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# WIND DROUGHTS AND WINTER COLD THREATEN EUROPE'S FUTURE ENERGY SECURITY



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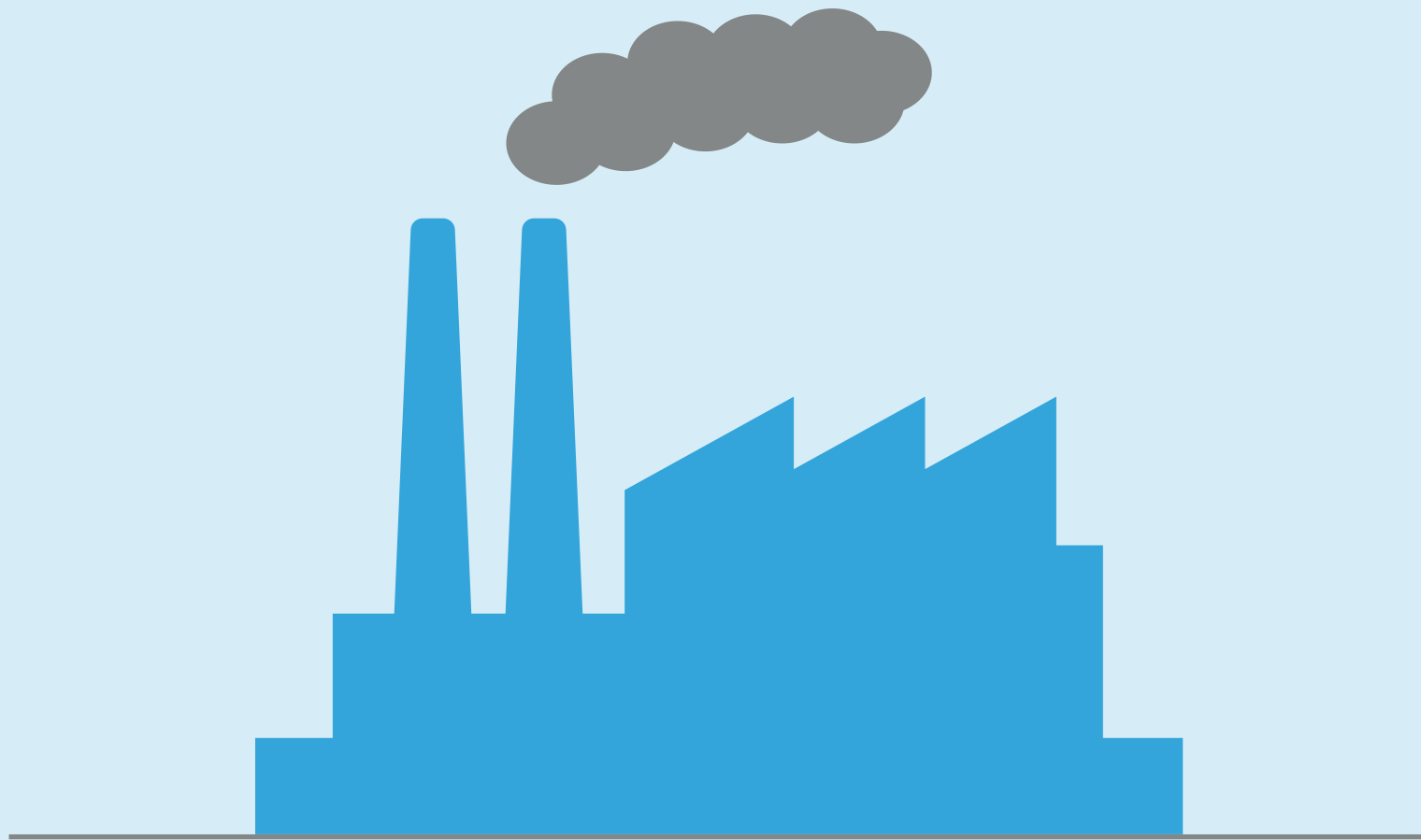
## ENERGY TRANSITION – AMBITION

- ▶ Limit CO<sub>2</sub> emissions to mitigate further global climate change
- ▶ Transition from carbon-intensive fossil fuels to renewable energy sources

