Le réseau de transport d'électricité

ESIG
ENERGY SYSTEMS INTEGRATION GROUP

RTE's Approach to Forward-Looking Weather Data

Long-Term Resource Adequacy Assessment

13 June 2023

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Thanks to Bénédicte Jourdier and many other colleagues

AGENDA

Introduction: what is the problem?

Long-Term Resource Adequacy Assessments : Energy Pathways to 2050

What's next?

Summary

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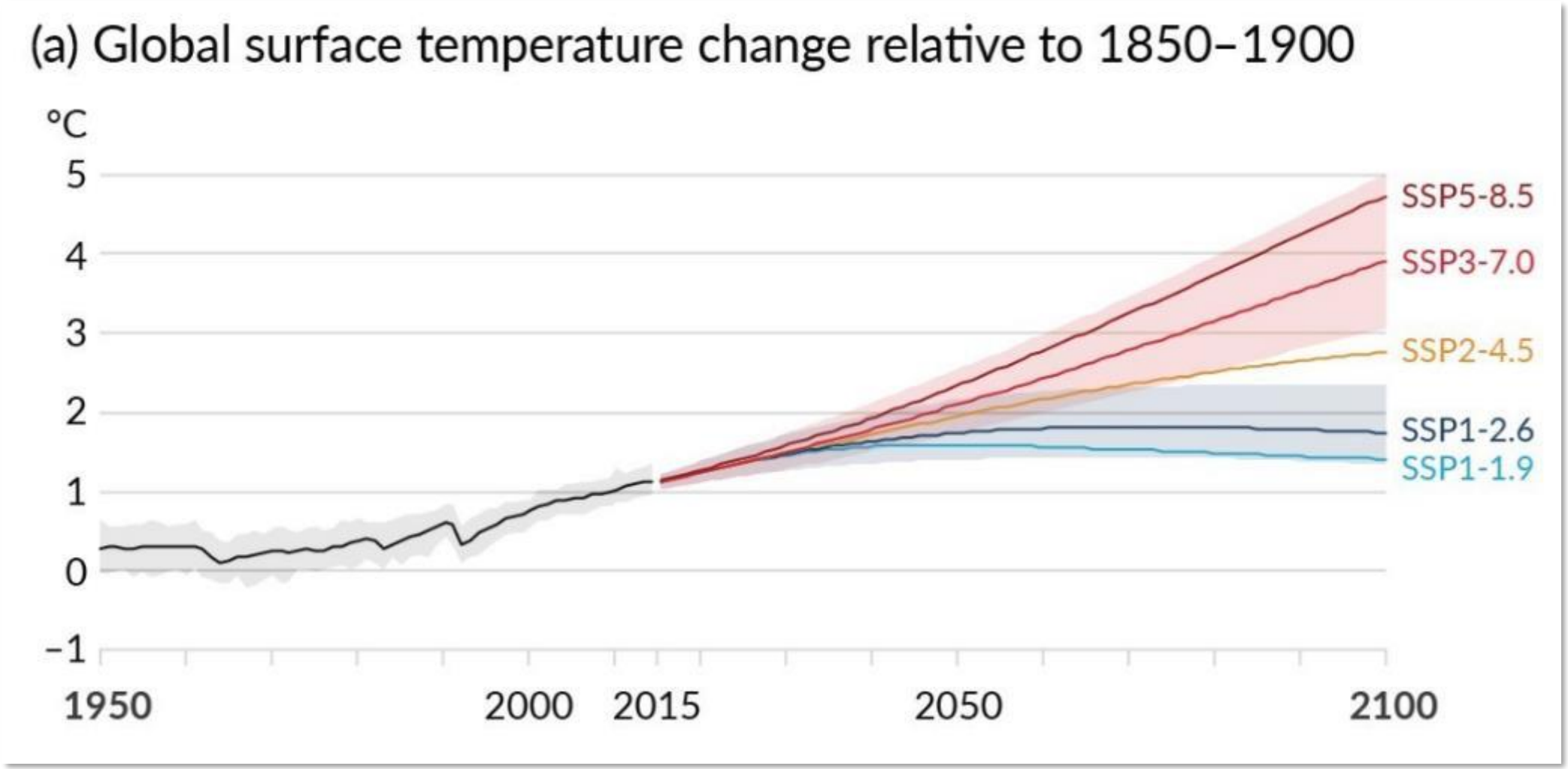
Climate change is a reality



