abundant domestic electricity for a long time lasted until the end of the 2000s. The last time a nuclear project was launched six years ago, in 1991 and the only project still officially envisaged was that of the Carnet power plant, which had been dragging on for more than 20 years.

Prime Minister Lionel Jospin arrived with his coalition's programme of a moratorium on the construction of new reactors, another on MOX and the closure of the Superphénix breeder reactor(1). Nevertheless, only the latter is expressly confirmed in its general policy statement made to the National Assembly on 24 June 1997, which at the same time expresses a fundamentally positive opinion on nuclear power; "*If the nuclear industry is an important asset for our country, it must not exempt itself from democratic rules, nor pursue projects whose cost is excessive and the success very uncertain: this is why the breeder reactor called "Superphénix" will be abandoned*."

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(1) *As a reminder, it planned to "reorient energy policy by establishing a moratorium on the construction of nuclear reactors and on the manufacture of MOX fuel (mixture of oxides) until 2010, while significantly increasing credits for energy saving and renewable energy. This policy includes the closure of Superphénix, the reversibility of nuclear waste storage by rebalancing research credits by real application of the Bataille law. The reprocessing at La Hague will be reviewed, which implies increased monitoring of the site and a new research effort. In addition, no new reprocessing contracts will be undertaken. The vote on an energy law will take place no later than 2005. »*

**Nevertheless, the shutdown of the Superphénix breeder reactor, confirmed from the beginning of his government, has sent a negative message about the future of nuclear power, destabilizing the sector, while reinforcing anti-nuclear claims.**

**THE SHOCKED STORY OF THE SUPERPHÉNIX BREEDER REACTOR**

Superphénix is a former French prototype fast breeder reactor (RNR) with sodium coolant, with a thermal power of 1,240 megawatts electric (MWe). Commissioned in Creys-Malville in 1986, it was designed to produce electricity and was cooled by liquid sodium. It is the only RNR to have reached the threshold of industrial electricity production.

**The principle of operation of fast neutron reactors**

In a conventional nuclear reactor, energy comes from the fission of uranium-235 nuclei. The fission of uranium-235 is obtained by slow neutrons, i.e. slowed down by a moderator (water or graphite) to an energy of the order of the electron (eV). For a fission reaction to be self-sustaining, natural uranium must be enriched to at least 3-5% uranium-235.

In a nuclear fast neutron reactor (FNR), the basic fuel is uranium-238. This isotope is called "fertile" because it has the property of absorbing a fast neutron (energy of about 1 MeV) to transform into plutonium 239, which is itself fissile under the impact of another fast neutron. The fission of plutonium-239 releases three neutrons and considerable energy that can be converted into heat. Of these three neutrons, statistically, one causes a new fertilisation (regeneration), the second a new energetic fission (plutonium 239), and the third, if it survives a sterile capture (probability of 50%), can "overgenerate" a second atom of plutonium if it is in the presence of surplus uranium atoms 238.

FNRs therefore consume, without prior enrichment or moderator, a still abundant resource (uranium-238) which they transform transiently into plutonium-239 to extract fission energy, and which they can even supergenerate. In this way, FNRs can achieve efficiencies nearly 100 times higher than PWR reactors.

**The technical functioning of Superphénix**

The Superphénix core used as fuel a mixture composed of 80% fertile uranium-238 (natural or depleted) and 20% fissile plutonium-239. Superphénix used liquid sodium at 550°C as its primary heat transfer liquid. 5,000 tons of sodium were present in Superphénix's pipes. Sodium is an excellent coolant with hydraulic characteristics similar to that of water but which does not slow down neutrons. On the other hand, it poses safety problems because it ignites in contact with air and explodes in the presence of water. An indirect pool-type cycle was therefore necessary to avoid a reaction between the sodium and the water in the electricity production circuit.

Located inside the main vessel, the core of the Superphénix reactor was embedded in a sodium pool. This sodium, in direct contact with the core, was heated from the energy released by nuclear fission. This primary sodium circuit then exchanged heat with a secondary sodium circuit, through an intermediate heat exchanger. This secondary sodium circuit in turn yielded its heat to a water-steam circuit. The latter drove the turbines of the alternator after vaporization of the water, allowing the production of electricity.

As a breeder reactor, Superphénix could produce more plutonium than it consumed; and as an incinerator, it could consume more plutonium than it consumed. It could therefore either regenerate its fuel stockpile or destroy radioactive waste.

**The history of Superphoenix**

Superphénix was designed by the CEA and was operated by NERSA, a collaboration between EDF, Enel in Italy and SBK in Germany. The operation of the facilities was entrusted to EDF.

It was preceded by the small research breeder reactor Rapsodie (20 MW thermal) and the experimental reactor Phoenix, built in 1968 (250 MWe). Superphénix was officially authorized by the French Government one May 12, 1977 (preliminary work had already begun); despite strong opposition, it was commissioned in 1986.

Technical problems (a first leak of sodium in the barrel in 1987 and then in a primary circuit in 1990 – but no leakage to the outside) require prolonged corrective actions during its first four years of operation. The collapse of the engine room roof in December 1990 extended STIs shutdown. A new public inquiry was launched on 23 December 1992. It gave as favourable opinion to the restart in June 1993, goal as new authorisation decree was not signed until 11 July 1994, with the aim of research and demonstration (and no longer electricity production).

At the end of 1994, has minor incident stopped it again until September 1995. In 1996 it will produce 3.392 TWh, i.e. has load factor of 31%. In December 1996, it stopped again for its ten-year visit. It will be final.

One 28 February 1997, the Council of State cancelled the 1994 decree because of the discrepancy between the research missions included in the decree and that of the nuclear reactor, which had been submitted to a public inquiry. His new mission is asking to be submitted to a new public inquiry. Finally, one 19 June 1997, Premium Minister Lionel Jospin announced STIs closure. It was adopted by decree on 30 December 1998.

Mr. Lionel Jospin acknowledges that this decision had a political origin: the agreement signed with the Greens during the legislative campaign. Voters had been informed of the intention and had made their choice.

**Without however producing any evidence to support his statements and in contradiction with almost all the opinionsof those interviewed (with the exception of Ms. Lepage and Ms. Voynet, strongly committed to the closure of Superphénix), the former Prime Minister explains that his decision was fundamentally based on industrial reasons**, **both technical and financial**: "*The breeder reactor technology was theoretically attractive. The plutonium obtained during the use of uranium in conventional power plants gave hope of being used as fuel to produce electricity in the breeder reactor system. In addition, the hoped-for transmutation of nuclear materials seemed to open a path to waste disposal. But the so-called breeder reactor plant launched in Creys-Malville in 1977 and completed in 1987 was an industrial failure. It had never operated stably, suffered incident after incident and experienced long shutdowns. The technologies used were risky, since sodium explodes on contact with water and they were not mastered after 20 years of effort. The project, which was becoming financially burdensome for EDF, did not promise success.*"

Mr. Jospin explains: "*Superphénix was both a research prototype and an industrial one.* ***If it had been only in the field of research, the research would have been continued as it is with ITER on fusion****. We do not know whether ITER will be* *completed in 2035 or 2045. Many countries are willing to spend large sums of money on future technology and on research that is first and foremost fundamental. Superphénix was a power plant and not just a laboratory prototype. The financial costs for EDF were considerable*."(1)

A report by the Court of Auditors, published in October 1996 – which examined the accounts and management of NERSA at 31 December 1994(2) – had already revived the debate on the question of putting money back into Superphénix when there are still "*questions about the usefulness and sustainability of this tool*". The breeder reactor will have required more than 60 billion francs (1994), or €12 billion (2010) for twenty-five years, for revenues of less than 2 billion francs. The Court also questioned the economic interest of continuing to operate Superphénix as an incinerator for nuclear waste, but noted that technically, it can destroy only 1 to 2% of the annual plutonium production of French power plants.

Corinne Lepage was then Minister of the Environment. It called on a group of scientists, the "Castaing Commission", to assess the situation. Their report concluded that Superphénix could function properly in the form of a research centre, as had been decided in 1994, so the Government of Mr. Juppé chose to keep a tool that exists for the needs of nuclear research. However, when the Conseil d'État annulled the 1994 decree in February 1997, considering, inter alia, that it presented a significant risk to safety because of the very high potential power of the reactor, Ms Lepage objected to its return to operation as an electricity producer. The Council of State recommended a new public inquiry, which the Prime Minister did not wish to organise. The latter then consulted the Council of State on the possibility of directly adopting a new decree limited to a single research activity. But "*we will never have the answer, because our successors have decided to close Creys-Malville and have asked the Council of State not to give its opinion*," comments Ms. Lepage.

In addition to the initial electoral commitment, the new majority saw recurring breakdowns, high operating costs, the threat of withdrawal of their Italian and German partners and the potential security risk.

Without providing any evidence to support her statements, Ms Dominique Voynet indicates in particular: "*At the time of deciding, we had the nuanced opinions of some of the senior executives of the nuclear sector, aware of the difficulties associated with the quantitative leap that this equipment represented compared to Rapsodie and Phoenix – with a power of 20 and 250 megawatts, respectively – and*

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*(1) ITER is financed by contributions from participating countries and by the state budget for France. This was also the case for the research and development costs borne by the CEA; on the other hand, the maintenance of Superphénix was carried out by EDF.*

*(2) Annual public report of the Court of Auditors to the President of the Republic for 1996, transmitted by Mrs Corinne Lepage.*

*the numerous stops for breakdown and repair. (...) They were all plagued by doubt."*

In reply to the Court of Auditors, in the above-mentioned report, the then Ministers for Industry, Economic Affairs and Finance and Budget confirmed that "*The decision to build Superphénix was taken in 1974 in a context of strong economic growth, when it became clear that primary energies would not be inexhaustible, and that France was embarking on an ambitious program of pressurised water nuclear power plants. However, in hindsight, the direct transition from a 250-megawatt reactor (Phoenix) to a 1,200-megawatt industrial-scale prototype was an overly optimistic choice and that the complexity of the technology led to significant additional investment costs and operational difficulties*."

In addition, adds Ms. Voynet, *"many told us that everything we did with Superphénix could be done with Phoenix, which had just benefited from major modernisation* work. – However, this only concerned his research activities, it should be noted.

Superphénix was then permanently shut down in December 1998 and the Phoenix reactor was allowed to restart (initially until 2004).

Thirteen years later, the dismantling of Superphénix is still underway, at a total cost of about €2 billion, according to the calculations of Mr. Cédric Lewandowski, which EDF assumes alone, not to mention the compensation it had to pay to its former partners.

**In view of the ongoing debates around Superphénix and other tests of fast neutron reactors, in view of the considerable investments that had been made and completed, in view of the challenges that the "closure of the cycle" represents for the energy independence of France and for the performance of national research and development, the rapporteur considers that the closure of Superphénix, without debate or involvement of the National Representation, constitutes a mistake and a serious strategic mistake whose consequences are being felt today.**

Admittedly, Parliament had not been consulted when the project was launched; but the **rapporteur points out, in the first place, that it is contradictory to take this decision to close Superphénix unilaterally and also to defend the importance of a democratic debate on the future of nuclear power**.

Admittedly, the former general administrator of the CEA, Mr. Yannick d'Escatha, confirms that some research on fast neutrons for which the CEA was responsible could indeed have been done in Phoenix, until its stop on February 1. 2010. But they obviously did not offer the same opportunities for acquiring knowledge and improving the technology of Generation IV reactors.

Moreover, while admitting that "*the increase from 125 to 600 megawatts is an extrapolation whose coefficient is not usual*", Mr. d'Escatha, also an engineer, told the rapporteur that "*the Superphénix reactor, after being 'debugged', like all prototypes [i.e. it must be developed to correct its initial imperfections before industrialisation], would have worked perfectly well*".

It is regrettable to think that France could thus have abandoned a technology already at the stage of industrial prototype, which made it possible both to produce fuel in a quasi-cyclical way, limiting imports to a very low level, and to absorb some of the nuclear waste that we do not know what to do with today.

Even if the Court of Auditors pointed out its limited scope, the option of transforming Superphénix into a long-lived waste incinerator could at least have been discussed.

The most damaging thing is that **the French nuclear industry has lost part of its lead in cutting-edge research that made its reputation worldwide**, and left room for its competitors.

Mr. Gadonneix acknowledges that Superphénix "*was not yet an industrial success*". But *" **it is not possible to be a world leader – which we were – without being at the forefront of research**. Breeder reactors are still a way of the future but we are not present in them – it's very boring*."

Mr. Pascal Colombani, who succeeded Mr. d'Escatha as general administrator of the CEA, explains that the decision had an immediate negative impact in this area: "*This decision (...) had deleterious effects abroad. Our Japanese partners did not understand why we were making this choice when, in their eyes, we were the leaders"* and other countries continued this research.

Seven years later, Law No. 2005-781 of 13 July 2005 on programming setting the guidelines for energy policy, adopted under the Government of Mr. Raffarin, reopened the track of so-called fourth generation reactors as an object of research on the technologies necessary for a sustainable management of nuclear waste. Then, under the government of Mr. de Villepin, Law No. 2006-739 of 28 June 2006 on the program relating to the sustainable management of radioactive materials and waste confirmed the **ASTRID project** with the objective "*to put into operation a prototype installation before December 31, 2020".* However, it was not until 9 September 2010 that the agreement between the State and the CEA setting the objectives of the ASTRID project and that of the Jule Horowitz reactor was signed and that a multiannual budget of €651.60 million was voted in the amending finance law for 2010 under the first Investments for the Future Plan.

In the meantime, **12 years of slow-motion research had passed**.

ii. The sector has become weakened and fragmented to the detriment of "Team France"

Mr. Colombani also observes that the shutdown of Superphénix has severely affected the morale of CEA researchers and probably also EDF. This decision did not accelerate the departure of skills from the sector. The end of the construction cycle of power plants in France is the main cause.

On the other hand, the closure of Superphénix has further reduced professional prospects in the nuclear industry and further diminished its image as a promising path or scientific challenge, discouraging young skills from coming to work in the sector, even though it was beginning to have to manage the renewal of the generations that had built our reactors.

However, as noted earlier, it took years for policymakers to begin to take stock of the phenomenon and the damage it will cause.

But **in these years 1990-2000, it is clear that the work of undermining the nuclear industry also came from itself**. With a very small national market and very competitive global markets, fierce competition has developed between its two main players, EDF and Areva. Instead of energising the sector, **it turned into a kind of fratricidal war, which ended up harming the interests of the "Team France".**

In the first place to the company Areva itself. It was born in 2001 from the merger of the activities of major companies in the nuclear value chain, Cogéma, CEA Industrie and Framatome – absorbed by AREVA NP in 2006. Essentially owned by the State, an international specialist in the construction of nuclear reactors, but also a major global player in nuclear fuels, it has the wind in its sails. Ten years later, politicians are worried about the serious difficulties of the company, strangled by the excesses of the Finnish EPR construction site in Olkiluoto and the costly failure to buy the company UraMin. Areva will therefore be subject to several divestments of major activities from 2010 and a complete industrial reorganisation between 2016 and 2018, when the company becomes Orano.

For the history and detailed analysis of the process up to 2012, we can usefully refer to the report of Deputies Marc Goua and Camille de Rocca-Serra of March 2012.[(1)]

Questioned by the Committee of Inquiry, Anne Lauvergeon, who was Chairman of Areva's Executive Board until 2010, recalled that the sector was at a crucial turning point: that of the renewal of its skills, while the staff who had been

*(1) National Assembly, Information Report No. 4463 on the financial situation and prospects of Électricité de France et d'Areva, 7 March 2012.*

Recruited in large quantities at the time of the nuclear start-up were now close to retirement or already retired and that of the weakening of Framatome and Cogema who *"had built all their plants in the logic of serving EDF"* in the face of the shutdown of the French nuclear program, at a time when some plants had to be reassessed by ASN. To bounce back, Areva has chosen to "*rebuild skills and factories"* and strengthen its position on the international market – with the idea of "*going beyond its role as a subcontractor of EDF*", comments Mr. Eric Besson – and the ambition to cover the entire value chain of the sector.

This strategy proved too adventurous for Areva and was not shared by EDF, which "*considered itself to be the leader in nuclear power in France*" (Mr. Jean-Louis Borloo). EDF's Chairman and CEO in the early 2010s, Mr. Henri Proglio, would even have had the will to take control of Areva, reports Mr. Pierre-Marie Abadie.

A competition that was more deadly than profitable then developed. Each has pushed its pawns on the global market (Finland, China) without benefiting from the synergies offered by the entire value chain from which France benefited, sometimes outbidding or even not sharing the necessary data – In its report on the EPR sector of June 2020, the Court of Auditors recalled that " *The rivalries between the two national public groups, not arbitrated by the political authorities of the time, resulted in a dangerous one-upmanship for the French nuclear industry*." Mr. Borloo recalls that "*The controversies between the two companies were incessant and daily on both sides*."

The peak was reached with the failure, in January 2010, of the application of the French sector to the call for tenders of the United Arab Emirates to develop their nuclear fleet, with a budget of € 20 billion at stake. Despite the intervention of the President of the Republic Nicolas Sarkozy, Abu Dhabi decided for the Korean proposal, more adapted in size to its needs and less expensive. But these are not the only reasons. Observers report that the various French companies that were to carry out the project together advanced their projects separately, without coordination; moreover, the Emirati customer only knows EDF, which had initially refused to participate. By the time he joins Team France, it's too late.(1)

The competitive strategies of these companies have caused heavy damage. This conflict has also created tension throughout the sector. "*Part of the expertise, coming from the CEA's research world, feared being taken hostage in this battle*," recalls Ms. Kosciusko-Morizet, which will have hindered the good management of the *design* and then the construction site of the EPR, she believes. The "Roussely report" of 2010, previously mentioned, did not fail to highlight the problem represented by the lack of coordination of the sector and the disagreements between these major players in the sector.

*(1) Cf. in particular the article* of *"Echoes" of January 11, 2010.*

If the managers of the companies concerned bear direct responsibility for this situation, one can however wonder – like Mr. Daniel Verwaerde, former general administrator of the CEA – "*on the way in which the State, in the decade preceding this collapse, had controlled* the functioning *of* the *Areva group so that such difficulties appear*" and **more generally** – **adds the rapporteur – the functioning of the great champions of the sector, which were nevertheless owned by the State or public persons**.

However, **it was not until 2010 that politicians really took up the problem**. The Minister for Industry in the government of François Fillon, Mr. Eric Besson, told the Commission of Inquiry that he had received a clear roadmap from the President of the Republic and the Prime Minister which consisted in reorganising the national nuclear industry. He explains that he first tried to do so through consultation. Then, following the failure of Abu Dhabi and the "Roussely report", he was mandated to set up a strategic committee for nuclear energy, created on 25 July 2011, in which EDF was explicitly designated as leader. On the same day, a new strategic, technical and commercial partnership was signed between EDF and Areva.

**The rapporteur regrets that it has taken so long, and accumulated so many difficulties for the players in our strategic sector, including the significant weakening of a former French champion, before the governments clean up the situation.**

This should lead us to **reflect on how the State should conduct its management of public enterprises and its industrial strategy**, more generally.

iii. A major, and transpartisan, turning point has nevertheless been achieved on nuclear safety, on transparency in this area and on waste management.

Protests against the nuclear program have accompanied its development since the 1970s. But the Chernobyl disaster in 1986 heightened the suspicion and fears that this technology can arouse. Controversies have developed in particular around the communication of the public authorities on the event, which have strongly marked public opinion even in our country, recalls Mr. Yves Bouvier. The Chernobyl accident raised in particular the question of the **underestimation of its effects and the need for independent expertise**. This led to the establishment of the Commission for Independent Research and Information on Radioactivity in May 1986.

In the 1990s, criticism, and even the hostility of certain political currents, had also crystallised on **the problem of long-term waste management**.

The CEA, in partnership with Framatome, EDF, Siemens, the new French and German safety authorities, immediately began work on the strengthening the safety of nuclear technologies. This took time – the long time of research – but resulted in results that were recognised in many countries.

Mr. Yannick d'Escatha, former general administrator of the CEA, tells it: "*This research had three parts. First, it was to reduce the probability of core fusion; The goal was a reduction of a factor of 10. Second, we were considering the case where, despite all our precautions, the accident occurred. If the core had melted, how would we keep the radioactivity inside the containment so that nothing comes out? Specific devices had to be invented. Third, we had to make all these demonstrations in a deterministic way: this means that we were not in the register of probabilities. Many safety authorities rely on probabilistic safety assessments. We wanted to make sure that if the heart melted, nothing would come out*.

"*This work took years and led to breakthrough innovations. I am thinking of all those that have actually made it possible to reduce the probability of an accident: instrumentation, control command, the multiplication of safety circuits. But I am thinking especially of the corium catcher, which few countries have managed to develop. It is a device that must make it possible to recover the molten core if it passes through the tank and to spread it to cool it, on layers of sacrificial concrete. All this was developed in the CEA's facilities in Cadarache. Cooling is done passively and does not require energy sources: it is gravity that acts*.

*"The technologies designed for this system have achieved all the objectives. The performance and characteristics of this reactor have been approved by the safety authorities not only in France but also in the United Kingdom, the United States, Finland and China*."

Unlike other nuclear issues**, French leaders have not been left out.**

Mr. Lionel Jospin has even made the security of the nuclear sector one of the priorities of his energy policy. **It has thus put in place numerous mechanisms in response, at the same time,** to the **expectations of safety and transparency on nuclear safety and to the challenges of the long-term management of radioactive waste**.

**These mechanisms have been supplemented or strengthened on different occasions by different political majorities**, **with all political and industrial actors agreeing in particular on the need to ensure the best possible level of nuclear safety**.

The current content of these arrangements has been presented in other parts of the report. We will not go back to that. But it is interesting to recall the stages of their construction to show the great movement that was engaged in this period.

● **With regard to nuclear safety and the independence of its experts**, essential to offer the indisputability and transparency desired by the French:

– Law No. 2001-398 of 9 May 2001 creates a French Agency for Environmental Health Safety, Article 5 of which creates the National Institute for Radiological Protection and Nuclear Safety (IRSN). It was set up at the beginning of 2002 by Decree 2002-254 of 22 February 2022.

Ms. Voynet observes that by giving sustainable means to radiation protection (i.e. the control of risks to the health of populations) and by bringing it closer to nuclear safety, they have "*restored credibility to the public control authorities and more broadly to the word of the State*";

– Act No. 2006-686 of 13 June 2006 on transparency and safety in nuclear matters, known as the TSN Act, creates the High Committee for Transparency and Information on Nuclear Safety (HCTISN), a body for information, consultation and debate on the risks associated with nuclear activities.

**The Directorate-General for Safety and Radiation Protection (DGSNR) also becomes an independent administrative authority: the Nuclear Safety Authority (ASN**). Ms. Voynet stressed that, although that reform had resulted in a law carried by the next majority, the principle had been laid down by her Government. Moreover, the 2006 law was adopted by consensus;

● **With regard to waste management**, which is necessary for the controlled operation of the sector:

The creation of the National Agency for Radioactive Waste Management (ANDRA) dates back to Law No. 91-1381 of 30 December 1991 on research into radioactive waste management, known as the Bataille Act, supplemented in the following years by:

– the decree of 3 August 1999 authorising ANDRA to install and operate an underground laboratory on the territory of the commune of Bure (Meuse) to study deep geological formations where radioactive waste could be stored;

– Law No. 2006-739 of 28 June 2006 on the programme relating to the sustainable management of radioactive materials and waste, which reinforces ANDRA's missions (design and operation of waste storage), imposes the reversibility of storage for 100 years, provides for financing modalities and the adoption every three years of a National Plan for the Management of Materials and Waste radioactive (PNGMDR);

– finally, Law No. 2010-237 of 9 March 2010 amending finance for 2010on investments for the future, which allows ANDRA to be allocated € 100 million to finance the development of solutions innovative treatment of radioactive waste to reduce the volume and hazardousness of certain wastes that are difficult to store (the agreement was signed on 3 August 2010 between the State and ANDRA).

*

*  *

At the beginning of the 2010s, the national electricity production system appeared to be very surplus, without ensuring all the needs of French consumers. Its future is also questioned: if the reluctance of ecologists vis-à-vis nuclear power and their influence between 1995 and 2002 slowed down the replacement of the fleet, they have not really called into question the preponderance of nuclear power in our model. Thus, the recovery carried out in 2005 remains timid. The causes are multiple, but they inevitably place the French fleet in a logic of extension rather than renewal in the short and medium term, exposing it, more or less consciously, to the risk that a technical impossibility forces managers to stop the operation of a whole series of reactors – which happened less than ten years later.

## II. THE YEARS 2012-2017 – OBJECTIVES THAT ARE GRADUALLY UNCORRELATED WITH ENERGY REALITY

The 2010s began with a nuclear accident with global repercussions that occurred on March 11, 2011 in Japan, at the Fukushima Daiichi power plant, following a tsunami following an earthquake. It was not, therefore, as at Chernobyl in 1986, a nuclear accident linked to the internal operating conditions of the plant[1].

**The Fukushima disaster: a natural disaster causing a nuclear accident**

It is a major nuclear accident classified at level 7 of the INES scale, which places it at the same level of severity as the Chernobyl disaster (1986), given the large volume of releases. It combines the effects of a nuclear accident and an earthquake.

Step 1: the earthquake. On March 11, 2011, at 2:46 p.m., a magnitude 9 earthquake occurred off the coast of Japan. The Fukushima Daiichi nuclear power plant loses its external power supply: the operating reactors are automatically shut down, and the emergency diesel units to keep the cooling pumps running are activated.

Step 2: the tsunami. The earthquake then caused a tsunami that devastated the Pacific coast of the country. At 3:30 p.m., several waves over 15 meters high hit the plant. This has several consequences: damage to water intakes at sea and the loss of emergency diesel generators. The emergency cooling means are no longer operational, so the reactor cores are no longer cooled. Water boils in the tank, steam is produced and the water level decreases in the tank. The cores enter partial fusion, before stabilising on March 17.

*(1) At Chernobyl, the uncontrolled increase in power had led to the explosion of the reactor.*

Step 3: Pressure build-up in containment: the water vapour produced in the containment vessel raises the pressure.

Step 4: Reactor decompressions: These decompressions are necessary to prevent damage to the containment.

Stage 5: Hydrogen explosion: The accumulation of hydrogen leads to an explosion in reactor No. 1 on March 12, in reactor No. 3 on March 14 and in reactor No. 2 on March 15.

Since the accident, the plant has been decommissioned, and the duration of its dismantling is estimated at forty years.

*Source: https:// www.asn.fr/l-asn-informe/situations-d-urgence/accident-de-fukushima#les- Fukushima nuclear-power plants*

While the accident is a reminder of the risks associated with nuclear energy in areas subject to significant seismic risks, its media impact far exceeds what actually happened and causes what was described as the "nuclear winter".

In **Japan**, the accident is, according to Mr. Philippe Sauquet, a "*real trauma*", accentuated by the fact that it occurs in a "*sophisticated country, with very good engineers and whose concern for safety is at least equal to ours*". The country **then decided to stop its nuclear production**.

The repercussions of the accident quickly spread to other countries. In **Germany**, where the choice to phase out nuclear power had already been made, Angela Merkel immediately decided **to accelerate the timetable for closing the plants**. **Belgium decides to phase out nuclear power by 2025**, and **Switzerland** takes the same decision **without setting a deadline**. While all these commitments will not be fulfilled according to the planned timetables (Japan has gradually restarted some of its reactors), the number of countries Europeans supporting nuclear energy is shrinking. In Italy, civil nuclear power was stopped in 1990, after the Chernobyl accident. In 2008, the government of Mr Sylvio Berlusconi nevertheless announced the return of this energy and envisaged the construction of an EPR. He declared to put a stop to it on April 19, 2011. This change in energy strategy is confirmed by the Italians who, during a referendum of popular initiative organised on 12th and 13th June 2011, express by more than 94% their desire to repeal the law authorising the construction of new power stations.

The United Kingdom and the countries of Central and Eastern Europe maintain their support for nuclear energy, as does France.

The President of the Republic, Nicolas Sarkozy, made a speech to this effect on 16 March 2011[(1)]: "*This nuclear accident raises a number of questions around the world about the safety of nuclear installations and energy choices. The France has chosen nuclear energy, which is an essential element of its energy independence and the fight against greenhouse gases. This choice was inseparable from an unwavering commitment to ensuring a very high level of safety for our nuclear facilities. The technical excellence, rigour, independence and transparency of our safety system are recognised worldwide. I remain convinced today of the relevance of these choices*." It undertakes to ensure that the lessons of the accident are learned in France with regard to the safety of the installations.

In 2013[(2)], during a trip to Japan, the President of the RepublicMr. François Hollande also comments on the accident. It recalls the need for safety and evokes the diversification of energy sources without calling into question "*It's true, you live it here, there is a post-Fukushima period. Nothing will be the same again. All lessons must be learned to ensure that such a disaster does not happen again, neither here nor elsewhere. We are working on it. Japan and France, we must show an indisputable level of safety, the best possible, the one that will allow countries to decide sovereignly to maintain nuclear energy production. We must also deal with the issue of waste and dismantle the power stations that we have decided to close. This is also a great challenge to take up together, Japan and France! We also need to diversify our energy sources. There is a coincidence of interests: Japan and France do not have oil resources. All the more reason to work together and ensure that we can be ahead of the curve on renewable energies*."

Despite this confirmation of the French choice of nuclear energy, and as many experts stressed during the hearings, the **repercussions on France sector are significant**.

**Described as a "*real reversal*" (Mr. Pierre-Marie Abadie), the disaster has, according to Mrs. Anne Lauvergeon "*reshuffled the cards of nuclear* power". Catherine Cesarsky, High Commissioner for Atomic Energy at the time of the disaster, explains that he has put a stop to the political will to revive nuclear power: "*For nearly a year, we only talked about safety (...). We never left with as much going as before. The media coverage of the accident has a lot to do with it.*"**

(1) *Statement by Nicolas Sarkozy, President of the Republic, on the nuclear accident in Japan and nuclear safety in France, Paris on 16 March 2011.*

(2) *Statement by François Hollande, President of the Republic, on Franco-Japanese relations, in Tokyo on 7 June 2013.*

The Fukushima disaster then created, to use the words used by M. Cédric Lewandowski, "*a new state of mind*", which results in "*The idea of nuclear development, its renewal and the construction of new plants [leave] the field of priorities at this time*", in a context where "*the opinion of opinion leaders [swings] below 50% vis-à-vis support for nuclear power*".

In the months following the disaster, **public opinion was also very strong**. An IFOP poll conducted on 5 June 2011 indicates that 77% of French people want a more or less rapid exit from nuclear power, 62% of French people want a gradual phase-out over 25 or 30 years and 15% want to a quick stop. While the level of concern about nuclear power plants is falling quite rapidly (from 56% in April 2011to 42% in March 2012), the **disaster has an impact on the image of nuclear power, and consequently reduces both the acceptability of the sector in general and its attractiveness**.

The disaster also has industrial and **technical consequences in France**, not only because of Germany's exit from nuclear power – Siemens withdrew from Areva NP in March 2011 – and the measures taken following the additional safety assessments carried out after the accident (see Chapter I, II, D, 2, f), which involve carrying out a lot of work.

For all these reasons, this accident is an important part of the context to be taken into account before studying the evolution of energy policy during this decade.

With regard to energy production, it is also useful to stress that overall, all energies combined, French energy production remained stable until the first half of the decade, before beginning to decline.

National primary energy production thus remained at a high level in the first half of the decade, reaching a peak of 140 Mtoe in 2015.

On the other hand, the second half of the decade saw the beginning of a decline in energy production, reflecting the lower availability of nuclear fleets. Since 2016, production has declined for two consecutive years with decreases of 4.8% in 2016 and 1.3% respectively in 2017. Nuclear production then fell (-7.8% in 2016), due to a high number of maintenance operations and controls at nuclear power plants. After a brief productive recovery of +4.2% in 2018, production fell again by 2.7% in 2019, with the level of nuclear production falling back to that of 2017.

**PRIMARY ENERGY PRODUCTION BY ENERGY**

| Year | 2000 | 2005 | 2010 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| Production in Mtoe | 131,1 | 137,6 | 139,1 | 137,9 | 139,1 | 140 | 133 | 132 | 138 | 134 |

*Source: SDES, key energy figures, annual balance sheets.*

Without going further at this stage into the analysis of the evolution of the energy mix of France, the outline of the lower availability of the nuclear fleet from 2016 and the continuous increase in renewable energies are two observable trends of a decade during which energy policy remains mainly focused on the issue of electricity. The reflection in terms of security of supply then focused on the ability to pass the peak consumption which reached, in February 2012, the record, never equaled since, of 102 GW, and on the question of the evolution of the thermal park according to the closure of coal and oil-fired power plants decided by EDF. The closure of these production capacities, which emit a lot of CO2, echoes another element of growing context in this decade: the consideration of environmental constraints, embodied by the organisation's preparation for Paris of the Climate Conference of the Parties in 2021, which leads to the adoption of the Paris Agreement in December 2015.

At the end of a series of hearings during which the Committee of Inquiry heard most of the decision-makers and actors in the world of energy of the period, this decade appears as that of an energy strategy lacking scientific, technical and industrial base.

With hindsight, the rapporteur notes that, despite the progress made in creating the multiannual energy programme, **energy policy has been conducted in the absence of steering tools, or even against the conclusions of these tools** (A).

**The Committee of Inquiry also wished to assess the decision-making process that led to the law for energy transition and green growth adopted in 2015. This law, by the admission of many protagonists of the time, appears as the counter-example of a long-term energy strategy that reconciles decarbonisation with security of supply** (B).

Finally, **as a result of a first decade of floating energy sectors and then of the signals sent to the nuclear industry, the rapporteur has taken stock of the weakening of the French energy industry, which has worsened during this decade** (C).

## A. THE PARADOXICAL IMPLEMENTATION OF STRATEGIC TOOLS WITHOUT A LONG-TERM INDUSTRIAL VISION

The steering of energy policy is the subject of reflection as part of the drafting of the law on energy transition for green growth, which leads to the need for planning being taken into account(1). However, whether it is a question of consumption forecasts(2) or the definition of security of supply through the failure criterion(3), the data and forecasts used are not in line with industrial objectives, climatic and sovereign of the country.

### 1. The salutary perception of a need for planning with the creation of multiannual energy programming

Before the adoption of No. 2015-992 of 17 August 2015 on the energy transition for green growth (LTECV), energy programming was based on scattered tools, mainly the three documents of "multiannual investment programming" covering electricity production (PPI electric), heat production (PPI heat) and the gas sector (PPI gas).

The **LTECV has produced a major step forward by providing energy policy with a single planning tool**, **set by decree: the multiannual energy programming (PPE).**

**This document, which sets out the roadmap for France's energy policy with a view to achieving the objectives set out in the Energy Code,** should make it possible to bring together all the elements necessary to achieve the Energy transition in which the country is committed. Pursuant to Article L. 141-1 of the Energy Code, the PPE therefore defines the modalities of action of the public authorities for the management of all forms of energy in the continental metropolitan territory (1) in order to achieve the objectives of energy policy.

**PEP: a content defined in Article L. 141-2 of the Energy Code**

The law lists the components to be included in the PEP, which must be enshrined:

– **security of supply**. In addition to defining the failure criterion, this component specifies in particular the measures implemented to guarantee the security of natural gas supply and identifies the import needs of fossil fuels, uranium and biomass as well as the cross-border exchanges of electricity planned in the context of supply;

– **improving energy efficiency** and **reducing primary energy consumption**, particularly fossil energy;

– the **development of the exploitation of renewable energies** and recovery;

– the balanced development of networks, energy storage and transformation and energy demand management to promote local energy production, the development of smart grids and self-production;

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*(1) The continental metropolitan PPE is drawn up by the Government. PEPs are also being developed for non-interconnected areas (Corsica, Réunion, French Guiana, Martinique, Guadeloupe, Wallis and Futuna and Saint-Pierre and Miquelon), EPP of each of these zones being co-developed with the local authorities*

– the **preservation of consumers' purchasing power** and the competitiveness of energy prices, in particular for companies exposed to international competition. This section presents policies to reduce the cost of energy;

– the **assessment of professional skills** needs in the field of energy and the adaptation of training to these needs.

The last five components must specify the challenges of development and diversification of industrial sectors in the territory, mobilisation of national energy resources and job creation.

*Source: Article L. 141-2 of the Energy Code.*

Through the creation of the multiannual energy programming, the LTECV designs a **relevant method to allow operational steering of public action in the field of energy**.

It is based on a transversal approach that makes it possible **to apprehend in the same strategy all energies** and the foundations of energy policy (energy production, demand management, infrastructures, networks, etc.).

It sets the steering of energy policy over the medium term: the PPE covers two successive five-year periods[(1)], and is revised every five years.

It makes it possible to draw the path to be taken to achieve the objectives provided for by the law by setting the quantitative objectives of the programming to be achieved. It specifies, as an indication, the maximum amount of public resources that should be committed to achieve them and is accompanied by a study to assess the economic, social and environmental impact of the programming, as well as its consequences on the sustainability of public finances, on the development of networks, and on energy prices.

The establishment of the energy strategy involves taking into account the future energy needs associated with energy-consuming activities, but also various assumptions such as demographic developments, economic situation, trade balance, or the energy efficiency criterion.

With a view to its preparation, various technical documents were therefore commissioned, mainly from RTE. Although the quality of these products is indisputable, the rapporteur was able to note that the consumption forecasts, as requested at the time by the public authorities, did not offer a sufficiently complete analysis of the situation.

*(1) The envisaged second five-year period is subject to the presentation of high and low options in view of the uncertainties in economic and technical projections.*

### 2. Insufficiently precise consumption forecasts due to lack of orders by the political power

The rapporteur noted that, unlike the scenarios currently proposed by RTE as part of the "energy futures 2050" analysis, the **forecast scenarios** submitted to the public authorities **during the 2010s responded** to a vision that was both less **prospective and less complete, which did not make it possible to define a properly informed energy strategy in the medium and long term.**

RTE's forecasts, in line with the expectations addressed to the transport manager by the government, were thus originally purely forecast-based and technical. They focused on compliance with the criterion of security of supply, and provided little or no other information related to future climatic, economic, industrial but also sociological developments.

Mr. Pierre-Marie Abadie, Director of Energy from 2007 to 2014 confirmed that during this period, the prospective models "*were not complete, from a technological, economic and environmental point of view*", citing the example of the failure to take into account elements such as the savings capacity of households, technological breakthroughs or the environmental footprint of different energy sources.

**Presentation by RTE of the content of the publications presented until 2016:**

*"Until 2016, RTE's publications mainly constituted short/medium term forecast analyses:*

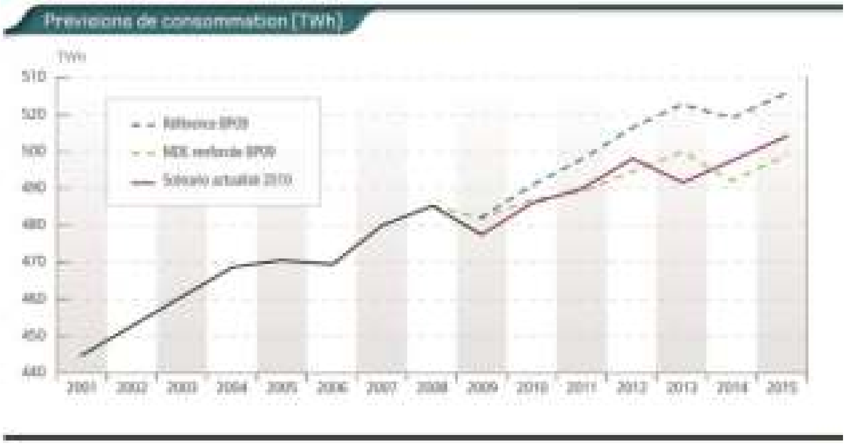
- *They assess the impact of the closure of the means of production in relation to the probabilistic risk of failure of the electrical system;*
- *They do not comment on the relevance of public choices;*
- *They are generally carried out a posteriori in relation to the declaration of intent of the public authorities or market players, of which they take note (on coal, fuel oil or nuclear), which they essentially lead to spreading over time, in an increasingly tense context regarding security of supply.*
- *Consumption forecasts are made solely on the basis of public policies in force to date or whose modification is expressly envisaged by the public authorities;*
- *Mix analyzes are carried out on the basis of projections by market players or trajectories decided by the Government;*
- *This type of analysis cannot be mobilised in a normative way: it does not contribute, in substance, to the analysis of the impact of public choices."*

*Source: document sent to the rapporteur of the commission of inquiry by RTE*

Under these conditions of realisation, the forecast balance sheets **forecast a slight increase in the short term only (2005-2010 balance sheets), a stagnation**

(2011 balance sheet) **and then a decline (2012 balance sheet) in consumption**, the hypothesis being that electricity consumption would decrease thanks to energy savings.

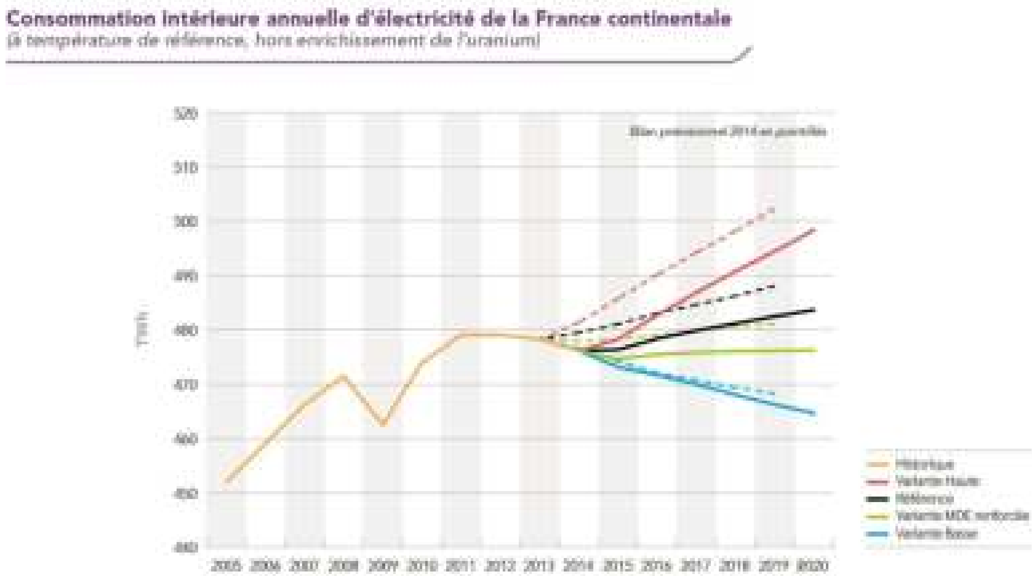
**Box 24: Forecast of RTE's electricity consumption (in 2010)**




Source*: RTE forecast report, 2010.*

The 2015 forecast report, in the knowledge of which the legislator announced objectives for reducing the share of nuclear energy or introduced a cap on nuclear generation capacity, was based on the fact that French electricity demand would remain "not very dynamic".

**Box 25: Forecast of RTE's electricity consumption (in 2015)**




*Source: RTE Forecast Bulletin, 2015.*

These forecasts from the beginning of the 2010s proved to be correct in the medium term: electricity consumption actually stagnated or decreased from the 2010s onwards. Nevertheless, the **lack of longer-term forecasts may have**

**contributed to the fact that governments do not perceive the risk of a reverse trend in a more distant horizon at a later stage**.

**The rapporteur is surprised that the decision-makers at the time were satisfied with such analyses** and did not note, even though reflection was underway on the management of energy policy through the creation of the PPE, the absolute necessity of basing the strategy on more comprehensive studies and planning for the longer term.

Mr. Pierre-Marie Abadie, Director of Energy from 2007 to 2014, confirmed that during this period, the prospective models "*were not complete, from a technological, economic and environmental point of view*". In particular, they did not include elements such as the savings capacity of households or the environmental footprint of different energy sources.

This observation is all the more striking since in February 2012 the "Energy 2050" report was published, prepared by a working group chaired by Mr. Jacques Percebois and commissioned by the Minister Mr. Éric Besson. This report (see Chapter II-I-A-1-c) considered multiple data such as the international context (the growth of demand on a global scale) or external uncertainties such as the volatility of oil prices or the outcome of international climate negotiations. He also highlighted the great uncertainty surrounding demand by 2030, while specifying that most scenarios rather predicted an increase in demand: "*We note that electricity demand responds to contrary impulses:* ***energy efficiency efforts tend to reduce it****, with "rebound* effects*",* ***while the greater electrification of uses and the development of captive uses are driving it*** *upwards. In the end, depending on the importance given to controlling* energy *demand in relation to electricity as an energy vector,* ***we can also hypothesise a decrease or an increase in electricity demand by 2030****.* ***Most scenarios predict an increase in this demand*** *for electricity*[1]".

During the first half of the decade, the **public authorities therefore confined themselves to studies to define the country's energy strategy that did not provide a clear basis for the evolution of energy consumption in the longer term** – even though the High-level Commission of Experts had begun this forward-looking work in 2010.

RTE has since carried out work to enrich its analyses but confirms that it was only from 2021 that it expressed itself, on the basis of a prospective analysis, on the long-term electricity needs for France, by 2050.

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(1) *Rapport Énergies 2050, working group chaired by Jacques Percebois, Centre d'analyse stratégique, études et documents, 2012, pp. 138-139,* http://archives.strategie.gouv.fr/cas/system/files/rapport-energies_1.pdf

**While we can be satisfied with this recent improvement, the rapporteur notes the impact that the incompleteness of such fundamental data as the forecast of electricity consumption may have had, and in particular its underestimation in relation to the climate and industrial objectives that France set itself.**

Furthermore, in the context of the shorter-term forecasting tools to verify the absence of risks to security of supply, the rapporteur noted that the method used from 2011 onwards had also proved to be frustrated.

### 3. But a crude approach to security of supply

While the LTECV confirms security of supply among the objectives of energy policy and provides for one of the components of the multiannual energy programming to be devoted to it, it appears that the approach adopted by this concept does not make it possible to anticipate energy crises with sufficient depth of vision.

For electricity, the expected level of security of supply is based on the definition by public authorities of the socially and economically acceptable risk of failure. Security of supply does not mean zero risk of imbalance between supply and demand. Such a reading would be extremely costly, since it would require having an installed capacity on the territory capable of permanently covering all the hazards affecting the electricity system (climatic hazards, accidents affecting the availability of the park), including those that are supposed to occur only at a very low periodicity.

The public authorities therefore define the accepted level of risk of default at the end of *"a trade-off of general interest between, on the one hand, the benefits derived by consumers as a result of a lower risk of supply disruption and, on the other hand, the cost borne by the community of the additional means of supply of production and demand response that must be developed to reduce this risk* (1) ".

In France, this arbitration leads to the definition of the **failure criterion**, which represents the level of interruption of the power supply, for reasons of supply-demand balance, accepted each year by the community. This is a decisive criterion since it allows public authorities to calibrate the sizing of the electricity system and anticipate the evolution of the generation fleet.

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*(1) RTE, provisional balance sheet for 2015, p. 12*

Historically, as RTE recalled, EDF used the "three-hour criterion" to size the generation fleet. This meant that the park had to be able to ensure supply all the time, except for three hours a year in probability.

In 2000, Article 6 of the NOME Law(1) provided that the Minister responsible for energy would adopt the multiannual programming of investments in electricity production on the basis of "*a multiannual forecast balance drawn up at least every two years*". The task of drawing up this assessment is endorsed by RTE, which is confirmed by a decree published in 2006(2) which specifies that in this document, RTE must characterise the **risk of failure**, the threshold of which corresponds to a "***average annual failure time of three hours due to imbalance between electricity supply and demand*"**. At its creation, RTE therefore uses the "3-hour criterion" to qualify the level of risk of the electricity system.

The aforementioned 2006 decree provides that to update this study annually, RTE "***relies on the most likely development prospects of electricity supply and trade with foreign networks*"**. It also specifies that in this regard, the balance sheet "*retains as a central hypothesis the* ***cancellation of the export balance of electricity at peak consumption*"**. This means that RTE reasons as if the system would not resort to any imports to pass the peak consumption.

In 2015, the LTECV confirmed this approach by listing :

– in Article L. 141-7 of the Energy Code, the fact that the objective of security of supply implies that "the failure of the *electricity system, the criterion of which is laid down by regulation", must be avoided* .

– in Article L. 141-8 of the Energy Code, the mission is to periodically draw up a "*multiannual forecast balance* sheet (3)" whose purpose is to identify the risks of imbalance between the needs of the continental metropolitan France and the supply of available electricity to meet them, and which must identify the power needs necessary to ensure compliance with the "failure criterion".

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*(1) Law No. 2000-108 of 10 February 2000 on the modernization and development of the public electricity service.*

*(2) Decree No. 2006-1170 of 20 September 2006 on multiannual forecast balance balances between electricity supply and demand*

*(3) First paragraph of Article L. 141-8 of the Energy Code: "The operator of the public electricity transmission system shall draw up each year a national electricity balance and a multiannual forecast balance evaluating the electricity system with regard to the failure criterion mentioned in Article L. 141-7. The national electricity balance shall cover the year preceding the date of its publication and the forecast balance shall cover a minimum period of five years from the date of its publication. »*

This criterion may, moreover, be based on criteria other than the average duration of failure: the duration of load shedding, their depth and frequency are so many elements that it is possible to take into account. Nevertheless, the 2016 multiannual energy programming[(1)] chose to 'maintain until 2018 the criterion of failure of *the electricity system at its current level, i.e. an average annual failure time of three hours for reasons of imbalance between electricity supply and demand*', while specifying that it would be necessary to carry out, '*by 2018, an assessment of the cost of default, in line with European reflections on the consistency of national criteria*". The decree on multiannual energy programming[(2)] enshrined this criterion in Article D. 141-12-6 of the Energy Code[(3).]

It is clear from the hearings conducted by the Committee of Inquiry that two objections can be addressed to the way in which the criterion of security of supply was apprehended.

● The first reason for questioning is that of the **scope of analysis chosen by RTE.**

Until 2011, the balance sheets are based on an analysis of security of supply **that does not take into account the production capacities of European countries**, which could be called upon through the interconnection system. Security of supply is assessed on the basis of a zero balance of trade, without taking account of import possibilities. **In 2011, RTE decided to change its approach and integrate imports into its assessment of security of supply**. As of 2015, the reasoning in "France interconnected' prevails for the assessment of investment needs[(4)]. Decree No. 2016-350 of 24 March 2016 amending Title IV of Book I of the Energy Code confirms the consideration of foreign trade in the supply-demand balance study.

(1) *Multiannual energy programming 2016-2023 in full, p. 160, https://www.ecologie.gouv.fr/sites/default/files/PPE%20int%C3%A9gralit%C3%A9.pdf*

(2) *Decree No. 2016-1442 of 27 October 2016 on multiannual energy programming .*

(3) *Article D. 141-12-6 specifies on this date that "the criterion of failure of the electrical system mentioned in Article L. 141-7 is set at an average annual failure time of three hours for reasons of imbalance between electricity supply and demand"*

(4) *Decree No. 2015-1823 of 30 December 2015 on the codification of the regulatory part of the Energy Code creates an Article D. 141-7 in the Energy Code, the first paragraph of which reads as follows:*
*"The analysis of investment needs in electricity production means necessary for the security of electricity supply in the continental metropolitan France takes into account changes in electricity consumption, production supply* ***and electricity exchanges with European networks****."*

*(5) .*

Mr. Dominique Maillard, who headed RTE at the time of this evolution, explained that the choice to take into account a margin of manoeuvre linked to possible imports, i.e. at that time 5,000 MW, had been proposed by RTE in order to **propose a better economic adjustment made possible by the development of interconnections with neighbouring** countries. In its view, it seemed excessive to consider that there was a risk to security of supply since the installed capacity on the national territory was less than the possible demand, since the development and diversification of interconnections made it necessary to take account of this possible room for manoeuvre.

It should also be noted that at that time, the France was preparing the capacity mechanism, of which the default criterion constitutes basis, and it seems unlikely that the European Commission will accept a French mechanism that will not integrate European trade. Moreover, the criterion defined by RTE had no economic or operational consequences: it was a risk analysis that did not lead to a decision being taken as to whether it was appropriate to close or maintain an electricity production entity. At that time, the closures of coal- and oil-fired power plants were the result of industrial decisions taken by the operators, which were therefore not ordered by the public authorities.

The Committee of Inquiry **nevertheless wondered about the blind spot that could constitute**, **in a national probabilistic scenario[(1)], the hypothesis of the occurrence of a European multifactorial crisis** (based, for example, on the combination of a cold wave and a geopolitical crisis at Europe's borders) **which would lead to France's neighbouring countries reducing their exports and France not being able to rely on interconnections to maintain its security of supply**. Also, and although RTE considers in its scenarios two types of cases. On the one hand the “isolated France” which cannot count on the margins of capacity linked to the possibilities of import, on the other hand the "interconnected France", with these exchanges, it would seem relevant that the hypothesis of a limitation or elimination of imports is one of the risks taken into consideration.

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*(1) For RTE, the probabilistic approach consists of comparing supply and demand levels "by simulating the operation of the European electricity system at an hourly pace over an entire year. These simulations take into account the main events likely to threaten security of supply: **cold waves** that can lead to large variations in demand power, **unavailability** production units that can reduce available capacity, variable hydraulic inputs that can restrict producible over several weeks or even months and the variability of wind and photovoltaic production." RTE, 2015 provisional review, p. 13.*

● The second reason for discussion relates to the definition of the default criterion.

As early as 2017, in its forecast report, RTE highlights the "*crude nature" of the* indicator "*based solely on the average duration of failure, which does not finally characterise the nature of the risks, their probability of occurrence and their impact*[(1)]". The wording of the criterion of security of supply in terms of the average number of hours of failure '*says nothing about the real probability of calling on exceptional means, the depth of such events, their frequency and their duration*[(2)]'. From that date, RTE considers it useful *"to go beyond the criterion to have a more detailed analysis of security of supply risks"*.

François Brottes, who headed RTE, nevertheless stressed that since 2019 it had been conducting *stress tests* that aim precisely to measure the depth of possible failures, which may be significant but are of a very low probability. It is a question of understanding a critical scenario in which, for example, an intense cold snap, the simultaneous unavailability of several nuclear reactors, a situation of low or very low wind in Europe or France. As renewable energies are deployed, these tests will prove all the more necessary as the complexity of managing intermittency and therefore balance on the grid increases, and this tool has now been integrated into RTE's studies since 2021.[(3)]

Despite the existence of these stress tests, Mr. Xavier Piechaczyk confirmed to the Commission of Inquiry that **this criterion of three hours did not seem sufficient for the public authorities to anticipate crises**, and that it was possible for him to improve it.

The debate on the definition of the failure criterion has recently been revived. Thanks to a reform aimed at bringing French law into line with European law[(4)] which provides that the method of defining the security of supply criterion is now the responsibility of national regulators (and no longer of the States), the decree of 23 December 2021[(5)] rewrote Article D. 141-12-6 of the Energy Code, which sets out the method used to determine it[(6)]. In parallel with these discussions, Mr. Xavier Piechaczyk indicated that RTE was currently in discussion with the DGEC on the issue.

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*(1) RTE, Bilan prévisionnel 2017, p. 196.*

*(2) Ibid., p. 360.*

*(3) See the 2021 forecast and the Energy Futures 2050 report.*

*(4) Regulation (EU) No 2019 /943 of the European Parliament and of the Council of 5 June 2019 on the internal market in electricity*

*(5) Decree No. 2021-1781 of 23 December 2021 on the criterion of security of electricity supply mentioned in Article L. 141-7 of the Energy Code.*

*(6) From now on, the CRE proposes a criterion on the basis of a RTE report. This RTE report was submitted to the CRE on 22 April 2022, which proposes to retain a criterion of 2 hours per year of load shedding (i.e. still 3 hours per year of failure). The CRE approved this proposal by deliberation dated May 25, 2022.*

## B. THE 2015 LAW, OR THE COUNTER-EXAMPLE OF AN ENERGY STRATEGY

President François Hollande's five-year term is marked by the adoption of Law No. 2015-992 of 17 August 2015 on the energy transition for the green growth session (known as the TECV law), which was the subject of numerous comments during the hearings conducted by the Committee of Inquiry. As pointed out earlier, this law has done useful work in steering energy policy through the creation of multiannual energy programming. **However, some of the principles underlying the development of PPE were not themselves followed by the 2015 legislator**.

This is the case with the aspiration for transversality in the conduct of energy policy. **Advocated with regard to the PPE, it is not really followed in the text of the LTECV, which is largely focused on electricity**, whether from renewable sources, nuclear or hydroelectric sources. Thus, even though the title of Title I mentioned having the ambition to define common objectives to succeed in the energy transition and "*strengthen energy independence*", the question of French dependence on fossil fuels (gas and oil) is not addressed. The provisions relating to the development of clean mobility are more in line with environmental reflection than with an approach to reducing dependence on oil imports. In the same spirit, the issue of gas is only very indirectly addressed through the renovation and energy performance of buildings.

**The same applies to the idea of basing the conduct of energy policy on an impact study assessing all the consequences of the measures taken. While imposing this tool in the context of the development of the PPE, the legislator frees itself from it** by posing, within the first title of the law, a multiplicity of non-prioritised objectives, some of which prove contradictory(1). In particular, the objective of **reducing the share of nuclear power in electricity production to 50 % by 2025** is not based on a rigorous study to ensure its feasibility(2). Finally, this measure, like that of capping nuclear production capacity, is more a symbolic and political choice than an energy strategy(3).

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*(1) The targets were: to increase the annual rate of decline in final energy intensity to 2 per cent by 2015 and to 2.5 per cent by 2030, and to achieve a 10 per cent rate of satisfaction of the country's energy needs from renewable energy sources by 2010.*

*(2) This law provides, inter alia, that France take part "in achieving the objective of reducing the European Community's greenhouse gas emissions by at least 20%", that it will contribute "to the achievement of the objective of improving the European Community's energy efficiency by 20% and undertakes to increase the share of the European Community's energy efficiency". renewable energy at least 23% of its final energy consumption by 2020", which the State has set itself the objective of "reducing the energy consumption of the existing building stock by at least 38% by 2020", or to reduce "in the field of transport, greenhouse gas emissions by 20% by 2020", as well as to by 2020 "a 50% reduction per passenger-kilometre in aircraft fuel consumption and carbon dioxide emissions, an 80% reduction in nitrogen oxide emissions and a reduction in nitrogen oxide emissions". 50% of the perceived noise".*

*(3) Ordinance No. 2011-504 of 9 May 2011 codifying the legislative part of the Energy Code.*

## 1. The multiplicity of non-prioritised objectives weakens the French energy model

While the law for the energy **transition** is accompanied by a reflection on the tools for steering energy policy supposed to be based on a rigorous analysis of trajectories, it **poses in its first title a multiplicity of non-prioritised objectives that are more of an incantation than an energy strategy.**

In this sense, it is in line with the 2009 programming law resulting from the Grenelle Environment Forum, which also legally defined quantitative objectives, expressed as a percentage, to be pursued by energy policy.

Before these laws, Law No. 2005-781 of 13 July 2005 on the programme setting the guidelines for energy policy (known as the NOME law) focused on the means to be implemented: only two objectives expressed as a percentage appeared in the operative part of the text(1). Later, Law No. 2009-967 of 3 August 2009 on programming relating to the implementation of the Grenelle Environment Forum introduced a number of quantified objectives aimed not only at reducing greenhouse gas emissions, but also at improving energy consumption and developing renewable energies(2).

Before 2015, Article L. 100-4 of the Energy Code relating to energy policy objectives and created by the Order of 9 May 2011(3) did not mention these quantified objectives: it referred to the objectives set out in Law No. 2009-967 above. In 2015, the LTECV rewrote Article L. 100-4 of the Energy Code to list nine objectives, six of which are declined in the form of a percentage to be achieved.

**The quantitative objectives set out in Article L. 100-4 of the Energy Code by Law No. 2015-992 of 17 August 2015**

– Reduction in greenhouse gas emissions of 4% between 1990 and 2030 and division by four between 1990 and 2050 (maintenance of the objective previously set by the aforementioned Law No. 2009-967);
– reduction in final energy consumption by 50% in 2050 compared to 2012, aiming for an intermediate target of 20% in 2030;
– reduction in primary energy consumption of fossil fuels by 30% in 2030 compared to 2012;
– determination of the share of renewable energies in gross final energy consumption: 23% in 2020 and 32% in 2030 with, to achieve this by that date, a share renewable energy in electricity production by 40%, final heat consumption by 38%, final fuel consumption by 15% and gas consumption by 10%;
– reduction in the share of nuclear power in electricity production to 50% by 2025;
– reduction in air pollution in accordance with the national reduction plan defined by the Environmental Code;
– renovation of all buildings by 2050 to "low-energy building" standards;

- energy autonomy of the overseas departments by 2030, with an intermediate objective of 50% renewable energy by 2020;
- 5-fold increase in the amount of renewable heat and cooling and recovery delivered by district heating and cooling networks by 2030.

The LTECV therefore sets out a series of ambitious objectives, both in terms of climate, in terms of reducing polluting emissions, and in terms of energy in terms of the development of certain types of energy production.

With regard to the deployment of renewable energies, the LTECV law maintains the objective previously set by the 2009 law of reaching, by 2020, the share of 23% of French final energy consumption, to which it adds a more distant objective of increasing this share to 30% in 2030. However, it is not enough to state an objective in the law for industrial reality to follow. Thus, the threshold of 23 % set in 2009 and confirmed in 2015 was still not reached in 2021, since the share of renewable energy in gross final consumption reached 19,3 % that year [(1)].

To the problem of the accumulation of ambitious objectives, the 2015 law adds a new type of quantitative objective relating to the **definition of the electricity production mix**. With a view to achieving the deployment of renewable energy, the LTECV specifies that in 2030, renewable energy will have to represent 40% of electricity production, 38% of final heat consumption, 15% of final fuel consumption and 10% of gas consumption. At the same time, it sets a target of reducing the share of nuclear power in the energy mix by less than 50% by 2025.

This focus of the legislator on the definition of the electricity mix appears problematic as it avoids the question of the first French energy dependence: dependence on hydrocarbons. Issues such as reducing the use of gas heating or electrifying the vehicle fleet to reduce oil imports are not really invested.

Moreover, **this orientation of the electricity mix contradicts the first objective set, which is that of decarbonisation**. It is opposed to reducing the share of nuclear power, which is a carbon-free energy constituting a real asset in terms of reducing greenhouse gas emissions. The German experience has shown that the reduction and then elimination of the share of nuclear power in the energy mix calls into question the achievement of climate objectives because of the need to restart thermal power plants, which emit high levels of polluting particles. The closure of nuclear capacity leads to the reopening of thermal capacity, because renewable energies, because of their intermittency or the insufficient size of the production fleet, do not compensate for the loss of nuclear capacity.

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*(1) Ministry of Energy Transition, Key figures on renewable energies, September 2022, p. 17,* https://www.ecologie.gouv.fr/sites/default/files/CGDD_A6_CHIFFRES_CLES_EnR_2022_v3_010922_GB_bookmarks.pdf

Moreover, the question of defining the electricity mix is overinvested on the basis of political programmatic objectives intended to give impetus to the renewable energy sector, but without first determining the feasibility of modifying the electricity mix within the time limits indicated with regard to the maintaining security of supply. Despite the legitimate desire of the legislator to adopt a proactive stance on the deployment of renewable energies, the legislator should have refrained from making the subject of the electricity mix a symbolic banner declined in the form of objectives. It was all the more so since it already appeared, in 2015, that the industrial sector of renewable energies was struggling to structure itself (see Chapter II, I, B, 2), and that the achievement of these objectives would clash with the reality of the country's energy production capacities.

**2. The legal definition of a target of reducing nuclear electricity to 50% in the electricity mix by 2025: a political objective maintained in disregard of scientific and technical reality**

In 2015, the examination of the draft law on the energy transition led the French legislator to approach the issue of the electricity mix in an unprecedented way: it inscribed, in the law, a percentage aimed at limiting the share of of nuclear production in the electricity mix.

Article 1 of the LTECV amends Article L. 100-4 of the Energy Code in order to list the objectives of the national energy policy, including includes that of " reducing the share of nuclear power in electricity production to 50% by 2025 ".

However, this quantitative objective, which takes the form of a percentage, appears to be devoid of industrial meaning and is disconnected from thinking in terms of security of supply.

