Le réseau de transport d'électricité

Energy Pathways to 2050

Evolution in weather-related risks to France's power system

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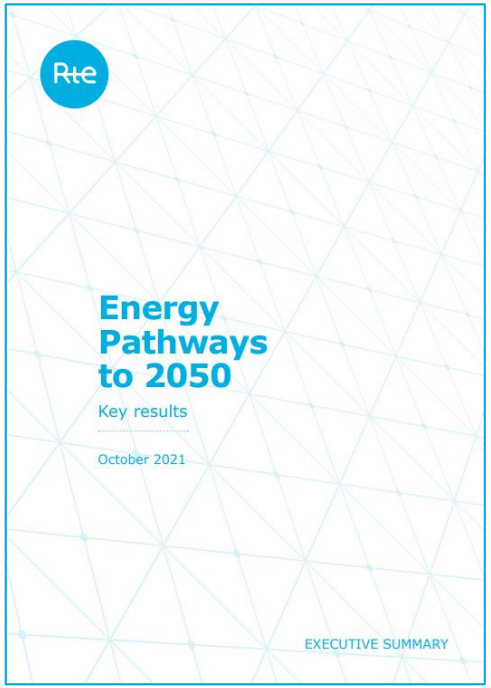
Energy Pathways to 2050

RTE's mission to enlighten the public and decision makers
& request of the French government in 2019



Scoping of the study, characterisation of the scenarios

9 working groups
40 meetings held with experts from >100 energy sector firms, NGOs, institutes, regulatory and government agencies ...

2021 S1: public consultation
≈ 4,000 answers

Simulations, analyses

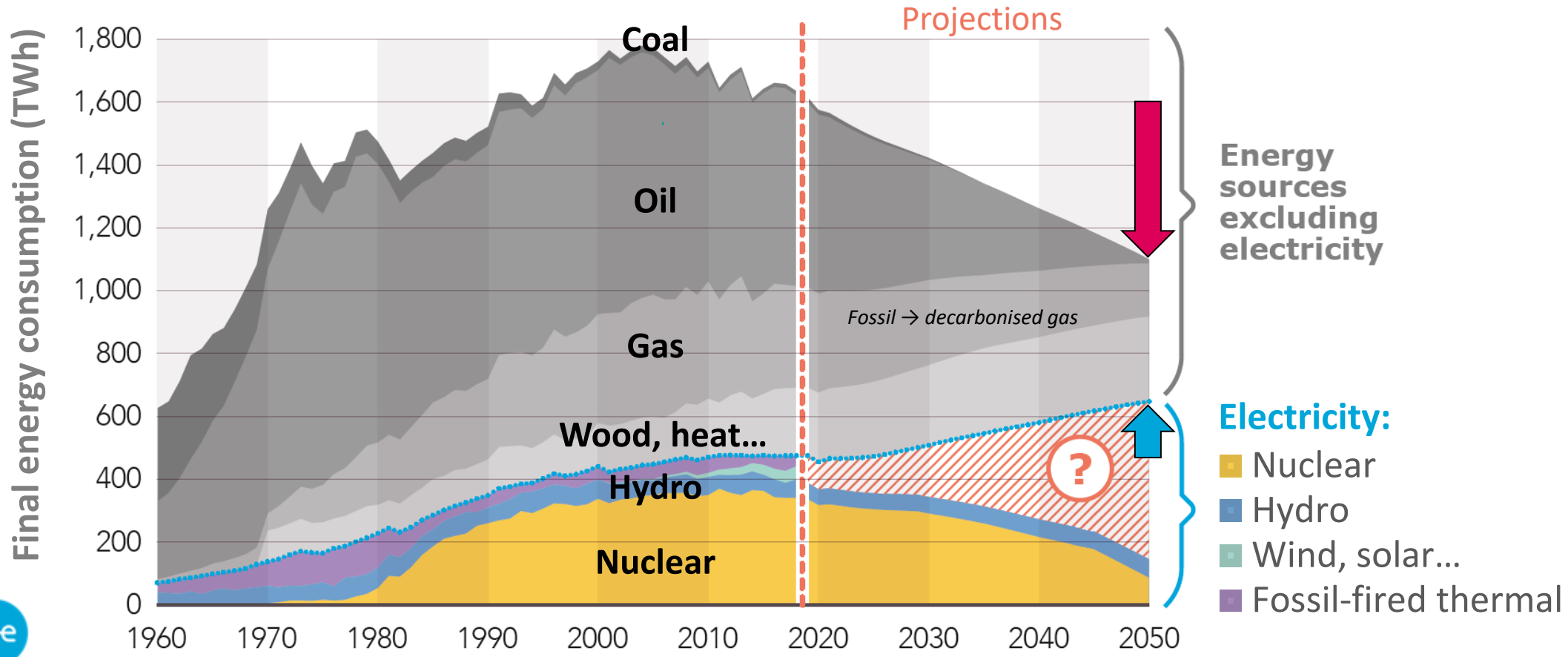
Over 8,000 simulations
and 500,000 hours CPU

