EXECUTIVE SUMMARY

Change of the French Electric Power System: realities and recommendations

ASSOCIATION NATIONALE RECHERCHE TECHNOLOGIE

FUTURIS

THE POWER OF COLLECTIVE INTELLIGENCE

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CAHIERS FUTURIS

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SUMMARY

INTRODUCTION

This note is intended for decision-makers, first of all in view of upcoming events that will involve energy policy for several years, namely the French presidency of the European Union and negotiations over the "Fit for 55" Package, the French presidential and legislative elections and the formation of a new government.
It is the result of several years of work by a group of companies, research organisations and public authorities. This group was convened by the ANRT under the chairmanship of Olivier Appert, former President of the IFPEN, member of the Academy of Technologies, and Denis Randet, former Director of the CEA-LETI, Delegate-General of ANRT. He was committed to the analysis of the electric system operations and its growth. He did so from a pragmatic, concrete point of view that aligned with experience from members.

The electric system is becoming increasingly complex as it involves not only the combination of multiple technologies and their direct and indirect effects on the environment, but also investment and operating costs, effects on the competitiveness of firms, household purchasing power and social acceptance, our international position and our independence. Important decisions cannot be made without taking all these elements and their interactions into account.
This is why we have completed the group's work with conclusions from a round table on energy foresight organized within the framework of a colloquium in memory of Jacques Lesourne, one of the best French prospectivists, who was particularly attentive to energy problems.
In the same spirit, we have not separated in our analysis research, development and industry. The lack of connection between the three, with the digging of "death valleys", is too often a French weakness.

In France and around the world, the demand for electricity will increase, owing to the electrification of several uses (e.g., electric cars) – which will contribute to the indispensable effort of energy sobriety -, economic development (e.g., information technology), and enormous unmet needs in many countries.
Electricity generation, transmission and distribution are therefore a major issue. Its conditions are profoundly altered by the widespread introduction of wind and photovoltaic renewable energy sources. This creates a radically new situation for the power system.

01 MAIN CHANGES IN THE ELECTRIC POWER SYSTEM - KEY RECOMMENDATIONS

A NEW SITUATION WITH MAJOR RISKS AND OPPORTUNITIES

Previously, the French electric system was safe and stable

- with sufficient production capacity to provide safety margins;
- a power plant fleet which is marginally sensitive to fluctuations in external supply;
- centralised management, under well-defined accountability;
- an operation capable of responding to climatic hazards, thanks to production that can be controlled on demand;
- a stable frequency and voltage, thanks to the inertia of central rotors;
- a technically homogeneous grid, with exchanges being governed by electrical engineering;
- the only major uncertainty was the conditions for renewing the nuclear fleet.

The massive introduction of intermittent production and the decline in manageable capacities is changing the situation:

- Non dispatchable power generation, which may fail for several weeks and cause general power cuts spreading throughout the European grid;
- as a result, increased interdependence with our neighbours, with risks, but also benefits that must be taken advantage of;
- a dissemination of sources which requires managing a complex and decentralized grid and reviewing the organisation of responsibilities in a system which extends to a very large number of actors;
- heavy investments with potentially considerable and costly capacity margins to deal with production hazards, which also must be reduced by various means to compensate for variations in current supply;
- large financing needs, which involve changing market organisation to attract and appropriately orient private investment;
- external dependance, not so much for sources themselves than for the construction of generator and grid components. Research and industrialization issues are enormous and span the entire electricity value chain (power electronics, digital, nuclear, batteries, electrolyzers, fuel cells, heat pumps, CCS, etc.). The arrival of new techniques entails risks to a loss of strategic autonomy and value-taking by foreigners, but it also offers opportunities to conquer international positions;
- induced macroeconomic effects that may affect the internal and external stability of the Union, for example a rapid rise in inflation linked to an excessive dependence on gas;
- arrangements to be made to maintain frequency and voltage stability by combining electronics and electrical engineering;
- a need to digitize the system in order to control it to the finest, with risks of intrusion and destabilizing cyber-attacks.

