Climate conditions associated with low wind power production and high electricity demand events in France

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Evolution of climate risks on the electricity supply-demand balance

• Share of renewables is intended to increase:
  ➢ Electricity supply + sensitive to climate variability.

• Climate conditions associated with a high risk of electricity demand > supply days shift from cold days (T<0°C) today to days with low temperatures and wind speed (T<5°C & wind power CF<15%) in 2050.

*Share of critical situations for the supply-demand balance for 2 climate conditions. Adapted from « Energy pathways to 2050 » report from RTE.*
Scientific questions

• What is the temporal evolution of compound events over 1940-2022 in France?

• What are the circulation regimes associated with compound events?
Method – Temperature indicator

Data:
- ERA5 reanalysis data: daily surface temperature (at 2m, t2m) for Nov, Dec, Jan, Feb of 1940-2022 at 32 French cities.
Method – Temperature indicator

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➢ Weighted average of t2m at 32 French cities to represent French electricity demand.
Data:
- ERA5 reanalysis data: daily surface temperature (at 2m, t2m) for Nov, Dec, Jan, Feb of 1940-2022 at 32 French cities.
- Weighted average of t2m at 32 French cities to represent French electricity demand.

Validation:
- Electricity demand observation 2012-2020 for France (from RTE’s eco2mix database).

*Daily observed electricity demand vs. temperature indicator for 2012-2020.*
Method – wind power indicator

Data:

- ERA5 reanalysis data: hourly 100-m wind speed for Nov, Dec, Jan, Feb of 1940-2022.
- Parameters of French onshore windfarms (Location, hub height, power, power curve) from windpower.net database
Method – wind power indicator

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• ERA5 reanalysis data: hourly 100-m wind speed for Nov, Dec, Jan, Feb of 1940-2022.
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➢ Daily wind power capacity factor in France.
Method – wind power indicator

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➢ Daily wind power capacity factor in France.

Validation:
• Wind power capacity factor observation for France 2012-2020 (from RTE’s eco2mix database).

Daily observed wind capacity factor vs. our indicator for 2012-2020.
Method - Identification of cold, wind drought and compound days

Cold days:
• Temperature indicator < 0°C
• 11 days / extended winter on average over 1941-2022

Daily Wind Power capacity factor vs. electricity demand indicator for extended winter of 1941-2022.
Method - Identification of cold, wind drought and compound days

Wind drought days:
• Wind power capacity factor indicator < 0.15
• 26 days / extended winter on average over 1941-2022

Daily Wind Power capacity factor vs. electricity demand indicator for extended winter of 1941-2022.
Method - Identification of cold, wind drought and compound days

Compound days:
- (Temperature indicator < 0°C)
- (Wind power capacity factor indicator < 0.15)
- 3 days / extended winter on average over 1941-2022

Daily Wind Power capacity factor vs. electricity demand indicator for extended winter of 1941-2022.
• Decreasing number of cold and compound days per extended winter for 1941-2022.
Average circulation and surface conditions for compound days

Composite of ERA5 (a) SLP anomaly (b) 100-m wind speed relative anomaly (c) surface temperature anomaly (c) for compound events over 1980-2022 period.
Circulation regimes for wind drought days

What are the circulation regimes associated with wind drought days in France? Which of these regimes are also associated with compound days in France?
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• K-Means classification applied on ERA5 daily sea-level pressure (hPa) of wind drought days over extended winters of 1980-2022.
Circulation regimes for wind drought days

What are the circulation regimes associated with wind drought days in France? Which of these regimes are also associated with compound days in France?


- Parameters of K-Means:
  - Classification domains (« North Atlantic », « Western Europe », « France »)
  - number of regimes \((2 \leq n \leq 15)\)

- Find the set of parameters that minimize the metric \(M = \frac{\sigma_{\text{intra-regime}(\text{Electricity Demand})}}{\sigma_{\text{inter-regime}(\text{Electricity Demand})}}\)

  - Parameters chosen: 7 regimes & domain « Western Europe ».
Circulation regimes for wind drought days

Composite of sea-level pressure anomaly for each circulation regimes.

Composite of 100-m wind speed relative anomaly for each circulation regimes.
Surface temperature associated with circulation regimes for wind drought days

Composite of sea-level pressure anomaly for each circulation regimes.

Composite of 100-m wind speed relative anomaly for each circulation regimes.

Composite of surface temperature anomaly for each circulation regimes.
Circulation regimes for wind drought days associated with compound days

- Circulation regimes c_2 and c_6 are associated with higher risks of compound days.
Conclusions:

• Decreasing number of cold and compound days per extended winter.
• Circulation regimes that resembles to NAO- and Scandinavian blocking *Weather regimes* are associated with higher proportion of compound days.
Conclusions and perspectives

Conclusions:
• Decreasing number of cold and compound days per extended winter.
• Circulation regimes that resembles to NAO- and Scandinavian blocking *Weather regimes* are associated with higher proportion of compound days.

Perspectives:
• Evaluation of climate models on their representation of these circulations regimes.
• Evolution of these circulation regimes during the 21th century in climate projections.