Energy Pathways to 2050 – Evolution in weather-related risks to France's power system

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1. Objective & Background

At the request of the French government, RTE – the French Electricity Transmission System Operator – published in 2022 a wide-ranging study on the evolution of the power system, called "Energy Pathways to 2050". To achieve carbon neutrality by 2050, France will need to generate more electricity (to substitute it for fossil fuels), while also replacing most of its current power plants (first-generation nuclear and renewables).

The study explored a variety of power systems combining several electricity demand trajectories with six generation mix options (ranging from 50% nuclear to 100% renewables in 2050). The methods and assumptions of the study were discussed and debated during a 2-year consultation including experts of about a hundred energy sector firms, NGOs, institutes, government agencies and other bodies.

2. Method

The study relied on significant simulation and computing efforts to characterize this variety of power systems. All scenarios were constructed to ensure carbon neutrality in 2050 and guarantee the same level of security of electricity supply. For each scenario, the resource adequacy was simulated at a 1-hour resolution over 1000 years and over all western and northern European countries. Input data (supply and demand) were based on meteorological variables from climate simulations done by Météo-France using their ARPEGE-Climate model. The reference dataset represents 200 years of a climate around the year 2050 under IPCC RCP4.5 scenario (or RCP8.5 for some stress-case scenarios). Another dataset consists of 200 years around the year 2000 as a baseline climate.

The resource adequacy simulations were analyzed in terms of weather events posing a threat to the power system.

3. Principal Findings

As of today, the supply tensions are associated with extreme cold events, as electric heating contributes to very high demand during cold spells. Over the coming decades the risk would shift towards events combining low winds and cold. For the studied scenarios, scarcity (energy not served) appears only during the extended winter period (November to February) and in days combining very low winds over most of Europe (especially around the North Sea) with low temperatures (in average, about 6°C below winter average over France and large parts of central Europe).

Hydrological droughts may be an aggravating factor as it reduces the hydro and nuclear generation (nuclear power plants located along rivers may be unavailable in case of low stream flows).

In summer, the large amount of solar power combined with flexibilities (storage, hydrogen…) in the studied scenarios enables no scarcity.

4. Conclusion and Perspectives

Changes in both the electricity mix and the climate will change which weather events may pose a threat to the power system. If future supply tension events may be restricted to winter cold "wind droughts", summer might not be without risk. Extreme hot events and associated wild fires may damage the grid infrastructures and create congestion by lowering the transmission line capacities. This is the subject of on-going research projects.