KEY RECOMMENDATIONS

To avoid supply disruptions or service quality degradation and **to keep costs with the shift to carbon neutrality at an acceptable level, all available resources must be implemented:** technical, organisation of responsibilities, market rules and sources of funding, communication, European taxonomy.

Given the time required to restore industrial capacity, **renewal of the nuclear power plant must be launched immediately.**

It is essential to not confuse wishes with reality, but **to take their maturity, their time for development and industrialization, and their cost into account for the solutions planned.** The clearest example is the premature hope put into hydrogen to solve the problem today without solutions for long-term (inter seasonal) storage.

While preparing techniques for the future (including hydrogen), **investments in research and development and industrial production must be focused on already proven low-carbon technologies: nuclear, hydraulic, solar, wind, CO_2 capture and storage, power electronics, digital** (including technologies that increase its own "digital sobriety"); all this by being mindful to master the entire chain as much as possible, from mining to recycling, within the context of European cooperation. Our sovereignty and our economic future depend on it.

Since the very short-term price signal given by the electricity market set up at the European level is not relevant to trigger the necessary investments, it is fitting to **develop appropriate mechanisms: capacity, CfD, coverage, AP, long-term contracts, group purchases, carbon offsets, etc.**

In order to design the change in the electric system in light of the many parameters on which it depends, it is essential to **have a collective vision based on a few guiding ambitions, based on models of forecasting that inspire confidence,** and covering the necessary time scale, which means several decades.

The government must fully assume its fundamental responsibility in the design, management and financing of this development, and **intervene more vigorously in defining European positions** (particularly for taxonomy).

02_ OPERATIONAL REALITIES AND DESIRABLE PROVISIONS

1/ ENSURE CONTINUITY AND QUALITY OF SUPPLY IN A DISRUPTED SYSTEM

The rise in intermittent renewable energy sources (IRES), both wind and photovoltaic in practice, and the decentralisation of the power system (self-consumption) are disrupting power grid characteristics and operation. These sources are irregular and use two primary energy sources
- wind and sun - which are not stored.
The upward trend in electricity consumption is now the subject of a quasi-consensus, owing to uses that need electrification. This electricity supply game changer has been documented by the International Energy Agency in its latest publications.
On the other hand, differences between electricity supply and demand over the course of the year occur with greater amplitude and frequency. This is a global problem, as the IEA pointed out.

HOW TO REACT?
First, we cannot deal with supply security as it happens that simultaneously, over large areas, IRES do not produce electricity for several days, the electrical system eventually comes up against the difficult problem on long-term storage.
It is essential to maintain voltage and frequency stability, despite the absence of natural inertia with wind and photovoltaic.
On the other hand, the production and distribution of electricity is decentralized, under the effect of European directives, the multiplication of IRES producers – especially in photovoltaics – and in line with a movement that promotes self-consumption and generally much shorter production circuits.
International issues are significant, and our economic

and strategic position is at stake. We sometimes hear that there is no urgency. This means forgetting, on the one hand, about the electrical interconnection in the European plate, which will expose us as early as 2022 to the consequences of a shutdown in our neighbours' nuclear and coal-fired power plants, and on the other hand, about the time needed to prepare for the renewal of the nuclear fleet.
Finally, the cost of new facilities and changes in the structure of the system is significant. The aim is to reduce it as much as possible, and to attract private funding without compromising the quality of the outcome.

1-1/ LONG TERM STORAGE, PREMATURE HOPES PUT ON HYDROGEN

The simultaneous seasonal failures of photovoltaics and wind power requires, if these two technologies are to be entrusted with a significant part of the electricity supply, the installation of massive storage capacities lasting several weeks.
Today there is only one technology really used: dams equipped with pumping stations (STEP). Unfortunately, in Europe, geography and obstructions from public opinion prevent them from developing significantly beyond what exists. STEP only stores electricity for a few days, to a few weeks at most.
Many hopes are put into hydrogen. Without neglecting security requirements associated with its handling, the main challenge is to achieve an acceptable production cost. This cost will depend on energy efficiency and the cost of electrolyzers and fuel cells. Part of the answer will come from research, which is expected to bring breakthroughs, but another part will be linked to the scale and increase of industrial investments.
Electricity storage in the form of hydrogen will find its economic value when new uses are opened to low-carbon energy (industry, transportation, residential). Economic models for hydrogen use in energy (Fuel cell, methanation) are more distant, especially since we risk electricty shortages. The leading market will first be for industrial hydrogen.
In France, sanitary hot water storage tanks have an