Source: IPCC 6th Assessment Report, 2021

Example 1: The Pacific North American Heatwave in June 2021

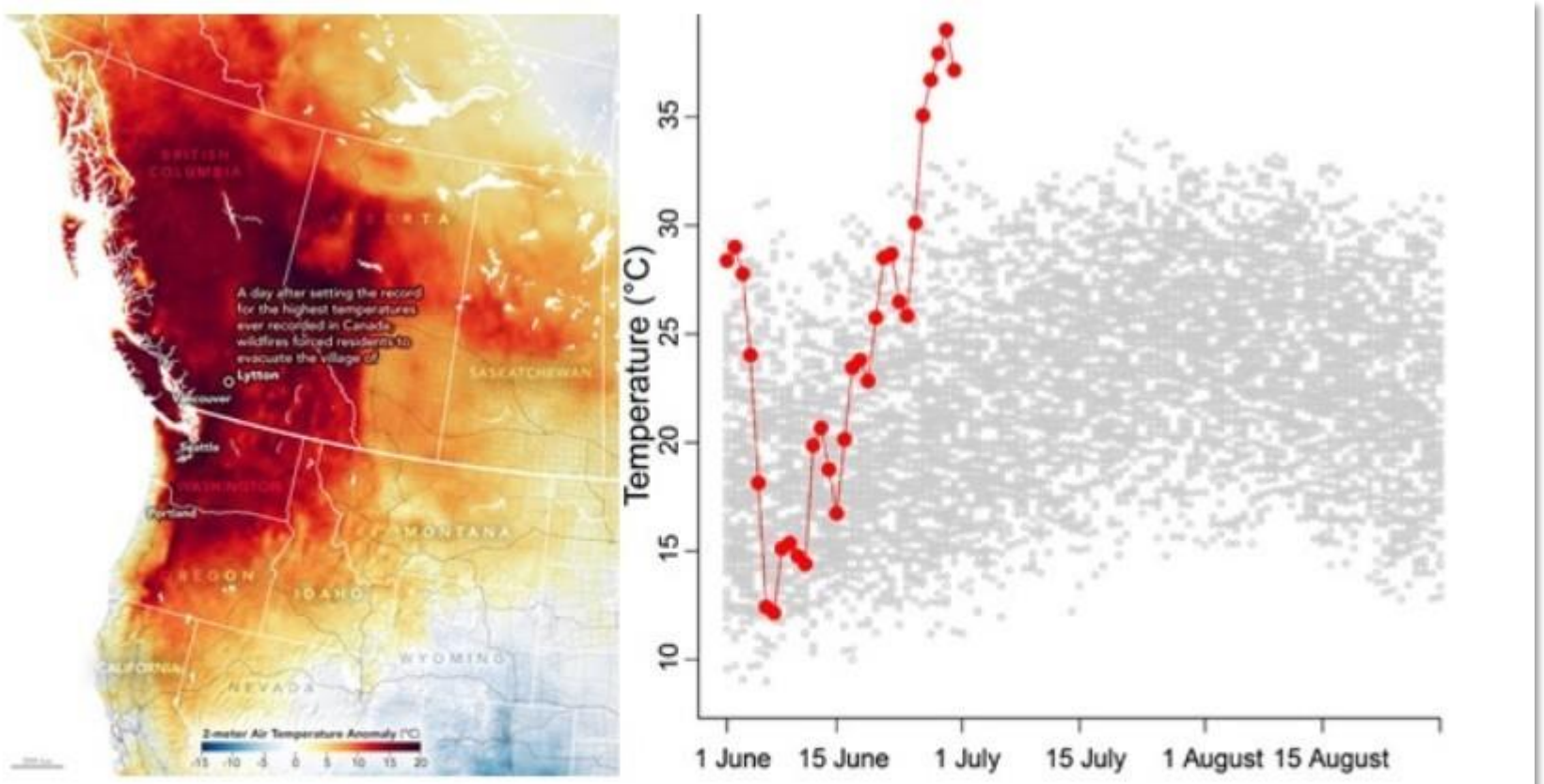
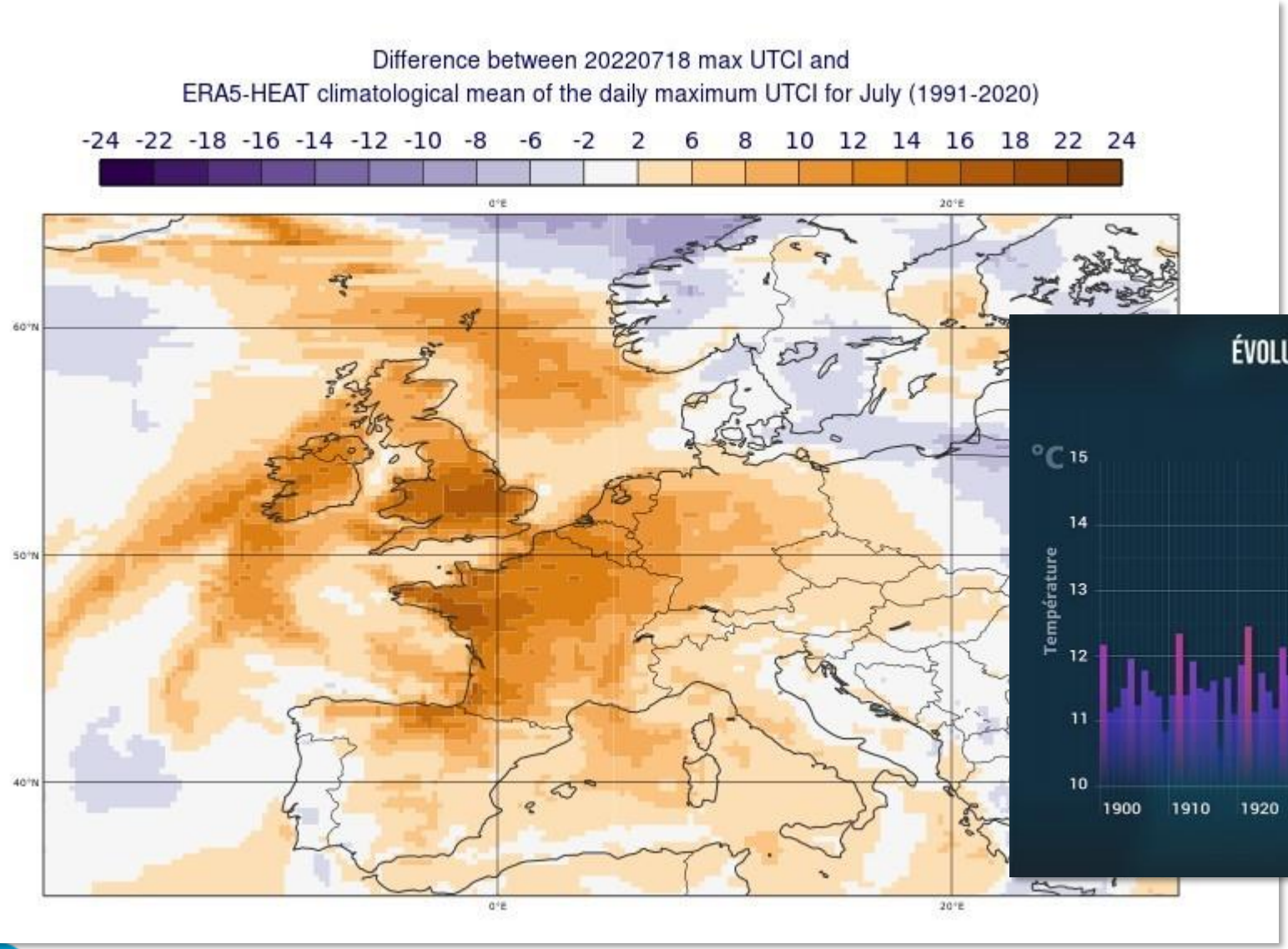
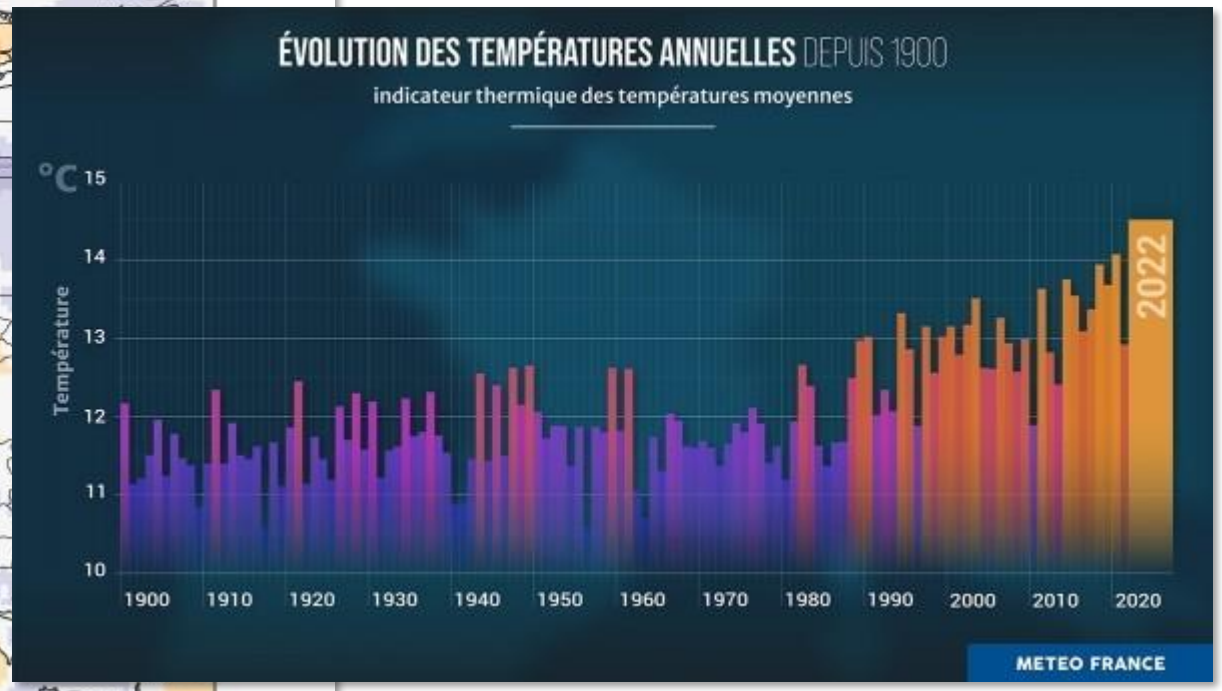