The Committee of Inquiry sought to retrace the decision-making process that led to this choice, which was denounced by many players in the energy sector as representing a **negative signal sent in 2015 to the entire nuclear industry**.

***a. A quantitative objective of political inspiration but without scientific or technical basis***

In response to the rapporteur's questions about the basis for the objective of reducing the share of nuclear power in the energy mix, reference has been made several times to the hypothesis of a transcription of an electoral agreement.

This electoral agreement is the one that took place the year before the 2012 presidential election, between the Socialist Party, whose first secretary was then Martine Aubry, and the Europe Ecology and Greens party, whose national secretary was Cécile Duflot. With regard to energy, this agreement, which has both programmatic and electoral content, does indeed retain, but not only, the commitment to reduce the share of nuclear power in electricity production to 50% by 2025:

**Extract from the agreement concluded between the Socialist Party and the Europe Ecology and Greens Party on 15th November 2011**

*"2) Rebalancing French electricity production in favour of renewable energies*

*We will reduce the share of nuclear power in electricity production from 75% today to 50% in 2025 and commit:*

*– A development plan for the existing nuclear fleet providing for the reduction of one third of the installed nuclear capacity by the gradual Closure of 24 Reactors, starting with the immediate shutdown of Fessenheim and then the most vulnerable installations, by their location in seismic or flood zones, their age and the cost of the work necessary to ensure safety Maximum. This evolution will integrate the assessments of ASN and IRSN as well as the necessary balance between supply and demand. (...) ».*

*Source: EELV*

The hypothesis of a direct filiation between this electoral agreement and the legislative provision studied would have been unfortunate.

In the opinion of the decision-makers interviewed, who were members of the Socialist Party when this agreement was drawn up, **the definition of this quantitative objective does not is based on no scientific or technical analysis** that would measure its feasibility or compatibility with the maintenance of energy security.

What Mr. Arnaud Montebourg(1) describes as a "*corner of the table agreement"* is for Mrs. Ségolène Royal(2) (who during the primary of the Socialist Party in 2011, had committed herself to Greenpeace as a candidate for a complete exit from nuclear energy within 40 years) a "*political agreement [which] is not technically robust, because [the political parties] did not have the means to carry out impact assessments*." Mr. Manuel Valls confirms that "*no impact study or needs analysis justified the transition from 75% to 50% nuclear in energy consumption. Some probably thought that* the *preponderance* of *nuclear power was holding back the emergence of new energies."*

*(1) Hearing of Mr Arnaud Montebourg, March 1, 2023.*

*(2) Hearing of Ms Ségolène Royal, 7 February 2023.*

No technical study, therefore, but a political agreement, presented as such by Mr. François Brottes, who chaired the special commission responsible for examining the energy transition bill in the National Assembly: "*It was a political agreement. Some were in favour of phasing out nuclear power, others were in favour of accelerating the deployment of renewable energies, without abandoning nuclear power. It was therefore decided to decide in the middle. This political agreement also aimed to abandon MOX fuel (mixed oxides) – which, by the way, has not been done.*"

Admittedly, the political agreement, which provides in particular for the closure of 24 reactors and the cessation of fuel reprocessing, is not transmitted as such and entirely in the law. Mr. Manuel Valls, who took part, also remembers that the debate on energy policy that took place there was marked by the post-Fukushima context of the time and marked by "a *form of runaway in a political formation*". Moreover, according to him, basically, "*most of the candidates were in favour* of the *objectives, but not* of the *content of* the *agreement with the Greens* ".

In fact, the presidential program presented by the nominated candidate, Mr François Hollande, does not correspond to the aforementioned electoral agreement. Proposal No. 41 of the programme reads as follows: "*I will preserve the independence of France while diversifying our energy sources. I will commit to reducing the share of nuclear power in electricity production from 75% to 50% by 2025, guaranteeing the maximum safety of installations and continuing to modernise our nuclear industry. I will promote the rise of renewable energies by supporting the creation and development of industrial sectors in this sector. The France will meet its international commitments to reduce greenhouse gas emissions. In this context, I will close the Fessenheim power plant and continue the completion of the Flamanville (EPR) site.*"

François Hollande's presidential project does not include the objective of closing 24 reactors, but only the closure of the two reactors of the Fessenheim power plant. Moreover, if the presidential program includes a target of reducing the share of nuclear energy to 50% of electricity production, it no longer provides for its achievement "in 2025", as provided for in the electoral agreement, but "*by 2025*".

However, qualify as the former President of the Republic Mr. François Hollande[(1)] of "*fantasy*" the idea of a transcription in the law of 2015 of the electoral agreement of 2011 is at the very least curious: it is the **political ambition announced during the presidential campaign, which has become totemic, which is translated into the law.**

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*(1) Hearing of Mr François Hollande, 16 March 2023.*

President François Hollande's five-year term therefore opens with this promise, which is included in the Prime Minister's general policy statement. Mr. Jean-Marc Ayrault[1], whose implementation is the responsibility of the Minister of the Environment and Energy responsible for preparing the energy transition law. Under this Government, three ministers of the environment succeeded one another (Ms. Nicole Brick, Ms. Delphine Batho and Mr. Philippe Martin) and left their functions before having been able to implement this reform.

Ms. Delphine Batho began the preparatory work as Minister of Ecology, Sustainable Development and Energy between June 21, 2021 and July 2, 2013. Heard by the Commission of Inquiry, she confirmed that her mission was to implement this presidential promise which, according to her, served *“the interest of the nation, because France's excessive dependence on nuclear power for its electricity production is a vulnerability*".

The preparation of the reform appears perilous. Ms Delphine Batho[2] said that she had commissioned her services to carry out studies on the feasibility of the objective. According to Ms. Batho, these lead to the conclusion *“that it was realistic to envisage reaching the 50% target between 2028 and 2030, but that it was not desirable to retain the date of 2025 – even if it were possible – because it would require the use of fossil fuels to replace nuclear* power". It is opposed to the second option, considering it preferable to *"close reactors as progress is made in terms of energy saving, phasing out fossil fuels and developing renewable energies*".

The change of Government in 2014 with the appointment of Mr. Manuel Valls as Prime Minister obviously has no impact on this process. For M. Manuel Valls, the desire to enshrine this objective in the law is based on the ambition to "*turn to a* different *course."* According to M. Valls, the question "*was not so much the 50% level set for electricity generation, but rather the direction to be taken to pave the way for other non-carbon sources of electricity than nuclear and hydro."*

Under his Government, it was finally Mrs Ségolène Royal, appointed Minister of the Environment, Energy and the Sea on 2 April 2014, in charge of International Climate Relations, which is responsible for implementing this presidential promise.

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*(1) General policy statement by Prime Minister Jean-Marc Ayrault before the National Assembly on July 3, 2012.*

*(2) Hearing of Ms Delphine Batho, 9 February 2023.*

She told the Committee of Inquiry that, since she felt that this objective "*had no place in the law"*, she first *"sought to extract this 50% target from the law, by proposing to place it in the PPE*", before proposing to extend the deadline to 2030, which she had to give up because of the ecologists "*mounted to the niche, at Matignon and at the Élysée* ". It would then have worked to include in the law “horizon 2025” (formula retained in the presidential program), rather than the formula "*in 2025*", which seems surprising given the fact that the presidential program had already replaced this firm deadline with the qualification of a "horizon".

Asked about her reaction to the reserved opinion of the administrations under her authority, which considered it difficult rather than "realistic" to respect the objective including by 2025, Ms. Ségolène Royal made this answer: " *Even if the objective seems unrealistic to me, leading me to advocate for 2030, the PPE will make it possible to readjust it. Rather, I seek to make the most of this political injunction for the French energy model, by pushing renewable energies and energy savings*." It considers that it has built on this objective "to *give France additional opportunities to get ahead of renewable energy and energy performance, while maintaining nuclear production at its level at the time*".

The fact that the impact assessment accompanying the bill is not accompanied by any element to establish the means to achieve this objective is not the subject of any explanation. **The impact study mentions this objective** of reducing the share of nuclear power to 50% of the electricity mix **only in a pithy sentence**: "*In* the *scenario of* the *law, the* electricity mix *continues to evolve Beyond* 2020*:* the share of *nuclear power is reduced to 50% by 2025, the share of renewable energies will reach 40% of electricity production by 2030*".

The "consultations" section of the impact study, however, mentions a reservation expressed by the National Council of Industry, to which no response is given: "In addition, the CNI is concerned about the objective of reducing the share of nuclear power *in electricity production, considers that the provisions intended to revive and Promoting renewable energies are not the most conducive to ensuring a recovery of the sector and generally criticises the project for not being integrated into a more global European policy.*

The task of drawing up an impact study for this measure to reduce the share of nuclear generation is in a way referred to the stage of drawing up the multiannual energy programming which, pursuant to Article L. 141-3 of the Energy Code, must include such a study.

At the time of the parliamentary debate on the LTECV, **no scientific or technical data was therefore provided to the national representation to inform this choice to enshrine in law the objective pursued. However, the rapporteur established that technical analyses requested from the administrations, in**

**particular relayed to the Prime Minister and the President of the Republic by the Minister in charge of industry, revealed doubts as to the feasibility of the objective in the chosen timetable.**

### *b. An objective enshrined in the law despite administrative alerts issued and known on the feasibility of the chosen schedule*

To understand the level of technical information of decision-makers, the Committee of Inquiry questioned the various administrations and bodies in charge of energy on this point.

First, the current Chairman of the Executive Board of RTE, Mr. Xavier Piechaczyk, told the Committee of Inquiry that the Government had not requested RTE's expertise to assess, before the discussion of the law, the consequences of the objective of reducing the share of nuclear power in production to 50% electricity. This is a significant observation of the lack of a solid basis for the legal provision in question.

The former President of RTE, between 2007 and 2015, Mr. Dominique Maillard, however, told the Commission of Inquiry that he had alerted the Government, both orally and in writing, to the tense nature of the implementation and its subordination to the realisation of technical conditions: "*As head* of *RTE, I confirmed* the *possibility of this scenario, subject to meeting several conditions. In view of the configuration of the French grid, the reduction of nuclear power and its replacement by other concentrated means of production would have posed no problem, gas turbines or coal-fired power plants located in the same places. On the other hand, if these nuclear power plants were replaced by smaller, diffuse and distributed plants, there was no guarantee that the grid would be strictly adapted to this new configuration. The conditions that could be attached to the feasibility of the scenario included an adaptation of the transmission network and, a fortiori, of the distribution network*".

Then, if it emerges from the hearings organised that **studies were carried out by the services of the Ministry of Energy Transition,** it turns out that the conclusions they reached consisted in stressing that **the 2025 deadline would be difficult to sustain**.

Mr. Pierre-Marie Abadie, Director of Energy from 2007 to 2014, confirmed that an alert had been made on the calendar. According to him, the 50% target was in itself achievable. On the other hand, the question seriously arose of its feasibility in 2025, because it involved overcoming a number of technical challenges, but also shutting down, quickly, a large number of reactors:

"*We didn't have an alert to issue about this 50%. On the other hand**, we had warned about the calendar**. A quick timetable meant shutting down a lot of plants. This also meant having extremely ambitious levels of renewables. The third topic* *was the extent of the transformation of the network, which was clearly not achievable in a decade. Finally, the fourth topic concerned incompatibility with continued reprocessing. However, the political framework was "50% 2025", with maintenance of the restatement. A contradiction therefore appeared between these two elements."*

Mr. Laurent Michel, Director General of Energy and Climate since 2012, used expressions that are at the very least cautious and almost contradictory to evoke these objectives and their work of instruction. If he did not wish to qualify the realisation of the hypothesis of 50% nuclear by 2025 as "realistic" in 2014, preferring to describe it as "plausible": "***It*** was ***quite clear that the goal was ambitious***, ***without seeming***, ***however, unattainable in*** 2014", he even more directly reports a doubt shared with the Minister Ms. Delphine Batho since 2012 on the ability to achieve this trajectory*: "We quickly realised that the 2025 horizon seemed unrealistic given the pace of development of renewable energies."*

He confirmed to the Commission of Inquiry that the difficulties in achieving this objective had indeed been reported to the Government.

Mr. Antoine Pellion[(1)], energy technical advisor in the office of Mrs. Ségolène Royal, confirms that these alerts were well known to the Minister and her office. He insists, however, that these studies highlighted difficulties, but not an impossibility: "*The difficulty of this scenario is clearly established. It is not totally impossible, but it depends on fairly voluntarist assumptions. The path exists*."

Mr. Dominique Maillard recalls that the response to the alert issued by RTE had "*undoubtedly consisted in affirming that the necessary means would be implemented when the time came*".

**The rapporteur was thus able to establish that the technical and scientific information according to which the achievement of the objectives sought, which were to be enshrined in the law, was not impossible but appeared unlikely or even presented a risk existed. The rapporteur noted that this information had been transmitted to the Government, that the Government seems to have been aware of it at the time but that, in full knowledge of the facts, it chose to persevere.**

It will be necessary to wait until 2017 for RTE to be asked to understand the means to be implemented to achieve the objective set in the law and to assess the technical, economic and environmental consequences that would result. It is on the basis of the analysis produced that Minister M. Nicolas Hulot will announce the extension of the deadline to 2035 (see Chapter II, III, A, 1, a).

*(1) Hearing of Mr Antoine Pellion, January 18, 2023.*

### c. *The unconvincing justification based on the weakly normative nature of the operative part*

The political choice to maintain the setting of a numerical objective in the law was relativised by the various decision-makers of the time, who all pleaded the low normativity of the provision.

The members of the cabinet of Minister Ségolène Royal insist on the purely programmatic nature of this political objective.

Mr. Manuel Valls develops the same idea when he explains that within the Government, "*the 50% was not a "lock"*".

Mr. François Brottes relies on the absence of an impact study to justify the non-normative nature of the provision: "*The 50% horizon is all the less prescriptive as it is not the subject of any trajectory in the impact study of the 2015 law or in the multiannual energy programming (PPE) of 2016* ".

**In the rapporteur's view, the declaratory aim of the objective, without any legal indication of the means mobilised to achieve it, is not such as to temper the judgment made on the decision adopted and on the criteria of that decision.**

The desire to send a clear signal in favour of the development of renewable energies is a legitimate political choice that the rapporteur does not intend to call into question. But this positive signal for renewables has turned into a negative signal for nuclear. However, in the absence of certainty as to the possibility of continuing the announced trajectory, the destabilising effects on the nuclear industry should have led to greater caution.

The lack of political listening to the technical and scientific warnings received embodies this lack of caution. It was **aggravated by the biased nature of parliamentary debate due to the absence of a robust impact assessment** produced by the Government in Parliament.

### 3. Symbolic elements devoid of energy logic: the capping of nuclear production at 63.2 GW and the closure of Fessenheim

The **limitation of nuclear generation to 63.2 GW** is another measure of the LTECV symptomatic of the change in political vision on nuclear energy during the 2010s. Contrary to the "50%" target of nuclear production, this cap is not programmatic and has a real normativity. **However, this measure is also a political and symbolic decision taken without any energy logic.**

The LTECV includes in the Energy Code a ceiling of 63.2 GW of power for nuclear power reactors[1]. When this ceiling is reached, no operating permit for a new nuclear power generation installation may be issued. In practice, the issuance of a new operating licence implies the definitive disconnection of equivalent nuclear capacity.

The logic underlying this provision appears here again quite symbolic: as recalled by Mr. Manuel Valls, "the closure of a *plant was* to *create a virtuous circle favorable to renewable energies and also to the possible opening of a dismantling of power plants, all this while leaving open the question of duration".*

Even beyond the possible judgement on the political choice that the new majority could legitimately decide to make, the rapporteur was able to establish that debates on this issue had animated the interministerial discussions prior to the reform.

**Mr. Arnaud Montebourg, Minister of the Economy, Productive Recovery and Digital Affairs, alerted Prime Minister M. Manuel Valls ahead of the tabling of the bill, in a letter dated June 6, 2014 sent to the Commission of Inquiry.**

The Minister evokes the ambition of the Ministry of Ecology to insert in the draft energy transition law currently being prepared not only the capping at 63.2 GW of the total installed nuclear capacity, but also "*a limitation of* the *lifetime of* the *plants to 40 years*" as well as *the* establishment of in the multiannual energy programming of "*a trajectory of decline in installed nuclear capacity, which the services of the Ministry of Energy have confirmed in recent months that it would correspond to the closure of about twenty reactors by 2025*".

The minister warns: "*This mechanism seems* to *me to be particularly dangerous in terms of security of supply, the competitiveness of the economy, public finances and employment*. (...) ", in particular because it "*consists in irreversibly* deciding on the *closure* of *reactors on* the *basis* of *forecasts for the development of renewable energies by nature very uncertain".* It adds that the "*limitation to forty years* of the *lifetime of the reactors would bring* back *into* question *causes the investment program of 55 billion envisaged by EDF for the extension of the life of its reactors*".

*(1) Article 187 of the LTECV includes an Article L. 311-5-5 which provides that ' The authorisation referred to in Article L. 311-1 may not be issued where it would have the effect of increasing the total authorised capacity for the production of electricity from nuclear sources beyond 63.2 gigawatts.*

*'The administrative authority, in assessing the total authorised capacity, shall take into account the repeals pronounced by decree at the request of the holder of an authorisation, including if it results from the application of the second paragraph of Article L. 311-6'.*

The reform actually included in the LTECV differs from this preliminary draft decried by Mr. Arnaud Montebourg. According to M. Antoine Pellion during the preparation of the, "*two families of ideas clash: on the one hand*, the *cap on installed capacity at 63.2 GW, the application of which leads de facto to close only one pair of reactors opposite Flamanville, and on the other hand the limitation of the age limit, by which all reactors of more than n years would have to close*". According to him, Minister Ségolène Royal gives "*The very clear direction to favor the first option and not to enter the second*."

The former technical adviser to the Minister, Mr Antoine Pellion, rejects the idea that a risk was taken with regard to security of supply. He recalls that at the time, France massively exported electricity. In addition, RTE's forecast balance sheet for 2015, available to the Government for the preparation of the reform, provides for a stabilisation or even a decrease in electricity consumption. Therefore, in view of the projection elements available to the Government and taking into account the conditional analysis according to which a plant must close only on the day when another is put on the grid, "*the cap of 63.2 GW does not call into question safety of supply*". For M. François Brottes, this threshold of 63.2 GW which corresponds to the installed nuclear capacity at the time of writing the text "*offers a* comfortable *margin to close and open plants".*

However, it appears to the rapporteur that the **setting of reduction targets or thresholds for limiting** energy **production in law** poses **an unnecessary risk to the country's** security of energy supply. However, it turns out that in this case, this **risk was taken to serve a symbolic and political objective: the closure of the Fessenheim power plant**.

Beyond the desire to send a signal of diversification of the electricity mix in support of the development of renewable energies, the **definition of the threshold of 63.2 GW has indeed a very specific purpose: to close a power plant.** The cap prevents the commissioning of the Flamanville EPR, then supposed to be ready in 2017[(1)], without the definitive disconnection of equivalent nuclear capacity.

The Fessenheim plant is not explicitly mentioned in the LTECV, but this choice refers to another promise made by the candidate.Mr. François Hollande, who was also included in the political agreement prepared by Ms. Martine Aubry and Ms. Cécile Duflot in 2011, and which is reiterated by the President of the Republic on September 14, 2012 in the framework of the Environmental Conference. Moreover, in 2012, an interministerial delegate to the closure of the plant was established by decree. Also, to justify this choice, Mrs. Ségolène Royal began her

(1) *Decree No. 2007-534 of 10 April 2007 authorising the creation* of the EPR provides for a period of 10 *years before the commissioning of the EPR, i.e. a deadline of 10 April 2017.*

remarks with a clear message: "*the closure of Fessenheim had been promised*".

However, by the admission of Mr. Manuel Valls, "the *closure of Fessenheim was not totally based on objective elements*" since "the *plant was the oldest but not the least safe".* On this point, the fact-finding mission on the follow-up to the closure of the Fessenheim nuclear power plant(1) recalled that the plant had been the subject of an "*overall positive assessment by ASN*". In 2019, the authority's report published in 2019 located the Fessenheim power plant *"favourably compared to the national average in the areas of safety and environment, and on average in the field of radiation protection(2)".*

During his hearing, former President François Hollande refuted the strictly political nature of the decision: "*Why Fessenheim? There were several reasons for this choice to close a power plant to open another, in this case Flamanville, of larger dimensions. The first was that the Nuclear Safety Authority, in an opinion of 3 February 2012 – so before I took office – stated that it was necessary to undertake very important work to sustain the operation of Fessenheim. The second argument, which was not the most decisive, however, was that it was the oldest of our plants. Yet another, disputed by local elected officials, was that the plant was located below the Alsace Canal, with a risk of flooding, which referred to what had happened in Fukushima, even if the two situations were hardly comparable. I would like to add one last point: during my predecessor's term of office, Fessenheim had already been mentioned as possibly closing. You have received Mrs Kosciusko-Morizet, who also invoked the fact that the thickness of the raft, that is to say the concrete floor of the plant, was lower than it was in all the other plants and did not reach the third-generation safety level".*

**This being noted, none of the technical arguments mentioned stands up to technical, scientific or industrial analysis**: the need to undertake maintenance work is common to all nuclear power plants, especially post-Fukushima and at the time of passing the ten-year visits; nor is the age of the power stations a reason since it was implicitly planned to extend a very large part of the power stations beyond 40 years; finally, the comparison between a risk of flooding of the Alsace Canal and the Japanese tsunami does not seem the most judicious.

Obviously, the diplomatic context also weighed on this choice. After the Fukushima disaster, German energy policy is based on the rapid phase-out of nuclear power. However, the Fessenheim power plant is adjacent to the German

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*(1) Information* Report *No. 4515 presented by Raphael Schellenberger and Vincent Thiébaut on 6 October 2021, https://www.assemblee-nationale.fr/dyn/15/rapports/cion-dvp/l15b4515_rapport-information#_Toc256000025*

*(2)* ASN, *Report on the State of Nuclear Safety and Radiation Protection* in *France in 2019, https://www.asn.fr/annual_report/2019fr/*

border. The pressure exerted across the Rhine was therefore strong for the closure of this plant to take place quickly.

Beyond the objective of limiting nuclear production to 50% of electricity production, the LTECV therefore contains another symbolic measure that is the cap of 63.2 GW for the closure of a power plant.

The decision-makers have certainly sought not to compromise security of supply by providing that the **closure of this plant can only take place when the Flamanville EPR opens**. However, when, a few weeks before the end of the five-year term, Mrs. Ségolène Royal presented on April 8, 2017 the first decree to close the Fessenheim power plant(1) it was difficult to believe that the government was unaware that a decision to close could only be made at the request of the holder – an application that had not been filed; it is also difficult to imagine that the timetable for commissioning the EPR will be kept. The decree will thus very logically be annulled(2).

But the continuation of this case, managed under the following five-year period, showed that that the context could evolve. For various reasons which will be explained below (see chapter II, III), this condition was ultimately not applied. **This is all the more powerful in view of the fact that legislators should commit themselves to taking no risks from the point of view of energy security by adopting symbolic measures.**

**The rapporteur thus points out that this law has indeed caused two direct damages: the sacrifice of the Fessenheim power station, on the one hand, and the attack, which could only be voluntary, on the attractiveness of the nuclear industry by sending an unfavourable signal against this energy.**

**With regard to the setting of political and symbolic objectives without scientific foundation, this law constitutes a counter-example in the method of defining French energy policy. However, the rapporteur stresses that it would also be a caricature to see in it the cause of all the ills of our energy industry and in particular of the** nuclear **industry, already weakened** at **that time by competition and the lack of anticipation of investments and monitoring of skills**.

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*(1) Decree No. 2017-508 of 8 April 2017 repealing the authorization to operate the Fessenheim nuclear power plant. Article 2 of the decree specifies that the repeal of the licence to operate the Fessenheim power plant 'shall apply on the date notified by EDF for the commissioning of Flamanville 3, on the conditions that:*

*"1 ° The request provided for in Article L. 311-5-5 of the Energy Code was received before that date;*

*"2 ° The commissioning of Flamanville 3* ***occurred before the expiry of the deadline set*** *in Article 3 of Decree No. 2007-534 of 10 April 2007 authorizing the creation of the basic nuclear installation called Flamanville 3, including an EPR type nuclear reactor, on the site of Flamanville (Manche), in the wording resulting from Decree No. 2017-379 of 23 March 2017 referred to above".*

*(2) By a decision of the Council of State dated October 25 , 2018.*

## C. THE WEAKENING OF OUR ENERGY INDUSTRY

Despite messages of support for the French nuclear industry after the Fukushima disaster, the sluggish market, characterised by the absence of new projects, is gradually undermining the competitiveness of the industry. Apart from the negative signals previously mentioned conveyed by the law on energy transition, no brutal political decision has yet come to clash head-on with French nuclear power: it is quietly that its weakening follows its course(1). Parallel to this downward movement, the rise of renewable energies is real, but insufficient(2).

### 1. Low-noise attenuation of the nuclear industry

Nuclear production remained at a fairly good level in the first half of the 2010s. High of 429 TWh in 2010, it rose to 436 TWh in 2014, before starting a decline that reflects a declining availability: it amounts to only 379.1 TWh in 2017.

During the decade, no new construction project being launched on the national territory, it is internationally that the French sector seeks to obtain contracts so essential to maintain its skills. However, in this respect, the decade is opening with a sector that remains marked by the loss of the tender passed by the United Arab Emirates to South Korea. In 2012, the Fukushima disaster dealt a new blow to the sector, then shaken by the message conveyed by the energy transition law adopted in 2015.

The weakening of the sector then increases without the State reacting quickly or strongly enough to anticipate difficulties or minimize their impact (a) or to remedy the thorny problem of skills decline (b).

#### *a. Questions about the inertia of a State shareholder lacking responsiveness to deal with files with destabilising potential for the sector*

i. A belated reaction to put an end to harmful competition between national nuclear champions

Whether it is the optimal management of projects on the territory or the international export capacity of French nuclear power, the 2010s are illustrated by what Henri Proglio describes as "*misalignment of the strategies of companies dependent on the State – EDF, AREVA, the CEA – driven by divergent interests*".

Regarding relations between EDF and the CEA, the High Commissioner for Atomic Energy between 2009 and 2012, Catherine Cesarsky, indicated that she had had to denounce in 2012 the absurdity of *EDF's* "*lack* of *openness vis-à-vis the CEA with regard to the monitoring of reactors in progress*.", EDF only soliciting the CEA when a problem occurred.

The current leaders of EDF and the CEA both praised the quality of the current relations between EDF and the CEA. The former High Commissioner, Mr. Yves Bréchet between 2012 and 2019, however, considered that there was still "*room for progress for better interaction between nuclear actors, starting with EDF, Framatome and the CEA*".

With regard to the difficult relationship between EDF and Areva, the rapporteur notes that the **procrastination of the State shareholder to manage the situation continued at the beginning of the 2010s**.

If the companies concerned and their managers are involved, it is important to stress, as Mr. Cédric Lewandowski did before the committee, that "it *was not only a quarrel of persons, there were also strategic differences that the State did not arbitrate".* Indeed, and as mentioned earlier (see Chapter II, I, B, 2, c, iii), the State shareholder has allowed itself to develop, to use the terms used by the High Commissioner for Atomic Energy M. Patrick Landais, a "*competition between project managers [which] has not been likely to constitute a national industrial force capable of harmonising skills to revive the sector on French soil and win markets abroad*".

However, this failure of the State to tackle the problem prevailed even though the report submitted to the President of the Republic, Mr. Nicolas Sarkozy by M. François Roussely in **May 2010,** identified the need for the State to regain control of the organisation of the sector and to remedy the disorganisation of the nuclear "Team France".

The former President of the Republic, Mr. François Hollande, explained that he had found, after his election, a network "*which was fragmented, divided and disorganised*". He said he began his reorganisation in 2014, with "*appointment decisions: Mr. Varin was called* to the *management of Areva* and Mr. *Fontana to that of Framatome, and Mr. Lévy replaced Mr. Proglio at* the head of EDF*",* followed by a clarification of the distribution of responsibilities: *"EDF thus became head* of *single file, in order to avoid a repetition of the difficulties encountered in the Emirates or Flamanville, while Framatome took care of the boilers and Orano of the fuel".*

**The project to overhaul the French nuclear industry presented by EDF and AREVA and validated by the State was actually presented in 2015**(1) The sector is being restructured to bring together the design, management and marketing activities of EDF and AREVA's new reactor projects in a joint subsidiary in which EDF becomes the majority shareholder. The rescue of Areva, which will then take over the name Framatome, is also achieved by means of a recapitalisation.

Mr. Jean-Bernard Lévy welcomed this restructuring decision which entrusted EDF with the role of leader in the construction of nuclear reactors, and to make Framatome the person in charge of the boiler and various equipment, noting that this company had subsequently returned to profit. Although the operation was successful, the **rapporteur can only regret the duration of the State's inertia for too many years** during which French energy industry champions failed to present the nuclear France team on a united front.

Former and current EDF Group CEO have insisted on the role played by ARENH in the deterioration of the company's financial situation, indirectly criticising the lack of state action to remedy this problem.

ii. A *status quo* on the non-updating of ARENH despite EDF's deteriorating financial situation

In order to identify how EDF's situation may have evolved unfavourably during the 2010s, the Commission of Inquiry questioned the three former CEOs who led the company during this period.

Mr. Pierre Gadonneix, who was CEO from 2004 to 2009, indicated that at the time of his departure, at the dawn of the 2010s, production was stable and the availability of the park, of the order of 80% satisfactory, even if it began to decline. According to him, this is what justified the investment efforts made to maintain the plants. He indicated that he had not been followed financially and tariffically so that when he left office, the "*French activities were no longer self-financing: cash flow resources were not sufficient to finance investments – which explains, in part, the stock market fluctuations"*. Nevertheless, the company's financial performance remained "*quite healthy*" at the time. **Mr. Pierre Gadonneix also indicated that the company paid at that time significant dividends to its shareholders – and therefore mainly to the State – to the tune of €4.5 billion per year**. However, the Court of Auditors(2) painted a more mixed picture of the company's financial situation at that time, stressing that two international acquisitions finalised in 2009(1) and the lack of anticipation of investments and monitoring of skills had "*accentuated the increase, which has become structural, of its debt*" and that the group had found itself "*at the end of 2009, in a situation of financial fragility*".

*(1) Communiqué of the Presidency of the Republic, dated June 3, 2015, on the refoundation of the nuclear industry, https://www.vie-publique.fr/discours/194980-communique-de-la-presidence-de-la-republique-en-date-of-3-June-2015-su.*

*(2) Court of Auditors, special report, EDF's international strategy, Fiscal years 2009 to 2013.*

Mr. Henri Proglio, appointed following Mr. Pierre Gadonneix, rationalised the group's activities abroad and made a number of disposals. Nevertheless, he considers that he found a "*house in fairly good condition, with very good skills*" and which "*did not encounter great financial difficulties. The company's indebtedness was the result, but it was perfectly acceptable*." He says that when he left in 2014, EDF was in great shape, "*despite all the vicissitudes to which we had been subjected by French and European regulations",* in particular the Nome law. He said that the net result after tax was €3.75 billion, and that the level of debt remained acceptable since the debt/EBITDA ratio, which counts more than the absolute value of the debt, was less than three.

When Mr. Jean-Bernard Lévy took the helm of the company in 2014, he said he was surprised to be aware of the implications of the Nome law on the company's financial situation. According to him, "*ARENH is increasingly weighing on EDF's debt at a rate of about €3 to 4 billion per year*". The situation is deteriorating: in 2016, "*EDF's revenues experienced a sharp fall since the wholesale price per megawatt hour fell to €30* (...). *This shortfall forces EDF to a severe restructuring plan, imposed de facto by the rating agencies that downgrade EDF's debt three times."*

**This statement raises questions: precisely, if wholesale prices fall to €30 or well below the ARENH tariff, the device can not have a negative impact on the company's results. Over this period as for the following ones, in the absence of precise and annualised data communicated by EDF, the rapporteur cannot accept the figures presented by the former EDF managers.**

EDF is then pursuing this restructuring plan, which is based on significant asset disposals, a trajectory of savings on operating costs and a concentration of EDF's investments on low-carbon activities.

**It was at this moment that the State decided**, **for the first time, to renounce that its dividend be paid in current flow.** On April 22, 2016, the State announced that it would receive its dividend in shares.

Finally, in 2017, **the State subscribed to about 75 % of the company's capital increase, which reached €4 billion**.

The story of these three successive CEOs reveals trends that emerge over the decade: the availability of the park begins to be a subject. However, in the future, it will have a significant impact on production, and therefore on the company's financial performance.

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*(1) There is talk of a stake in the American company Constellation and the purchase of British Energy.*

Results remained stable over the first half of the decade at around €4 billion in net profit from recurring activities[1]. These results nevertheless fell to €2.8 billion and €2.5 billion in 2017 and 2018, before experiencing a strong recovery (€3.9 billion) in 2019, where the declining results of nuclear production were offset by good results in the renewable energy sector. Despite the overall maintenance of the group's results, the former CEOs agree on one point: the role played by ARENH in the decline of the group's financial capacities. The former President of the Republic Mr. François Hollande joined this analysis when he stressed that through the renunciation of the State of the payment of the dividend and its participation in the recapitalisation of the group, "*for* the first time since the *creation of EDF, that is to say since the Liberation, the State supported* the *national company, And that's because of a bad law: that of 2010*."

However, estimates of the damage suffered by EDF as a result of ARENH are difficult to establish. The figure communicated by Mr. Luc Rémont to the questionnaire sent by the rapporteur puts it at a total of €9.1 billion since its entry into force until the end of 2022. The CRE replied to the rapporteur that it had "*no visibility on the financial* impact *of the device for EDF. The group's public results do not allow us to completely isolate the impact of ARENH*." The Court of Auditors noted that "the *implementation* of the *ARENH did not proceed as planned, but allowed* the *full costs to be covered* on *the period considered*[2]", while stressing **that in the absence of ARENH, nuclear revenues would probably have been "*higher*[3]"**.

While ARENH has been presented as one of the main reasons for EDF's indebtedness, it appears that nuance must be shown, since the mechanism has gone through very different phases depending on the wholesale market price of electricity.

A first observation is necessary in any case: it is surprising that the public authorities did not go to the end of what the application of the law required by publishing the decree that would have made it possible to revise both the initial price of the ARENH and its device.

As previously presented (see Chapter II, I, A, 2, c), the **ARENH system was initially** to **be reassessed before 31 December 2015**, and then every five years.

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(1) *According* to the *annual* balance sheets *published by* the EDF group, *the group's current net income*, in *billions of euros, was 3.9 in 2010, 4.2 in 2012, 4.1 in 2013, 4.8 in 2014, 4.1 in 2016.*

(2) *Court of Auditors, The organisation of electricity markets, Thematic Public Report, July 2022, https://www.ccomptes.fr/system/files/2022-07/20220705-rapport-organisation-marches-electricite_0.pdf.*

(3) *The Court indicates that "Subject to the precautions of interpretation associated with the conventional nature of the calculation, the results suggest that in the absence of ARENH, the balance sheet for the period would have been much more to EDF's advantage", Idem, p. 113.*

In addition, the **ARENH tariff should**, pursuant to VII of Article 1 of the NOME Law, "*in order to ensure fair remuneration*" to EDF, cover the costs and allow the depreciation of the park by 2025, and, above all, be "reviewed annually".

**However, neither the system nor the ARENH tariff were revised during** the 2010s, despite **the** warnings issued by EDF's CEO from 2014.

The Commission of Inquiry sought to understand the inertia of the public authorities on the subject.

As regards the tariff, first of all, it should be borne in mind that, as stated in Mr. Pierre-Marie Abadie, who was Director of Energy at the time of the implementation of the reform, this tariff of €42 corresponded to the amount requested by the president of EDF at the time. According to the calculation method chosen to cover all the costs associated with the Grand Carénage, the price was to be €39. As part of the work of the Champsaur commission, the CRE had estimated that the full cost of existing nuclear power was €39.5/MWh. The additional cost of investments related to the Fukushima disaster had been added, and the executive had finally arbitrated in favor of a tariff of €42.

Later, in 2014, when Mr. Jean-Bernard Lévy arrives at the head of EDF, he considers that this tariff does not cover the real cost of production, which would rather be around fifty euros. He indicates that at that time, there was talk of increasing the price of the ARENH to €52. According to him, "the Government *of the time agreed*", but "the *increase* did not *take place because the wholesale price fell below €42, then €35 then €30. The (European) Commission considered that the market should be allowed to function. If the latter decided that* the price of *electricity* was *less than €42, there was no* reason to raise *the price of ARENH. The door was therefore closed on this issue in the course of 2016*." Mr. Laurent Michel, Director General for Energy and Climate, confirmed that "the ***Government had wanted to make increases****, which had sparked debate in the context of the previous Hercules project. The latter aimed to give EDF a vision attested by an audit of the CRE, by remunerating nuclear at €49 /MWh. We defended this upgrading, but were not the only decision-makers."*

Due to a disagreement between the French authorities and the European Commission, which has never approved the method of calculating the update of the ARENH, the decree in the Council of State taken after the opinion of the Commission de régulation de l'énergie (CRE), provided for in X of Article 1 of the Nome law, **which was never published.**

In its report, the Court of Auditors reviewed the situation: "*The updating of the ARENH price is subject to approval by the European Commission* of *its method of calculation*, *since* the *decision settling* the *European litigation relating to* the *existence*, *on the one hand, of TRVs "green" and "yellow"* and, *on the other hand,* *Tartam for large and medium consumers. However****, the establishment of this calculation methodology proved to be conflictual****. Divergences of positions between* the *Government*, the *CRE*, the *Competition Authority (ADLC),* the *European Commission and EDF, have emerged concerning the various parameters to be taken in consideration (...). The CRE ultimately voted in favour of the draft decree to establish this methodology, while the ADLC issued a more mixed opinion and the Commission expressed reservations.* ***The exchanges did not succeed, the decree was not adopted and the situation became bogged down[1] ".***

According to Mr. Pierre-Marie Abadie, the **lack of publication of the decree "*was really penalising, because we could not adjust to the real cost of the large refit*.** *In addition,* ***we could not take into account inflation or the real cost of post-Fukushima investments****. In addition, it has left no economic space with an interest in signing long-term contracts elsewhere*." In retrospect, he considers that minimal indexation should have been carried out, even if at the time this was not the priority because of low inflation. He also concedes that such large price fluctuations with low prices over a long period of time seemed impossible. However, the absence of a rise in prices above the ARENH tariff contributed to the creation of a free right of option for EDF's competitors, who, because of the asymmetrical nature of ARENH, then went to buy their electricity on the market, at a price of less than €42 /MWh. This led EDF to sell its electricity well below its own cost price.

The rapporteur is surprised that, despite the difficulties in reconciling the French and European positions, successive energy ministers did not seem to take stock of the problem.

At the beginning of the five-year period of 2012, even if the lack of publication of the decree is open to criticism, the question of the tariff did not yet arise. Ms. Delphine Batho confirmed it to the Commission of Inquiry: during her many exchanges with the CRE, no alert had been issued on a still recent device.

On the other hand, the inertia of the public authorities appears more surprising in the years that follow in view of the warnings than Mr. Jean-Bernard Lévy claims to have done. However, Ms. Ségolène Royal, who described this device as a "*scandal*", said she did not remember having been seized to remove the ARENH, increase the tariff, or even to have "*seen this possibility*" to modify the volumes of the ARENH.

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*(1) Court of Auditors, op. cit. cit., p. 96-97.*

While other objectives, foremost among which is the desire to avoid increases in electricity tariffs for the benefit of the consumer, may have prevailed in arbitration, the rapporteur is surprised that a dossier as crucial as that of the ARENH mechanism for a minister responsible for energy does not appear to have been treated as a priority.

That being said, a second observation must be made: it appears very exaggerated on the part of EDF and in reality, very unlikely to attribute the responsibility for its indebtedness to the ARENH device alone, which is more without being able to produce finer data on the evolution over time of the weight of this device on EDF's finances.

However, the ARENH system has experienced significant fluctuations in terms of its attractiveness. The Commission de régulation de l'énergie([1]) (CRE) has precisely described the variations in the volumes of ARENH issued over the period of the five-year period 2012-2017. It turns out that for a number of years, the low attractiveness of ARENH could not lead to a burden on EDF's debt.

The CRE notes that "the *volumes of ARENH delivered remained broadly stable between July* 2011 *and December* 2013, *despite a slight* increase in the first half of *2013(...). The inclusion of losses in the scheme from January* 2014 *led* to *an increase* in *demand in the first* half *of 2014. ARENH's deliveries then reached a level of 36.8 TWh. Volumes delivered to large consumers were slightly reduced due to the increased attractiveness of wholesale market prices.* In the first half of 2015, the ***significant drop in wholesale market prices***, to *levels significantly lower than the ARENH price*, led to a ***sharp decrease in ARENH subscribed volumes*** *(-64*% in the first half of 2015*,* followed by a further decline of 69% in the second ***half of 2015****). In the second half of 2015, only 3.8 TWh of ARENH were delivered, including 2.8 TWh for losses. (...)* In the first ***half of 2016***, for the *first time since the start-up of the scheme,* ***no volume of ARENH was delivered to alternative suppliers.*** *Only two providers applied for this semester, both at zero.* ***The context of low market prices also led to zero demand for ARENH in the second half*** of ***2016***. *The* ***increase*** in the prices of futures ***products on the wholesale*** market in the second half of 2016, *combined with the establishment of the capacity market from 1 January 2017,* ***has increased the attractiveness of ARENH.*** *The total volume of ARENH requested for the year 2017 amounted to 82.1 TWh (including 0.8 TWh for losses*)".

**EDF's** indebtedness **has therefore not constantly worsened as a result of the ARENH system**. On the other hand, the CRE has confirmed that "*beyond* the *dysfunctions caused by the displacement of the ceiling, the asymmetry of the device, that is to say* the *possibility of leaving the choice to alternative suppliers to ask of ARENH*

(1) *CRE*, *Rapport Arenh, "Evaluation of the ARENH system between* 2011 *and* 2017", *18 January 2018, https://w ww.cre.fr/Documents/Publications/Rapports-thematiques/Rapport-ARENH/consulter-le-rapport*

*volumes when market prices are high, and not asking for them when market prices are lower than ARENH's volume price*, is *a weakness that was detrimental* to *EDF in the years* 2015 *to 2017»*.

The Court of Auditors[1] observed that during those years, '*EDF was forced to sell on the wholesale markets the volume of nuclear electricity it had reserved for these alternative suppliers*, *at a price lower than its production cost (which is, subject to its discounting, the price of ARENH)*'. Consequently, the optional nature of the ARENH did not allow "*to guarantee EDF that its production costs will be covered in the event of a* '*low*' *market price (lower than ARENH)*".

This observation makes all the more damaging the inertia of the authorities to publish the decree provided for by the law that would have made it possible to change the device. The same propensity not to apply the regulations is also reflected in the declining periodicity of the meetings of the Committee on Atomic Energy.

iii. The declining periodicity of meetings of the Atomic Energy Committee

The former High Commissioner for Atomic Energy Mr. Yves Bréchet drew the attention of the Commission of Inquiry to the question of scientific and technical analysis that would have *"deserted the decision-making machinery of the State* " on energy subjects. He referred, in support of his arguments, to the fact that the atomic energy committee in its civil form had no longer been convened with the annual periodicity provided for by decree.

*(1) Court of Auditors, referee, "the evaluation of the implementation of regulated access to historic nuclear electricity", Letter from* the *First President* of *the Court of Auditors M. Didier Migaud to MM. Bruno Lemaire and Nicolas Hulot dated December 22, 2017,* https://www.ccomptes.fr/fr/documents/41952.

**The Atomic Energy Committee**

Created by Ordinance No. 45-2563 of 18 October 1945 establishing an atomic energy commission, this committee's mission, defined in Article L. 332-2 of the Research Code, is to " *stop the research, manufacturing and work program of the Alternative Energies and Atomic Energy Commission* ".

Chaired by the Prime Minister when the committee deals with civil nuclear energy, it is composed of a list of personalities defined by decree including in particular the general administrator of the CEA, the High Commissioner for Atomic Energy, the Director General of Energy and Climate, the Director General of the Research and Innovation, the Director-General for Enterprise and the Director-General for the Budget.

The Committee may be referred to the Committee by the Ministers responsible for energy, research, industry and defence all draft legislative and regulatory acts concerning the mission or organisation of the CEA.

Article 9 of Decree No. 2016-311 of 17 March 2016 on the organisation and functioning of the Alternative Energies and Atomic Energy Commission specifies that it "meets once a year to deal with defence activities and **at least once a year to discuss civil activities".**

The rapporteur noted that the **periodicity of meetings of the Committee on Atomic Energy in its civilian component had indeed declined during the decade.** While this committee met once or twice a year between 2006 and 2012, it was subsequently met only for one meeting in 2015, one in 2017, and one in 2019.

These meetings were, however, an opportunity to discuss topics that were essential for the future of the nuclear industry, such as issues related to research reactors, work on the fourth generation of nuclear reactors, safety and radiation protection research, the organisation of R&D in the nuclear field and international cooperation.

The political leaders in office during these periods do not seem to have perceived this break in rhythm in the periodicity of the meetings and the Director General of Climate Energy indicated that meetings had taken place in other forms.

Over the same period, more meetings of the **Nuclear Policy Council**(1) were certainly organised (see box CPN). But the two bodies have distinct compositions and roles. The Nuclear Policy Council "***defines the broad guidelines*** of ***nuclear policy*** and ***ensures their implementation***" and therefore does not equate to the Atomic Energy Committee, which seems to retain its relevance for reporting, in particular to the Prime Minister and the Minister of Energy, on the programme and results of ongoing research. These regular status reports should make it possible to verify the adequacy of the research program with energy policy in the long term,

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*(1) Since 2008, the Nuclear Policy Council has met once in 2008, three times in 2010, once in 2011, twice in 2012, once in 2013, once in 2013, once in 2013. 2015, once in 2016, once in 2018 and once in 2023.*

but also to adjust the policy according to the results of the research. Above all, the application of the law and the decree by the Government is not an option, and this situation seems to indicate, if not inertia, at least a lack of rigour.

#### *b. A problematic decline in skills*

All those involved in energy policy heard by the Committee of Inquiry shared the same observation: the **loss of skills in the nuclear industry has contributed to its weakening.**

Although already identified at the end of the previous decade, the movement did not stop under the 2010 decade. Without having built power plants for more than a decade, skills have declined at all levels, from engineers to subcontractors.

As Yves Bréchet pointed out, the decline in skills in the nuclear sector is part of the broader movement towards the loss of the French industrial fabric and the disappearance of many industrial jobs. Mr. Hervé Machenaud[(1)] shares this observation when he indicates that with "*The industrialists have gradually demobilised and the welders have left*."

Whether it is the industry in general or the nuclear industry in particular, the principle on which competence is based is the same: only exercise, repetition of gestures, work at work make it possible to train, maintain and perfect techniques. As a result**, the lack of construction of new reactors is** the **main cause of the decline in skills**. Mr. Jean-Bernard Lévy made it clear: "*It is not possible to be competent and efficient when you build a reactor every fifteen years*." For Mr. Pierre-Franck Chevet, *"skills and know-how are acquired in the field*" so that the exercise of the profession *"on a first plant, then on others, guarantees the progression of skills*".

The negative consequences of this decline are significant. They have been in the past and remain so in the present, as illustrated by the setbacks of the construction of the EPR, partly linked to this phenomenon.

The loss of skills is a cycle that is all the more worrying as it is self-sustaining: skills have fallen due to a lack of work to be done, new projects are struggling to be carried out because of the decline in skills, and it is difficult to carry out new projects. Difficult to recruit because the lack of prospects has reached the attractiveness of the sector.

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*(1) Hearing of Mr Hervé Machenaud, February 8, 2023.*

Several personalities interviewed, including former ministers as well as the representative organisations of the energy sector or EDF's CSE, insisted on the development of subcontracting, which would have been harmful to EDF and to the good performance of its facilities (loss of visibility on service providers sometimes of rank 5 or 6, loss of interest evoked for the profession); While the rapporteur has not been able to substantiate this negative impact, he stresses the importance of a controlled value chain for the robustness of the industrial model and for industrial relations.

i. A decline in skills slowed down but not erased by the Grand Carénage or international projects

Faced with the decline in skills that became increasingly clear at the beginning of the decade, the nuclear professions had few new sites on which to work on the national territory.

**The public authorities and the industrialists of the sector have, although belatedly, identified the problem to which they have tried to find a solution, in a framework nevertheless affected by a major restriction: the political decision taken not to launch new projects**.

The ongoing projects, the continuity of which had been confirmed by the President of the Republic, Mr François Hollande, namely the Flamanville EPR site, the ASTRID project and the construction of the Jules Horowitz research reactor, contributed, without sufficient, to the exercise of both technical and engineering skills.

**Part of** the **strategy adopted** to **limit this phenomenon was, according to former President of the Republic M. François Hollande**, to **turn to the international:** "*it was very important to maintain this export strategy to maintain skills, make factories work and make the EPR benefit from a semblance of a series effect*".

**It seems contradictory, to say the least, to conduct, on the national territory, an energy policy sending negative signals to the sector, while hoping to be able to export French nuclear expertise abroad.**

It is nevertheless in this perspective that the launch of the Hinckley Point project, which consists of the construction of two EPR nuclear reactors in Somerset, England, for a total capacity of 3,200 MWe, is taking shape, with a target of starting unit 1 power generation in June 2027, with an estimated project completion cost of between £25 billion and £26 billion.

Prepared under the five-year term of President Nicolas Sarkozy by Mr. Henri Proglio, the project gave rise to controversy because of funding difficulties and the union opposition it encountered. The former President of the Republic, Mr. François Hollande, nevertheless considers that "*it was absolutely necessary to carry out this project, which allowed us to ensure a load plan for the French factories in the sector and to remedy the loss of skills for Framatome* as well *as for EDF or Orano*". The State therefore confirmed, in 2016, its support for the project, despite the debt it implies. After years of absence of perspectives and new projects for the French nuclear industry, Mr. Jean-Bernard Lévy sees in the success of this project "*an important signal addressed to all countries that are wondering: despite the delay of Flamanville and the criticism on our own territory, another country has chosen the EPR*". Mr. Luc Rémont[1] also stressed the essential contribution of the project to the "*maintenance of the sector's competence*".

**At the strictly operational level, however, it must be stressed that this strategy is incomplete. While it was undoubtedly possible to count on feedback from engineering or the manufacture of parts for export sites, this strategy could not in any case be sufficient to maintain the skills of all the trades present in France.**

Industrialists have also been looking for ways to maintain skills. For Framatome, for example, Mr. Bernard Fontana described the "Juliette program", which corresponds to an envelope of €400 million and which it obtained the launch to preserve the skills of its employees by maintaining their activity. A program was therefore designed to manufacture useful and standardised parts on which workers could improve by repeating gestures.

At EDF, the Grand Carénage programme is launched with the aim of maintaining the skills necessary to keep the fleet in good condition, so that it is available in compliance with ASN requirements.

*(1) Hearing of Mr Luc Rémont, February 28, 2023.*

**Presentation by EDF of the chronology of the Grand Carénage program**

In 2008, the Group included in its strategy the industrial project of the nuclear fleet in operation, which aims *to "remain a world reference in terms of safety, maintain a high level of production and extend the duration of its operation significantly after 40 years*". Work will then be carried out for the implementation of an investment program called "Grand Carénage", exceptional both by the volume and complexity of the work it involves and by the fact that it is to be carried out over a long period, on all the reactors in operation.

In 2014, the Group finalised this program, whose mission is to secure, with the engineering and the nuclear operator, the renovation of the French nuclear fleet, to increase the level of safety of the reactors and, if the conditions are met, to continue their operation. It incorporates the additional safety improvements identified following the Fukushima accident and aims to allow the operation of the 32 900 MW reactors and then the other 24 reactors to continue operating beyond 40 years.

On 22 January 2015, the Board of Directors of EDF, at the initiative of Mr. Jean-Bernard Lévy, approves the principle of the "Grand Carénage" program. The total amount of investments authorised is a maximum of €55 billion in 2013 over the period 2014-2025. Over this period, the program includes the completion of the third ten-year visits to the 20 reactors of the 1,300 MW level, the bulk of the safety improvements related to the lessons learned from the Fukushima accident, the launch of the fourth ten-year visits to the 900 MW reactors and routine maintenance.

The technical outline of the 3rd safety reviews of the 1,300 MW reactors had been sent to ASN in 2009, which enabled the first Permanent Group to be held. on the guidelines for this review in 2010 and led to ASN taking a position on the content of this review in 2015. With regard to the fourth safety reviews of the 900 MW reactors, ASN took a position in 2021 at the end of a 6-year investigation period, which began with the Standing Group holding on the guidelines for this review in 2015.

To date, the work of the first period of the Grand Carénage program is very advanced: about forty ten-year visits have been carried out on the 900 MW, 1,300 MW and 1,450 MW. In particular, 2021 marked an important milestone for the programme since, on 23 February 2021, ASN considered that all the provisions laid down by EDF for the fourth ten-year visits to the 900 MW reactors and those it prescribes open up the prospect of these reactors continuing to operate for the ten years following their fourth periodic review. She highlighted the particularly ambitious objectives of the 4th periodic review of the 900 MW reactors and the very substantial work carried out by EDF, as well as the scale of the planned modifications, the implementation of which will bring very significant improvements to the safety of these reactors. As of 31 December 2022, the nuclear fleet has 10 reactors under the VD4 900 standard (Tricastin 1, 2 and 3 / Bugey 2 , 4 and 5 / Dampierre 1 and 2 / Gravelines 1 and 3), all of which have received authorisation from ASN to restart at the end of their 4th ten-year visit.

*Source: Reply* to *the questionnaire sent by the Rapporteur to Mr. Luc Rémont, CEO of EDF.*

By the extent of the work involved, this plan has made it possible to maintain the skills essential to the maintenance and operation of the existing park.

However, this plan is not sufficient in terms of the skills needed to build new power plants, which involve specific operations that only take place at the construction stage, such as the realisation of the cabling or the control system.

These various projects have therefore made it possible to mitigate the trend of decline in skills without solving it entirely. The fact that the Grand Carénage was only launched in 2014 and that the authorities seem to take the measure of the situation only belatedly raises questions. According to the former High Commissioner for Atomic Energy Catherine Cesarsky, this movement of loss of skills that she saw emerging during her mandate between 2000 and 2012 "*has not received enough attention*".

While indicating that it was difficult to identify the slow dynamics, the Director General of Energy and Climate Mr. Laurent Michel acknowledged that "*More anticipation on the part of the various actors would have helped to take action earlier."*

**The rapporteur shares this conclusion and considers that this problem could and should have been collectively – State and industry together – better identified and prevented**.

ii. The consequences of negative signals on the attractiveness of the sector

The problem of the loss of skills can still be linked to that of the **loss of attractiveness** of the sector. This is manifested both in terms of recruitment and the ability of manufacturers to retain their trained staff. Here again, the **image of the nuclear industry**, damaged after the Fukushima disaster, **the negative signals emitted against nuclear power in the** energy transition law, as well as the **absence of large-scale projects** have certainly contributed to dissuading engineering students, scientists, and technicians, from considering their future in the nuclear industry.

Mr. Pascal Colombani highlighted how, citing the example of the ASTRID project, the sector "*needs research projects that can attract and train human resources*". Mr. Yannick d'Escatha confirmed that he had noticed a disaffection of young people for nuclear power, who "*did not see a future in nuclear power*".

At EDF, several representatives on the Central Social and Economic Committee also highlighted the impact of social conditions on the company's loss of attractiveness. Catherine Nicolas-Michon[(1)] mentioned EDF's management in this lack of attractiveness, as well as the drop in the company's salaries compared to other industries.

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*(1) Hearing* of Ms *Catherine Nicolas-Michon as part* of *the round table of 17 January 2023.*

Mr. Philippe Page Le Mérour also highlighted the challenge that the phenomenon of resignations represents for the sector. While stressing that this phenomenon remained very marginal, the CEO of EDF confirmed that it had become perceptible and followed by the company from 2012.

**Data one Resignations in the EDF Group since 2012**

Resignations have been monitored by the Group since **2012, when their volume exceeded the threshold of 100 resignations per year**.

The number of Resignations increased from 108 in 2012 to 290 in 2022. Has resignation rate that remains marginal at 4.8 ‰ (the resignation rate in France which is 2.7% in 2022 – source Ministry of Labor).

On average, 60% of resignations concern the technical and project field. There has also been year increase since resignations from the IS domain, which rose from 4% to 19% of total resignations. In the support sector, resignations (42 in 2022) relate to financial engineering, taxation or legal affairs.

The resignations mainly concern executives (around 65%) with an average seniority of 5 years and an average age of 35 years.

*Spring: Response from Mr. Luc Remont to* the *questionnaire Feels by the protractor.*

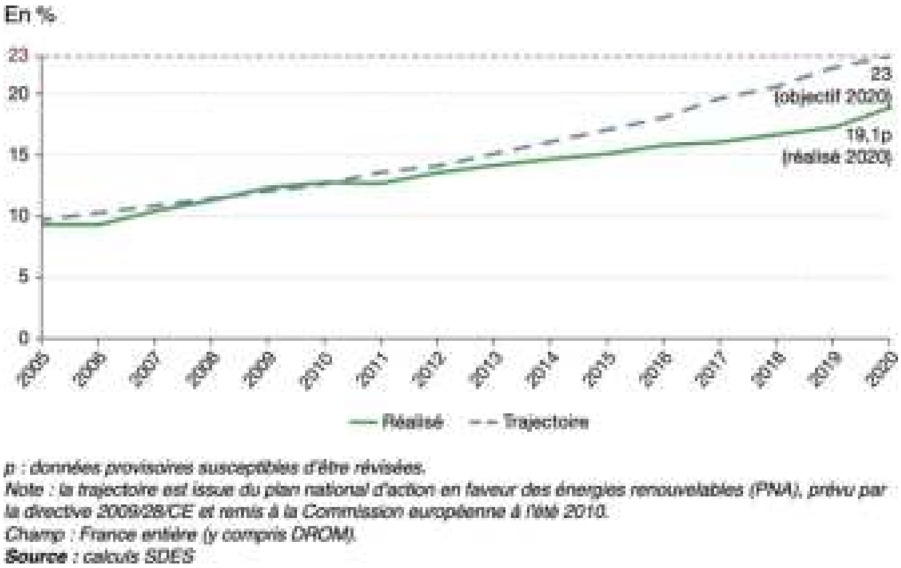
The loss of attractiveness of the sector has contributed to accentuate the problem of loss of skills, by reducing the pool of candidates not only for the positions offered but also in training around nuclear professions. It has also been able to contribute to reducing the time spent in the nuclear industry by workers or engineers whose training period to reach the highest level of excellence is very long, on the order of more than ten years. If on this point, EDF stressed that the *turnover* rate of employees had been 2.5% since 2018, which would constitute an indicator of employee retention, the data transmitted to the rapporteur also showed that seniority of employees at EDF SA and ENEDIS had decreased from 40 years in the 70s to 90 to 30 years in the 2000s to reach 26 years since 2020. These data show that the group continues to be able to count on experienced employees, these trends are an interesting signal and an invitation to public authorities and manufacturers to redouble their efforts to restore the level of excellence and attractiveness to the sector that it once had.

### 2. A gradual but very insufficient deployment of the renewable energy sector

President François Hollande's five-year term is part of a very ambitious dynamic from the point of view of the development of renewable energies. The contribution of energy policy to climate goals is seen as critical, and the development of renewable energy is a priority.

The five-year period begins on the basis of the renewable energy development objectives previously set by Law No. 2009-967 of 3 August 2009 on programming relating to the implementation of the Grenelle Environment Forum: France has committed to increasing the share of renewable energies to at least **23 % of its final energy consumption by 2020**.

**Figure 36: Share of renewables in gross final energy consumption and projected trajectory to reach the 2020 target**

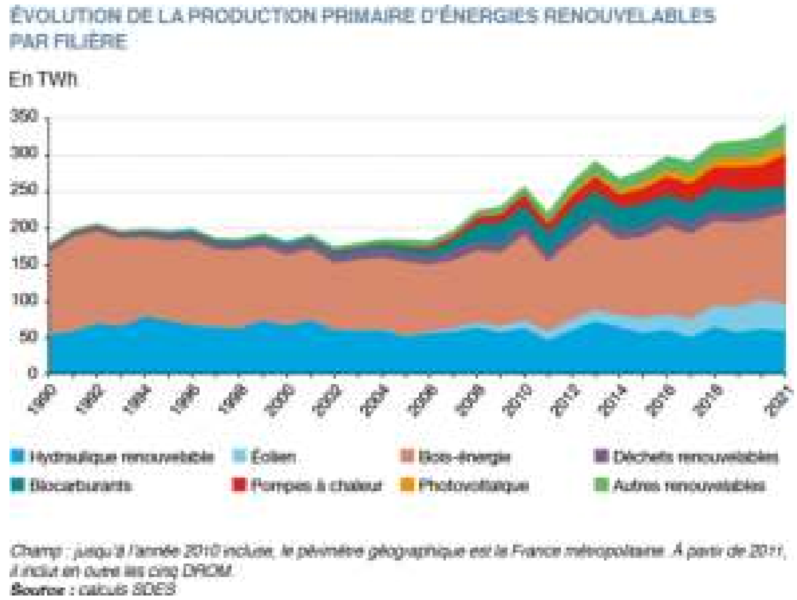



*Source: SDES*, *Key Energy Data , 2021.*

In 2015, the LTECV maintains this target for 2020, and adds the objective of increasing the share of renewable energy to 32% of gross final energy consumption by 2030. The law specifies that to achieve this target, renewable energies must "represent 40% of electricity production, 38% of final heat consumption, 15% of final fuel consumption and 10% of gas consumption". At the same time, and as has already been mentioned, the law provides for the reduction of the share of nuclear power in electricity production to 50% by 2025. Given the objectives set in terms of reducing greenhouse gas emissions (– 40% between 1990 and 2030 and factor 4 between 1990 and 2050), and consequently the impossibility of increasing the share of fossil fuels in the energy mix, the achievement of these objectives must be based on the reduction of demand, on the one hand, and the consequent rise of renewable energies on the other. The combination of these different climate (reducing emissions) and energy (reducing the share of nuclear power) ambitions is then based on a political ideal whose feasibility by 2025 has not been demonstrated. The impossibility of its realisation will also be confirmed in 2017, which will lead to the postponement until 2030 of the reduction of the share of nuclear power in the energy mix. Nevertheless, it is within the framework of these very ambitious objectives that the energy policy for the five-year term is inscribed.

While these targets have still not been met - in 2021, the share of renewables in gross final consumption reached 19.3% [1] The progress of these energies is undeniable. Primary production of renewable energy since 2005 has increased by 85%, mainly due to the rise of biofuels, heat pumps and wind power.

The development of renewable energies, which began in the previous decade, is therefore confirmed during the decade 2010-2020:




*Source: Ministry of Energy Transition, Key figures on* renewable *energies, September 2022.*

The question arises, however, whether this progress can be considered sufficient in view of the stated ambition.

Former President François Hollande partly answered this question when he told the Commission of Inquiry that one of the two regrets he had about the energy policy of his mandate was "*for not having succeeded in sufficiently increasing the share of renewables, whose development was certainly hampered by blockages, appeals and procedures, but whose profitability is proven and whose prices have become very competitive*".

The main failure of the policy of support for renewable energies undoubtedly lies in its **inability to structure an industrial sector**.

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*(1) Ministry of Energy Transition, Key figures on renewable energies, September 2022, p. 17,*

At the beginning of the five-year term, however, there was a reflection in terms of the industrial sector. According to Ms. Delphine Batho, "*public support in* the *field* of *renewable energies should lead to the structuring of industrial* sectors". That is why she had asked, with Mr. Arnaud Montebourg, Minister of Productive Recovery, a joint report to the General Council for the Economy, Industry, Energy and Technology (CGEIET) and the General Council for the Environment and Sustainable Development (CGEDD) on this issue. The mission letter preceding this report stated that while the renewable energy sector had experienced significant growth in recent years, no French company was "*referenced among the world leaders in the photovoltaic sector".* ", and that the challenge was "*to build a real French industry*"(1).

Ten years later, Ms. Delphine Batho notes that "*no industrial strategy [has] accompanied*" the renewable energy support mechanisms put in place, so that, "*as we do not have the mastery of technologies, we fall back into dependence on foreigners*".