estimated storage capacity of 4 GW. This capacity is not negligible, but it remains very short term and the stored heat cannot physically be returned in the form of electricity.

1-2/ TORAGE FOR A FEW HOURS, BATTERIES

To compensate for fluctuations at the scale of a second to a day, batteries are now usable, due to the sharp fall in their price. This is a consequence of the development of electric cars and huge Asian investments in the lithium-ion industry. There is still great progress to be made: increasing storage capacity, taking into account the full battery life cycle - depth of discharge, temperature ageing, charge/discharge cycle, maintaining performance, source and recyclability of materials, safety. However, Li-ion technology dominates so much that R&D efforts will have to focus mainly on improving it, without forgetting technologies of the future that seem to be, for example, "all solid" batteries.
Since transporting batteries is expensive, there will be factories in Europe, but can they be controlled by European manufacturers? The future of current plans will depend on the attitude of car manufacturers. Will they agree to favour European suppliers?

1-3/ WHAT STORAGE CAPACITY WOULD ELECTRIC VEHICLES BRING?

According to estimates made in 2017, Enedis used a range between 3 and 9 million electric vehicles for 2035, and an annual consumption between 8 and 25 TWh; the French committee for car manufacturers was considering on a median scenario of 9 TWh, 3% of national consumption. In terms of power, however, the impact could be significant, requiring a strengthening of the distribution network. In reality, this impact will depend on charging behaviour and modes. Above this, there is a lot of uncertainty. Estimates vary from 1.6 GW to 10.2 GW, the extreme value depending on peak evening consumption. A regulatory framework may be required, such as a tariff signal or a load management system.
For storage, 15 million cars, each with a 30 kWh battery would provide a capacity that is equivalent to the production of the French nuclear fleet for 7 hours. But how will this be distributed during the day? And then charging facilities and cars would have to be designed to exchange electricity in both directions. That's a lot of speculation. In any event, it would be useful to quantify the cost of investments, the value of the potential service and to see how to pay those who would provide it.

2/ HOW TO CORRECT INSTABILITIES DUE TO IRES FLUCTUATIONS?

Several weeks of shutdowns of wind and photovoltaic installations are fortunately rare. On the other hand, their production follows variations in wind and sunshine. If these fluctuations were not compensated for, they would eventually result in changes in frequency and voltage that electrical appliances cannot withstand, or in breakdowns that could spread across Europe. What can we do?

2-1 / MODULATE PRODUCTION

The amount of electricity produced by thermal power plants and dams can easily be varied. Unlike most other countries, French nuclear power plants were designed to be able to do "load monitoring" while being used as a base means. Two drops per day per reactor can be programmed and reach up to 80% of rated power in about 30 minutes. This is an asset for IRES integration. However, low speed operation cannot last; it is crucial to power up or shut down the reactor. On the other hand, shutting down nuclear power plants leads to a significant shortfall for the community. If the proportion of wind and photovoltaic is too high, however, such shutdowns will have to be accepted to maintain balance on the grid.

2-2 / LOAD SHEDDING A PART OF THE POWER DEMAND

Electrical load shedding has been practised for a long time with industrial consumers, especially electro-intensive ("interruptibility") companies. Going further than the currently estimated 5 GW would involve a "flexi-design" of industrial facilities, in order to preserve production despite power interruptions. However, how will this investment be financed so as not to reduce the competitiveness of French companies? For individuals, short-term demand-side response begins to appear, via the solutions offered by aggregators, which are facilitated by digital interfaces.
Demand management by operators most often uses intelligent algorithms, and offers solutions that range from real time to long-term is very low capacity and very fast adjustment services to maintain the frequency at 50 Hz (automatic primary reserve); sale of erased

energy to the energy market; sale of power availability to the capacity market; or services to the distribution network to help resolve network constraints. We must also ensure that this type of management does not create congestion.
Load shedding blocks created by operators represent an alternative to production, but also to investments on the grid in terms of deployment, reinforcement, or maintenance of works.

