



Voices of
Nuclear

TerraWater

Energy scenario for
carbon neutrality in France
in 2050 and beyond



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the TerraWater
scenario

In the context of the necessary review of the French Multi-Year Energy Plan and Energy Transition Law, and further to the 2022 RTE report on France 2050 scenarios, Voices of Nuclear wish to contribute to the debate with a realistic and credible alternative view of an energy transition that France could choose.



Why consider a different scenario?

The purpose of energy transition scenarios in the current debate is to inspire future energy policies. However it seems they often, unwillingly, overstep their role of laying out options and highlighting prospects and instead promote pathways with a greater risk of failure. Breaking free of ideological or social pressure, the Voices established the first scenario whose baseline is chances of success, rather than desirability. Here is how.

Scenarios previously published, and forming the base of France's debate on its future energy policy, contain a certain number of elements, which, if selected, would lead to an energy policy that compromises achievement of our objectives, be it in terms of the climate, the environment, or energy supply to citizens.

The scenario proposed by the Voices intends to break free from the political and ideological constraints that affect the technical choices of the existing scenarios and penalise the credibility of the trajectories they propose. As independent as possible from technical, societal and geopolitical uncertainties, the scenario put forward by The Voices proposes an intentionally realistic vision whose baseline is avoiding what we consider pitfalls for the energy transition.

Pitfalls avoided by the Voices scenario



Decarbonisation of our energy is an objective that **must not entail any system-wide challenges**: neither technological, nor human, nor geopolitical.



Compliance with the operational constraints of the electricity network, in particular the stability requirement, is a prerequisite for any credible scenario.



Reduction of the **environmental footprint must be a priority**. This environmental impact includes the consumption of natural mineral resources, land use and land take, generation of waste and the pollution of air and soils.



Each energy source must be used at its technical optimum, misappropriated use must be avoided. Variable Renewable Energies (VRE) are particularly essential for decarbonisation, but cannot be used to ensure supply security.



Redundant duplication of infrastructure performing the same functions must be avoided, including for energy distribution networks (gas and electricity for example).



Hydraulic energy is dispatchable, low-carbon, resource-efficient, takes up little space, and is sovereign. Discounting it would not be justifiable.



Energy solidarity cannot be thought of as a one-way process, assuming that we can make up for the shortfall of electricity by receiving it from our neighbours, and that we will have access to critical mineral resources. France must re-establish the room for manoeuvring and independence that will enable it to export its low-carbon electricity, share its technological expertise (including nuclear power), and free up its wind and solar capacities as soon as possible for the benefit of its neighbors.



Once an energy scenario has been selected, **our nation is committed to it for several decades**. Reconstitution of generation margins and the choice of domestic technologies are essential for peace and democracy. Ensuring that energy remains affordable for all is a factor in the stability of our society.

Difficulties resolved in figures

There is always another side to the story, no choice is entirely free of disadvantages or limitations that we would prefer not to face. A scenario is by definition the result of arbitration. We believe that we have resolved some of these, in such a way that achieving one objective does not mean we are heavily penalising another.



Prioritising electricity

Decarbonising the energy mix

by electrification, minimising the environmental impacts of energy production.

Division by 3.5
of the energy-based carbon intensity
of the electrical system by 2050.

2035

end of use of gas in **electricity production**.

2050

end of use of gas in **stationary uses**
(particularly heating and cooking).

Half

the land use per kWh produced
compared to the Négawatt or ADEME scenarios.

The most effective energy vector

Prioritising electricity, the most effective, deployable and multi-use energy vector

Electricity jumps from

24 to 71%

of the total mix in 2050 in line
with changes in end uses.

Channelling of existing gas expertise

into non-electricity uses (merchant shipping,
chemical industries, agricultural vehicles, etc.).

- 30%

in heating demand

through thermal renovation works and the
energy efficiency of buildings.

Electricity storage

**Propose an efficient, sober, well-managed
and sovereign electricity storage solution.**



**Hydraulic
storage**

serving a robust and stable network, for all.

Costs 10 times less

than batteries, lifetime ~100 years,
no critical metals.

2 to 3 times

more efficient compared to "power-to-gas-to-power".

+ 8 TWh

from 19 new facilities (compared to 0.08 TWh
from 6 facilities to date).



Guaranteeing sovereignty and solidarity

European solidarity

Guaranteeing energy sovereignty whilst contributing to European solidarity.

No dependence

on electricity imports.

Margin of 10%

available for export to support the Europe-wide network.



Conservation of ecosystems

Allowing space for other land uses

by limiting the use of biomass to a minimum.

Prioritising where possible energy sources that are more efficient and have smaller footprints.

Biomass reserved for merchant shipping and aviation (replacing hydrogen).

Supporting re-industrialisation

Giving industry the resources it needs to transition to low carbon and grow, whilst minimising new risks.

+165 TWh/year

of electricity consumption by industry in 2050, from 115 TWh/year in 2021 to 280 TWh/year in 2050.

Domestic hydrogen production, so no costly and accident-prone transport network.

Securing the democratic system

and achievement of objectives well beyond 2050.

+60 years

choice of infrastructure with a long lifetime, resilience and sovereignty.