Reflection on the subject has thus not prospered. The Court of Auditors notes in a report published in 2018, that in the explanatory memorandum of the draft law for energy transition and green growth, the Government retains "a *very broad understanding* of *the notion* of *sectors, which include all economic activities related to the energy transition, without focusing particularly on manufacturing activities. The economic externalities associated with renewable energies and the energy transition are therefore due to the creation of jobs of all types, without seeking to promote their industrial impact*(2)".

In total, the Court of *Auditors* draws up a severe observation of the inability of the policies carried out to have structured a sector: "failing to *establish a clear strategy* and *stable and* coherent *support mechanisms*, the *French industrial fabric* has benefited little from *the development of renewable energies. Unlike other European states,* ***France has not managed to establish champions in this sector****.* ***A clarification of France's industrial ambitions in terms of renewable energies is therefore necessary****, in view of the economic opportunities that the growth of this sector holds, particularly with regard to new technologies, such as storage and smart grids.* ***This disappointing industrial balance sheet must be weighed against the considerable resources devoted to the development of*** renewable energies*, in particular electric renewable energies*(3)*"*.

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*(1) CGDD and CGEIET*, *wind* and *photovoltaic: energy, industrial and* societal *issues.* https://igedd.documentation.developpement-durable.gouv.fr/documents/Affaires-0007493/008504-01_rapport-final.pdf

*(2) Court of Auditors*, *Support for renewable energies*, *March 2018, p. 24.*

*(3) Court of Auditors*, *idem, p. 7-8.*

Not only has France failed to promote the emergence of a real industry on its territory, but it has also failed to retain certain assets in this area: as Delphine Batho and Arnaud Montebourg have recalled, the loss of control of Alstom, which manufactured hydraulic turbines for offshore wind, has weighed heavily on the French decline.

**The answer given at the time to the question - highly strategic in terms of energy sovereignty - of the availability of critical materials, such as rare earths, necessary for the energy transition also appears to have been quite light in view of the issues at stake**. The response has thus essentially relied on calls for projects in the field of renewable energies in order to guarantee manufacturers orders, a buy-back price and a profitable business model. According to Ms. Ségolène Royal, this system should allow industrialists to invest and search for rare materials. The responsibility for the subject was therefore left to them, while its strategic nature for French industry would undoubtedly have required better public support in order to deploy a strategic vision on the subject and to raise awareness among companies.

This acknowledgment of failure should not make us believe in fate. According to Bruno Bensasson, CEO of EDF Renewables, said: "*The relocation of industrial production within the European Union would be a possible way to reduce our dependencies, but in the state of the competitive context, it calls for industrial policy choices whose economic cost must be assumed while recognizing the merits in terms of resilience*.

To explain this failure, **the instability of policies in** this area was highlighted. Ms Delphine Batho regretted the abolition, in March 2014[(1)] of the increase in the purchase tariff for photovoltaic panels manufactured in Europe [(2)]. Ms. Ségolène Royal regretted that some projects launched when she was at the Ministry of Energy Transition then stopped: "*We could have developed tidal turbines, and I myself had inaugurated a tidal turbine farm in Dunkirk. We could also have developed marine energies thanks to our maritime domain, through the calls for projects that I had launched and which were then stopped*." In addition to this problem, there is the issue of the social acceptability of renewable energies, which, as pointed out, has been pointed out by Mr. Bruno Bensasson, generate difficulties because of their visibility and the tensions they cause on access to land.

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*(1) Order of 25 April 2014 containing various provisions relating to installations using the radiative energy of the sun as referred to in 3 °* of *Article 2* of *Decree No. 2000-1196 of 6 December 2000 fixing by category of installations the power limits of installations eligible for the obligation to purchase electricity.*

*(2) Order of 7 January 2013 increasing the tariffs for electricity produced by certain installations using the radiative energy of the sun as referred to in 3°* of *Article 2 of Decree No. 2000-1196 of 6 December 2000.*

The rapporteur also notes that **the desire to develop renewable energies has been excessively concentrated on renewable electric energies**. Ms. Delphine Batho indicated that in her opinion, the issue should be both "*to transfer uses of electricity to non-electric renewable energies and transfer uses of fossil fuels to electricity*". It is for this reason that one of his first actions in favor of renewable energies when he arrived at the Ministry of Energy Transition consisted in developing biomass and supporting renewable heat *via* the ADEME heat fund. It is an unfavourable budgetary arbitration on this fund that will lead to his departure from the Government.

An analysis by the Court of Auditors has measured the disproportionate nature of the support provided to renewable electricity to the detriment of renewable energy thermal in the analysis of the distribution of financial support for these energies: "***electric renewable energies benefit from the bulk of this public expenditure** with, in 2016, €4.4* billion *compared to €567 billion for thermal RE. This last amount does not appear to be commensurate with the needs corresponding to the objectives set and therefore to the achievement of French climate commitments. Thus*, ***thermal renewable energies now receive the equivalent of a tenth of the volume of public support devoted to renewable energies, even though they represent 60% of national production**, excluding transport*."

### III. SINCE 2017, AFTER A CONTINUATION OF THE DAMAGING DECISIONS OF THE PAST, A REVIVAL OF NUCLEAR POWER AND RENEWABLE ENERGIES ON THE BASIS OF AN ENERGY PROJECTION

In 2017, the presidential election and the change of government only led to a gradual evolution, and not to a complete questioning, of the decisions taken in previous years. The latter have a shadow cast and continue to produce their effects, even if several studies are commissioned to make a precise inventory of the nuclear industry. It is on this basis that a gradual, albeit partial, questioning of past energy decisions takes place (A). **The climate** objective **remains** a **priority** and in this perspective, the failure of the strategy of opposing nuclear energy and renewable energies is noted. The ability to project the energy strategy over the long term is understood and is reflected in the commissioning and publication of RTE's Energy Futures 2050. These new prospective studies make it possible to develop a strategy for reviving nuclear power without opposition to renewable energies (B).

#### A. FROM 2017, A GRADUAL AND PARTIAL QUESTIONING OF THE ENERGY OBJECTIVES AND DECISIONS OF THE PREVIOUS FIVE-YEAR PERIOD

The change of course in energy policy only took place very gradually after the 2017 presidential election. In the first years of the five-year term, a correction of certain obvious errors and an analysis of the French energy system was carried out, a preliminary step essential for instructing subsequent changes of orientation(1). It was also during the first years of this five-year period that difficult decisions for French nuclear power finally found to be applied, in a form of continuity with the orientations of the previous five-year period(2).

### 1. A gradual awareness of the challenges facing the nuclear industry

From the beginning of the five-year period, the Government took note, on the basis of technical studies, of the impossibility of applying the LTECV objective of reducing the share of nuclear power to 50% of electricity production by 2025 without contravening the trajectory necessary to achieve the climate objectives. One of the first major energy decisions is therefore to delay the achievement of this goal in order to allow time for reflection to build the future strategy. At the same time, the Government is accumulating technical and industrial elements in order to have all the information necessary for making an informed decision (b).

#### *a. From 2017, the reactors' closure horizon is shifted to 2035*

The five-year term opens with preparatory work for the five-year revision of the PPE of the continental metropolis, which began in mid-2017. In order to better document the upcoming debate on the future of the electricity system, RTE published, at the beginning of 2018, its "2017 forecast report"which includes a number of developments intended in particular to "*draw up an overview broad and credible possible* developments".

RTE therefore indicates scenarios with detailed trajectories to achieve the configurations studied by 2035.

One of the scenarios, the "Ohm scenario", examines the trajectory to be pursued towards the LTECV objective of reducing the share of nuclear to 50% of electricity production by 2025. Its conclusions are clear: whatever trends are envisaged with regard to the demand and the pace of deployment of renewable energies, achieving this objective according to this temporality will imply not only closing at a demanding pace between 24 and 26 nuclear reactors, but it will also be necessary to open thermal production facilities in a short and difficult time interval. Moreover, this scenario highlights that "*achieving the 50% target is incompatible with* maintaining *CO2 emissions from the electricity sector at their current level*(1)".

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*(1) RTE, Bilan prévisionnel 2017, p. 164*

*(2) Hearing of Mr Nicolas Hulot, February 28, 2023.*

Thus, in November 2017, Mr. Nicolas Hulot, Minister for the Ecological and Inclusive Transition[(2)], said he "*prefers realism and sincerity to mystification*", announces that the horizon of 2025 is not sustainable and evokes the horizon "2030 or 2035" as a new object of study.

**Excerpts from the Ohm scenario presented as part of RTE's forecast for 2017**

“The Ohm Scenario: an unprecedented adaptation of the fleet to achieve the objective of the law on the share of nuclear. The sensitivity analysis confirms the order of magnitude of the number of reactors that need to be shut down to meet the 50% target. (...)

The Ohm scenario was tested with many variants, in order to ensure the robustness of the results presented, and in particular to analyse the sensitivity of the assessment of the number of nuclear reactors to be closed. (...) **The variants confirm the order of magnitude announced, with deviations of one or two reactors compared to the 24 closed reactors in the base case**. With the "intermediate 3" trajectory, the number of reactors to be decommissioned rises to **26.** ( ...) With the "high consumption" variant, the number of reactors to be decommissioned is **23**.

5.3.2 With a slower rate of deployment of renewable energy, the number of reactors to be shut down is increasing. With less **renewable** production (respectively of the order of 20 TWh or 45 TWh for the "EPP pace" and "trend rate" trajectories), **more thermal production is needed** (...). Nuclear production must then fall to actually reach the 50% target.

5.4 The trajectory to reach the 50% target: **dynamics whose practical feasibility raises serious doubts**

(...) In the base case, **the closure of 24 reactors is necessary** to achieve a 50% share of nuclear generation in electricity generation. **(...)**

In all cases studied, reactors that have not reached 40 years of operation must be shut down. **This choice raises questions from the point of view of the industrial logic chosen** because it leads to not fully exploiting the potential of the power plants that have carried out their third ten-year visit and have an operating permit. **In all the cases studied, a massive development of new means, mainly thermal means of production, is necessary**.

5.5 **Achieving the 50% target is incompatible with maintaining CO2 emissions from the electricity sector at their current level**.

5.5.1 Emissions increase in all tested variants

**In the different configurations tested, CO2** emissions **increase significantly.** In the base case, emissions reach 42 million tonnes of $CO_2$, almost double current emissions. Depending on the variants considered, the volume of emissions is between 38 and 55 million tonnes of $CO_2$.

The reduction of the share of nuclear power to 50% of the mix by 2025 and the stability of emissions thus seem to be two irreconcilable objectives.

*Source: RTE, 2017 Provisional Balance Sheet.*

The reflection on the energy strategy continues in the context of a public debate in spring 2018, while the draft law on energy and climate is tabled in the National Assembly on 30 April 2019.

The impact study of the bill refers to the provisional balance sheet published by RTE in 2017, and indicates that in view of the work carried out between June 2017 and December 2018 as part of the multiannual energy programming "and *faced with* the *impossibility* of *reconciling the achievement* of *this objective and that of reduction of greenhouse gases, the Government proposes to Parliament to postpone this objective to 2035* ".

The explanatory memorandum to the bill takes up this argument of "*The impossibility of meeting at the same time all the climate and energy objectives set by the energy transition law. Reducing the share of nuclear power to 50% by 2025 would have required the construction of new gas-fired power plants*, *in contradiction with our climate objectives. It is therefore proposed* to *extend this deadline to 2035, making it possible to initiate a realistic and managed transition*."

Article 1 of Law No. 2019-1147 of 8 November 2019 on energy and climate thus postpones by ten years the objective of reducing nuclear power in electricity production to 50%, now set for 2035.

The Committee of Inquiry wondered what could have led to the fact that, from the opening of the five-year term, the need for the delay became obvious and urgent, even though the LTECV had only been adopted two years earlier.

Mr. Antoine Pellion stressed that this was part of the transition from "a *logic where we set objectives a priori, then defining the ways and ways to reach them, to a radically different vision, since we are now able to document the path and trajectory to get there. The substantive* work of *readjusting* the *trajectory was carried out by* the *first PPE, between* the *law and the beginning of the five-year term. It has led* to *conclusions* that quickly lead *to* the *conclusion that the parameters must be changed, and in particular the horizon of objectives. This point is supported by RTE analyses*."

The purpose of this time lag is to give the Government time for reflection. The revival of nuclear power is, at that time, not yet decided. The postponement of the ten-year target makes it possible to recover margins before determining what path should be taken in terms of nuclear production to ensure security of supply without going back on France's climate commitments.

This rapid evolution of legislation underlines the importance of rigorous steering of energy policies, which should not be based on the expression of totemic objectives, set in the absence of rigorous technical, scientific and projection analyses.

The LTECV has finally, paradoxically, made a mistake while creating the tool that would make it possible to avoid it in the future, with the multiannual programming of energy. These are the work carried out in the context of the preparation of this PPE which quickly confirmed that the 50% target could not be met within the indicated deadline.

The law on energy and climate has also completed this mechanism by inserting an Article L. 100-1 A to the Energy Code, which provides that "*before 1 July 2023, then every five years,* ***A law determines the objectives and sets the priorities for action of*** the ***national energy policy*** to ***respond to the ecological and climate emergency*** **".** The "Energy and Climate Programming Law" (LPEC) thus created will set the main objectives of the PPE and the national low-carbon strategy (SNBC), these two documents must be compatible with the LPEC. These three documents form the French strategy for energy and climate.

**Presentation of the content of the energy programming law, defined in Article L. 100-1 A of the Energy Code**

The Energy and Climate Planning Act must specify the objectives:

- reduction of GHG emissions (for three successive five-year periods);
- the reduction of final energy consumption and in particular the reduction of fossil primary consumption (for two successive five-year periods), as well as the minimum and maximum levels of energy saving obligations;
- the development of renewable energies (for two successive five-year periods), and, since the adoption of Law No. 2023-175 of 10 March 2023 on the acceleration of renewable energy production, the storage of renewable energies;
- diversification of the electricity mix (for two successive five-year periods);
- energy renovation in the building sector (for two successive five-year periods), for which financial measures are foreseen;
- to achieve or maintain energy autonomy in the French overseas departments.

It is also provided that programming instruments must be "compatible" with the objectives set out in the ECPA. This concerns the PPE, the national cap on greenhouse gas emissions known as the "carbon budget", the low-carbon strategy, the carbon footprint of France and the carbon budget specific to international transport, the integrated energy and climate as well as the long-term strategy and the long-term renovation strategy provided for in the European texts.

The creation of this new steering tool, resulting from a parliamentary amendment, aimed to make the debate on the PPE a parliamentary debate and thus to allow "*the national representation to be able to seize it, study it and enrich it by legislative means*". It was thus a question of putting Parliament back at the heart of the energy debate, and of placing this action in the long term: "*Planning and preparing our energy policy over the long term, within Parliament, must allow the legislator to* *stay the course in order to achieve carbon neutrality in 2050,* an *ambitious and essential objective to the preservation of our environment and future generations."*

The preparation of the Government's energy strategy is also based on the commissioning of reports to enable decision-making to be taken in full knowledge of the state of the nuclear fleet and the reasons for the delays on the Flamanville site.

### *b. The commissioning by the Government of analysis and foresight reports on the nuclear industry*

In addition to the various analyses carried out by RTE and the ministerial services as part of the preparation of the PPE, two reports were commissioned, one requested by two members of the Government, the other by the CEO of EDF at the request of the Minister of the Economy[(1)]. M. Bruno Le Maire, which are part of the sequence of analysis that the Government wishes to conduct to make an informed decision on energy policy.

As of March 2018, Mr. Nicolas Hulot, Minister for the Ecological and Inclusive Transition, and Mr Bruno Le Maire, Minister for the Economy and Finance, commission Mr Yannick d'Escatha, former General Administrator for Atomic Energy and Mr Laurent Collet-Billon, former General Delegate for Armaments, to produce a report to complement the government's analyses on the sustainability and performance of activities, skills and jobs essential to the nuclear industry to be able to succeed in future constructions.

According to Michèle Pappalardo, former Chief of Staff of Mr. Nicolas Hulot, the choice of these personalities from civil nuclear and military nuclear was based on the observation of the decline in skills in civil nuclear power, which did not seem to affect military nuclear power. The cross-look between these two sectors was to make it possible to "*draw inspiration from the practices of the Ministry of Defense, in particular to strengthen the attractiveness*" of civil nuclear power. However, it explained that the report had, in its view, been disappointing, as the subject had not really been approached from that angle.

The report, classified as confidential defense, is delivered to its sponsors in 2018. Before obtaining the declassification of this report, a number of elements were brought to the attention of the Committee of Inquiry on the basis of information which had been disclosed in the press when it was submitted.

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*(1) In the mission letter that Mr. Jean-Bernard Lévy to Mr. Jean-Martin Folz, the CEO of EDF explains the ambition of the order: "after a meeting with the Minister of the Economy, Mr. Bruno Le Maire, I wish to be able to provide the State shareholder with a precise and complete analysis of the reasons that led to the choice of the EPR at the time of the launch of this programme, the causes of the successive delays in the construction of the Flamanville EPR, the discrepancies observed between the initial forecasts of the costs of implementation and the costs at completion such as than planned today and the responsibilities of the various parties involved in this project".*

Thus, this report recommended proceeding with the revival of nuclear power by the construction of new reactors – at least three units. Beyond the question of the proposed figure, the motivations that led to it appear particularly interesting. According to M. Yannick d'Escatha, the launch of new projects was essential “to *attract again people who were turning away from nuclear power, especially young people".* In addition, the idea of announcing a milestone – namely the launch of several construction sites – was necessary to give visibility to the sector, but also to "*express the potential*" of the sector, which involves mass construction, as for any industrial activity. The question of the means to remedy the decline in skills, a central issue for the sector, therefore seems to have at least justified the conclusions of the report.

According to Benoît Ribadeau-Dumas[(1)], this report also addressed "the question of the *sustainability of the sector, i.e. the time we had before having to take a decision*". Without knowing the answer on this point, the delay between the delivery of this report and the announcements of the Belfort speech of February 10, 2022 suggests that it was possible to take the time for the precise investigation of the files to decide. The Commission of Inquiry finally obtained the declassification of this report, which placed particular emphasis on the importance of reviving construction projects on the national territory with a view to maintaining skills.

**Presentation of the report submitted in July 2018 on maintaining** the **capacity of the nuclear industry with a view to potential new reactor construction**

The report identifies as a key point the availability of the human resources needed to anticipate, prepare and implement nuclear policy. It draws a worrying observation of the state of the sector: its image is degraded, half of the industrialists are experiencing recruitment difficulties, departures to other industrial sectors are observed, the number of applications at EDF is down sharply, training courses are experiencing a significant disaffection and correspondingly the level of applications is decreasing.

The report stresses that the continuation of this declinist trajectory "*will make it illusory to maintain the industrial capacities of the nuclear sector with a view to potential new reactor constructions*". Thus, "the *primary risk is human, with a fundamental question of confidence in the future*". As the lack of a load plan for the nuclear industry is identified as the cause of these difficulties, the report considers how skills could be maintained.

The report highlights the inadequacy of the export strategy to maintain skills in France, for several reasons:

Export only brings France burden to a few companies. On the HPC site in the United Kingdom, the workload remains, for 63%, located across the Channel. The success of export projects is based on the commitment to construction in France: if France does not engage in construction on its territory, it will lose attractiveness and will not obtain new international contracts.

*(1) Hearing of Mr Benoît Ribadeau-Dumas, January 19, 2023.*

The demobilisation of the teams is mainly caused by the lack of prospects in the nuclear sector on the national territory. The postponement also highlights the inadequacy of care and maintenance operations to safeguard construction skills, as they are very different operations in terms of project size and technical implementation.

The report therefore concludes that it is necessary to announce quickly – before 2021 – the decision to launch a series of three pairs of 3rd generation EPR2 reactors, the three pairs being the condition to benefit from the Series effect deemed Essential to reduce costs and maintain competitiveness.

This first scenario of a short-term recovery is considered necessary to reassure engineers, researchers, technicians, and students who, otherwise, will choose another professional career. Year Announcement before 2021 should also allow the ramp-up of certain EDF and Framatome Sites identified In the report as in sharp decline.

In the second Scenario envisaged of a relaunch after has "Long Shutdown" of 5 gold 6 years after the commissioning of the Flamanville EPR, the report specifies that "the remobilisation would be very long, very *difficult, very expensive and very uncertain. The risk of failure of a remobilisation in the context of the "long shutdown" would be very high and would sign the definitive end of French civil and therefore military nuclear power.*

At the beginning of the five-year term, the hope persists of being able to benefit from the feedback from the commissioning of the Flamanville EPR. During his speech delivered on 27 November 2018[(1)], the President of the Republic, Emmanuel Macron, clarified this method: "And if we do not *take any decision today on the construction of new reactors, because we do not have an immediate need and because we do not have* the ***necessary hindsight, in particular on the Flamanville*** *power plant. , we must take advantage of the few years ahead of us to move forward. I therefore ask EDF to work on the development of a new nuclear program, making firm commitments on the price so that it is more competitive. Everything must be ready in 2021, so that the choice that will be offered to the French can be a transparent and informed choice*."

This phase of expertise is completed, in October 2019, by the submission of the report of Mr. Jean-Martin Folz on "the construction of the Flamanville EPR"[(2)]. The study is commissioned by the CEO of EDF, who requests an *"analysis* of the *reasons that led to the choice of the EPR, the causes of the successive delays and the discrepancies between* the *initial forecasts and* the *costs at completion of the construction of this reactor at Flamanville*".

*(1) Transcript of the speech of the President of the Republic on the strategy and method for the ecological transition delivered on November 27*, 2018, https://www.elysee.fr/emmanuel-macron/2018/11/28/transition-energy-let's change-together.

*(2) Report to the Chairman and Chief Executive Officer of EDF by Mr. Jean-Martin Folz*, *La construction de l'EPR de* Flamanville, https://minefi.hosting.augure.com/Augure_Minefi/r/ContenuEnLigne/Download?id=104AF2DA-FA4D- 4BED-B666-4D582E2C7A8A&filename=1505%20-Rapport%20Flamanville%20pdf.pdf

**Main conclusions of Mr. Jean-Martin Folz on the construction of the Flamanville EPR**

Mr. Folz identified nine main causes of the delay and difficulties of the site:

1. **The initial** estimate **of the project**, both in terms of time frame and budget, was **unrealistic**;
2. The **project was exceptional in its size and complexity** ;
3. **The governance of the project was inadequate**: the report notes that "*unlike usual practices in other industrial sectors implementing major projects,* the *Flamanville* project *does not have a master of well-identified* work, who *should be the future operator*, *and a project manager, responsible for leading a powerful dedicated team".* In Flamanville, both positions were held within EDF's research department. It was not until 2015 that a real full-time project manager was appointed;
4. **The project teams were "*struggling*",** due to the lack of use, at the time of the launch of the project, of management methods "*essential to the management of a project of this size*";
5. **The organisation of engineering resources was too complex, the** engineering of the different elements (boiler, conventional island) being entrusted to different parties (Areva NP, Sofinel), which lead to "*costly co-ordination and monitoring efforts and sometimes inconsistencies with their negative consequences on the site* ".
6. **The studies were insufficiently advanced at** the launch since, apart from *basic design*, "*the detailed engineering work had barely begun and the safety, fire, aggression, qualification of equipment that is not very committed*";
7. **The continuous evolution of the regulatory context has** weighed on delays: while ASN's additional assessments carried out after the Fukushima disaster have imposed only minor changes, the situation has been different from the evolution of the Nuclear Pressure Equipment regulations, reformed in 2005, which also gave rise to difficulties of interpretation;
8. **Relations with companies were not satisfactory**, due in particular to tensions related to the underestimation of fixed-price contracts, a lack of commitment by these companies to meet deadlines, and the conflicting nature of relations between EDF and Areva when EDF took control in 2018.
9. **The loss of skills was widespread** both with regard to the project management of a major project and the industrial component manufacturers, all of whom suffered from the absence of projects for many years, but also for the entities responsible for control.

In the absence of the commissioning of the EPR within the planned time, this report enabled the Government to receive elements of assessment on the causes of the malfunctions of the site, and also prompted the industrialists of the sector to react urgently on the issue of the decline of skills.

Thus, while the report specifies in its conclusion that "*an effort to reconstitute and maintain the skills [*of the *sector] must be undertaken*", the CEO of EDF M. Jean-Bernard Lévy decides in the wake of the creation of a new management which launched the plan entitled "Excell", "*aimed at improving the level* of *skills and* the *quality* of *execution of the sites*, *mainly new* sites, *but also*, *if necessary, sites on the existing park”*. EDF has forwarded to the rapporteur the various measures taken to remedy the main findings made by Mr Folz.

### 2. But damaging decisions continue to be taken in the continuity of previous five-year periods.

First, from 2017, the negative consequences of ARENH, introduced by the NOME law adopted in 2010, became particularly noticeable. Despite the ongoing investigative work to provide a solid basis for the energy strategy, the five-year period 2017-2022 is also the one during which some of the negative decisions included in the LTECV will have their effects, such as the closure of the Fessenheim power plant (b). Shaken, the sector is also destabilised by the decision to stop the ASTRID program without a consequent alternative tool (c).

#### *a. The worsening of the negative consequences of ARENH*

As described above (see Chapter II-II-C-1-a-ii), the failure of the public authorities to issue the decree that would have made it possible to change both the ARENH system and its tariff did not immediately reveal its negative consequences. But it later prevented countering the problematic evolution of the system, to the point that the President of the CRE Mrs. Emmanuelle Wargon[1] stresses that according to her, "*the difficulties* of *the ARENH are linked*, *not to its general principle or* its overall *effectiveness, but its modalities and in particular its inability to evolve over time*".

In practice, the impossibility of modulating the system proved to be very problematic as soon as wholesale market prices fell.

Indeed, given the optional nature of the ARENH for alternative suppliers – the latter having a free option to supply their customers on wholesale market conditions when it proves more interesting than the ARENH – the volatility of the electricity markets has led to ARENH experiencing a very variable attractiveness over the past decade.

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*(1) Ms. Wargon's* reply *to the questionnaire transmitted by the Rapporteur.*

**The fluctuation of ARENH's Attractiveness over the decade**

The first phase, which corresponds to the first three years of ARENH, allowed the development of competition in the retail market: between 2011 and 2014, alternative suppliers gradually issued requests for ARENH.

A second phase began in 2014, following the fall in wholesale prices that led to ARENH's demand being zero in 2016.

At the end of 2016, wholesale prices rose again, so alternative suppliers resumed ARENH applications.

ARENH's ceiling of 100 TWh was reached for the first time in the November 2018 window, then also in the November 2019, 2020, 2021 and 2022 windows.

In the elements sent to the rapporteur, the CRE sets out the problems revealed from 2017 onwards: "*ARENH's applications increased continuously between 2017* and *2022 due to the attractiveness of the scheme compared to wholesale prices and the growing number of* alternative suppliers *(in* 2010*, there were three alternative suppliers) until finally exceeding the ceiling of 100 TWh for the first time at the November 2018 window". However,* "*exceeding* the ***ARENH ceiling leads to malfunctions of the retail electricity market to the detriment of consumers***": to the extent that suppliers obtain a larger share of their supplies on the wholesale market – the ceiling being reached – prices rise, and become unpredictable.

For EDF, this also results in a very unbalanced mechanism since, as the Court of Auditors points out, "*alternative suppliers can benefit according to their annual expectations from electricity at* the *price of ARENH,* ***without bear the long-term commitments associated with the means of nuclear productio*** (1)**"**. Prime Minister Elisabeth Borne(2) stressed that during the Covid-19 epidemic, and while market prices had fallen below ARENH prices, alternative suppliers had "*returned ARENH to EDF, which had not anticipated the sale of these volumes and was taken aback. This situation has certainly been detrimental for EDF*."

In addition to these malfunctions of the mechanism both for price formation and for EDF's coverage of the production costs of the electricity produced, since 2017, the system has proved just as ineffective as during the previous five-year period in encouraging alternative suppliers to develop means of electricity production.

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*(1) Court of Auditors, referred, "the evaluation of the implementation of regulated access to historic nuclear electricity", Letter from* the *First President* of *the Court of Auditors M. Didier Migaud to MM. Bruno Lemaire and Nicolas Hulot dated December 22, 2017, https://www.ccomptes.fr/fr/documents/41952.*

*(2) Hearing of Ms Élisabeth Borne, 2 March 2023.*

The Court of Auditors' finding[1] in this regard is clear: "***investments*** by *alternative suppliers* ***in*** *basic* means of production ***are non-existent*** *and no long-term contract has enabled them to prepare for the end of ARENH after 2025*".

Article 6 of the Nome law had provided that "each electricity *supplier contributes, according to the consumption characteristics of its customers, in power and energy, on the continental metropolitan territory, to the security of electricity supply*". However, the legislator had not defined an obligation to develop production capacity. No mechanism for monitoring these possible investments has therefore been effectively implemented. While the CRE informs the rapporteur that alternative suppliers had fulfilled the obligation prescribed in Article 6 of the NOME law by participating in the capacity mechanism created in 2016, the lack of investment illustrates a new unthought during the development of the device in 2010.

**Faced with a mechanism that is defective from several points of view, the Government is faced in 2017 with a difficult choice between:**

**– compliance with a mechanism validated by the European Commission, which still has the advantage of partially preserving industrial competitiveness (due to the price reduction that ARENH offers to final consumers via suppliers) but which weakens EDF;**

**– the violation of the principle of competitive tendering defined at European level by leaving** the **mechanism, which would also** imply **finding a solution on State credits to financially protect companies from the increase in the price of electricity without offending European regulations on State aid to companies.**

**To temper the criticism made against the maintenance of this system in recent years, it is useful to point out that the CRE has indicated to the rapporteur that the ARENH mechanism had "*played an essential protective role before and during the energy crisis for all French consumers*".**

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*(1) Court of Auditors, referred, "the evaluation of the implementation of regulated access to historic nuclear electricity", Letter from* the *First President* of *the Court of Auditors M. Didier Migaud to MM. Bruno Lemaire and Nicolas Hulot dated December 22, 2017, https://www.ccomptes.fr/fr/documents/41952.*

**Illustration by the CRE** of **the Protective Role played by ARENH because of STIs share of procurement costs**

ARENH's share, after capping, in the supply costs of an offer at regulated sales tariffs is 45%. Very concretely, for an offer with regulated sales tariffs, 45% of the supply part is provided at 42 € / MWh by ARENH. This percentage can rise to 60% for electro-intensive companies that have a more stable consumption during the year and therefore benefit from a greater share of ARENH in their supply.

Today, for companies and communities that are not eligible for TRVE, 40 to 60% of the supply share of their invoices is sourced at 42 € / MWh rather than the wholesale price which has been around 180 € / MWh in recent weeks and which was between 400 and 600 € / MWh in the last quarter of 2022.

A significant part of French consumers' bills is therefore protected by ARENH where the supply share of European consumers' bills depends more directly on wholesale electricity market prices.

*Source: CRE reply to* the *questionnaire of the rapporteur.*

While stressing the symmetry issues posed by the ARENH system, Prime Minister Elisabeth Borne herself called not to forget too quickly the advantages of the device, which is "*a major tool to support the competitiveness of our industries and to avoid exposing French consumers to fluctuations in the price of electricity*".

### *b. The execution of the closure of Fessenheim*

It is during the first five-year term of the President of the Republic Mr. Emmanuel Macron that materializes the consequence of the cap of installed capacity at 63.2 GW, included in the LTECV, with the closure of the Fessenheim power plant, promised by the President of the Republic Mr. François Hollande.

As delays continue to accumulate on the EPR site, the closure of the Fessenheim power plant will finally occur independently of the connection to the EPR network.

The fact that the two operations may not occur simultaneously is announced for the first time on October 4, 2018 by the Minister of Ecological and Solidarity Transition, Mr. François de Rugy, at the third meeting of the steering committee for the conversion of the Fessenheim territory.

A decisive factor explains the decision. Since the adoption of the LTECV, EDF has integrated the objective of closing the Fessenheim plant into the development of the schedule of the fourth ten-year visits intended to extend the nuclear fleet beyond 40 years. The studies prior to the fourth ten-year visit, which was to take place for the Fessenheim power plant before September 2020 for reactor No. 1 and before June 2022 for reactor No. 2 are not concluded. M. Jean-Bernard

Lévy stressed that it is in application of the LTECV that EDF has chosen to exclude the Fessenheim reactors from the perimeter of both the fourth ten-year survey and the major refit, authorised by the Board of Directors of EDF in January 2015. Thus, according to him, "*in* the *second half of 2015, the closure of the two reactors becomes inevitable*", but that the decision results from the application of the law voted: "*It goes without saying that the CEO of EDF as corporate officer of the company would have committed a management fault if EDF had continued the work to extend* the *life of* the Fessenheim *reactors by ignoring both the 2015 law and the 2012 decree*."

ASN draws the consequences of EDF's failure to integrate the Fessenheim power plant into these various projects. In a letter dated 22 October 2018, the Chairman of ASN replied to EDF's CEO that "*given the lack of commitment on your part to the studies and works allowing the continuation of operation of these two reactors beyond their fourth periodic review, I share your analysis that their operation cannot be continued beyond this review*[(1)]."

**It was therefore not impossible to launch the studies and works prior to the fourth ten-year visit and the feedback from Fukushima and therefore to abandon the closure of the plant, even if this would have led to a grounding of the plant site for several years, with the social and economic consequences associated with this uncertainty.**

**But it is the choice of continuity with the previous five-year period that is retained and that the rapporteur can only regret in view of the production of carbon-free electricity that the two reactors of the Fessenheim power station would undoubtedly have been able to provide over several decades to come, given the level of safety indicated and the extension now envisaged of the current fleet**.

A month later, during the presentation of the guidelines of the PPE, the President of the Republic M. Emmanuel Macron announces that the definitive shutdown of the two Fessenheim reactors will take place in the summer of 2020[(2)]. The decree repealing the licence to operate the plant is published on 18 February 2020[(3)].

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(1) *Letter from* the *Director General of ASN M. Olivier Gupta on* the *declaration* of *definitive shutdown* of *reactors No. 1 and 2 of the Fessenheim nuclear power plant,* *https://www.asn.fr/content/download/160971/file/courrier%20de%20l%27ASN%20-%20modifications%20prescriptions%20Fessenheim%20October%202018.pdf*

(2) *Transcript of the speech of the President of the Republic on the strategy and method for the ecological transition, delivered on November 27, 2018 at the Élysée, https://www.elysee.fr/emmanuel-macron/2018/11/28/transition-energetique-change-ensemble.*

(3) *Decree No.* 2020-129 *of 18 February 2020 repealing* the *authorization to operate the Fessenheim nuclear power plant*

The question of whether it would have been possible, especially when alerts on security of supply began to emerge in 2022, to reverse the decision to close Fessenheim could have been raised. Before the Commission, for example, Anne Lauvergeon, without presenting any credible evidence, and contrary to the technical and industrial analyses of specialists, considered it "*not absurd, in a context of climate change and energy needs, to restart two nuclear reactors shut down rather than a coal-fired* power plant. "even if it meant putting back in place the spare parts already removed or relaunching a public inquiry. The Director General of Energy and Climate Laurent Michel retorted that the prospect of reopening the plant would involve particularly complex and expensive work to carry out. He thus indicated that the "*authorizations, steps and investments necessary to strengthen the safety of the plant have led the Government (...) to consider that its extension or restart was not desirable*". In fact, once the decommissioning phase had begun, the revival of the plant would have required extremely substantial investments.

Regardless of the justification relating to the technical difficulty of reversing the decision taken, it must also be stressed that the closure of the Fessenheim power plant is part of the overall context of the decision taken by closure of twelve other 900 MW nuclear reactors by 2035.

During his speech of 27 November 2018 mentioned above, the President of the Republic Mr. Emmanuel Macron recalls that it has been decided to "*maintain this 50% cap but by postponing the deadline to 2035*" and announces, in accordance with his commitment to "*make transparency on the trajectory we want to follow to achieve this goal*", that "*concretely, 14 reactors of 900 megawatts will be shut down by 2035. This movement will begin before the summer of 2020, with the definitive shutdown of the 2 Fessenheim reactors. It will then remain to organise the closure of 12 reactors between 2025 and 2035. 4 to 6 reactors by 2030, the rest between 2030 and 2035. And the pace will vary according to the evolution of the energy mix in our own country and in our European neighbours*." It is therefore the preparation of the PPE by the Government that should make it possible to develop a realistic trajectory, the pace of closure of power plants being dependent on other parameters such as the pace of development of renewable energies, innovations in energy storage and European interconnections.

The documents accompanying the 2019-2028 PPE indicate the will to" *close 14 nuclear reactors, including 4 to 6 by 2028 (including the two Fessenheim in 2020)*". However, the decision is the result of a different approach from the one that led, in 2015, to the display of ambitious objectives. Ms. Élisabeth Borne, Minister for the Ecological and Inclusive Transition who signed the decree of the PPE[(1)], stresses that in 2020 this is "the *first founded non- not on a programmatic objective*, in

(1) *Decree No*. 2020-456 *of 21 April 2020 on multiannual* energy *programming* .

*particular that of the campaign of Mr. François Hollande, but on a documented and educated objective, in particular the hypothesis that 50% of the reactors could pass the fifth ten-year* visit *and 50% the following visit.*

The number of reactors whose closure appears conceivable is therefore defined on the conservative basis of assumptions deemed "*statistically credible as to* the *ability to overcome the various ten-year visits*". On the basis of the studies commissioned to determine, among the 28 reactors that will reach forty years of age, the number of reactors likely to pass the fourth ten-year survey, then among these, the number of reactors likely to pass the fifth ten-year visit, it emerged that half of them, fourteen, could not be extended beyond forty years. It is on the basis of this figure that the closure trajectory of 14 reactors by 2035 was established.

**If the change in method is clear compared to the TECV law of 2015, the signal sent to the sector to close fourteen reactors in fifteen years remains the same and the attrition of skills and the industrial apparatus can only be aggravated – even though in hidden time, the options for building new pairs of EPRs are examined.**

***c. The end of the ASTRID project***

After the shutdown of the Superphénix breeder reactor in 1998, the launch, in 2010, of the industrial fast neutron reactor (RNR) project cooled with sodium ASTRID (for "Advanced sodium technological reactor *for industrial demonstration*") had revived hopes that France would succeed in developing a technology to meet two major challenges in the nuclear industry: minimising its need to import natural uranium – winning thus in independence – and reduce the volumes of high-level radioactive waste, so-called long-term waste that requires very secure storage.

Unlike Superphénix, the ASTRID reactor project did not immediately aim to "regenerate" the fuels in an almost endless cycle of their use, but to optimise the use of natural uranium by operating directly with uranium-238, which makes it up of 99.3%, rather than uranium-235, which constitutes only a tiny part of it (0.7%) but which is the essential element of nuclear fission of PWRs. *Ultimately*, this reactor, called 4th generation, was to considerably reduce the need for imported uranium, to avoid the costly step of enrichment and to allow the multirecycling of plutonium (recycling in France is currently limited to a single cycle in the form of MOX).

Like Superphénix, it also needed to be able to burn plutonium and turn it into shorter-lived nuclear waste, reducing the volumes subject to the heaviest storage requirements. Finally, it was to allow the subsequent deployment of so-called "future" industrial reactors, more sustainable, because using resources already available in France (stockpiles of depleted uranium or spent fuel) while offering a better yield than the existing fleet.

This research axis has been supported by the CEA since the 1950s. It allowed France to be the first to have an industrial prototype of a sodium-cooled fast neutron reactor with Superphénix and to earn its place as a major player in nuclear research and development in the world.

The closure of Superphénix had seriously shaken its international position and greatly slowed down its research, since the CEA only had an older and smaller reactor to continue its experiments. the Phoenix reactor, which had stopped permanently in 2009.

In order not to lose the achievements of decades of research – which other countries were pursuing – the laws of 13 July 2005 and 28 June 2006 had reopened the option. Then the amending finance law for 2010 committed €651.60 million to the project under the first investment plan for the future, as part of an agreement signed on 9 September 2010 between the State and the CEA. The project was supposed to be carried out by 2020 and had to involve industry in its design to ensure the relevance of technical and economic choices. In fact, ASTRID has indeed associated EDF, Areva and Alstom but also several foreign partners, including subsidiaries of Mitsubishi.

Research and preliminary studies had been carried out since then and were to lead to the decision whether or not to build a high-power demonstrator. Mr. Daniel Verwaerde, former general administrator of the CEA, explains that he has repeatedly asked the Minister in charge of energy, Ms. Royal since 2016, about her intentions to take this decision and declares that he has never had an answer.

It was through an article published on August 29, 2019 that France finally learned of the decision not to pursue the project to build a prototype reactor. This news is confirmed the next day by a press release from the CEA management, specifying that "the *construction of the prototype reactor* is *no longer programmed in the short or medium term and that the CEA will propose by the end of the year to* the *Government a revised research program on the 4th generation – for 2020 and beyond*".

This decision is a new blow for French research. The Democratic and Republican Left (GDR) group quickly submitted to the Bureau of the National Assembly a request for a study by the Parliamentary Office for the Assessment of Scientific and Technological Choices (OPECST) to clarify the reasons and context. The latter granted it on January 15, 2020 and the "study on the nuclear energy of the *future and the consequences of the abandonment of* the *4th generation nuclear reactor* project *'ASTRID'*", carried out by Mr. Thomas Gassiloud, M.P., and Mr. Senator Stéphane Piednoir was released on July 8, 2021.

Their first observation is that the justifications remain to be clarified. They note that, at the beginning of 2017, the CEA had already decided, without official explanation even if the cost of the project – equivalent to that of an EPR, of the order of ten billion according to former CEA officials – could be an obstacle, to reduce the wing by reducing the power of the reactor studied, from 600 MWe to 150 MWe, and to work now through numerical simulations, postponing the construction of the prototype to the second half of the century.

As to the reasons for the next decision, to suspend the ASTRID project permanently, the rapporteurs merely made assumptions. Mention is made in particular of the level of expenditure already committed, of €1.2 billion since the beginning of the project, the low price of uranium - which the reactor is supposed to save -, the abandonment of the strategy of closing the fuel for the benefit of strengthening work on multi-recycling in PWRs, etc. On the other hand, the parliamentarians highlight the impacts that could be feared, in terms of the image of the French nuclear industry in the world, less attractiveness for the student world, risk of loss of the achievements of 70 years of research and a possible eventual questioning of the strategy of the closed cycle.

The rapporteurs concluded that "the question of the *status of nuclear material cannot be decided without considering all possible options and must be raised as part of a broader democratic debate on long-term options to ensure France's energy sovereignty and independence* ".

The Committee of Inquiry questioned several stakeholders about this decision to stop the ASTRID project. These hearings show sometimes divergent analyses, including within the CEA, which illustrate the complexity of this type of file:

– Mr. Daniel Verwaerde, General Administrator of the CEA from 2015 to 2018, explains that he had proposed to continue the project by simulation because the actual construction of the reactor posed a significant financial problem: the first estimates of the prototype led to the conclusion that it would cost between €7 and €10 billion, not to mention the adjustments of the project still necessary that could make it slip to a budget of €15 or €20 billion. However, this construction was not budgeted and "the *signals that (he) received or thought to receive were that France would not be able to finance [it] from 2020" or*, at least, that "*there would be no urgency to build*". In any event, there was no hostility on the merits.

Mr. Verwaerde nevertheless recalls that this project "*went better than* the *Jules Horowitz project (RJH)*" and that "*the young people of ASTRID [had] succeeded in proposing a heart of great stability and safety*". He continues to believe in the relevance of this technological sector for the optimisation of our 300,000 tons of pending depleted uranium; Ms Catherine Cesarsky observed that the long and costly delays that were accumulating on the RJH, on the ITER project and on the construction of the Flamanville EPR must have weighed on the decision.

This is confirmed by the former Chief of Staff of Prime Minister Édouard Philippe, Mr. Benoît Ribadeau-Dumas: "*We were able to save ITER, the international thermonuclear experimental reactor, because Édouard Philippe personally negotiated with the US Department of Energy and other countries. We also saved the Jules Horowitz reactor (RJH), which in the short term, is more important for the sector than ASTRID, which we have certainly given up. This decision was taken as part of an in-depth review of the CEA's priorities, a consultation of stakeholders in the sector and a nuclear policy council, which did not call into question* the *foundations of the closed fuel cycle,* a *subject that on which we have accompanied new research programs. We did consider it necessary to carry out research on the fuel before launching this reactor, which represented a budget of 7 billion euros, which was not reasonable for the CEA. (...) This decision stems from a budget impasse. (...) We kept ITER*, *RJH* and *the* military *test reactor, which is a huge amount of money and exploded to unimaginable proportions. When it was asked to strengthen* the *CEA's budget, we stressed that it could already support EDF on the current design before preparing the next generation*."

Mr. Thibaud Normand, former Energy Technical Advisor, adds: "*In the second half of 2017, the question of the industrial relevance of starting the construction of the demonstrator arose. This relevance was clearly questioned by industrial nuclear players, because the reactor*, *which* was *an* industrial *demonstrator*, *was* to *give rise to the construction of a large number of reactors of a new generation, i.e. fast* sodium reactors. *They were going to collide with a third-generation fleet*, composed of EPR and *EPR 2, which will be in service between 2035 and 2050. Industrial interest was therefore shifting towards the second half of the century, which necessitated the establishment* of *alternatives in terms of research. The* idea of *a small ASTRID or simulation program is a research one, because it corresponds to the idea of an experimental reactor. We then asked* the *CEA to investigate these options* and the *new deputy head was appointed at* the *end* of the *first quarter* of *2018: he took charge of the subject as soon as he arrived and he fed the decision of the State. to direct work towards multi-recycling* of *PWR and research on the fuel cycle of fast reactors. This second option was chosen with regard to the construction of an experimental reactor.* »

"*As a reminder, RJH is a materials irradiation reactor and is essential for nuclear research and the proper operation of EPR 2*."

To the criticism of the lack of explanation, Mr. Normand replies that the main orientations of the multiannual energy programming were made public in November 2018 by a speech by the President of the Republic and a public lecture given by Mr. François de Rugy, in which the maintenance of the closed fuel cycle based on multi-recycling in PWR is explicitly included;

– For M. François Jacq[1], who succeeded Mr Jacq in 2018. Verwaerde as general administrator of the CEA, fast neutron reactors and the ASTRID project responded more to the challenges of matter – very cheap at the time – than of nuclear waste reduction. However, "*waste management issues alone* cannot *justify* the *deployment* and the *very heavy investment in a new generation of reactors and the new cycle plants that this would require*".

Mr. Jacq does not really believe in the option of transmutation, studied as part of the ASTRID project, to solve the issue of high-level radioactive waste. Work carried out in 2005 had shown that it would probably not be possible to do without deep geological disposal, the feasibility of which had been demonstrated by ANDRA. "*On the other hand, the separation-transmutation route would probably not produce the expected effects, in particular because fission products, which are the main components of the dose at the outlet of storage, could not be treated, and the treatment of all minor actinides would have posed a whole series of difficulties*"

As for the construction of a reactor, even if reduced in power, he observes that "*if we accept the assumption that the high-power sector will not be deployed before* the *end of* the *century, it is not necessary to start now. to acquire experimental means. We have some time to think about the cycle and the whole nuclear policy*.";

– Finally, on the EDF side, for Mr. Jean-Bernard Levy, "the *engineers felt that the ASTRID program was justified in its research component of technologies to manage the technical difficulties encountered in particular with sodium as a heater better than Superphénix had done. But they were skeptical about the possibility of moving directly from a technology demonstration to the immediate construction of a new reactor*."

In any case, none of the scientific experts interviewed denied the interest of continuing research on the closed cycle and the future transition to fast neutron reactors (RNR) and all stressed the importance of **preserving and building on the achievements of this research** – that have much better features than previous models, experts like Catherine Cesarsky acknowledge – **and even continue to develop them, possibly at a more modest level**.

To these two crucial issues, the CEA responds that an important work of formalisation, ordering and capitalisation of knowledge has been carried out and that research continues on the basis of this work. The CEA still has 135 people working on fourth-generation sodium-cooled reactors, in connection with multi-recycling, small reactors, knowledge capitalisation and international programs (Japan is particularly interested).

*(1) Hearing of Mr François Jacq, December 7, 2022.*

**Without claiming an exhaustive scientific understanding of this particularly complex research and with the necessary caution, the rapporteur is surprised by several apparently contradictory elements:**

– The Committee of Inquiry has not received any specific evidence of the content and extent of the research that would be specifically (and not on PWR multi-recycling) carried out internally on the fuel cycle with a view to fast neutron fission, for example in connection with the manufacture and reprocessing of what would be a new fuel;

– On several occasions, it has been stated that the link between research on multi-recycling in pressurised water reactors and research on the $4^{th}$ generation is logical and obvious; this point, disputed by other experts, still seems neither logical nor obvious to the rapporteur, given the difference in fuel and even more so fission (slow neutrons *versus* fast neutrons); moreover, in view of the challenges of reprocessing spent MOX, waste (whose lifespan for the most radiotoxic is significantly reduced in the case of the 4th generation) and the availability of fuel (multi-recycling does not lead to technological breakthrough compared to current technology), it seems surprising to say the least to put this EPR multirecycling on a similar level with the fourth generation;

– The decision not to build any demonstrator, even of a very modest size, seems to be in slight contradiction both with Article 3 of the law of 28 June 2006 which explicitly provides for research on the closure of the cycle and both with the long-standing desire to work on small 4th generation reactors.

**In summary, the decision not to build a high-power demonstrator (as ASTRID was thought *ab initio)* undoubtedly contains an economic logic. But the combination (i) of the choice not to build a reactor, even of more modest power as proposed by the former CEA officials, (ii) of the absence of elements supporting the continuation, within the CEA, after this decision, of varied and consequent research on the $4^{th}$ generation, as well as (iii) the preference obviously given to multi-recycling in pressurised water reactors appears regrettable and damaging for the development of the nuclear industry.**

## B. BASED ON A NEW ENERGY PROJECTION, AN UNPRECEDENTED REVIVAL OF NUCLEAR POWER WITHOUT OPPOSITION TO RENEWABLE ENERGIES

As part of a more rigorous method of conducting France's energy policy, the Government and Parliament can now rely on much more solid analyses conducted by RTE, such as the "Energy Futures 2050" study[(1)]. On the basis of the scenarios thus achieved, it has been possible to draw the evolution of the country's energy trajectory, which is based on a revival of nuclear power without opposition to renewable energies[(2)].

### 1. Energy Futures 2050, a new and essential exercise for any energy programming

The publication in February 2022 of the "Energy Futures 2050" report completes the recent evolution of RTE's publications, in the very positive direction of better understanding the determinants of energy policies. Despite the progress thus made, however, public authorities must bear in mind the limitations inherent in such forward-looking exercises, so as not to reduce the margins of the electricity system too dangerously (b).

#### *a. The renewal of RTE's prospective studies, a major asset for the definition of energy policies*

The forecast balance sheets published by RTE have undergone significant changes in recent years. Originally purely forecasting and technical, the analyses are gradually enriched by a forward-looking approach, based on the analysis of different scenarios taking up the different trajectories of possible evolution of the electricity sector.

The provisional balance sheet published in 2017 marks a real change of approach in the approach. Prior to this review, RTE's publications focus on compliance with the failure criterion. These are short-term analyses, which mainly assess the impact of closures of means of production on the risk of failure, and consider only the public policies in force, without considering the changes they could experience.

In 2017, the forecast balance sheet marks a first evolution by exploring different trajectories in order to identify the conditions for the success of the objectives set by the LTECV, both in terms of defining the electricity production mix and achieving climate objectives.

Mr. François Brottes, Chairman of the Executive Board of RTE from 2015 to 2020, said that he had wished, as soon as he arrived at RTE, that " the *exercise of presenting the forecast balance sheets would be an opportunity to show, rather than* *a single word, several solid, credible and widely discussed prospective scenarios. They thus enable actors and policy makers to understand the implications of their choices, and give rise to the most rational debate possible on hypotheses hypothesesvery broad issues on potentially controversial subjects, such as the balance of the network by integrating the European scale, the risks related to the non-execution of industrial production projects, the impact on $CO_2$, innovation or the impact on the economic model*".

The 2017 forecast balance sheet therefore presents several novelties. In terms of method, first, the hypotheses considered were the subject of a **public consultation of all interested stakeholders** (suppliers, producers, distributors of electricity and gas, professional organisations, NGOs, *think tanks*, academics, institutions). On the content, then, the report presents **five scenarios presenting detailed trajectories** to reach the configurations studied by 2035. **The evolution of the context is also integrated into the reflection to assess its consequences on supply and demand**. The evolution of electricity consumption, the evolution of production, the constraints posed by the climate objectives set and by the effects of climate change, the economic reflections on the profitability of different means of production, the development of interconnections and technological innovation are all data that the scenarios integrate.

Trajectories are therefore assessed not only in terms of the security of supply criterion, but also in terms of the costs of the different means of production and their impact on greenhouse gas emissions. The assessment makes it possible to understand the impact of public policies, which can, conversely, be defined with reference to these analyses.

**Presentation by RTE of the five scenarios set out in the 2017 forecast balance sheet**

**The Ohm scenario** describes the range of solutions that need to be implemented to date to meet the LTECV framework. The analyses identify the main issues in terms of $CO_2$ emissions, changes in the nuclear generation fleet and the need for new means (renewable and thermal).

The other four scenarios cover the years 2025, 2030 and 2035. They take for granted the closure of coal-fired power plants and the impossibility of building new ones.

In the **Ampere scenario**, the reduction in the share of nuclear power is taking place without recourse to new thermal means. Some reactors can be shut down after 40 years of operation if the development of renewable energies is sufficient to allow the same level of electricity production while respecting security of supply. This scenario makes it possible to identify when the objective of 50% nuclear power in electricity production can be achieved in a context of strong development of renewable energies. Once the 50% target is reached, reactor decommissioning stops.

In the **Hertz scenario**, the diversification of the electricity mix takes place in a context of slower development of renewable sectors by relying on new means of thermal production. This evolution is studied in the light of compliance with a $CO_2$ emissions ceiling so as not to degrade the environmental performance of the French electricity fleet. This scenario makes it possible to study the role of the thermal sector to achieve the objective of 50% nuclear in electricity production. As in the Ampere scenario, the decommissioning of reactors is completed once the 50% target has been reached.

In the **Volt scenario**, the development of renewable energies accelerates compared to the current situation, and the share of nuclear in the mix evolves according to economic opportunities. This scenario makes it possible to study a logic of diversification of the electricity mix based on the economic profitability of the French generation fleet, by integrating the actual outlets on the European electricity markets for French "low-cost" production (i.e. for production from renewable or nuclear energies, competitive in European electricity markets).

In the **Watt scenario**, nuclear reactors are stopped on a technical decommissioning criterion (no extension of operating license beyond 40 years – initial operating hypothesis foreseen during the design of certain materials and equipment of the reactors), and the development of renewable energies is steered according to a proactive trajectory. This scenario makes it possible to assess the consequences of a situation in which France should very quickly do without nuclear reactors, raises the question of the technologies available to ensure the transition, and makes it possible to study a mix involving a very high penetration of renewable energies.

*Source: Introduction to RTE's 2017 Forecast Report, pp. 14-15.*

Between 2017 and 2021, RTE begins to issue alerts on the reduction of margins of the electricity system. As mentioned earlier (see Chapter II-III-A-1-a), the forecast balance makes it very clear that the targets for reducing the share of nuclear power to 50% and the emission reduction targets cannot be achieved together in 2025, the implications of the first of these two objectives is in terms of reopening thermal capacities with negative consequences in terms of greenhouse gas emissions.

On the other hand, in this assessment, RTE does not comment on the long-term needs of the electricity system.

This step was reached in 2021, with the publication "**Energy Futures 2050**", **which includes a very long-term prospective component**, **in order to meet an order from the Government carried out in 2019**. Prime Minister Elisabeth Borne justified this approach as follows: "*In an approach that can be described as scientific, we wanted to carry out the most precise possible instruction of the different choices of energy mix. It was a question of leaving somewhat dogmatic positions to enter into choices based on educated scenarios. RTE was therefore asked to examine different scenarios to examine what choices were before us, in terms of technology, sovereignty, implementation costs, competitiveness and electricity prices*."

RTE therefore opened, in 2019, the first phase of the study, intended to frame its objectives, the method to be followed and the hypotheses to be considered. This phase was the subject of a broad **public consultation**, the results of which were also published. The study was then carried out in **consultation with interested stakeholders**.

With regard to the scenarios, the prospective analysis was based on an analytical grid based, according to the methodological presentation made in the introduction to the report(1), on the following four axes:

– The **technical component**, which describes the operation of the electrical system in the different scenarios. It analyses the balance of the system and the needs for flexibility and network, includes an analysis of sensitivity to different global warming hypotheses.

– The **economic component**, which consists of quantifying the cost of the scenarios studied.

– The **environmental component**, which provides quantified elements on the different scenarios studied to shed light on the main issues raised in the context of the consultation (climate change, protection of biodiversity, depletion of natural resources, human health, etc.).

– The **societal component,** which assesses the implications of scenarios on lifestyles. The question of the acceptability of infrastructure falls, for example, under this component.

This study completes the recent evolution of RTE's analyses in the direction of a better identification of the electricity system necessary to get out of fossil fuels

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*(1) RTE*, *Full report*, *Energy Futures* 2050, *February 2022, p. 68.*

and achieve carbon neutrality by 2050. It is based, among other things, on a report also published in 2021 and co-signed by RTE and the International Energy Agency on the technical conditions of a 100% renewable scenario, implicitly criticised for its great uncertainty and in particular the fact that "The technical solutions on which this stability would be based for a large-scale system such as France are not currently commercially available"[(1)].

**Description by TEN of the Developments included in the analysis "Energy Futures 2050"**

– Consumption forecasts are no longer made according to the public policies In strength to date goal to those that should be implemented to achieve a specific objective;

– These analyses have reassessed upwards the needs anticipated by the State in the background of the SNBC: they include sectoral policies published since (France Relance, France 2030, hydrogen strategy, regulations environmental 2020, new European standards on mobility and the building sector, etc.);

– Mix analyses consider has broader spectrum of possibilities, including some that are not in line with existing laws and regulations (including the 50% nuclear target by 2035 since several scenarios do not respect this crossing point);

*Source: Response* sent by *RTE to the questionnaire sent by the rapporteur.*

The rapporteur can only stress the **need for government commissioning and the development of such work, which allows, for the first time, an a *priori* analysis of the impact of public choices, with a view to preparing public energy and climate policies**. Nevertheless, it warns of the need for public authorities not to forget the limitations inherent in projection. These should encourage caution in the changes given to the energy system, which must retain some room for manoeuvre in order to ensure energy security.

### *b. The limitations inherent in forecasting exercises should encourage a certain caution in the realisation of energy choices*

Despite the undeniable progress represented by this analysis, the **rapporteur wishes** to draw the **attention of parliamentarians and** the **Government**, who will have to draw the country's energy trajectory tomorrow, to the fact that **these scenarios remain marked by a significant amount of uncertainty**.

**Depending on the trajectories taken by each of the data analysed, the gap between the scenarios and reality could indeed be significant.** This would be the case, for example, if the future reality consisted of a France where energies

(1) *RTE and IEA, 2021,* ***Conditions*** *and* ***prerequisites*** *for technical feasibility for an electricity system with a high proportion of* ***renewable*** energies *by 2050*

Renewables and energy efficiency would not progress sufficiently, and where, conversely, the reindustrialisation of the country would take place and where the electrification of uses would progress, with the consequences that this would have on the growth of demand.

It is on the basis of such an analysis that in hearing, Mr. Jean-Bernard Lévy considered that these scenarios remain "*inspired by a somewhat old approach drawing the consequences of the deindustrialisation of our country that we have observed for twenty years*", even though priority is now given to the fight against GHG emissions - which uses carbon-free electricity instead of fossil energy - and the reconquest of our industrial and energy sovereignty. **The volume growth in electricity consumption envisaged in the medium scenario appears modest**: it considers that many factors could bring it to between 1.5% and 2% per year. "*Demographics; increasing the number of homes with a constant population*; *reindustrialisation and the effort to control our energy sovereignty; the digitisation of society; very strong sectoral measures such as stopping the sale of new combustion vehicles for individuals from 2035*; the *need for carbon-free hydrogen, particularly in industry; the new thermal regulation on housing which, finally*, favours *carbon-free electricity over* gas*, at least* for *new housing; the substitution of electric ovens for natural gas furnaces in many industrial processes"* are all **factors for the growth of electricity demand that could defy forecasts of modest demand growth**.

Uncertainty also prevails over the results of the sobriety and energy efficiency efforts carried out. Here again, according to Jean-Bernard Lévy, the results on which RTE is counting in the scenarios are "*significantly better than anything observed for thirty years in France or comparable countries"*. Consequently, Mr Jean-Bernard Lévy indicated that it would seem to him less risky to refer to a range of annual domestic electricity consumption between 750 and 645 TWh rather than to refer to an average point of 645 TWh.

Without commenting on the consumption range that should be used, the rapporteur wishes to draw the attention of the public authorities to the importance of introducing a safety margin in the scenarios envisaged, which would reduce the uncertainty linked to differences in the actual development of data compared to original forecasts.

This reservation having been made, the quality of the analyses carried out nevertheless makes it possible to apprehend the energy strategy today on a more solid scientific and technical basis than before. It is on this basis that the current President of the Republic and the Government have been able to define a new strategy based on the revival of nuclear power – always marked by a difficult context – and the acceleration of renewable energies.

## 2. Elements of analysis and projection that allow the announcement of the revival of nuclear power and the reinforced support for renewable energies

### *a. A strategy that strongly reaffirms the priority given to carbon neutrality since 2017, without forgetting security of supply*

From the first months of the legislature, the government of Édouard Philippe, through its Minister of Ecological and Solidarity Transition, Mr. Nicolas Hulot, presents and adopts the law 2017-1839 of December 30, 2017 putting an end to the exploration and exploitation of hydrocarbons and containing various provisions relating to energy and the environment by 2040. This is the first law carried by the government of the new President of the Republic and the message is strong.

The year 2018 sees the first bricks of the energy and climate strategy of the new majority put in place: with Law No. 2018-727 of 10 August 2018 for a State at the service of a trusted society, which simplifies in particular the procedures for installing offshore wind turbines, and the Order of 19 December 2018(1), which, inter alia, strengthens the obligations of actors in the gas chain with regard to security of supply.

The consultation on the new draft Multiannual Energy Programme (PPE) 2019-2028 is being organised before being launched on 25 January 2019.

Subsequently, in this year 2019, are published Ordinance No. 2019-501 of 22 May 2019 simplifying the procedure for drawing up and revising connection schemes to the network of renewable energies, which should facilitate their deployment throughout the metropolitan territory, and Ordinance No. 2019-1034 of 9 October 2019 on the greenhouse gas emission allowance trading scheme (2021-2030), which transposes into national law the novelties introduced by Directive 2018/410 of 14 March 2018, improves the existing system with a view to its fourth phase, and, above all, accelerates the decline in authorised GHG emission ceilings.

2019 is also the year of Law **No**. 2019-1147 **of 8 November 2019** on energy **and climate,** which lays the first foundations for the **climate-energy** policy of the mandates.

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*(1)* Ordinance No. 2018-1165 *of 19 December 2018 amending the missions and obligations incumbent* on transmission *system* operators, *suppliers, storage infrastructure* operators *and LNG terminal operators with regard to operation of* the gas *system and defining the rules for offloading the consumption of natural gas.*

Two of these measures (the 50% share of nuclear power and the introduction of a periodic programmatic meeting with the National Representation on energy policy choices) have been commented on previously.

However, with its 69 articles, the law of 8 November 2019, known as the law "Climate Energy" has broader ambitions. It stares, for the first time, in French law, a **carbon neutrality objective in 2050 and reinforces the objective of reducing fossil fuel consumption by 2030 to 40%, against 30 %** previously.

To do this, it decides to close the last coal-fired power plants in 2022, by introducing a GHG emissions cap (specified by a decree of 26 December 2019[(1)]), and puts in place measures to combat thermal sieves (rent limitation, audit energy, obligation of works by 2028) and to accelerate the development of renewable energies.

This law also places **a strong emphasis on energy efficiency and the diversified development of carbon-free energy sources**.

The PPE for the periods 2019-2023 and 2024-2028, published by Decree No. 2020-456 of 21 April 2020, sets out the guidelines of the "Energy-Climate" law.