2-3 / DEVELOP INTERCONNECTIONS BETWEEN ELEMENTS ON THE GRID

Interconnections have been an important factor in the stability of the European grid for a long time now. They compensate for local failures. For wind and photovoltaic installations, they have an additional potential virtue: to moderate wind and sun variations by enlarging the surface affected. Unfortunately, in European countries, building new high-voltage lines is difficult. In 2019, Germany, despite its obvious need to connect wind turbines in the North with factories in the South, was only able to build 36 km of lines.

2-4 / COMPENSATE FOR RAPID FLUCTUATIONS

In a transitional regime (for example following a strong disturbance), the aim is to quickly regain balance and avoid a blackout. Currently, frequency is the basis for operation on the European electricity grid, where France and Germany occupy a privileged geographical position within the UCTE zone. If a local imbalance occurs, it is instantly compensated by the reserves built up by all means in the interconnected area, which restore balance between production and consumption, and frequency. The larger the grid is, the greater the overall kinetic energy, and safer the system is. This is the trend that has prevailed until now.

But wind and photovoltaic installations do not contribute to the magnetic and kinetic energies that stabilize the grid. The higher the penetration rate, the faster the decrease in frequency will be in the event of an incident. There is a risk to reaching the critical load shedding threshold before defence systems are activated. Energy injection with batteries associated with power electronics or with additional rotors (synchronous compensators) is a means to reducing risk by providing artificial inertia. Additional work will be carried out to assess needs and define the sizing of storage reserves and their geographical distribution, as well as system management.
Because of the IRES connection, we are facing a system combining electronics and electrotechnics. Managing critical situations requires a strong adaptation of protections, via power electronics. Particular attention should be paid to the components required for the cut-off chain (protection, relays and circuit breakers), AC/DC interactions and DC transformation.
Finally, the need for local regulation is growing. Today balance of the European interconnected grid is managed by transmission system operators (TSOs). In order to take self-consumption and decentralisation of production into account, it will be crucial to set up local/national coordination with distribution system operators (DSOs). Actions at the local level can have impact at the global level and vice versa.
Resilience in the electricity system after a major incident is also an important issue. With digital, decentralized productions, local loops and auto-consumption, the usual pattern needs to be rethought.

It is also necessary to identify possible synergies between energy networks (electricity, natural gas, heat). Non-Interconnected Zones (NIZ) and island territories allow, assuming higher costs, to test new solutions.

2-5 / IMPROVE WEATHER FORECASTS

Wind and photovoltaic generation depend directly on weather conditions. With wind generation, forecast errors at J+1 are quite small, but larger errors may occur a few times a year. Photovoltaic production is more difficult to predict, especially with fine mesh, because of a difficulty to predict the formation of clouds and their precise position. To manage the electrical system as close as possible to real time, and to make the best use of devices to compensate for supply and demand discrepancies, it is necessary to link consumption forecasts with weather forecasts. The quality and precision in weather prediction models (particularly fine mesh) are important in a context of an electrical system increasing exposure to climatic hazards.

3/ MANAGING AN INCREASINGLY DECENTRALISED GRID

More than half of the new electricity generation facilities currently built in Europe are an intermittent renewable energy source (IRES). However, although the installed capacity is significant, their average energy contribution remains generally low compared to conventional means (nuclear, hydraulic, thermal, etc.) and there are wide disparities between European countries. In France, growth scenarios proposed by RTE are very contrasted, with by 2035 a proportion of electricity coming from renewable energy sources between 40% and 70%, including wind, photovoltaic and hydraulic. This increase is mainly due to wind (production multiplied by 3 to 5) and photovoltaic (multiplied by 5 to 7). Wind power plants are mainly large, with capacities of several MW. Most photovoltaic installations are smaller and require significant investments in grid connections.