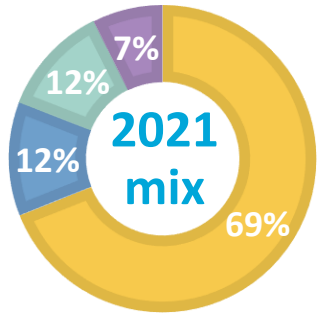
Publication of results

- **Key results** (Oct. 2021)
- **In-depth analyses** (Feb. 2022) ≈ 1,000 pages

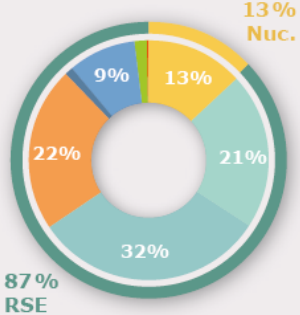
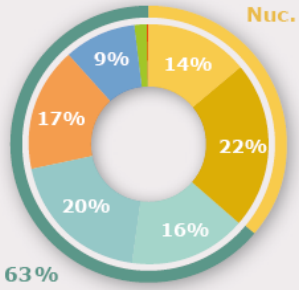
Energy Pathways to 2050 | Achieve carbon neutrality in 2050

To achieve **carbon neutrality in 2050**, total energy consumption would decrease (**– 40%**) but demand for **electricity** would increase (**+ 35% in baseline trajectory**) as fossil fuels are replaced (in transport, industry…)
→ Need to produce more decarbonised electricity (how?) while **replacing the current nuclear power plants**.





Energy Pathways to 2050 | Six generation mix scenarios

	GENERATION MIX IN 2050	INSTALLED CAPACITY IN 2050 (IN GW)*					MIX OF FLEXIBLE RESOURCES IN 2050
		Solar	Onshore wind	Offshore wind	Historical nuclear	New nuclear	
RES only # Large Farms		~125 GW (i.e. x12)	~72 GW (i.e. x4)	~60 GW	16 GW	/	15 GW 1.7 GW (1.1 M EV) 20 GW 13 GW
RES + new nuclear #2		~90 GW (i.e. x8,5)	~52 GW (i.e. x2,9)	~36 GW	16 GW	23 GW (i.e. 14 EPR)	15 GW 1.7 GW (1.1 M EV) 5 GW 2 GW

New decarbonised thermal

Batteries

capacities set to have a similar level of **security of supply** in all scenarios

Demand-side flexibility (excl. V2G)