Figure1: (left) Temperature anomalies during the 2021 Pacific Northwest heatwave (NASA 2021) and (right) area-average temperatures in 2021 (red) compared to the period 1950-2020 (grey dots) in ERA5 reanalysis (plot by Erich Fischer).

Source: XAIDA project

Example 2: Heatwave in western Europe in July 2022





Source: [ECMWF severe events catalogue]

The power transport network is dependent on weather and climate…

… at all time scales

… Climate Change & RES Development will increase the dependance
➔ Climate Change MUST be taken into account for prospective studies

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Long-Term Resource Adequacy Assessments : Energy Pathways to 2050

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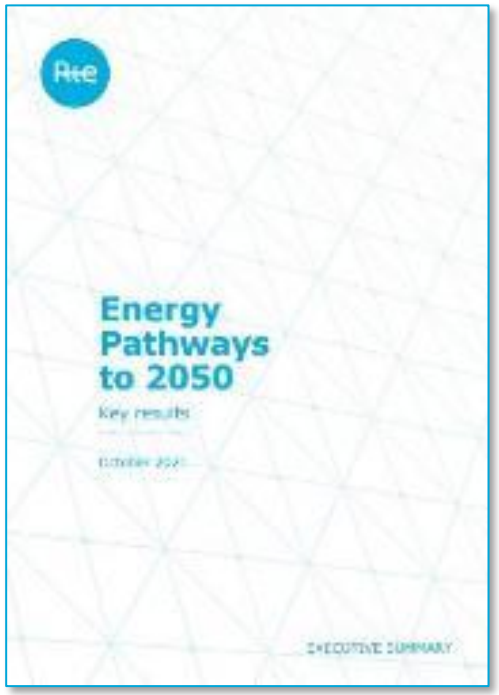
Long term prospective: « Energy Pathways to 2050 »
A comprehensive modelling and an extensive analysis

- A document required by the French authorities
- Based on International, European and French objectives and policies to fight climate change and reach decarbonation targets by 2050
- Complete power system modeling under different energy mix scenarios and several consumption trajectories
- First such study of its kind to include climate change considerations



Long term prospective: « Energy Pathways to 2050 »
A comprehensive modelling and an extensive analysis

3 sets of **200 climate years**, hourly data, 20 km resolution over Europe:
- 2000
- 2050 - RCP4.5
- 2050 - RCP8.5

Assumptions France & Europe

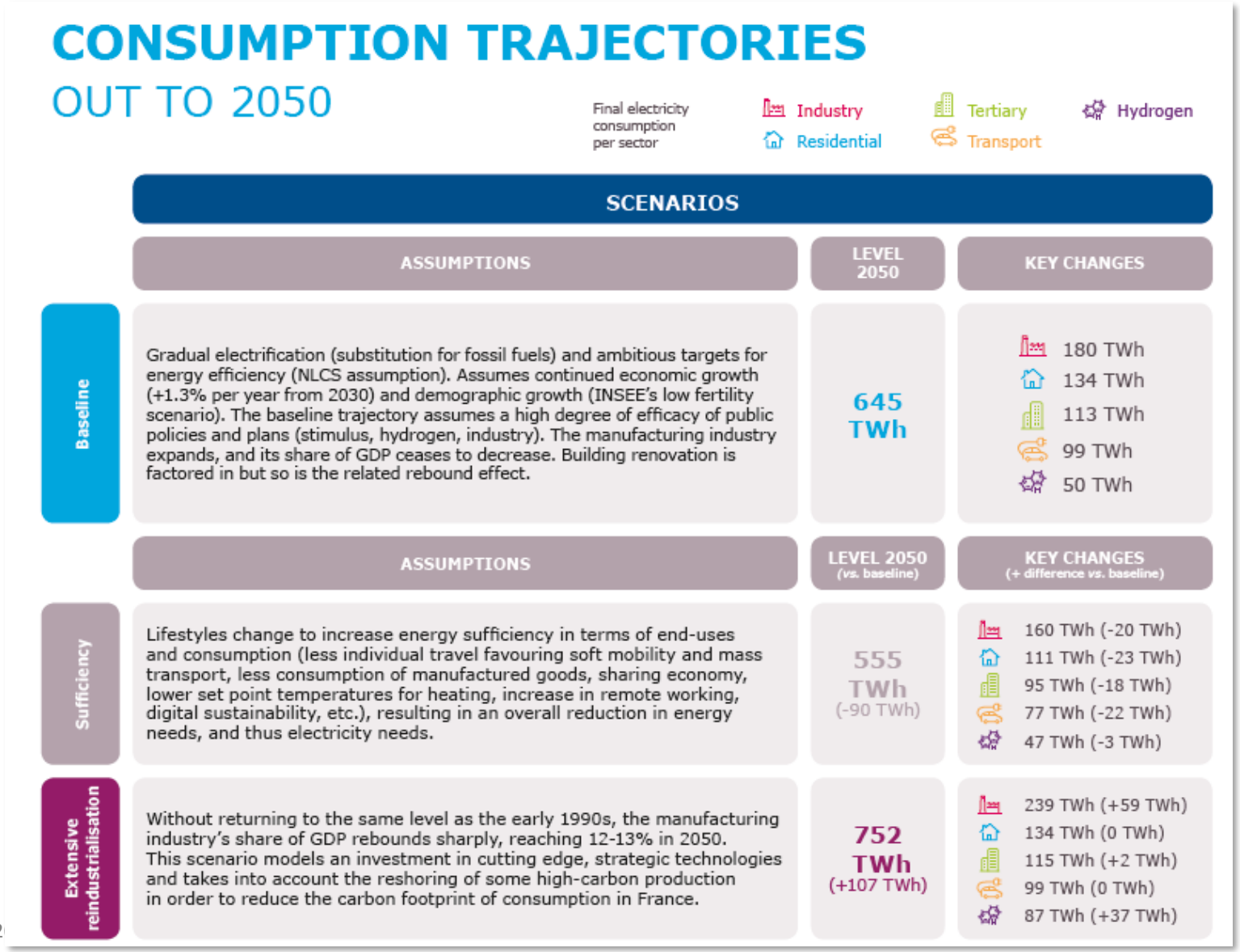
- **Climate database**
- **Thermal units availability time series**
- **RE generation time series**
- **Consumption time series** consommation
- **Flexibilities and sectorial coupling**