Self-consumption, still marginal in France (less than 1% of 37 million subscribers), is expected to grow significantly as of 2025, and massively as of 2035. Installed capacity could then reach 10 GW, but consumption will remain low. However, the local impact, in terms of grid management, will have to be taken into account. Local loops can share different types of generation and distribution, but they lack the flexibility reserves in the electricity grid, and grid connection remains essential security.

The current pricing for dispatch - TURPE 2 - at 80% energy and 20% power does not charge this security at its fair price. The development of self-consumption could question national solidarity provided by the electricity grid and, a fortiori, the infrastructure financing model (TURPE principle and tariff equalization).
In any event, the proliferation of installations and those implementing them will require coherent management of an increasingly decentralised system, by using new resources intelligence control and steering, thanks to digital technology. The most complex part is electricity distribution, with several operators having direct contact with millions of users.

Reconfiguration of the European energy landscape is leading to an emergence of new businesses and new actors such as aggregators and flexibility operators, new electricity suppliers, local energy managers, information technology actors, etc. Coordinating these actors is essential and will allow a match between: (i) technologies to be designed and deployed (new equipment, production or storage facilities);
(ii) the evolution of industrial production processes;
(iii) the evolution of energy markets (contracts offered to customers, pricing adjustments, etc.).

4/ DIGITAL TECHNOLOGY: CONTRIBUTIONS AND VULNERABILITIES

Digital technology will contribute to decentralized management and will open new B2C and B2B products and services to modulate and aggregate offers and requests. Already, tens of millions of Linky meters collect consumption data every hour and run them every 24 hours.
Using this data can facilitate, at the territorial level, a balance between demand and decentralised production, by relying on software to control the system. To encourage the development of new services, some advocate for the rethinking of the French regulatory framework, for example, by drawing on the European Directive PSD2 (Payment Services Directive) which requires banks to make their customers' banking data available to new players. The data may be production, use and context data, consumer feedback data or forecasts. Their use, combined with artificial intelligence and the Internet of Things, can also meet other needs on the grid such as asset management, maintenance, fault diagnosis, electromobility, visualization & data processing, observation of networks, etc.

THE OTHER SIDE OF DIGITAL TECHNOLOGY: ITS OWN ENERGY CONSUMPTION

Like cholesterol, digital technology superimposes the good and the bad.
Far beyond their beneficial applications in the energy sector, electrical consumption with connected objects and digital operations is growing to such an extent that the entire development of digital technology is affected. Consumption is now seen as a limit to the design of equipment and to the programming and calculation methods, even if levels of consumption (including the 40% related to equipment production) do not reach the heights denounced by some environmental associations. With the end of the easiness that Moore's Law has allowed for sixty years, we are moving towards a complete overhaul of the hardware, architectures and software chain, from integrated circuit technology to supercomputers. This constraint is fully taken into account today by digital actors.
France is the only European country active on the entire chain. It is an asset that gives us accountability and leadership in building a European position.

RISKS TO VALUE CAPTURE AND CYBER-ATTACKS

Decentralization of the grid, multiplication of injection points, availability of data and the arrival of new services open up new opportunities, but are exposed to value capture by foreign operators (GAFAM and others)
They also pave the way for cyber-attacks. To defend against this, two areas are to be prioritized: 1) prevent the occurrence of an attack, 2) study its consequences and how to restart the grid. Restarting is a complex operation, as returning to nominal operation may take several days.

5/ THE MARKET, REGULATION

Financing and public guarantee will be paramount, but French and European public authorities must organise the market to attract as much private financing as possible. With the arrival of IRES, the need to compensate for their variations and a considerable increase in the number of sources and actors, new rules must be introduced allowing for new equipment and services to be remunerated according to their short, medium and long term usefulness. As such, for example, storage can find economic value with differences in energy prices and the different services it can render to networks.
The conceptual framework for defining long-term investments needs to be rethought. Analyses point to a lack of confidence in the rules put in place such as the carbon tax, energy savings certificates, regional planning of IRES, pricing mechanisms for electricity, the new dynamic return meters.
The principles of action coordination by setting price signals as incentives or charging efforts under the polluter pays rule are increasingly criticised.