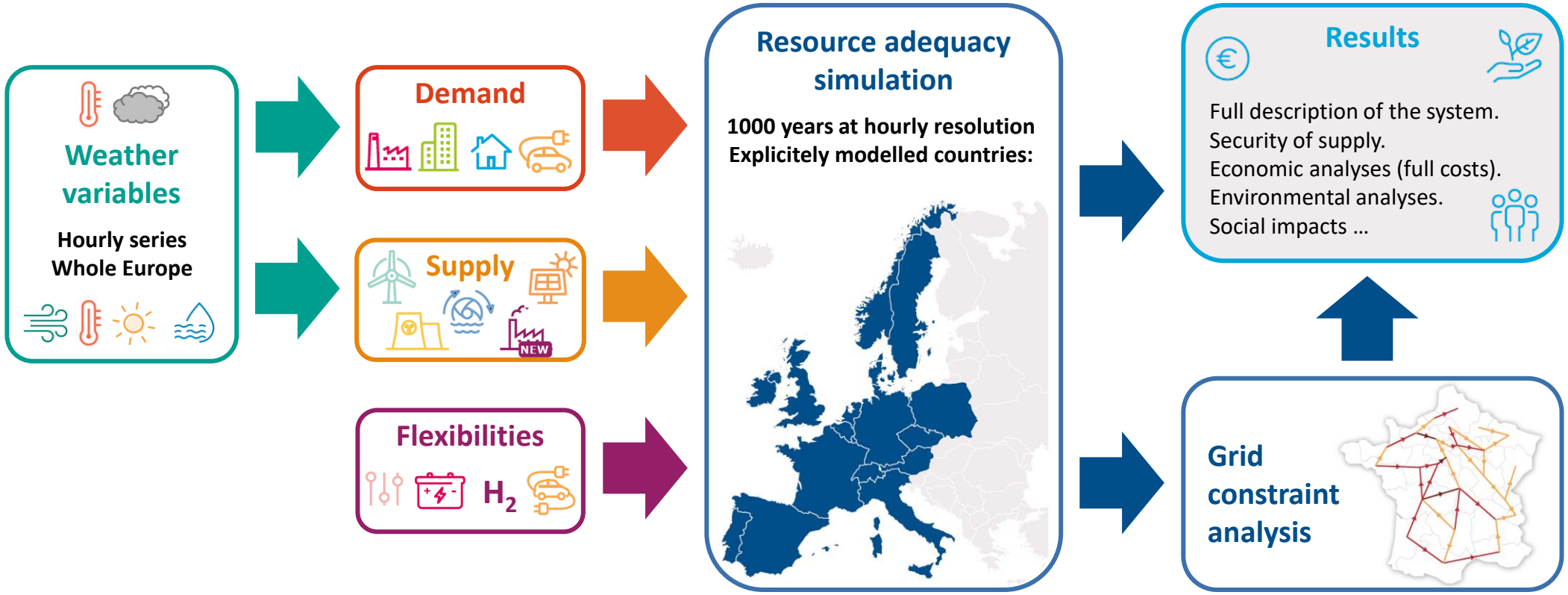
Vehicle-to-grid

** For the baseline demand scenario*

1 Method: input data to the simulations

What changes between now and 2050?

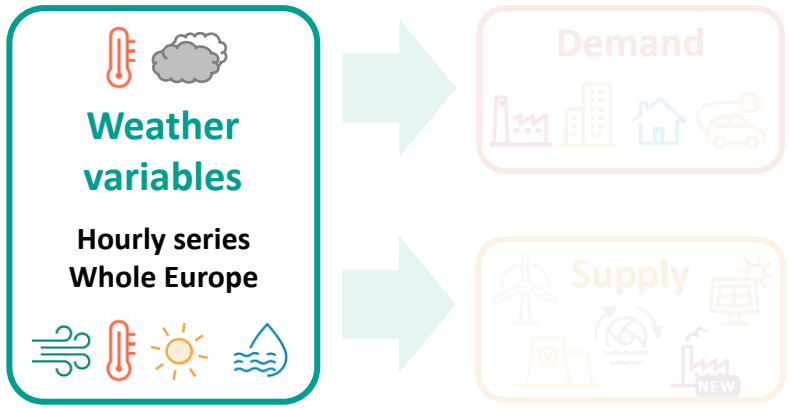
Simulations

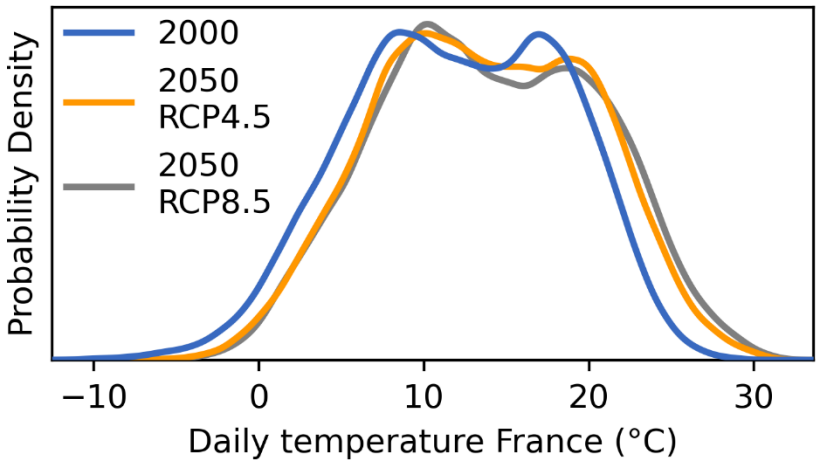


One simulation for each **demand × generation mix × … × horizon** (2030, 2040, 2050, 2060).

By construction, they all enable **carbon neutrality** in 2050 and all have a similar level of **security of supply** as today (expected energy not served of 10 GWh/year).

Simulations | Climate database





Climate simulations

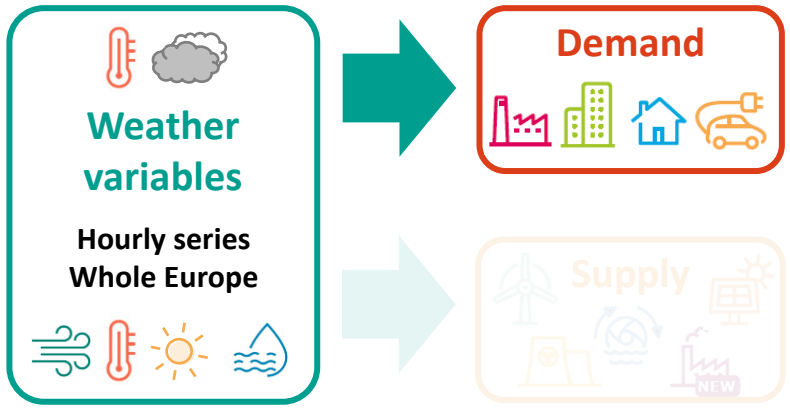
by Météo-France using ARPEGE-Climate model.