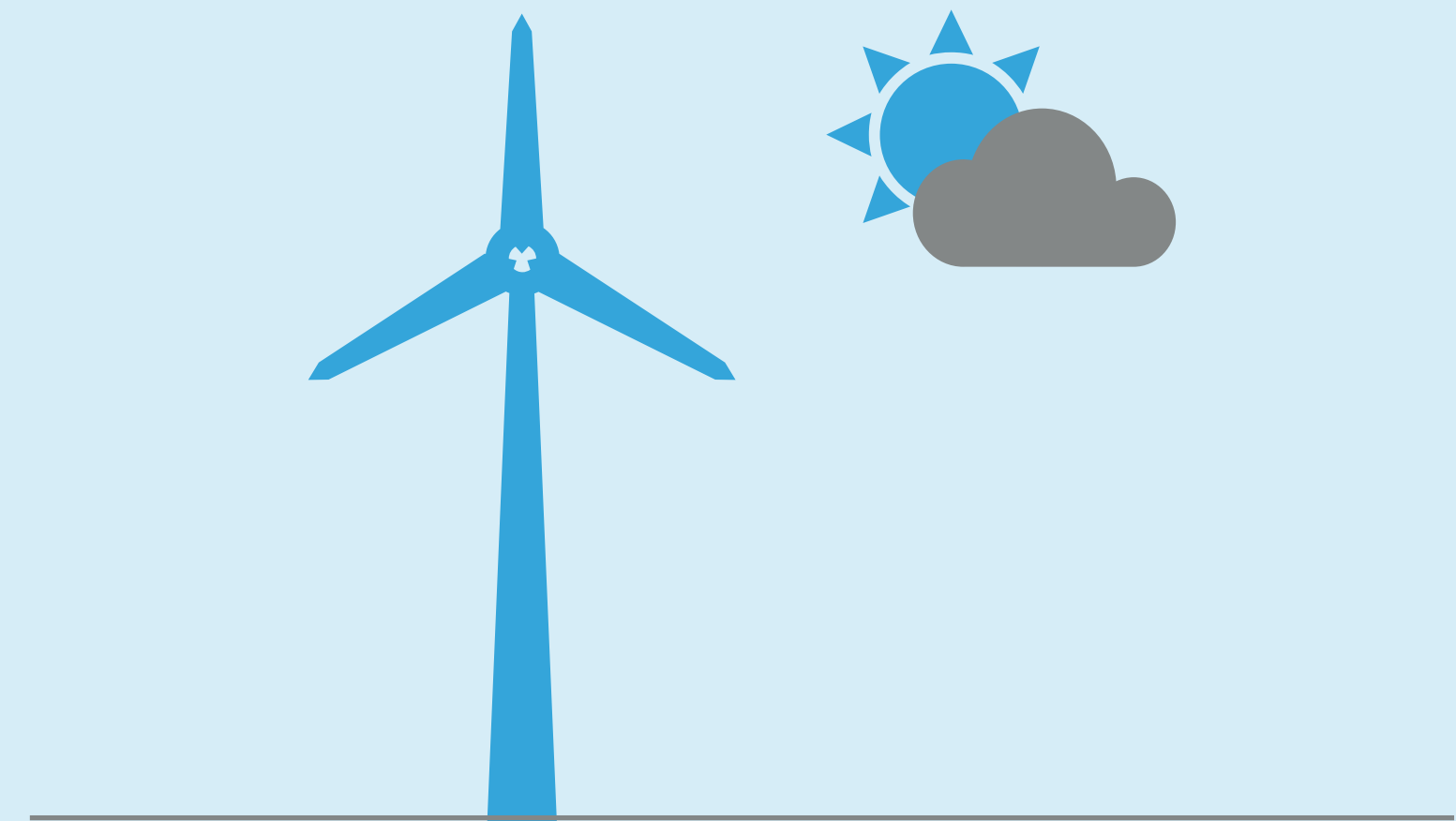


## ENERGY TRANSITION – CONSEQUENCES

- ▶ Carbon-intensive fossil fuels
- ▶ Production can be planned

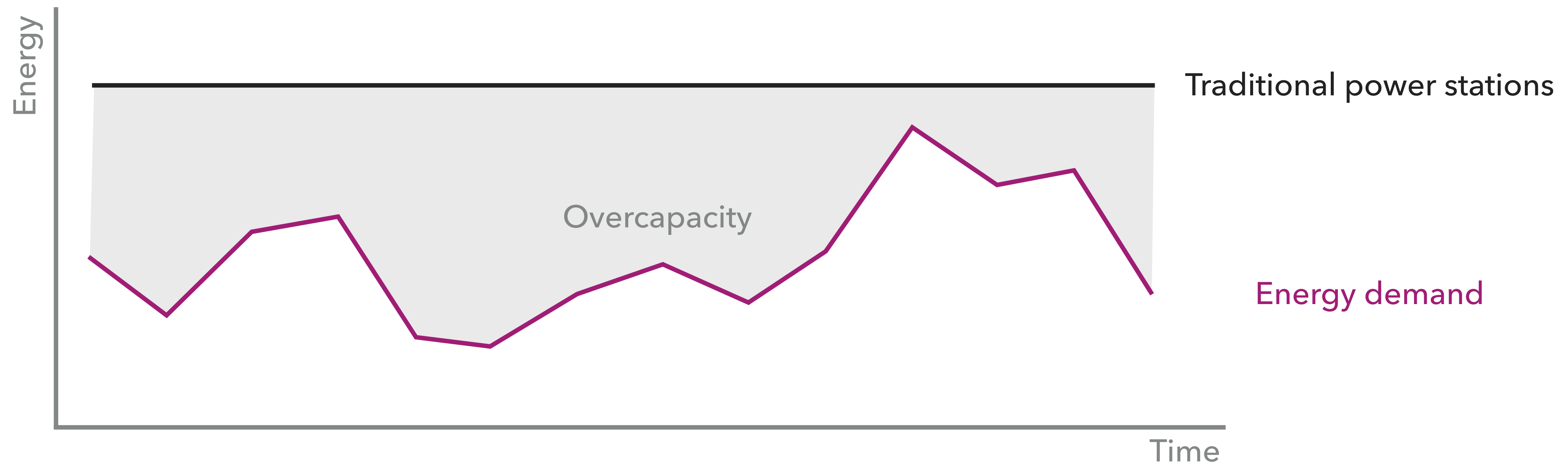


- ▶ Low-carbon renewable energy
- ▶ Production will depend on the weather



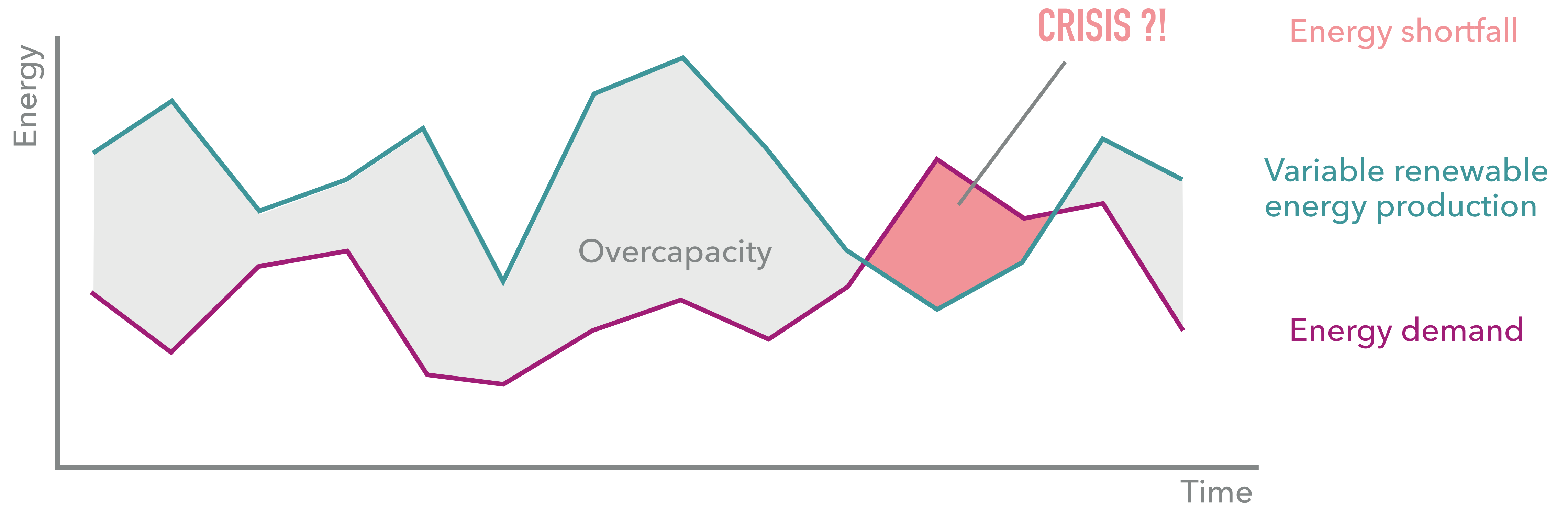
## ENERGY TRANSITION – CHALLENGE

- ▶ Matching variable energy demand with variable energy production



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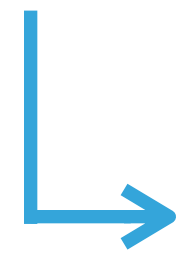


## RESEARCH OBJECTIVE

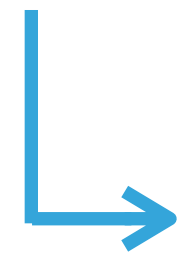
Investigate the meteorological conditions that lead to high risk for European energy safety in a highly renewable power system

## LARGE ENSEMBLE MODELLING METHOD

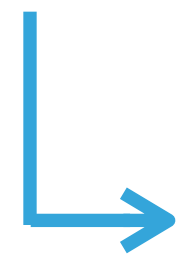
Simulate 2000 years of present-day weather