All these tools (including standards, which have on what they prohibit, the effect of infinite taxation) will be better accepted as they will refer to essential objectives (CO_2, cost, safety) and will be based on economic models of decision support.

6/ MODELING

The global energy system is facing profound changes with the fight against global warming, the introduction of digital technology, new lifestyles, the emergence of local events and the role of citizens, the arrival of new international actors on markets, mass development of IRES due to legislation and the lower cost of some of their components... Decision-makers need tools to steer France's energy policy towards a low-carbon trajectory, particularly for the next EPP planned by 2023. Forward-looking models of electricity grids are fully in line with this ambition to lighten the country's energy future.

However, diversity in expectations among different actors involved, the plurality of modelling methodologies, and sometimes the opacity of hypotheses make foresight exercises complex to understand, and can provoke a certain distrust. We recommend:

- Transparency and rationalization of hypotheses, after pooling and comparing non-competitive data used by actors.
- Integration of the systemic dimensions neglected into some models (including macroeconomic, multi-vector and multi-sector, climate, and SHS dimensions).
- Articulation of technical system optimization models and macro-economic general equilibrium models, to represent models of human activities that are generally developed separately within the same framework (energy, transport, land cover) and work on different geographic scales.
- Models integrating all energy sources (electricity, gas, heat, hydrogen, etc.) while taking acceptance constraints into account.
- In relation with research organizations, establishing a grid capable of responding quickly to requests made by elected officials and the government.
- Pooling the work of modellers on a national and European scale.
- It is also important for France to be able to follow foresight conducted at the European level on the same subject (notably via the JRC).

7/ FRENCH POSITIONING (SWOT ANALYSIS)

The SWOT analysis makes it possible to map the positioning of an actor in relation to a project, and the effect of an external environment on this positioning.
The "actor" considered here is the French electricity system, including electricity producers, grid operators, competent public administrations, research laboratories and universities, major tier 1 suppliers, current and future known consumers.

This method can be applied to any particular element in the system. In general, we do not adequately take our positioning into account, that is to say, our real strengths and those of our competitors. Thus, neglecting Chinese determination and capacity in photovoltaic panels led us to subsidize this production with our taxes...

STRENGTH

- Basic and semi-basic decarbonised and stable production
- Fine daily coordination between producers and grid operators
- Elaborate relations with consumers (tariffs for erasure, aggregators...)
- Strong R&D in technical elements and their integration
- Energy foresight tools based on a quantitative and qualitative tradition
- World-class industrial groups in energy, electrical engineering
- and power electronics, integrated components and computers

WEAKNESS

- Lack of government organisation on a collective vision
- Lack of long-term price signal to encourage investment
- Dispersion of responsibilities and public funding in the energy sector
- Lack of coordination between energy policy and industrial policy
- Loss of industrial skills
- Dispersion of European mix and a lack of coordination Limited visibility for energy transition and carbon neutrality by 2050
- Electricity grid and generation fleet with some age and climate change vulnerabilities
- Frequent underestimation of time and costs for development and industrialization
- Low acceptance of any major infrastructure project

OPPORTUNITY

- European support to government assistance for certain industrial innovations (IPCEI)
- Desire for European re-industrialization with a logic for strategic autonomy
- Strong mobilization of energy communities and new energy carriers

THREATS

- Tensions on the energy market : gas, raw materials, semiconductors,...
- Geopolitical pressures using Energy
- Costs (social acceptance)
- Potentially complex financing
- Lack of solidarity mechanisms to decarbonize the European energy system (beyond electricity)
- Difficulties to make the positive characteristics of the French electric system acknowledged by the European Union

8/ THE NEED FOR A COLLECTIVE VISION, THE PROPER USE OF PLANS

The evolution of the electricity system depends on multiple technical, economic, political, social and cultural parameters, especially since its consequences affect almost all sectors of activity. It is therefore essential to build a collective vision capable of inspiring public and private action. It is up to the government to organize this construction by bringing actors together, as the Commissariat au Plan used to do.