Three datasets representing **3 different climates**

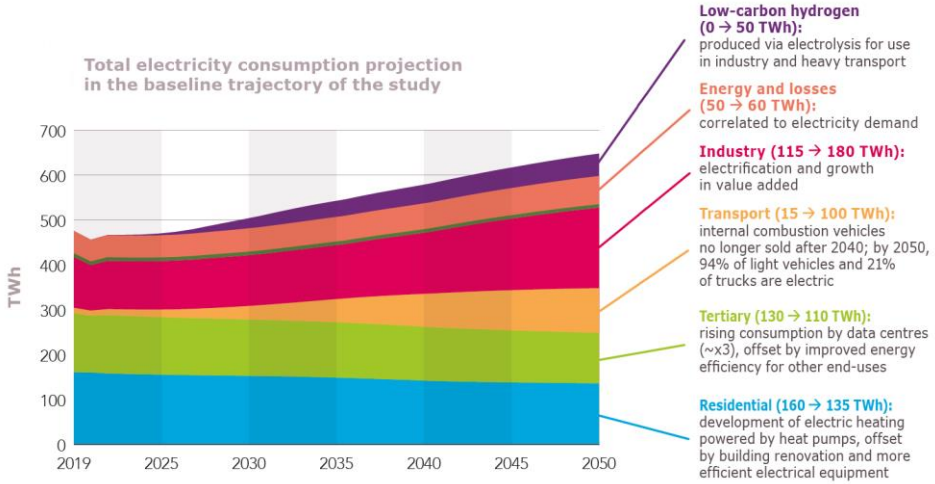
Each dataset = **200 years**

- **Climate around year 2000**
  (and a 2025 variant for temperature)
  - baseline for past/current climates
- **Climate around year 2050 (scenario RCP4.5)**
  - reference for future climate
- **Climate around year 2050 (scenario RCP8.5)**
  - used for stress-case scenarios

Simulations | Demand

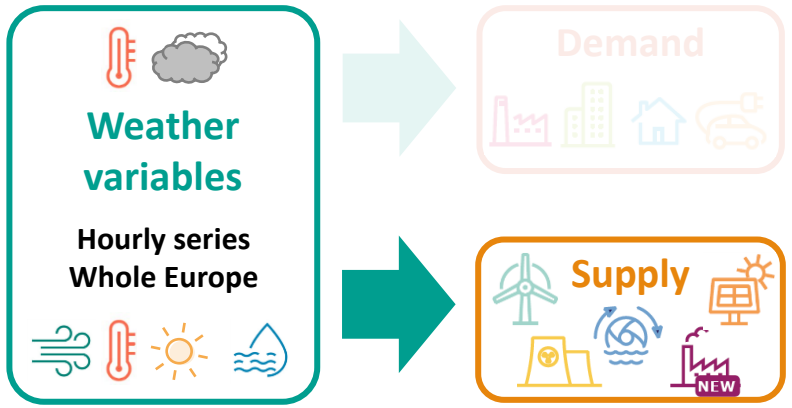


- **Climate change impacts**
  - Less cold days → less demand for electric heating
  - More and hotter days → more demand for air conditioning

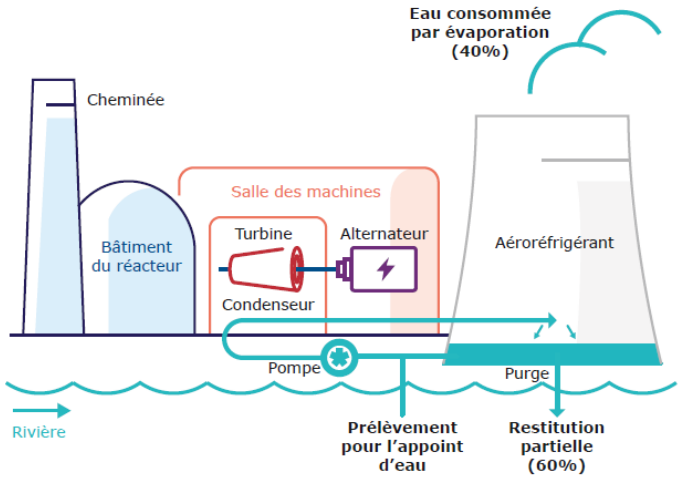


- **Structural changes**
  - **Reduced** consumption through **efficiency** and possibly sufficiency
  - **Increased** consumption from **fossil fuel substitution** (transport, industry, hydrogen)

Simulations | Supply



- **Climate change impacts**
  - Small impacts on wind and solar generation in FR
  - Changes in hydropower's seasonality.
  - Reduced availability and efficiency of thermal plants (low streamflows or high river temperatures)



- **Structural changes**
  - **Generation mix**
    Wind & solar share: 12 % → 40 to 90 % in 2050
  - **Interconnections**
    Import capacity 13 GW → around 40 GW in 2050