Calculate 2000 years of energy variables



Select 1-in-10 year extreme events

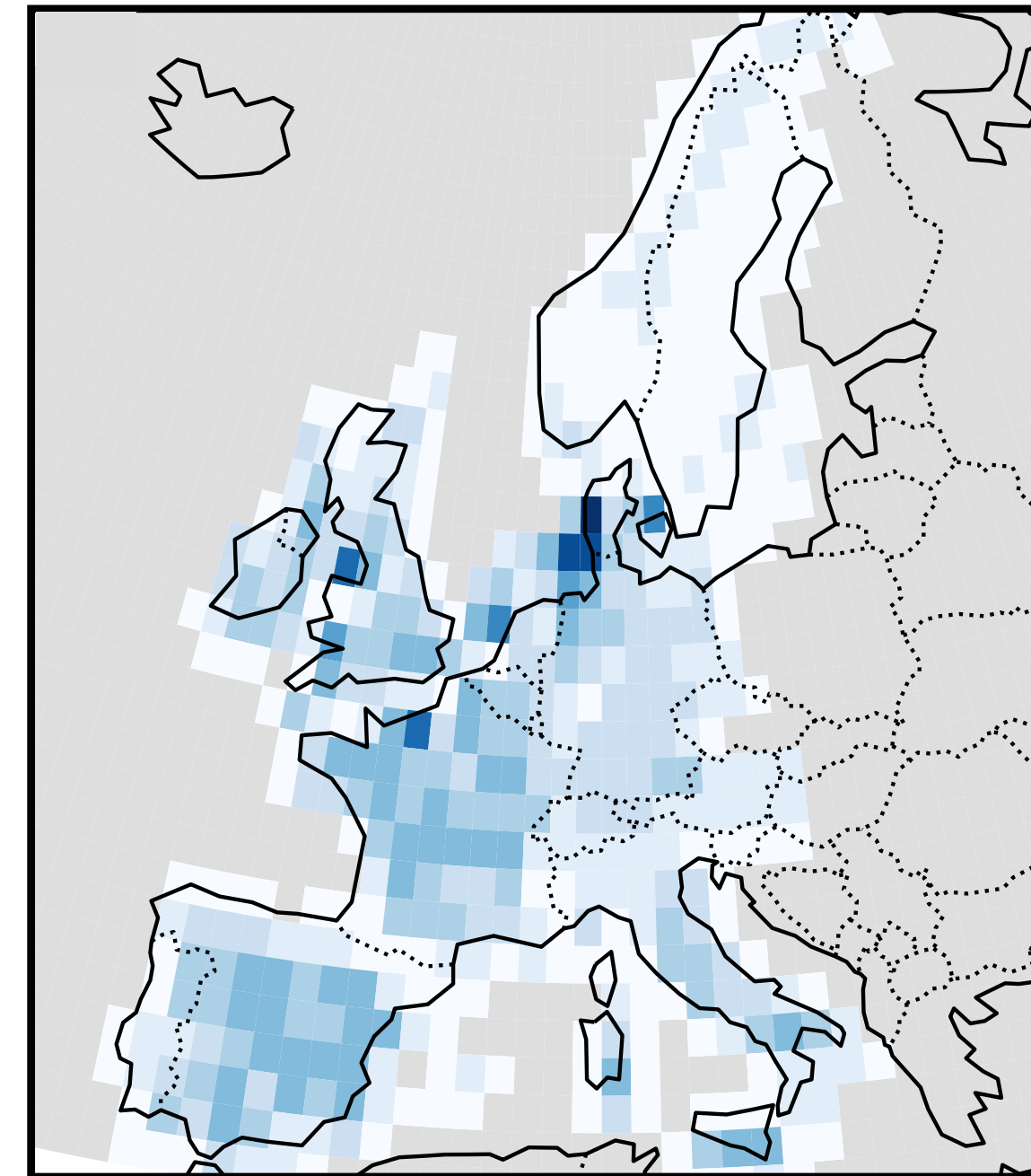


Investigate meteorological conditions

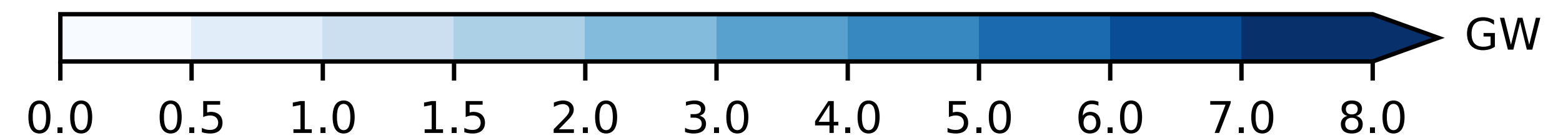
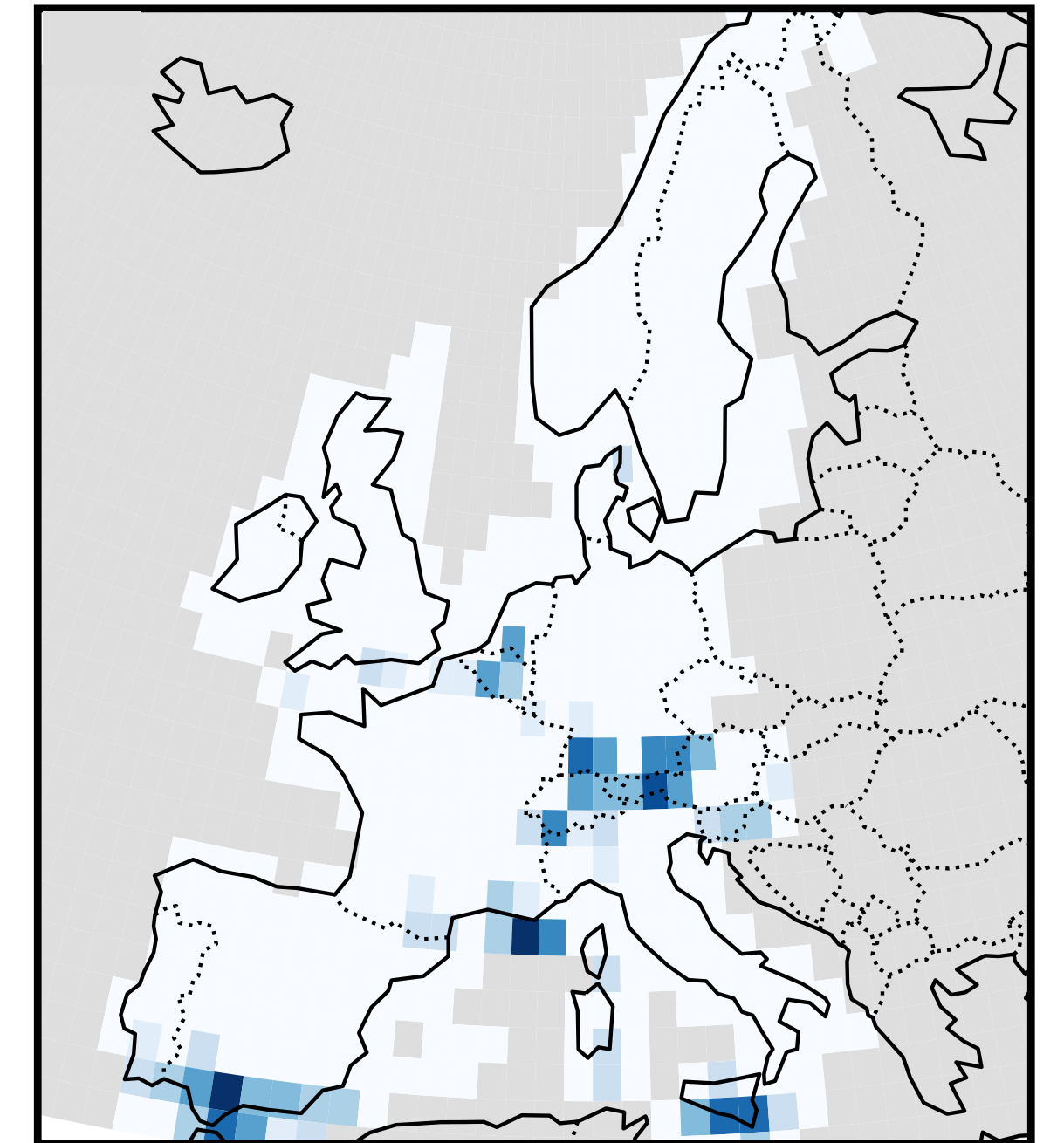
## INTERMEZZO – ENERGY MODEL

- ▶ 15 western European countries
- ▶ Energy production  
Wind turbines, solar panels

