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# French electricity demand - outlook to 2050

In recent years, annual electricity consumption in France amounted to around 470 TWh, 90% being decarbonised; at the same time, oil and natural gas consumption has been around 900 TWh and 450 TWh respectively. At present, electricity accounts for only a quarter of energy consumption. Energy savings alone will not be enough to move away from oil and natural gas: as equally anticipated for Germany[1] and Great Britain[2], French reliance on electricity will have to increase significantly to replace oil and gas consumption. Various recent projections underestimate this growth. However, erroneous assumptions would affect the security of our energy supply and the daily life of the French people; the impacts on the cost of electricity and energy in general, and on the competitiveness of our economy would be considerable. In this position paper, the National Academy of Technologies of France (NATF) proposes a reasonable assessment of electricity demand in 2050. It points out that the European electricity system will be more vulnerable in coming years. It proposes some principles for the choice of economic data to be used in optimisation models. On the basis of these elements, it highlights some key points for managing change in the electricity system.

## 1. Some important trends

After energy savings (50% of current consumption according to some ambitious projections), and assuming a bioenergy potential of 425 TWh (the Multiannual Energy Programme considers this to be optimistic as bioenergy currently represents only 180 TWh), electricity demand (currently 470 TWh) could rise to somewhere between 730 TWh and more than 840 TWh in 2050 if we include a doubling of hydrogen demand compared to its current level (Annex 1). Electricity demand will be even higher if the share of intermittent renewables is high and the share of nuclear power low or zero. Indeed, a mix dominated by intermittent energies requires significant decarbonated production and storage of methane or hydrogen, then reconversion into electricity (*Power-to-Power)*; the poor efficiency of this chain weighs on the primary electricity requirement. The development of geothermal or solar thermal energy will not significantly affect the need to increase the use of electricity as energy carrier.

Moreover, the exit from oil and natural gas will not be done on a "TWh for TWh" basis. The electrification of parts of the uses entails a reduction in final energy consumption thanks to the high efficiency of certain electrical processes. However*,* for other uses, it will be necessary to develop liquid or gaseous synthetic fuels from hydrogen (produced by electrolysis) and carbon dioxide. An important component of the energy transition to achieve "Net Zero Emissions" of greenhouse gases will therefore be intersectoral coupling, which will lead to the use of electricity to decarbonise current hydrocarbon uses. However, the efficiency of processes for producing synthetic fuels from electricity rarely exceeds 40%. The consequences of inter-sectoral coupling on total electricity demand must be taken into account.

Another essential parameter for sizing an electricity system with a high proportion of intermittent energies is the peak power demand; in France it did exceed 100 GW in 2012 and was 89 GW in the frequent climatic

[1] Germany anticipates a near doubling of its annual electricity consumption in 2050 to 1,000 TWh - Leopoldina and acatech Academies and Federation of Regional Academies - Coupling the different energy sectors - Options for the next phase of the energy transition - August 2018.

[2] According to the UK Government, annual electricity consumption is expected to double by 2050 - The Energy White Paper - Powering our Net Zero Future - Presented to Parliament by the Secretary of State for Business, Energy and Industrial Strategy - December 2020.

conditions of early January 2021. This peak demand is decisive in determining the volumes of energy storage needed to get through periods with little wind or sunshine and to right-size the electricity grids. It can be assumed that better demand management through relevant tariff signals, greater efficiency of the heating equipment and the development of capacity markets will make it possible to contain the growth of peak demand below the growth of average demand; however, it could reach, or even exceed, 130 GW, especially as direct heat pumps, even if they allow a reduction of energy consumption, experience a significant drop in efficiency at low outside temperatures.

The assumptions of the French National Low Carbon Strategy (630 TWh in 2050) are set too low. In addition, large margins must be included in the projections, especially as the horizon is remote and uncertain. These margins will have to be revised as we get closer to the destination. However, planning based on estimated levels of electricity demand that are too low will entail risks for security and cost of energy supply.

**Recommendation 1: Prepare for strong growth in electricity generation**
The exit from oil and natural gas will require a 55% to 85% increase in electricity generation.
Peak demand will increase by more than 30%.
In order to avoid the risk of constraining the availability of energy and letting its cost getting out of control, long-term assumptions about power generation and electricity grids need to take into account appropriate margins.

## 2. Making cost-assumptions

Some recent studies[3] presume a steady decline in the capital cost of intermittent renewable energies. It is true that these energies have experienced significant cost reductions over the last twenty years; but extrapolations to distant horizons without an asymptotic approach to this horizon are questionable. Furthermore, published studies do not generally take into account the costs of reinforcing the transmission grids.