2 Principal findings

Analysis of the outputs from a meteorological perspective

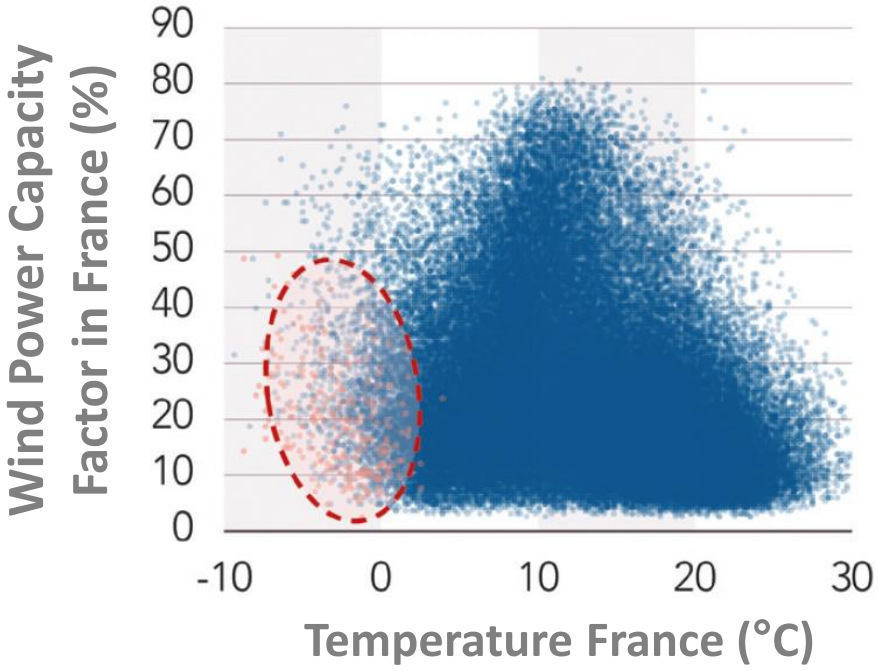
Weather-related risks shifting to cold « wind droughts »

Simulations over 200 weather years.

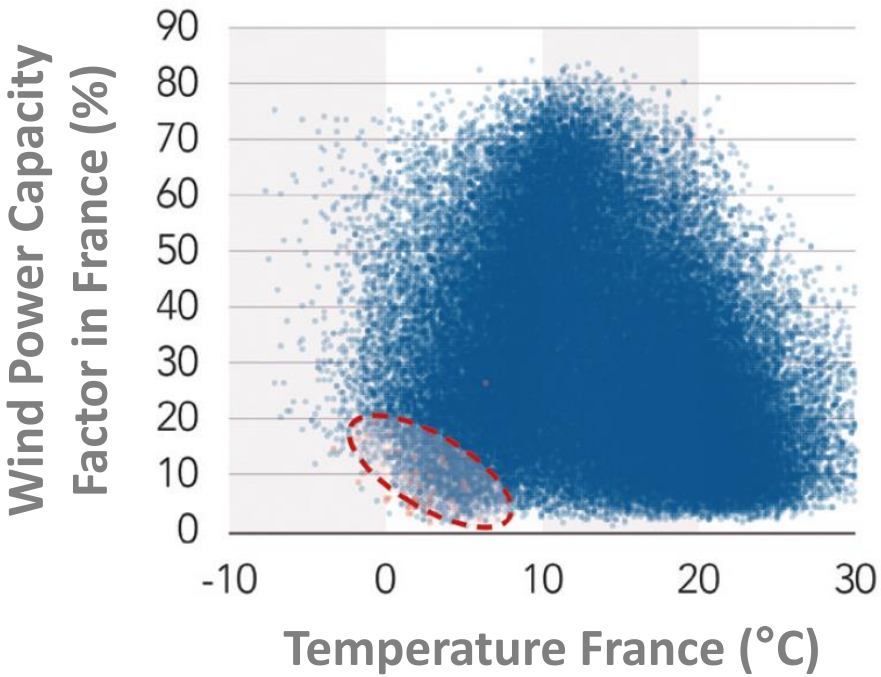
Risk of scarcity (energy not served) in France :

- Days without risk
- Days with a risk

Present day

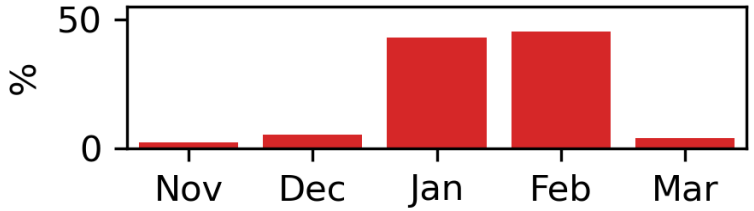


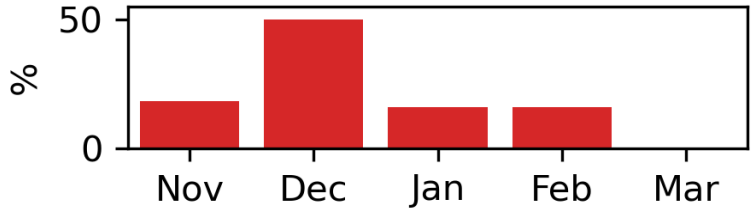
2050 (scenario RES)