Wind turbines 479 GW

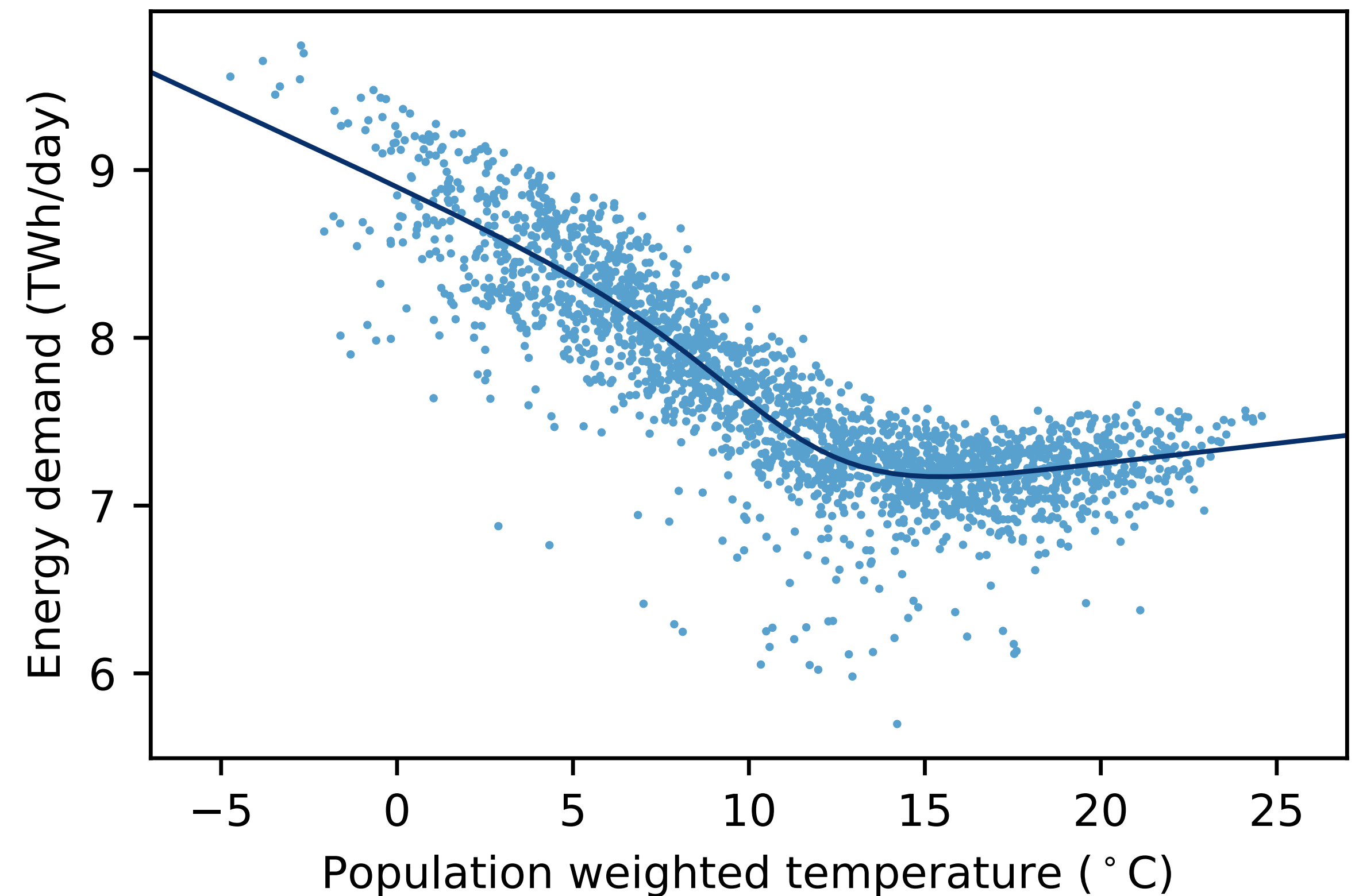


Solar panels 161 GW

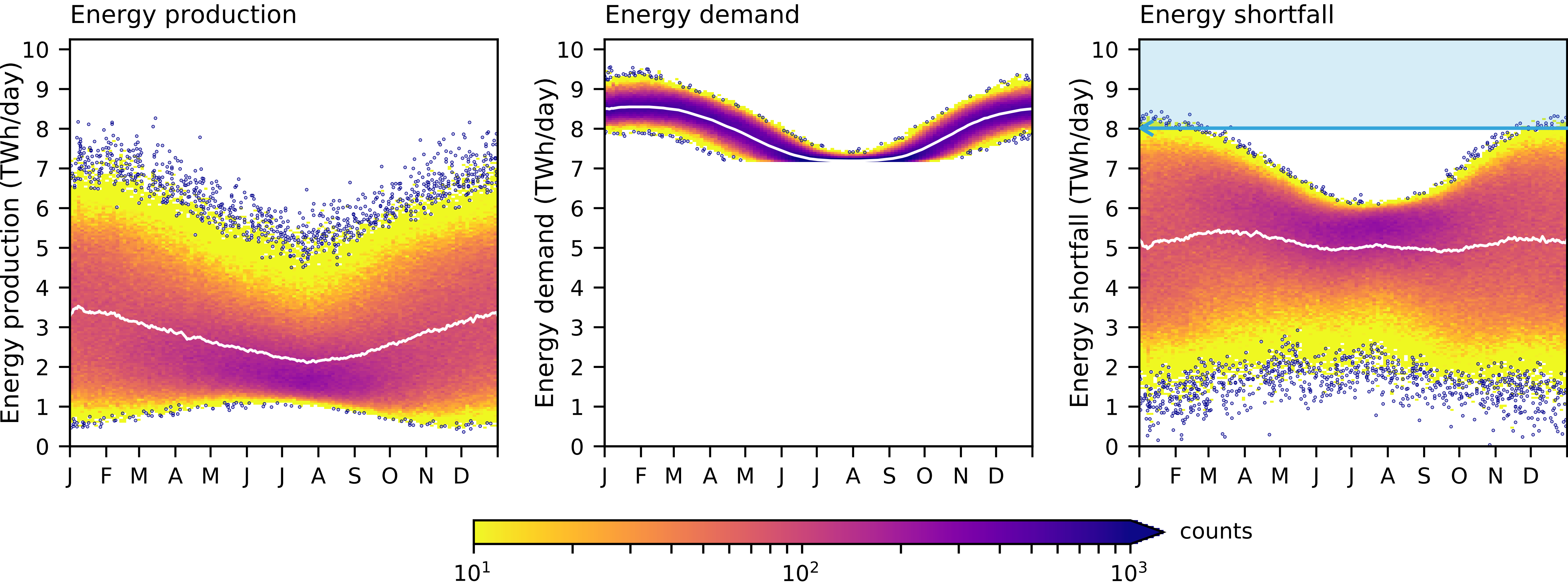


## INTERMEZZO – ENERGY MODEL

- ▶ 15 western European countries
- ▶ Energy production  
Wind turbines, solar panels
- ▶ Energy demand  
Winter heating, summer cooling