Simulation of supply/demand balance at hourly time resolution + economic closure

Network needs study

- **Network volumes**
- **Energy balance, flexibilities**
- **Complete system costs, investments needs**
- **CO2 emissions, raw materials consumption, soil artificialisation, nuclear wastes…**

Different scenarios for electricity consumption

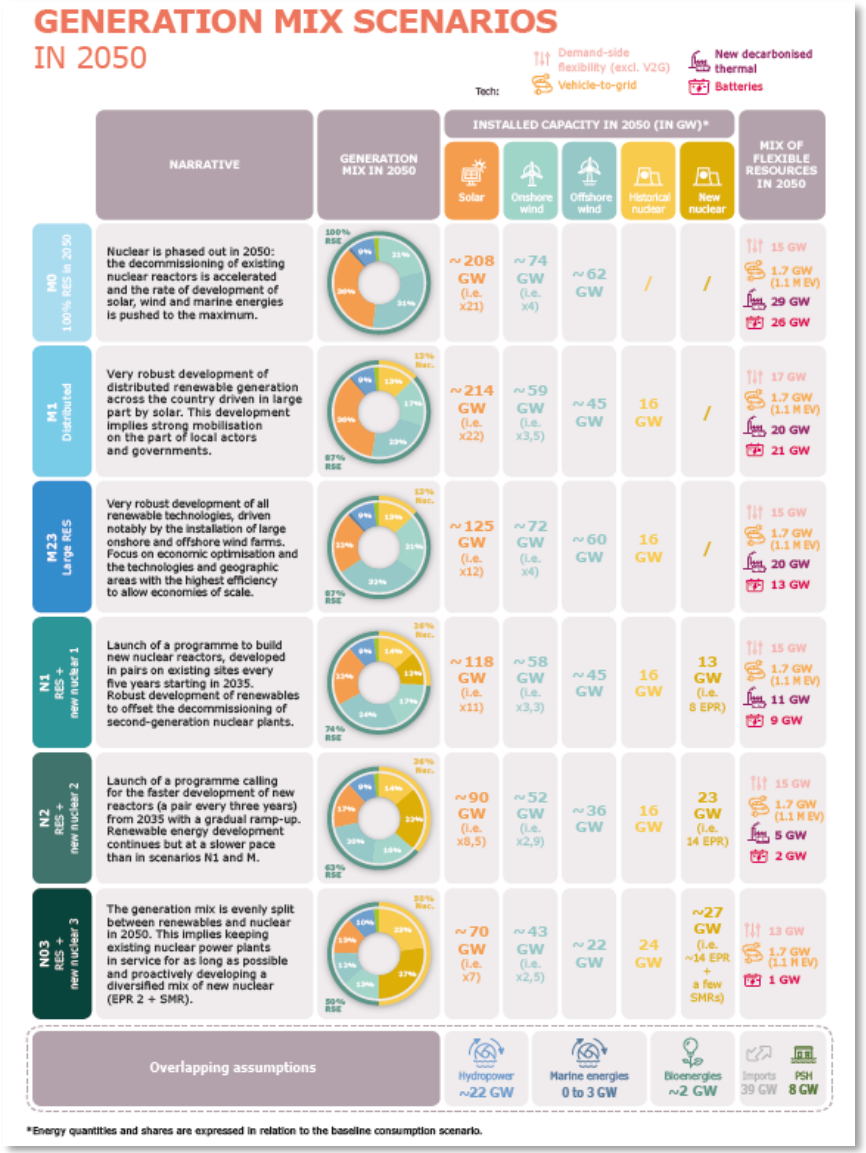


+ Variants

And 6 generation mix scenarios

Family 1: RES mainly

Family 2: new nuclear plants



GENERATION MIX SCENARIOS IN 2050

Tech: Demand-side flexibility (excl. V2G) · Vehicle-to-grid · New decarbonised thermal · Batteries

	NARRATIVE	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	
M0 100% RES in 2050	Nuclear is phased out in 2050: the decommissioning of existing nuclear reactors is accelerated and the rate of development of solar, wind and marine energies is pushed to the maximum.	100% RSE	~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	Very robust development of distributed renewable generation across the country driven in large part by solar. This development implies strong mobilisation on the part of local actors and governments.	13% Nuc. · 87% RSE	~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	Very robust development of all renewable technologies, driven notably by the installation of large onshore and offshore wind farms. Focus on economic optimisation and the technologies and geographic areas with the highest efficiency to allow economies of scale.	13% Nuc. · 87% RSE	~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	Launch of a programme to build new nuclear reactors, developed in pairs on existing sites every five years starting in 2035. Robust development of renewables to offset the decommissioning of second-generation nuclear plants.	26% Nuc. · 74% RSE	~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	Launch of a programme calling for the faster development of new reactors (a pair every three years) from 2035 with a gradual ramp-up. Renewable energy development continues but at a slower pace than in scenarios N1 and M.	36% Nuc. · 63% RSE	~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	The generation mix is evenly split between renewables and nuclear in 2050. This implies keeping existing nuclear power plants in service for as long as possible and proactively developing a diversified mix of new nuclear (EPR 2 + SMR).	50% Nuc. · 50% RSE	~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
Overlapping assumptions			Hydropower ~22 GW		Marine energies 0 to 3 GW	Bioenergies ~2 GW	Imports 39 GW · PSH 8 GW	

*Energy quantities and shares are expressed in relation to the baseline consumption scenario.

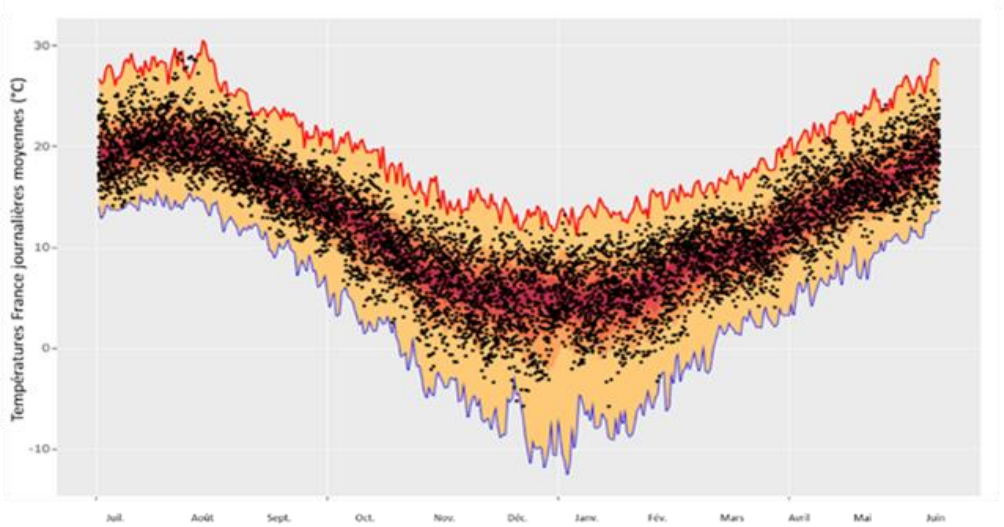
Climate: our current approach

→ Météo-France specific climate simulations with fixed GHG

Available data

- Temperature
- Cloud Cover
- Wind Speed
- Solaire Irradiance
- Precipitation & river flow