Today, the vision is incomplete, and available elements are scattered among several institutions that are not working to develop common benchmarks.
Public action takes the form of plans that are more or less broad. There is no shortage of titles such as PIA, recovery, renewable energies, nuclear, batteries, hydrogen, power electronics, ... However, their number and the lack of common framing, correspondences and explicit hierarchies may lead to confusion, especially since responsibility is divided between several departments and agencies.

And it is important to monitor their execution more methodically, taking into account feedback and evolution of the situation.

9/ ROLE OF THE GOVERNMENT

Several crucial choices affecting the future of our energy systems depend on the state as follows:

- Electricity generation mix, in relation to the European system, and taking the international situation into account.
- National coordination of investments, which will eventually plan the increasing integration of IRES and new uses on networks.
- Long-term benchmarks needed to provide a support point for energy markets within the European framework, such as sending economic signals incentives.
- Access rules to make valuable assets visible and profitable, including an adaptation of market architectures and/or grid codes.
- All this involves five roles: a strategist and organizer of a collective vision, a legislator, an investor, a regulator, and an international guarantor.

STRATEGIST AND ORGANIZER OF A COLLECTIVE VISION

The importance for the country of the future in the electricity system, the size and long range of investments, the extent of the value chain, from mining supplies to individual consumption and lifestyle, effects on the environment, sensitisation and questions from citizens, and international implications, make it necessary to restore the strategic capability of the government and for that its organization of a long-term global vision, shared with the main actors.

With very different political regimes, that's what the U.S. and China are doing today. In France, public foresight has lost its influence by being scattered among several institutions (High Commission for Planning, France Stratégie, SGPI, CRE, Ademe, Ministries, etc.), and action in the field of energy is dispersed among several agencies and ministries (attachment of energy to the Ministry of the Environment as being a French particularity).

A strong initiative of the government, accompanied by a reorganization of its own services, seems indispensable to federate our skills and make them effective.

LEGISLATOR

For a long time, the law has regulated electrical system development. In 1946, a new framework was introduced for gas and electricity to contribute to reindustrialization. From the 2000s, in accordance with the 1996 European directives, French law opened up gas and electricity markets.

The legislator can define a normative framework adapted to national objectives combining efficiency and social justice.

INVESTOR

In the energy sector, a large proportion of investments are outside profitability conditions accepted by private capital, as returns are distant (decades) and partly indirect. It is up to the state to invest and it has done so massively for IRES. It has several means at its disposal such as the endowment of national operators, loan guarantees, tax advantages, compensation for tariff advantages.

REGULATOR

The government first ensures a technical standardization (Afnor). It participates in the regulation of tariffs on electricity and gas networks with the Energy Regulation Commission with regulatory procedures conducted by the Ministry in charge of energy.
It also regulates through the taxation of energy and the prices of electricity purchases from IRES.

Previously, the market had been organised to promote the optimum use of production and distribution investments at all times. With the arrival of IRES, a considerable increase in the number of sources, and the unpredictability of their production, it is necessary to introduce rules allowing for new equipment and services to be remunerated according to their short, medium and long-term usefulness. The CRE and the European Commission are the guarantors in the regulation of these markets and must therefore be involved in the process.

GUARANTOR OF EUROPEAN SOLIDARITY AND INTERNATIONAL AGREEMENTS:

The Europe of controllable power plants was electrically homogeneous. Today, while each country remains partly responsible for its electricity mix (modulo the renewable share and the necessary decarbonization of the mix), the rise in wind and photovoltaic creates deep divergences. However, interconnection in the European plate makes solidarity necessary. Which one? It is being debated in Brussels. The clearest example is that of taxonomy, the list of technologies eligible for State assistance in Europe, so will nuclear energy be one of them? France is trying to make its point.

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