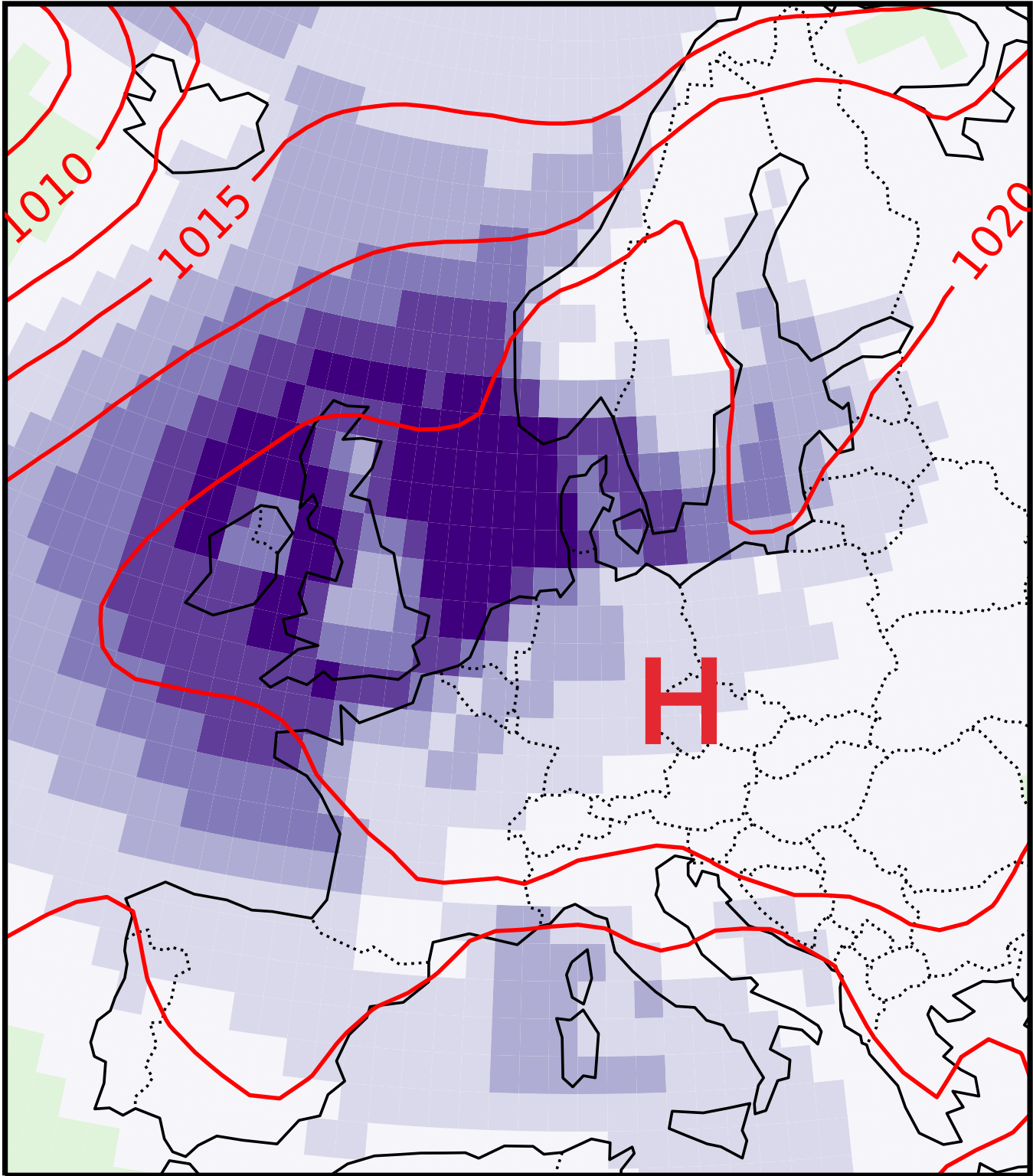


# ANNUAL CYCLE OF ENERGY VARIABLES

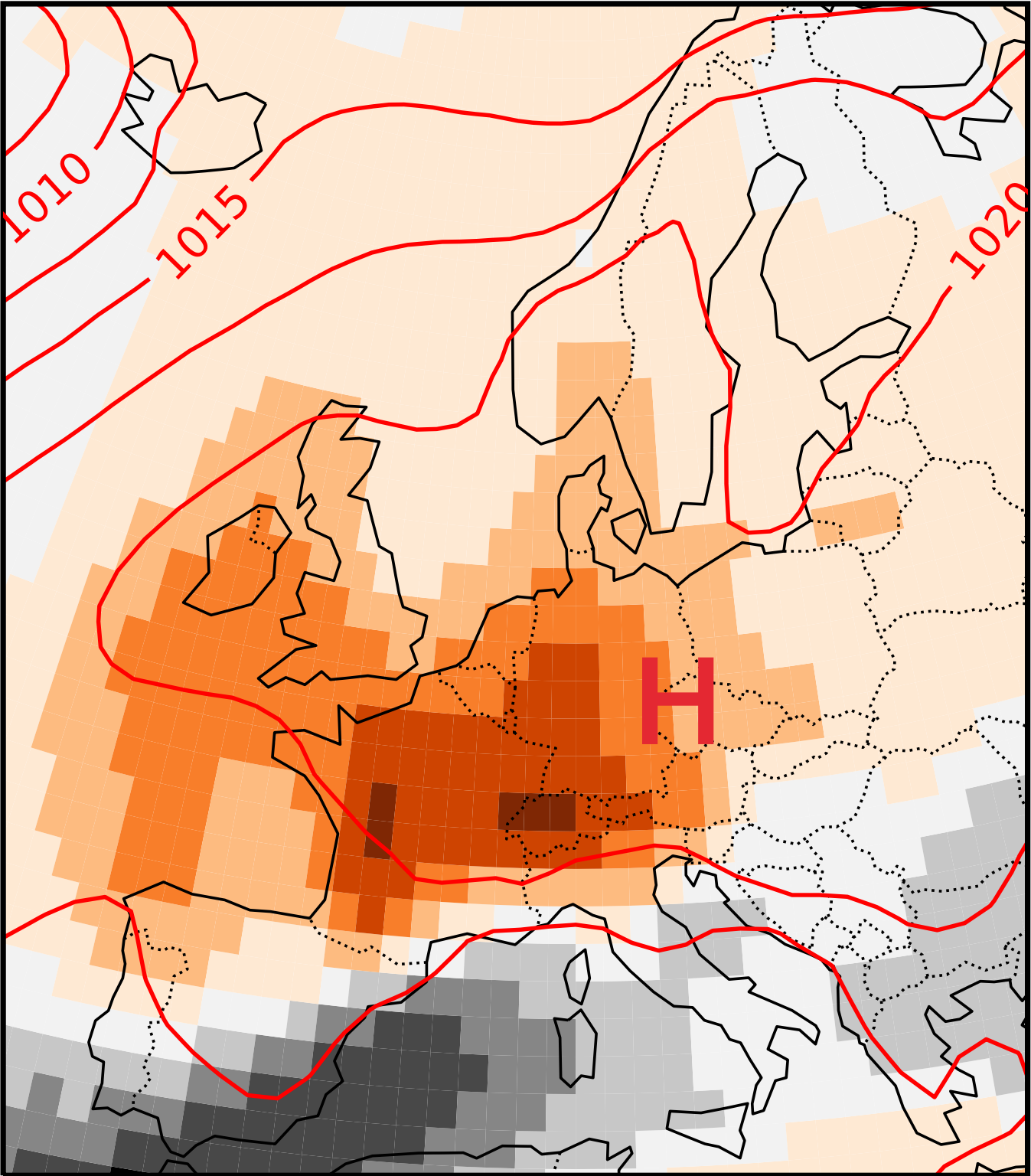


# METEOROLOGICAL CONDITIONS FOR HIGH ENERGY SHORTFALL

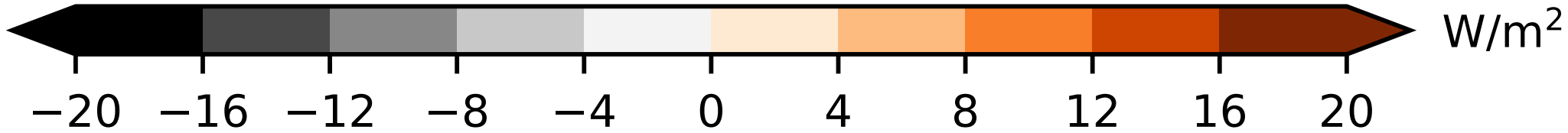
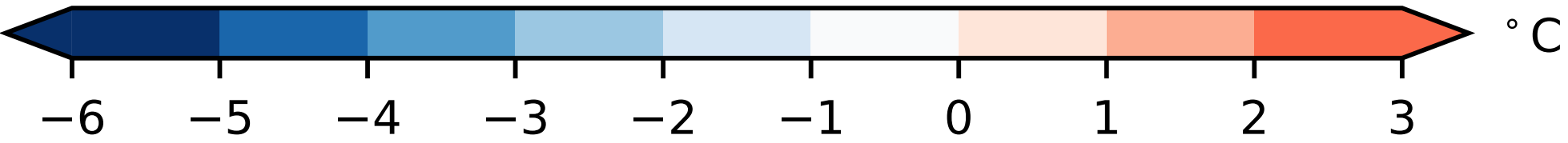
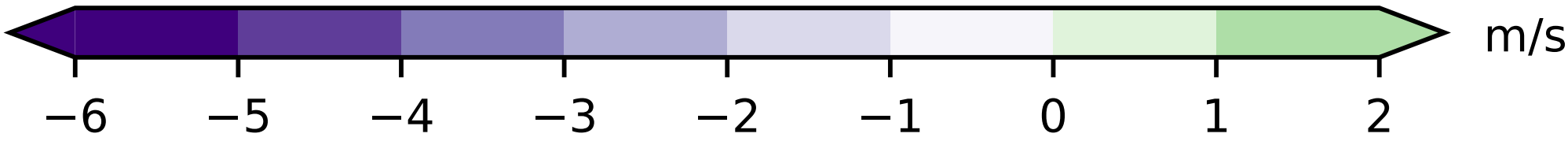
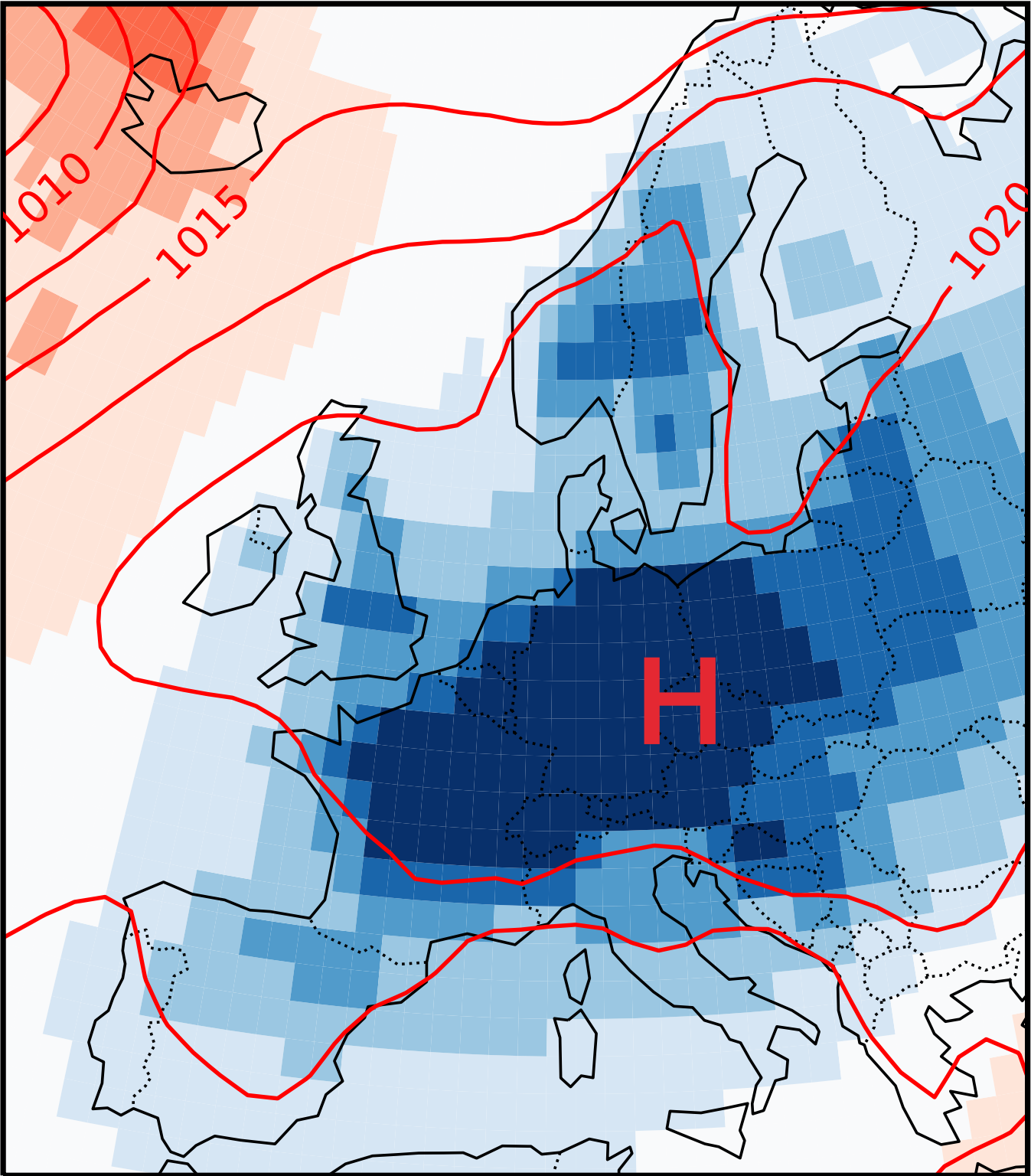
10 m wind speed