200 years, hourly time resolution
37 000 points over Europe



Black dots represent the actual observations over the last 33 years

Bias correction with Hirlam Reanalysis

Extrapolation of extreme temperature values

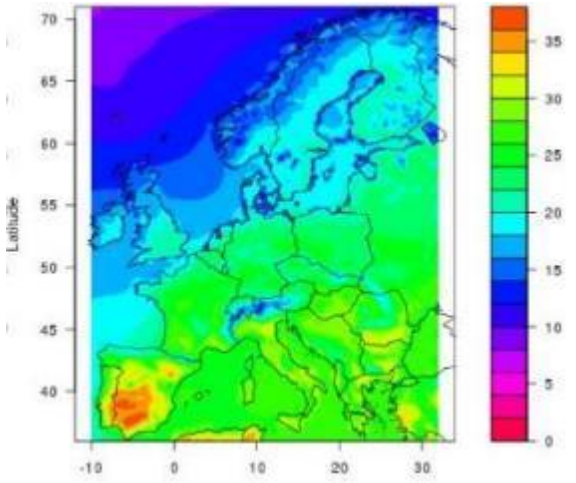
- **3 simulations sets with « constant climate »**

❑200 years « climate 2000 »

❑200 years « climate 2050 » RCP4.5

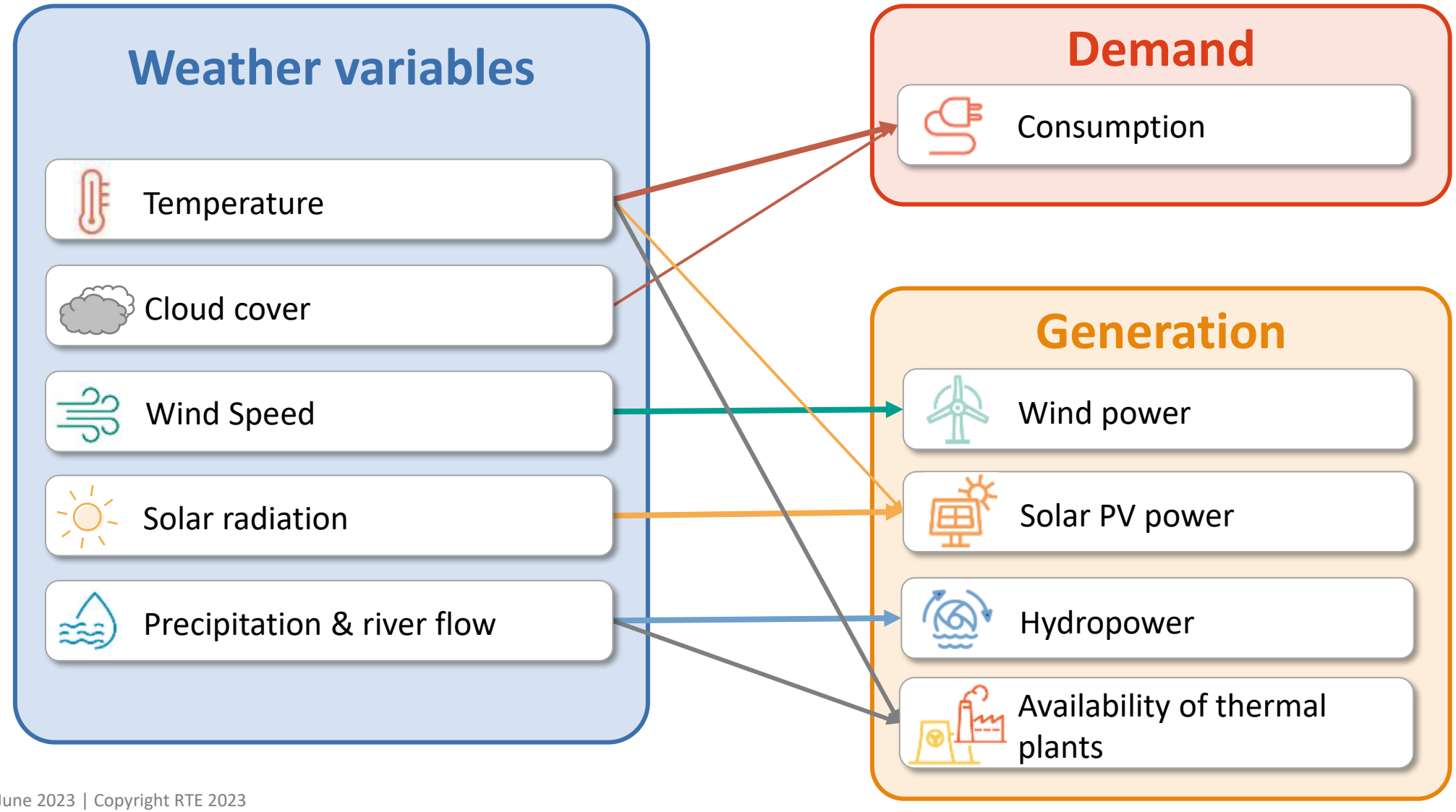