A law and a series of ordinances complete these devices in the following years, such as Ordinance No. 2021-167 of 17 February 2021 on hydrogen. It lays the first foundations for the legal framework for renewable or low-carbon hydrogen, the development of which the government wants to encourage, convinced that sustainable hydrogen is one of tomorrow's solutions for the decarbonisation of certain energy-intensive industrial processes and even certain forms of mobility.

The second major structuring step for the energy policy of Mr. Macron's presidency is **Law No**. 2021-1104 **of 22 August 2021 on the** fight **against climate change and strengthening resilience to its effects**.

Responding to the work of the Citizens Convention for the Climate, it includes, on energy and carbon neutrality issues, several provisions aimed at promoting renewable energies, the modernisation of the mining code – to strengthen the consideration of the environmental interests to be protected and the opinions of local populations – new measures on the renovation of thermal sieves, the strengthening of low emission mobility zones (ZFE-m) and the ban on the sale of the most polluting vehicles from 2030 and 2040 for the heaviest.

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*(1) Decree No*. 2019-1467 *of 26 December 2019 establishing a greenhouse gas emission* cap *for electricity production facilities from fossil fuels.*

### *b. Awareness of French energy vulnerability*

The year 2022 will be marked above all by texts focusing on **strengthening measures to ensure security of energy supply**.

In the meantime, there has been the war in Ukraine, the resulting tensions over gas supply and soaring energy prices, as well as **a combination of difficulties that have heavily affected national electricity production from 2021**

The covid-19 crisis began by shifting the maintenance schedule of nuclear power plants, reducing its level of availability, when stress corrosion problems [(1)] discovered in several reactors at the end of the year led to their shutdown. These difficulties continued and even accentuated in 2022. Up to 32 reactors were shut down in August, out of the 56 in operation in the French fleet. While it was at 335 TWh in 2020, in the midst of the covid-19 crisis, nuclear electricity production then fell to 361 TWh in 2021 and then to 279 TWh in 2022.

At the same time, the output of hydropower plants also declined in 2021 and again in 2022 due to low rainfall and relatively low hydro stocks.

**The decline in French electricity production is thus due to the combination of the decline in availability of the nuclear fleet (ten-year visits, stress corrosion) and the decline in hydroelectric production. This has shifted France from a global electricity exporter position to a net importer, and has given rise to long-term fears that the country's needs may not always be covered, despite the support of European interconnections.**

This situation led the government to issue an urgent decree[(2)] exceptionally raising the ceiling on authorised GHG emissions from the last two French coal-fired power plants in order to relay its partially shut down nuclear fleet.

Subsequently, Law No. 2022-1158 of 16 August 2022 on emergency measures for the protection of purchasing power will include provisions supplementing and strengthening the emergency mechanisms available to the operator of public electricity transmission networks in the event of a major threat to the security of electricity supply. **Some of these measures seem to go back on national ambitions to reduce fossil fuel consumption and decarbonise energy production**, such as the authorization of a floating LNG carrier, the introduction of a possibility of using coal-fired power plants – which were already closed or were about to be closed – or even oil-fired generators.

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(1) *These are cracks detected in the elbow welds of the safety injection pipes, the "RIS" circuit designed to inject bored water into the main primary circuit of the reactor in order to cool it in* the event of *an incident,* as *well as on* the *shutdown cooling circuit (SRA) which allows the circulation and a minimum water level in the primary circuit to evacuate waste heat from radioactive fuels when the reactor is shut down.*

(2) *Decree No. 2022-123 of 5 February 2022 amending the greenhouse gas emission ceiling for electricity production facilities from fossil fuels.*

This is not the nature of these devices, designed as crisis solutions that are intended to be used only as a last resort.

The EcoWatt system, set up at the same time, aimed precisely at informing each consumer so that he adapts his consumption in the event of too much voltage on the networks. And the energy sobriety plan presented on October 6, 2022 by the Prime Minister, Ms. Elisabeth Borne, and her Minister of Energy Transition, Ms. Agnès Pannier-Runacher participated, more structurally, in raising awareness among end consumers of energy saving efforts by explaining the actions within their reach. Both the alert system and the call for the mobilisation of all seem to have met with a positive reception by the French. And if the economic constraint has undeniably played a role, the results have been higher than the expectations of RTE, which announced in March that national electricity consumption fell by **12% between October and December 2022**. It would have receded by 20 TW, regardless of milder than usual temperatures.

**From this period, several lessons can be drawn**:

– Ensuring the country's security of supply is a top priority, which will never be sacrificed to the objectives of decarbonising electricity production. Throughout the five-year period, rules and mechanisms have been adjusted and strengthened in this direction;

– By making progress on energy sobriety and efficiency, France is getting closer to its goal of carbon neutrality but also relieving tensions on its supply (and energy bills);

– The 2022 results show that this progress is possible.

And they are indispensable, as all RTE scenarios demonstrate.

With these observations, the government launched Act 2 of its energy sobriety plan on February 21. It is a question of "*anchoring sobriety in* the *long term*" by taking stock of the first period and reflecting on ways to go further.

However, the strategy of controlling the energy demand of the governments of President Emmanuel Macron is not limited to measures taken " in response" to the serious difficulties recently or to cost-saving gestures required of everyone.

Not only did each major energy text of his first mandate include a section devoted to energy renovation or efficiency, not only state budgetary aid for the thermal renovation of housing, the renewal of the car fleet, etc. have made significant progress, but the President of the Republic is implementing **massive support for the energy transition** of **our largest consumers** of **fossil** fuels, whether by supporting the search for innovative solutions but also by directly supporting investments in the decarbonisation of French industry.

In parallel with the investments for the future still underway, **the two major investment** plans, **France Recovery** and **France 2030**, **have indeed included these objectives in their priorities** and mobilise very significant funds for this purpose.

In the first, committed in September 2020, out of €100 billion, €30 billion is intended to finance the ecological transition, among other things through **aid for the decarbonisation of industry**. The second, presented to succeed him on October 12, 2021, is endowed with €34 billion over 5 years, including:

– €8 billion for the energy sector, "*to build a decarbonised and resilient France*" by creating **small,** innovative **nuclear reactors** with better waste management in France working to decarbonise our industry and become the leader in green hydrogen, which must be one of the vectors of this decarbonisation;

– €4 billion to produce nearly 2 million electric and hybrid vehicles, as well as the first low-carbon aircraft.

– €1 billion for projects to produce and recycle strategic materials for the electrification of the economy, which attests to the revival of this strategic subject.

On the occasion of its launch, in Belfort, on February 10, 2022, the President of the Republic detailed the orientations of his energy policy: "more *ecological, more sovereign and creator of purchasing power for the French, This policy aims at the energy independence of France through the reindustrialisation of the country*. And to do this, there are two conditions: consume less energy and gain energy sobriety – without there being any question of austerity – and increase our carbon-free energy production capacity.(1)

### *c. An unprecedented announcement to revive nuclear power*

Even before the Belfort speech, which remains the pivot for the sector, France Recovery plan has already strengthened the resources of the nuclear industry sector:

On 16 April 2021, Ministers Barbara Pompili, Bruno Le Maire and Agnès Pannier-Runacher signed a Addendum to the sector contract that incorporates the new support of the investment plan to strengthen the skills of the sector: a new **university of nuclear professions** (UMN), a scholarship to promote the attractiveness of the sector and a call for expressions of interest to develop and maintain skills.

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*(1) Cf. Élysée website*, "Take back control *of* our energy destiny! ", *February 10, 2022.*

Since then, this objective has been presented as **a strong priority** by the government of Ms. Élisabeth Borne. At a hearing before the Committee of Inquiry, the Prime Minister drew lessons from the difficulties in carrying out the maintenance operations and ten-year visits scheduled during the COVID-19 period: one of the reasons for the delays that began to accumulate was that "the *engineering teams needed to carry out these maintenance operations were, for an apparently significant part, not French.* ***When we talk about sovereignty, we must ensure that engineering is present on our territory to carry out maintenance operations and construction operations for new reactors****. We need to be able to train the welders, boilermakers and electricians we need to carry out our* maintenance *operations. This is one of my Government's priorities*. » ;

On April 16, 2021, ministers announced that the first 20 projects had been selected as part of the Relance France call for projects to support investment, research and development and modernisation of the nuclear industry. These projects were to benefit from nearly €32 million in support from the Plan and represent a total of €114 million in industrial investments.

As part of France 2030, **nearly €1 billion will be directly earmarked for the emergence of innovative nuclear technologies** – we note that as much is planned for innovation and support for the industrialisation of our means of renewable energy production. The revival of nuclear power has indeed become the third pillar of the President of the Republic's energy and climate strategy.

During his speech in Belfort on 10 February 2022, Mr. President Emmanuel Macron announced: "*The world of tomorrow will be more electric. We* must be able, *and here again* to *use the figures produced by our experts,* we must be able to produce up *to 60% more electricity than we do today. (...) even if we are going to reduce our consumption (...). And* the ***key*** to ***producing*** this ***electricity in*** the ***most carbon-free***, ***safest, sovereign way is precisely to have a plural strategy, the one we have chosen on the basis of this work and to develop both renewable energies and nuclear*** *power. (...) It is the most relevant choice* from an ecological point of view and the most opportune from an economic point of view and finally the *least expensive from a* financial *point of view. That* is *why this is the choice we are going to pursue*."

With regard to nuclear power, several structuring orientations that have been long awaited by the sector have been given:

– extend all nuclear reactors that can be extended without compromising safety. "*I ask EDF to study* the *conditions for extending beyond 50 years, in conjunction with the nuclear safety authority*."

– Launch a programme of new nuclear reactors today. I want six EPR2s to *be built and for us to launch studies on the construction of 8 additional EPR2s. We* *will thus move forward in stages"*

– finally, alongside these EPRs, a call for projects will be launched to create small modular reactors but also innovative reactors to close the fuel cycle and produce less waste. For 500 million euros, these will be projects led by EDF NUWARD. This new program could lead to the commissioning of 25 gigawatts of new nuclear capacity by 2050, complementing the EPR2.

To implement these decisions within the deadlines now required by the climate emergency and the rapid recovery of a French nuclear industry too often shaken over the last 20 years, the government of Ms. Borne has therefore tabled a **bill "*on the acceleration of procedures related to the construction of new nuclear*** *facilities. in the vicinity of existing nuclear sites and the operation of existing facilities*", currently under consideration by Parliament. This bill is complementary to the law on the acceleration of renewable energy production(1), which pursues the same objectives of decarbonising the electricity mix and strengthening the energy sovereignty of France. The aim is to speed up procedures where possible, in particular during the administrative examination phases of files, **without changing the level of nuclear safety requirements.**

**However, the rapporteur stresses that all crucial issues remain open and to be resolved in the coming months**, including:

– **the financing of these six new EPRs and the translation of this revival of nuclear power into future electricity prices;**

– **the exact role entrusted to EDF, whose nationalisation is in the process of being completed by the purchase of all the shares by the State, but whose financial fragility is obviously worrying;**

– **the ability of the nuclear industrial sector**, **which is recovering from twenty years of weakening, to complete such projects within the required deadlines.**

The bill creates has Derogation Diet forum the construction of new nuclear power reactors. It only applies to reactors whose Application for Authorisation to establish is filed within 20(2) years of the promulgation of the law and located in the vicinity immediately or within an existing basic nuclear installation (Article 1). The compatibility of urban planning documents and the control of compliance with urban planning rules are facilitated (Articles 2 and 3). Clause 4 of the bill is particularly important: it allows work not directly related to the nuclear island to begin as soon as the environmental Authorisation is issued, while work related to this island will not be able to start only after the creation permit has been issued. This better sequencing is a key aspect to save time during construction.

*(1) Law No*. 2023-175 of *10 March 2023 on the acceleration of renewable energy production* .

*(2)* Duration *adopted at the end* of the *first reading of* the *bill in* the *Senate and the* National *Assembly.*

These measures are complemented by other provisions related to the existing nuclear fleet, which make it possible, in particular, to clarify the modalities applicable to the periodic review of basic nuclear installations beyond their 35th year of operation (Article 9) and to abolish the automatic shutdown of an installation when it has ceased to operate for a continuous period exceeding 2 years (Article 10).

During the examination of the bill, the senators also adopted the removal of the objective of **reducing** the **share of nuclear in electricity production** to **50% by 2035**(1)**, as well as the ceiling applicable to the total authorised** capacity of nuclear electricity generation, fixed at 63.2 GW(2). The deletion of these two provisions was also voted by the National Assembly on first reading.

### *d. The desire to accelerate the development of renewable energies again*

As expressed by the former ministers in charge of energy, the turning point of the years following the five-year term of President François Hollande consists, in the face of the energy emergency, in stopping to oppose nuclear energy and renewable electric energies and on the contrary to associate them explicitly.

The Prime Minister, Elisabeth Borne, reaffirmed this before the Commission of Inquiry: "*The third pillar of our action concerns the development of renewable energies. Energy sovereignty is also about not being dependent on a single source of energy. It would be too risky to rely solely on nuclear energy, especially since nuclear* power *alone cannot meet the rapid increase in our electricity needs for the next few years, when it takes at least fifteen years to commission a reactor. On the other hand, a 100% renewable mix is not possible, because it would be particularly expensive and its technical feasibility is not proven today. For our part, we are resolutely choosing pragmatism and therefore a balanced energy mix. A diverse mix is an asset and a protection,"*

With, already, a particular attention to the very promising sector of offshore wind, which is found in Law No. 2018-727 of 10 August 2018 for a State at the service of a trusted society that integrates initial measures to simplify the procedures for the installation of *offshore* wind turbines, as well as in Law No. 2020-1525 of 7 December 2020 acceleration and simplification of public action, which provides for additional simplifications.

The "Energy-Climate" law of 8 November 2019 contains more varied provisions: strengthening the obligations of photovoltaic installation on roofs, the support and traceability system for virtuous hydrogen, etc.

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*(1) 5° of I of Article L. 100-4 of the* Energy *Code* .

*(2) Article L. 311-5-5 of the* Energy *Code* .

The "Climate and Resilience" law of 22 August 2021 strengthens the obligations regarding roof equipment, while continuing the work of simplifying the procedures applicable to renewable energies. And to further mobilise the territories in the implementation of national objectives, the law provides that the objectives of the multiannual energy programming (PPE) are broken down at the level of each region.

However, obstacles remained to really accelerate the increase in our capacities, particularly in terms of planning territorial actions. The law on the acceleration of the development of renewable energies has made it possible to remove a number of them.

**Law No. 2023-175 of 10 March 2023** on the acceleration of **renewable energy production** should thus strengthen the decarbonisation of the French energy mix and our energy sovereignty, in conjunction with the nuclear acceleration bill adopted by Parliament. Among the most important measures can be mentioned:

– measures to speed up administrative procedures, such as the creation of a prefectural referent for the appraisal of renewable energy projects (Article 6) or the possibility for the administrative judge to regularize certain acts during disputes related to renewable energies (Articles 23 and 60). Above all, a presumption of recognition of the imperative reason of overriding public interest for certain RE or storage projects has been created (Article 19);

– measures to facilitate the planning of the deployment of renewable energies and improve their local acceptability. Article 15 provides for the definition, by the municipalities and with the opinion of the regional energy committee, of acceleration zones for the establishment of onshore renewable energy production installations and their related structures. Similarly, with regard to offshore wind power, the strategic façade document, drawn up for each coastline, should make it possible to map the priority areas for the deployment of such installations. The pooling of public debates for these offshore projects is also facilitated (Article 56). These planning measures are complemented by provisions on value sharing, which require, in particular, successful applicants following a competitive tendering procedure for renewable energy production to finance local projects related to the energy transition and biodiversity (Article 93);

– measures to facilitate the installation of photovoltaic or thermal panels in areas already artificialised or suitable, for example along roads and near railway tracks (Article 34), on the shades of car parks with an area of more than 1 500 m² (Article 40), or on brownfield sites in coastal areas. Agrivoltaism is subject to strict supervision, in particular for the installation of ground-mounted photovoltaics and the clearing of forest areas to set up the same type of installation (Article 54);

– energy market measures to facilitate the conclusion of long-term sales contracts directly between a producer using renewable energy sources and a final consumer (Article 86).

**If these measures to speed up procedures or even obligations appear essential, they probably call for important additions in view of the last two decades: the simple incentive and diffuse support of industrial sectors are not enough to find a sufficient pace of installation for the required production capacities.**

### *e. In the light of the crisis, preparation for a reform of the European market*

To meet the Community's demand for electricity, the single European market establishes the principle of using production capacity according to their order of merit: renewable energies and nuclear power are first called to meet demand, before fossil sources. It is the cost of production of the last power plant called that sets the price of all the electricity produced, in practice gas-fired production.

However, in 2021, economic activities, which had fallen sharply during the first year of the health crisis, are rebounding and demand for coal and gas is reaching record levels and cause their prices to soar. In October, gas prices had increased by +256% since the beginning of the year. As a result, electricity prices in Europe have risen to completely unprecedented levels, passing the €100/MWh mark on wholesale markets(1). This upward momentum will not stop for months, and will worsen further with the conflict between Russia and Ukraine and the questioning of Russian gas imports, with the wholesale price rising to €222/MWh in December 2021 and €700/MWh in the summer of 2022.

As early as autumn 2021, the French government raised the problems posed by the European pricing model, its inability to moderate a runaway price that does not reflect the reality of average production costs and, therefore, to protect European consumers, its failure to take into account the specificity of the French market largely powered by amortised nuclear electricity, etc.

After months of discussion, **on 14 March, the European Commission presented its ideas for reforming the electricity market**.

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*(1) The **wholesale** market is the market where electricity is traded and purchased by suppliers to generators, before being marketed on the retail market and then distributed through the distribution network. These transactions may take place on exchanges, on the over-the-counter market and /or the intermediated over-the-counter market. Spot products, those that are sold and consumed on the short term (no more than two days), and **forward products**, purchased well before their delivery by anticipating demand several weeks or months in advance, are traded. This allows them to minimise price spikes in spot markets during consumption peaks.*

Stating that its objectives are "*to accelerate the rise of renewable energy and the phasing out of gas, reduce the dependence of consumer bills on the volatility of fossil fuel prices, better protect consumers against future price spikes and market manipulation and to make EU industry clean and more competitive", "in order to compete* with *gas*", it provides for measures that encourage longer-term contracts for energy production in the future. from non-fossil fuels and devices to strengthen clean flexibility solutions in the system, such as demand response and storage.

In particular, all public support schemes for new investments in renewable energies (excluding bioenergy) or nuclear will have to take the form of "bidirectional CFDs". These are long-term contracts, setting a price guaranteed by the State to the producer and where the revenues (or losses) resulting from the difference between this price and that of the market are paid back to the State (or compensated by it). Any revenue will have to be redistributed to consumers, according to the Commission. If there is no question of retroactively imposing CFDs on existing generation capacity, CFDs will be able to finance new renewable energy or nuclear projects, as well as new investments in existing projects to extend the production capacity or lifetime of a plant.

On the other hand, the proposed reform retains the fundamentals of the functioning of the electricity market: the order of merit is preserved, considering that an auction system or an average price mechanism within the EU would raise prices.

However, Member States will be able to extend regulated retail prices to households and SMEs in the event of a crisis.

And to protect Europe's businesses and industrial competitiveness, the Commission proposes to facilitate the deployment of more stable long-term contracts, such as power purchase agreements (PPAs), under which companies organise their own direct energy supply and can thus benefit from more stable prices for energy produced from renewable and non-fossil sources.

**In any case, the rapporteur stresses the current inability of the European electricity market to reflect production costs and more particularly the French electricity mix, to avoid situations of explosion of costs while ensuring the most carbon-free security of supply possible. As detailed in Chapter 3, a major reform is therefore necessary and urgent and must be carried out in conjunction with the definition of European energy policies.**

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Reading the events as they have taken place, avoiding anachronisms as much as possible, should not lead to scapegoating, even if certain decisions and certain hearings of the Commission of Inquiry may surprise by their lightness or even their casual nature.

After three decades of hesitation and difficulties in projecting oneself into an energy future that combines industrial strategy, climate coherence and economic sustainability, the rapporteur has identified 6 major mistakes.

**THE SIX MISTAKES OF OUR ENERGY POLICY**

**1. Energy** forecasts: having underestimated our electricity needs in relation to our ecological objectives and the necessary exit from fossil fuels, without long-term reflection on our industrial and climate ambitions

**2. Opposition of renewable energies and nuclear in** a law without impact study and without industrial basis. **The focus** on the **electricity *mix***, **while it** is **already decarbonised**, **is necessarily** to the **detriment of the exit from fossil fuels**, which leads to immense challenges such as the electrification of uses and the impact on the network, the ability to assume a share of energy sobriety, etc.

**3. Nuclear fleet**: not having anticipated the extension of nuclear power plants and their renewal in industrial series and not in an isolated site, which has weakened both the nuclear industry, its skills and the country's ability to relaunch a major project

**4.** Renewable energy: not having built industrial renewable energy sectors to replace fossil fuels more quickly, as targets were set.

**5. European market**: having allowed a framework to be built that has weakened the French and EDF energy model, through the European taxonomy, the NOME law, the ARENH system, the status of hydroelectric concessions and electricity trading rules

**6. Research**: having closed Superphénix and not having ensured the development of research on the 4th generation

## CHAPTER III :
## FACED WITH THE EMERGENCY, DEPLOY AN INDUSTRIAL, ECOLOGICAL, SOVEREIGN AMBITION

Between the essential exit from fossil fuels, the projected increase in electricity consumption in France but opposite, the dependencies of our energy production apparatus, the rapporteur calls for a general awareness of the energy wall: of the urgency facing the country to ensure its sovereignty, both on the horizon of next year and next three decades.

As a method and as a conclusion to the analysis of the three decades that are coming to an end, the rapporteur therefore proposes six lessons to be drawn from our energy past:

1. **The long term counts**: to make coherent (*via* RTE and other public bodies) our climate ambitions (reduction of emissions), industrial (reindustrialisation), energy (ability to produce this or that energy in France)

2. **Energy is not a good like any other**: within the European Union, each country first defends its energy mix, France must also defend its controllable and carbon-free electricity mix as well as its central operator, EDF, whose nationalization must be supported

3. **Energy is an industry, the 3rd largest in France:** we need to master the entire value chain and have the skills, but also to choose the most profitable technologies and renewable energy sources (of which hydraulics are the most important and the only controllable) and the most likely to ensure our security of supply

4. **Electricity is not everything**: not focusing excessively on electricity when it is decarbonised in France, and accelerating the development of heating networks, thermal renewable energies to replace fossil fuels

5. **Demand management is being prepared**: to reduce our dependence on fossil fuels and our energy consumption, sobriety and energy efficiency require our own resources

6. **Without research, we are doomed** to **fall behind**: providing research and development with the means to be able to answer the questions of the coming decades: closure of the nuclear cycle; recycling of critical materials, etc.

**These six lessons irrigate the new method proposed in this third chapter and irrigate the thirty proposals made by the rapporteur.**

## I. ANCHORING OUR ENERGY AMBITION FOR THE COMING DECADES

### A. PURSUE **A 30-YEAR AMBITION , ENSHRINED IN LAW** AND **UNDERPINNED BY SCIENCE AND INDUSTRY**

The history of the last three decades as revealed in the hearings attests to the **need for a long-term vision,** in line with our climate ambitions and compatible with our industrial capacities.

This long-term energy vision that we must build must assume an **increase in carbon-free energy production** to face energy and climate emergencies and to achieve the commitment to carbon neutrality by 2050**.**

RTE's "Energy Futures 2050" report forecasts a decrease in overall energy consumption, but an **increase in electricity consumption** that will replace fossil fuels.

The report concludes that accelerating the **country's reindustrialisation** will increase electricity consumption, but **will reduce France's carbon footprint.** Therefore, in view of the climate and industrial objectives that France has set itself, it must **assume a significant increase in its electricity production.** To do this, it must follow the **path close to "deep reindustrialisation"** identified by RTE – that is to say, anticipating an increase in electricity consumption of 58% by 2050, compared to 2019, i.e. bringing current electricity consumption from 459.3TWh[1] to 752 TWh in 2050 – which will remain to be refined.

In 2022, RTE recorded electricity production of 445 TWh, 87% carbon-free, including 279 TWh of nuclear electricity (63%) and 110 TWh of renewable electricity (24%). The gap between France's electricity production and its consumption must therefore be bridged by an imminent strengthening of **actions** and **measures** of **energy sobriety and efficiency**, by **efforts to produce electricity, spread over the different sectors**, driven by a revival of nuclear power**,** which will retain a significant share of production, and through an accelerated deployment of renewable energies. For example, in its reference trajectory of 645 TWh (weaker than the trajectory "deep reindustrialisation"), considering the extension of some (but not all) reactors beyond 50 years, RTE arrives at an electricity production gap

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*(1) According to RTE data, in* 2022, *electricity consumption adjusted for climatic hazards and calendar effects amounted to 459.3 TWh. RTE, Bilan électrique 2022 – Main results.*

of almost 400 TWh in 2050 (nuclear production declining in this scenario) – this is the order of magnitude of our current electricity mix that would therefore have to be completely renewed. This gap increases by a further 100 TWh if we look at the deep reindustrialisation trajectory – hence the rapporteur's proposals on the extension of the current fleet and the development of new carbon-free capacity.

This increase in production will have to be based on a controllable electricity mix and ensure the permanent security of supply and the proper functioning of the network, which a production entirely based on intermittent energies cannot guarantee without means of storage and flexibility on a large scale, the demonstration of which has not been achieved. RTE underlines this point in its joint report with the International Energy Agency: "*With the exception of small electricity systems mainly based on controllable hydropower units, there is indeed no experience of operating such systems on a large scale. Proponents of a "100% RE" target say — and rightly— that many alarmist predictions about* the *technical limits to RE integration made in the past have proved wrong. However, there is no proof of the feasibility of a very advanced integration of variable renewable energies such as wind* and *photovoltaic on a large electricity system, and new technical challenges are bound to emerge*[(1)]».

Finally, it will have to be accompanied by an adaptation of the structure of the electricity **transmission network**, all the more profound as the share of renewable electricity will be significant in this production. Procedural deadlines require rapid **planning of these investments and final decision-making.**

**Proposal 1: in line with our climate and industrial objectives, assume a growing need for electricity, for the end of the decade, by 2050 and beyond, and note the production gap that we separates from energy sovereignty.**

After the introduction of the multiannual energy programming by the "TECV law" of 2015, the energy climate law of 2019 introduced a five-year energy climate programming law. The next one will have to be adopted in 2023 and set priorities for action on climate and energy policies by integrating the European target of a 55% reduction in GHG emissions by 2030. Reviewed every five years, with certain 10- or 15-year objectives (reduction of GHG emissions, development of renewable energies, diversification of the electricity mix, etc.), it will ensure regular monitoring and make our various objectives coherent.

(1) *RTE, IEA,* 2021 Conditions *and prerequisites* for *technical feasibility for an electricity system with a high proportion of renewable energies by 2050.*

**The construction of this energy law must be a highlight of society. To give** back **its full place** to **Parliament**, the only one able to participate in the creation of an energy consensus that needs the long term, this programming law should be **made consistent with energy** time**, which is a time of industry** and sovereignty, and should present:

– decarbonisation, sobriety and energy efficiency objectives ;

– energy production targets and in particular electricity production that are compatible with the cross-party desire to increase the share of industry in GDP, which would be more or less close to RTE's "strong reindustrialisation" scenario, which would be refined;

– targets for installed capacity and average production of carbon-free energy, and not energy mix targets as a percentage, which have amply demonstrated their technical and scientific absurdity;

– In support, an impact study including: the industrial and technical underlying, the impacts on the electricity network, the energy efficiency of each energy source (*cf. infra*);

– regular evaluations of the implementation of energy policy. This legislation would be:

– prepared and then monitored by a special committee, or *at least* by a transpartisan working group set up within the Economic Affairs Committee of the National Assembly;

– followed by a regular report from OPECST which would be debated in the relevant standing committees;

– regularly informed by an opinion of the Academy of Sciences or the Academy of Technology.

**Proposal 2: adopt a 30-year energy-climate programming law with climate, energy and industrial objectives and related resources, which will be closely and regularly monitored by Parliament and expert institutions.**

The **quality of OPECST's work,** its working method, outside traditional media and political field thanks to its transpartisan tradition and bicameral functioning, are major parliamentary assets that can be better valued and used[(1)].

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*(1) OPECST produces numerous reports which have fed into the work of your rapporteur; we can mention in particular the 2022 report by Mr. Henriet and Mr. Longuet "For an energy renovation of buildings piloted, encouraged and accelerated"; 2021 by MM. Gassilloud* and *Piednoir "The nuclear energy* of the *future and the consequences of the abandonment of the 4th generation nuclear reactor project "ASTRID".*

Therefore, it would be beneficial for parliamentary debates and political decision-making to strengthen their cooperation with OPECST, in order to benefit from its long expertise and its specific working method – more suited to the examination of decisions with long-term effects.

To this end, the rapporteur highlights the ongoing study by OPECST, carried out on referral by the Chairman of the Committee on Sustainable Development and Regional Planning (DDAT), which makes it possible to present and measure the implications, in terms of research and technological innovation, of the objective of the energy sobriety. This study was launched in October 2022 and will see its conclusions presented in June 2023 to the members of OPECST and the DDAT commission. The conclusions of this study will have to be taken into account when examining the texts relating to energy policy.

OPECST's powers should be strengthened by allowing it to **take up** matters **relating to security** of **supply, the country's** energy **sovereignty** and one of the objectives set for energy policy in the Environmental Code [(1)].

An intervention of the **OPECST in the general discussion of bills and proposals relating** to **energy** could be beneficial to the debate. It could be considered upon request to the Conference of Presidents and would require prior deliberation within OPECST. It would, however, presuppose that the time of deliberation of the OPECST and the time of the legislative procedure are compatible.

Moreover, a **co-construction of energy texts with OPECST**, **with the Government, would be advantageous.** To be consistent with the current principles of OPECST, this association will have to concern the main objectives and levers of action of public policies under the prism of science and technology. Such an evolution of OPECST's competences would imply legislative revisions identified by the rapporteur[(2)].

**Proposal 3: strengthen the consultation of Parliament, and in particular OPECST, on energy policies and the control they exercise over their implementation.**

(1) *Article L. 100-1 A to L. 100-5 of the* Energy *Code* .

(2) *Based on the OPECST's replies to your rapporteur's questionnaire, the amendments could relate to Articles L. 100-1, L. 100-2 and L. 100-4 of the Energy Code to incorporate a wording similar to that of Article L. 1412-1 of the Public Health Code; on Article L.100-1. A and Articles L. 141-1 and L. 141-4* and *Chapter* IV , *Book IV*, *Title I* of *the* Energy *Code so that, respectively, the five-year law, the multiannual energy programming (PPE) and the national energy research strategy are the subject of a prior evaluation by OPECST.*

## B. GIVE ADMINISTRATIONS THE INSTRUCTIONS AND THE MEANS TO MONITOR OUR VULNERABILITIES

Beyond the attitudes, positions and individual convictions of the senior officials heard by the Committee, it became extremely clear that **the public administrations have not had as their primary compass**, in recent decades, the **objective of security of supply and the reduction of dependencies**, and have not been are therefore not concretely equipped with the tools to measure our dependencies and the levers to reduce them.

**While a recent turning point has taken place with many regulatory and organisation al innovations (creation of the** Strategic Information and Economic Security Service (SISSE) within the DGE, creation of inter-ministerial delegations respectively for new nuclear power and supplies of minerals and strategic metals, creation of the French Observatory of Mineral Resources for Industrial Sectors (OFREMI) and with the release of new budgets. for the energy industry (France Revival, France 2030, BPI Fund), **much remains to be done**. **The ability** to **measure our vulnerabilities, to establish the risks** weighing on our energy industry, on our security of supply, is decisive for rebuilding a sovereign long-term energy policy.

In the first place, we must draw all the consequences of the fact that energy is an industry, and even "the **industry of industry"** to use the formula of former Minister Arnaud Montebourg. This involves:

– replace, as before 2008, the Directorate in charge of energy within the Ministry in charge of Industry, so that it is at the heart of our economic and industrial policy;

– provide this administration, like the Directorate-General for Enterprise (DGE), with the human and technical resources to monitor our industrial vulnerabilities in energy: monitoring our supplies of critical materials and our imports of components useful for manufacturing energy installations; in-depth study of European and global industrial value chains; monitoring of the situation of our companies in the sector and skills and training needs; monitoring technological advances in other countries, etc.

**<u>Proposal 4: put the Directorate-General for Energy back within the Ministry of Industry and provide it with the means to identify, monitor and reduce our industrial vulnerabilities.</u>**

More specifically, our approach to energy sovereignty in the sense of security of supply lacks an overall vision: on the one hand, gas and oil are monitored and strategic stocks which, according to the work carried out by our Committee of Inquiry, do not include prospective studies on consumption or action plans to be activated in accordance with the scenarios (inability to activate sobriety plans); on the other hand, the security of electricity supply is analysed, anticipated, followed by RTE according to the criteria described in Chapter I of this report.

In particular, the current basis for qualifying security of supply – an " expectancy " in the sense of a probability of 3 hours of failure – should, by RTE's own admission, be reviewed and supplemented:

– In the short term this criterion could be deepened and harmonised at European level, and risks to security of supply could be observed more without counting on a significant share of imports from other European countries...

– In the medium term, the doctrine of security of supply could be refounded: the increase, in France and even more at European level, in the share of non-controllable energies will lead to much larger standard deviations, and therefore to a need to anticipate potentially very rare, but very problematic situations (occurrence of an anticyclone, and very little sun on a extended period, for illustrative purposes only).

However, it must be borne in mind, as RTE points out, that the scenario of risks on electricity supply has no limit in itself; that there is therefore a political arbitration *in fine*, on the level at which we wish to stop.

**Proposal 5: ask RTE to change its security of supply criterion in the short term, and launch an overhaul of our global security of supply doctrine under its responsibility**

### C. BUILDING A EUROPEAN FRAMEWORK THAT STOPS PUTTING FRANCE AT A DISADVANTAGE

Nuclear energy, on which the French energy mix is based, is a carbon-free energy, and it is necessary for its economic balance and development that it be recognised as such on the European scene.

As part of its environmental roadmap – the European Green Deal – the European Union has proposed **to invest heavily in sustainable activities.** In order to guide these investments, the EU planned to **revise the green taxonomy**, i.e. the classification of economic activities contributing to its environmental objectives.

The debates on the revision of the European taxonomy have crystallised around the integration of nuclear and gas into sustainable activities: this is indeed the condition to be fulfilled to massively direct public investment, that of companies and those of banking institutions, towards these energies. Although nuclear power has finally been recognised by the European Parliament as a green energy, this qualification is accompanied by many limiting criteria (building permits) established before 2045 and works authorised before 2040, guarantees for the treatment of nuclear waste and the dismantling of installations, etc.).

Thus, the progress achieved on European taxonomy is encouraging for the sector, but still insufficient. It is necessary to reach a consensus between Member States in order to clearly consider this carbon-free energy as an indispensable tool for achieving climate and environmental objectives.

European discussions are still ongoing on energy and ecological issues, and nuclear power must not be excluded for ideological or national reasons, to the detriment of the environment and our sovereignty.

The hydrogen production model currently under construction in the European trilogue already includes nuclear power, as an energy to produce low-carbon hydrogen, itself aligned with the same greenhouse gas emission threshold as renewable hydrogen. But it is important to harmonise the support measures associated with these two types of hydrogen.

In addition, discussions are starting on the proposed *Net Zero Industry Act* regulation presented at the end of March 2023, in which nuclear is again too partially included, limited to new nuclear, and excluded from strategic decarbonisation technologies that can benefit from specific investments, in the annex to the regulation.

We must consider, once and for all, in all future European texts, nuclear energy as a carbon-free and strategic energy, which should be supported in the **same way** as renewable energies, to encourage investment in this technology, for the production of hydrogen, to decarbonise our industry.

**Proposal 6: adopt a common and sustainable European position to define nuclear energy as a decarbonised and strategic energy, which should be supported in the same way as renewable energies**

The European energy crisis we are experiencing, particularly since 2022, has highlighted the limits and dangers of the mechanisms of the **European electricity market**, which does not take into account the electricity mixes of different countries, in particular that of France which is almost entirely decarbonised – and which by the same token has also contributed to destabilising EDF *via* the ARENH mechanism.

France said it was determined to change the key rules of the European market; the European Commission presented a first proposal on 14 March 2023, in order to accelerate the deployment of renewable energies, the exit from fossil fuels and to reduce consumers' energy bills.

Through the revision of European acts[1], the European Commission is paving the way for contracts for difference for low-carbon energies and long-term fixed-price contracts. More specifically, it proposes to strengthen the use of three contracts:

– ***Power Purchase Agreements*** (**PPAs**), long-term private contracts (15 years) under the conditions (price and supply) set between the contracting parties;

– **forward contracts**, similar to PPAs but contractualised for a shorter period (3 years);

– **contracts for difference (CFDs), contracts between the State and** suppliers specifying a range of price changes whose difference between the high or low threshold of the range and the market price is offset or collected by the State. The latter contract would be mandatory for low-carbon energy contracts.

This is a welcome development, but the rapporteur believes that France must ask for and obtain more**. Four objectives must be pursued:**

– the **European Union's good consideration of the French specificity**: quasi-self-sufficiency in electricity mainly carried out by a single operator, EDF, *via* nuclear and hydroelectricity;

– the **decarbonisation** of the European electricity ***mix***, which must involve the decorrelation of gas and electricity prices, since the current market tends to allow thermal power plants to continue;

– **the protection of final consumers** and in particular SMEs ;

– the **correct allocation of production** and therefore the ability to cope with shortages.

As a result, France **must request a decorrelation between the price of gas** to generate **electricity** and other sources of generation. This can be done through:

– **a complete decorrelation**: the market must be rethought and the logic of the plant called at the lowest marginal cost changes, which can be problematic for the support of renewable energies whose marginal cost is low, as well as for security of supply at all times, because thermal power plants can be called very quickly and at any time;

- **a partial decorrelation:** only the *spot* market retains this logic and most volumes can be or are contracted at fixed prices over the long term;

(1) *In its draft*, the *European Commission proposes*, *in particular*, the *revision of* the electricity *regulation*, the *electricity directive* and *the regulation on market integrity and transparency*. *wholesale energy.*

- **a cap that would have** the **same effects**: in a similar way to Spain and Portugal, countries can freeze the price of gas used to produce electricity, and pay any difference (in case of lower production through budgetary appropriations rather than, as in Spain, taxation of the final consumer. This system should be applied on a European scale and could lead to overconsumption of gas.

In fact, such a reform of the European market would render the ARENH system obsolete. In times of high prices, ARENH weighs heavily on EDF (*cf.* Chapter 2): it is the operator who, in a way, pays part of the reduction in the electricity bill of companies. In any case, it is an irrelevant option from an economic point of view and very problematic for EDF. Pending the reform and the end of the negotiations, France should therefore be able to suspend ARENH and offset the impact on final consumers by an ad hoc temporary tariff shield for businesses, including if this implies a derogation from State aid rules.

**Proposal 7: link the reform of the electricity market to the negotiations on the EU's overall energy policy by carrying out a profound reform of the European electricity market to protect French specificity, uncorrelate the price of gas from that of carbon-free electricity; in the meantime, suspend without delay and compensate the ARENH**

More broadly, France can and must take the lead in a coalition of EU Member States that use nuclear energy, whereas the Treaty of Lisbon guarantees that the principle of subsidiarity applies to the determination of national energy mixes. Faced with the specificity of this energy and the unjustified discrimination it suffers in the European taxonomy, an alliance and an organisation are needed. The rapporteur therefore welcomes the French initiative for a nuclear alliance and encourages its enlargement.

Beyond this alliance, it is desirable to strengthen industrial, technical and scientific cooperation, in the spirit of the Euratom Treaty signed on 25 March 1957, whose objectives of developing and supervising the European nuclear industry are still being pursued. To this end, over the period 2021-2025, Euratom is funding various research projects to the tune of €1.38 billion aimed at research and development activities in the field of fusion (€583 million), fission, safety and radiation protection (€266 million) and the Centre's activities. Joint Research Committee (JRC) which takes the form of a network of six laboratories on European soil (€532 million).

Between 2009 and 2014[(1)], Member States also extended the Euratom field of action to include nuclear safety and security and spent fuel and radioactive waste management.

This research and cooperation, in its content and in its ambitions, are not on the scale of the European project or the urgency of decarbonisation.

**Proposal 8: Following the recent announcement by the Minister for Energy Transition, demand compliance with the Lisbon Treaty and give new impetus to the Euratom Treaty.**

Beyond nuclear energy, the hearings highlighted the acuteness of the problem of French hydroelectric concessions: the European framework provides that these (some of which expired in 2003) should be put out to competition since 2008, which was followed by formal notices from the European Commission in 2015 and then in 2018, without the French authorities having taken a decision. This in-between weighs heavily on EDF and its investment in these concessions, the maintenance and ramp-up of which are crucial for our energy model.

In view of the best national interest that hydropower represents for our country and the historical legacy from which it results, the rapporteur stresses the urgency and imperative need for France to assume its responsibilities and to maintain in the public domain, potentially in quasi-governance, as recently proposed by the Senate, its concessions.

**Proposal 9: Keep hydroelectric concessions in the public domain, for example by applying a quasi-governance mechanism to avoid competition and boost the necessary investments .**

## II. RAPIDLY REDUCING OUR DEPENDENCE ON FOSSIL FUELS

In the last thirty years, debates have tended to focus on the French electricity mix, which is almost entirely decarbonised, to the detriment of our much stronger and problematic dependence on imported fossil fuels. Reducing this dependence requires further reducing our energy consumption, decarbonising and changing uses.

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*(1) Directive 2009/71/Euratom of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations (revised 2014); Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for* the *responsible* and *safe management of spent fuel* and *radioactive waste and the Directive* 2013 */59/Euratom of 5 December 2013 laying down basic safety standards for* health *protection against the dangers arising from exposure to ionising radiation.*

## A. ACCELERATING TOWARDS SOBRIETY AND ENERGY EFFICIENCY

The **France is still largely dependent on fossil fuels**, which are its main vulnerabilities in terms of sovereignty, since it must import 99% of the oil and gas consumed by three sectors in particular: residential, transport and industry.

In 2021, the transport sector consumed 501 TWh of energy, of which about 91% was petroleum products, 7% incorporated biofuels, 2% electricity and 0.6% natural gas. The residential sector consumed 492 TWh of which 34% electricity, 28% natural gas, 24% renewable energies and 10% petroleum products. As for industry, it consumed 311 TWh, of which 37% was natural gas and 36% electricity, followed by petroleum products (10%), renewable energies (7%) and marketed heat (6%) as well as coal (3%).

**The most energy-consuming sectors will necessarily have to reduce their consumption of fossil fuels by** 2028: the PPE forecasts a final energy reduction of 16.5% in 2028 compared to 2012 including a 22% reduction in primary consumption of gas, 34% of oil and 80% of coal.

If this was not the primary purpose of the hearings of this Committee of Inquiry, the rapporteur strongly stresses that the very first way **to reduce our dependencies** and our energy bill remains the reduction of our **consumption** of energy and in particular of fossil fuels, both *through* sobriety (reduction of the consumption resulting from an adaptation of uses, or even a reduction or cessation of certain activities) and energy efficiency (lower consumption for the same activity).

This part is therefore not intended to be exhaustive but illustrative of the many efforts to be made or strengthened[(1)].

To this end, the rapporteur highlights the ongoing study by OPECST, carried out on referral by the Chairman of the Committee on Sustainable Development and Regional Planning (DDAT), which makes it possible to present and measure the implications, in terms of research and technological innovation, of the objective of the energy sobriety. This study was launched in October 2022 and will see its conclusions presented in June 2023 to the members of OPECST and the DDAT commission. The conclusions of this study will have to be taken into account when examining the texts relating to energy policy.

In any case, the sobriety plan for winter 2022-2023 has allowed an unprecedented reduction in electricity consumption of 9% (20 TWh), according to meteorology.

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*(1) The rapporteur refers to the work on energy sobriety by Ms Olga Givernet and Mr Stéphane Piednoir, organised within the framework of OPECST and whose conclusions are expected in the first half of 2023.*

constant, compared to other winters, and three quarters of the reduction would be related to the price signal and the sobriety chosen[1]. This dynamic must absolutely be pursued and amplified in order to meet our European objectives and reduce our dependencies on all sides.

**Proposal 10: Perpetuate and increase the ambition of the winter 2022-2023 sobriety plan, and extend it to all individuals, public services, and businesses without ignoring the financial and industrial cost of erasure**

In particular, and because of the energy consumed by the transport sector (501 TWh in 2021), but also the critical materials needed for the electrification of mobility, the rapporteur stresses **the importance of stepping up efforts in the field of public passenger transport and rail freight**, by supporting major projects in this area, including the new accesses to the Lyon-Turin link, which plays a crucial role in industrial matters. To take into account the full impact of the industrial chain, it is also important to reduce the weight of vehicles to effectively reduce their overall carbon footprint[2].

**Proposal 11: Strengthen the decarbonisation efforts of all emitting sectors, particularly in transport with the acceleration of public transport and rail freight projects and with the reduction of vehicle weights through incentive schemes**

Among the major sources of energy efficiency, the rapporteur finally highlights the need to drastically improve the efficiency of the energy renovation policy for buildings, the significant cost of which is currently reflected neither in the number of overall renovations nor in the energy gains, which are not measured, but only estimated.

**Proposal 12: evaluate energy renovation schemes to prioritise the most effective, set measurable consumption reduction objectives and break them down by department; launch a sector plan to develop training.**

## B. FURTHER DEVELOPING THERMAL RENEWABLE ENERGIES

As evidenced by the vast majority of hearings and as noted by the Academy of Technologies[3], the focus of debate and public policies on the electricity mix has often led to underestimating the potential of non-electric renewable energies in the decarbonisation of our energy consumption. Public policies to support renewable

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(1) *RTE, Winter 2022-2023 review : power cuts avoided thanks to lower consumption, 16 March 2023.*

(2) *Nicolas Meilhan, How to finally reduce CO2* emissions *from cars, France Strategy, June 2019.*

(3) *Academy of Technologies, Contribution: energy sobriety or new technologies?, November 2022.* https://www.academie-technologies.fr/wp-content/uploads/2023/03/Cahier-d-acteur-AT-Concertation-national-energy-mix.pdf

heat have thus developed in recent years, notably *through* the Heat Fund since 2009, set up following the Grenelle Environment Forum. This fund, managed by ADEME, represented between 2009 and 2021 a support of more than 3.3 billion euros, divided between more than 7,000 operations (geothermal energy and heat pumps; biomass; renewable gases), which have prevented the emission of almost 10,000 tonnes of $CO_2$ per year.

Although the objectives set by the last EPP for 2030 have not yet been achieved, the potential remains visibly much higher than our current ambitions, even though:

– These energy sources have been deemed increasingly competitive[(1)];

– In many cases, they allow a direct decarbonisation of uses, such as renewable gas, which requires little new infrastructure compared to existing ones for fossil gas.

However, their development requires significant technological and industrial mastery so as not to repeat the mistakes of the past, when objectives on certain technologies were set while the country was already lagging behind other partners. In France, the technologies are mature and the cost per tonne of $CO_2$ avoided has been widely documented by the Court of Auditors and the Treasury Directorate[(2)], as particularly low. A massive development of renewable heat will allow us both to decarbonise our heat production, and to offer an alternative to natural gas for district heating networks and industrial sites that are currently dependent on it.

**Proposal 13: revise our renewable heat targets, which according to several institutes could be at least doubled by 2030, and strengthen the associated Heat Fund**

(1) Court of *Auditors*, *The cost analysis of the electricity production system in France, 13 December 2021.*

(2) *Trésor, Letter n°222 Trésor-Eco, " Renewable thermal energies", June 2018*

# I. BUILDING OUR ELECTRICITY SOVEREIGNTY

## A. MEETING THE CHALLENGE OF ELECTRIFICATION, FOR INDUSTRY AND FOR THE GRID

The first question raised by the electrification of our energy mix, even before the ability to produce more electricity on our soil, is that of being able to assume the prerequisites in terms of uses: ability to replace the uses of thermal vehicles (long distances, mountain roads, isolated territories) by electric vehicles; transformation of thermal energy heating systems. This capacity will depend very much on technology, on our industrial capabilities but also on the evolution of individual behaviour.

The second issue, closely linked and discussed at length during the hearings, is that of our ability to reduce our dependence, which is currently total, on certain materials essential to new uses, which could also come to be lacking[(1)], well beyond the rare earths frequently cited for the manufacture of electric batteries.

This already critical situation was identified by the Government with the report commissioned from Mr. Philippe Varin and the launch in November 2022 of OFREMI. The rapporteur stresses the importance of scaling up vulnerabilities and reducing them as much as possible:

– have a precise and dynamic vision by 2050 of our needs and imports of critical materials whose list is being developed by OFREMI;

– build a recycling chain for all components containing critical materials as part of the energy transition; This sector will be difficult to design and will not in any case be able to satisfy a majority of needs;

– Launch a new mining inventory on French territory to establish the list of available and useful resources on our soil.

**Proposal 14: launch a new mining inventory on French soil, accelerate the identification of critical imports and the creation of rare earth processing and recycling channels**

(1) *IFPEN estimates that 80 to 90% of copper resources known* in *2010 could be extracted in 2050*: *https://www.ifpenergiesnouvelles.fr/article/cuivre-transition-energetique-metal-essentiel-structurel- et-geopolitique*

Finally, massive electrification will have a major impact on the electricity grid: both *through* the **multiplication** of **energy production sources**, the **variability of their production, the associated** flexibilities and storage needs. The rapporteur insists on the necessary investments, highlighted by RTE in its latest reports and in particular in the Energy Futures 2050 report. While the grid operator indicates that investments of the order of €2 to €3 billion per year can be carried directly by RTE, the capacity to assume larger investments still needs to be deepened. Thus, by way of illustration, the choice of the "N2" scenario in strong reindustrialisation would lead to investment needs of the order of €5 billion per year on average between 2030 and 2050[(1)].

**Proposal 15: deepen the forecasting of investment needs on the network, in particular in the case of the strong reindustrialisation trajectory**

## B. REMAKING THE NUCLEAR INDUSTRY THE GREAT FRENCH FORCE

### 1. The existing nuclear fleet

Faced with the urgency of decarbonisation by 2050, the lack of large-scale demonstration of an electricity mix operating with 100% renewable energies and the industrial and sovereign asset that the entire sector represents, nuclear energy can be more than ever a great French strength. The announcement of Belfort in February 2022, unprecedented since the Messmer plan, then the adoption of the acceleration bill in March 2023 have concretised the leap: they must now be followed by long-term decisions, not only on reactors, but on the entire nuclear industry.

**The management of the existing nuclear fleet must be subject to increased transparency, as** well as **anticipation of the challenges ahead**: management of shutdowns for maintenance, aging and replacement of certain components; monitoring of possible cracks, whether thermal fatigue, stress corrosion or other elements; climate change and water resources in particular.

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(1) *In the Energy Futures 2050, the first estimates for 2050 estimate the need for investments at around €80* billion over the *period 2035-2050 in* the *case of the N2 –* reindustrialisation *scenario* (just *over €5 billion/year). This scenario is the one that comes closest to the energy policy orientations known to date ( Belfort speech). These estimates will be further developed in the framework of the next SDDR (ten-year network development plan) by the end of the year. In its contribution to the national consultation on the energy mix, the Academy of Technologies specifies, for its part*, that if *France does not* use its *full production potential – that is to say, if it renounces reindustrialisation -, " its balance commercial* will *deteriorate, especially since it will have* to *import equipment required by the* energy *transition. The inevitable result will* be *the destruction of jobs." Academy of Technologies, Contribution: energy sobriety or new technologies?, November 2022. https://www.academie-technologies.fr/wp-content/uploads/2023/03/Cahier-d-acteur-AT-Concertation- national-energy-mix.pdf*

*(2)*

First, because of the many ten-year visits and scheduled maintenance shutdowns planned in the coming months and years, but also in the coming decades given the recurrence of these visits, it is imperative that these regular visits and shutdowns continue to be optimised to minimise the risk of production being too low at critical times.

In addition, if EDF has already presented a revised strategy for stress corrosion control for the year 2023, a detailed, broader presentation submitted to OPECST is essential to preserve the confidence that binds the nation to our nuclear industry.

Similarly and more prospectively, the impact of climate change in all its forms (water resources, impact on populations and therefore on the activity of power plants, electricity demand in summer, etc.) must be anticipated and detailed precisely by EDF in the coming months and years for national representation and public debate to be informed.

**Proposal 16: on all major short-term challenges (stress corrosion, thermal fatigue) and medium-term challenges (impact of climate change), ask EDF to produce and present to the Government, to the OPECST and the general public, a precise and prospective inventory of the measures taken to ensure the operation of the nuclear fleet, dams and all energy installations**

In addition, the rapporteur stresses the need to include in the public debate, particularly ahead of the Energy and Climate Planning Act (LPEC), a theme that has been relatively little highlighted in recent decades: the **anticipation of the shutdown of nuclear reactors – whether this occurs simultaneously or at the same time gradually**, **at** 40, **50, 60** or older. RTE's work in the context of Energy Futures 2050 gives an order of magnitude over time, but does not answer the question of the concrete transition with other energies or new reactors, nor the industrial needs, over time, for decommissioning. Beyond the work and recommendations carried out by the Court of Auditors[1] on the provisioning of related costs, which is already provided by EDF, an evolving strategy of closing the park is necessary.

In addition, with a view to operating nuclear reactors beyond 60 years in France, studies according to several scenarios must be completed by ASN, with the help of EDF: the effects, impact and consequences of the extension of reactors up to 60, 70 or 80 years must be studied. According to the Chairman of ASN, an in-depth investigation could be carried out by this authority by the end of 2026, the objective being to identify in the first place the elements that cannot be replaced or are difficult to replace.

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*(1) https://www.ccomptes.fr/system/files/2020-03/20200304-rapport-arret-demantelement-installations- nuclear-2_0.pdf*

**Proposal 17: conduct the preliminary studies necessary for the extension of all reactors that can be extended under different scenarios, and anticipate today and within the framework of the EPML the needs, impacts and consequences of the closure and dismantling of the existing fleet, regardless of the effective shutdown date of the reactors**

## 2. Construction of new pressurised waterreactors (EPR2)

The speech of the President of the Republic in Belfort, the vote of the law on the acceleration of procedures relating to nuclear installations and the creation of a delegation for new nuclear power act a **major turning point** and set, upstream of the LPEC, the milestones to make possible the construction of new 3rd generation reactors on French soil.

The hearings and contributions addressed to the Committee of Inquiry show the importance of an extremely close follow-up of the project, in view of the construction of the EPR of Flamanville, even if the *design* of the EPR2 envisaged has been reviewed and simplified to ensure easier constructability. In this sense, this year will be the year of the program review by the delegation, in connection with the entire sector, scheduled for October 2023. The work of the journal, whose steering committee brings together the actors of the sector, includes monthly meetings and two audits, one on skills and the other on costs, conducted over several months. The objective is also to complete, by 2023, the *basic* design of the installations to then progress on the *detailed design*. The conclusions of the programme review will be instructive for the new nuclear power and for the organisation of the sector.

Beyond the many lessons learned from the EPR project explained and listed in the report of Mr. Jean-Martin Folz in 2019 and largely integrated by EDF(1), maximum transparency on the evolution of possible projects must be guaranteed and project monitoring at the highest level.

Finally, the nationalisation of EDF must come to an end to fully secure the company on the verge of a project of this magnitude.

**Proposal 18: increase as much as necessary the resources allocated to the delegation to new nuclear power in the monitoring of the project for the construction of new EPRs and obtain regular and public monitoring reports on the progress of the project; strengthen EDF as a single and nationalised operator.**

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*(1) In its reply to the questionnaire of the report ahead of the hearing of Mr Cédric Lewandowski, EDF reviews the lessons learned from the Folz report and presents the industrial levers for action (simplification of the design of the EPR , search for standardisation, skills, revision of* contractual *conditions) and governance (separation of project management and project management).*

More generally, in hidden time and during the construction of the first EPR2, it must be up to the Government and EDF to prepare the construction of a significant number of reactors to anticipate the **renewal of the existing** fleet: the announcement of 6 EPRs, and the reflection on 8 additional reactors, must be extended to a reflection on the advisability of eventually replacing the entire fleet whose reactors have fairly similar ages: partial or total replacement, in number of reactors or installed capacity for example.

The rapporteur also encourages studying the interest of deploying small modular reactors on the model of the EDF NUWARD project, which could lead to the commissioning of 25 gigawatts of new nuclear capacity by 2050, in addition to EPR2.

**Proposal 19: anticipate the need for renewal and development of the entire existing fleet, in number of reactors (including SMR) or installed capacity, in the coming decades and on existing or new sites**

### 3. The fuel cycle

From all the hearings conducted, a striking paradox emerges: the fuel cycle is perceived as a critical and central element of the nuclear power industry; However, most of those interviewed consider that it is underestimated in the value chain, with the consequences that we know today (transparency that can be improved on supplies; industrial control of the value chain; storage capacity alerts).

In recent parliamentary debates, in the public debate and in some of our hearings, alternative truths have emerged on the issue of uranium supply: ignoring, or pretending to be unaware, that the natural uranium transported does not present dangerous radioactivity; that our dependence on fuel is particularly limited, since the availability of uranium is particularly limited. Natural on Earth, the number and variety of our suppliers, and especially the number of years ahead that the existing fleet has, are important.

**The false elements that circulate and have circulated must encourage EDF** and the **public** authorities **to increase transparency**, within the limits of business secrecy and the protection of the strategic interests of France and its partners.

**Proposal 20: ask EDF for greater transparency on its supplies of natural and enriched uranium, at least one geographical grid per country**

**The nuclear burst must therefore also be a burst in the fuel cycle.** It presents in fact weaknesses but also opportunities that must be thought of in coherence with new nuclear ambitions, with a view to mastering value chains and energy sovereignty.

**Our natural uranium enrichment capabilities are** crucial, even more so in the run-up to new pressurised water reactors. In a context where the Orano Melox plant in Marcoule had reached in 2021 a historic low of production since its opening in 1996, at 50 tons of so-called "MOX" fuel. Orano has announced an additional investment of €85 million by 2025 to upgrade the plant and return to over 100 tonnes per year [(1)].

**Proposal 21: Support the strengthening of enrichment capacities on French territory**

These enrichment capacities could be coupled with **a capacity to reenrich uranium from spent fuel** that is currently being reprocessed at La Hague. If Orano indicates that it has mastered the technology, this reprocessed uranium is currently partly exported to Russia, in the Rosatom plant in Seversk, which ensures its re-enrichment, without this service is a strong dependence for the country since imports could come from other countries, and without the need for enriched reprocessed uranium.

The industrial capacity, interest and economic conditions of a short-term installation of a re-enrichment plant on French soil must be assessed in association with Orano and EDF.

**Proposal 22: study the industrial feasibility and economic options for installing a new re-enrichment plant on French soil in the short term**

Downstream of the cycle, the storage of spent fuel is a key step, which precedes reprocessing or transformation into waste that is then prepared into containers and stored, before its storage planned by the Cigeo project (Industrial Centre) geological disposal) in deep geological layer. This storage takes place first in the nuclear power plants themselves, then in the pools of La Hague.

**There is a risk of saturation of these pools by 2034**; this is why the following are planned:

– **the densification** of the **swimming pools at** the **Orano** – **La Hague site** in compliance with regulatory limits, reducing the size of the current storage baskets with the aim of saving up to 30% additional places[(2)];

(1) *Orano's replies to the rapporteur's questionnaire*

(2) *Orano, C-D-E Orano La Hague swimming pool densification project, March 8, 2022. http://www.hctisn.fr/IMG/pdf/05_2022_03_08_hctisn_projet_de_densification_des_piscines_de_la_hague.pdf .*

– the construction of an **EDF centralised storage pool in La Hague,** whose commissioning is targeted by 2034. It will be dedicated to the storage of spent MOX and ERU fuels(1);

– temporary **dry storage** of sufficiently cooled spent fuel in TN Eagle new generation packaging is being studied.

As the first commissioning of the new EPRs is projected for 2035 at the earliest , it would have little impact on Orano's 2040 capacity projections.

**Proposal 23: Provide all necessary financial and administrative support for the expansion of spent fuel storage capacity in The Hague**

As in any industry, research and development are at the heart of the quality of the nuclear industry, which is constantly improving its production and safety processes. It is also, quite logically, often through research that the proponents of phasing out nuclear power began by asking for the cessation of research, the closure of these facilities, so as not to give perspective to the sector.

Firstly, the rapporteur recalls the need to complete as quickly and efficiently as possible the **Jules Horowitz reactor,** the construction of which is currently being completed on the CEA site in Cadarache. It should, within a few years, be the only European research reactor able to examine the behaviour and in particular the ageing of irradiated materials and fuels: it is therefore a major tool for technological and industrial sovereignty in the context of the probable extension of the service life of reactors and even more so in the context of the construction of new reactors. After numerous time overruns (initially 2013, now 2025) and costs, the year 2023, marked by a progress report with the Government on the preparation of the assembly and the cost at completion in particular, will be a key moment.

**Proposal 24: validate the final steps and ensure State support for the financing of the Jules Horowitz reactor while controlling deadlines and costs**

Secondly, research on new nuclear technologies, in particular the actions to be taken, was the subject of numerous exchanges by the Committee of Inquiry and marked disagreements between the personalities heard, both on multi-recycling. REP only on the 4th generation of nuclear reactors.

(1) *EDF, EDF swimming pool in La Hague, project to build a wet storage facility for spent fuel in La Hague, 7 October 2022. https://www.debatpublic.fr/sites/default/files/2022- 10/EDF%20Piscine%20-%20Enseignements%20de%20la%20concertation%20préalable%20-%20071022.pdf*

Without commenting on the physics underlying each of these technologies, the rapporteur first highlights a few points on which there has been consensus.

Research conducted on the multi-recycling of spent fuel since 2019, or "multi-recycling pressurised water reactors", will only be completed in several years. These could make it possible to recycle spent fuel several times, compared to only one today thanks to "MOX" (*see* Chapter 1) and thus allow even greater material savings. However, they will not provide a new solution to the question of ultimate waste, since ultimately nuclear fission in slow neutron reactors produces minor actinides, or transuranics, which are long-lived high-level waste. In addition, they imply a strengthening of the fuel cycle industry, since today no plant would be able to recycle spent MOX even for a "second round".

To the rapporteur's knowledge and according to the information provided to him, this research on EPR multi-recycling is mainly being carried out in France.

From the hearings conducted, the information transmitted and the work previously carried out by OPECST(1), and in particular in view of the cost/benefit ratio in terms of research and material and the industrial needs relating to a multi-recycled MOX, the rapporteur cannot conclude that there is a need to strengthen ongoing research. It takes up and supports the formulation of the President of the National Commission for the Evaluation of and Studies on the Management of Radioactive Materials and Waste (CNE2) "*we must make a choice, stick to it and not take middle paths that could divert the investments that will have to be made*"(2).

**The 4th generation is a technology and a field of research independent** of this question, in which the main issue **is** that **of** matter, because schematically:

– the use of fast neutrons makes it possible to fission uranium-238, available in nature, without the need for enrichment;

– In addition, the 300,000 tons of so-called depleted uranium, usable in these reactors, are France from enrichment and today simply stored;

– Finally, this technology has the merit of fissioning "transuranics", heavier than uranium, which ordinarily, in the context of fission by slow neutrons, high-activity and long-lived waste, while thanks to the 4th generation, they would become part of the fuel.

— *On the subject* of *investment in MRREP research*, the *rapporteur also refers to the hearing of Mr. Gilles Pijaudier-Cabot, President of the National Commission for the Evaluation of Research and Studies on the Management of Radioactive Materials and Waste (CNE2) heard by OPECST on July 22 2022 and declaring that "multi-recycling does not seem to us to have any interest (...) So we don't really see any significant interest at this stage."*

— *Hearing of Mr Gilles Pijaudier-Cabot, President of the National Commission for the Evaluation of Research and Studies on the Management of Radioactive Materials and Waste (CNE2) by OPECST on 22 July 2022.*

It should be noted, however, that this generation would not completely eradicate the waste, since "fission products" would result from the induced reaction, although these products would have a much shorter lifespan and would therefore not necessarily be subject to the same storage constraints as the current waste that will be stored in a deep geological layer.