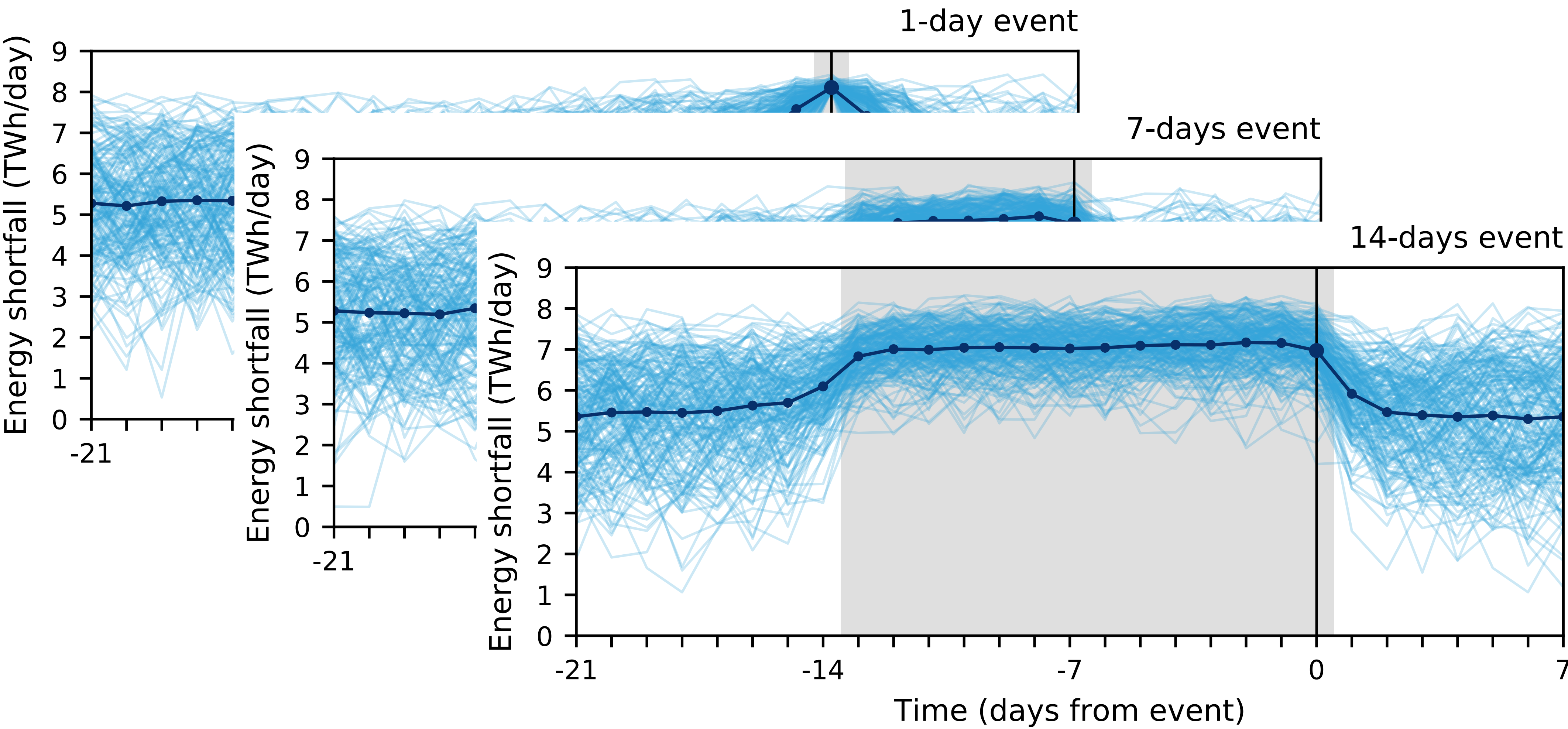
Solar radiation



2 m temperature



# LONG LASTING HIGH ENERGY SHORTFALL



## SUMMARY

**Ambition** European energy transition to mitigate climate change

**Challenge** Match variable energy demand with variable energy production

**Extreme high energy shortfall** due to **wintertime high pressure systems**

Low wind speeds → low production  
Low temperatures → high demand  
└─→ high shortfall

**Important** Design our future energy system with these events in mind

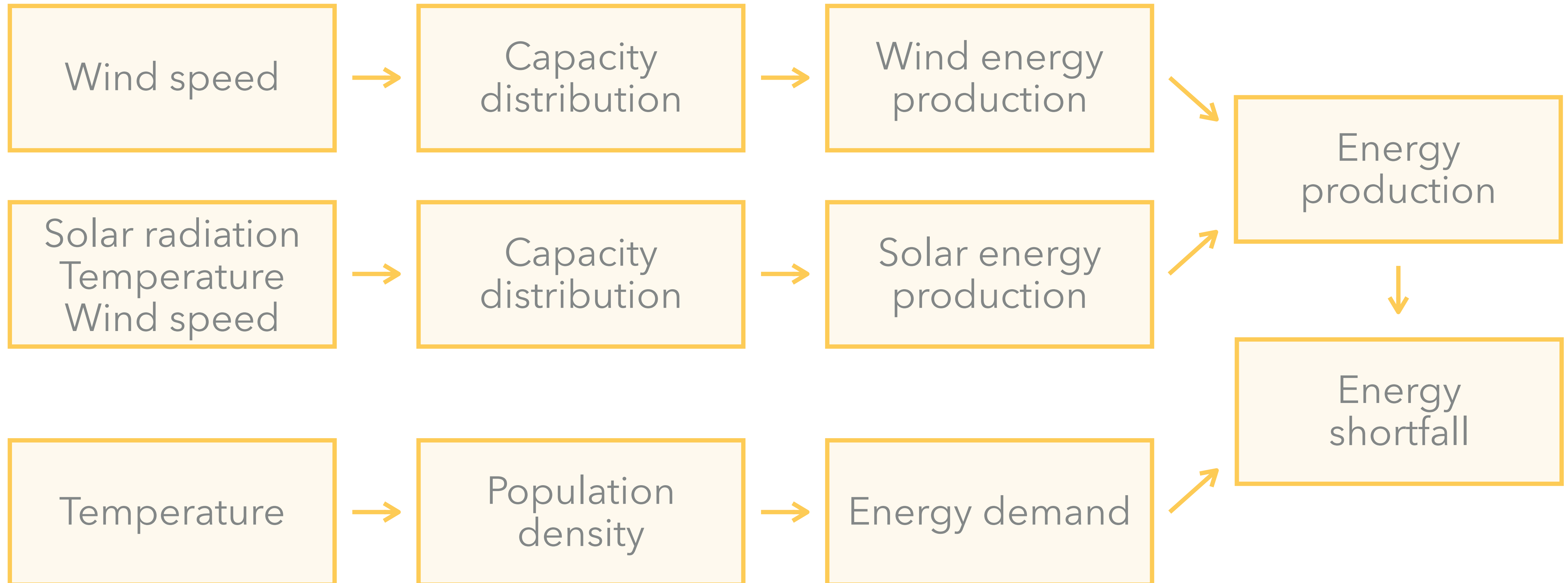


## RESEARCH PAPER

Van der Wiel et al. (2019): Meteorological conditions leading to extreme low variable renewable energy production and extreme high energy shortfall, *Renewable and Sustainable Energy Reviews*, 111, pp. 261-275.