❑200 years « climate 2050 » RCP8.5

Data on more than 37,000 grid points over Europe

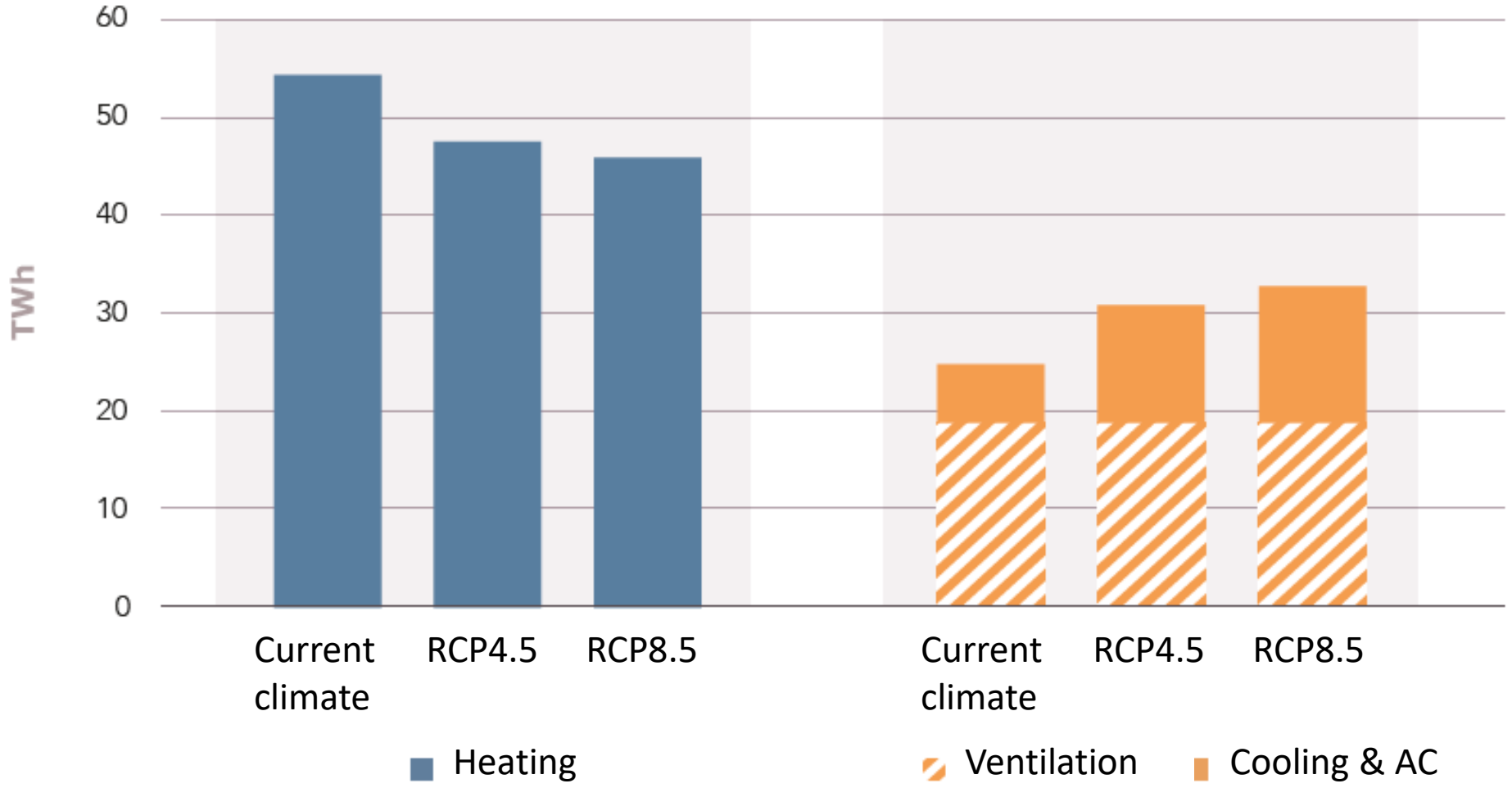


Source Météo-France

From climate to energy

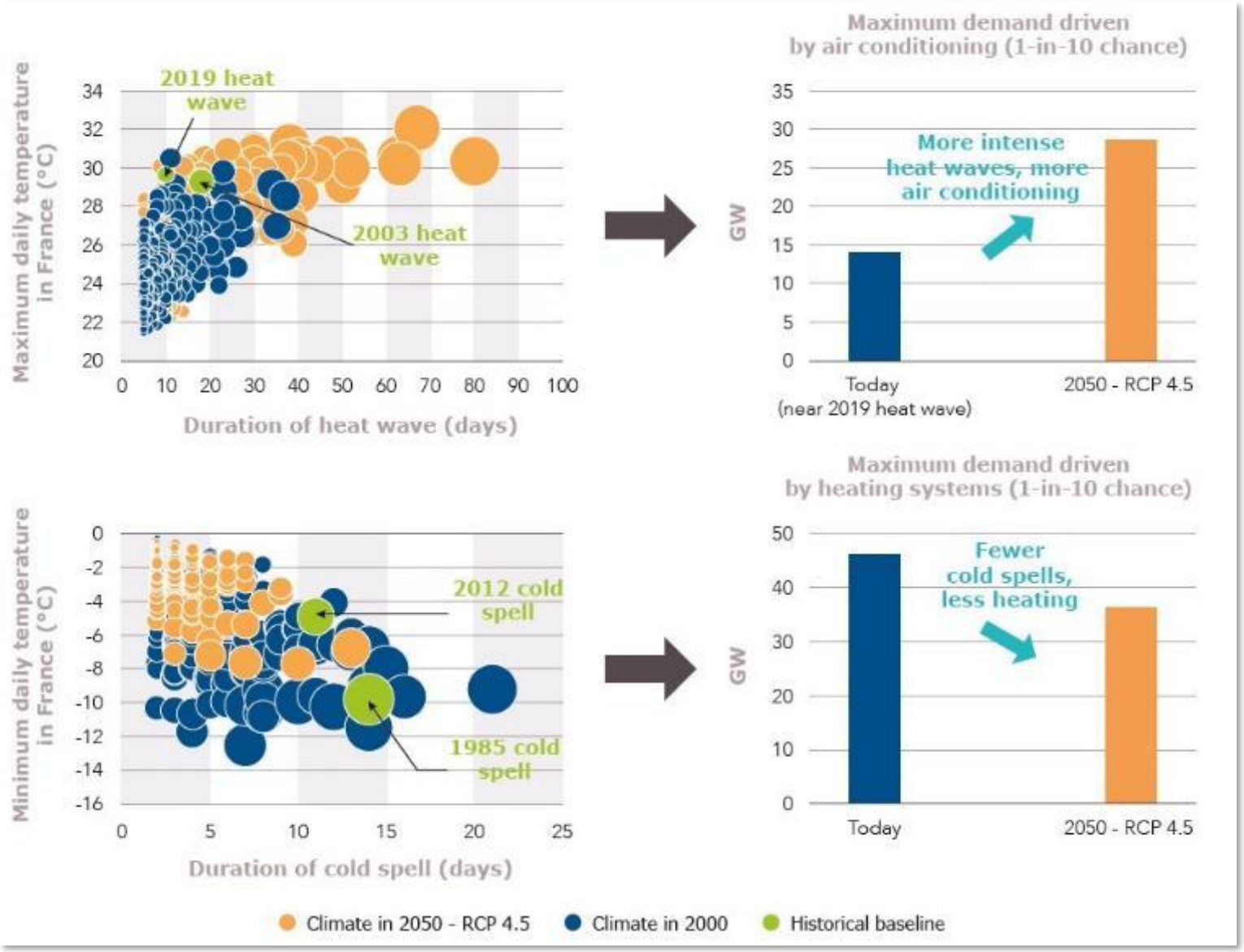


2050 Heating & cooling consumption in the reference scenario



Evolution of heat and cold waves and power consumption

Heat waves



Cooling needs

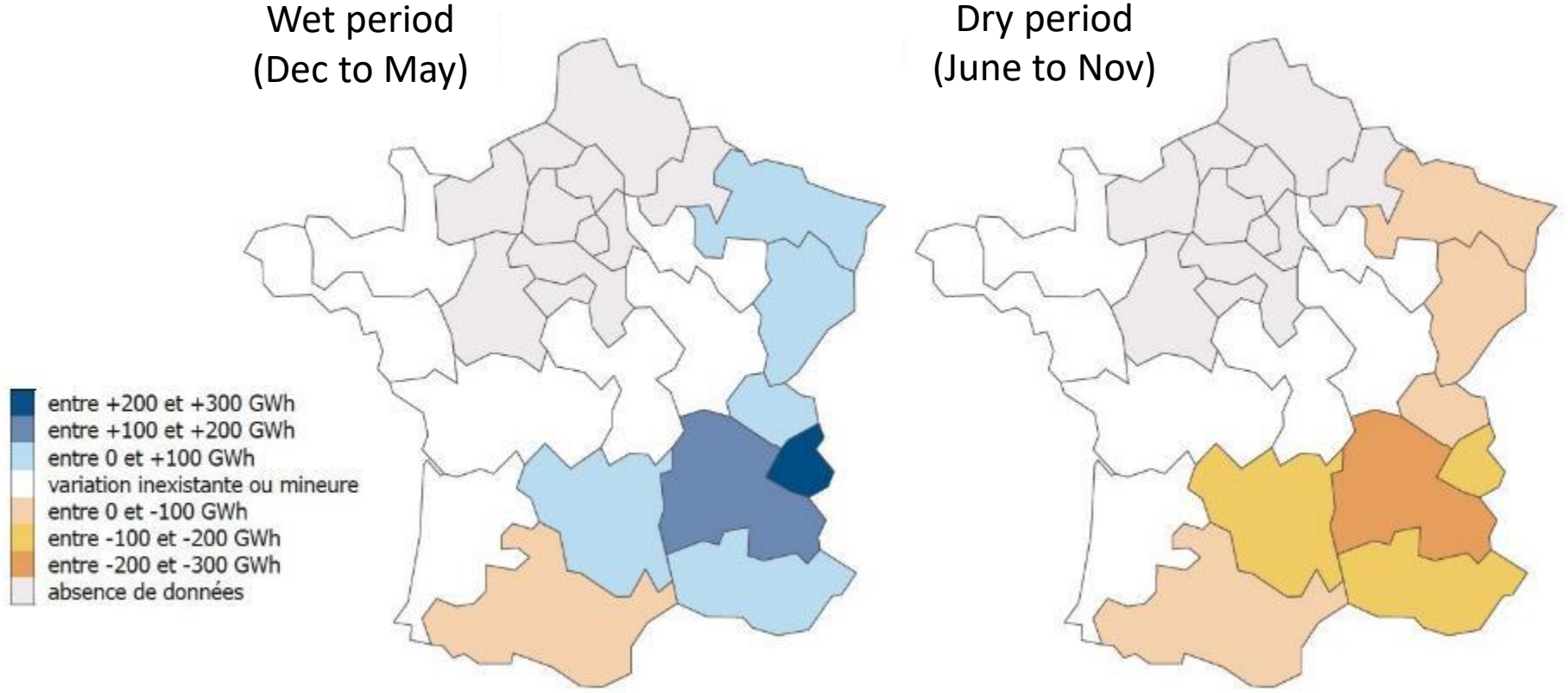
Cold waves

Heating needs