➢ **Today: very cold days** (almost only Jan & Feb)

➢ **2050: low wind & cold** (Nov to Feb)



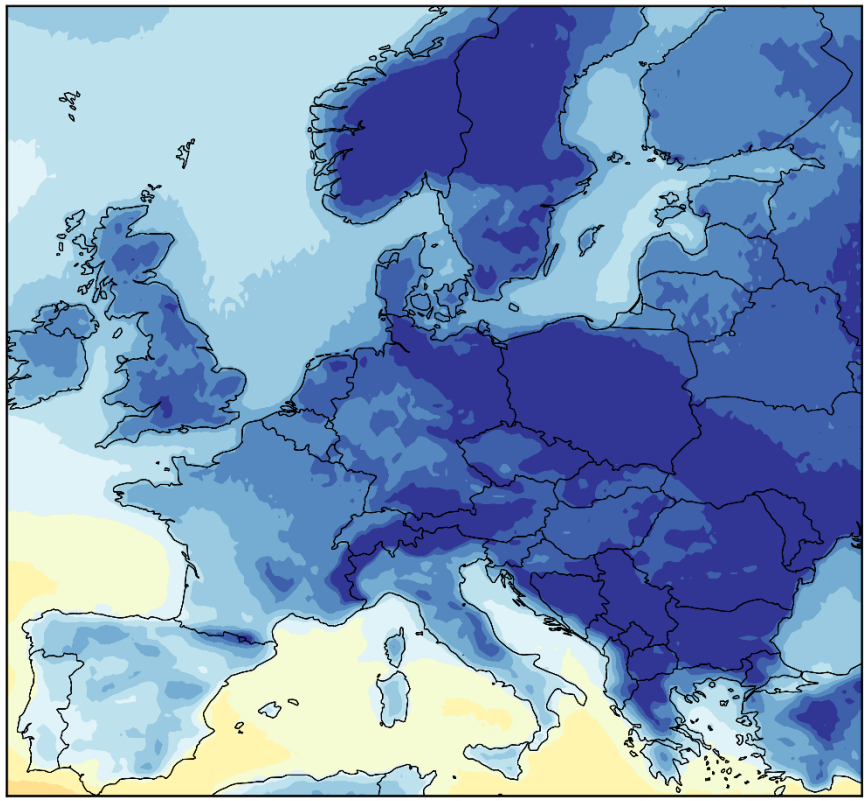


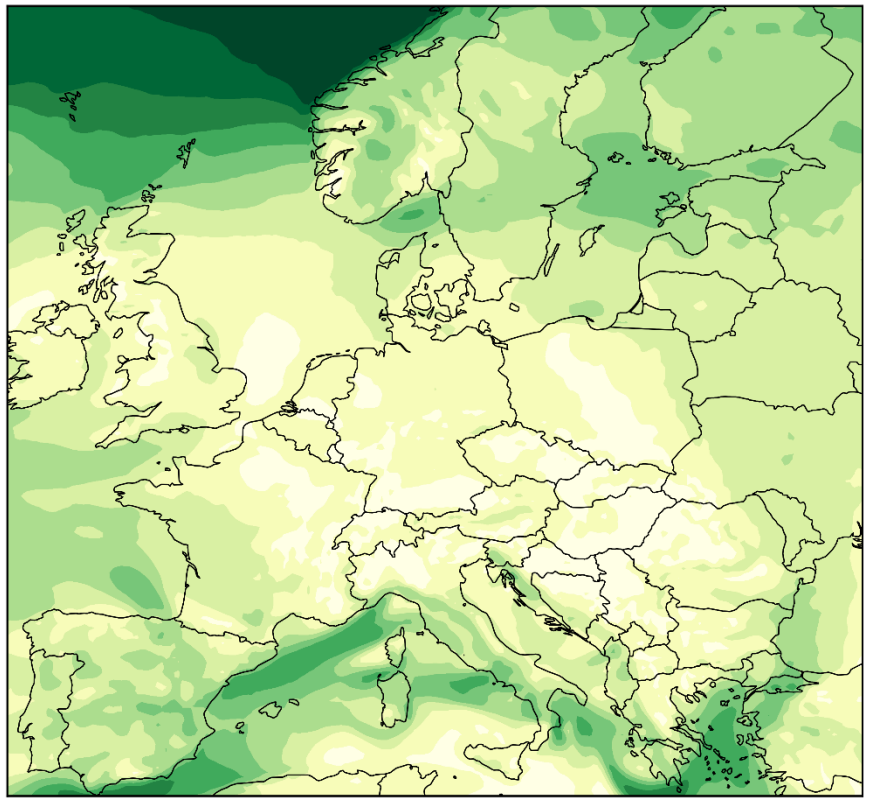
Weather-related risks shifting to cold « wind droughts »

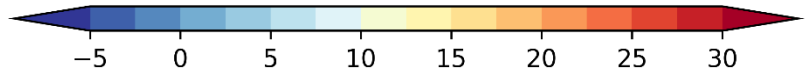
Example of a day with scarcity in France in 2050 (whatever the generation mix).