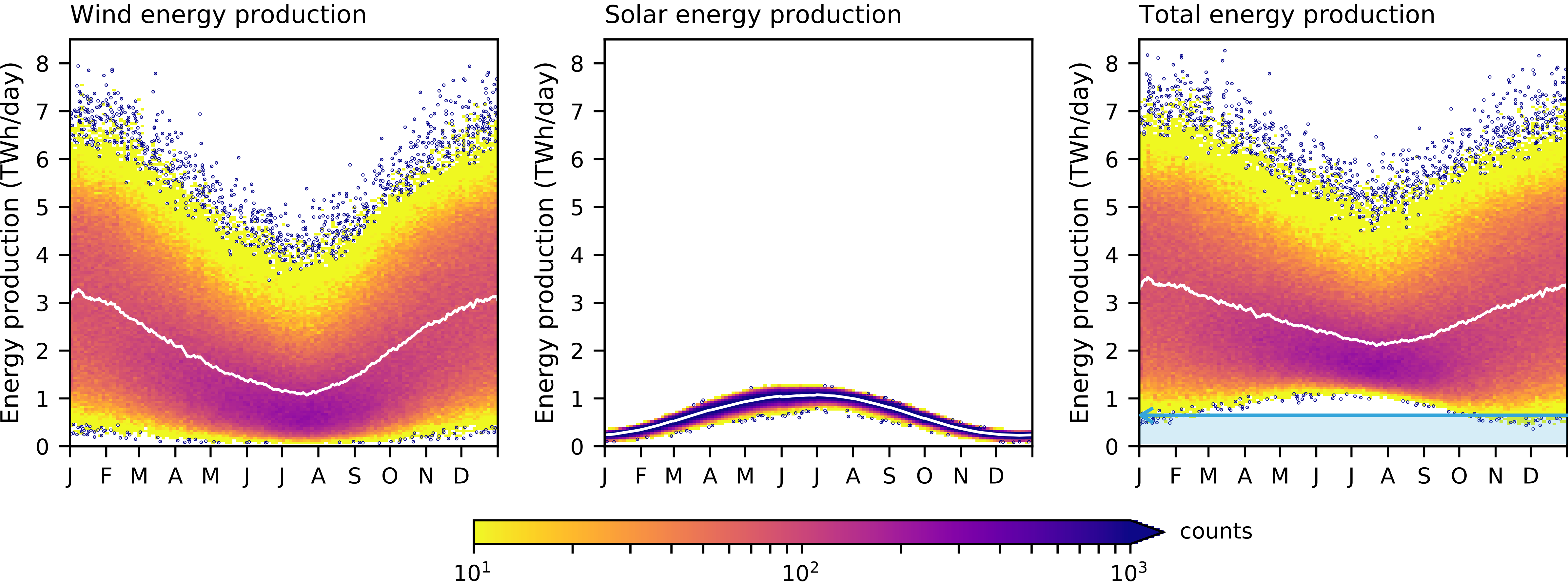
**EXTRA SLIDES**

## INTERMEZZO – ENERGY MODEL



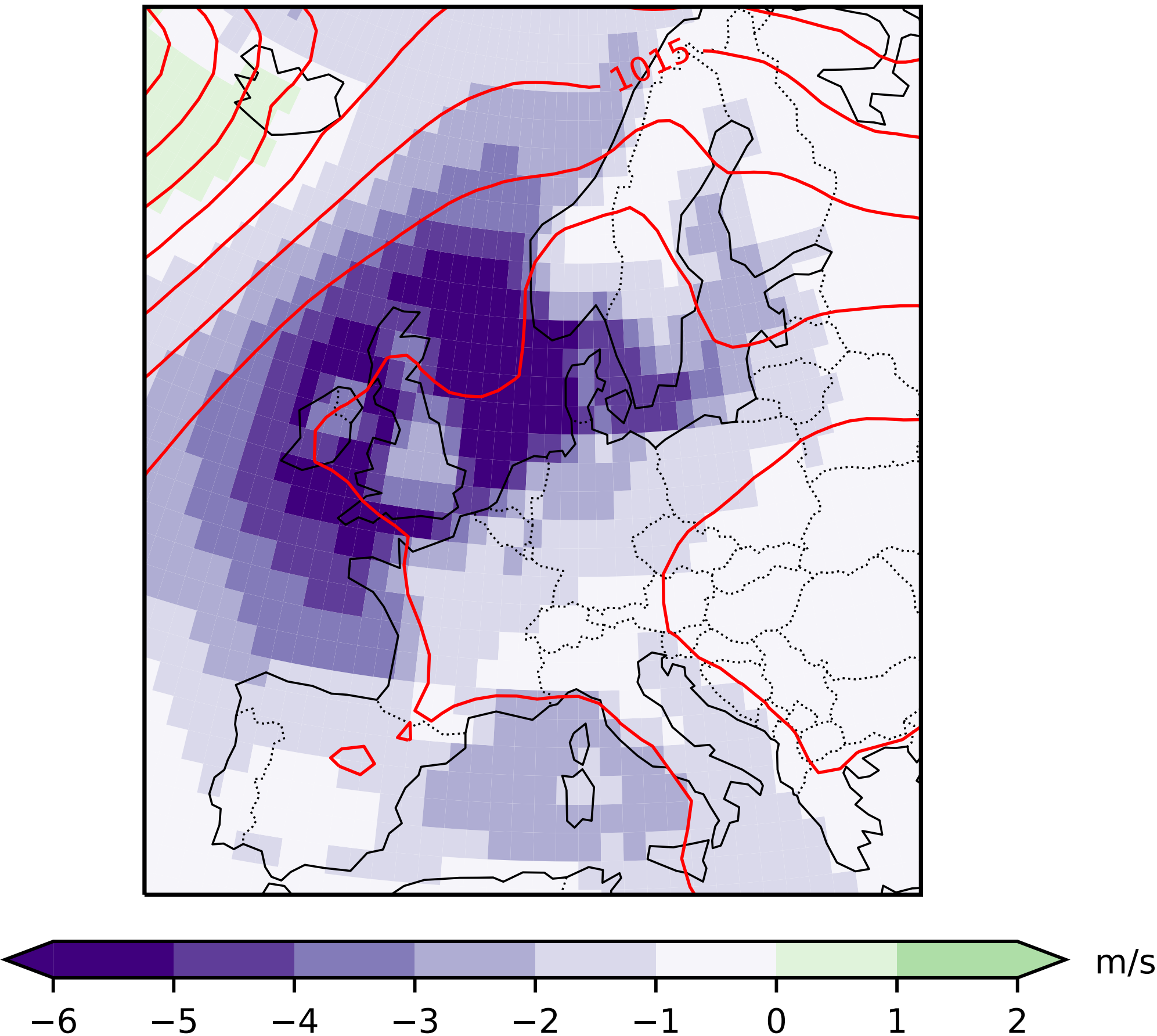
# ANNUAL CYCLE OF ENERGY VARIABLES

1-in-10 year  
low production events

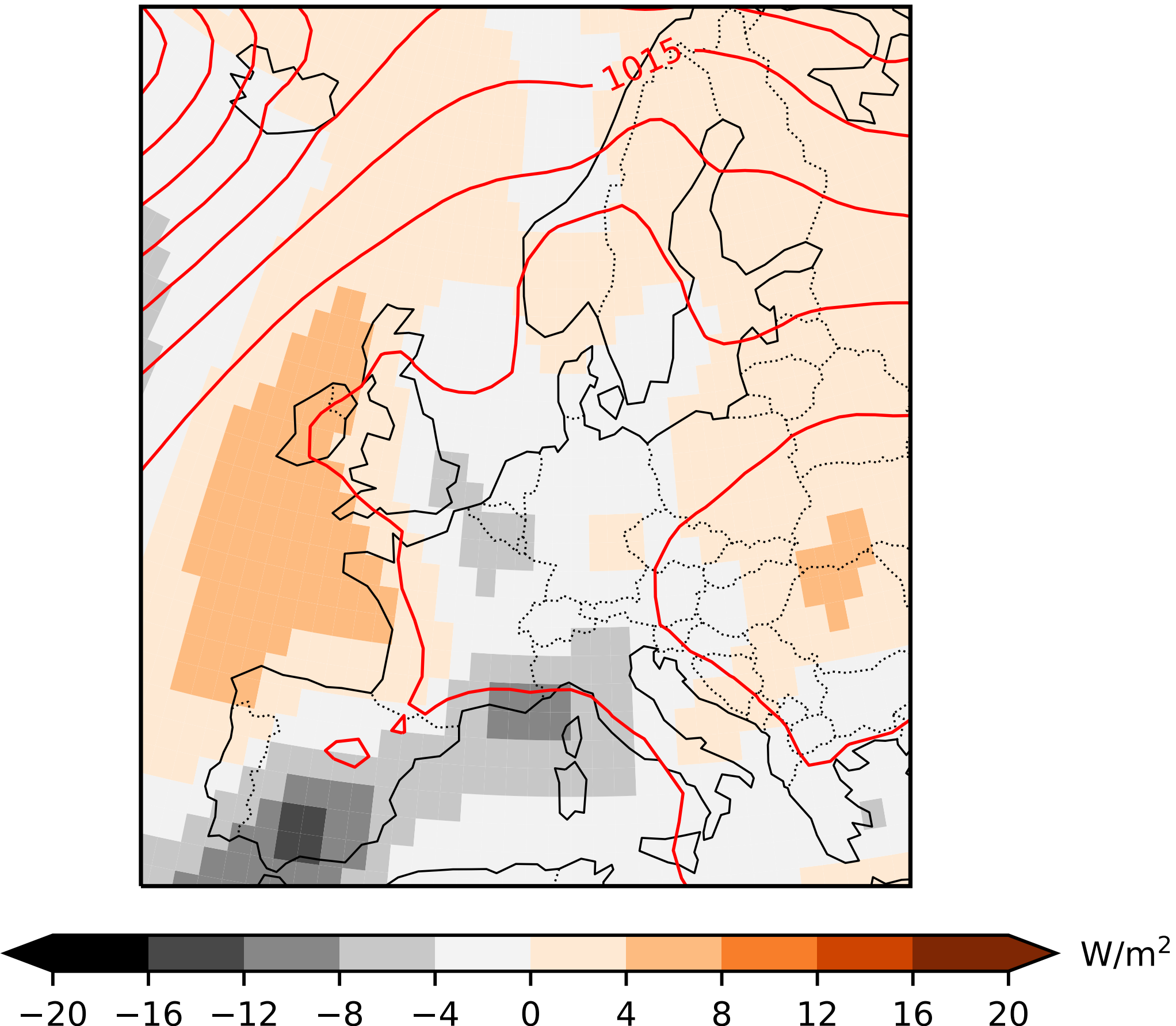


# METEOROLOGICAL CONDITIONS FOR LOW ENERGY PRODUCTION

10 m wind speed

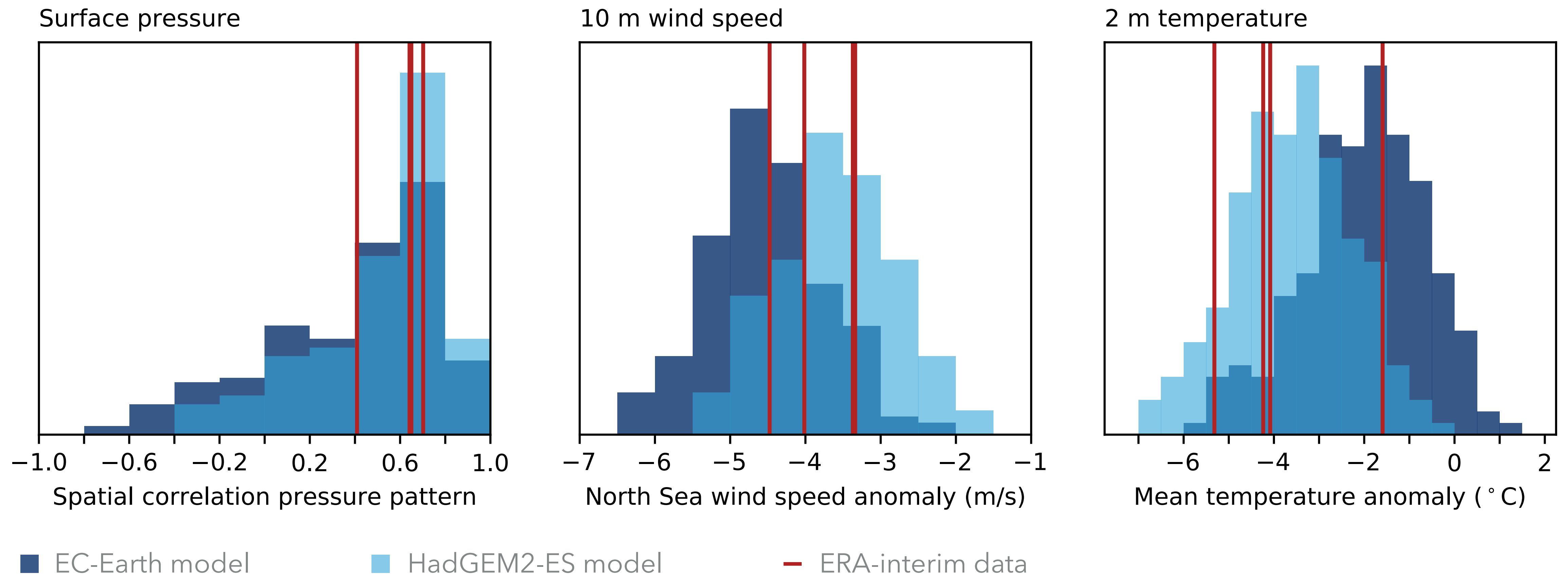