It is important to note that several states in the world are engaged in research on 4th generation reactors, mainly sodium coolant: in China, India, Russia and Japan and at the scale industrial in Russia (BN-600 & BN-800). China and Russia signed a new research protocol on this technology in March 2023.

In France, the **shutdown** of the **Superphénix reactor**, then the choice not to launch the construction of the ASTRID demonstrator in 2019 after a decade of research without research on the fuel cycle of 4 th generation is not continued, **generated a considerable delay** while the country was clearly ahead of the technology. **This delay must be made up**, as the 4th generation is a technological breakthrough that meets material and energy production requirements. This can only be achieved by operating concretely, technically and industrially a reactor of this type, of a smaller size which will correspond to economic and financial requirements, in order to be able to prepare the fuel and examine their behaviour during and after the reaction.

**Proposal 25: relaunch the construction of an ASTRID-type demonstrator, of potentially more modest power, to make up for the delay accumulated for 30 years, and continue to develop associated research on the fuel cycle.**

The principle of fission by fast neutrons can be translated into different technologies (sodium coolant, molten salts, lead, etc.) and industrial uses (small, medium or large power reactors), which have different consequences in terms of industrial needs or safety. These are supported by the CEA as part of France 2030 plan, likely to create significant technological emulation, particularly around reactors with various technologies, of small or very small power. It is important, however, that the significant funding released can be directed towards solutions that have at least been able to attest to a certain experimental success and not only "on paper".

**Proposal 26: increase support for technologies related to the 4th nuclear generation, giving priority to companies that are able to present experimental and/or industrial results, and not only numerical simulations**

In any case, given the potential represented by depleted uranium in view of the possible development of these technologies, it is appropriate to initiate a reflection on the classification of this depleted uranium, possibly in strategic stockpile .

### 4. Safety, the keystone of the French nuclear power industry

The French system that ensures the nuclear safety of our facilities is unique in the world, and recognised internationally as one of the most demanding. If its performance is not called into question, it is important today to look at the means at our disposal to make it evolve, so that it can assume the new burden linked to the revival of nuclear power under the best conditions.

In this system, two aspects must be distinguished: firstly, the **safety criteria** themselves, which result from French and international standards. In particular, we have chosen to adopt a **deterministic** method, unlike other states in the world that rely on a probabilistic **method**, such as the United States *via* the NRC (*Nuclear Regulatory Commission*). Our particularly high safety requirements must not be called into question .

On the other hand, the observation is clear and shared by all those interviewed: the current means available to the bodies guaranteeing this safety are largely insufficient to face the challenges of tomorrow, to ensure a large-scale recovery of nuclear power.

That is when the second part of our system must be questioned. In France, the **nuclear safety system** is unique, separating decision-makers, some of the expert instructors, and researchers in bodies independent of each other, first and foremost ASN, IRSN and CEA. **The multiplicity and partial overlap of the missions of these entities, which share certain competences** (expertise within the decision-making authority; research within the expertise), **must be questioned and seriously investigated, typically by OPECST, beyond polemics** in order to optimise the existing system, as it has been with each major evolution of our nuclear strategy and obviously without undermining the quality and accuracy of expertise and decisions relating to nuclear safety.

Indeed, the human needs will be immense to guarantee the recovery, and no construction will be possible without a massive increase in the salaried workforce of these entities. In this context, the **interest of a reorganisation of the current system would be to optimise processes and the free management of resources.**

In any case, our system must not be weakened. Any modification must be preceded by a broad consultation of stakeholders, co-constructed with them, and be the subject of an in-depth impact study.

**<u>Proposal 27: ensure an increase in the number of employees in nuclear safety, by optimising the administrative organisation and by questioning the existing relations to date between the various nuclear safety bodies, in order to assume the new burden linked to the revival of nuclear power.</u>**

## C. DEVELOPING RENEWABLE ENERGIES FROM THE POINT OF VIEW OF ENERGY EFFICIENCY

In the gap that separates us from the 2035/2040 horizon and the objectives and commitments we have set ourselves in terms of energy and climate (reduction of energy consumption and GHG emissions) and faced with the anticipation of the increase in electricity demand, **the only sustainable and responsible solution is to develop carbon-free electricity** production as **quickly as possible**. and in particular renewable.

The deployment of renewable energies must be anticipated and evaluated according to the parameters specific to each installation – data that is lacking at the macro level.

**The industrial, economic and energy parameters** of each energy, depending on its installation and location, in the short term and in the long term must be evaluated. It is therefore necessary not only to measure the **energy yield and production and the intermittency** of each installation at the time of **its installation** but also to do so **over a longer period** of time, in order to measure the effects of climate change on these parameters.

These assessments must also consider the balance of the electricity network, integrate and **target the investments necessary to adapt the infrastructure** (geographical location, capacity to support the increase in flows on the network) and **measure the cost related to the targeted facilities**, their operation (maintenance and availability of parts and materials) and **their dismantling**. They will have to involve the actors of the sector (RTE, EDF, etc.), will be able to follow on from RTE's first work on the subject (see Future Energy 2050 report) and intervene upstream of the next LPEC.

The environmental and landscape parameters of each installation must be considered insofar as the deployment of the installations requires land consumption, which competes with that of other installations. sectors (housing, agriculture, industry), and can affect landscapes as well as biodiversity. These consequences regularly generate reluctance on the part of local residents who must be taken into account and successfully mitigated.

This evaluation of renewable electrical energies, by energy source, by installation and by territory, must take into account the pace of deployment planned by the PPE and the specificities related to each sector (*see* Chapter 1).

Among other uncertainties, the deployment of **hydropower** is confronted with legal **uncertainties** related to the concession regime and competitive tendering (cf. *proposal (9*). The development of knowledge on both the improvement of the potential of existing and small hydropower would also make it possible to effectively target the investments to be made.

**Proposal 28: ask RTE for an in-depth analysis, based on renewable energy, integrating their potential, their energy and economic profitability (calculations of average, minimised intermittency, acceptability, land consumption, longevity)**

More specifically, the deployment of **offshore wind installations**, which combines a relative proliferation and therefore a limitation of the load factor, as well as an industrial involvement in line with the development of the sector requires a common progression in terms of **planning of locations.**

Offshore wind power, and especially floating **offshore wind turbines**, is a start-up sector with significant potential, for which territorial **planning** of installed or floating installations is already examinable – The possible locations are already known and strictly limited. It must be accompanied by long-term work to stabilise the sector, while the objective of 50 wind farms has been announced. This support may take the form of a **reinforcement of financial guarantees** with the inclusion, in calls **for tenders**, of a **condition** of commitment of the **project owner** at the time of submission of his tender or during the contract with the supplier, as well as a particular attention paid to the carbon footprint of the projects and therefore their possible European or French origin. The deployment of wind installations must be based on a sector in which it is necessary to invest in terms of skills and production.

**Proposal 29: launch calls for tenders for the 50 offshore wind farms as soon as possible, make their installation binding and secure the financing and commitment of the project owner**

## D. PUTTING SKILLS BACK AT THE HEART OF THE STRATEGY

Finally, we have already been confronted with it in recent months, and we know that we may again encounter **recruitment difficulties** in the years to come, in all the sectors necessary to increase our production of carbon-free energy, renewable or nuclear energies.

It is therefore necessary to continue the efforts undertaken by the University of Nuclear Professions, the creation of specialised schools or the establishment of scholarships, to attract young people to **the professions of carbon-free** energy, not only production **but also energy renovation.**

To achieve this objective, we need to combine the general measures that have already been put in place or initiated by the Government, such as the **reforms of apprenticeships and vocational schools**, with targeted measures in the energy field, a source of good health for our entire economy.

To this end, it is necessary to enhance existing training in the field of energy, for example through a contract between the State, the regions and craftsmen, operators and builders. The establishment of a **label "Energy apprentices",** which would bring together all training, from welding to engineering, would allow young people to move towards easily identifiable training courses of the future.

This certification must be accompanied by facilities so that everyone can access these training courses in the best conditions. To ensure their attractiveness, it is necessary to remove the most frequent obstacles faced by students, and which guide their professional orientations in spite of themselves.

Thus, particularly when training is delivered near energy production sites, outside metropolises, two main limiting factors exist: mobility and housing. It is on these levers that it is necessary to offer facilities to high schools, apprentices or students, to give them equal access to these training courses of the future, which will have positive consequences in terms of employment, and will allow our country to succeed in its energy and ecological transition. While the resources deployed to date, for example with regard to the costs of new nuclear power, are particularly low, it is necessary to change the budgetary scale and to launch scholarships based on merit criteria to make energy sectors a sector of social advancement.

**Proposal 30: create an "energy apprentices" label to enable young people to identify the training of the future, associated with financial aid, mobility and housing facilities.**

## CONSIDERATION IN COMMITTEE

**President Raphaël Schellenberger.** We are coming to the end of our work. During these six months, we held 88 hearings and worked 150 hours in committee; More than 5 000 pages of contributions have been analysed by the rapporteur.

I thank him and all the members of the Committee of Inquiry for the quality of our exchanges and the atmosphere in which we worked. I am grateful for your assiduity at a time when the parliamentary agenda is made up of contradictory injunctions. At a time when Parliament is being looked at critically, this approach can restore the image of our house.

I would also like to thank the officers of the National Assembly who accompanied our work. We can be pleased to have a parliamentary civil service of this quality.

I also thank the personalities who responded to our invitation, whether they come from the industrial, scientific or administrative world, as well as, of course, the two former Presidents of the Republic who appeared before us when this is not the custom under the Fifth Republic. Their hearings are not the most technical we have conducted, but they have helped to contextualise the framework of energy decisions and to show that this strategic subject is dealt with at the highest level of the State.

The context in which we worked was particular: a very tense situation in Europe following the war in Ukraine; the responsiveness of French actors to it, despite the difficulties of our nuclear power plants; the social movements mainly related to the pension reform, which did not, however, disturb our hearings; concurrent parliamentary work on energy issues, with two draft laws and the Government's statement on energy policy.

Our work was thus at the heart of the news, and it was particularly followed. I am convinced that they have already made it possible to move some lines. I hope that what we are about to discuss will leave a trace and serve as a guide for future decisions.

I, who have not always been a fervent supporter of greater transparency, which risks encouraging people to do theatre rather than work, I note that the publicity of our work and its live broadcasting have not made us fall into this trap. This seriousness has allowed them to be particularly noticed, both in the political and energy world.

Once again, I thank the rapporteur for the quality of his work, but also for the good relations we have had.

**Mr Antoine Armand, rapporteur.** I welcome the initiative of the Les Républicains Group, which has called for the creation of this Committee of Inquiry. It has indeed had a particular echo because of the context. While a potential crisis cannot be welcomed, we can rejoice in the fact that current events have brought to light such a crucial subject, which has often gone under the radar.

I thank the President for the way in which he has animated our debates, sometimes very late at night or for hours. Everyone, including the rapporteur, was able to ask all their questions and we were able to interact with the people interviewed – which is quite rare – to ask them for confirmation or an answer to a forgotten question.

I, too, would like to thank all the services of the House. That does not prevent me from taking responsibility for every line of the report. Some of the politicians we interviewed referred to their former chief of staff, senior civil servants or administrators to try to justify this or that decision, but it is to the credit of politicians to assume their responsibilities, however essential the support they receive.

The report reflects the hearings as much as possible, incorporating the subjects raised spontaneously by the members of the Committee of Inquiry. It is also based on the nearly 5,000 pages of documents that have been sent to me. We have also integrated themes that are rarely addressed during our work because of the people interviewed and the initial purpose of the Committee of Inquiry: dependence on fossil fuels, energy sobriety, efficiency. The fact that certain topics, such as non-electric renewable energies, appear very little in the hearings and in the documents transmitted is in itself symptomatic of the way in which energy policies have been constructed. For decades: by focusing on an electric mix, which is also very decarbonised.

Among the documents sent to us, we received earlier this week the two declassified reports we had requested: the "Roussely report" of 2010 – which does not bring anything new compared to the public synthesis we already had – and the "Escatha-Collet-Billon report" of 2018 – which was classified as confidential-defense, was sent to me in a very redacted version because of the interweaving of civilian and military and is difficult to exploit, knowing that the conclusions that emerge correspond exactly to what had leaked in the press about the idea of building a new pair of reactors and the importance of taking into account the state of the fleet.

We have collected all the hearings and documents received to draw up an inventory that relies as much as possible on data. The first step is to define the terms of energy independence and sovereignty to avoid all myth on this subject: if we can and must aim for energy sovereignty understood as the reduction of dependencies, vulnerabilities and the ability to insert the French model into a European and international framework, there is no question of dreaming of magical self-sufficiency. We use the example of Norway, Estonia and the United States to show that countries with very high energy independence rates do not have a desirable or replicable model in France.

This does not preclude the need to work on the issue of sovereignty. It is therefore through this prism that we then try to describe the different types of energy production – and not just electricity – in France, indicating for each the volumes of production, the sources of vulnerability, the progress and the history, but also the industrial aspects, because all energy production calls for an industrial foundation for the model to endure and achieve its objectives – this is one of our main conclusions.

This is also why I chose to talk about the delay in energy sovereignty, rather than the loss of a sovereignty that we would have held and that would have only deteriorated over the decades, which none of the figures and facts do not attest to this. What we see is that year after year, at each milestone, each crossing point, we fall a little behind in terms of energy sobriety and efficiency, decarbonisation vis-à-vis fossil fuels, energies thermal renewables, then electric renewables, and also with regard to nuclear power. It is this set that creates the accumulated delay.

The second part of the report gives an account, as faithful as possible to the hearings, of what we have witnessed. The first fifteen years considered appear to be a latency period during which many things could and should have been done, which would have prevented us from being in a hurry. This is the post-Fukushima decade, where the questions of renewable energies electric and nuclear energy are raised. The much-talked about 2015 law is just one episode of it. The big delay we are taking then concerns less nuclear than electric renewables. Public policies indicate that we will gradually phase out nuclear power and develop these energies, but we are not in a position to deploy them. This is a real problem for sovereignty and for security of supply.

With regard to the following decade, I have made three formal but substantive changes to the version of the report that you have been able to consult. It is a question of "hardening" the observation on three points: to regret the decision to close Fessenheim and its method; to point out that the abandonment, after Astrid, of any form of research on the fourth generation – according to the documents received from the CEA (French Alternative Energies and Atomic Energy Commission) –, in favour of multi-recycling which does not have the same properties, seems problematic to me; to underline the urgency of reforming the European market, since the years 2016-2018 and even more so in the recent period – it is when prices rise that we see the dysfunctions of this market and that companies like EDF are most affected.

If we present these errors, it is not to point out individual responsibilities, which would distract us from the essential: it is in the long term that the process takes place; the errors are cumulated, combined and multiple and emanate from companies, public authorities and the sector.

We are putting forward some thirty proposals, which are based on a central idea: to put Parliament back at the centre of political decision-making on energy, because it is through a parliamentary decision that we have the best chance of building consensus in the long term, which is the most likely to be essential so as not to call our main guidelines into question every five or seven years. In this respect, institutional proposals are being made, but it is the responsibility of each of us to take up the subject in order to bring this debate to life in Parliament.

This is followed by more sectoral proposals, by energy sector, before skills are discussed. In recent months we have had lively debates on energy renovation, renewable energies and nuclear power; Each time, this question comes up like a litany. How to train, how to attract young people to these professions, how to allow people who work in these sectors to progress in their careers? This is essential for an industrial policy.

We proceeded with great caution. In the report, all positions are substantiated and sourced; when they are not, it is because they emanate from a document that has been sent to me – otherwise I specify it, not to fault anyone but to establish this lack of data. For example, until the years 2016 to 2018, there is no visible trace year by year of the impact of the Arenh (regulated access to historic nuclear electricity) in EDF's accounts. This does not mean that this impact does not exist, simply that EDF has not been able to transmit a document to this effect. My responsibility as rapporteur was not to write that the Arenh – a device that I also criticise extensively – has always been a cost for EDF, but to indicate that statements to this effect have not been supported by documents.

**Ms Olga Givernet (RE).** Thank you to the chairman, the rapporteur and all those who have participated in this long-term work, which has made it possible to link different points, to restore context and to shed light on grey areas. Some directions that have not been taken in the past deserve to be brought up to date. The proposals put forward are forward-looking.

The report is a reference document for future decisions and for the next multiannual energy programming. The media coverage of our work bears witness to this.

There is a striking contrast between the speed of implementation of energy policies at their very beginning, in the twentieth century, and the doubts and obstacles that their deployment has increasingly encountered; this must be addressed as soon as possible.

**Ms Natalia Pouzyreff (RE).** I salute a colossal and remarkable piece of work. The hearings fascinated all French people who are interested in energy issues and who are eagerly awaiting the report.

What will you say about the electricity mix in the summary of the report? The result is a huge mess. Is it the decision-making process that you will insist on?

I note some very firm proposals, such as the immediate cessation of the Arenh.

Regarding Astrid, it seems to me that one element is missing: if we wanted to continue on this path, we had to create a complete upstream and downstream fuel sector, including waste treatment. It was not just a question of running a reactor, but of guaranteeing a whole cycle, at a time when we wanted to stabilise other aspects of the system.

One point that interested me a lot when we heard the representatives of the BRGM (Bureau de recherches géologiques et minières) was the scarcity of certain materials and the need to secure strategic supplies at European level. I did not find it in your proposals, but perhaps it will be included in the synthesis.

**Mr. Maxime Laisney (LFI-NUPES).** I, too, welcome the amount of work that has been done. I regret that the hearings were held at the same time as the examination of two pieces of energy legislation.

Our work has shown the importance of transparency and democracy, particularly with regard to nuclear power, which is, however, only one aspect of energy issues. Sovereignty is first and foremost popular sovereignty. We must involve not only the representatives of the nation, as you said, rapporteur, but all our fellow citizens.

Independence from fossil fuels has been discussed, but perhaps not enough.

We worked on the notions of independence and sovereignty, but the interviewees instead insisted on the need to reduce vulnerability and on the fact that true sovereignty results in our ability to make independent and informed choices.

We agree with the report on several points: the need to take into account the long time to make forecasts and plan; the virulent criticism of the Arenh and the Nome law; the proposal for a quasi-public authority for dams; the observation of a lack of anticipation on the part of the nuclear industry.

Regarding this last point, there is still a corpse in the closet: even though the film *La Syndicaliste* was released recently, at no time was it said that if the sector is in difficulty, it is not the fact of environmental activists but because at the time when Mr. Oursel headed Areva and M. Proglio EDF, there would have been an agreement with the Chinese, denounced by Mrs. Maureen Kearney – the famous trade unionist, which earned her to suffer what we know – and confirmed today by the facts. It is a pity that this major element does not appear anywhere.

We also agree with you about the delay in renewable energies, due to a lack of political will, as evidenced in particular by the moratorium on photovoltaics in 2010, and to insist on sobriety.

Some discrepancies all the same.

We are in favour of suspending the Arenh, but on condition that we immediately return to the regulated sales tariff, otherwise the bills will explode.

Entrusting energy to the Ministry of Industry rather than the Ministry of Ecology, even if we understand the idea – we have heard several times that "energy is the industry of industry" – would not be a good signal.

Regarding the problems of stress corrosion, the difficulties in building the EPR (European pressurised reactor) and the EPR 2, the fact that SMRs (small modular reactors) exist only at the prototype stage and the difficulties of Flamanville, it is strange to ask for reports when we have just vote on an acceleration bill. This is turning things upside down – but the problem is posed by Government policy rather than by this report.

With regard to uranium supplies, you say little about Russia, whereas, during our work, Greenpeace published a report showing that we are 40% dependent on uranium transiting through that country.

I am surprised that the merger between IRSN (Institute for Radiological Protection and Nuclear Safety) and ASN (Nuclear Safety Authority) is included in the recommendations, although it was not discussed during the hearings.

Finally, I found nothing in the report on the difficulty for nuclear power to meet the challenge of climate change in view of the delay involved in the possible construction of new plants.

It is important that the draft programming law on energy and climate – I hope we can discuss this – puts all scenarios on the table, including 100% renewables.

As far as the European market is concerned, it is possible to get out of market mechanisms, firstly because the treaties allow it, secondly because it does not pose any technical difficulties – we will remain interconnected with neighbouring countries.

EDF must be nationalised and have the status of Epic (public industrial and commercial establishment), and the Hercule project or its equivalents must be abandoned.

We are making an innovative proposal, which has not been rejected by Mr. Percebois when we heard him: the creation of a single, public purchaser of electricity, to pay for it at the cost of production and resell it at reasonable costs, by implementing regulated tariffs of Selling for everyone – homes, communities and businesses.

It would even take a large public energy pole, focused on the objective of energy transition, to face the electrification of uses, reindustrialisation and the fight against climate change – which presupposes sobriety, as opposed to market mechanisms and competition.

We will vote against the publication of the report, not because it is bad, because the Committee would not have worked or to position us in accordance with what you expected of us, but for this set of reasons.

**Ms. Marie-Noëlle Battistel (SOC).** It is my turn to thank you, Mr President, for having taken the initiative of this Committee of Inquiry with your group. It has allowed even those of us who have been interested in the energy sector for a long time to clarify a number of points and to look a little differently at a number of things.

I am very pleased that the temporal scope of our work has been broadened compared to what was originally envisaged. This allowed us to look at three decades and to measure that the responsibilities – if there are responsibilities – are multiple, cumulative and do not concern only a particular period.

Overall, the report shows that the delays we are experiencing are the result of successive decisions taken during the various presidential terms.

First of all, there is a lack of anticipation regarding the renewal or extension of nuclear power plants – which every government knew are not eternal.

Then there is inertia in the development of renewable energies. Beyond the various turns that have been taken, it is the lack of collective will to develop industrial sectors in this field that stands out.

The transposition by the Nome law of the European directives relating to the opening of the market to competition and the Arenh have weakened our model and hampered EDF's investment capacities.

You said, rapporteur, that no one had been able to provide you with precise information on the consequences of ARENH for EDF. Nevertheless, they can be considered extremely unfavourable from 2019 onwards.

**Mr Antoine Armand, rapporteur.** That is stated in the report.

**Ms. Marie-Noëlle Battistel (SOC).** Previously, its consequences were limited by the level of electricity prices.

**President Raphaël Schellenberger.** That is what the report describes.

**Ms. Marie-Noëlle Battistel (SOC).** The report mentions without too much emphasis the war between EDF and Areva – perhaps because it was not mentioned much during the hearings and we hardly asked questions on this point. It has caused internal disorder that has weakened confidence in the sector.

As far as the proposals are concerned, we must collectively learn from the exercise we have carried out to make more informed energy policy decisions in the future. This is the case, for example, for the issue of water, which is too little addressed in a general way in the debate while it will directly affect nuclear power and hydroelectric production.

It is also necessary to propose to diversify the energy supply as much as possible, so as not to be weakened by the consequences of a failure in a sector – which we have experienced recently.

I find that the proposals go far beyond the usual frameworks, apart from the one that provides for suspending the Arenh pending the reform of the European electricity market. Many of the proposals are linked to texts under discussion and to come. From this point of view, I am a little reassured that you speak of the draft programming law on energy and climate as a project that is still real.

**Ms. Julie Laernoes (Écolo-NUPES).** I will be voting against this report because I find it very biased and biased. It does not reflect the richness of the work and debates.

It is not illogical to draw different conclusions from the hearings, but it seems that we have not always heard the same arguments. This is particularly striking in the second part of the report and in the proposals. Some sentences give the impression of having the function of justifying the energy policy of Mr. Emmanuel Macron and the Government, which was not the initial objective of the resolution that is at the origin of the creation of this Commission of Inquiry.

Some proposals are not substantiated. The Jules-Horowitz nuclear research reactor project is one of the proposals, but it seems to me that it was not mentioned during the hearings. In addition, the CEA explained why it had abandoned research on the fourth generation in favor of multi-recycling; It is astonishing that the report proposes the opposite.

While the period we have studied has been extended, it has not been possible to open up reflection on the reasons for the loss of energy sovereignty. The report talks about this half-heartedly. The systematic attempt to discredit the scenario of a switch to 100% renewable energy is not appropriate – in any case, it does not reflect either the research carried out on this subject or, in my view, the hearings, most of which were devoted to nuclear energy. Energy sobriety and efficiency have been very little addressed during our work. It took a great deal of insistence at the Bureau meetings to devote more time to it, in particular by hearing Mr Yves Marignac.

The report contains a number of untruths and contradictions.

**Mr Antoine Armand, rapporteur.** Which ones?

**Ms. Julie Laernoes (Écolo-NUPES).** It clearly confuses the scope of the Committee of Inquiry with that of the discussions on the draft law on the acceleration of procedures related to the construction of new nuclear installations. This is the case, for example, with regard to the merger of ASN and IRSN. This subject was certainly raised during the hearings, but above all it gave rise to a battle between the rapporteur and Mrs Barbara Pompili. At that time, we were considering the bill on speeding up procedures for nuclear installations. It is a pity that we did not wait for the conclusions of this Committee of Inquiry to debate them.

The report gives the impression of serving a *posteriori* as a guarantee to the energy policy led by Mr. Emmanuel Macron since 2017 – knowing that it was the subject of a fairly clear reversal at the end of the previous five-year term.

Not everything is to be thrown away. I learned a lot from the hearings, which gave rise to rich debates. They are not reflected in the report, which unfortunately forms part of a political perspective of justification. It would have been possible to do otherwise thanks to the material provided by the hearings.

Their dissemination was desirable and it enabled this Committee of Inquiry to be useful, even if I do not agree with the conclusions of the report.

**Mr. Francis Dubois (LR).** I have participated in a very large number of auditions. Leaving aside one's political preferences and considering the general interest and that of the nation, the report reflects the hearings very well. It is of great quality; I consulted him twice.

The proposal to suspend the Arenh is extremely important, particularly in order to obtain a reform of the European market that makes it possible to decouple the price of electricity from the price of gas.

The report also includes some very interesting proposals for the renewal of hydroelectric concessions.

I regret not having been able to ask all the questions I wanted to President François Hollande – whom I know well because I am a member of parliament for Corrèze. But his hearing took place when the Government's commitment to responsibility was announced.

If we want to restore our energy sovereignty, we should put more emphasis in the proposals on the need to set the energy mix in stone. The 2015 law slowed us down – but everyone can have their own opinion about its consequences. To project oneself into the future, one must propose something that holds. And all the more so since the nuclear industry is part of a particularly long time. The report clearly shows that by 2050 electricity consumption will be much higher.

I also regret that no chairman of EDF has been able to tell us precisely the cost of Arenh for this company. The report mentions an amount of 9 billion for the year 2022 alone. When I asked Mr. Luc Rémont, he replied that the calculations had not yet been done. He has certainly been in office for a short time, but I find it desperate that EDF has not been able to give us the annual cost of the Arenh since its establishment.

It would have been preferable to pass a law on energy in general rather than one on accelerating the production of renewable energies. And I agree that we should have waited for the conclusions of this Committee of Inquiry to define the energy mix combining nuclear and renewable energies – including hydroelectric energy.

With regard to hydroelectric concessions, the conditions for the application of the quasi-governance system deserve to be specified.

**Mr. Vincent Descoeur (LR).** I chaired the fact-finding mission on the thermal renovation of buildings, for which Mrs Meynier-Millefert was the rapporteur. I am pleased that Proposal No 12 raises the question of the effectiveness of the measures for this renovation. The report questions the resources devoted to it in view of the disappointing results, and rightly points out that energy gains are evaluated but not measured.

Personally, I very much welcome Proposal No 9, which provides for hydroelectric concessions to remain in the public domain. In my opinion, this is essential and I welcome the fact that the report reaffirms their strategic nature by referring to the quasi-governance system.

**Ms Marjolaine Meynier-Millefert (RE).** This report is going to be a reference, not least because it puts an end to the illusion of energy independence, the definition of which would in fact be closer to that of autarky. This idea hovered a little at the beginning of our work. She was quickly evacuated and that's fine.

Although I was unfortunately not able to attend many auditions, I did follow them with great assiduity – like many French people. They were really appreciated and many people in my riding told me about it. This Committee of Inquiry was therefore welcome.

I would particularly like to thank you for extending our work, even modestly, to the issue of renewable thermal energies and the issues of energy sobriety and efficiency.

The purpose of this commission was to trace the happy and unfortunate history of nuclear power in recent years. But it would take another Commission of Inquiry to write that of the thermal insulation of buildings in France since the seventies.

Buildings consume half of the final energy in our country. The rapporteur indicated that the habitat represents 486 terawatt hours. But if we take into account the tertiary sector, this is 700 terawatt hours, twice the output of the nuclear fleet when it works well.

We should have set ambitious energy sobriety objectives as early as the 1970s, by putting in place a real thermal regulation – which was done in other countries. As noted in a report by the High Council for Climate, our climate regulation only reached the level of performance required in Sweden in the 1970s in 2012.

Energy sovereignty cannot be achieved if we waste the energy we need in buildings. Half of the energy needs are related to the need for heating. We will miss the target if we try to meet this need only through electricity generation. One of the challenges of the energy mix is to require high energy efficiency from buildings and to increase the use of renewable thermal energies.

I would therefore like to thank you for the proposals to increase the Heat Fund and to work towards improving the energy efficiency of buildings.

**Mr. Jean-Philippe Tanguy (RN).** I will not prolong the suspense unnecessarily: we will vote in favour of this report.

On behalf of my group, I would first of all like to thank the chairman, the rapporteur, the administration and all the political forces that have participated in our work.

I welcome the very high quality of this report, including in its drafting: its more than 400 pages are well written, accessible to all, which is rare enough to be highlighted. The high quality of the illustrations also contributes to the understanding of the report by all: this is all the more important as our work is not intended for ourselves, but for the outside.

I also welcome the working method chosen by the President. I say this all the more willingly because I was initially worried, since the National Rally group was not associated with the bureau of the Committee of Inquiry. I recognise that this did not affect the smooth running of the hearings and that the directions taken were the right ones. You listened to all the groups, including those that were not represented in the office. You yourself were no doubt able to appreciate that all the political forces participated in this commission with the desire to work well, and not to make films. The quality of our work also depends on the freedom of speech that you have given us and the time that has been given to us, in particular to myself and to the members of the National Rally who have sometimes been talkative – these are subjects that interest us. Everyone was able to express the true substance of his thoughts, his reflections, without postures or caricatures. It has allowed us to move forward. My political group believes that the truth always comes from debate. Obviously, I do not agree with all the analyses and conclusions of the report. This does not prevent this document from being founded in fact and reason.

This method deserves to be used again on substantive issues that span several decades and necessarily concern, because of democratic alternation, several different majorities. Political polemics and partisan posturing have no interest, especially on scientific subjects. In this respect, I welcome the promotion of the Parliamentary Office for the Assessment of Scientific and Technological Options (Opecst). If we had read the proceedings of this parliamentary body, we would not be where we are today.

I am pleased that you went back to the mid-1990s, which not only allowed you to analyse the nuclear cycle over time, as we had advocated, but also avoided being accused of producing a partisan report or settling scores, which would have been of no interest.

Allow me to alert you, rapporteur, to the two pages of introductory remarks of Title III that you named as follows: "Since 2017, the priority given to carbon neutrality and, recently, a revival of nuclear power, both of which remain to be implemented." Your writing is free, but I am afraid that these two pages are not of the same quality and do not show the same neutrality as the rest of the report. It's a shame because you know the media phenomenon like me: I fear that some will use this passage to accuse you of having wanted to save Mr. Macron's record.

Another regret of our group, perhaps related to the separation of powers and the limits of Committees of Inquiry, is that Mr Macron is not mentioned as a former economy minister – I could be wrong, however, because I had to read the 400 pages of the report in four hours. During the five-year term of Mr. François Hollande, Emmanuel Macron played a role that should not be ignored.

Like Mrs Battistel, I believe that we have not put enough emphasis on the internal wars of the oligarchy, the big bodies, the elites who all know each other and remain very concentrated in France – this certainly has advantages, but also disadvantages. This regret is linked to one of the disagreements I have with the Committee: in my opinion, the notion of responsibility needs to be more asserted, whether it is that of politicians or that of certain experts and senior officials. During his hearing, Mr Montebourg stressed the need to set up a *spoil system*. It is even an ardent necessity: politicians must have the possibility of excluding, without being perceived as an abuse of rights, senior civil servants, members of major bodies or personalities who exert structural influence that could become toxic to the state they are supposed to serve. No one is perfect, no one is unassailable, not even great bodies. That is the basis of our democracy.

Another of our disagreements concerns the European treaties and the role played by Germany. While the latter is obviously an allied power and a strategic partner, the fact remains that several very different personalities interviewed described it as a hostile, or at least aggressive, power in the field of energy policy. Just because Germany is a friend doesn't mean we can't have deep disagreements with it. A friend may wish you good, but sometimes also, unconsciously, bad.

The report highlights that our country has focused too much on the debate around nuclear power, to the detriment of the exit from fossil fuels. It makes me happy because that's what I've been saying for twenty years without interest anyone! In my opinion, we need to think more about the different perspectives that will really get out of fossil fuels. This goes back to the question of how difficult it is to take technological bets. While we have already lost thirty years, we can no longer afford to make technological bets that call into question the reindustrialisation of France and the ability of our country and the major industrial powers to succeed in the energy transition. Otherwise, we will be heading for disaster: the latest report of the Intergovernmental Panel on Climate Change (IPCC) is alarming, and no one here wants to leave their children or nephews and nieces a world where the average temperature would have increased by four degrees. The technological bets on sobriety, on energy efficiency or on the 16% of supplementary energies mentioned in the RTE (Réseau de Transport d'Électricité) report, which we still do not know what they correspond to, are dangerous, and we cannot allow them to be lost. Yet this is what has happened in the last thirty years, especially on the German side. Only the nuclear bet made under the Messmer plan has been successful.

The hearings we conducted highlighted the difficulties encountered in terms of mastering skills and mastering the sector, which are very well described in the report and correspond to vital issues. However, the load and training plans adopted today suggest a risk of a new nuclear low, which would be all the more damaging as the level of cooperation in Europe, the West or with countries such as India is low.

It is perhaps paradoxical that it is we who are discussing this issue, but here I want to throw a bottle into the sea: the National Rally will not oppose European or international cooperation on nuclear matters because this subject is too important to make nationalism or chauvinism "with two bullets ". I regret that the hand I have already extended several times has not been grasped.

There are still two major issues on which we disagree or ask questions.

The first concerns the closure of Fessenheim. Contrary to what you may think, I came to this Committee of Inquiry thinking that it was too late. The hearings rather contradicted my intuition: it is certainly too late to reopen the plant for fifty years, but it is possible to use it for something else – to make it a laboratory or a hydrogen or heat plant, for example. I come back to the *spoil system*: the Fessenheim affair shows a caricature of the pride of large bodies and public decision-makers who refuse to acknowledge that they were wrong, because the State can never be wrong! We have two high-quality industrial tools, which are worth several billion euros: throwing them in the trash while we are in trouble in terms of energy transition is a responsibility that I would never take and that no one should take.

Finally, with regard to cogeneration, I do not understand why this technology, which opens up considerable prospects, particularly in the tertiary sector and housing, is not being encouraged more, whereas the hearings have rather gone in this direction. The rapporteur himself has said several times publicly, including in the Chamber, that he was not a technological dead end. There is a huge pipeline to be launched, but it again requires transpartisan action, based on facts and reason.

**Ms. Julie Laernoes (Écolo-NUPES).** I may have read the report too quickly, but I did not see the subject of subcontracting mentioned, either in the description of the difficulties of the sector, or in the recommendations. However, this issue was widely discussed during the hearings.

**Mr Antoine Armand, rapporteur.** Mr Tanguy, I will revisit the wording of the two pages you mentioned.

You raised the issue of the accountability of senior officials. As I said in my introduction, I am quite convinced that it is important to leave full responsibility for decisions to politicians. This means allowing the latter to replace civil servants if they consider that they are unable to respond to the political order. We must not give the impression that there is some kind of state that would manage things instead of politics; If this is the case, it is a fault of politicians not to take the reins.

I have taken note of your comments on cogeneration.

It is true that a number of people interviewed spoke rather virulently about Germany. They have expressed accusations of intent that may be fair, but that I have not been able to substantiate. I have therefore applied a precautionary principle.

Mr. Descoeur and Mr. Dubois, the debate on hydroelectricity has been intense. My recommendations do not exhaust the subject. A bill was passed by the Senate. It is necessary to reflect not only on the status of this energy, but also on production capacities.

Mrs Givernet, Mrs Meynier-Millefert, Mrs Pouzyreff, and Mrs Battistel, it is important to agree that successive decisions have led to the current situation. It is a political imperative: we would really get away with it cheaply if we put the blame on one or the other majority. Moreover, it could give the impression that we are clearing all the other politicians, whereas when it comes to sobriety, nuclear power and renewable energies, it is clear that everyone has unfortunately contributed to the current situation – even if we must beware of anachronisms. I retain the idea of an electricity and energy mix. I will highlight renewable thermal energies in the presentation of the report.

Mrs Battistel, the question of the Arenh is dealt with at length in the various subsections of the second part of the report. I can redirect you directly to some specific points.

Mr Laisney, it seems to me that we are talking in a rather harsh and unpleasant way, in the middle of the second part of the report, about the sectoral issues concerning EDF and Areva, but it is true that this subject has not come up again at the top of the list of recommendations. However, I have heard that you have asked for a Commission of Inquiry to be set up on this matter, so you will have plenty of time to look into it.

**Mr. Maxime Laisney (LFI-NUPES).** We will have to support our request so that it can succeed!

**Mr Antoine Armand, rapporteur.** In this case, I am not sure that a case of industrial espionage or an economic intelligence problem between France and China has a direct link with our country's energy production or saving capabilities. The current situation can be explained by many other industrial reasons. If I decided to exclude this subject from the report, it was not out of ideology, but for lack of sufficient information or time, since the issue was raised a little late during the hearings.

I criticised the introduction of a moratorium on photovoltaics, but I did not want to go any further because there is nothing to say that the curve of the development of photovoltaic installations has changed after this three-month moratorium.

**Mr. Maxime Laisney (LFI-NUPES).** I said I agreed with you on that.

**Mr Antoine Armand, rapporteur.** At the time for me.

One of our recommendations is to ask EDF for full transparency compatible with commercial secrecy on uranium supplies. The debates on this subject have been quite heated, but in reality somewhat ethereal because the existing sources are neither very reliable nor concordant. We need reliable enough data to discuss in full transparency. The same is true, moreover, with regard to water and the impact of climate change on the operation of nuclear power plants.

Mrs Laernoes, almost all the CEA officials were interviewed on the Jules-Horowitz project, which is also mentioned in almost all the documents they sent us.

Only two or three interviewees spoke favorably about multi-recycling in pressurised water reactors (PWRs) – a subject addressed by many of our guests and in a large amount of documents provided by former CEA officials. You will see that, in my conclusions and recommendations, I wonder about the arguments expressed. Multi-recycling and fourth generation are not of the same order. One may prefer one or the other, but it is not accurate to say that multi-recycling prepares the fourth generation.

You accused me of having modelled the recommendations of the Committee of Inquiry on the texts under examination. However, we began our work three months before the adoption, at first reading, of the draft law on the acceleration of the production of renewable energies, while we are finishing it after the adoption of the draft law on the acceleration of procedures related to the construction of new energies nuclear facilities in the vicinity of existing nuclear sites and the operation of existing facilities. We have studied thirty years of energy policy. The report includes institutional proposals, mix proposals, industrial proposals, proposals on skills. This accusation seems to me to be guided by other concerns.

I will not answer your question about the untruths contained in this report, since you did not mention any of them. I am obviously prepared to remove any error, inaccuracy or falsehood. At this point, however, we haven't detected any very visible ones!

**President Raphaël Schellenberger.** Ladies and gentlemen, I would like to clarify a few points of order. After the vote on the report, our rapporteur will be responsible for tabling it on the desk of the President of the National Assembly, which he will certainly do in the next few hours or half-days. Some editorial corrections still need to be made, but there will be no substantive changes.

Once the report has been tabled, no later than six months after the Committee of Inquiry has been set up, the Rules of Procedure of this House impose five clear days of secrecy on us. Although the report does not contain any classified information, it cannot be published before the expiry of this deadline, which could occur around Thursday 6 April at noon. Since everything has gone very well since the beginning of our work, I have no doubt that we will be silent on this report until that date.

**Ms. Marie-Noëlle Battistel (SOC).** When will we be able to submit contributions?

**President Raphaël Schellenberger.** From now until 5 April. These contributions, which will be annexed to the report, are free and may take any format.

**Mr. Maxime Laisney (LFI-NUPES).** Will the publication of the report lead to a press conference?

**President Raphaël Schellenberger.** We will try to organise one next Thursday, but everything will of course depend on the precise date on which the rapporteur tables his report.

*The committee* ***shall adopt*** *the report and* ***authorize*** *its publication.*

# CONTRIBUTIONS FROM POLITICAL GROUPS AND MEMBERS

## CONTRIBUTION BY MS OLGA GIVERNET, DEPUTY VICE-PRESIDENT OF THE RENAISSANCE GROUP

Contribution of MP Olga Givernet, Vice-Chair April 5, 2023

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As a preliminary point, I would like to pay tribute to the very good organisation of the work of the Committee of Inquiry by its Chairman and its Rapporteur. In a limited time, we were able to hear all the main decision-makers, politicians, scientists and industrialists of French energy policy in recent decades, as well as competent experts and observers. This report is based on a synthesis and factual, methodical, rigorous and thorough analysis. There is no doubt that it will be a reference in determining future energy policies.

In addition, I would like to make three points.

### 1) French energy sovereignty, victim of an electoral arrangement

If France was afraid of running out of electricity in the winter of 2022, it was primarily because of a political coup. Preparing for François Hollande's five-year term, the electoral agreement between the socialists and the ecologists of 2011 recorded the decision to curb and then reduce nuclear production capacity. The post-Fukushima context served as a pretext for Europe Ecologie Les Verts to revive their old anti-nuclear antiphon. To consolidate an uncertain electoral platform, the Socialist Party has accepted a reduction in the share of nuclear power from 75% to 50% by 2025, without scientific basis or economic logic.

In the early 2010s, France had a nuclear fleet unique in the world, inherited from the visionary energy policy initiated by Pierre Messmer in 1974 in response to the first oil crisis. For decades, thanks to nuclear power, the French economy has been able to count on a reliable, carbon-free and cheap supply of electricity. Until recently, France was Europe's power plant, posting surpluses and exports. It is a politico-ideological sham that will have the effect of devitalising this sector of excellence.

It is a fact that from the moment the process was initiated, the concrete effects on national production and the satisfaction of the energy needs of the French were neither analysed nor anticipated. The loss of sovereignty and energy independence of France is the result of a "corner of the table agreement", based on the prophecy of a long-term decrease in energy needs in the form of degrowth.

This blind policy, inspired by "waning thinking" hit electricity production in the first place. The dogma of 50% nuclear power and the gradual closure of 24 reactors constituted an enterprise of sabotage of the French tool of electricity production.

These political decisions jeopardised the industrial potential of France and affected the purchasing power of the French.

### 2) The development of new generation nuclear power restrained by doubt and indecision

Faced with technical and economic changes and the imperative of decarbonisation, the prospects for reindustrialisation require a lucid assessment of our needs. Productive recovery will have to be based first of all on a revival of nuclear energy. This is one of the great challenges of our generation.

However, the contrast is striking when comparing the current situation and the dynamics of construction of nuclear power plants from the 1950s onwards, even more so in the 1970s. The lack of political anticipation, unfounded doubts about the future coupled with a dose of indecision limit political will and industrial realisation.

The recent adoption of the law on the acceleration of procedures related to the construction of new nuclear installations opens up encouraging prospects, which should be confirmed with the programming law on energy and climate in the second half of 2023. In order to ensure the sustainability of our existing facilities, I have introduced into law, on behalf of the Renaissance group, a request for a report from the government to the Parliament with a view to extending the current nuclear power stations to 60 years and over.

The report of our Committee of Inquiry includes this extension provision in the context of a renewed, global and sustainable national and European energy strategy.

### 3) And tomorrow, sobriety: a key factor in our energy independence

The new energy paradigm must also take into account a trajectory of sobriety, which the 6th IPCC report defines as "a set of daily measures and practices that avoid the demand for energy, materials, soil and water while offering everyone a decent life within planetary boundaries" (2021 report: "Sobriety and climate justice at the heart of solutions to adapt to climate change").

This report makes two useful mentions of the objective of energy sobriety. He cites in particular the report of the Parliamentary Office for the Assessment of Scientific and Technological Choices (OPECST) on "the implications in terms of research and technological innovation of the objective of energy sobriety", expected in June 2023.

The France must restore its capacity to produce. It must also better regulate its energy needs, in conjunction with our European partners. To this end, the country must optimise the use of technological tools to manage energy consumption and infuse a culture of sobriety. Along with renewable energies, new generation nuclear power and sobriety are the pillars of our newfound energy sovereignty.

## CONTRIBUTION BY MARJOLAINE MEYNIER-MILLEFERT, MEMBER OF THE RENAISSANCE GROUP

### Written contribution by Marjolaine MEYNIER-MILLEFERT, Member of Parliament for Isère *Commission of inquiry to establish the reasons for the loss of sovereignty and energy independence of France*

As a preamble, I would like to pay tribute to the work done by the Chairman and Rapporteur of this committee and to highlight the extremely large number of hearings, as well as the rapporteur's synthesis work, which is of very high quality. To choose is to give up, and no doubt the report will not have been able to put into perspective all the abundant wealth of the raw material collected during the hours and months of hearings. Nevertheless, what the report yields to completeness will undeniably have gained clarity.

I would also like to reiterate that the possibility of following the hearings on a deferred basis was particularly appreciable, in a context where the activity of parliamentarians was singularly saturated, including on legislation relating precisely to the energy. But also, because this open, traditional format of committees of inquiry has also made it possible to capture, quite rightly, the interest of citizens and the media, who have regularly followed its progress. They too, through their comments and feedback "off camera", on our constituencies, finally also took part in this work on energy. This underlines the desire for citizen participation, if it were still necessary to demonstrate it.

This Commission of Inquiry was part of the need to explore a kind of presupposition present in the minds last autumn, that the "loss of French energy sovereignty" would be intimately linked to episodes of political disenchantment with French nuclear power over the past decades. I would like to pay tribute to the investigative work carried out by the chairman and the rapporteur, who have endeavoured to retrace the chronology of the more or less happy history of French nuclear power, and the series of events which have led today to the paradoxical observation of a great know-how and a dangerous erosion of competences at present. The speed with which the Commission dismissed the mirage of a "energy independence" or even "energy autarky" based on nuclear power is noteworthy. By focusing on the dimension of sovereignty, which represents the capacity of a state to act on its future, (and by not succumbing to the temptation to establish political accounts of a series of responsibilities past, fragmented and diluted) The work of the committee makes it possible to feed usefully the debates expected from the French energy climate strategy.

In this work on energy sovereignty, I want to highlight that, just as in the Committee of Inquiry on renewable energies for which I was rapporteur, it is not possible to limit the energy issue to the simple question of French electricity production. The fact that we start from the state of French nuclear power to arrive in the recommendations on the need to control energy consumption (through sobriety and energy efficiency) and to develop the "heat fund" just as my own report starting from the production of electric renewable energies had led me to make the same observation on energy savings and thermal renewable energies, must be of particular concern with regard to the budgets that we are prepared to deploy for these respective objectives.

This report rightly highlights the approximately 450 TWH of annual energy consumption related to the residential, which could be extended to the 740 TWH annual consumption of the entire French built stock (all uses combined), to recall that the current nuclear fleet generates at the best of its production 350 TWH annually. This might suggest that the first "Energy producer" French potential is actually the buildings sector. Because by implementing renovation works it could "return" to other uses the energy it currently consumes. Similarly, it must be considered that France heat needs are the first energy need. With 45% of the final energy consumed and 60% of fossil fuels, the challenge is largely to meet these needs with carbon-free energies. However, the way in which thermal renewable energies are under-considered in favour of electrical solutions in France seem to be a factor in the loss of sovereignty denounced today.

Indeed, imagine another Commission of Inquiry that would explore French choices in terms of energy efficiency since the 70s and the last oil shock. This commission would discover that we have implemented in France a thermal regulation that is less ambitious than other countries (perhaps because of the availability of nuclear energy?). According to the report of the High Council for the Climate on Renovation we waited until 2012 to implement the same levels of insulation that our European neighbors had decided to do in the 70s. What would be the levels of reinvestment necessary for the French state in national electricity production if for almost 50 years we had worked to reduce the need for consumption? What would be the French energy history if, as in Sweden, heating networks based on thermal renewable energies and heat recovery had been deployed in a very proactive way? What would be the social situation of our country with these heat needs now almost erased from household bills? This Commission of Inquiry could identify the mechanisms that led in the 70s to think that massive and carbon-free electricity production was preferable to reducing need, and perhaps here too it would to refer some persistent ideas in some minds to the status of mirages or dangerous beliefs.

No doubt a new Commission of Inquiry such as this one would also feed the work of the next French energy-climate strategy!

Another avenue to explore undoubtedly in our objectives of sovereignty at a time when we move from the belief of "an endless world" to the awareness of" a finite world": the transition from the almost unique vision of energy producers to the emergence of that of energy managers (who have the difficult task of redeploying the energy already available where it is most useful), the refocusing of the reflections of supply on the need (with an entirely new place for the role of consumers), the finally switching from a vision of centralised and then distributed energy to the idea of energy produced and consumed locally. These are all reversals that the current energy crisis allows us to explore more effectively and probably more boldly.

## CONTRIBUTION OF THE NATIONAL RALLY GROUP

### Contribution of the National Rally on the report of the Parliamentary Commission of Inquiry on the reasons for the loss of energy independence and sovereignty

Attached to the general interest and to overcoming sterile sectarianism, the National Rally group voted in favour of the publication of this report, faithful in every respect to the quality of the work of our committee.

Despite the differences and oppositions that naturally persist, we agree with most of the analyses and recommendations set out in the report. If only because they validate the spirit and often the letter of the diagnoses, proposals and vision that we have defended for twenty years, reaffirmed during the last presidential campaign by Marine Le Pen with our complete project "Marie Curie".

The vote in favour of this report also supports a rigorous and rational working method, based on facts and reason. The National Rally group can only hope that this ethic will be respected for the understanding, programming and implementation of the major scientific and industrial projects that our country must put in place to succeed in the energy transition, recover its independence and return to prosperity.

These types of programs and infrastructure span several years or even decades. It is essential that the various political forces that may eventually govern adopt a transpartisan method of working of this type, based on facts and reason, so that success is ensured beyond the Vibrations.

In this respect, the six months of work of the Committee of Inquiry have made it possible to carry out rich and in-depth work. Members from all the political groups were able to enjoy a wide freedom of speech on the substance and form provided by the presidency of Raphaël Schellenberger, whose high standards our group wishes to commend.

The present work rendered by Antoine Armand faithfully reflects the hearings and debates, with great intellectual rigor but also, it must be said, real courage in its conclusions and recommendations against the doxa of the majority. We would also like to highlight the quality of writing and integrated resources to the report, which allow everyone to fully understand the issues at stake and to access parliamentary work as it should be in a democracy.

However, the remarkable holding of this Commission of Inquiry was not guaranteed at the outset. On the one hand, because there was no indication, with an unprecedented political configuration and strong ideological tensions, that the commissions could be held in such a spirit. On the other hand, because the constitutive meeting had excluded the RN from the board in favor of the NUPES. This choice was incomprehensible since we are the leading opposition party but also the only force that has no responsibility for the collapse of energy policy that this report can only observe, like all French people.

The first salutary decision, recommended by the RN elected representatives, was to go back the work of the Commission of Inquiry to the 1990s. This choice is based on two logics. First of all, it is a question of avoiding any accusation of political manipulation, by choosing an arbitrary date like 2012 that excluded the responsibilities of the UMP. Secondly, nuclear power is an industry organised in a long cycle. Only an assessment of the last thirty years corresponded to the reality of the sector and its challenges.

The second salutary decision was the wide choice of hearings, covering almost all experts, senior officials, industrialists and political decision-makers of the last thirty years on energy policy. Admittedly, the issues of fossil fuels and energy savings have been less addressed than our electricity system. This is a recurring trend in the French political debate from which we have not escaped. Nevertheless, the rapporteur's work restores a balance by showing, in particular, that governments have not reduced our dependence on oil, gas and fuel oil for at least 30 years. They have focused public resources and democratic debate on absurd and suicidal competition between electric renewable energies and nuclear instead of decarbonising housing, industry and transport.

The National Rally group, however, regrets the conditions of the hearing of Nicolas Sarkozy and François Hollande who, not being subject to the oath for constitutional reasons that are moreover questionable, were able to tell what they wanted, unlike all the other people interviewed under oath and criminally responsible for their statements to the national representation. No better hearing than these political interventions.

## I) <u>Our main differences with this report :</u>

Although we voted in favour of the report, we do not agree with all its analyses and recommendations. Here are the essential, but not exhaustive, points of our disagreements:

1) Energy independence remains possible, desirable and even vital.

First of all, we do not believe that energy independence is an illusory or unattainable goal; this objective is more desirable than ever while Russia's war against Ukraine but also the Covid 19 crisis have hit our democracies.

The report confuses independence with autarky. Independence is not based on the absence of all imports. In this respect, the example of nuclear or hydroelectricity is edifying. The materials required, in quality and quantity, to build and operate these plants are not particularly critical. In addition, the development of 4th generation reactors would have long made France independent of any import of fissionable material.

With a massive nuclear and hydroelectric sector, the production of electricity and hydrogen would eliminate gas and oil imports, while exploiting new forms of biofuels or other sovereign technologies such as geothermal energy and STEP storage.

In reality, France stopped in the process of acquiring its energy independence. If the nuclear program has drastically limited its dependence on fuel oil and coal for electricity, our country has not pursued the development of a nuclear fleet to decarbonize the uses of the sectors transport, industry or housing. This is intolerable since over the last ten, these imports have cost the French at least €700 billion!

The massive production of low-carbon electricity is also the means to relocate our industry, including a mining and primary ways of valorisation, all ways to promote our general strategic independence.

In this respect, we also regret the refusal to develop the exploitation of our possible resources in parallel with the decarbonisation of our economy. Indeed, refusing to exploit its resources with the most sustainable technologies while continuing to massively import expensive fossil fuels and exploited in worse conditions than in France makes absolutely no sense other than a political posture.

2) Democracy must establish clear responsibilities to move forward

We disagree on the refusal to establish political and sometimes even personal responsibilities linked to the absurd decisions taken by each other. Indeed, far from being mistakes in good faith, it is in full awareness of the physical, economic, financial and even scientific limitations and shortcomings that decision-makers have chosen to sacrifice our assets and vital programs. Thus, the asserted credibility of the objective of reducing to 50% the share of nuclear power in the electricity mix was indeed a campaign manipulation transformed into a state lie, organised by the socialists and then macronia with the support of a significant number of senior officials and experts often self-proclaimed. This scheme cannot be considered part of the Hollandian "bottom of the bowl".

As such, even if it recognises that the revival of the nuclear sector announced by the government remains to be realised, we regret that the report minimises the personal responsibility of Emmanuel Macron in the ransacking of the nuclear sector (sale of

Alstom to the American General Electric, pursuit of the objectives of 50% nuclear in the electricity mix, etc.) both as Minister of the Economy and as President of the Republic.

The Rassemblement National group considers that the establishment of a French "spoil system", namely the possibility for an elected government to replace senior civil servants and major public officials, is the only way for the state to be embodied by people who are both competent, responsible and effective.

3) The government is underestimating the electricity production needed by our country by 2050 and is making risky technological bets.

Succeeding in the energy transition and reviving our economy requires massive reindustrialisation, far from the objectives of 12 to 13% of industry in GDP in 2050 studied by RTE. We must at least return to 20% of industry in GDP, which implies massive consumption of electricity and low-carbon hydrogen.

Similarly, energy sobriety and efficiency targets are too optimistic compared to credible expectations. Above all, who can do more can do less! We cannot afford wishful thinking against global warming, so it is better to provide too much low-carbon electricity than not enough, which would lead to a new disaster.

This unfounded optimism can also be seen in the "technological bets" made to combine the massive development of intermittent energies with energy needs, including the balance of the electricity grid. These technological bets are based on nothing and will lead to the development of gas-fired power plants.

On the contrary, the report plays down innovative technologies whose success is certain, such as the massive development of nuclear cogeneration or the maximum development of WWTPs.

In the same way, refusing, for administrative reasons without technical basis, the proposals of the RN to revive Fessenheim finally to make it the first power plant capable of going to 60 or 80 years seems to us a sterile posture. How can we afford not to use such an industrial tool in the face of the monumental energy challenge we face?

4) The revival of the nuclear and hydroelectric sector is very uncertain under the current conditions planned by the government and Emmanuel Macron.

Most of the fears of the Rassemblement are based on the few nuclear reactors planned (6 to 14 in 30 years, against 20 to 30 for the RN group) and the fear of a new" nuclear low" leading to loss of skills. We also deplore the lack of ambition for hydroelectricity, the 4th generation of nuclear reactors or disruptive technologies such as nuclear cogeneration or hydrogen.

The Rassemblement group believes that the timetable and the means do not correspond to the revival of a real nuclear sector, which should be ensured by a load plan at least comparable to the Messmer plan.

Moreover, the choice not to launch EPR 1 now on the basis of British achievements pending the validation of the design of EPR 2 seems incomprehensible and dangerous to us.

Finally, it seems obvious that to succeed in a real nuclear revival, à la carte cooperation with our European partners through Euratom is essential, even other powers such as the United States or South Korea, this list being non-exhaustive.

5) Unfair and inefficient energy taxation

The RN regrets that the effectiveness of the fiscal policy hitting fossil fuels, presented for decades and in particular since 2014 as a means to reduce our dependence on fossil fuels has not been questioned by Commissioners other than our own members.

The lack of response from Prime Minister Elisabeth Borne says a lot about the fraud of such a tax, which aims only to raise taxes on the popular and middle classes without any effect other than sacrifices and shortages.

## II) **The assessment and vision of the National Rally group on French energy sovereignty.**

- *The incompetence of all governments for 20 years* and the *mistakes of Emmanuel Macron have put electricity production in high tension, exploded the bill and weakened the EDF model.*

- *Massive and urgent investments are needed because the needs related to the electrification necessary for* the *ecological transition and the reindustrialisation of France have not been anticipated or have been underestimated.*

- *All scenarios anticipating consumption in 2050 rely on sympathetic but not very rational energy efficiency performance.*

- *The plan announced by Emmanuel Macron in Belfort is less a revival of nuclear power than a gigantic plan for intermittent energies.*

- *It aims to reduce France's total energy consumption by 40% while increasing electricity production by 55% while ceasing any promise of reindustrialisation.*

- *It still plans to effectively lower nuclear power to 50% of the electricity mix in 2050, with 50% renewables, leading to the multiplication by 2 of wind turbines on earth, by 10 of solar panels and the installation of 50 wind farms offshore wind.*

- *This project is also based on the construction of 6 to 14 EPR2 reactors between 2035 and 2050, and a few SMRs, insufficient number for a real sector.*

- *The 50% nuclear/40% ENRi mix will inevitably lead to the use of gas.*

- *The RN's nuclear plan anticipates much greater electricity needs, in particular to reindustrialise France and is based on 3 pillars:*

  - *Strengthening the historic nuclear fleet: EDF will once again become a natural monopoly with regulated prices, the availability of power plants will be improved, the fleet will be extended to 60 years, Fessenheim will be reopened with an operating objective of 80 years.*

  - *Develop hydroelectric and geothermal renewable energies and accelerate the "green hydrogen revolution" as well as nuclear cogeneration and WWTPs.*

  - *Launch a "Messmer II" plan , which will be named "Marie Curie" capable of renewing our nuclear fleet, increasing its power and safety.*

## A. Why is energy also a choice of civilisation?

Public debate generally limits this issue to regalian, economic and educational issues. Naturally, these questions are major in the future that the French will choose, but energy issues and, in general, the major technological choices we will make, are just as fundamental.

Energy is the beating heart of our economy and human societies. The entire human adventure is a constantly renewed quest for the mastery of natural resources and the laws of physics that allow it to thrive.

From the mastery of fire to the domestication of animals, from the invention of mills to that of steam engines, from the use of oil to the miracle of electricity, from the conquest of atomic fission to that of fusion, humanity has done and will only extend the energy power which she has to live better.

All the productive revolutions of humanity, from the oldest to the most contemporary, are all based on the mastery of one or more forms of new energy. These technological achievements have accumulated far more than they have replaced each other for a simple reason: humanity  has always need more energy to improve living conditions, relieve the hardness of work, conquer new territories, including now, the sea and space.

Energy perspectives dictate the model of society and our lifestyles much more than the other way around. Confined to wood, the forces of wind, water and sun, humanity has experienced almost no economic growth for millennia. Mastering coal, oil, gas and then the atom, prosperity has transformed our civilisations from top to bottom, upsetting our anthropological foundations to give the illusion of an infinite world, without limit of resources.

While humanity has lived almost all of its history in deprivation, sacrifice and constraint, an ever-increasing part of it has experienced the intoxication of economic growth even if wealth has been very unfairly distributed, merit and work rarely rewarded in their rightful place.

Abundant for a few decades, energy and natural resources seem to be constrained again. When shortages appear, injustices burst into the open among the peoples and tensions between states multiplied for the control of wealth.

## B. The French nuclear exception, an industrial, economic and ecological miracle that has been wasted

The choice of energy model is a societal choice. Although essential in essence, often close to what even liberals identify as a "natural monopoly", energy is not a wealth like any other. It conditions access to healthy food, dignified housing, freedom of movement.

The choice of energy model also determines our relationship with the world. Natural resources are not equitably distributed on Earth. The rarer they are, the more bitterly contested they will be. Choosing dependency, as French governments have done for 30 years, in defiance of General de Gaulle's legacy, has put us in a dead end, resulting in an energy bill that the French are paying more and more heavily.

In 1972, the Club of Rome drew up a very clear report, based on reason and common sense : the miraculous growth that the West experienced after the Second World War, based on fossil fuels, intensive resource exploitation and an irrational global population explosion, will somehow lead us to disaster.

The oil crises that followed lent credence to their analysis: low-cost fossil fuels were an economic illusion while the problems environmental pollution, especially air pollution, became indisputable evidence.

Particularly aware of France's dependence on fossil resources and raw materials, General De Gaulle had already perceived before the oil crises that France had to produce its own energy and, as far as possible, a maximum of its strategic resources.

France therefore embarked on the mastery of the civil atom and then engaged in the largest possible nuclear program in relation to its size. 58 reactors were built in just 30 years, from nascent industrial sectors. Up to 3, 4, 6 and even 8 reactors will be delivered per year!

With the success of this "Messmer plan", France invents the first "green growth": France is enriched by producing 75% of its electricity with nuclear, 15% with hydroelectricity, or 90% of its energy without greenhouse gas emissions or air pollution. With the best integrated sector in the world, from fuel to reprocessing, our country has conquered a very competitive energy for its economy and its inhabitants.

The France then took the lead in a real energy revolution: in a gram of uranium, there is as much energy as in a ton of oil. The prospects for innovation are considerable, opening up horizons of abundant energy by limiting risks and waste.

The technological and anthropological revolution is based on the nuclear equation: with a minimum of space occupied, resources consumed and waste produced, maximum energy is obtained.

However, instead of preparing for the future, guaranteeing a long-term prosperity dearly won while solving the problems of pollution on health and the environment, the French governments have seen in nuclear power only a rent that they will waste on all possible political whims: clientelism, European federalism, electoral agreements, impasse of intermittent renewable energies (ENRi)...

This last point is undoubtedly the most representative of the tragic consequences of political incompetence and the weight of lobbies. From 2007, France massively subsidised the development of onshore wind turbines, solar panels and, from 2011, offshore wind turbines.

These energies can help countries that do not have nuclear skills, but for France, it is absurd! Nuclear power is already a low electricity source of electricity carbon and without air pollution but which also produces massive and controllable energy. On the contrary, ENRi, subject to the vagaries of the weather, are unable to supply a developed economy without the use of coal and gas plants that compensate for their failures. The massive development of ENRi has served no purpose except to disrupt the French and European model, to increase our dependence on gas/coal power plants. These power plants occupy a considerable space, massacring landscapes, ruining the land value of homes, polluting the soil.