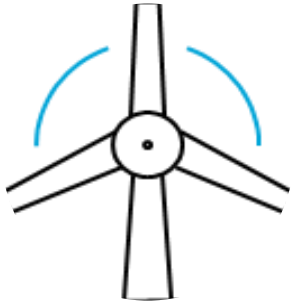
Evolution of hydro power inflows in 2050 RCP 4.5 wr.r.t. 2000

Wet period
(Dec to May)

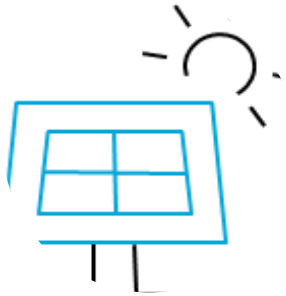
Dry period
(June to Nov)



Impact of climate change on Wind and Solar PV generation

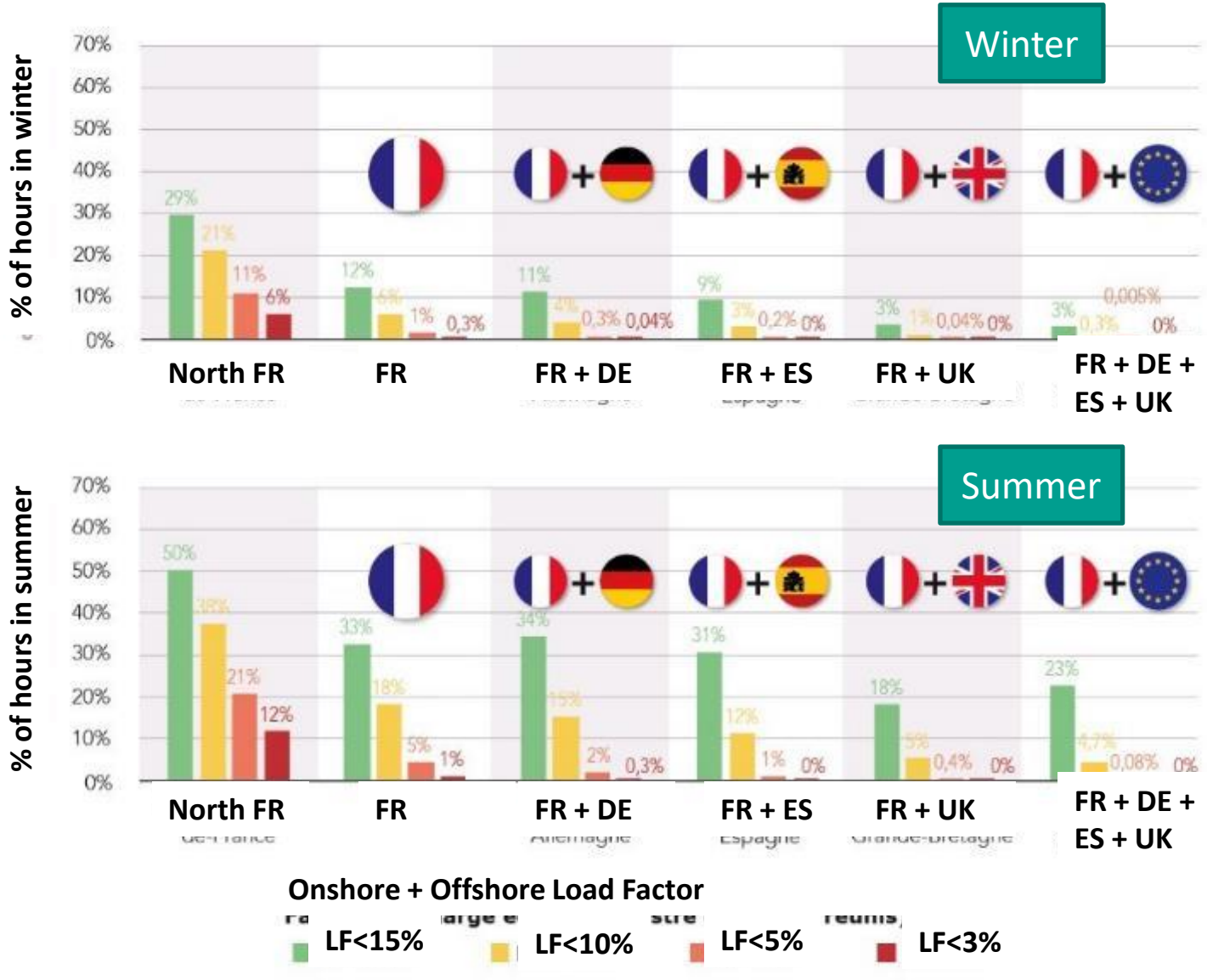


Wind energy capacity factor marginally influenced by climate change, but increases due to the development of offshore installed capacity