The same applies to the cost assumptions for a new nuclear power plant: they cannot be based solely on the cost of building prototype units such as the Finnish and French EPRs, the construction of which was started when the supply chain had disappeared and the experience of running a major project had been lost (no new construction for fifteen years)[4].

Particular attention should be paid to anticipating the cost of energy storage and conversion facilities (*Power-to-Power*). These facilities are essential to guarantee the supply of electricity (both for energy consumed and power demand) when intermittent energy sources produce only limited amounts, which can last several days or even weeks in a row; the orders of magnitude of the capacities to be installed to satisfy peak demands can exceed 80 GW, with very low load factors and therefore high costs[5].

Some scenarios with a strong component of variable and highly decentralised energy production pose delicate problems of stability of the electricity network. Their solutions are not yet proven; it is necessary to define the technological steps to remove the uncertainties and ensure validation.

As proposed by the French TSO[6], multiple scenarios must be investigated; however, decisions must not be taken solely on the basis of necessarily very uncertain economic simulations. The risks of insufficient dimensioning, which would impact energy security, or late implementation of investments, which would

[3] CIRED - *How sensitive are optimal fully renewable power systems to technology cost uncertainty?* https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3592447 - Mai 2020.

[4] OECD NEA - *Unlocking Reductions in the Costs of Nuclear: A Practical Guide for Stakeholders* - https://bit.ly/3b1TF1

[5] D. Vignon et al. Can hydrogen enable a 100% renewable electricity mix - Enerpresse - 8 July 2020

[6] Transmission System Operator

weigh on growth, must be considered. Moreover, grid failures (blackouts) have a direct and immediate cost.

**Recommendation 2: Anticipate reasonable and justified cost developments**
Do not extend the cost reductions of renewable energies ad infinitum. Allow for cost reduction in other modes of energy production through learning and serial production effect.
Take into account the cost of the *Power to Power* chain required in scenarios with a high intermittent energy component (high capacity, low utilisation).
Include direct costs, but also induced costs (security of supply) in decisions.
Take into account the increased cost of the transmission and distribution grids (low economies of scale; long lead times).

## 3. The short-term situation

It will take about thirty years to renew the French electricity infrastructure. But we must also be concerned about the near future (2020-2030). During the first week of January 2021, electricity supply under normal winter conditions was tight, requiring massive imports within the limits of cross-border interconnections, maximum use of hydroelectric resources, reduction of industrial demand, even targeted load shedding. Notwithstanding, in the next few years, most European governments are planning to decommission large amounts of dispatchable generation capacity. By 2030-2035, according to Elia - the Belgian TSO - more than 110 GW of dispatchable power will be removed from the European grid. This is made up of 23 GW of nuclear power (of which about 13 GW in France and 10 GW in Germany), 70 GW of coal/lignite (of which about 40 GW in Germany) and 10 GW of gas or oil as well as other decommissioning in Belgium, the UK, Italy and Spain. Decommissioning of coal- and lignite-fired power stations in Germany[7] will start in 2022 while the decommissioning of all remaining nuclear plants will be accomplished by the end of 2022.

The withdrawal of coal and lignite-fired power stations will thus greatly reduce Germany's electricity export potential. It is true that Germany has a fleet of gas-fired power stations that are not used very much. Although the French TSO is generally reassuring about the security of the French electricity supply for the next ten years, one may wonder whether it is appropriate to phase out nuclear power plants in the present decade, before the end of their life without replacing them with decarbonised and controllable electricity. It would be preferable to keep them in service for the benefit of the decarbonisation of European electricity.

**Recommendation 3: Anticipate the early decommissioning of European production units**
Assess in detail the consequences of decommissioning coal-, lignite- or gas-fired power plants in neighbouring countries.
Update the import potential regarding the capacity of transborder transmission lines and European supply capacity during French demand peaks.
Accelerate the development of generating capacity markets and demand management.

## 4. Managing the transition

The transformation of the energy system will extend over about thirty years. It will concern energy uses and production as well as transmission and distribution infrastructure. It will take place in an uncertain economic and technical environment. Many technologies are already available for immediate action; others are only at the development stage (e.g. stabilisation of highly decentralised electricity networks without self-synchronising rotating machines; flexible methanation; high-temperature electrolysis; inter-seasonal hydrogen storage). Making responsible choices implies a realistic assessment of the moment when they are pertinent for enabling the transformation, which will be difficult to plan, and a great deal of flexibility will

[7] Taken from France Stratégie - What security of electricity supply in Europe by 2030? Étienne Beeker with the participation of Marie Dégremont - January 2021.

be required. In particular, the definition of the economic and legal framework that will motivate investors to build new production or storage facilities is far from obvious. There are, however, some certainties:

1. There will be no French energy production industry without a clear and stable vision of the future. Currently, the added value of solar and wind equipment and batteries is mainly imported. The re-localisation of the French investments that are needed for the energy transition requires that the choice of technological solutions be made in advance. The same applies to the appliances used by end consumers.
2. A considerable reinforcement of the electrical grid system will be necessary if the expected strong increase in electrical power supply is to be transmitted from sites that are located far away from the current electrical grid (offshore wind power) and/or very dispersed (solar energy, power supply to electrolysers for the production of hydrogen or the rapid charging facilities for electric vehicles, etc.)[8]. Experience shows that there is serious reluctance on the part of the territories in which new high, medium or low voltage power lines are to be built. This reluctance must be addressed, and information and consultation campaigns must be initiated well before proceeding with the application for administrative authorisations.
3. The intermittent energies under consideration will necessitate storage facilities; an option on the required technologies must be taken quickly, which will certainly include batteries, but also probably storage in the form of gaseous molecules ($H_2$ or methane). A storage chain using methane (methanation) has the important advantage of using existing installations, but it is penalised by a lower yield than an $H_2$ chain. The pertaining decision will obviously have far-reaching consequences. A realistic technical and economic assessment of the various alternatives is a prerequisite for choices to be made in the middle of this decade.
4. The future place of nuclear energy in the energy mix must be decided in terms of costs, risks and benefits. This form of energy can guarantee a continuous supply of decarbonised and dispatchable electricity. It can therefore greatly reduce the amount of energy that needs to be stored to cope with the variability of intermittent energies, but also reduce the costs of reinforcing and extending the electricity grid; and it contributes very significantly to the stability of the electricity system. Waiting is not an option, given the inevitable disappearance of nuclear skills and industrial facilities in the absence of new projects.

**Recommendation 4: Taking into account the time constants, specify without delay reasoned choices for the energy transition!**
Decide on major technological choices (including nuclear and inter-seasonal energy storage).
Build an industrial policy associated with the energy transition.
Anticipate the extension of the high voltage electricity grid and the reinforcement of the low, medium and high voltage electricity grids.

[8] Germany plans to spend €100 billion by 2035 to reinforce its HV networks alone. Grid Development Plan 2035 - grid operators (50 HZ, Amprion, Tennet, TransnetBW) - January 2021. Grid Development Plan Electricity | Grid Development Plan (netzentwicklungsplan.de)

# Annex 1

## A realistic order of magnitude of energy demand in 2050

### 1) The sources of French energy consumption in 2019

| Main energy (or chemical) sources excluding electricity and renewables (2019) | | | Comments |
|---|---|---|---|
| | Mtoe | TWh | |
| Oil (excluding power generation) | 79 | 919 | Including bunkers, which in 2050 will be produced in France |
| Gas (excluding electricity generation) | | 455 | INSEE statistics TWh Pcs |
| Coal (excluding electricity generation) | 7,4 | 86 | INSEE statistics |
| Subtotal | 86,4 | | |
| **Electricity and thermal renewables (2019)** | | | |
| Electricity | | 470 | INSEE statistics |
| Thermal and waste EN (excluding electr.) | 15,29 | 178 | INSEE statistics |
| **Grand total** | | **2 108** | |

Coefficient 1 kWh = 0.086 Tep; this is an international convention.
Geothermal and solar thermal represent about 20 TWh, included in Thermal Renewable Energies.

### 2) Final energy demand in 2050

- Halving of all demands (optimistic estimate of energy saving potential): 2108/2 = 1 054 TWh)[9]
- Available biomass: 425 TWh (qualified as very ambitious by the PPE) of which 100 TWh are used for electricity production, leaving 325 TWh for other uses.

**The electricity demand is then 729 TWh** (1054-325) of which 40 TWh is produced by biomass (40% efficiency).

### 3) Impact of Hydrogen and renewables in 2050

- According to the French National Low Carbon Strategy, 40 TWh must be added for green hydrogen production. This is a rather modest ambition: 55 TWh are needed to produce one million tonnes of hydrogen (this is current French hydrogen consumption, the production of which, mainly in refineries, is highly $CO_2$ emitting).
- **Excluding Hydrogen production and in the absence of a *Power-to-Power* conversion chain**, electricity demand would be around 729 TWh
- **With the production of two million tons of hydrogen, it could reach 840 TWh**

### 4) Potential for improvement

- Doing better than 50% energy savings. This is probably possible in the transport sector; hardly for heating and industry. The Ademe scenario ("2030-2050" scenario) only foresees a 45% reduction in primary energy demand between 2010 and 2050[10].
- Having more biomass; but the targets set are already described as very ambitious.

[9] The national low-carbon strategy uses the very similar figure of 1,060 TWh
[10] Selected by Ademe in "A 100% renewable gas mix in 2050?" - January 2018