Low temperatures & low winds
=> high residual loads

not only in France but **over most of Europe**







Temperature (°C)

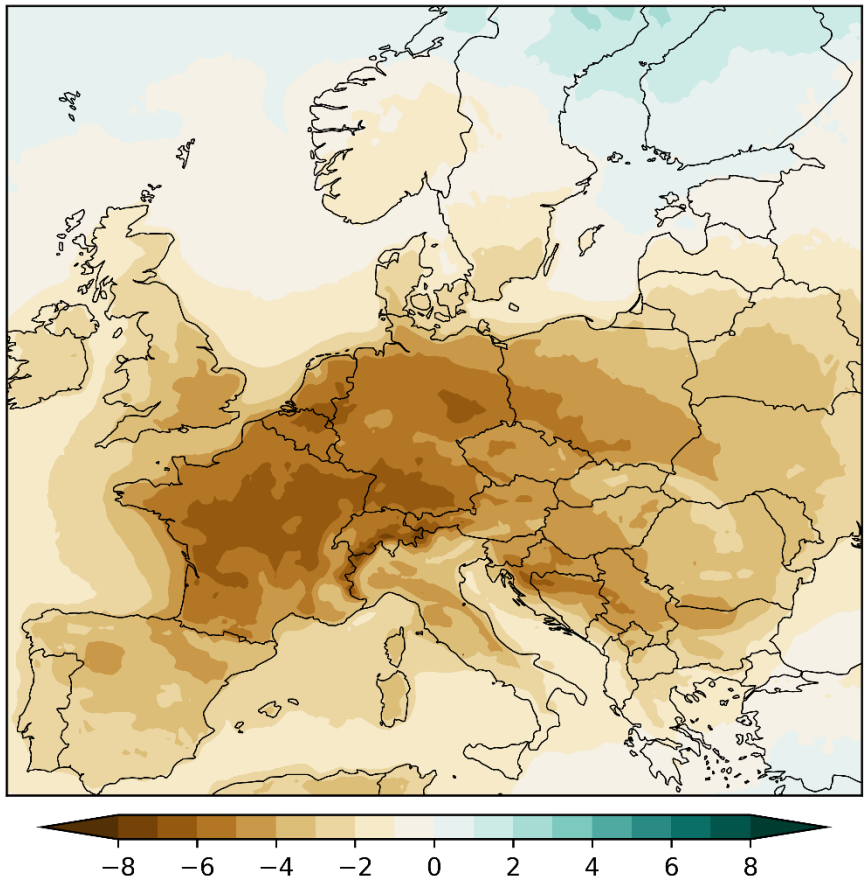
Wind speed at 100 m (m/s)

Weather-related risks shifting to cold « wind droughts »