The money wasted on ENRi has not been spent on the nuclear power of the future. Innovation sectors have been abandoned or slowed down, investments have become scarce and then, finally, almost no reactor has been built for 30 years apart from a head of series whose setbacks illustrate the extent of the loss of skills of France.

This mismanagement weakened the national flagship that was EDF. To satisfy the absurd European treaties, the company has been dismantled and robbed of 25% of its nuclear production sold at cost price to its competitors without any beneficial effect for the consumer, prices having increased on average by more than 50% for ten years!

## C. Emmanuel Macron's choices lead France into deadlock

Winter 2022 marks a break for the electricity market: the nuclear rent can no longer hide the mistakes of France and Europe for 30 years. The prices of all energies are exploding, especially electricity. The government, once again, is using EDF and the nuclear fleet as an expiatory victim and an electoral adjustment variable.

While the French mix is very little exposed to the price of the gas or coal market, the inclusion of our country in the European market has deprived us of our energy sovereignty. When gas explodes in Europe, France pays full price while it consumes almost no electricity for its electricity.

A caricature of all the evils that have befallen French nuclear power, Emmanuel Macron has played a considerable role in the weakening of French nuclear power. Deputy Secretary General of the Elysée and then Minister, he co-organised the dismantling of Alstom, closed the Fessenheim power plant, remained passive in the face of the difficulties of the Flamanville site, saw the availability of the plants deteriorate as never before. It has handicapped the future by really not financing any program for the future and worse, by closing the Astrid project for a new generation reactor… that he now wants to relaunch! The Multiannual Energy Program (2019-2028) that he voted in Parliament for France acts the reduction of the share of nuclear in the electricity mix to 50%. On November 27, 2018, Emmanuel Macron announced the closure of 12 reactors in addition to Fessenheim before 2035. This decline is supposed to be offset by the massive development of onshore and offshore wind turbines as well as solar panels.

Neither of these two objectives has ever had the slightest credibility and five precious years were lost to build the energy future of France, to improve the purchasing power of households and make a success of the ecological transition. It is now established that this was at best incompetence or worse a state lie.

In Belfort, Emmanuel Macron presented his new energy policy. The latter essentially consists of taking up the conclusions of RTE's "Energy Futures" report. While this company has undeniable expertise, it remains at the orders of the government and has often been wrong.

For example, it was RTE that, for two decades, claimed that France would not need to produce more electricity just because governments did not want to make the necessary investments and rely on the French deindustrialisation.

First of all, Emmanuel Macron considers that France must reduce its total energy consumption by more than 40% while increasing electricity production by 50%.

In other words, it is a plan for energy sobriety coupled with a massive electrification plan for France. The challenge is monumental because never since the beginning of history has a society that reduced its energy consumption by 40% managed to produce more wealth.

As such, Emmanuel Macron acts the  non-reindustrialisation of France with this energy plan. The RTE report is very clear, its scenario is only possible with an industry that remains at 10% of GDP! To increase to 12-13% of industry in 2050, electricity production would have to increase by 16.5%.

To electrify France, Emmanuel Macron has chosen to extend the current nuclear fleet as much as possible, then launch the construction of only 6 to 14 EPRs by 2050, reinforced by SMRs whose number is unknown. In the end, the objective would be to have 50% nuclear in 2050 with a lower installed capacity than today. This is therefore a serious decline in nuclear power in France.

6 to 14 EPRs in 30 years are also insufficient to recreate a real sector. In reality, we are witnessing a scattering of public money on no less than 6 electricity sectors, which will obviously lead France to not control any of them! Moreover, Emmanuel Macron has chosen to launch an EPR2 program whose design is not completed and which will only be operational in 2035 minimum, and probably rather 2037!

In other words, Emmanuel Macron will never assume the slightest follow-up of his energy plan. It wants to invest in 23 to 27GW of new nuclear against 180 GW of intermittent energy: doubling of onshore wind turbines, 50 wind farms at sea and multiplication by 10 of solar panels i.e. an increase of 15 to 30% of the bill excluding inflation for the French.

This energy mix works on paper but not in reality. An industrial company cannot have 40% of its electricity mix stop on a winter night when there is no wind or sun. Emmanuel Macron is betting on technological "revolution" in electricity storage But there is no evidence that this will be achievable with an acceptable ecological and financial cost.

In reality, Emmanuel Macron's plan will lead to the development of gas-fired power plants.

## D. Energy challenges to be met according to the RN

The France now faces at least four challenges that will require a significant increase in electricity production within a much tighter timeframe than governments have promised since the 1990s:

1) Protect the purchasing power of the French and the competitiveness of our companies from the fossil fuel crisis we have been going through since September 2021, which will be either sustainable or recurrent. Only a policy of sovereignty and maximum autonomy can preserve us.

2) The reindustrialisation of France is a priority to counter the economic downgrading and impoverishment of the French. Bringing back the 10 points of industrial GDP that we have lost in 30 years will also require massive electricity. In addition, imports represent 50% of our greenhouse gas emissions. Reindustrialisation means saving the climate.

3) In order to respect the Treaty of Paris, we must electrify our economy. The objective of carbon neutrality is noble but it involves heavy choices that have strictly never been debated by the French. The "German model" based on ENRi was a "crash test" and a fiasco. €500 billion to pollute 7 times more than France!

4) The ageing of France's nuclear fleet is beginning to pose serious problems. Admittedly, the "Grand Carénage" plan will make it possible to extend the life of the fleet by 10 to 20 years, but we must now choose: do we start again in a new nuclear fleet or do we change the model? The choice is obvious.

We have chosen: nuclear energy, allied with our hydroelectric dams, has proven its worth.

To be independent, to offer a dignified standard of living to our inhabitants, to respect the environment while returning to prosperity, we must launch a major nuclear production plan: to succeed in a " Messmer 2 ", the equivalent in number of reactors produced of what France has achieved but with much more powerful reactors.

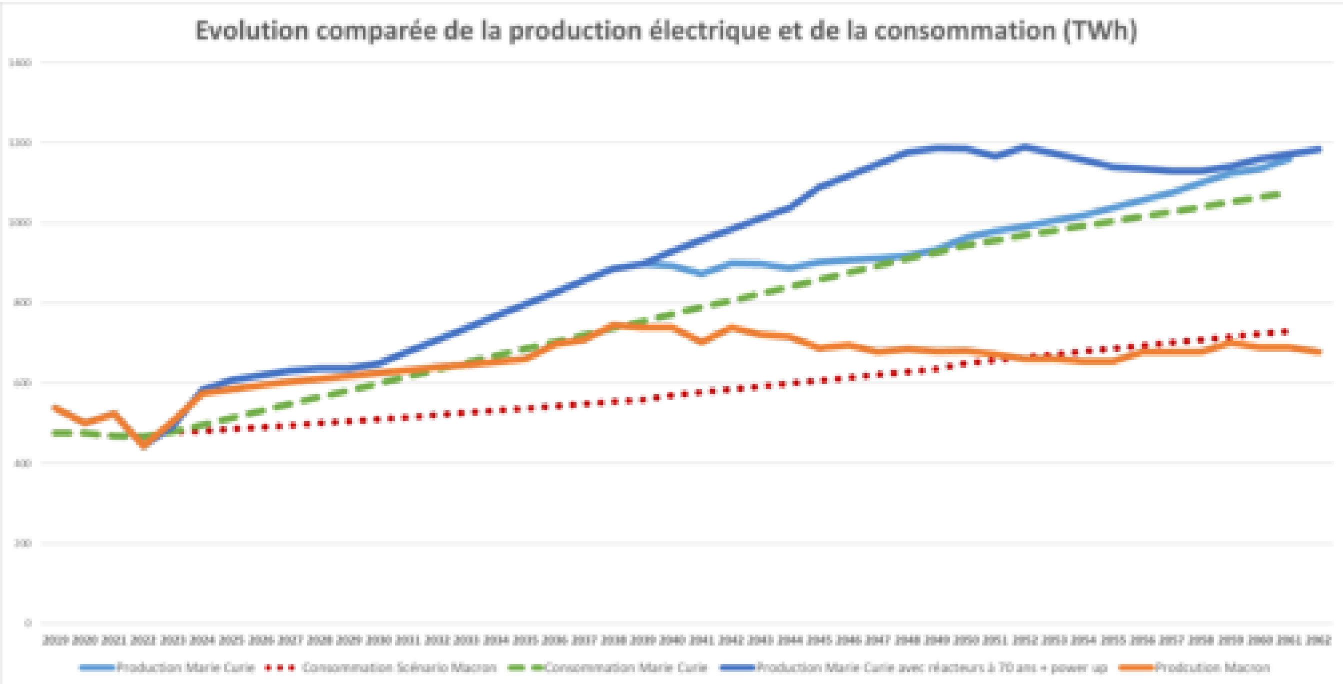
## E. Only a Messmer 2 plan can save the French nuclear industry and guarantee the sustainable prosperity of France.

On this graph, two dotted lines represent the increases in electricity consumption that will be created by the electrification of uses, technological progress, reindustrialisation and the hydrogen revolution.

In red, a curve models the upward trend in consumption generated by the RN program. In orange, the central scenario of the government.

The green curve models the nuclear power that will be operational with the Messmer II plan. We note that all the other scenarios illustrated by the other curves, including Emmanuel Macron's "massive" recovery plan (blue curve) delay the collapse of the nuclear fleet but do not prevent it: ENRi are supposed to fill the gap, which is in fact impossible.

The energy needs will be so great that even with a Messmer 2 plan, electricity production will barely pass the test of closing the historic park after 60 years.




## F. The structural causes of the weakening of French nuclear power and how to remedy them

While French nuclear produced about 75% of French electricity with 400 to 430 terawatt hours/year in the 2000s, the production of the park has steadily deteriorated, falling to less than 70% of the mix in 2020. In 2022, this production will fall to 295-315 TWh, or -25% in 15 years. This winter, up to 15 out of 56 reactors were shut down; 5 still are. 6 other reactors will be shut down for checks, 3 of which were not planned. The reasons for the weakening are the direct or indirect consequences of the considerable decline in structural investment in the sector since the 1990s in favor of the impasse of the development of intermittent, wind and photovoltaic energies.

***Structural underinvestment in the nuclear sector for the benefit of ENRi*** The deterioration of the nuclear fleet has been known since the Fillon government, which underestimated the consequences of the ageing of power plants, thought that France would need of less electricity and chose to invest in wind and solar energy. A suicidal choice: intermittent and expensive renewable energies are unable to replace stable and controllable nuclear production. By way of comparison, the current nuclear fleet cost €80 to 100 billion to supply up to 75% of French electricity until 2005. On the contrary, since the 2000s, more than €150 billion has been spent on wind and solar, for less than 7 to 8% of electricity production.

***The organised decline of the industrial and professional nuclear sector*** For 30 years, the professional sector has been weakened: too few workers and engineers have been trained, the use of service providers and subcontractors in cascade is too important, the paralysing bureaucracy has been invaded the sector like the entire French economy. On the Flamanville 3 EPR, a considerable number of welding operations were carried out by foreign operators, due to a lack of French expertise. The Nuclear Safety Authority and the Ministry of Industry have regularly sounded warning signs about the loss of technical skills: to no avail. The major companies in the sector, real industrial flagships, have been ransacked, looted or simply sold:

- Areva, darling of the 2000s, was ruined following ridiculous quarrels, mismanagement and supervisory governments. Finally cut into pieces and saved by EDF, the company became Orano, refocused on fuel.

- Alstom Energie, sold to General Electric, whose Arabelle turbines were finally bought by EDF on the orders of E. Macron this February 10, 2022.

- Other industrial branches are dispersed, without any real operational and strategic unity of the sector.

***The voluntary weakening and dismantling of EDF*** The creation of the European electricity market is the monstrous child of Brussels' obsession with pure and perfect competition, including against liberal theories recognising that electricity is a "natural monopoly".

While EDF had an integrated model that worked perfectly, French leaders applied the Brussels directives by dismantling EDF, removing the management of the networks with RTE and Enedis, artificially transformed into independent entities.

To create competition that did not exist, EDF was forced to sell 100 TWh of its electricity production, or between 25 and 33% of its nuclear production, at cost, if not at a loss, to private companies that then resell it. This is called ARENH (Regulated Access to Historic Nuclear Electricity).

The losses caused by this looting have never been quantified, to our knowledge, by the public authorities. As an indication, we estimated the losses between 15 and 30 billion euros for EDF since 2011 before the Commission, we probably underestimated the scandal. It is time to establish the facts.

This looting of public goods was supposed to have only had a time, but private companies ultimately invested in their own power plants with very few exceptions.

In addition, EDF has been fully integrated into the European electricity grid. While our electricity mix is 93% decarbonised, Europe's is highly dependent on coal and gas. Thus, when prices explode, France, which should be protected, must pay full price for Europeans!

***A nuclear "hollow" demonstrating a lack of vision*** Convinced that France would not need more electricity in "happy globalisation" with a factory-free economy equipped with ENRi, governments stopped any major program of plant construction after Chooz and Civeaux in the late 1990s.

Without sustainable orders, the skills and techniques of industrial subcontractors were not preserved after the end of the Messmer plan.

In 2007, only one EPR was launched as a seed, but the rest of the series never came. However, experience dictated that reactors had to be built in pairs to gain economies of scale. How to revive an industrial sector with a single isolated site? What young engineer, welder would want to specialise in a field without a long-term perspective?

In reality, governments have deliberately created a "nuclear hollow" that could have been a grave while China builds several reactors a year... China's nuclear power generation surpassed France in 2020, as did the mastery of new technologies.

***The consequences of intermittent renewables.*** Wind turbines and solar panels produce energy according to the vagaries of the weather, completely unrelated to the real-time needs of the economy. European countries and France have decided to give priority to access to the grid to the electricity produced by these plants. In other words, it is up to nuclear power to adjust to the production of ENRi. This permanent modulation forces the plants not to be fully utilized, lowering their load factor and leading to a constant degradation of the profitability of the installations.

***The distressing delay of the Flamanville EPR*** The intolerable delays of the Flamanville EPR are not due to nuclear technology but to the loss of skills of France, consequences of deindustrialisation and the lack of follow-up of the file by governments. In China, two EPRs were built and delivered in less than ten years. In France, delays and additional costs follow one another but no one is ever responsible for anything. Emmanuel Macron has suffered the umpteenth delays of this project without ever taking the slightest initiation.

## G. Emmanuel Macron's irresponsible and contradictory decisions on the nuclear industry.

***Direct responsibility for the looting of Alstom*** According to the Parliamentary Commission of Inquiry into the sale of Alstom, Emmanuel Macron, Deputy Secretary General of the Presidency of the Republic, commissioned in 2012 a secret report from the American consulting firm AT Kearney via the State Holdings Agency in order to consider the sale of Alstom's activities to a foreign group, in particular General Electric (GE). After fighting against Arnaud Montebourg to finally replace him at Bercy, Emmanuel Macron signed on November 5, 2014 the agreement to sell Alstom's "Energy" activities to General Electric, including the Arabelle nuclear turbines. The latter are bought by EDF in 2022 at double their selling price!

On the entire Alstom Energie group, this takeover will destroy 4,000 jobs, blackmail to increase the maintenance contracts of French power plants, the transfer of order books and technology. The magazine Challenge also revealed quite serious losses of technical competence, which had consequences on the quality of the machines delivered.

***The irresponsible closure of Fessenheim*** In 2020, Emmanuel Macron acts the closure of Fessenheim and withdraws 12 TWh of nuclear electricity production per year. This is only a decision resulting from an electoral agreement between the Socialist Party and the Greens in 2012 without any rational basis. It was doubly irresponsible: not only did the two reactors work perfectly, but the law provided for waiting for the commissioning of the Flamanville EPR to avoid supply voltages. A 2021 parliamentary report confirms that the closure was political and unjustifiable financially and technically.

***Five years wasted to invest in the revival of nuclear power*** Emmanuel Macron supports the closure of 12 reactors after Fessenheim and the lowering of the share of nuclear power to 50% of the electricity mix by 2035. Such an announcement has deeply demoralised the nuclear industry, aggravating underinvestment, lack of adequate training and loss of vocation of young people. It also stopped the ASTRID project, which had already committed hundreds of millions of euros in investments to build a prototype generation 4 reactor capable of reusing part of current nuclear waste but also of using new, more abundant uranium resources.

***The fall in nuclear production in the middle of winter shows that the government is not even able to organise a schedule.*** Many reactors are experiencing extended shutdowns for the upgrade and equipment renewal program, the "Grand Carénage" (2014-2025), which is expected to extend the operating life from 40 to 60 years. Reactors also undergo shutdowns for ten-year visits, or fuel reloads. This winter, "unannounced" technical problems were also spotted on the 4 largest French reactors.

This led EDF to shut down other reactors to inspect them. As the government no longer has any room for manoeuvre, any shutdown is dramatic, not to mention the effects of Covid, which it did not anticipate on the maintenance of power plants.

### H. France's considerable electricity needs in the 21st century contradict the absurdities of the government.

***The mind-boggling mistakes of the "expert consensus".*** Until very recently, the consensus of pseudo-experts with a say in the decisions taken by France, including RTE experts, had estimated that our country's electricity consumption would be stable in the 2000s and then declining. It would take too long to explain all the reasons for this fiasco, but the main thing is linked to the irrational belief in the virtues of globalisation, oil counter-shocks and European integration. The profound deindustrialisation of France has reduced the need for electricity while impoverishing our economy. Leaders did not anticipate the electrification of uses related to the digital revolution, the climate transition. They have never prepared any possibility of reindustrialisation and ignored the inevitable exit from fossil fuels.

***The government continues to be mistaken about the real electricity needs to be achieved for the next 50 years.*** The RTE report "Future Energy", now seems to be the government's reference, forecasts a decrease in total energy consumption in France (electricity, fuels, oil, gas, others) from 1600 TWh to 930 TWh, a huge decrease of 42% by 2050. On the other hand, the report forecasts an increase in electricity production, which would rise from 475 TWh in 2019 to 645 TWh in 2050, i.e. a change from 29% to 55% of electricity in the final energy consumed in France.

This scenario is actually very optimistic about the energy savings that society is able to achieve, especially in housing, transport and the tertiary sector. RTE also does not foresee any reindustrialisation of the French economy, with a constant share of 10% of GDP coming from manufacturing activities. An adjacent scenario provides for a "reindustrialisation +" but it would only be 2 to 3 additional points by 2050 while it exceeded 20% in the 1990s, a rate that Germany or Italy have maintained.

In reality, the TEN reference scenario does not break with the delusions on the " sobriety " of the Greens and diminishing lobbies. These groups confuse the just cause of ecology with their punitive vision of human society, doomed to "pay" for its sins towards nature. Beyond the fact that this scenario is unfair and absurd, it has no chance of success since most of our compatriots have absolutely no means to make such sacrifices, a considerable part already living in poverty or energy poverty. This project is all the more worrying as there is no "plan B " from the government to reduce energy consumption in France.

***The electricity mix anticipated by RTE is simply unrealistic and intolerable, in line with the mistakes of the last 30 years.*** In its reference scenario, RTE, faithful to the government's Multiannual Programming, provides for a 50% nuclear and 50% renewable electricity mix.

To achieve these objectives, the plan includes :

- A multiplication between 2.5 and 4 wind turbines on land, i.e. the installation of 6,000 to 12,000 more masts in France.
- The ransacking of the coasts with at least 3000 offshore wind turbines (up to 9000). For example, the park of Erquy has 62 masts.
- The multiplication by 7 of solar panels, but other scenarios propose a multiplication by 11 and even 22.

The intensive development of ENRi is all the more important when we see that this scenario foresees the construction of only 14 EPRs by 2050. This choice confirms a reduction in France's nuclear power, from 75 to 50% in relative value, but also from 61 to about 46GW of absolute power. RTE has not studied maintaining nuclear power at 75% of the electricity mix or even maintaining 61 GW of installed capacity.

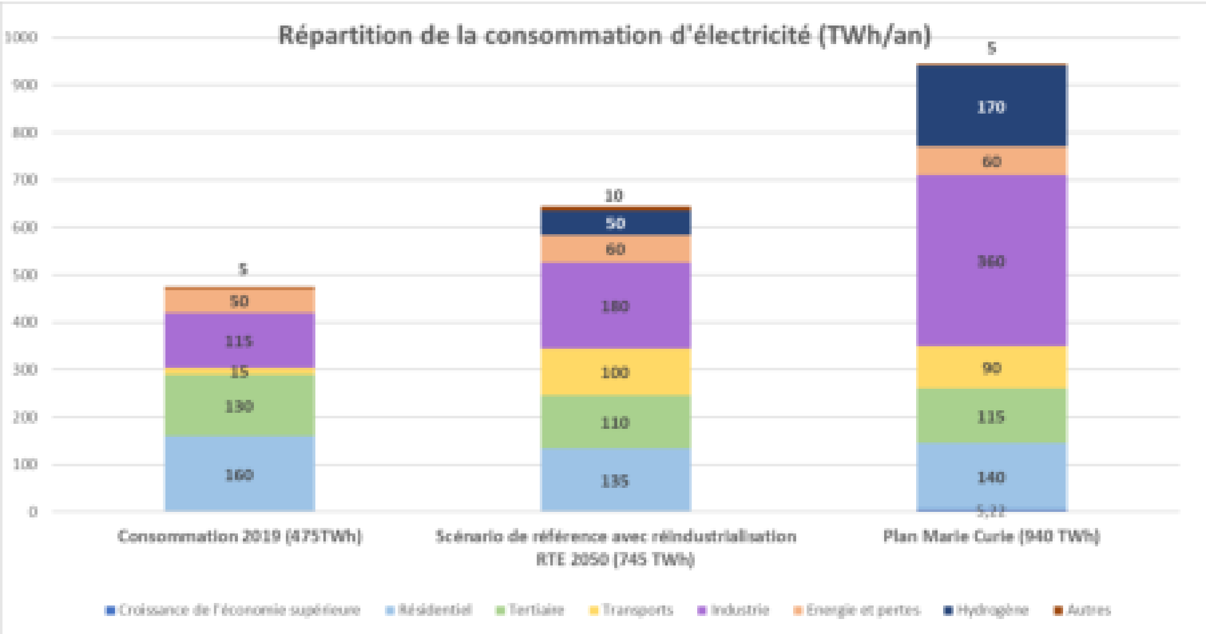
The excuse given would be that the French industrial sector would not be able to produce so many reactors in 28 years! This argument is not credible. At the beginning of the Messmer plan, which built 58 reactors in less than 30 years, France had neither the current experience nor the current expertise. Admittedly, industrial skills have been lost, but nothing irreversible.

## I. RN Group's proposals are based on ambitious but realistic assumptions.

***Electricity demand revised upwards through reindustrialisation, relocation and the hydrogen revolution.*** The RN group's ambition is an electricity system that guarantees the purchasing power of the French, the competitiveness of companies and sustainable economic growth, without air pollution or excessive consumption of resources and land use. This plan also aims to sustainably reindustrialise France by returning, at least, to 20% of industrial production in our GDP in 2050, i.e. the level of the 1990s or the current level of Germany or Italy.

France will also be fully committed to the hydrogen revolution, the only credible way to sustainably free ourselves from fossil fuels without reaching our standard of living and our energy needs. Our plan also makes less optimistic assumptions than RTE on the residential and tertiary sectors, because any overestimation of savings can lead to a catastrophic under-sizing of the electricity fleet. Nevertheless, we consider it a good policy to provide greater room for manoeuvre in the event of a slight drop in consumption in these sectors, as well as, moreover, transport.

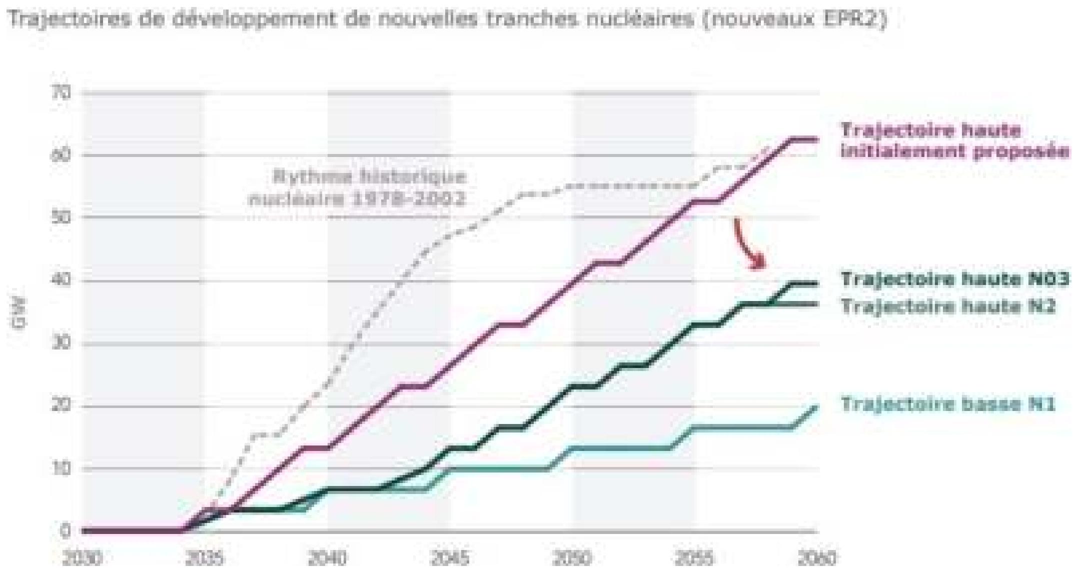
Such a plan requires more than 250 TWh of additional electricity between 2022 and 2050 for reindustrialisation, and 170 TWh for hydrogen. We must thus go from 475 TWh in 2019 to 600 TWh in 2030 (against 500 for RTE), 770 TWh in 2040 (570 for RTE) and 940 TWh in 2050 (compared to 650). On this graph, we can see the very important differences between our projections, very realistic and focused on the reindustrialisation of the country, and those of RTE and Emmanuel Macron, particularly optimistic and in fact, unrealistic.




***Only our electricity production plan realistically meets the economic, social and ecological challenges*** While we are strengthening French hydroelectric production while encouraging relevant bio-energies and geothermal energy, most of our project is based on two axes for the nuclear fleet. First of all, it is a question of breaking with the most absurd rules of the European Union to restore the strength of the EDF group and make it a powerful economic tool at the service of the purchasing power of the French and the competitiveness of companies.

EDF reinforced, we will be able to succeed in deploying an emergency plan for historic nuclear power that will restore optimal electricity production and quickly recover room for manoeuvre to reindustrialise the country. Then, we will extend the life of our historic power plants to 60 years, at which we will return to Fessenheim for a test at 80 years. Once the historic nuclear fleet has been strengthened, we will be able to successfully deploy a new "Messmer" plan, which we will call "Marie Curie". We will renew our 58 reactors, starting with one new pair per year starting in 2030.

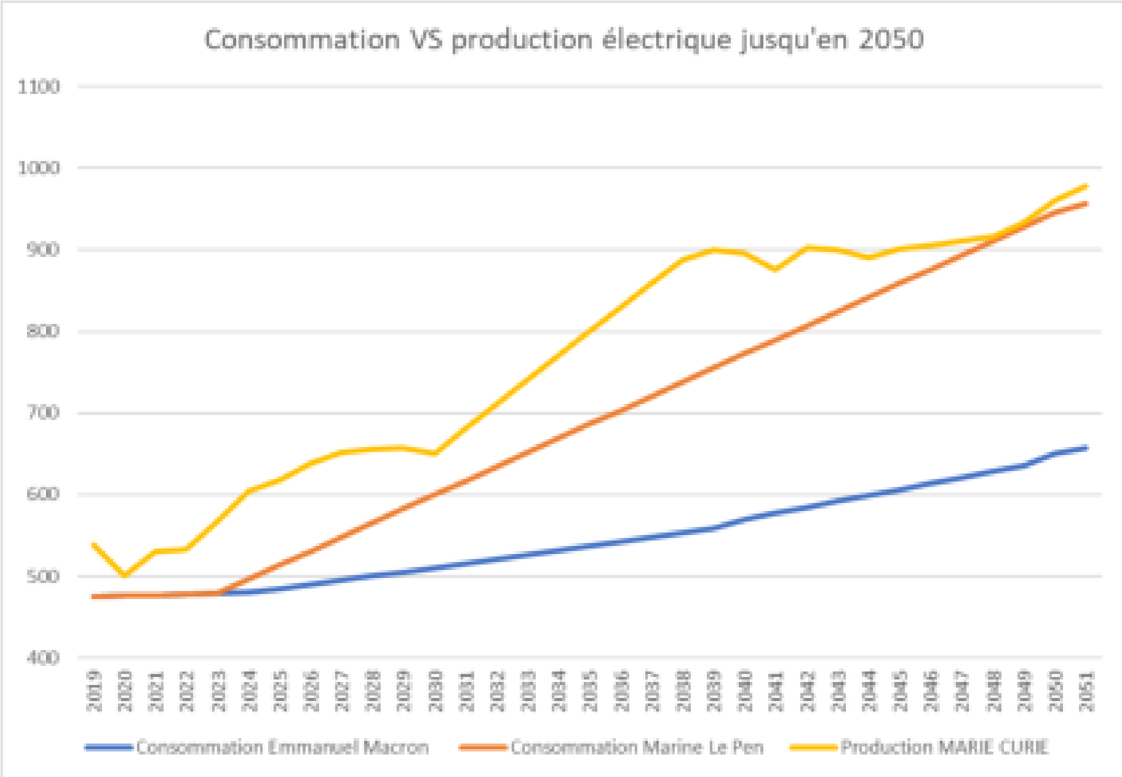
A nuclear development plan closer to the Messmer pace had been planned by RTE, but it was set aside for political reasons (graph from the Future Energy report) in favor of a particularly weak plan. In 2050, the "Macron" plan is half as ambitious as the Messmer plan. We also notice that Emmanuel Macron's projects are very long. This is because instead of launching EPRs on the basis of experience, he wants to launch EPR2 projects with a new design that still requires several years of study, with a risk of failure that the majority does not take into account.



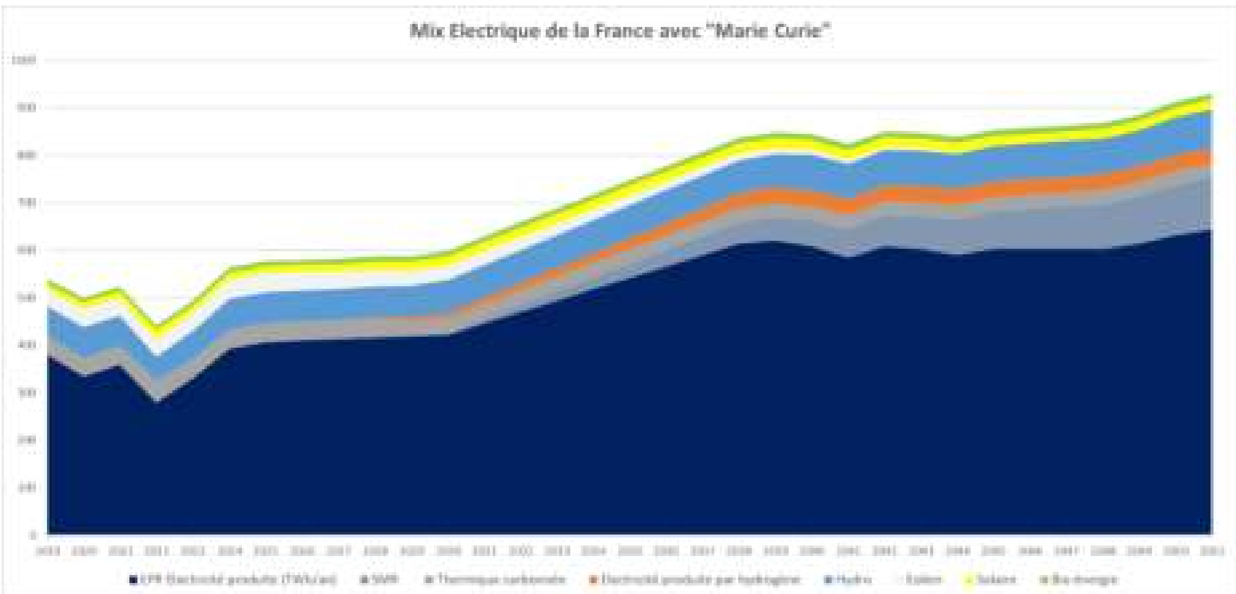

The RN plan relies on a much denser plan, which aims to recreate a real nuclear sector throughout the 21st century with a regular and certain load plan:

- 5 pairs of EPR reactors will be launched from 2022 under the five-year period for delivery between 2031 and 2035, i.e. 9 years of work for the 1st pair. The power generation system will be able to tolerate 12 to 18 months of delay as room for manoeuvre.
- In parallel, the EPR2 program will be confirmed to finalise the studies and deliver 5 pairs between 2036 and 2040.
- From 2041, a pair of reactors, whose technology remains to be defined, will be delivered until 2050. Between 2043 and 2045, a supernumerary pair will be delivered to ensure the transition with the closure of the old fleet, unless it is possible to slightly postpone the closure beyond 60 years for a few well-preserved reactors.
- The Astrid program will be relaunched in 2022 in conjunction with foreign partners and without denying Superphénix's achievements. It must produce a prototype before 2030 and then an industrial model before 2040.
- If Astrid succeeds, the 4th generation program will take over in the 2041-2050 phase.
- At the same time, from 2022, an SMR sector will be deployed for delivery from 2030 to adjust low-carbon production upwards, in particular to put an end to the use of thermal power plants.
- Two other research programmes will be strengthened: fusion with ITER but also very high temperature reactors, which are particularly promising for producing hydrogen.

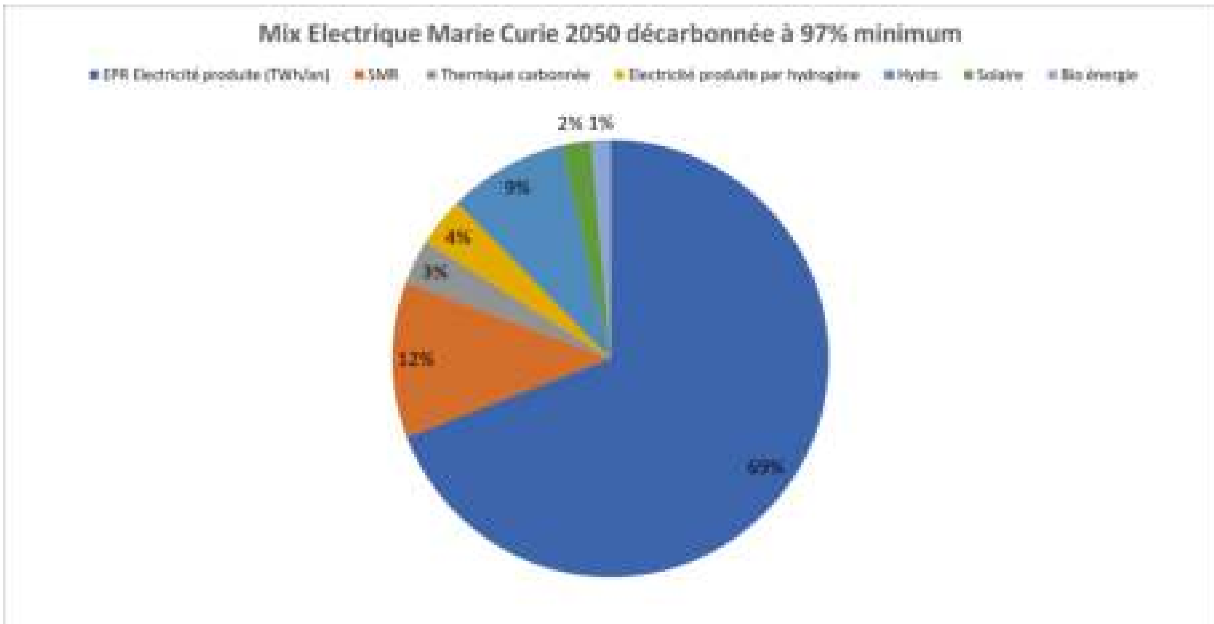
As can be seen in this graph, "Marie Curie" is deliberately oversized to keep room for manoeuvre and avoid any shortage while making electricity a remunerative export good when Europe will be in short supply because of his stupid and Malthusian choices.




The final objective is a French electricity mix that maintains nuclear power between 70 and 80% of production, adjusted on the one hand by hydroelectricity and the new hydrogen sector to ensure 600 TWh of carbon-free electricity in 2030, 770 in 2040 and 980 in 2050. Note the maximum development of French hydroelectric capacities as well as the maintenance of 20GW of solar, especially in the Overseas Territories.



In 2050, the mix is 97 to 100% carbon-free, 98% controllable, 80% nuclear.




To make the Marie Curie Plan a success, the initial reindustrialisation effort of France will focus on skills lost over the past 30 years in the sectors necessary for this nuclear industry, but also useful for other cutting-edge fields. Concentrating the nation's effort on the nuclear sector also means prioritising a sector in a rational and constant way.

The projection of France in a new nuclear industry over more than half a century will give confidence and prospects for young people to choose to train for the necessary technical and engineering professions.

In February 2022, the government submitted the three audit reports on the nuclear industry.

The considerable role of the interest rate of project financing increases the price per MWh produced from €40 to €100. Marie Curie will be financed by the French sovereign fund for a rate of 2%, i.e. an expected cost per MWh of €50, a very competitive price for reliable and controllable electricity. In addition, gains from the sale of electricity to exports will be boosted, ensuring between €100 and 120 billion over 30 years in France.

Our project must commit 150 to 180 billion euros to produce 70% of French electricity.

- Phase 2022 – 2035: The ten EPR reactors will cost between 70 and 90 billion euros, with a construction schedule of 9 to 13 years.
- Phase 2022 – 2040: the ten EPR 2 will cost between 75 and 85 billion euros, deliverable from 2036, i.e. 14 years of construction.

- Phase 2022 – 2050: Astrid is budgeted for 5 billion euros, less with pooling if foreign partnership.

The SMR Program will eventually provide 10% of electricity, i.e. 2 units of 340MW per year deployed on concentrated sites, without dispersion, for €1 billion for the first models. In the end, Marie Curie will cost €6 - 7.5 billion per year between 2023 and 2050, i.e. barely more than the annual cost of subsidies to ENRi which produce only 7% of electricity...

***Bonus program: nuclear cogeneration.***

- *A major study on nuclear cogeneration capacities to be launched without delay.*
- *Indeed, most of the heat produced by nuclear reactors is now lost.*
- *This heat could supply a district heating network, produce hydrogen and meet industrial uses.*
- *It* is *impossible today to quantify* the *potential* for *the RN group but it is certain that it is considerable.*

## II) The proposals of the RN Group

1) Immediate measures to remake the French electric model a strength for the country, its companies and its people.
2) Rebuild EDF so that the group can regain its economic efficiency and the means of its public service missions.

- EDF will reintegrate RTE and Enedis into the same group. Its total renationalisation is not necessary.
- The law will set EDF the following public service mission:

  "*Ensure that the French have reliable, controllable, low-carbon electricity that is as competitive as possible for businesses and households.*»
- The €4.5 billion in annual subsidies for onshore/offshore wind turbines and photovoltaic panels are being phased out. A moratorium is decreed, current projects cancelled.
- Abandonment of the privatization of hydroelectric dam concessions and sanctuarisation of this public good within EDF.
- The AREHN will be immediately repealed, EDF will regain full control of its electricity production from the summer of 2022. Competitors will be allowed to produce their own electricity in accordance with the technological choices made by France.
- The France will move away from the liberalised European electricity market in

favour of bilateral agreements to maintain the necessary trade with our European neighbours. The real average price replacing the marginal price.

- The price of French electricity will once again reflect the French means of production, i.e. 93% of production independent of fossil fuels.
- Companies will find a favorable regulated price, especially electro-intensive.

3) Implement an existing nuclear contingency plan

- The 12 reactor closures planned by Emmanuel Macron are cancelled in favor of a plan extending the operating life of our plants to 60 years and then 80 years.
- The dismantling of Fessenheim will be suspended, an emergency plan for recommissioning will be put in place for a reconnection to the grid in 2024 with an operating objective of 80 years.
- Regaining its financial room for manoeuvre, EDF will be able to provide the necessary means to restore a satisfactory level of availability of its power plants, i.e. 75% initially, around 400 TWh. As a reminder, the park produced 430 TWh in 2005.
- A training plan with industrial nuclear players will be organised for critical sectors with career and remuneration prospects sufficiently interesting to motivate young people.

4) Accelerating the hydrogen revolution

- The France will aim to convert all its current consumption of polluting hydrogen into green hydrogen of nuclear origin by 2030, i.e. about 1 million tonnes, mainly for industry.
- The hydrogen plan planned by the government will be accelerated to install 6 to 8 GW of electrolysers before 2027 near industrial basins such as Gravelines.
- These electrolysers will be powered by basic electricity, mainly nuclear, mechanically leading to an increase in the load factor of the reactors. To produce 1 million tons of hydrogen in the long term, it will take about 50 TWh/year.

5) Deploying renewable technologies relevant to purchasing power and ecological transition

- Small hydropower deposits, i.e. 6 to 12 TWh/year more, and geothermal energy will be upgraded, i.e. 5TWh/year more by 2027.
- All possibilities for installing new Pumped Energy Transfer Stations (STEP) will be deployed to strengthen our hydroelectric capacities to meet peaks.

- Launch operational studies on the deployment of nuclear cogeneration, with the potential of several tens of TWh per year, while significantly reducing household heating and energy bills for beneficiary industries.

**III Launch a "Marie Curie" plan capable of fulfilling social, economic and ecological objectives on the Messmer model.**

- In 2050, France will target a following electricity mix: between 70 and 80%.
- To replace the aging of the fleet while producing enough electricity for new uses, France must achieve a performance similar to the Messmer 1 plan.
- While skills and industrial tools have been degraded, the experience gained by France enable it to meet this great challenge.
- Given the strategic importance of nuclear power as the "base" of French economic power, a significant part of the initial reindustrialisation efforts will be concentrated on this project.
- The financing of the Marie Curie Plan will be financed by the French sovereign wealth fund, a long-term investment that guarantees a certain and sustainable return.

**The 1st phase (2022-2031) of the plan will consist in reviving a real sector to meet electricity needs**

- Launch 5 pairs of EPRs from summer 2022, delivered from 2031.
- Launch the EPR2 program in summer 2022, for a delivery of 5 pairs from 2036.
- The load plan aims to deliver two reactors of 1650MW per year from 2031 until 2050, the only way to have the necessary power without recourse to wind turbines on land and offshore.
- The objective will be to build these reactors within the timeframe set by the Taishan EPRs in China.
- In other words, twenty EPRs and EPR2s will be delivered between 2030 and 2040, then a total power of 32GW and an estimated production of 240 TWh.
- This phase accompanies French reindustrialisation, whose needs are estimated at between 8 and 10 TWh additional per year, or 140 to 180 TWh between 2022 and 2030.
- The 1st phase aims primarily to regain industrial control of a series production of reactors and construction of power plants for France and export.
- This ambitious plan requires strict planning for half a century. It will prioritise human and technical resources towards nuclear power, considering that energy is the basis that will allow both the improvement of living standards, the ecological

transition and global reindustrialisation.

- This planning requires the reconstitution of an industrial champion. All of Alstom's energy activities will be bought by the French sovereign wealth fund and then merged with Framatome.
- A "national centre of excellence" will bring together all relevant subcontractors and training organisations in order to upgrade French human resources, skills and technologies.

**The 2nd phase (2031 - 2040) is the operational deployment of the launched programs.**

- From 2025, it can be estimated that the means of mass production of EPRs will be operational, then those of EPR2 around 2030.
- The objective is to launch and install each year, a pair of reactors representing 24 TWh/year of production.
- 20 reactors will therefore have been commissioned while the first reactors of the historic park will be closed from 2039.
- Before 2045, at least one year of 4 reactors would have to be supplied.
- From 2040, the installed reactor technology may no longer be an EPR.

**The 3rd phase (2040-2060) will complete the reindustrialisation, deployment of the 4$^{th}$ generation of reactors and the finalisation of the hydrogen economy.**

**IV In parallel with Marie Curie, France will launch several technology initiatives and partnerships from 2022.**

1) France can be the big winner of decarbonisation and European autonomy thanks to nuclear power:
    - "Marie Curie" will be proposed to our European allies who so wish. This partnership will aim to deploy on the continent a nuclear sector large enough to create economies of scale and synergies of skills.
    - The United Kingdom has already embarked on an EPR program, Poland and Italy have urgent and massive needs to get out of their dependence on fossil fuels and energy imports.
    - In this respect, the Euratom Treaty, stillborn because of Germany, could be revived, being initially one of the three pillars of European construction.
    - The reinforcement of the French nuclear fleet, like a nuclear "water tower", will

give our country the keys to the energy balance of the continent undermined by the impasse of the ENRi/fossil fuel mix.

2) The France will regain the initiative in civil nuclear innovation that it lost to Russia and China.

   - Accelerate the development of SMRs based on French successes in the nuclear propulsion of the Charles de Gaulle and our submarines.
   - These SMRs will be useful to complete the 1st phase of the Marie Curie Plan, because it is less cumbersome to build than an EPR, while being particularly suitable for hydrogen production.
   - Relaunch the Astrid project via the CEA, with a Generation 4 industrial prototype reactor with supergeneration on the achievements of Superphénix unnecessarily abandoned.
   - Indeed, the supergeneration sector will make it possible to recycle a significant quantity of products of current fissions while ensuring hundreds of years of fissile material resources, including in the event of the generalisation of civil nuclear programs in the world.
   - The overgeneration sector can be accelerated through partnerships with nations that have continued research: Japan, Russia, China.
   - In connection with China, research into Very High Temperature Reactors, particularly suitable for hydrogen production, will have to be considered.
   - Guarantees will be provided that the ITER project will respect its schedule and produce its first plasma in 2025.

3) Strengthening the French fissile materials production and waste treatment sector

   - Weakened by the Areva fiasco, the French fuel and waste reprocessing sector, the best in the world, must be strengthened.
   - The revival of civil nuclear programmes and the technological breakthroughs it will inevitably provoke must question us about the storage of final waste, whose recycling and reuse in new generations of reactor can no longer be ruled out.

# CONTRIBUTION OF THE GROUP LA FRANCE INSOUMISE – NEW ECOLOGICAL AND SOCIAL POPULAR UNION

*Contribution of the LFI-NUPES group*

*Commission of Inquiry to establish the reasons for the loss of sovereignty and energy independence of France*

We welcome the important work carried out by the Committee of Inquiry. However, we regret that its work has been affected by the examination of two draft laws relating to the energy sector, which do not always allow its members to participate in hearings or to link the conclusions of the committee and legislative work .

Beforehand, the deputies of France Insoumise group were struck by the opacity surrounding the management of the nuclear issue, the preserve of the highest level of the State, as highlighted by the hearings of two former Presidents of the Republic. Many ministers interviewed, from all political sides and over the last twenty years, have found it difficult to hide their inability to act or even their ignorance of the decisions taken. **The issue of democracy and transparency therefore seems to us to be paramount**.

Secondly, the members of the LFI-NUPES Group regret that the work of the committee, and as pointed out by a number of those heard, did not give sufficient space to the **question of dependence on fossil fuels,** which are nevertheless predominant in final consumption and are primarily responsible for the failure to respect our commitments. international climate issues.

Last preliminary remark, the semantic question around the notions of "Sovereignty" and "independence" seemed fundamental to us, each agreeing on the fact that no energy allowed to be totally sovereign and totally independent. In this context, the notion of "reducing the vulnerability" of our energy system seems more appropriate to understand the issues. Basically, what could be described as "sovereignty" would therefore be the ability of the state to make its decisions independently.

Specifically on this report, we agree with a number of its recommendations:

First, **the need to take a long-term view** and anticipate **forecasts of energy needs, in particular through a programmatic law over a period of 30 years**. **The State must, in fact, once again become a strategic and planning State**.

Secondly, the report points to a strong idea: **electricity is not a good like any other.** It is a common good of primary necessity which must therefore be the subject of a **public service** through a **nationalised operator** freed from the requirements of profitability of the markets. We therefore share the

**disavowal of the energy market, the European liberalisation directives and, consequently, the opening up of EDF's capital as well as the NOME law which allowed the establishment of the ARENH.** This mechanism artificially created a competitive sector, where there was a natural monopoly, and fictitious operators who took advantage of the nuclear rent without creating any production capacity. The **idea adopted by the report of a quasi-public authority concerning hydroelectric dams seems** to **be going in** the **right direction,** to get out of the impotence into which the country has sunk over the last ten years in the face of the risks of reprisals from the European Commission.

Thirdly, we agree with the **observation of a lack of anticipation of the difficulties of the nuclear industry**, which reflects the **opacity of the sector and the unhealthy game of responsibility** between successive governments, EDF and AREVA. This opacity has been the breeding ground for a real loss of sovereignty as evidenced by the scandal revealed by Maureen Kearney regarding the contract with the Chinese company CGNPC. This lack of ambition is also the result of the lack of democratic legitimacy of decisions on the subject.

Fourthly, and we have repeatedly denounced this, **renewable energies have suffered from a clear lack of political will**, even though these technologies are increasingly reliable and efficient. to guarantee our energy independence. This desire to curb renewable energies was expressed in 2010 through a moratorium on the financing of photovoltaics. It was still palpable in our debates on the draft law on renewable energies, in particular by the introduction of a veto right in favour of local authorities. While we note with satisfaction the report's particular attention to the issue of renewable heat, it must be acknowledged that these issues have been very little addressed during the discussion of this law. The same is the question of production chains, which are essential to guarantee our sovereignty. Finally, the organisation of the deployment of renewable energies has largely suffered from a lack of planning and the place left to private actors, which means that even today the Prime Minister, Madame Borne, "*does not have a number in mind"* when it comes to investing in renewable energies. **Such a statement illustrates double standards.**

Fifthly, and this point seems central to us, sovereignty over our energy needs can only be achieved through a **major plan for sobriety**, **decarbonisation and electrification of uses,** a **necessity on which** all people have **agreed**. **auditioned**. We also highlighted this winter the lack of ambition of the plan presented, largely incantatory by relying only on incentives and never questioning our economic model of production and consumption.

On other subjects, this report seems to us to be in the middle of the river, even contradictory to its objective of strengthening sovereignty and independence in energy matters.

This is particularly **the case** with **the** recommendation **concerning the immediate suspension of ARENH. While we fully subscribe to this objective, it seems to us that it must imperatively be accompanied by a return to regulated tariffs for all by changing their method of calculation.**

The same applies to the recommendation to **put the energy directorate back within the Ministry of Industry.** While we do not dispute the eminently industrial nature of this sector, it seems to us that this paradigm shift would be a bad signal that economic criteria prevail over environmental and social aspects, placing itself in a productivist and growth logic without end.

Finally, if we share the **needs identified by** the evaluation and **study report**, **in particular** on the **needs** of the **network, on the state of EDF's fleet and on the extension and dismantling of power plants**, we believe that the report could have gone further in the recommendations in the light of all the elements that have been made available to us. This is the case with the phenomenon of stress corrosion, which does not date from 2021 and which should have been the subject of a more in-depth treatment since ASN warned in 2013 about the risk to security of supply in the event of Generic defect of the park. This element is not likely to reassure us for the future and the commissioning of new reactors. In addition, the need for special attention to welding trades and the widespread loss of competence was highlighted by the Foltz report as early as 2019. The massive use of subcontracting mentioned during the hearings does not appear in the report, which seems to us a pity, since clearly, this use has contributed to a loss of competence and therefore of sovereignty, as Barbara Pompili's report revealed. Regarding the lack of engineering on EPR2 or SMR type projects and doubts about the feasibility of these projects, EDF's CEO himself acknowledged that SMRs "*were at the preliminary definition stage."* Finally, there is the fiasco of the EPR of Flamanville 3 which, according to several interviewees, was only due to the desire to avoid a loss of competence of the sector at the cost of a considerable delay and of a historic cost without any political leader having been able to stop this project. We regret that the report merely asks for reports, **without ever advancing on the relevance and effectiveness of a technology whose mastery seems fragile.**

If the uranium cycle is mentioned in the recommendations in terms of transparency, we regret that the question of dependence on Russia is not raised as well as dependence on uranium supplier countries.

In addition, **the recommendation to implement EPRs or SMRs on new sites seems to us inopportune or even dangerous**. This recommendation goes further than what is contained in the draft law on the acceleration of nuclear procedures. It perpetuates, against all odds, the idea that we must persist in a system that is seriously flawed. Especially since this new nuclear program is not accompanied by any funding track, however colossal. Worse, we share Yves Marignac's idea that *"this reflex of reviving nuclear power and pursuing aging power plants leads to significant risks* of *dependence of the energy system on an aging and therefore increasingly vulnerable nuclear fleet"*. This return of the policy of the atom does not therefore sign an improvement in our independence but on the contrary its weakening by accentuating dependence on a predominant source of electricity production.

Particularly serious, the **recommendation** of the **report which opens** the **door to** the **merger between ASN, IRSN and CEA** even though the work of the commission has shown how much safety issues must be being the priority and that the duality of our system separating expertise/research and control/decision was valuable. Moreover, no interviewee suggested this merger. We are vehemently opposed to this. We will also recall that the High Committee for Transparency and Information on Nuclear Safety, in its March declaration, was very reserved on this subject. Finally, we regret that the risk of accident is never mentioned, even though several hearings have pointed out that reality often goes beyond fiction, reinforcing the importance of the deterministic doctrine in the approach to risk. The president of IRSN declared that *"the crises have shown that the scenarios identified at the outset, even if completed, will always be less inventive than reality"*.

**To conclude, we have identified several avenues of work from this work to strengthen our energy sovereignty.**

**We defend sovereignty as the ability of politicians to make informed and actionable decisions.** This presupposes, therefore, first of all to strengthen the democratisation of decision-making. It is therefore necessary to put an end to the stranglehold on this subject and to renounce the policies of fait accompli. The upcoming debates on the LPEC are, from this point of view, fundamental as they must breathe a different way of producing public policies involving actors, citizens and political powers. As such, and as the scenarios of RTE, ADEME and Negawatt invite us to do, the prospect of a 100% renewable energy mix must be part of the scenarios submitted to the French without being discredited by systematic way by nuclear lobbies and their relays in administrations.

Moreover, the conception of a certain form of energy independence implies both measuring the consequences over time so as not to weigh on future generations, but also, and this has not been taken into account in this work, in the very short term in view of the urgency of responding to climate challenges. France has twice been condemned for climate inaction and the prospect of building new plants in 2035 at best cannot be a relevant response.

**Sovereignty also presupposes full public control** of the **energy** sector in order to free oneself from private interests and guarantee the interest of the energy sector. In this context, the nationalisation of EDF must be able to succeed while maintaining its integrated character, in the form of a public industrial and commercial establishment, as a tool for the energy transition, with the roadmap for guaranteeing the energy mix defined by the LPEC. Such a vision supposes to bury definitively the Hercules project and the hazardous adventures of the historic operator abroad.

**Sovereignty therefore requires us to get out of the European straitjacket of liberal European** directives that have forced an opening to deadly competition weakening the incumbent operator. We must therefore **take energy out of the European market**, which is safe for our interconnections since, as Professor Percebois confirmed, '*interconnections existed* before the *Europe of energy and even before the Treaty of Rome'*.

**Finally, we propose to base this return of public control on the creation of a single, public and national purchasing buyer** based on **a** pricing of the energy produced **based on production costs. This would be articulated with the return of regulated tariffs as part of a real public energy pole**. This regulation by the State is justified by the fact that the electricity system is a whole. These objectives are part of a vision of planning to guarantee visibility, stability, response to needs, sobriety and energy sovereignty.

For all these reasons, the members of the LFI-NUPES Group voted against this report which, although it contains points of support, does not provide the State with sufficient tools for public control and confirms a highly nuclearised prism of our energy policy.

# CONTRIBUTION OF THE GROUP LES RÉPUBLICAINS

**Commission of inquiry to establish reasons the loss of sovereignty and energy independence of France**

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**Contribution of the group The Republicans – April 2023**

The work carried out for more than six months by the Commission of Inquiry to establish the reasons for the loss of sovereignty and energy independence of France was aimed at assessing the performance of public policies on energy. They have made it possible to bring out several observations about how to regain our energy sovereignty, undermined by ten years of recklessness and errors in energy policies. The current context of crisis that Europe has been experiencing for several months has highlighted the need for a strategic energy policy both in its production and distribution. The global economic recovery from Covid and the armed conflict in Ukraine have created a supply tension and therefore, a price increase that has become uncontrollable. The daily lives of the French have been severely affected this winter and companies have had to face soaring energy and raw material costs, undermining their economic model.

Yet this situation was not inevitable at first glance. Indeed, since France was a country poor in natural resources, General de Gaulle's entire policy consisted in developing nuclear and hydroelectric energy at the end of the war. Thus, the nuclear industry for civilian purposes is deployed via the "Messmer Plan" in order to no longer depend on oil-producing countries and external geopolitical hazards. The nuclear industry was then supported by all the Presidents in place, from Valéry Giscard d'Estaing to Nicolas Sarkozy via Jacques Chirac who launched the EPR plan. Our nuclear sector is a major element of our independence and security of supply in our energy mix electrical. Indeed, the share of nuclear power in the French electricity mix represents 67%, far ahead of hydropower which amounts to 13%, solar to 2.5% and wind to 8%[1].

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[1] *2020 figures, source: website* of *the Ministry of Ecology*

At a time when we are thinking about the electrification of all our daily uses, our nuclear fleet should be perceived as an energy of the future to meet the objectives of decarbonisation and growth. However, this is not the case. The successive governments of the last decade have profoundly and durably weakened the French nuclear industry. By ideology, dogmatism and electoral considerations, President François Hollande and his successor Emmanuel Macron have weakened our production by closing production capacities while cutting back on our room for manoeuvre that we had until recently. These energy choices have serious consequences: in recent months, the industry has had to reduce its production, many companies have gone bankrupt and the French have had difficulty heating themselves. The turtleneck policy advocated by the Minister of Economy and small slogans was not enough. For the first time in 43 years, we had to import mainly German electricity, produced with lignite (which is the most polluting coal) even though before 2019, we exported our electricity to the tune of 43 TWh which brought 3.6 billion euros to the coffers of the French State. The energy balance of the last decade is of course disastrous, but what is even more serious is that it is the result of bad decisions taken out of pure ideology and flippancy.

## I - Emmanuel Macron, the "at the same time" applied to nuclear power

Already in 2012, in his "60 commitments for France", candidate François Hollande promised to reduce the share of nuclear power in the electricity mix by 75% to 50% by 2025. This objective was also included in the Energy Transition Law carried at the time by its Minister of Ecology at the time, Ségolène Royal. To carry out this purely ideological trajectory, the President of the Republic François Hollande then promised the closure of the CNPE of Fessenheim and the shutdown of its two nuclear reactors, as part of the political agreement with Europe Ecology The Greens. During the hearings conducted within the framework of the Committee of Inquiry, the question of the technical and intellectual basis of such a ceiling was raised on numerous occasions. After 150 hours of hearings with experts, technicians and politicians, it is clear that this ceiling was set arbitrarily. Former Prime Minister Manuel Valls conceded during his hearing that no impact study had been carried out and nothing justified this reduction to 50%. The former Minister of Productive Recovery, Arnaud Montebourg, evoked for his part "*an agreement of corner of the table*" and readily admitted that it was a "*political marker*".

It was his successor and former Minister of the Economy, Emmanuel Macron who took over the commitments made by François Hollande in 2012. Its 2017 program included several measures including the exit from the fossil fuel France, the closure of 14 nuclear reactors, the achievement of the objective of 32% of energy produced by renewables and the reduction of the share of nuclear in the electricity mix from 75% to 50% before 2025. This objective, which was already known to be unrealistic, had been promoted with the idea of rallying the socialist and ecologist electorate, sensitive to the anti-nuclear discourse.

In addition, it is also the current President of the Republic who has definitively recorded the shutdown of the two reactors of Fessenheim. Indeed, if François Hollande had negotiated the closure of this plant in the PS/Greens agreement of 2012, no binding measure had been formalised during his five-year term. The decree closing the Fessenheim power plant was signed on 18 February 2020 by the then Prime Minister, Édouard Philippe and the Minister of Ecological and Solidarity Transition, Élisabeth Borne. Until then, it was still possible to turn back on this issue.

Also, in the light of the hearings that took place within the framework of this Committee of Inquiry, the abandonment of the ASTRID project remains an enigma because nothing justified it. The hearing of the former High Commissioner to the CEA, Yves Bréchet, is in this sense implacable: "*Unless it is assumed that no one, in the ministries and administrations*, *reads* the technical *reports,* the *decision to stop* the Astrid *project was taken with full knowledge of the facts (...) The abandonment of the sector with the judgment of Astrid* is *more than* a mistake*: it is a serious mistake*". Yet this decision was indeed taken at the highest level of the State, a decision that goes against innovation, our energy sovereignty and the mastery of the entire nuclear industry.

These major strategic mistakes, the consequences of which we are paying heavily for today, were taken under the presidency of Emmanuel Macron.

It is also noteworthy to note that since 2017, the President of the Republic has placed in the Ministry of Ecological Transition, personalities openly unfavorable to the atom: Nicolas Hulot, François de Rugy, Elisabeth Borne, Barbara Pompili.

## II – The questioning of the piloting of the ARENH

In its initial version, the law of 7 December 2010 on the new organisation of the electricity market, known as the NOME law, allows the implementation of the ARENH (regulated access to historic nuclear electricity) from 1 July 2011 until 31 December 2025.

In its article 1, the law specifies that concerning the management of volumes: *"The ministers responsible for energy and the economy may, by joint order, suspend* the *regulated access system to historic nuclear electricity and the transfer by Electricité de France of all or part of the volumes of electricity corresponding to the said device in the event of* ***exceptional circumstances*** *affecting the plants mentioned in II. »*

Also in Article 1, it is also specified that the price may be updated each year: "In order to ensure fair remuneration for Electricité de France, the price, reviewed each year, *shall be representative of the economic conditions of electricity production by the plants mentioned in II over the duration of the device mentioned in VIII. It shall take into account the addition of:*

*"1 ° A return* on *capital taking into account* the *nature of the activity;*
*" 2° Operating costs;*
*"3 ° The costs* of *maintenance investments or necessary for the extension* of the *duration of the operating authorisation;*
*"4 ° Estimated costs related to the long-term burdens on the operators of basic nuclear installations mentioned in I* of *Article 20* of *Law No. 2006-739 of 28 June 2006 on the program relating to the sustainable management of radioactive materials and waste."*

Following the accident at the Fukushima nuclear power plant in 2012, the French Nuclear Safety Authority (ASN) imposed major refit work to secure our French nuclear fleet. In accordance with Article 1 of the NOME law, the Commission de Régulation de l'Energie (CRE) then proposes an update of the ARENH tariffs to Mrs. Ségolène Royal, Minister of Ecology, Sustainable Development and Energy under the chairmanship of Mr. François Hollande.

Moreover, during his hearing on January 19, 2023, Mr. Philippe de Ladoucette, President of the CRE at that time, told our committee about the possibility of piloting the ARENH "*We have often asked this question to the executive* and the *administration between July 21*, *2014* and *the two and a half years that followed. Then the discussions dried up and we did not have the power to challenge the Government. However, you can ask Ms. Royal* that question. Mr. de Ladoucette adds, "*In addition, the idea of the annual review of ARENH was part of the law itself. Indeed*, *three years after its promulgation, a decree was* to *define* the *calculation elements in order to determine the price of the ARENH. This was* to *be* the subject of a *proposal from* the *CRE to* the *executive and* the *content of this decree is mentioned in the CRE deliberation of 21 July 2014, but it then disappeared. The absence of the annual revaluation of the ARENH price finally created a relatively significant problem for EDF from the moment when prices on the wholesale market increased. Therefore, this is more a matter for the executive and the European Commission.*»

Since 2014, successive governments under the Presidencies of François Hollande and Emmanuel Macron have therefore taken no decision on the management of ARENH both on volumes and price: with regard to the initial volume 100 terawatt hours, or 25% of the 400 terawatt hours produced by EDF at the time, whereas today

EDF produces only 240 terawatt hours of nuclear electricity following safety obligations requiring the major refit, plant maintenance obligations and stress corrosion incidents.

The Republican Deputies adopted, against the advice of the Government in July 2022 during the discussion on the Draft Law *on emergency measures for the protection of purchasing power*, a measure increasing the ARENH tariff to at least €49.5 per megawatt hour before January 1, 2023. It should be noted on this point that the Government has not yet taken the necessary steps to implement the increase in this new tariff.