Sobriety

a desirable, important margin, not a requirement for success.



Taking physical properties into account

Nuclear, the cornerstone of our mix

Reposition nuclear energy as the cornerstone of our mix.

80~90 GW

including 50 GW of original fleet + 22 EPR2s in 2050 constituting 70% of the electricity mix. The fleet operates without load following and with 83% availability.

2 reactors/year

ramp-up, then capitalisation of the industrial production rate achieved to deploy EPR2s at a rate of 2 reactors/year as of 2041.

69 years

extension of the average lifetime of the historical fleet to 69 years.

Transform VRE* into a true pathway to decarbonisation

Limit the impact of intermittence on the network.

18%

of stored VRE production helps ensure supply security.

Restrict the consumption of natural resources associated with VRE*.

-66 GW

of VRE power installations not renewed as of 2050 thanks to the maturity of the nuclear fleet.

*Variable Renewable Energy

Ambitious objectives, clear criteria, realistic resources

A firm stance on the objectives to achieve

1

Decarbonisation

A national objective, a global challenge

Decarbonisation of energy - electrical starting in 2035, and total in 2050 - is achieved through **widespread electrification of uses, including the production of hydrogen**. The proposed trajectory also provides support for global decarbonisation by relocating the production of goods and services (re-industrialisation), and by liberating, as soon as possible, facilities, skills or low-carbon electricity production capacities for others.

2

Environment

Reduced impact

Choosing dense, dispatchable energy sources - such as nuclear or hydroelectricity - **reduces the requirements for natural resources (raw materials, metals) in comparison with other alternatives, together with the sub-surface and supra-surface footprint**, and the quantities of waste and pollution produced per kWh generated. **In cutting back on the use of biomass**, competition with other land uses is limited, in particular agricultural land or biodiversity reserves. **In using PSPs (Pumped Storage Powerplants)**, we reap the benefits of the additional services these installations can provide in terms of adapting water management to climate change.

3

Sovereignty

Geopolitical and economic realism

The scenario opts to re-establish a 10% margin in capacity and in energy generation which ensures supply security, including during spikes in demand. This "self-sufficient France" mode puts control of our presence on the interconnected electricity market back into our own hands, along with our **capacity to support European energy stability and sovereignty**. It prioritises solutions sober in materials and technologies over which we have ownership and control, rapidly leads to **the end of oil and gas imports for energy purposes**, and encourages relocation of industrial production sites to France.

4

Solidarity

Not just a challenge, a global priority

Energy - in particular electricity - conditions access to many essential services, and its importance in this regard is only expected to increase. The meaning of solidarity can be expressed clearly as:

- On a national level, optimised technical and industrial choices (electricity vs. gas, collective vs. individual production capacities), with a focus on providing a public service, in order to **offer all French citizens equal and fair access to energy**, regardless of their economic resources, ability to take action themselves, access to property ownership, or where they live.
- At the European and worldwide scale, by freeing up margins in terms of electricity generation and flexibility capacities (via PSP storage), and the **capacity to participate in the global decarbonisation of industry**.

Deliberate choices regarding the resources

5

Technical realism

Rise to the challenge of industrial deployment and the transfer of end-uses

In order to minimise the uncertainty represented by widespread reliance on innovation - within such short time frames and faced with such large challenges - the Voices scenario prioritises tried-and-tested technologies in a 'low-tech' mindset. For example, it chooses hydraulic storage solutions (98% of the world's electricity storage) over chemical batteries and hydrogen, or uses rotating machines to maintain network stability.

6

Technological neutrality

No technological dogmatism

The key, sine qua non selection criterion retained by the Voices scenario for its choice of energy sources is the **low carbon factor**. The next criteria applied are **the environmental footprint** and **industrial maturity**, along with the technical optimum. The economic criterion is not used as such in any choices made in the scenario. However, it should be pointed out that application of the above criteria leads to an energy mix that is capital-intensive - being based on large infrastructure - though **economically pertinent for the nation from the outset** and in the long term.

7

Secure supply

Reliability, robustness and sustainability of energy supply

Guarantees are extended to future generations through the choice of dispatchable or storable energy sources, using tried-and-tested yet sober technologies and with sovereign (or soon to be so) supply chains. **Calculated on a basis that takes into account the challenges faced by current industries, whilst recovering lost margins, this scenario delivers an energy transition in the form of concrete results, rather than promises.** It is addressed to the future generations who will have to live with the consequences of the policies we implement today. It achieves France's decarbonisation objectives for 2050, but it also stabilises a sustainable energy mix from 2070 onwards, for both individuals and the infrastructure and services that will accompany their lifestyle choices. Their own choices, not the choices we impose on them.

8

Changes in society

Desirable margins, not a requirement

Although the association advocates a deep change in behaviours toward energy and resource consumption, it purposefully chooses not to condition the energy future of France and its citizens on such a change, which in the context of a democracy is too dependent on individual choices. **Practising sobriety provides a welcome margin, but remains too uncertain to be a reliable guarantee.**

How to get there

By working on how to articulate the deployment of various low-carbon energy sources to take into account their contributions over time and the possible industrial trajectories. The stabilised mix combines all these energies according to their physical properties and the services they contribute to the system.