Average of all days with scarcity risk

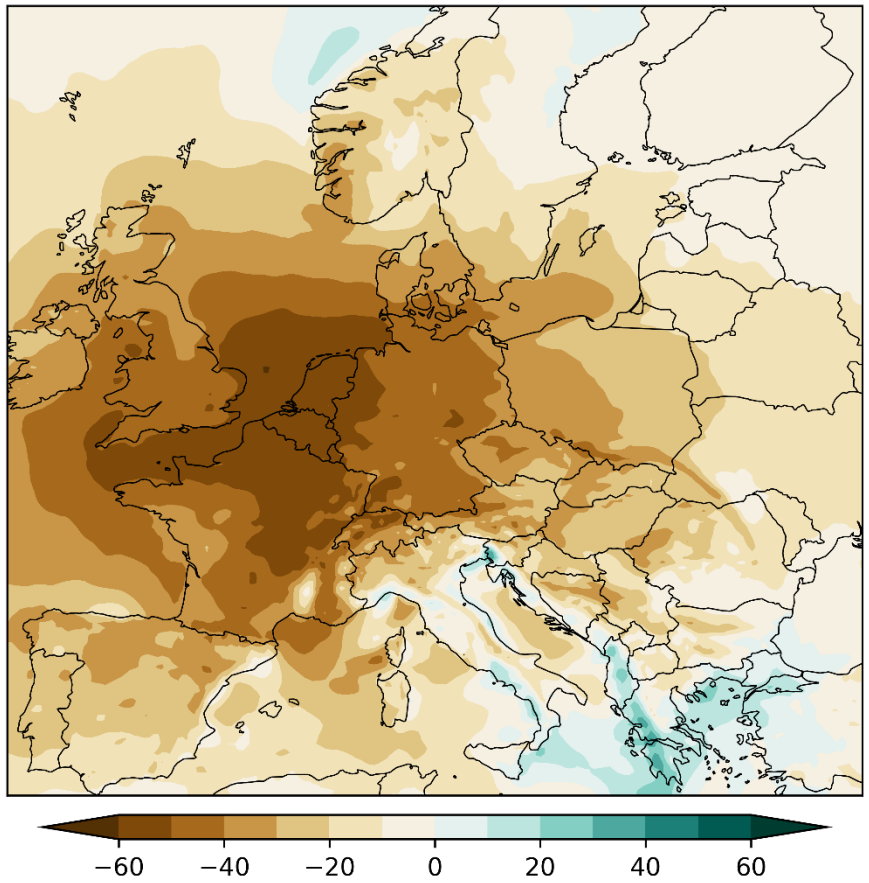
compared to

average over the whole extended winter (NDJF)



−8 −6 −4 −2 0 2 4 6 8

Absolute difference in temperature (°C)



−60 −40 −20 0 20 40 60

Relative difference in wind speed at 100 m (%)

Conclusion and perspectives

Under those assumptions and scenarios:

- Tension situations for France's power system would evolve from very cold periods to **cold wind droughts** covering most of Europe (between November and February)

- In summer:
  - No risk terms of scarcity
    - ✗ Reduced availability of nuclear power plants (because of low streamflows and high river temperatures)
    - ✓ Very large solar generation (≈100-200 GW of installed PV) and enough flexibility
  - But there could be risks to the system's **infrastructure and operation** in case of extreme heat and wild fires. → Perspective work

Le réseau de transport d'électricité

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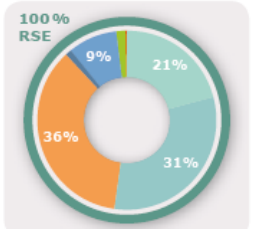
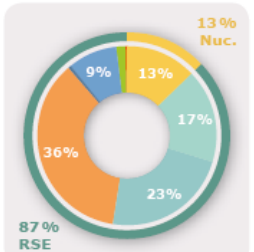
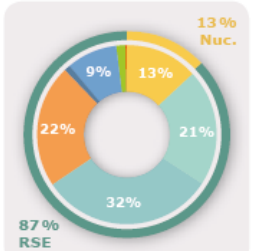
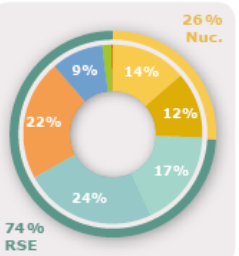
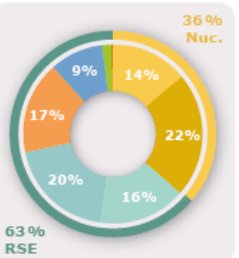
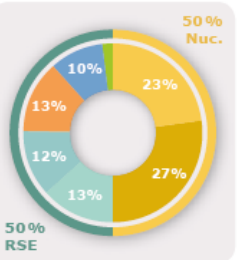
Key findings (in English): https://www.rte-france.com/en/home

Whole study (in French): https://www.rte-france.com/analyses-tendances-et-prospectives/bilan-previsionnel-2050-futurs-energetiques

Generation mix scenarios

	GENERATION MIX IN 2050	INSTALLED CAPACITY IN 2050 (IN GW)* Solar	Onshore wind	Offshore wind	Historical nuclear	New nuclear	MIX OF FLEXIBLE RESOURCES IN 2050
M0 100% RES in 2050		~208 GW (i.e. x21)	~74 GW (i.e. x4)	~62 GW	/	/	15 GW 1.7 GW (1.1 M EV) 29 GW 26 GW
M1 Distributed		~214 GW (i.e. x22)	~59 GW (i.e. x3,5)	~45 GW	16 GW	/	17 GW 1.7 GW (1.1 M EV) 20 GW 21 GW
M23 Large RES		~125 GW (i.e. x12)	~72 GW (i.e. x4)	~60 GW	16 GW	/	15 GW 1.7 GW (1.1 M EV) 20 GW 13 GW
N1 RES + new nuclear 1		~118 GW (i.e. x11)	~58 GW (i.e. x3,3)	~45 GW	16 GW	13 GW (i.e. 8 EPR)	15 GW 1.7 GW (1.1 M EV) 11 GW 9 GW
N2 RES + new nuclear 2		~90 GW (i.e. x8,5)	~52 GW (i.e. x2,9)	~36 GW	16 GW	23 GW (i.e. 14 EPR)	15 GW 1.7 GW (1.1 M EV) 5 GW 2 GW
N03 RES + new nuclear 3		~70 GW (i.e. x7)	~43 GW (i.e. x2,5)	~22 GW	24 GW	~27 GW (i.e. ~14 EPR + a few SMRs)	13 GW 1.7 GW (1.1 M EV) 1 GW