**Nine years without an annual revaluation of ARENH, both in terms of volumes and prices, have finally created a significant problem for EDF** from the moment wholesale market prices have risen. In addition, today Mr. Luc Rémont, CEO of EDF, tells us that EDF's production cost is €135 per megawatt hour.

<u>III - Third lesson: regaining our mineral sovereignty</u>

At the hearing of Mr Christophe Poinssot, Deputy Director General and Scientific Director of the Bureau of Geological and Mining Research (BRGM), it was confirmed that **France had completely lost its mineral sovereignty**, extractive activities and initial processing having been transferred to countries with low labour costs and less attentive in terms of environmental standards.

This strong dependence on Asia, Central America or Africa greatly weakens us since it has a direct impact on the sustainability of the skills and on the industrial fabric related to these mineral resources. And the absence of an extractive industry in metropolitan France has even changed the way our society looks at this industry, thinking it outdated and not respectful of the environment.

However, many metals will be needed to meet our needs in terms of carbon-free and digital energy: by 2050, it is recognised that it will be necessary to produce more mineral resources than since the beginning of humanity. It therefore seems essential today to secure the supplies of metals that we will need in the years to come, to (re)**develop a French mining industry**.

And this, especially since the **resources are there: France is endowed with soils rich in metals** (lithium, tungsten, zinc, gallium ...), **with a strong potential in the Massif Central** or in Brittany. There are many sources of economic interest on our territory. We must reinvestigate our subsoil, relocate by assuming the needs of mineral resources necessary for the choices of our society and thus regain mineral sovereignty.

Rather than transferring this activity to the other side of the world, in conditions that are difficult to control in terms of environmental damage, it is probably wiser to **develop this mining industry on our territory, minimising as much as possible its environmental impact** by respecting the standards applicable to responsible mining. Companies specialising in this field are now developing very promising exploitation projects reconciling resource extraction and reducing the environmental footprint.

Obviously, minimising the environmental impact necessarily has a cost, but given the economic and energy benefits, **it seems appropriate to bear these costs** and assume the financial risk associated with them. It will also be necessary to consider consultation processes with local populations to get these new projects accepted, involve them and demonstrate pedagogy in order to build in connection with these local populations.

Moreover, like what Spain or the Scandinavian countries are doing today, it is important to remember that it is quite possible to **reconcile the development of the mining industry with that of green energies: these two trajectories are not contradictory**.

Finally, to promote the emergence of a new mining industry in France, it will obviously be necessary to **proceed beforehand to a new "mining** inventory**",** that is to say a referencing of the resources available in the French subsoil. The last inventory we have dates back about fifty years, and it was carried out with the technological means of the time, therefore limited means. It provides details of resources up to a depth of only 300 meters, while it is now possible to extract ores up to 1000 meters deep.

In this sense, the mineral resources observatory will soon be re-established and in this context a new mining inventory will be launched. The cost of this new inventory - which would cover the entire territory - is estimated by the BRGM at €70 to 100 million over five to ten years. However, a significant part of this cost is represented by airborne prospecting, which involves flying aircraft and helicopters equipped with sensors to collect information on the structure of the subsoil. However, as the BRGM rightly points out, the information collected would also make it possible, through a domino effect, to better understand our subsoil and could thus benefit much larger sectors than just the mining inventory. We could thus make progress in the knowledge of water resources, natural hazards, or land use planning.

Even if it is certain that the French subsoil will not be able to ensure the supply of all the resources we will need and that imports will remain necessary, we have under our feet a mining treasure that it would be a shame not to exploit. It is therefore **a**

**whole** sector to **start** and **specialised** French **companies are ready to participate in this effort to reindustrialise and develop the mining energy sector.**

IV – The volatility of public opinion on nuclear power under the influence of NGOs

Political time is not industrial time. An industry sector is created and built over a long period of time that far exceeds a decade. It is therefore not analogous to the time of political decision-making that citizens want fast, with immediate and sometimes radical effect while energy requires constancy and prospecting.

However, tragic nuclear accidents have shaken up the citizen's relationship of trust in civil atomic energy. Chernobyl or more recently Fukushima were significant events that have permanently damaged the civil nuclear industry. Political actors then seized on this question to make it a political marker of a somewhat simplistic binary divide: "for or against nuclear power". The atom has over the last decade become an electoral issue, even though before 2012, our nuclear energy was largely consensual and accepted by society.

Beyond these tragic events that have marked people's minds, public opinion has been shaped and largely influenced by the speeches of non-governmental organisation s (NGOs), such as Greenpeace, with marked anti-nuclear positions.

With the energy crisis that we have been experiencing for several months, the French are rediscovering this carbon-free, controllable and cheap energy that is nuclear. It is striking to see in the latest opinion polls on this subject a reconciliation between the French and their historic nuclear fleet. This new attraction for the atom is also fueled by the sensitive question of the acceptability of renewable energies, which are by nature intermittent, unreliable and expensive. At a time when our uses are being decarbonised and green plans are being rolled out for industry, our nuclear sector is increasingly emerging as a solution for the future. Good. Because even if our French industry has suffered from many irrational decisions over the past 10 years, we still master the entire nuclear process: from uranium extraction to the operation of nuclear power plants, including their design and the control of the entire fuel chain.

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**To conclude**, it is certain that the various public policies pursued over the last ten years in the field of energy and the resulting decisions have put a stop to our sovereignty in this area. The positions defended during this period by our leaders now clearly threaten our energy independence.

Yet we have the means and resources to remedy this situation, which is greatly weakening our country. In order for our country to reconnect with its political destiny, we must first of all reconnect with industrial time, which is a long time. We also need to adopt an ambitious energy strategy that serves our sovereignty and national interests in this area. The beginning of the 2020 decade is marked by unexpected and major crises that have shaken the world and invite us to rethink the organisation of the economy and our trade on a global scale. The question of sovereignty must be addressed in all strategic areas, whether food, health, energy or industrial. It is at this price that France will regain its independence and remain in the concert of the great powers.

# CONTRIBUTION BY VINCENT DESCOEUR, FRANCIS DUBOIS AND RAPHAËL SCHELLENBERGER MEMBERS OF THE GROUP LES RÉPUBLICAINS

**Commission of inquiry to establish reasons for the loss of sovereignty and energy independence of France**

**Contribution of Members of Parliament Vincent Descoeur, Francis Dubois and Raphaël Schellenberger April 2023**

## Hydropower: breaking the deadlock to boost investment

The work carried out over six months by the Commission of Inquiry aimed at establishing the reasons for the loss of sovereignty and energy independence of France has made it possible to identify several avenues likely to allow our country to regain its energy sovereignty: among them, the **opportunity to restore hydropower to its major place among renewable energies.**

With more than 2,000 installations, **France is one of the main producers of hydropower in the European Union.** The 25.7 GW of installed capacity, including 14 GW fully flexible, represents more than 20% of total French electrical power and almost all of the electrical storage, making it the second largest source of production behind nuclear. In addition, in 2020, hydropower accounted for 49% of gross renewable electricity production in France. As a renewable and carbon-free energy, hydropower is both a tool in the fight against climate change and a factor of resilience to its effects.

Hydropower therefore represents **a strategic sector** for France, for the production of **renewable** electricity **but also for** the **management of water resources** in the territories that host the dams, with important economic and tourist stakes.

**But the** development of this energy was put on hold from the 2000s because of repeated formal notices from the European Commission which, in 2015 and then to new in 2019, urged France to open up expired concessions to competition. The French State has not responded to these injunctions to open up to competition, which the elected officials concerned by these works consider dangerous and irrational.

**Elected from the Dordogne, Lot and Rhine valleys, we reaffirm our wish that hydroelectric concessions remain in the public domain and that this national heritage, perfectly controlled by our industrialists, is thus protected.**

This grotesque situation has led to the immobility and freezing of the **development of the hydroelectric potential of France.** Indeed, due to a lack of visibility, operators had to abandon the investments and modernisation works they were considering on hydroelectric structures, which would have significantly increased their productivity and reduced their environmental impact. The RTE study "Future of Energy" presented during the hearings estimates that the production capacity of our hydroelectric installations could be increased by 15%.

**It is therefore urgent to get out of this impasse, break with the immobility** and decide as quickly as possible on a legal framework that allows our industrialists to launch in the short term the essential projects to revitalise this sector.

**We welcome proposal No. 9 of** the report of our Committee of Inquiry, which proposes to **"maintain hydroelectric concessions in the public domain by applying a quasi-governance mechanism to avoid competition."**

It is essential to enable the development of hydroelectric energy, which will play an increasingly important role, particularly because of the development of renewable energy sources that cannot be controlled.

Whatever solution is chosen, quasi-governance mechanism or even authorisation regime mentioned for a time, **we expect the executive to take a rapid decision in order to get the hydroelectric sector out of the impasse in which it finds itself and to be able to engage in investments that have been delayed for too long.**

# CONTRIBUTION FROM THE SOCIALISTS AND ALLIES GROUP

## Contribution by the Socialists and Allies Group to the report drawn up on behalf of the Committee of Inquiry into the reasons for the loss of sovereignty and energy independence of France

By Marie-Noëlle BATTISTEL and Valérie RABAULT, MNAs.

The impartiality of the report

The summary of Motion for a resolution n°218 of 5 September 2022 of the group Les Républicains, at the origin of the Commission of Inquiry in question, left no doubt as to the responsibilities that the work of this one should highlight.

François Hollande, subject to the diktat of Europe Ecologie les Verts (EELV), would bear sole responsibility for decisions that led to France in a spiral of loss of sovereignty and energy independence of which his successor, Emmanuel Macron, would have been the executioner. The choice of the time period chosen, from 2012 to the present day, was consistent with this objective but unjustifiable in view of the temporality of the issues targeted and that of the nuclear industry.

In this respect, our group is pleased to have been supported by a majority of the members of the Commission on our request for an extension of the period studied until the end of the 1990s, allowing a global vision over the last 25 years, encompassing the end of the mandate of Lionel Jospin and especially those of Jacques Chirac and Nicolas Sarkozy whom the group Les Républicains clearly aimed to absolve.

The Rapporteur, Antoine Armand, sought in Chapter II of his report to restore a balance of responsibilities between the period 2002-2012 and the period 2012-2017 more in line with the facts and their real consequences.

On the other hand, if the period after 2017 is the subject of some polite criticism, the third part of the aforementioned chapter is excessively laudatory and abandons the balance that prevailed until then within the report for an after-sales service operation of the orientations announced by the President of the Republic for a new nuclear power program.

However, this is to forget that Emmanuel Macron's "Belfort speech" only dates from February 10, 2022.

The Elysée speech of 27 November 2018, presenting the Multiannual Energy Programming 2019-2023, confirmed the objective of reducing the share of nuclear electricity in our energy mix to 50% by 2035 by closing 10 to 14 nuclear power reactors. Le Creusot's speech of 8 December 2020 reaffirmed the role of nuclear power in the French energy mix and presented the "*conditions for decision-making on the possible launch of a new construction program. reactors and on EPR2*".

Emmanuel Macron will therefore have started his first term by announcing the closure of 14 nuclear power reactors before deciding, at the dawn of the second, the potential construction of 14 new nuclear power reactors.

However, if there is one common thread running through the very many hearings carried out by our Committee of Inquiry, raised by all industrial players, it is the need for visibility and long-term stability of the choices made in the field of energy and, in particular, in the field of the nuclear industry.

Thus of all the public officials whose choices were questioned by the Commission of Inquiry, if those of Emmanuel Macron are not the most decisive, they are certainly the most erratic.

Finally, this last part of the report presents the revival of a nuclear power programme as an acquired necessity although Parliament has not yet been able to give its opinion on the programming law on energy and climate provided for in Article L. 100-1 A of the Energy Code. It is not Parliament's vocation to be satisfied with major decisions taken without it being able to give an opinion.

We therefore regret that the report did not implement a balanced assessment of Emmanuel Macron's five-year term, as it was able to do for his predecessors.

<u>The decisions that weakened EDF's ability to intervene</u>

In 1998, i.e. on the threshold of the period examined by the report of the Commission of Inquiry, the EDF group had a monopoly on electricity production in France, with a controlled debt of €22 billion for a gross operating surplus of €12 billion representing 40.7% of its turnover. A quarter of a century later, in 2022, the group's debt reaches €64.5 billion and its EBITDA is negative at -€5 billion.

First of all, the transformation of a public industrial and commercial establishment into a public limited company following the law of 9 August 2004 and the IPO on 21 November 2005 initiated the gradual dismantling of EDF's capacity.

Since then, the State, via the State Holdings Agency, has used both EDF's capital and the dividends received as a financing tool for its benefit according to the needs of the moment.

Between 2006 and 2022, EDF paid €20.4 billion in dividends to its shareholders, most of which went to the State, and up to €2.3 billion in 2008 alone, in the midst of the *subprime* crisis. This represents, almost over the same period, the final projected cost of the Flamanville EPR. Given the residual share of other shareholders, the State has therefore made short-term financial choices to the detriment of a long-term strategic vision and the company's investment capacity. In order to correct this situation, we have been led to propose on several occasions that dividends paid to the State by companies in which it is a shareholder be earmarked by decision of the Parliament, rather than being paid automatically into the general budget.

However, this IPO is only the first step in this impoverishment.

The law of 7 December 2006 on the energy sector paved the way for the opening up of the energy market to competition on 1 July 2007 and put an end in principle to EDF's monopoly. However, EDF's generation capacity and in particular its nuclear power plant of 56 reactors, most of which were depreciated, made it impossible for competitive competitors to enter the market.

Thus, by the law of 7 December 2010 on the new organisation of the electricity market, adjustments to competition between electricity producers and suppliers have been made.

It is in this context that France proposed to the European Commission a mechanism to compensate for the difference in competitiveness between EDF and its competitors by requiring the latter to supply them with a volume of nuclear electricity at a fixed tariff, according to their requests, so that they can form competitive offers for consumers.

While the report of the Committee of Inquiry rightly draws a negative assessment of this mechanism, in particular since 2019 in view of the price levels observed on the energy markets and the difficulties of availability of the nuclear power plant, it is necessary to extend the analysis of the consequences of the ARENH in the light of the Commission's purpose. investigation.

ARENH was conceived in 2010 as a mechanism for the effective and competitive entry of alternative suppliers into the French electricity market. The counterpart, inherent in the temporary and transitional nature of ARENH, which is due to expire in 2025, was the investment of these suppliers in means of production, in particular renewable ones.

However, the 2010 legislature wrongly did not make ARENH's profit conditional on such investments. Thus, these have remained almost insignificant compared to the cost that this mechanism represented for EDF between 2011 and 2020 or 5.3 billion euros (regulatory method) according to the Court of Auditors. A loss that reached 8.3 billion euros for 2022 alone due to the low availability of the park, the increase in the ARENH ceiling and exceptional prices on the energy markets.

In doing so, not only did alternative suppliers not implement sufficient renewable energy production capacity, but EDF found itself deprived of a part of its investment capacity due to the significant losses generated by ARENH, both because of the loss of potential income and because of the insufficient price to cover the actual production costs of the nuclear power plant, including future costs. With debt at the end of 2022 reaching €64.5 billion, the group is in great difficulty.

Correlative to the impact of ARENH on the development of renewable energies by the group, the latter is also faced with a wall of investments to ensure the major refit of the current fleet and the prospect of a 2nd generation EPR program.

Thus, if the current Government has announced that it does not want to oppose nuclear and renewable energies, the non-updating of the price of ARENH before January 2023 and the increase of its ceiling in 2019 in the law and then in 2022, have greatly aggravated EDF's financial situation to the benefit of competitors who have distinguished by their financial results rather than their investments in renewable energy.

While nuclear power generation increased from 380 TWh in 2019 to 280 TWh in 2022, the ARENH ceiling was raised from 100TWh to 120TWh forcing EDF to buy at a high price on the markets enough to satisfy its own customers while it sold its ARENH at a loss to Total Energies, in particular, which made €19 billion in profits in 2022.

Pending its necessary abolition, as soon as possible, the ARENH ceiling should be modulated according to EDF's projected nuclear power output compared to the average of financial years prior to 2020. Compensation could also be imposed on beneficiaries for the investments they make in their production capacities.

It is worth recalling that the 2004 law on the transformation of EDF into a public limited company and that of 2010 creating at ARENH were implemented by Nicolas Sarkozy as Minister of State, Minister of Economy, Finance and Industry and then as President of the Republic respectively.

President Emmanuel Macron also bears significant responsibility for his misuse during the 2021-2023 energy crisis, which should not be underestimated.

While some of the industrial choices of EDF itself deserve to be noted and are in the report of the Commission of Inquiry, we cannot ignore the fact that tens of billions of euros in dividends paid and income losses related to ARENH have heavily burdened EDF's finances and its ability to invest so much in its fleet. current nuclear power than potentially, future, as in renewable energies. An important part of our loss of energy sovereignty is thus the result of financial predations by EDF's main shareholder as well as its competitors.

Dispersion linked to industrial "Totems"

In a field as technologically complex and industrially heavy as nuclear energy, the attachment of some public officials to whims or symbols may have distracted from the priorities of the sector. The report of the Commission of Inquiry is no exception to this pitfall.

First, part of the report focuses on the closure of the Fessenheim power plant in 2020. While the initial decision and the reasons for the closure of the Fessenheim power plant could be criticised, it is necessary to recall that this follows a decision by Parliament to reduce the share of nuclear power in our energy mix, in the context of the law of 17 August 2015 on energy transition and green growth. We also hope that any change in these objectives will be the subject of a debate in the same way within the framework of the programming law for energy and energy. Climate forecast at most late July 1, 2023. In this respect, the closure of Fessenheim was a logical consequence of this orientation.

The choice to proceed with this before the entry into service of reactor No. 3 of Flamanville (EPR), unlike that made by François Hollande, was decided by Emmanuel Macron and cannot be attributed to his predecessor, especially since no change in the trajectory of reduction of the share of nuclear power in our electricity production had been decided at the time, on the contrary.

It is also useful to return to the Superphénix and Astrid research projects whose discontinuation has been criticised and which some would like to relaunch.

Research on fast neutron reactors with sodium coolants now benefits from a solid database and evaluations by both the Court of Auditors and Parliament.

Thus the report of 26 June 1998 made on behalf of the Commission of Inquiry of the National Assembly on Superphénix and fast neutron reactors recalled that this technology had been largely abandoned during the 1980s by the other civilian nuclear powers in view of its complexity, the low cost of supply of uranium, and the specific risks posed by the transformation of uranium-238 into plutonium and the use of liquid sodium as a coolant as the latter ignites on contact with air and explodes on contact with water. An incident related to these particularities led the Japanese Monju reactor to be dismantled 22 years after its entry into service during which it operated only 250 days at a total cost of 44.8 million euros per day of operation including the cost of dismantling.

As early as 1977 the Carter administration had banned all fuel cycles based on the use of plutonium and the *Clinch River* research reactor was abandoned in 1983.

As for the interest of the Soviet Union and then Russia in this technology, it was first motivated by the opportunity to offer military plutonium an outlet for recycling in the context of nuclear disarmament following the START II and SALT treaties.

Beyond the technological constraints, the Court of Auditors, like the above-mentioned Commission of Inquiry, stressed the excessive cost of Superphénix (28 billion francs in 1982), i.e. an additional cost of 166% compared with a "conventional" reactor of the same power.

In addition, to this very high construction cost, the report adds the insufficient economic profitability of this technology compared to that of other pressurised water reactors. In the absence of a substantial increase in the price of uranium and in view of the evolution of the cost of production of renewable energies, this insufficient profitability is not likely to have improved since then.

The revival of active research on this technology can therefore only be envisaged with a view to creating an "incinerator" aimed at treating the most important waste stockpiles radioactive and longest lived but has no medium-term industrial future for electricity production.

This dispersion of resources and the debate on projects whose appropriateness is questionable has distanced us, as sometimes the content of the report, from the major issues such as those of the fuel cycle, the management of the storage and storage of waste, or the sovereignty of our supplies. Nor did it allow the consideration of technologies other than those of EPR 2 or the RNR mentioned above.

Finally, the ideological decision in 2010 by Minister Kosciusko-Morizet to implement a moratorium on onshore wind power generation facilities has led to a major delay in the deployment of renewable energies in France, comparison of our European neighbours and is a cause of France's failure to meet its international commitments. It has also had the effect of slowing down or even blocking the development of French industrial sectors in this field, making the massification of the deployment of onshore wind energy more difficult today and more dependent, in particular, on Asian suppliers.

<u>The reasons for the loss of confidence in the capabilities of the French nuclear industry</u>

While the delays and additional costs of the Flamanville 3 EPR project have largely contributed to degrading the image of the French nuclear industry, the reasons for this failure are well identified and summarised in the Folz report.

The causes of the sector's ills, however, go far beyond this project. The rivalry that emerged between EDF and Areva in the mid-2000s had a deleterious effect on the attractiveness of the sector, the image of the two companies and on the conduct of the projects they carried. Confrontations, for example, over waste reprocessing have generated a spirit of confrontation that has weakened the export capacity of both groups with the failure of the Abu Dhabi tender.

The two companies also found themselves involved in the catastrophic management of the *Hinkley Point* EPR contract, from which EDF finally took over, following the intervention of the State, Areva's share and the carrying of the entire risk representing €25 billion.

The concomitance between these scandals and the announcements of a gradual reduction in the share of nuclear power in the French energy mix have led to a period of dips in the generational renewal of jobs and skills at EDF, as well as among its suppliers and subcontractors. Its impact will be lasting and was clearly visible in 2022 in view of the difficulties encountered by the group to cope with the planned work and those induced by understress corrosion problems.

In this regard, we regret that our planning proposals for training and education in the nuclear industry and in research have been rejected by the Government and its majority. The implementation of the large fairing and of a new nuclear power programme is illusory in the absence of an ambitious nuclear power strategy.

<u>On the blocking of hydroelectric concessions and its impact on the balancing capacity of the energy mix and therefore of our sovereignty</u>

Mostly operated by EDF, hydroelectric concessions are inherited from the law of 16 October 1919 on the use of hydropower. The abolition of the right of preference at the request of the European Commission in order to neutralise a "distortion of competition incompatible with the liberalisation of the internal market" of electricity" by the law of 30 December 2006 on water and aquatic environments paved the way for the reopening of competition of concessions hitherto passed by mutual agreement.

In 2008, the Minister of State, Jean-Louis Borloo, made a commitment to the European Commission to put these works out to tender from their expiry date.

The French hydroelectric fleet is the largest in Europe: it comprises 340 concessioned structures, with a capacity of 25.4 gigawatts (GW) and a production in 2021 of 62.5 terawatt hours (TWh), or 12% of the French electricity mix. It is mainly managed by EDF (70% of national hydroelectric production), the Compagnie Nationale du Rhône (25%) and the Société Hydro-Électrique du Midi (3%).

As recalled in the information report n°1404 of 7 October 2013 on behalf of the Economic Affairs Committee of the National Assembly: "*The integrated nature of the hydraulic park is essential to the overall performance of the French electricity* *system. In its management* of water *resources,* the *incumbent operator takes into account* the *level* of *reserves necessary to* "pass *the* peak" *of* electricity of *winter. It also takes into account the maintenance* program *of* nuclear *power plants. Turbinage decisions are therefore* not *solely based on* the market *price signal: EDF plays* the *role* of *insurer of the system that is currently not remunerated.*»

The strict application of the European framework, which France would be one of the only Member States to apply in this way because of EDF's status as a public limited company, would therefore have major consequences for our country, beyond energy issues.

Public officials have gradually identified these difficulties, leading to several postponements of the competitive tendering of expiring concessions and their gradual changeover to the rolling deadlines regime. Thirty-eight are so far and they will be sixty-one in 2025. This situation has led to a dispute between France and the European Commission.

However, this situation is very unsatisfactory. In an interim measure of 2 December 2022, the Court of Auditors highlighted the risks that this situation posed to investments in the upkeep, maintenance and development of production facilities with a high risk of deterioration of the park.

By leading to a gradual freeze of the French hydroelectric fleet, this situation undermines the central role of the park in balancing the network and runs the risk of a postponement of investments which would constitute tomorrow a wall difficult to cross for EDF in view of the aforementioned issues.

A solution, other than competitive tendering, must therefore be urgently implemented, at least for the treatment of concessions that have expired or are about to expire.

<u>The severe assessment of the so-called 'TEPCV' law</u>

The report of the Commission of Inquiry makes a harsh judgment on the law of 17 August 2015 on energy transition and green growth. While four laws (Energy and Climate, Climate and Resilience, Acceleration of Renewable Energy and Acceleration of Nuclear Procedures) have been adopted or are about to be adopted since 2019, amending each other even before the entry into force of some of their provisions and taking up again today proposals rejected yesterday, one can be surprised at the criticism thus made.

In addition, it should be recalled that this "TEPCV" law introduced important national and local management tools for the ecological transition and its programming with the creation of a national low-carbon strategy (SNBC), a multiannual energy programming (PPE), the clean mobility development strategy, annexed to the PPE, the plan to reduce air pollutant emissions, the national energy research strategy, the national biomass mobilisation strategy, regional energy efficiency plans or by strengthening and territorializing at the intermunicipal level the climate air energy plans (PCAET) which now include an air quality component.

Finally, it has set climate and energy objectives that were not called into question by the President of the Republic during the presentation of the 2019-2023 PPE, which are:

- Reduce greenhouse gas emissions by 40 % between 1990 and 2030 and divide greenhouse gas emissions by four between 1990 and 2050 (factor 4). The trajectory is specified in the carbon budgets;
- Reduce final energy consumption by 50% in 2050 compared to the 2012 benchmark by aiming for an interim target of 20% in 2030;
- Reduce primary energy consumption of fossil fuels by 30% in 2030 compared to the 2012 baseline;
- Increase the share of renewable energy to 23% of gross final energy consumption in 2020 and 32% of gross final energy consumption in 2030;
- Increase the share of nuclear power in electricity production to 50% by 2025; Some have even been strengthened under the above-mentioned laws. Thus the so-called TEPCV law has been a tipping point in the preparation of our ecological transition and if inadequacies can be opposed to it, these are very far from the analysis given in the report of our Commission of Inquiry.

Conclusion

The hearings conducted within the framework of the Commission of Inquiry clearly show that the reasons for the loss of energy sovereignty of France are multiple, complex and attributable to choices that have been the responsibility of all Governments since 2004. The wealth of the numerous hearings carried out by the Commission gives hope for the non-repetition of past mistakes and the implementation of a real strategic planning of the energy transition, from the definition of our objectives and our energy mix to the structuring of our training and industrial sectors to implement them. This is the condition for our future energy independence and security.

# CONTRIBUTION OF THE ECOLOGISTS GROUP – NUPES

*Contribution by Julie Laernoes on behalf of the Ecologist-NUPES Group*

## Introduction

First Commission of Inquiry of the XVIth legislature, on a hot and topical subject: the loss of independence and energy sovereignty of France. The blackout of half of our nuclear reactors this summer, the conflict in Ukraine and soaring electricity prices have demonstrated the energy vulnerability of European Union member states and our collective inability to wean ourselves quickly from burning fossil fuels to halt climate change. This Committee of Inquiry could and should have looked in the rear-view mirror to make it possible to clearly identify the mistakes of the past, and to understand their foundations, in order to identify avenues for our future.

The report, like the hearings, has unfortunately not escaped a political logic, that of justifying the decisions recently taken by the President of the Republic Emmanuel Macron on energy: the turn towards all nuclear. While responsibilities and the period observed have been extended, little attention has been paid to the lag in France in renewable energy and energy efficiency and sobriety policies. The focus was placed on the nuclear sector with the political agreements between the Socialist Party and Europe Ecology – The Greens as a key to entry. The closure of Fessenheim, the shutdown of the Astrid project or Superphénix were the subject of long hours of hearings in contrast to the difficulty of hearing those who advocate for reducing our energy consumption as well as the feasibility of a 100% renewable model.

Isn't consuming less energy a central issue when addressing the issue of France's energy independence and sovereignty? Is not depending on the resources present in our country, namely renewable heat, geothermal, wind and solar, a priority? The objective of the Commission of Inquiry was unfortunately quite different: that of supporting an assertion widely propagated by the nuclear industry which stipulates that thanks to the nuclearisation of France, our country would be independent and sovereign in terms of energy and that the supposed weakening of our nuclear industry by the public authorities would be the reason for a loss of independence and energy sovereignty.

During the first hearings, statistical data recalling the figures of our energy consumption (the final consumption of France consists of more than 60% of fossil fuels (42% refined petroleum products, 20% of natural gas, and 1% of coal), 25% of electricity, 10% of thermal renewable energies, and 2% of marketed heat[1]) should have led us to really investigate these absolutely essential topics for the future.

## I. From the myth of independence and energy sovereignty to notions of resilience and vulnerability

From the beginning of the first hearings, a **consensus** quickly emerged among the words of many interviewees: the **sovereignty and energy independence of France do not exist and have never existed**. Many interviewees questioned the relevance of the very title of the Committee of Inquiry. The latter induces by its formulation a cognitive bias even before the examination of the real conditions of the energy situation of France.

According to Nathalie Ortar, energy anthropologist and research director at the Ministry of Ecological Transition, "*the* energy *sovereignty of France is a myth. It never existed*." In the same way, François Jacq, General Administrator of the French Alternative Energies and Atomic Energy Commission (CEA) said "*it seems* to *me that* energy *sovereignty does not* exist*; this would presuppose total autonomy*, *autarky*", and concludes that "as *soon as there is trade or exchange, we are part of a form of dependence*".

Certainly, since the industrial revolution, our economic system has been based on the import of energy raw materials: the use first of coal, then of gas and oil has fundamentally transformed our societies and lifestyles. Jean-Marc Jancovici, professor at Mines Paris, stressed that "*no country is independent or sovereign energetically*" and that "*conducting a philosophical debate on independence did not have much practical interest*". Patrick Pouyanné, Chairman and CEO of TotalEnergies, also said that "the *notion of independence*, *which has long animated French* energy *policy*, *is difficult*, *if* not *impossible to achieve, given that our country does not have on its territory all the energy it needs*".

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1 Energy transition in France, Ministry of Ecological Transition and Territorial Cohesion, Ministry of Energy Transition, https://www.ecologie.gouv.fr/transition-energetique-en-france

Xavier Jaravel, professor of economics at the London School of Economics, stressed the difficulty of achieving real energy "*sovereignty*" "*in a globalised world where everyone depends on several value chains*" and instead introduces the notion of "***resilience***", defined as "*the ability to withstand internal shocks, such as the unavailability of the nuclear fleet, and external shocks, such as a war making energy supplies difficult*".

The notion of **vulnerability** has also emerged as an alternative to the notions of sovereignty and energy independence. Jacques Percebois, professor emeritus at the University of Montpellier and director of the Centre for Research in Energy Economics and Law, insisted on the importance of distinguishing between the notions of dependence and vulnerability: "*one can be dependent without being vulnerable, and independent while by being.* He continues that "*in* the *field of fossil fuels, we have no choice: France produces neither oil, gas nor coal and therefore imports all of its consumption. [...] The role* of the *State is to take into account the risks of vulnerability.* Similarly, Yves Marignac, head of the nuclear and fossil energy division of the association négaWatt, stressed that "*sovereignty is also at stake in the level of vulnerability of our energy system, whether with regard to external hazards or the risks it generates for itself*". This terminology of vulnerability is also the one used by Nicolas Hulot, former Minister of Ecological and Solidarity Transition.

The reliability of national equipment, such as nuclear fleets, is thus clearly taken into account in the factors that influence our energy supply capacity.

## II. An exclusively nuclear focus that does not allow us to question our dependence on fossil fuels and to consider the potential of renewable energies, efficiency and energy sobriety.

We regret that, throughout the hearings, the Committee focused **almost exclusively on the nuclear issue. This bias has not allowed us to sufficiently examine** the **dependence of our economy on fossil fuels, the delay in France in in terms of renewable energies, and the need to activate the levers of energy efficiency and sobriety and to rethink our model of society.**

To examine the energy question, the nuclear angle is too narrow and confines the debate to the electrical problem. By channelling the whole debate around nuclear power and examining only the electricity part of the energy mix, the Committee of Inquiry has unfortunately overshadowed the panoply of challenges that remain to decarbonise the use of energy in France. However, it should be remembered that today, electricity represents only 25% of final energy consumption in France. And, in the projections of Réseau Transport Électricité (RTE), it is projected that electricity will account for 55% of final energy in 2050. Even with this increase, we must not lose sight of the fact that 45% of our energy will have to be decarbonised by means other than electricity. Sobriety and energy efficiency solutions will be essential to achieve carbon neutrality by 2050.

### 1. Too much dependence of France on fossil fuels

This bias and obsession with the nuclear sector has unfortunately not sufficiently allowed us to question the **dependence of our economy on** imported **fossil fuels**. As Delphine Batho, former Minister of Ecology and Patrick Pouyanné recalled, our energy mix is still 63% composed of fossil fuels. According to the Ministry of Energy Transition, our energy mix is still 41.6% dependent on refined petroleum products, 19.9% on natural gas, and 0.7% on coal[1].

Yet, as the International Atomic Energy Agency (IAEA) points out, "to *achieve a carbon-neutral global economy, it is necessary to decarbonise all sectors that currently rely heavily on fossil fuels, including heating and industrial processes requiring combustion and transport, in particular heavy transport, maritime transport and air transport*"[2]. In view of the climate and energy emergency, we deplore the short time spent discussing the decarbonisation issues of each sector, particularly those of transport, buildings, and industry. The hearing of Patrick Pouyanné, as a rare representative of the fossil fuel industry, unfortunately does not mention any outline of a plan to get rid of these energies. On the contrary, Patrick Pouyanné blindly maintains the need to continue investing in fossil fuels, oil and infrastructure such as gas terminals, in parallel with renewable energy projects.

Once again, fossil fuels and the urgency of weaning the French economy from them remain a blind spot of this Committee of Inquiry, even though our energy vulnerability is largely explained by our dependence on these energies. Indeed, as expressed by Delphine Batho, "*all the risks are associated with the fact that the main energy consumed in France is 63% of fossil origin and imported. France is at* the *mercy of rising oil prices and geopolitical dependencies induced by the desire to ensure its supply.*"

1 Energy transition in France, Ministry of Ecological Transition and Territorial Cohesion, Ministry of Energy Transition, https://www.ecologie.gouv.fr/transition-energetique-en-france

2 Beyond electricity generation : nuclear power for non-electrical applications, IAEA, December 2021, https://www.iaea.org/fr/newscenter/news/au-dela-de-la-production-delectricite-lelectronucleaire- at-the-service-of-non-electrical-applications

This dependence on imported fossil fuels, oil and gas is the primary cause of the energy crisis that France experienced in the winter of 2022/2023. In the same way, Dominique Voynet, former Minister of the Environment, highlighted our "*pathological dependence on fossil fuels*", which is barely mentioned and thought of, preventing us from sending "*the right signals*". *users and consumers with regard to, for example, the purchase of SUV (Sport Utility Vehicle) vehicles or the regulation of the aviation sector*".

**Thus, even if they can be stored, hydrocarbons only provide an illusion of sovereignty, since we do not produce them on our territory and we are perpetually forced to import them.**

Our economy remains sickly dependent on fossil fuels in the fields of transport, industry and heating: in 2020, 34.7 Mtoe (million tonnes of oil equivalent) of oil was destined for the transport sector, 9.9 Mtoe of natural gas was destined for industry and 16.3 Mtoe of natural gas was destined for the buildings sector[1].

Regarding cars, for Dominique Voynet, "the *solution does not lie in their electrification but in reducing their weight* and *in the development of public transport and softer forms of mobility*". With regard to the decarbonisation of sectors such as buildings, we need an ambitious housing renovation policy to structurally reduce energy consumption. Unfortunately, energy renovation has hardly been addressed, even though "*heating remains the first lever for reducing consumption*" of energy according to RTE[2]. Refusing to discuss key structural factors such as the need to insulate buildings and design them to anticipate climate variability is a testament to the narrow-mindedness of the Committee of Inquiry. As summed up by François Hollande, former President of the Republic, "*thermal insulation is undoubtedly the most profitable* investment *for us to have to use less electricity and energy. This would require us to be able to allocate a budget volume to this priority*."

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1 IEA, 2020, Sankey diagram, https://www.iea.org/sankey/#?c=France&s=Balance

2 RTE winter 2022/23 review, March 2023,Winter 2022-2023 review: Electricity cuts avoided thanks to lower consumption, https://www.rte-france.com/actualites/bilan-hiver-2022-2023-coupures-electricite-evitees-grace-lower-consumption#:~:text=reduction%20de%20consommation-,Bilan%20de%20l'hiver%202022%2D2023%20%3A%20Des%20cuts%20d,%C3%A0%20la%20baisse%20de%20consommation&text=RTE%20pr%C3%A9sente%20ce%20Thursday%2016,d'approvisionnement%20a%20%C3%A9t%C3%A9%20assur%C3%A9e.

Similarly, the subject of the decarbonisation of industry has barely been the subject of the committee's work. And this, even though in his conclusions the rapporteur decides to rely on the scenario Deep reindustrialisation of RTE's work, in which "*the share of manufacturing industry in GDP drops sharply to reach 12 to 13% in 2050* ". However, within RTE's work there is a Sobriety scenario, in which "*lifestyle habits evolve in the direction* of *greater sobriety of uses and consumption, causing a decrease* in *general energy needs*". This choice of the rapporteur to rely on a hypothesis of strong reindustrialisation and to rule out the possibility of tending towards greater sobriety of uses has not yet been the subject of any debate within the Committee of Inquiry, and is obviously simply based on government announcements concerning reindustrialisation of France. We deplore the rapporteur's bias in this way to virtually ignore energy efficiency and sobriety.

The hearing of Catherine MacGregor, CEO of the Engie Group, was one of the few during which the subject of the decarbonisation of industry was discussed. After praising the potential of gas decarbonisation, Catherine MacGregor nevertheless admitted in her hearing the low decarbonisation potential of gas by 2030 (only 20%) and agreed that green hydrogen is produced only in very small quantities at very high prices. The challenges of decarbonising gas and industry to inform France's energy policy unfortunately remain a blind spot for this Committee of Inquiry.

**2. A broad consensus on the need to diversify the electricity mix**

**Beyond the need to reduce our dependence on fossil fuels, a sovereign energy policy must necessarily involve diversifying the energy sources on which it is based. This diversification of the electricity mix, reflected in part by a reduction** in the share of nuclear energy in the French electricity mix, was rightly an integral part of the law on energy transition for the 2015 Green Growth (LTECV). Indeed, all experts agree on the need to diversify the electricity mix to avoid vulnerabilities related to internal shocks - such as the vulnerability of the nuclear fleet - and external shocks - such as the shutdown of Russian gas supplies.

This objective of reducing the share of nuclear power in the electricity mix to 50% was the subject of much discussion in this Committee of Inquiry. At the same time, it was abolished by the government during the examination of the draft law on the acceleration of procedures related to the construction of new nuclear installations and the operation of existing ones. This objective, which had been included in the LTECV, then postponed to 2035 by Minister Nicolas Hulot in 2015, has been repeatedly criticised and questioned by many hearings: Manuel Valls, former Prime Minister, admitted a "*political* objective", and Nicolas Hulot admitted the impossibility of meeting the 2025 target without increasing greenhouse gas emissions.

However, it seems important to us to remember the words of François Brottes, former president of RTE, former deputy, and energy advisor to François Hollande during the 2012 presidential campaign. The latter recalled that it was never a question in this law of doing without nuclear power, but of reducing the preponderance of this energy in the electricity mix in response, not to political pressures or orientations, but to a technical observation: **The dominance of the nuclear electricity mix reinforces our dependence and makes us vulnerable**, as demonstrated by this winter's crisis. Indeed, as Yves Marignac put it, "the *current situation is rather one of increased dependence on nuclear power, as evidenced by the desire to extend nuclear reactors even more.* "François Hollande also clearly explained himself during his hearing on this objective: "the *objective of 50% was not to do without nuclear power but to diversify the electricity mix and to increase renewable energies*."

Also, as many interviewees repeated, such as Pierre-Franck Chevet, former Chairman of the Nuclear Safety Authority (ASN) and Bernard Doroszczuk, current Chairman of ASN, **it is necessary to be able to preserve margins in installed nuclear production capacities. Thus the electrical system must be able to manage the shutdown of fifteen reactors at any time.** However, we were able to see in the winter of 2022 that faced with the forced shutdown of half of the nuclear fleet due to maintenance and stress corrosion, electricity production was strongly affected and reduced, and the availability rate of nuclear reactors severely degraded. This situation has posed the threat of high strains on the electricity system and induces a real risk of load shedding in the country. Remember that this was not the first time this situation had occurred; in 2009, 18 out of 58 reactors were shut down due to unexpected accidents. This structural unreliability of the nuclear fleet has been too little noted in the eyes of the Green Group.

François Brottes also recalled that the legislative translation of the 50% objective was accompanied by safeguards to ensure that the reduction in the share of nuclear energy takes place as part of the reduction of our greenhouse gas emissions: **it has therefore never been discussed in the law to reopen coal-fired power plants to compensate for the lack of nuclear energy**. All scenarios considered at the time as quite feasible the objective of reducing the share of nuclear power in the French electricity mix to 50%, while doing without new fossil fuel capacity. Thus, it is clear that, contrary to what the Committee of Inquiry has worked hard to point out, the decline in the nuclear industry is not due to the objective of reducing nuclear power. Not betting on France's energy sovereignty solely on nuclear power and diversifying the mix simply seems like common sense. **The observation after these hearings is simply that, unfortunately, beyond the political announcement, few politicians have really set about achieving this objective.**

### 3. Chronic underinvestment in renewable energy

The **chronic underinvestment of France in renewable energy** (RE) has not been thoroughly examined, as evidenced by the lack of attention paid to the subject during the hearings. As Bruno Bensasson, Chairman and CEO of EDF Renewables, noted, "*these renewable energies are absolutely necessary to reduce dependence on fossil fuels*". *All the reports of RTE or the French Environment and Energy Management Agency (ADEME) insist on the absolute need to massively develop* renewable *energies, even by providing for of nuclear power by 2050*," said Corinne Lepage, former Minister of the Environment.

Unfortunately, apart from acknowledging the delay in France in this area, very little attention was paid in the Committee of Inquiry to the challenges of the renewable energy sector. Contrary to the approach taken with regard to nuclear energy, the members of the Committee did not attempt to establish responsibility for the delay in France in meeting the targets set for renewable energy. And this while at the end of 2022, renewable energies represented only 19.1% of France's final energy consumption, compared to a commitment to reach 23% by 2020.

In contrast, Nicolas Hulot recalled that renewable energies represent 75% of electricity production in Denmark, 50% in Germany and 47% in Spain, and that these countries have a goal to reach 80% or even 100% by 2030. He also noted that by 2025, renewable energy is expected to be the world's leading source of energy.

We regret that no representative of the renewable energy sector was interviewed, except Bruno Bensasson of EDF Renewables. EDF's many representatives were mainly asked about nuclear power generation, but renewable activities such as hydropower and alternative renewable energies such as biomass, geothermal, biogas and recovered energies were not sufficiently addressed.

Little attention has been paid to the French failure to set up a real industrial sector in terms of renewable energies. The failures of the renewable industry in France and Europe were briefly mentioned by some interviewees (Nicolas Sarkozy mentioned that "*photovoltaics posed the problem of money going to China")* but not sufficiently developed to explain the delay in France in this area. More attention could have been paid to China's industrial policy regarding photovoltaic panels, which has led to a trade collapse in Europe. China has chosen to massively subsidise Chinese companies to enable them to charge prices below production costs for manufacturers and thus become competitive on the European market. This strategy, coupled with the ineffectiveness of European industrial policies, low financial investment and lack of political support from Europe towards renewable energies, explains the industrial flight of solar panel production to China. Further analysis of this failure could have made it possible to understand an essential part of the loss of energy sovereignty of France, beyond the nuclear which has concentrated the interest of the rapporteur and the chairman.

However, the lack of will and political support to push renewable energies at the whim of governments is glaring. As Corinne Lepage put it, "the *current situation is explained by the refusal to launch a real policy in favour of renewable energies. Opposition to wind power dates back* to 2005 and in ***2010, the government decided to sacrifice the French solar sector*** *simply because of the moratorium. 10,000 jobs have been lost and companies have set up shop in Europe and elsewhere*." François Hollande also admitted during his hearing that he regretted "*not having been able to further develop renewable energies to achieve our energy objectives*", saying that "*we need such a sector*".

The words of Eric Besson, former Minister of Industry and Energy, also testify to a desire of the public authorities to privilege nuclear to the detriment of renewables: "*We had such an advantage with nuclear that we could have had an interest in waiting for the marginal price of solar and wind power before rushing and take advantage of this time to create solid industrial sectors.* Fatalistic, he declares, "*despite the efforts undertaken and the sums spent, we do not have a French renewable energy sector of sufficient size*".

Eric Besson's scepticism about renewables is palpable in his words when he recounts his meeting with Commissioner Günther Oettinger ahead of the European Energy Council on 14 February 2012: *"On this day,* I ask *Commissioner Oettinger and those who are call for a strategy primarily focused on renewable energies to* *tell European citizens the truth about the consequences of increased use of fossil fuels to manage intermittency*, *on the price of electricity, on greenhouse gas emissions and the impact on our electro-intensive industries*". He even went so far as to mention "the problem of the *social acceptability of these modes of energy production*", to justify the lack of ambition of his industrial policy with regard to this sector. However, according to a Harris Interactive poll for the Ministry of Ecological Transition "71% of French people are in favour of the development of wind energy, with higher rates in regions where wind power is already developed"[1].

Nathalie Kosciusko-Morizet, Minister of Ecology under the same government as Eric Besson also conceded this desire of the State to bet everything irrationally on nuclear to the detriment of renewables: "*In the context of the Grenelle Environment Forum, most of the direct energy credits were earmarked for nuclear power*" while *"public investment programmes were not discussed in the working groups".*

Arnaud Montebourg, former Minister of Productive Recovery, said that "the *second cause of the current situation is the failure of renewable energies to replace fossil fuels*". He insists on the fact that "*renewable energies are not controllable – we do not decide the wind or the sunshine – they are expensive as nuclear and they reduce the balance of electricity exports since nuclear power makes it possible to export electricity produced by depreciated reactors, and therefore cheap*." However, Patrick Pouyanné, said that "*nuclear power, in France, is an inflexible electricity base. It is difficult to adjust the output of a nuclear power plant, unlike that of a gas plant*."

Geothermal energy has been somewhat mentioned, but treated marginally. Little attention has also been paid to hydropower, which is the second largest source of electricity generation in France behind nuclear. Hydroelectricity is nevertheless a flexible and storable source of energy, thus making it possible to deal with the imperative of a balanced electricity system and a secure grid, representing 68% of our peak capacity, according to Delphine Batho.

Furthermore, it is essential not to lose sight of the fact that renewable energies are not limited to electrical energy, i.e. wind turbines and solar panels. According to Delphine Batho, producing renewable heat and, in the years to come, renewable cold, will be absolutely essential.

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[1] Acceptability of new energy transition infrastructures: transition undergone, transition chosen? EESC opinion of March 2022: https://medias.vie-publique.fr/data_storage_s3/rapport/pdf/284603.pdf

For example, solar thermal could replace the consumption of electricity to heat water.

**Finally, according to the hearings, and contrary to what the rapporteur said, there is a very French opposition between nuclear power and renewable energies, which explains that France is the only country in Europe not to meet its renewable energy targets.**

The bias to discredit 100% renewable scenarios was palpable during the hearings. The feasibility of a 100% renewable scenario, which has been proven in the TEN scenarios, has not been the subject of further discussion. Without any real investigation or foundation, the rapporteur's remarks ("*the absence of large-scale demonstration of an electricity mix operating at 100% renewable energy*") or the description of a model for renewable energies "*highly subsidised and dependent on materials*" testify to the lack of seriousness of the light that this commission could have brought to our energy mix.

**Thus, the Committee of Inquiry has not been able to ignore its presuppositions simply wishing to affirm that 100% renewable energy is not possible and without any real basis.** Existing solutions, such as storage to ensure network flexibility in a 100% renewables system were too quickly rejected. However, Barbara Pompili, former Minister of Ecological Transition, did mention that the International Energy Agency (IEA) and RTE had submitted a report in January 2021 confirming that it was possible to achieve a 100% renewable mix by 2050.

Xavier Piechaczyk, Chairman of the Executive Board of RTE, also said during his hearing that all paths, including that of 100% renewables were possible, and that they all managed to ensure the security of supply of France. **While he acknowledged that 100% renewable scenarios posed both technical and acceptability challenges, he also noted that scenarios involving new nuclear were faced with the challenge of extending existing nuclear units, a point around which great uncertainty remains.** Xavier Piechaczyk finally recalled that the way to achieve carbon neutrality was above all a choice of society, allowed by several trajectories.

Finally, as Yves Margignac indicated in his hearing, "*the negaWatt scenario, consisting in reducing our overall energy needs* (thanks to more energy sobriety and efficiency), *and to rely on 100% renewable* energy in the long term*, carries much* *less* risk and much *more long-term energy sovereignty and security*."

### 4. The need to re-examine our model of society and move towards sobriety

Recognising the realities of the Anthropocene means putting an end to an illimitist worldview when Earth's resources are limited. The stubbornness in nuclear overcapacity perfectly illustrates the energy model chosen by France in the 1970s, which is still not questioned today.

**The model advocated by many interviewees does not call into question this race for electricity consumption and the need to rethink our uses.** From an energy point of view, however, it is essential to think systemically about how to imagine uses that consume less by design. For example, designing smaller cars impacts not only the amount of gasoline consumed, or the size of batteries, but also the amount of steel used to make them, an activity that also generates its share of greenhouse gas emissions. It would have been useful to mention that overcapacity in nuclear electricity production has France led to greater vulnerability and dependence on electricity in the winter period because of this peculiarity of electric heating, an inefficient heating method. Unfortunately, relaunching nuclear power today does not invite us to get out of this logic of permanent overconsumption of electricity, which increases our risks and our dependence in times of electrical tension.

We **also deplore the lack of attention paid to energy efficiency and energy sobriety.** Unfortunately, they are still the forgotten ones of French energy strategy. However, energy efficiency was the first potential source of domestic energy by 2020 according to the Economic, Social and Environmental Council (EESC)[1]. As RTE points out, "*actions on energy demand through lifestyles are an obvious tool for achieving carbon neutrality, which must now be systematically investigated*"[2]. According to the IEA, "*energy efficiency also reduces the likelihood of supply disruptions; The only source of energy that cannot be interrupted is energy that is not used*." [3]

1.Energy efficiency ; a source of savings; a priority objective, EESC opinion of January 2013, https://www.lecese.fr/travaux-publies/efficacite-energetique-un-gisement-deconomies-un-objectif-prioritaire

2. Energy Futures, RTE report, October 2021, https://www.rte-france.com/analyses-tendances-et-prospective/forecast-balance-2050-energy-futures#Documents

3.Energy security, IEA, https://www.iea.org/reports/multiple-benefits-of-energy-efficiency/energy-security

The notion of sobriety is also at the heart of ADEME's Transition(s) 2050 scenarios, which highlight that a reduction in energy demand from 23% to 55%, depending on the scenario, itself linked to the demand for goods and services, is a key factor in achieving carbon neutrality. The association négaWatt defines sobriety as an approach to reduce unnecessary consumption organised by a hierarchy of needs, and promoting behaviors and activities that consume little energy at the individual and collective level.

According to François Hollande, "the *big issue* is *energy sobriety*, *the one we talk about but do not see – by definition*, *indeed, there is no power plant of sobriety. energetic, but behaviors.* As Delphine Batho recalled, "*any roadmap to achieve carbon neutrality must start by halving energy consumption in France. There is no plan B for demand reduction.* Nicolas Hulot also affirmed that "*all those who have taken a little interest in the issue will say*, *the energy model of tomorrow*, *whatever it is*, *will be based on sobriety, the keystone of any success.* He also adds that "*sobriety is a condition for success. Without it, we will not be able to achieve our goals.* "

The Committee's discussions focused almost exclusively on the issue of electricity production, i.e. a focus focusing only on electricity supply. However, many solutions, which make it possible to strengthen the energy autonomy of a country and regions, are intimately linked to demand management, a subject that has been too little addressed.

The need to "*implement a global and coherent strategy aimed at sharply* reducing *individual and collective consumption*" was pointed out by Dominique Voynet. This strategy must "*mobilise all sectors of activity – industry, transport, agriculture, tertiary, housing and households – and combine energy efficiency and energy savings*". Designing energy in a transversal way across all sectors is absolutely essential to avoid that the discussion focuses only on energy production and forgets the issues of energy efficiency and structural organisation that are also crucial.

**Thus**, **this attention paid exclusively to the nuclear sector misses an essential fact, that of the model of society that we choose through our energy policy**. Beyond discussions about electricity production and efficiency measures, any serious energy strategy must raise the question of changing our uses, through profound changes in our organisation as a society to fundamentally change the way we consume, move, house and work. **Failure to address these critical questions**

**is essentially ignoring the shared scientific fact that we do not have infinite resources.**

## III. The nuclear industry did not need anyone to self-destruct

### 1.Nuclear overcapacity has made France heat-sensitive and vulnerable

Corinne Lepage recalls that exactly 50 years ago, in 1973, faced with the oil crisis and the energy management policy of the time, we actually experienced a considerable drop in consumption, leading to overcapacity and overproduction of nuclear electricity. According to Yannick d'Escatha, former general administrator of the CEA, "*in the 1990s, we talked about overproduction; at that time, 80% of the energy produced was of nuclear origin, a significant part of which was exported*."

According to Corinne Lepage, "*since it could not be stored, this electricity had to be consumed. With* the agreement of *the State, EDF has implemented a policy of very low prices to consume electricity. This* is the *reason* why *electric heating has increased* in *France and why we are experiencing a peak in consumption related to cold. 50% of the European tip is French. This political, economic and financial choice made in the 1980s led to the situation in which French households find themselves today, faced with an increase in the price of electricity, despite the government's efforts to limit it.* "The overproduction of electricity in France therefore led to a policy of very low costs, as well as to the development of the European electricity market, useful for exporting the surplus electricity we produced.

For RTE, we speak of thermosensitivity phenomenon when the electricity consumption of a country is a quantity sensitive to temperature. Energy consumption rises when it is colder, especially because of the use of electric heating. This phenomenon exists in all European countries, but it is in France that it is most marked.

As Yves Marignac points out, "*the choice of* "*all nuclear, all electric*" *has led to a massive development of electric heating, which creates an extremely important winter peak phenomenon, and a dependence on the* "*gradient thermal"*". Indeed, the energy overcapacity resulting from the nuclear programme of the 1970s encouraged France to turn to electric heating, which is known to be inherently inefficient.

The Jean Syrota report of 1988 described electric heating as a "*French particularity*" and considered that nuclear power should be used as a base for industrial and/or regular needs and not for climatic uses mainly in winter.

**We regret that the subject of French thermosensitivity has been brushed aside, even though it constitutes a major challenge specific to our country. Indeed, this historical thermosensitivity is largely responsible for our energy vulnerability, which forced us this winter to increase our use of the dirtiest fossil fuels to meet our heating needs.**

As a reminder, faced with the shutdown of many nuclear power plants this winter, the purchasing power bill of July 2022 has, to guarantee "security of supply", authorised the reopening of the Emile-Huchet coal-fired power plant in Saint-Avold (relaunched in November 2022) and the construction of an LNG terminal in Le Havre to import liquefied natural gas. Climaticide projects to respond to a lack of foresight on our energy situation.

**2.Risky foreign investment and repeated industrial failures**

Corinne Lepage cited during her hearing the 1999 report of the Parliamentary Office for the Assessment of Scientific and Technological Options (OPECST), by Robert Galley and Christian Bataille, which evoked "*the options for using the **nuclear rent***" and proposed " *to invest in the maintenance of existing plants, but warned against privatisation*." However, as Corrine Lepage points out, "*we have done the opposite*" and "*the choices that have been made of massive investments abroad have proved absolutely catastrophic*". Ms. Lepage recalls the calamitous investments in projects abroad (€5 billion for Constellation in the United States, €14 billion for the purchase of British Energy when it was initially worth only €7 or 8 billion, investments in South America). The policy of favouring nuclear investments abroad has led to a worrying loss of skills in our national sector, and to a lack of maintenance on the French nuclear fleet. **This risky export policy based on unmastered technology that began in the 1990s was counterproductive and largely contributed to the discrediting of the sector.**

This discrediting of the French nuclear industry is particularly illustrated by the **loss of a key contract** with the United Arab Emirates in 2009. Despite the proven complexity of the EPR, industrialists have shown stubbornness in this technology in order to be able to export this French technology and assert a fanciful industrial power. This relentlessness in exporting EPRs abroad without questioning this industrial and commercial strategy has led EDF to underestimate and under-anticipate maintenance needs in the French fleet, logically leading to the energy crisis we suffered in the winter of 2022/2023.

All the interviewees also acknowledged that the **rivalries between** the **leaders** of Areva and EDF, particularly Anne Lauvergeon, former president of Areva and Henri Proglio, former chairman and CEO of EDF, have contributed to export failures, but also to a hostage of political decisions **and** a weakening of the industrial capacities of the sector. Corinne Lepage noted that the Court of Auditors in 2010 presented the conflict between Areva and EDF as one of the causes of the failure of the EPR[1] sector. Eric Besson acknowledged that "*the affinities between Henri Proglio and Anne Lauvergeon were not particularly marked, which did not contribute to the serenity of the sector*". He also admitted about these tensions in the sector that "the *most damaging consequence was the loss of the Abu Dhabi tender*". Finally, for Nathalie Kosciusko-Morizet, the conflict between EDF and Areva had "*a very large share* of *responsibility*" in the failures *of the* sector, "*tense around this* conflict" and "*leading the actors to gradually isolate oneself*".

The **successive failures of the EPR abroad** (Taishan in China, Olkiluoto in Finland, Hinkley-Point in Great Britain) have also been examined and reveal the flaws of this product of the nuclear industry. The repeated delays and financial setbacks suffered by the sector testify to a lack of industrial reliability of this technology. Regarding the Finnish EPR, Corinne Lepage recalls the "*erroneous technical references; insufficient detailed studies; an unrealistic initial estimate; a lack of organisation of monitoring; contracts that have seen significant increases between* 100 *and 700%; a lack of control; a delay in* the *recognition of lack of competence; EDF's refusal to inform the Nuclear Safety Authority (ASN) in good time of the rules for the exclusion of rupture that were not respected*".

The **exaggerated complexity of the EPR's design** has been acknowledged many times. Henri Proglio notably declared that "the EPR *is an overly complicated, almost unbuildable machine, whose difficulties we see today*", continuing that "*EDF's big bosses of nuclear power had anticipated them, but the drift of organisation of the nuclear system and the predominance of Areva* in this device, for *non-technical and absurd reasons, made the EPR the only tool available in this system*".

[1]The EPR sector, report of the Court of Auditors of July 2020, https://www.ccomptes.fr/fr/publications/la-filiere-EPR

Corinne Lepage points out that "*this single bet on the EPR has correspondingly led to a lack of interest in the existing fleet and a loss of competence that we are complaining about today*".

Finally, the interviewees analysed the **industrial and financial fiasco of Flamanville**. According to Nathalie Kosciusko-Morizet, the launch of the construction of the EPR was made in an emergency in order to satisfy industrial concerns about the loss of skills in the sector. In her hearing, she stated that "*engineering debates*, *linked to the question of the market, have not been completed, in particular because the construction of the EPR appeared to be a strong political marker. Thus*, *even if the project was not mature enough, it seemed urgent to launch it*." Finally, Pierre Gadonneix, former president of EDF, acknowledged that EDF's organisational and engineering skills had declined before the construction of Flamanville, and that the consequences of the complexity of the EPR had been underestimated by engineers.

Yannick d'Escatha noted that the facilities not concerning the reactor (concrete, logistics, move-ins, coordination of trades) were considered "*simple*" and "*were neglected, which wasted a lot of time*". He also noted that "*many of the mechanical and electrical equipment installed on the site at the beginning of the works have aged due to delays; indeed, unused, they have deteriorated, which required maintenance: rust spots to be removed, dried joints to be changed*, *insulation of connectors to be reviewed, etc.*", which testifies to the poor management of the Flamanville site and explains the setbacks that have been observed. Bernard Doroszczuk notes for his part that "*Jean-Martin Folz's report highlights the lack* of *rigour in project management in the case of Flamanville*". Nicolas Sarkozy, former President of the Republic, finally conceded: "*there have certainly been weaknesses in the organisation of the monitoring of the site by EDF, which cannot be exempted".*

Faced with this observation now shared by many political, industrial, and scientific leaders, we can question the relevance of the current government to continue to persist in the path of the EPR.

### 3. The belief in an all-powerful sector that continues to fail

To explain the energy situation in winter 2022, the failures of the nuclear fleet were investigated, highlighting the **lack of anticipation of the maintenance needs related to the large refit**, both in terms of human and financial resources and in terms of schedule, and the losses of skills of the sector. We wonder why we have delayed the identification of this "*cliff effect*", which is inherent in the very nature of the nuclear fleet.

The problem of **stress corrosion**, a phenomenon discovered in October 2021 at Civaux 1, was addressed during hearings conducted with EDF representatives who tried to reassure parliamentarians in an expeditious manner. It should be noted, however, that Cédric Lewandowski, EDF's Executive Director in charge of the nuclear and thermal fleet management, confirmed that stress corrosion is a "*very serious problem and a generic defect feared from the outset by our house",* and that Karine Herviou, Deputy Director General in charge of nuclear safety at the Institute for Radiological Protection and Nuclear Safety (IRSN) admitted that the phenomenon of stress corrosion was considered to be excluded or almost, but that "*the recent event [showed] that this risk has been poorly evaluated*".

Marcel Boiteux, Chairman and CEO of EDF until 1979, explained that the longevity of the reactors was calculated for 12,000 thermal cycles, or just over 30 years. **This illustrates that stress corrosion is not a bad fate, but a logical consequence of the aging of power plants too little anticipated by industrialists**. As François Hollande points out, *"the phenomenon of corrosion and cracks is the result, not from a lack of maintenance, underinvestment, mistrust of the sector, insufficient staff, but the very design of historic power plants".* Thus, he concludes that "*the necessary extension of nuclear power plants beyond fifty years, under the control of the Nuclear Safety Authority, could not concern them all, and that closures were inevitable*". It is therefore absurd to bet on their extension, without waiting for ASN's validation, which will only be available at the end of 2026.

Moreover, if the loss of skills within the nuclear sector and its disastrous consequences on the sector have been widely discussed: renewal of generations, cost control, etc., the **massive use** of **subcontracting** is absent from the final report. As if this explicit element would be to hide conclusions to remember. However, this point seems essential and raises strong concerns raised by OPECST, which, in 2011, submitted a report on nuclear safety and the future of the sector advocating limited subcontracting. The report pointed out that on some sites, up to 8 levels of subcontracting had been observed. Since then, another report, that of Barbara Pompili in 2018 on the safety and security of nuclear installations, warned of the risk of accidents in the national nuclear fleet and the loss of skills of EDF staff, due to the increasingly "*massive*" use of subcontracting. The report recommended "*promoting the reintegration of skills within operating companies in order to contain the level of subcontracting and thus better control the management* *of sites*". Have these recommendations been taken into account? Where are we today? Unfortunately, few answers have been provided and we regret it, as this appears to be a key issue in the context of nuclear revival.

The use of subcontracting for the manufacture of replacement parts for circuits affected by stress corrosion (CCS) also raises questions. In a November 2022 report, following an October 2022 inspection at the Tectubi Raccordi plant in Podenzano, Italy, ASN noted a serious quality problem, a lack of traceability and insufficient monitoring. The replenishment of replacement parts for the circuits affected by the CCS is identical, in the absence of feedback incriminating the materials or manufacturing processes. This alarming situation, although raised during the hearing of Jean-Bernard Lévy, former Chairman and CEO of EDF, unfortunately could not be clarified.