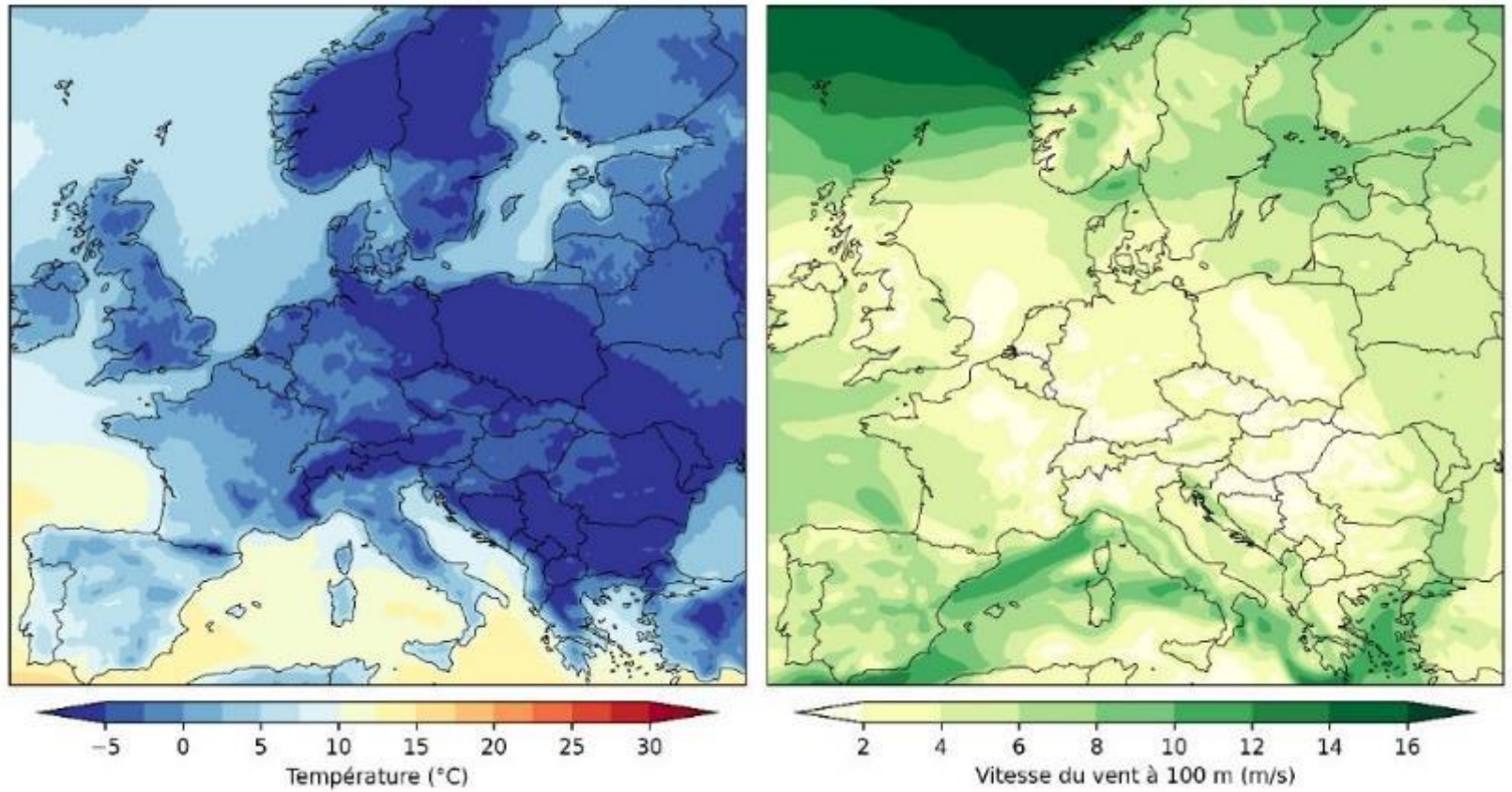


Solar PV load factor is ~not affected by climate change, larger and more uncertain changes to be expected due to technological evolutions and changes

Geographical compensation of wind variability



Stress tests: the nature of critical situations changes from [extreme cold] to [cold wave + wind drought]



Due to:

Temperature ↗

Wind power installed capacity ↗

Typical daily temperature and wind speed during energy scarcity situations

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Limits of our current approach

- 1 single climate model ➔ overall a good one, but does not cover the full climate response spectrum
- Based on ~CMIP5 model ➔ quite « old »
- Fixed time horizon to 2050 [2040-2060] ➔ not adequate to study the time evolution of the climate impacts
- Not public data ➔ lack of transparency & replicability

What's next? New Target Databases

Currently

- RTE
  - 1 climate model (Météo-France)
  - 2 GHG emission scenarios (RCP4.5 & RCP8.5)
  - Climate ~2000 and ~2050
- ENTSO-E
  - Historical data (reanalyis)

Target

- Convergence of the approach at EU level
  - ✓ Switch from 1 model to multi models
  - ✓ Add other emission scenarios (other RCPs, new SSPs2.6, 1.5°C, 2.0°C ...)
  - ✓ Include the temporal dynamics (1950 to 2100)
  - ✓ Integration of more recent projections when available (CMIP6)
  - ✓ Data in open access

Status

- MoU ENTSO-E / Copernicus Climate Change Service, 3-year contract (2022-2025)
- Bilateral contracts RTE + French academics (IPSL, CERFACS…)

See Dubus et al., 2022: https://doi.org/10.1088/1748-9326/aca1d3

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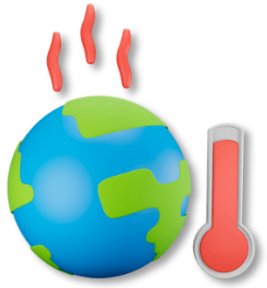
Take away messages



Climate change is a reality, it is already there, and MUST be taken into account in power systems planning, prospective and infrastructure design

Climate change and **power systems evolution** towards low emissions generation mixes **increase** energy systems' **dependance on weather and climate**

Energy planning and operations require **relevant**, **state-of-the-art** and **authoritative information** about climate

Climate services are key, and user/provider collaboration is essential to deliver user-driven & science-based information and services

Le réseau de transport d'électricité

https://www.wemcouncil.org/wp/icem-2023

Thank you

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