**In view of these elements, ecologists note that the decline of nuclear power is inherent in the functioning of the sector itself. She brushed it aside and tried to minimize the many problems she had to face for years. And this, even though industrial players were noticing daily a loss of competence and a progressive deterioration of the park.**

### 3. An aging fleet unsuited to climate change

Faced with runaway climate change, environmentalists expected an extremely rigorous treatment of the question of the extension of the **plants of the current fleet**. Although the Committee of Inquiry was concerned about this, the answers provided unfortunately did not allay our fears in this regard. ASN has indeed warned of the impossibility of guaranteeing the safety of an extension of the power plants now, and of the importance of not building energy scenarios based on this hypothesis. It should be borne in mind that ASN's validation concerning the possibility of extending the plants will not be available before the end of 2026; it therefore seems foolish and extremely risky to build our energy strategy based on the risky assumption of extending existing reactors, which could imply safety risks, as Bernard Doroszczuk warned. During his hearing in the Senate in May 2022, the latter insisted on the fact that the possibility of an impossibility of extending existing reactors to more than 50 years was not sufficiently taken into account by the public authorities at the moment, and he warned that "*This scenario is unjustified at this stage and presents a risk of putting the electricity system into a dead end, in the event that the number* of *reactors capable of operating beyond 60 years is ultimately insufficient or is known only too late*."

We also regret the lack of attention paid to the **adaptation of power plants** to climate change, which leads, on the one hand, to an increase in heat waves, and on the other hand to an increase in the frequency of episodes of drought. These trends will have a direct effect on the cold source of nuclear reactors, and potentially on their availability. For example, as Philippe Sauquet, former CEO of Gas Renewables & Power of TotalEnergies acknowledges: "*the level of the Loire, which continues to fall in summer, makes it difficult for nuclear power plants to operate*".

The recent statements by the President of the Republic on an investment program aimed at saving water also raise questions about the credibility of the measures proposed by the government for the adaptation of power plants to climate change. Indeed, in his remarks he evokes an investment plan, to save water and make it possible to operate our plants much more in a closed circuit, which is not planned. Today, no budget is programmed, and none of the 53 measures of the Water Plan, unveiled on March 30, concern nuclear power. In addition, the feasibility of the measures envisaged by the President and the Government to solve the problem of water resources is questionable. Especially since the transformation of an open-circuit reactor into a closed-circuit reactor is extremely complicated and expensive, depending on the sector itself. Worse, such a measure would be counterproductive for water resources, given that in a closed circuit, a reactor consumes much more water than in an open circuit.

Since no expert or industrial player was heard on this subject in the framework of our Committee of Inquiry, it is shocking to note that the report states that there would be no problem with the use of water resources for the operation of the existing nuclear fleet and for the use of the nuclear fleet to come. Once again, this report is being used to sweep away legitimate questions that remained unanswered during the examination of the draft law on the acceleration of nuclear power.

In addition, the issue of water discharge temperature is essential for the protection of local fauna and flora. The derogations obtained by some power plants to continue discharging their cooling water at temperatures above the permitted thresholds raise serious questions about the impact on biodiversity, which is already heavily subject to water reductions in the rivers and a rise in their temperature due to heat waves and lack of precipitation. We regret that the lack of anticipation of these extreme weather events is once again making biodiversity an adjustment variable in order to maintain electricity production. Climate change also involves risks related to the flooding of nuclear power plants, which have barely been mentioned. Rising water levels and waves of marine submersion are real risks mentioned by Bernard Doroszczuk in his hearing.

To the questions asked during the hearings on the subject, we were referred to the fact that the operator was working on it without specifying the measures envisaged. Examination of the draft law on the acceleration of procedures related to the construction of new nuclear installations near sites existing nuclear power and the operation of existing installations has also failed to enlighten the national representation on the consideration of the structural effect of climate change on the functioning of the old fleet.

The recent report of March 2023 of the Court of Auditors raises that the technical and industrial challenges of nuclear power "*will have to be met in a context where the nuclear fleet is experiencing an increase in intensity and frequency of heat episodes and climate extremes*". In addition, it recalls that "*the initial design* of *the plants in the current fleet and the provisions relating to nuclear safety predate the emergence of the concept of climate change*", which is concerning, to say the least, in terms of our ability to adapt to these risks. The costs of adapting to this climate change are also monumental - "*in the order of one billion euros for the past period and about 600 million euros for the next fifteen years*" - and are not even evaluated by EDF "*completely and precisely*".

### 4. Ensuring nuclear safety

The hearings also only marginally addressed the issue of our safety model. Some interviewees mentioned the Fukushima effect on the investments needed to guarantee the safety of our power plants in the face of accident risks and to learn the lessons of this nuclear accident. The eruption of the subject of safety via the debate on the draft law on the acceleration of procedures related to the construction of new nuclear installations in the vicinity of existing nuclear sites and the operation of existing installations has provoked in particular a battle between the rapporteur and former Minister Barbara Pompili on the subject during her hearing. In any event, the work of the Committee of Inquiry has not brought this point to light and it would be presumptuous to rely on this work to justify any reform. During the hearings of Lionel Jospin and Pierre Gadonneix, however, it was clearly recalled that the confidence of the French in a robust model of safety in the most nuclearised country in the world is an essential element in the acceptability of the nuclear power in our country. Pierre Gadonneix pointed out that public opinion trusts ASN because it is recognised as independent. For him, "*this is the sine qua non condition for the* *acceptability of nuclear power*".

The Fukushima accident has, according to many interviewees, marked a turning point for the acceptability of nuclear power in public opinion, in Europe and France. Pierre-Franck Chevet declared that "the *Fukushima accident has changed the political trajectory of nuclear power*". Yves Bouvier, a university professor, stresses that "*Fukushima played a role in accelerating the nuclear phase-out in Germany and the organisation of a referendum in Italy*". For François Jacq, "*chronologically, there is a before and after Fukushima*", and for Anne Lauvergeon, former President of Areva, Fukushima has "*reshuffled the nuclear cards*". Nicolas Sarkozy stressed that in May 2011, when he announced only a few weeks after the Fukushima accident that "*we would continue* to *invest in nuclear power to develop electricity production*", he did not receive applause.

When she talks about the ultimate diesels, which could not work when the tsunami arrived, Anne Lauvergeon warns: "*There was a tendency to consider nuclear power as a technology like any other. However, nuclear power must not be trivialised; It is not suitable for all countries. You can't supply nuclear power to countries that aren't managed rationally.*" **Avoiding trivialising nuclear power at all costs and maintaining an extreme level of safety requirements therefore seems to us to be absolutely essential.**

It was the Fukushima accident that triggered many reflections on the management of nuclear accidents: according to Pierre-Franck Chevet, Fukushima has led to a worldwide and in particular France work to review the safety of reactors. As Sylvie Supervil, in charge of Nuclear and Radiology at the General Secretariat of Defence and National Security (SGDSN), points out, "*The ten years that have passed since the Fukushima accident have unfortunately been an opportunity to accumulate a fairly large amount of information on feedback, especially on post-accident management, which is heavy on this type of accident*". Yannick d'Escatha continues: "*Following the Fukushima disaster, safety reassessments were indeed carried out, with the aim of increasing the resilience of the plants*."

The fear of nuclear accidents continues to weigh on public opinion, as Philippe Sauquet demonstrates: "*In many countries, nuclear power is considered to be marginal energy. It represents 5% of the world's primary energy. The fear of accidents weighs on public opinion. The nuclear accident at Three Mile Island in the United States, those at Chernobyl and Fukushima, have struck people's minds. My friend Jean-Marc Jancovici may think that a nuclear accident will always* cause *fewer deaths than road accidents, but people are afraid, which limits the use of this energy in many countries."*

Thus, whether one is for, against or indifferent to nuclear energy, there is an indisputable consensus: to guarantee safety in a context of extension of existing power plants and construction of new nuclear reactors. Faced with the colossal challenges that lie ahead - ageing and vulnerability of power plants, industrial failures, geopolitical context, conflicts of use over resources - it is important to identify possible improvements to the current governance system to guarantee a high level of nuclear safety. **Nevertheless, any improvements to the system must not call into question the balances put in place for decades, which could raise fears of consequences for the credibility of the expertise.**

Indeed, in view of the requirements linked to the project to revive nuclear power in France, we consider it essential to preserve the main principles that ensure the robustness of our dual nuclear safety system, in order to avoid a loss of independence, transparency and very strong scientific skills in the field of expertise. The Court of Auditors also recalled in 2014 that it would be a mistake to significantly reform our current organisation of nuclear safety.

### 5. Problems inherent to nuclear power that remain unresolved

Moreover, no answer was provided by the Committee of Inquiry with regard to the host of problems and questions that remain around nuclear energy: waste, storage of spent fuel, and decommissioning.

The issue of **nuclear waste** storage has received too little attention. The Cigeo project in Bure questions the scientific basis for guaranteeing the impermeability of the site for the next 100,000 years, while accidents have occurred in other similar projects, co-operated by Orano. The hearing of Pierre-Marie Abadie, Director General of the National Agency for Radioactive Waste Management (ANDRA) did not provide answers regarding guarantees to avoid public health problems on the surface.

As Nicolas Hulot pointed out, the issue of waste is a "*philosophical*" question: "*we give power of attorney to future generations to take charge of [our waste]. We delegate this responsibility to them without their knowledge*. However, according to former minister Hulot, "*a society that claims to be civilised must assume its own* *responsibilities and be able to contain the risks associated with its activity in time and space*." In the same way, Ségolène Royal, former Minister of Ecology, Sustainable Development and Energy, recalled that "*the issue of waste is not resolved*", and questioned "*how can we consider burying waste whose lifespan reached 100,000* years*, even though the pyramids of Egypt were forgotten in 3,000 years?*". In his view, "*the burial of nuclear waste is irresponsible to future generations*" and should be morally banned. The issue of burial thus raises many technical and ethical questions, which remain unresolved, which is regrettable.

The **storage of nuclear materials** at the La Hague d'Orano and Andra sites also raises real concerns about the management of this sector. ASN Chairman Bernard Doroszczuk stressed in his hearing the lack of anticipation and delays to avoid saturation of the La Hague swimming pools. A new swimming pool should be built by EDF but will not be commissioned before 2034. The "*parades*" envisaged are cause for fear; they involve "the *densification of swimming pools (the most advanced method to date), dry storage of fuels in transport packaging and an increase in reprocessing, using more MOX in EDF* reactors". Far from being lasting solutions, these measures are temporary, as Bernard Doroszczuk reminds us, and do nothing to solve the worrying problem of the management of nuclear materials and spent fuel.

The issue of **waste and spent fuel** has been systematically brushed aside by the prospect of a **fourth generation** of nuclear reactors. In particular, the hearings focused on the closure of Superphénix and the termination of the Astrid research program. The rapporteur's conclusions seem to point to a revival of these research programmes, in order to magically solve the problem of uranium resources and rubbish. This utopian perception obscures the many obstacles to the development of fast neutron reactors that have motivated the discontinuation of previous research programs on this subject: in particular their high cost, the risks associated with sodium (which explodes on contact with water and burns on contact with air), and the inability to industrialise them. In any case, previous research programmes have not been conclusive. The rapporteur's recommendations seem to lack lucidity and are not based on tangible or conceivable facts in the medium term, and hypothetical in the long term. Thus, building on the capacity of future generations to manage the nuclear waste generated by our activities on the uncertain advances of research seems unconscious and utopian to us.

On the **decommissioning** of nuclear power plants, the hearings failed to demonstrate that we are able to anticipate the costs and means that will be necessary to dismantle the current fleet, research reactors and new nuclear reactors. However, in a March 2020 report written at the request of the Senate Finance Committee, the Court of Auditors severely judged the schedule and costs envisaged by EDF, Orano (formerly Areva) and the CEA to ensure the end of its plants and called for greater caution in cost assessment. Asked about this, Philippe Knoche, CEO of Orano, was unfortunately unable to provide reassuring elements regarding the provisioning of dismantling costs, which often tend to be much higher than initial estimates.

For example, former minister Nicolas Hulot and his chief of staff Michèle Pappalardo recalled that the former Brennilis power plant, which was shut down in the 1980s, still employs 70 people, and that the budget planned for its dismantling has already cost €850 million while it is not completed. This example illustrates how little information we have to anticipate the costs and needs in terms of decommissioning nuclear power plants.

**Relaunching a nuclear programme implies that the volumes of radioactive waste and materials from nuclear power generation and the dismantling of end-of-life reactors will multiply over the coming decades. Unfortunately, there is no viable and acceptable solution for their management, processing, and storage.** Once again, this blind spot has not been the subject of proposals or serious documentation during our work.

## IV. Thinking about the energy sovereignty of France over the long term: neither energy independence nor response to the climate crisis...

It is also important to remember that nuclear power does not bring us **any energy independence**, since the report of our work sweeps away the question of our absolute dependence on nuclear fuel.

Indeed, we import 100% of nuclear fuel, the uranium resource is no longer present on French soil. Despite a diversification strategy claimed by the government, nearly half of the natural uranium imported into France comes from Kazakhstan and Uzbekistan, a considerable part of which passes into the hands of Rosatom, the Russian nuclear firm controlled by Putin. As François Hollande points out, *"the uranium used by nuclear power plants comes from Kazakhstan, Niger and some other countries.* ***So we are never completely free and sovereign.*** *"*

In the same way, we continue to export a large part of our nuclear materials to Russia and are dependent on Rosatom for the re-enrichment of reprocessed uranium. The hearings of Jean-Marc Jancovici and François Jacq also recalled that uranium does not exist in unlimited quantities on earth, and that in the event of a strong revival of nuclear power in France and throughout the world, the question of the availability of nuclear power uranium-235 will have to be laid by the end of the century. As Nicolas Sarkozy admits, *"uranium is a big subject. There is an urgent need to think about our supply."*

Uranium mining also has harmful effects on human health and the environment, a subject which was unfortunately totally absent from the hearings, even that of Philippe Knoche, Director General of Orano.

Let us also remember that nuclear technology itself, of which France is so proud, is actually American; the Uranium-Natural Graphite Gas (UNGG) sector, developed by France in the1950s, has indeed been abandoned in favor of the American technology of Westinghouse, whose pressurised water reactors make up almost the entire French nuclear fleet, as Pierre Gadonneix recalled.

**Finally, let us remember that nuclear power in France only brings a statistical illusion of energy independence, due to a simple statistical convention**. Indeed, the energy independence rate (about 55%) is calculated without taking into account the fact that uranium is imported. As Corinne Lepage pointed out, "*the nuclear origin of our electricity is considered a source of independence in French accounting, but this is not the case in other countries, because of the absence of uranium on their territory.*" Indeed, when we calculate the rate of energy independence, we count as primary energy the heat emitted by the reactor, and not the fuel (uranium) that is used to operate it. This reasoning is based on a statistical convention of the IEA and Eurostat. Without this convention, France would actually achieve only 10 to 12% energy independence. Thus, we regret the lack of global vision and lucidity regarding the perception of energy independence that nuclear power supposedly confers. **Contrary to what the government claims, the energy independence made possible by nuclear power is a chimera.**

**Finally, we warn of the false perception that nuclear could be a relevant solution to reduce our greenhouse gas emissions in order to mitigate the effects of climate change.** Indeed, the latest IPCC report indicates that to remain under a global warming of 1.5 ° C, the peak of greenhouse gas emissions must be reached by 2025 at the latest. The delays of at least fifteen years for commissioning a new nuclear reactor do not respond to the climate emergency. Invoking the climate emergency to justify a revival of nuclear power is therefore simply intellectually dishonest and unrealistic.

New nuclear power cannot be a coherent and relevant solution in view of the urgent fight against climate change in the coming years. Only a very significant reduction in our energy consumption, and a massive use of renewable energies can allow France to drastically reduce its greenhouse gas emissions within the given time.

## Conclusion

First of all, we noted a **flagrant lack of plurality in the choice of persons heard** by the chairman and the rapporteur. All the players in the nuclear industry - EDF, Orano, ANDRA, Framatome - as well as the actors of the CEA were able to be interviewed. Personalities from the nuclear lobby such as Philippe Stohr, president of the French Energy Company Nuclear (SFEN), Bernard Fontana, member of the board of directors of the Voix du nucléaire, and Philippe Knoche, president of the SFEN from 2017 to 2019 were auditioned, where associations such as Greenpeace were not received. We therefore deplore the direction given to the report by the choice of the people to be heard and the questions put by the chairman and the rapporteur during the hearings.

We also note that the **conclusions of the report were written in advance**; they were never intended to really draw up an inventory of French energy sovereignty in order to inform the parliamentary debate on energy issues, but It is good to **give** a **guarantee to the revival of a strong nuclear programme by blaming certain political groups** for the weakness of the sector. The many hearings on fast neutron reactors that have failed in the past were also intended to motivate the revival of the Astrid research program, whose shutdown had been decided under Emmanuel Macron's five-year term.

As Dominique Voynet pointed out during his hearing, when this report will be published in April 2023, the major choices of political orientation will have already been recorded as part of a backwards parliamentary calendar, with first the law on the acceleration of procedures relating to renewable energies in December 2022, then the law on the acceleration of procedures for nuclear installations in March 2023. Finally, there remains uncertainty regarding the arrival in Parliament of the Energy-Climate Programming Act (EPCA) in the summer of 2023, accompanied by the Multiannual Energy Programming (PPE), even though it is this text that should determine the energy policy of France, and not the conclusions of a Commission of Inquiry or procedural legislative texts that have become in reality programmatic.

Finally, **we regret the unformulated but clearly felt objective of establishing political responsibilities for the so-called abandonment of the nuclear industry**. First of all, assigning the entire responsibility for the decline of the sector to political decisions is tantamount to forgetting the structural flaws of the nuclear industry. Blaming environmentalists for a five-year energy policy is absurd and bad faith. Let us recall that within the left-wing coalition of the Jean-Marc Ayrault I and II governments, only two ministers out of 34 were from Europe Ecologie-Les Verts (Cécile Duflot, Minister for Territorial Equality and of Housing, and Pascal Canfin, Minister Delegate for Development). It should be noted that neither of these two ministers had energy or nuclear power in their remit. Finally, energy policy must be thought of over the long term; examining only François Hollande's five-year term without acknowledging the fragility of the decisions taken in previous and successive governments amounts to crystallising the entire responsibility for the decline of nuclear power over a period too short for it to have significantly altered the destiny of an entire industrial sector. **In conclusion, the nuclear industry did not need policies to self-destruct, but did succeed in this exercise alone.**

**CONTRIBUTION BY Mr. SEBASTIEN JUMEL,**
**MEMBER OF THE DEMOCRATIC AND REPUBLICAN LEFT GROUP – NUPES**

## Contribution – Commission of Inquiry on energy sovereignty – GDR-NUPES group – Sébastien JUMEL

In 1946, as an extension of the ambitions of the National Council of the Resistance, France set up a large public energy sector, with two major energy production and distribution companies at the centre of this unique model: EDF for electricity; and GDF for gas. It is thanks to this choice that France has been able to guarantee its energy autonomy and its ability to have a cheap and largely carbon-free energy mix. By acquiring a real public energy service in the aftermath of the Second World War, with a protective and ambitious status for the personnel of the electricity and gas industries, France also ensured a strong public technological mastery and irreproachable safety in independent technologies, such as nuclear. An asset that has been at the service of the real economy for several decades and has been one of the determinants of our competitiveness.

However, for more than twenty years, the liberalisation of the energy market in Europe and France has profoundly transformed this framework, weakening the EDF company, privatising and carving up GDF, both stifled by the logic of the market and the policy of taking dividends of the State shareholder. Over the years, there has been an almost virtual political consensus between Governments, leading to a considerable weakening of our energy sovereignty.

In the space of twenty years, four European legislative "packages" have been adopted to reorganise energy production. The first European "package" of 1996 led to a first challenge to the monopoly of EDF and GDF on the French electricity and gas market. It imposed accounting unbundling between the various activities specific to the electricity and gas sectors and initiated the opening up of generation and supply activities to competition.

The second "package" adopted in 2003 aimed at the total opening up to competition of the supply of electricity and gas, while imposing a genuine legal separation between the different activities. EDF therefore changes its status and becomes a public limited company. Two EDF subsidiaries are created: Réseau de transport d'électricité (RTE), in charge of electricity transmission and which becomes a public limited company and Électricité Réseau Distribution France (ERDF), which became Enedis in 2016, a public limited company in charge of electricity distribution. For GDF, the fate was the same in 2006 with a transformation into a public limited company and the spin-off of storage and distribution activities.

The main measures of the "third energy package" have made it possible to deepen the separation between regulated activities (transmission and distribution) and those open to competition (generation and supply), by imposing ownership unbundling between the various actors.

The "fourth energy package" dates from 2019 and has been dubbed "Clean Energy for All Europeans". In particular, it aims to promote the development of renewable energies, energy efficiency and self-consumption schemes. Its transposition into French law was initiated with the "energy-climate" law and remains in progress.

Far from taking a strategic view of our energy sovereignty, successive governments since the beginning of the liberalisation of the energy market have taken up these injunctions of the European Commission in terms of energy, without any scientific, technical and economic analysis corroborating the benefits of competition to ensure our energy autonomy. All the transpositions have ensured unwavering compliance with the doctrine of competition and the theory of markets questionable, in defiance of any logic of industrial investment and energy transition.

The Commission of Inquiry highlighted the precise responsibilities of political actors in these decision-making processes. Processes with lasting and costly effects on our national sovereignty. Because if the energy industry is the "industry of industry", its dismantling has played a pivotal role in the flow of massive deindustrialisation of our territory.

To the detriment of a planning state, capable of supporting intelligent protectionism on our energy production technologies, political leaders have preferred a shareholder state with only support for a policy of market liberalisation and development of private actors. Also, despite the exemplary commitment of the employees of our public companies, EDF and GDF found themselves, given their respective destinies, in a very deteriorated economic, social and technological situation.

Deprived of strong public support, vertically disintegrated in favour of a "archipelisation" of the organisation of the energy sector, between supply, production, marketing, storage and distribution, companies that once enjoyed the organisational advantages of a public monopoly have lost the efficiency of unity to respond to Brussels' competitive injunctions. After having "ingested" and over-transposed more than four European legislative packages, France found itself plunged into an energetic capernaum. The new market organisation depriving EDF and GDF of past synergies and supporting the development of alternative producers to the detriment of quality of service, has largely contributed to the industrial sacrifice we have experienced.

This institutional and economic architecture was aggravated by the NOME law in 2010, which after the various laws of privatisation and dismantling of the energy sector, enshrined the organisation of the market, in particular with the introduction of the Arenh mechanism. This technocratic device, initially conceived as a pledge to the European authorities to guarantee the development of competition in electricity production, has in reality only served to deprive EDF of considerable financial resources that are nevertheless essential to the safety of the installations, to finance the activity of the company's competitors. The NOME law has also been the lever for the disappearance of the regulation of energy sales tariffs, essential elements of our price competitiveness and social shield against energy price inflation.

All governments since, from those of Nicolas Sarkozy to those of Emmanuel Macron, via François Hollande, have affirmed their tacit or enthusiastic attachments to the European energy market. A blind attachment that has largely contributed to the deterioration of access to the energy market: security of supply, prices, continuity of service are all indicators that have experienced an overall deterioration in their assessments since the beginning of market liberalisation. The massification of bad practices such as aggressive commercial canvassing by alternative suppliers are also remarkable consequences of liberalisation.

In this context, our energy sovereignty has deteriorated sharply. Several industrial flagships of energy have been sold and dismantled: Alstom, Technip, and other industries participating in the value chain of the energy industry have also been looted. Other infant industries this time were not supported, especially with regard to the so-called "renewable" part of energy. Worse, our country's inability to support the electrification of energy demand has led us into an ecological impasse.

While France had a nuclear fleet with 56 reactors that could be mobilised and could count on a strong industrial energy sector, capable of meeting the challenge of developing renewable energies, our country has given up on giving itself the means of its independence. As opposed to planning intelligent and concerted around a strong public sector, energy policy has been reduced to encouraging the anarchic development of energy production methods. Renewable energies have thus been at the forefront of a crazy commodification of energy, to the detriment of users and industrial facilities.

The abandonment of several pilot and strategic projects over the years (Superphénix, Astrid), the inclusion of a 50% ceiling in the energy mix for nuclear electricity (closure of Fessenheim and programming of closure of 14 reactors), the strategic rout of our players pilots (EDF, Engie), combined with a phenomenon of budgetary rationalisation within companies are all examples and causes that have presided over the erosion of our energy sovereignty. In addition to these deliberate actions on the part of the public authorities, there are betrayals by the private sector, encouraged by the State, as was the sale of Alstom's energy branch to the American General Electric, a real industrial and financial scandal.

However, the crisis in the industrial energy sector and our loss of sovereignty were only really visible after the price crisis in autumn 2021. Faced with unprecedented energy prices, soon reinforced by the war in Ukraine, our country quickly realized the growing dependence of our economy on imported fossil fuels. In just a few months, the rise in electricity and gas prices, whose method of calculating the price has contributed to making industrial and low-carbon energy production methods less attractive, has led France to the brink of the threat of load shedding.

At the height of the crisis, the closure of 32 reactors out of the 56 that could be mobilised for maintenance or corrosion problems, such as the delays at the Flamanville 3 site, underline the successive years of renunciation of investment in our know-how, the and research and human development and especially in the preservation of controllable means of energy production.

A dramatic situation that highlights the fact that the strength of the French energy model has hitherto been based, in large part, on a carbon-free, controllable energy mix, capable of providing cheap energy to all the players in our economy, as a strategic element for many economic sectors within industry or agriculture, in particular livestock for example.

With this in mind, the Commission of Inquiry was able to draw up the specific responsibilities of each stakeholder in the governance of the energy sector in France for twenty-five years now. The Communist deputies, attached to an integrated, innovative model rich in industrial jobs, participated in this work in conscience, carrying firm and determined questions about energy policy.

Satisfied with the extent of the work and the level of precision achieved in this Committee, the Communist MEPs nevertheless regret that a number of recommendations are not sufficiently ambitious on the organisation of the energy sector. They also deplore the fact that the proposals made do not question the entire field of energy sovereignty.

Thus, we believe that the conclusions of the Committee of Inquiry should have put forward more ambitious proposals on the organisation of the energy sector in France, in particular by questioning the form, status and means of financing to be granted to the incumbent companies, Engie and EDF, in order guarantee concrete national sovereignty. No proposal has been made to support the idea of a complete nationalisation of the energy sector, from production to final distribution.

The Committee of Inquiry could have been interested in formulating proposals on the EDF and Engie sectors to guarantee 100% public control over these structures, in particular for the sectors that create technologies – for example the Nuward sector specializing in the design of small modular reactors. In this sense, the communist deputies believe that it is urgent to enshrine in the law a new model of governance of strategic companies by strengthening in particular the existing position of the Government Commissioner within strategic companies interested in the electricity and nuclear sector, such as EDF, RTE, Enedis, Orano and Framatome. Such a provision would make it possible to formalise in the law the power of the Government Commissioner to present observations to any general assembly, and to be able to request the postponement of examination of subjects submitted to the or oppose the decisions of the deliberative bodies of these companies when the latter are not consistent with the guidelines laid down in the multiannual energy policy. It would also guarantee access to the company's information and websites to the

Government Commissioner.

A more global reflection on a renewed public governance of companies in the energy sector would have been a point of support for our reflection on the preservation of our energy sovereignty. We believe that citizen management, wages, which results in the renewal of the composition of the boards of directors of companies in the sector with the decision-making pillar of trade unions representing employees, for example, can be an element capable of better integrating sovereignty issues into company policies.

We also consider that it would have been useful if the conclusions of the Committee of Inquiry had been able to address the question of the control and development of energy sectors. For strategic reasons, it would have been wise to reflect on the integration of companies contributing to the production of our energy tools (power plant turbines, wind turbine blades, etc.) within a unified public group, which brings together all the companies in the value chain within a single consortium. Such an industrial structure could be an asset of efficiency in commercial and productive matters and it would also be likely to protect our know-how from international competition but also from the phenomena of labour aspiration between sectors. Little thought is given to the control that the State must have within companies that are part of the so-called "strategic sectors", in particular on the control of capital and foreign investment.

We regret that the conclusions of the Committee of Inquiry do not develop more proposals relating to the industrial control of all energy sectors, in particular the creation of renewable energy sectors. As our country is still largely dependent on imports in this industrial segment, the Committee did not make precise and clear recommendations on how to support a structured renewable energy sector, or proposals relating to the use of public procurement to support "made in France" productions. Amendments to the public procurement code would have been certain points of support, particularly with regard to the French photovoltaic sector.

Furthermore, we consider that, although the report of the Committee of Inquiry stresses the question of the human and organisational factor in the revival of part of the energy sector, in this case nuclear energy, it does not make a broader assessment of the overall human needs of the sector from production to marketing. In this respect, we regret that the Committee of Inquiry did not take up the proposals of the trade union organisations on the status of employees. The progressive questioning of the historical status of the electricity and gas industries is today one of the factors that explains the difficulties recruitment of the sector. However, energy sovereignty, if it passes above all through industrial organisation measures, cannot ignore the human resources necessary for its realisation.

Finally, we note the relatively conciliatory position of the Committee of Inquiry with regard to European energy policy. The translation of European injunctions has destroyed part of our energy sovereignty. However, the final report does not call into question the very role of the European energy market. The proposal to leave the ARENH for the nuclear sector is a useful and urgent proposal, but it must not hide the deeper problem posed by European competition rules on the preservation and development of our industrial tools. The abolition of regulated tariffs for the sale of gas and electricity, as well as the end of public monopolies, are all measures that have led to the "industry of industry" no longer being able to fulfil its role. In this respect, the Communist MEPs, attached to European energy solidarity, regret not to see in the list of proposals an exit from the European energy market, a framework that favours competition to the detriment of solidarity. The crisis we are experiencing would, however, have been likely to encourage the Commission to take strong measures that break with the European framework, particularly with regard to tariff policy.

## LIST OF INTERVIEWEES

*The minutes of* the *hearings are available at the following* address *:*

*https://www.assemblee-nationale.fr/dyn/16/organes/autres-commissions/commissions- Survey/EC-Energy-Independence/Documents?subDocumentType=crc*

The hearings are presented in the chronological order of the meetings of the Committee of Inquiry.

***November** 2, **2022***

– Round table bringing together Mr. Yves Bouvier, University Professor, History Research Group (GRHis), University of Rouen, and Ms. Nathalie Ortar, Energy Anthropologist, Research Director at the Ministry of Ecological Transition at LAET (Transport Economy Planning Laboratory), ENTPE/University of Lyon.

– Mr. Jean-Marc Jancovici, Professor at Mines Paris.

***November** 9, **2022***

— Round table, open to the press, bringing together Mr. Jacques Percebois, Professor Emeritus at the University of Montpellier, Director of the Center for Research in Energy Economics and Law (CREDEN), and Mr. Xavier Jaravel, Professor of Economics at the *London School of Economics*, member of the Council of Economic Analysis.

– Mr. Jean-Luc Tavernier, Director-General of the National Institute of Statistics and Economic Studies (INSEE) and Mr. Sylvain Moreau, Director of Business Statistics.

***November** 15, **2022***

– Round table, open to the press, bringing together:

• Ms. Ketty Attal-Toubert, Head of the Department of Statistics and Foreign Trade Studies (DSECE) of the Directorate General of Customs and Indirect Taxes, and her Deputy Mr. Boris Guannel;

• Ms. Béatrice Sédillot, Head of the Data and Statistical Studies Department (SDES) at the General Commission for Sustainable Development (CGDD), Ms. Bérengère Mesqui, Deputy Director of Energy Statistics and Ms. Virginie Andrieux, Office of Energy Supply Statistics;

• Mr. Tanguy de Bienassis, Finance and Investment Analyst, and Mr. Jérôme Hilaire, Investment Analyst and Supply Modeler, International Energy Agency (IEA) or International Energy Agency (IEA);

• Ms Madeleine Mahovsky, Head of the Energy Unit and Mr Gaston Bricout, Statistical Manager, Eurostat, European Commission.

***November* 17, *2022***

– Mr. David Marchal, Deputy Executive Director, Expertise and Programmes, and Mr. Patrick Jolivet, Director of Socio-Economic Studies at the Environment and Energy Management Agency or Ecological Transition Agency (ADEME).

– Mr. Nicolas de Maistre, Director of State Protection and Security, General Secretariat of Defence and National Security.

***November* 22, *2022***

– Round table, open to the press, bringing together:

• Mr. Pierre-Franck Chevet, Chairman and CEO of IFP Énergies Nouvelles and Ms. Catherine Rivière, Deputy Chief Executive Officer;

• Mr. Christophe Poinssot, Deputy Director General and Scientific Director of the Bureau de recherches géologiques et minières (BRGM), and Mr. Patrick d'Hugues, Scientific Program Director "Mineral Resources and Circular Economy".

***November* 23, *2022***

– Mr. Patrick Pouyanné, Chairman and CEO of TotalEnergies.

***November* 24, *2022***

– Mr. Marc-Antoine Eyl-Mazzega, Director of the Energy & Climate Center of the French Institute of International Relations (IFRI).

– Mr. Thomas Courbe, Director General of Enterprise and Commissioner for Strategic Information and Economic Security, Ministry of Economy, Finance and Industrial and Digital Sovereignty.

***November* 29, *2022***

– Mr. Yannick d'Escatha, former General Administrator of the CEA, and Member of the Academy of Technologies.

– Mr. Yves Bréchet, former High Commissioner for Atomic Energy, and Member of the French Academy of Sciences.

***November* 30, *2022***

– Mr. Pascal Colombani, former General Administrator of the CEA, and Member of the Academy of Technology.

***December* 1, *2022***

– Mr. Philippe Sauquet, former Managing Director Gas Renewables & Power, former member of the Executive Committee of TotalEnergies.

***December* 6, *2022***

– Ms. Catherine MacGregor, CEO of the Engie Group.

– Mr. Daniel Verwaerde, former General Administrator of the CEA, and Member of the Academy of Technology.

***December* 7, *2022***

– Ms. Stéphanie Dupuy-Lyon, Director General of Planning, Housing and Nature at the Ministry of Ecological Transition and Territorial Cohesion, and Mr. Brice Huet, her deputy.

– Mr. François Jacq, General Administrator of the French Alternative Energies and Atomic Energy Commission (CEA), and Mr. Philippe Stohr, Director of Energy.

***December* 8, *2022***

– Mr. Bernard Fontana, President of Framatome.

– Mr. Pierre Gadonneix, Honorary Chairman of Électricité de France (EDF).

***December* 13, *2022***

– Mr. Laurent Michel, Director General of Energy and Climate at the Ministry of Ecological Transition and Territorial Cohesion.

– Mr. Henri Proglio, Honorary Chairman of Électricité de France (EDF).

***December* 14, *2022***

– Mr. François Brottes, Senior Adviser at the Court of Auditors, former Chairman of the Management Board of Réseau de transport d'électricité (RTE), former Member of Parliament.

– Mr. Jean-Bernard Lévy, Honorary Chairman of Électricité de France (EDF).

***December* 15, *2022***

– Mr. Xavier Piechaczyk, Chairman of the Management Board of Réseau de transport d'électricité

– Ms. Anne Lauvergeon, former President of AREVA.
– Mr. Patrick Landais, High Commissioner for Atomic Energy.

***January* 10, *2023***

– Ms. Corinne Lepage, former Minister of the Environment.

– Mr. Pierre-Marie Abadie, Director General of the National Agency for Radioactive Waste Management (ANDRA)

***January* 12, *2023***

– Bruno Bensasson, Chairman and Chief Executive Officer of EDF Renewables**.**

– Mr. Philippe Knoche, CEO of ORANO.

– Ms Catherine Cesarsky, Member of the French Academy of Sciences, High Commissioner for Atomic Energy (2009-2012).

***January* 17, *2023***

– Round table, open to the press, bringing together representatives of EDF's Central Social and Economic Committee (CSE):

• Mr. Philippe Page Le Mérour, Secretary of the CSE Central;

• Ms Virginie Neumayer, FNME-CGT union representative at CSE Central;

• Mr. Arnaud Barlet, CFE Energies representative at CSE Central;

• Mr. Julien Laplace, elected FCE-CFDT to the CSE Central;

• Ms. Catherine Nicolas-Michon, FO Energies and Mines representative at CSE Central

***January* 18, *2023***

– Mr. Antoine Pellion, Secretary General for Ecological Planning, Energy-Transport Advisor at the Élysée (2017-2019), Energy Technical Advisor at the Ministry of Ecology (2014-2016).

***January* 19, *2023***

– Mr. Philippe de Ladoucette, former President of the Commission de régulation de l'énergie (CRE).

– Mr. Cédric Lewandowski, EDF Group Executive Vice President in charge of the Nuclear and Thermal Park Department.

– M. Benoît Ribadeau-Dumas, Chief of Staff to the Prime Minister (2017-2020) and Mr. Thibaud Normand, former Energy Technical Advisor.

***January* 24, *2023***

– Bernard Doroszczuk, Chairman of the French Nuclear Safety Authority (ASN), and Olivier Gupta, Chief Executive Officer.

***January* 25, *2023***

– Round table of energy trade unions bringing together:

• Mr. Jacky Chorin, Representative of the National Federation of Energy and Mines (FNEM FO), former EDF Director (2004-2009 and 2014-2021);

• Mr. Alexandre Grillat, National Secretary for Public and European Affairs at the CFE CGC Energies Federation;

• Mr Julien Lambert, Federal Secretary for Industrial and Energy Policy, Fédération nationale des mines et de l'énergie CGT (FNME-CGT);

• Mr. Christophe Béguinet, CFDT Energy Project Manager.

***January* 26, *2023***

– Mr. Dominique Maillard, former Chairman of the Executive Board of RTE (2007-2015).

– Mr. Jean-Louis Borloo, former Minister of State, Minister of Ecology, Energy, Sustainable Development and the Sea, in charge of Green Technologies and Climate Negotiations.

***January* 31, *2023***

– Mr. Lionel Jospin, former Prime Minister (1997-2002).

***February* 1, *2023***

– Mr. André Merlin, Honorary President of the Réseau de Transport d'Electricité (RTE).

– Mr. Yves Marignac, Head of the Nuclear and Fossil Energy Division of the négaWatt Institute

***February* 2, *2023***

– Mr. Manuel Valls, former Prime Minister (2014-2016).

– Nathalie Kosciusko-Morizet, former Secretary of State for Ecology, former Minister of Ecology, Sustainable Development, Transport and Housing (2010-2012).

***February* 7, *2023***

– Ms Ségolène Royal, former Minister of Ecology, Sustainable Development and Energy (2014-2017).

– Dominique Voynet, former Minister of Regional Planning and Environment (1997-2001).

***February* 8, *2023***

– Mr. Hervé Machenaud, Member of the French Academy of Technology, former Executive Director in charge of Production and Engineering, Director of EDF's Asia-Pacific branch (2010-2015).

***February* 9, *2023***

– Mr. Eric Besson, former Minister for Industry, Energy and the Digital Economy (2010-2012).

– Ms Delphine Batho, MP, former Minister of Ecology, Sustainable Development and Energy (2012-2013).

***February* 15, *2023***

– Ms Barbara Pompili, MP, former Minister of Ecological Transition (2020-2022).

***February* 16, *2023***

– Mr. Jean-Christophe Niel, Director General of the Institute for Radiological Protection and Nuclear Safety (IRSN), and Ms. Karine Herviou, Deputy Director General in charge of Nuclear Safety.

***February* 28, *2023***

– Mr. Nicolas Hulot, former Minister of State for the Ecological and Inclusive Transition (2017-2018), and Ms. Michèle Pappalardo, Member of the Academy of Technologies, former Chief of Staff of Mr. Nicolas Hulot.

– Mr. Luc Rémont, Chairman and Chief Executive Officer of Électricité de France (EDF).

***March* 1, *2023***

– Mr. Arnaud Montebourg, former Minister of Productive Recovery (2012-2014).

– Mr. Dominique Ristori, former Director-General for Energy at the European Commission (2014-2019).

***March* 2, *2023***

– Elisabeth Borne, Prime Minister, former Minister of Ecological and Solidarity Transition (2019-2020).

***March* 8, *2023***

– Mr. François de Rugy, former President of the National Assembly, former Minister of State, Minister of Ecological and Solidarity Transition.

***March* 16, *2023***

– Mr. Nicolas Sarkozy, Former President of the Republic.

– Mr. François Hollande, Former President of the Republic.

## ANNEXES

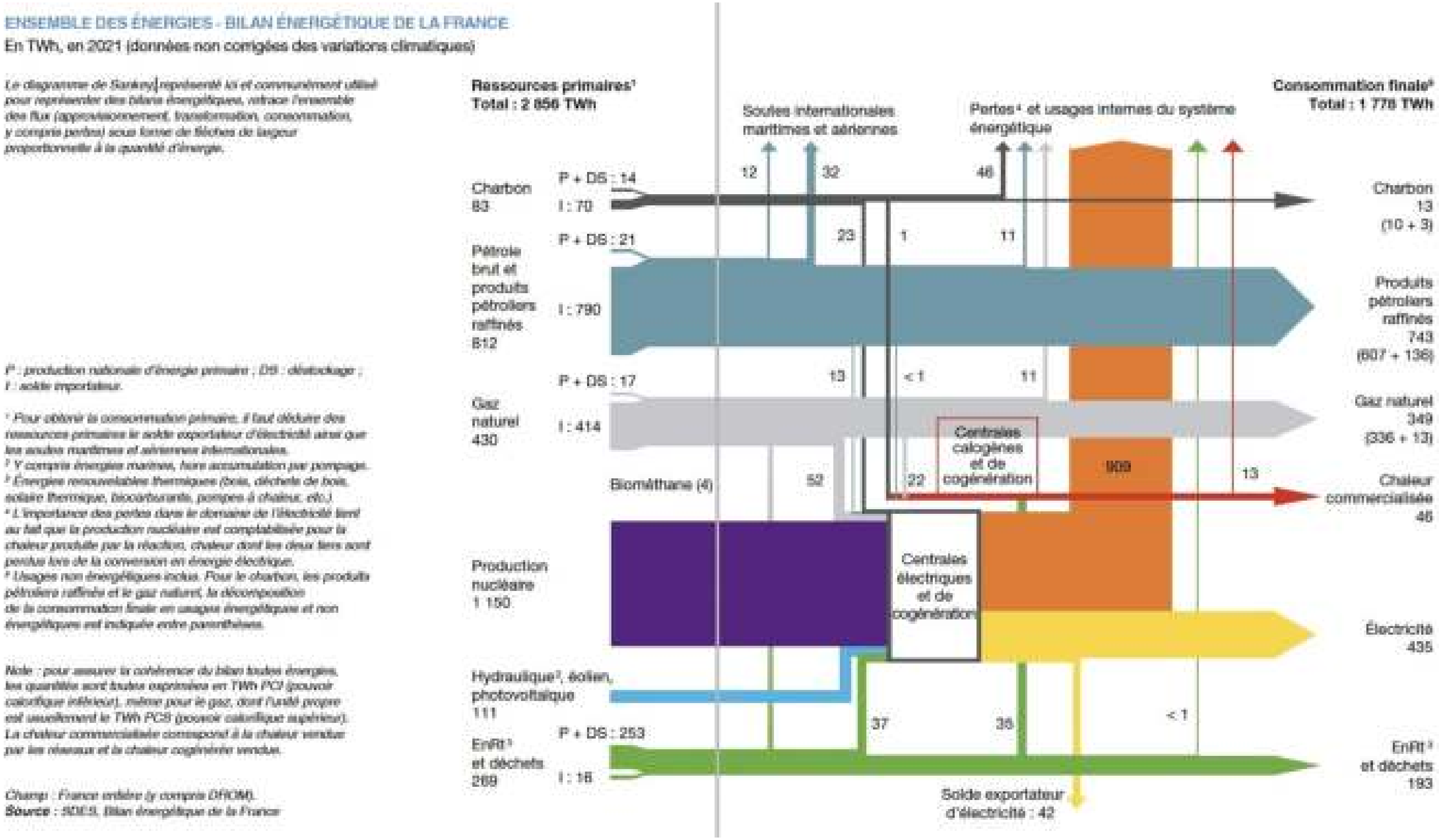
## APPENDIX 1: FRANCE'S PHYSICAL ENERGY BALANCE IN 2021 (ACTUAL DATA, IN TWH)

| | Charbon | Pétrole brut | Produits pétroliers raffinés | Gaz naturel | Nucléaire | EnR élec-triques* | EnR ther-miques et déchets** | Électri-cité | Chaleur commer-cialisée | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Production d'énergie primaire | 0,0 | 9,5 | 0,0 | 0,2 | 1 149,6 | 111,5 | 253,1 | 0,0 | 0,0 | 1 523,9 |
| Importations | 69,9 | 404,1 | 541,3 | 473,5 | 0,0 | 0,0 | 24,5 | 21,3 | 0,0 | 1 534,7 |
| Exportations | - 0,0 | - 1,3 | - 153,6 | - 59,8 | 0,0 | 0,0 | - 6,7 | - 63,7 | 0,0 | - 287,2 |
| Soutes maritimes internationales | 0,0 | 0,0 | - 12,4 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | - 12,4 |
| Soutes aériennes internationales | 0,0 | 0,0 | - 32,3 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | - 32,3 |
| Stocks*** | 13,6 | 2,9 | 9,0 | 16,4 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 41,9 |
| **Consommation primaire** | **83,4** | **415,2** | **352,0** | **430,4** | **1 149,6** | **111,5** | **268,9** | **- 42,4** | **0,0** | **2 768,6** |
| Écart statistique | 1,1 | 7,8 | - 11,3 | 1,3 | 0,0 | 0,0 | 0,0 | 1,4 | 0,0 | 0,2 |
| Production d'électricité | 22,7 | 0,0 | 12,8 | 51,7 | 1 149,6 | 111,5 | 36,9 | - 550,5 | 0,0 | 834,7 |
| Production de chaleur | 1,4 | 0,0 | 0,2 | 22,1 | 0,0 | 0,0 | 35,0 | 0,0 | - 50,2 | 8,5 |
| Injections de biométhane | 0,0 | 0,0 | 0,0 | - 3,9 | 0,0 | 0,0 | 3,9 | 0,0 | 0,0 | 0,0 |
| Raffinage de pétrole | 0,0 | 434,4 | - 428,2 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 6,2 |
| Autres transfor-mations, transferts | 32,2 | - 27,0 | 25,9 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 31,2 |
| Usages internes de la branche énergie | 12,6 | 0,0 | 9,6 | 6,5 | 0,0 | 0,0 | 0,0 | 34,0 | 0,0 | 62,7 |
| Pertes de transport et de distribution | 0,0 | 0,0 | 0,0 | 3,6 | 0,0 | 0,0 | 0,0 | 38,5 | 4,5 | 46,6 |
| **Consommation nette de la branche énergie** | **70,0** | **415,2** | **- 390,9** | **81,3** | **1 149,6** | **111,5** | **75,9** | **- 476,7** | **- 45,7** | **990,1** |
| Industrie | 9,8 | 0,0 | 32,5 | 115,3 | 0,0 | 0,0 | 22,6 | 113,0 | 18,5 | 311,7 |
| Transports | 0,0 | 0,0 | 455,7 | 3,2 | 0,0 | 0,0 | 32,7 | 9,5 | 0,0 | 501,1 |
| Résidentiel | 0,3 | 0,0 | 49,2 | 142,4 | 0,0 | 0,0 | 120,4 | 170,0 | 16,2 | 498,5 |
| Tertiaire | 0,4 | 0,0 | 32,7 | 73,2 | 0,0 | 0,0 | 12,7 | 133,7 | 10,7 | 263,4 |
| Agriculture-pêche | 0,0 | 0,0 | 36,9 | 2,3 | 0,0 | 0,0 | 4,6 | 8,1 | 0,2 | 52,1 |
| **Consommation finale énergétique** | **10,4** | **0,0** | **607,0** | **336,4** | **0,0** | **0,0** | **193,0** | **434,3** | **45,7** | **1 626,8** |
| **Consommation finale non énergétique** | **3,0** | **0,0** | **135,9** | **12,8** | **0,00** | **0,0** | **0,0** | **0,0** | **0,0** | **151,7** |
| **Consommation finale** | **13,4** | **0,0** | **742,9** | **349,2** | **0,0** | **0,0** | **193,0** | **434,3** | **45,7** | **1 778,5** |

** Énergies renouvelables électriques (hydraulique, énergie marémotrice, éolien, photovoltaïque).*
*** Énergies renouvelables thermiques (bois, biocarburants, pompes à chaleur, solaire thermique) et déchets.*
**** Les variations de stocks sont comptées positivement en cas de déstockage et négativement en cas de stockage.*

*Source: SDES, Key Energy Data , 2022*

# APPENDIX 2:  SANKEY DIAGRAM




*Source*: SDES, *Key Energy Figures*, 2022.

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# APPENDIX 3: SCHEDULE OF NUCLEAR POWER PLANTS

| Power plant | Reactor | Spinneret REP or tier | Thermal power (MWt) | Net power (MWe) | Start of construction | 1st connected to the | Commercial commissioni | Closures Start 4th$^{visit}$ Decennial in course |
|---|---|---|---|---|---|---|---|---|
| Belleville | 1 | P4 | 3817 | 1310 | 1980 | 1987 | 1988 | |
| | 2 | P4 | 3817 | 1310 | 1980 | 1988 | 1989 | |
| Blayais | 1 | CP1 | 2785 | 910 | 1977 | 1981 | 1981 | 2022 |
| | 2 | CP1 | 2785 | 910 | 1977 | 1982 | 1983 | |
| | 3 | CP1 | 2785 | 910 | 1978 | 1983 | 1983 | |
| | 4 | CP1 | 2785 | 910 | 1978 | 1983 | 1983 | |
| Brennilis | FP4 | HWGCR | - | 70 | 1962 | - | 1967 | **1985** |
| Bugey | 1 | UNGG | - | 540 | 1965 | - | 1972 | **1994** |
| | 2 | CP0 | 2785 | 910 | 1972 | 1978 | 1979 | 2020 |
| | 3 | CP0 | 2785 | 910 | 1973 | 1978 | 1979 | |
| | 4 | CP0 | 2785 | 880 | 1974 | 1979 | 1979 | 2020 |
| | 5 | CP0 | 2785 | 880 | 1974 | 1979 | 1980 | 2022 |
| Cattenom | 1 | P4 | 3817 | 1300 | 1979 | 1986 | 1987 | |
| | 2 | P4 | 3817 | 1300 | 1980 | 1987 | 1988 | |
| | 3 | P4 | 3817 | 1300 | 1982 | 1990 | 1991 | |
| | 4 | P4 | 3817 | 1300 | 1983 | 1991 | 1992 | |
| Chinon-A | 1 | UNGG | - | 70 | 1957 | - | 1963 | **1973** |
| | 2 | UNGG | - | 210 | 1959 | - | 1965 | **1985** |
| | 3 | UNGG | - | 480 | 1961 | - | 1966 | **1990** |
| Chinon-B | 1 | CP2 | 2785 | 905 | 1977 | 1982 | 1984 | 2023 |
| | 2 | CP2 | 2785 | 905 | 1977 | 1983 | 1984 | |
| | 3 | CP2 | 2785 | 905 | 1980 | 1986 | 1987 | |
| | 4 | CP2 | 2785 | 905 | 1981 | 1987 | 1988 | |
| Chooz-A | | REP | - | 310 | 1962 | - | 1967 | **1991** |
| Chooz-B | 1 | N4 | 4270 | 1500 | 1984 | 1996 | 2000 | |
| | 2 | N4 | 4270 | 1500 | 1985 | 1997 | 2000 | |
| Cities | 1 | N4 | 4270 | 1495 | 1988 | 1997 | 2002 | |
| | 2 | N4 | 4270 | 1495 | 1991 | 1999 | 2002 | |
| Creys-Malville | Superphénix - RNR | | - | 1200 | 1976 | - | 1986 | **1998** |
| Cruas | 1 | CP2 | 2785 | 915 | 1978 | 1983 | 1984 | |
| | 2 | CP2 | 2785 | 915 | 1978 | 1984 | 1985 | |
| | 3 | CP2 | 2785 | 915 | 1979 | 1984 | 1984 | |
| | 4 | CP2 | 2785 | 915 | 1979 | 1984 | 1985 | |
| Dampierre | 1 | CP1 | 2785 | 890 | 1975 | 1980 | 1980 | 2021 |
| | 2 | CP1 | 2785 | 890 | 1975 | 1980 | 1981 | 2022 |
| | 3 | CP1 | 2785 | 890 | 1975 | 1981 | 1981 | |
| | 4 | CP1 | 2785 | 890 | 1975 | 1981 | 1981 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Fessenheim | 1 | CP0 | - | 880 | 1971 | - | 1978 | **2020** |
| | 2 | CP0 | - | 880 | 1972 | - | 1978 | **2020** |
| Flamanville | 1 | P4 | 3817 | 1330 | 1979 | 1985 | 1986 | |
| | 2 | P4 | 3817 | 1330 | 1980 | 1986 | 1987 | |
| | 3 | EPR1 | | 1650 | 2007 | - | - | |
| Golfech | 1 | P4 | 3817 | 1310 | 1982 | 1990 | 1991 | |
| | 2 | P4 | 3817 | 1310 | 1984 | 1993 | 1994 | |
| Gravelines | 1 | CP1 | 2785 | 910 | 1975 | 1980 | 1980 | 2021 |
| | 2 | CP1 | 2785 | 910 | 1975 | 1980 | 1980 | |
| | 3 | CP1 | 2785 | 910 | 1975 | 1980 | 1981 | 2022 |
| | 4 | CP1 | 2785 | 910 | 1976 | 1981 | 1981 | |
| | 5 | CP1 | 2785 | 910 | 1979 | 1984 | 1985 | |
| | 6 | CP1 | 2785 | 910 | 1979 | 1985 | 1985 | |
| Marcoule | G1 | UNGG | - | 0 | 1955 | - | 1956 | **1968** |
| | G2 | UNGG | - | 39 | 1955 | - | 1959 | **1980** |
| | G3 | UNGG | - | 40 | 1956 | - | 1960 | **1984** |
| | Phoenix - RNR | | - | 130 | 1968 | - | 1974 | **2010** |
| Nogent | 1 | P4 | 3817 | 1310 | 1981 | 1987 | 1988 | |
| | 2 | P4 | 3817 | 1310 | 1982 | 1988 | 1989 | |
| Paluel | 1 | P4 | 3817 | 1300 | 1977 | 1984 | 1985 | |
| | 2 | P4 | 3817 | 1300 | 1978 | 1984 | 1985 | |
| | 3 | P4 | 3817 | 1300 | 1979 | 1985 | 1986 | |
| | 4 | P4 | 3817 | 1300 | 1980 | 1986 | 1986 | |
| Penly | 1 | P4 | 3817 | 1330 | 1982 | 1990 | 1990 | |
| | 2 | P4 | 3817 | 1330 | 1984 | 1992 | 1992 | |
| Saint-Alban | 1 | P4 | 3817 | 1335 | 1979 | 1985 | 1986 | |
| | 2 | P4 | 3817 | 1335 | 1979 | 1986 | 1987 | |
| Saint Lawrence River | A1 | UNGG | - | 480 | 1963 | - | 1969 | **1990** |
| | A2 | UNGG | - | 515 | 1966 | - | 1971 | **1992** |
| | 1 | CP2 | 2785 | 915 | 1976 | 1981 | 1983 | |
| | 2 | CP2 | 2785 | 915 | 1976 | 1981 | 1983 | 2023 |
| Tricastin | 1 | CP1 | 2785 | 915 | 1974 | 190 | 1980 | 2019 |
| | 2 | CP1 | 2785 | 915 | 1974 | 1980 | 1980 | 2021 |
| | 3 | CP1 | 2785 | 915 | 1975 | 1981 | 1981 | 2022 |
| | 4 | CP1 | 2785 | 915 | 1975 | 1981 | 1981 | |

| | | | | | |
|---|---|---|---|---|---|
| | Before 1981 | | 1981 - 1995 | | 1995 - 2002 |
| | | | | | |

**72 generator reactors built or under construction; 56 in operation to date.**
**5 streams**:

– EPR: pressurised water reactor of the EPR type, under construction in Flamanville.

- HWGCR: gas-cooled heavy water reactor. The only one built in Brennelis is being dismantled.
- PWR: pressurised water reactors. The France counted as many as 59; one is being dismantled in Chooz and two have been definitively arrested in Fessenheim.
- RNR: sodium-cooled fast reactors. This sector included an experimental reactor and a prototype, which is currently being dismantled.
- UNGG: natural uranium graphite gas sector. The 9 reactors built are now all decommissioned.

**REP Bearings:**

- 900 MWe: 34 reactors of types CP0 (between 1970 and 1980), CP1 (between mid-70 and mid-80) and CP2 (between late 80 and late 90).
- 1300 MWe: 20 P4 reactors.
- 1450 MWe PWR bearing: 4 N4 reactors.

## APPENDIX 4: EVOLUTION OF EDF'S ANNUAL FINANCIAL RESULTS FROM 1997 TO 2022

Sources*: EDF Group press releases from* 2001 *to 2023*

| Exercise | Turnover * *In €bn* | EBITDA * (Gross operating surplus) *In €bn* | Net income Group share *In €bn* | **Net financial** debt ***In €bn*** | Indebtedness / EBITDA |
|---|---|---|---|---|---|
| 1997 | 28,9 | Nc | Nc | **19,9** | Nc |
| 1998 | 29,5 | Nc | Nc | **19,5** | Nc |
| 1999 | 32,1 | Nc | Nc | **17,4** | Nc |
| 2000 | 34,4 | 9,7 | 1,1 | **17,6** | Nc |
| 2001 | 40,7 | 9,5 | 1,3 | **22,2** | Nc |
| 2002 | 48,4 | 11,2 | 4,8 | **25,8** | Nc |
| 2003 | 44,9 | 11 | 0,94 | **Nc** | Nc |
| 2004 | 46,2 | 12,6 | 1,6 | **19,7** | Nc |
| 2005 | 51,1 | 13 | 3,2 | **18,6** | Nc |
| 2006 | 58,9 | 9,4 | 5,6 | **14,9** | Nc |
| 2007 | 59,6 | 9,99 | 5,6 | **16,3** | Nc |
| 2008 | 63,8 | 14,2 | 5,3 | **24,5** | Nc |
| 2009 | 59,1 | 15,9 | 3,9 | **42,5** | 2,5 |
| 2010 | 65,2 | 16,6 | 1 | **34,4** | 2,2 |
| 2011 | Nc | 14,8 | 3 | **33,3** | 2,2 |
| 2012 | 72,2 | 16,99 | 3,3 | **39,2** | 2,4 |
| 2013 | 71,9 | 15,1 | 3,5 | **33,4** | 2,1 |
| 2014 | 73,4 | 16,5 | 3,7 | **34,2** | 2 |
| 2015 | 75 | 17,6 | 1,2 | **37,4** | 2,1 |
| 2016 | 71,2 | 16,4 | 2,9 | **37,4** | 2,3 |

| Exercise | Turnover * *In €bn* | EBITDA * (Gross operating surplus) *In €bn* | Net income Group share *In €bn* | **Net financial** debt ***In €bn*** | Indebtedness / EBITDA |
|---|---|---|---|---|---|
| 2017 | 64,9 | 13,7 | 3,2 | **33** | 2,4 |
| 2018 | 68,5 | 14,9 | 1,2 | **33,4** | 2,2 |
| 2019 | 71,3 | 16,7 | 5,2 | **41,1** | 2,46 |
| 2020 | 69 | 16.2 | 0,7 | **42.3** | 2,61 |
| 2021 | 84,5 | 18 | 5,1 | **43** | 2,4 |
| 2022 | 143,6 | - 5 ** | - 17.9 | **64,5** | Nc |

** Restated (consolidated) figures in the following year .*

*** The deficit is solely due to a loss of €23.1 billion in production and marketing activities in France, which* the *Group explains by a sharp drop* in *its* electricity *production* and *the need to buy back electricity at high prices on the markets to ensure supplies to suppliers and consumers from whom it is located. committed.*

## ANNEX 5: LIST OF THE 30 EU CRITICAL SUBSTANCES

| Liste 2020 des matières premières critiques (les matières nouvelles par rapport à 2017 apparaissent en gras) | | |
|---|---|---|
| Antimoine | Hafnium | Phosphore |
| Baryte | Terres rares lourdes | Scandium |
| Béryllium | Terres rares légères | Silicium métal |
| Bismuth | Indium | Tantale |
| Borate | Magnésium | Tungstène |
| Cobalt | Graphite naturel | Vanadium |
| Charbon à coke | Caoutchouc naturel | **Bauxite** |
| Spath fluor | Niobium | **Lithium** |
| Gallium | Platinoïdes | **Titane** |
| Germanium | Phosphate naturel | **Strontium** |

*Source: Communication from* the European *Commission to* the European *Parliament*, *the Council,* the *European Economic* and Social Committee and the *Committee of the Regions - Resilience of critical raw materials: the way forward for enhanced security and sustainability.*

## ANNEX 6: STOCKPILE BALANCE SHEET OF RADIOACTIVE MATERIALS AT THE END OF 2020

| Catégorie de matière | | À fin 2020 | Évolution 2020-2019 | Part étrangère |
|---|---|---|---|---|
| Uranium naturel | extrait de la mine | **39 800** | +1 700 | |
| | enrichi | **3 390** | -50 | |
| | appauvri | **324 000** | +2 500 | |
| Uranium issu du retraitement des combustibles usés[1] | enrichi | **0** | - | |
| | sortie de retraitement | **34 100** | +1 400 | 8 % |
| Combustibles à base d'oxyde d'uranium (UNE, URE) | avant utilisation | **611** | +192 | |
| | en cours d'utilisation | **4 070** | -90 | |
| | usés | **11 700** | -118 | négligeable |
| | rebuts | **0** | - | |
| Combustibles à base d'oxyde mixte (MOX, RNR) | avant utilisation | **27** | +11 | |
| | en cours d'utilisation | **323** | -25 | |
| | usés | **2 350** | +80 | |
| | rebuts[2] | **315** | +16 | |
| Combustibles des réacteurs de recherche | avant utilisation | **0,04** | +0,03 | |
| | en cours d'utilisation | **1** | - | |
| | usés | **60** | - | 2 % |
| Plutonium | | **60** | +2 | 24 % |
| Thorium | | **8 564** | -5 | |
| Matières en suspension | | **5** | - | |
| Autres matières[3] | | **70** | - | |
| Combustibles de la Défense nationale | | **198 tonnes** | - | |

*Les évolutions ont été calculées sur la base des chiffres exacts puis arrondis.*

*Source : ANDRA. In tonnes of heavy metal (tMl1), except for spent national defence fuel expressed in tonnes of assemblies.*

# APPENDIX 7 : DEFINITIONS AND CONCEPTS

*Source: SDES, Key Energy Data , 2022*

**Energy balance:** accounting table, breaking down supplies on the one hand and energy uses on the other. The energy balance of France, which is published annually, is based on the recommendations of the Handbook on Energy Statistics co-published by the International Energy Agency (IEA) and Eurostat (the last edition of which dates from 2005).

**Primary energy consumption**: final consumption + losses + consumption of energy producers and transformers (energy branch). Primary energy resources are the sum of primary consumption, electricity export balance, and international sea and air bunkers.

**Final energy consumption**: sum of final energy consumption and final non-energy consumption.

**Final energy consumption:** consumption of energy, through combustion or in the form of electricity, of all branches of the economy, except for the quantities consumed by energy producers and processors (e.g. a refinery's own consumption) and the quantities of energy products transformed into other products. It is net of distribution losses (example: losses in power lines).

**Non-energy final consumption**: corresponds to uses of energy (excluding electricity, all consumption of which is considered as energy) that do not give rise to combustion. These are mainly uses of energy as a raw material: petroleum products in petrochemicals, natural gas for the manufacture of fertilisers...

**Climate-adjusted consumption:** consumption that would have been observed if winter temperatures (which affect heating needs) had been equal to the average of those observed over a reference period. Uncorrected consumption is described as real.

**Renewable energies (RE):** these are energies derived from natural processes in perpetual renewal. Purely electric renewables include hydro, wind, tidal, solar photovoltaic. Renewable thermal energy (EnRt) includes firewood (collected or marketed), wood and crop residues incinerated, incinerated urban and industrial waste of biological origin, biogas, biofuels, solar thermal, geothermal energy recovered in the form of heat or electricity and heat pumps.

**Primary energy production**: production of unprocessed energy, e.g. from nature (sun, rivers or wind) or from **energy** products derived from nature (such as fossil fuels or wood). By convention, primary energy from hydro, wind, tidal and solar photovoltaic is counted as the corresponding electricity production.

# APPENDIX 8: INFOGRAPHIC