Solar radiation



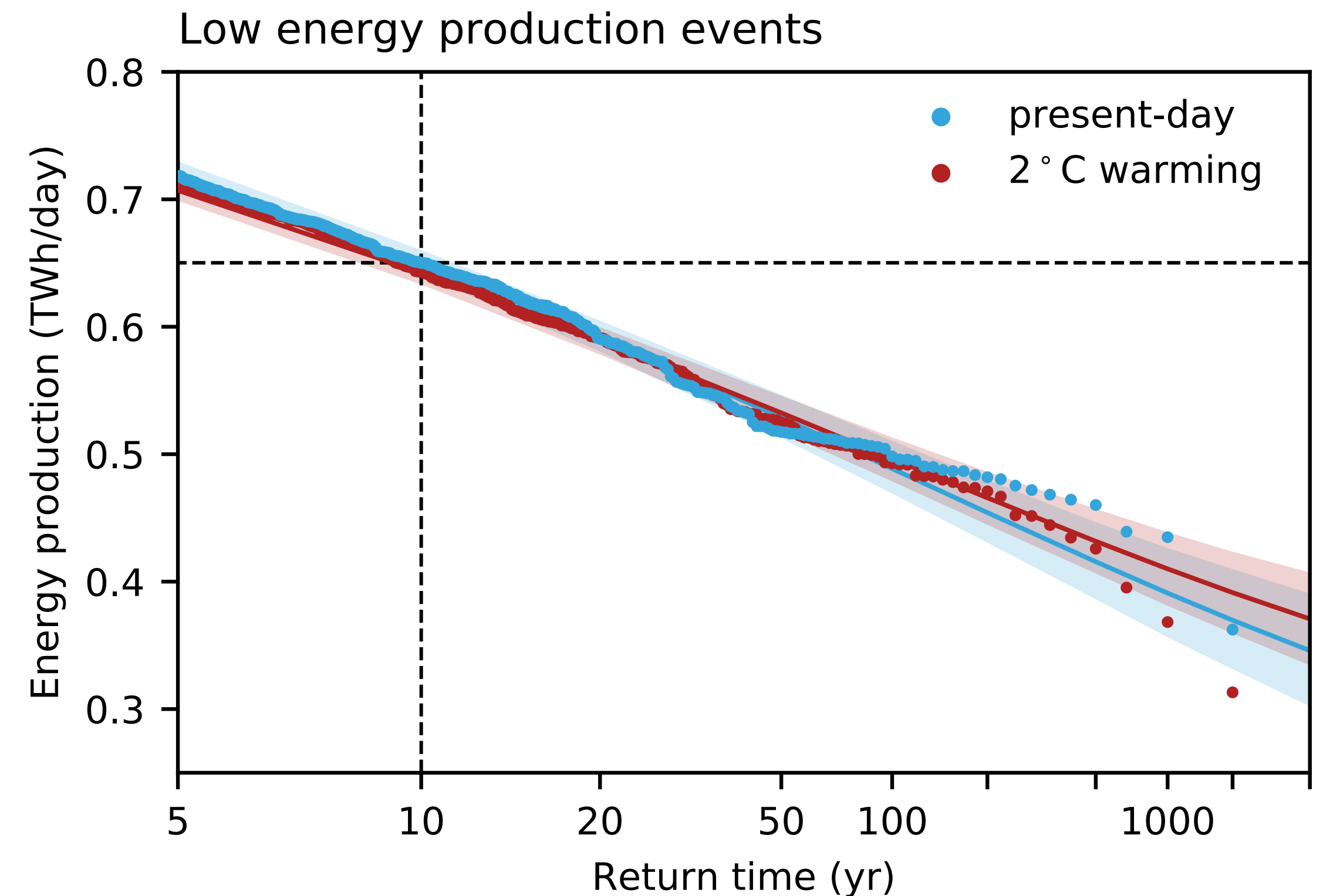
## MODEL RESULTS VERSUS OBSERVATIONAL EVIDENCE

- Observed shortfall events fall in the distributions of modelled shortfall events



## CLIMATE CHANGE EFFECTS – LOW PRODUCTION

- ▶ Interannual variability exceeds changes due to further global climate change
- ▶ No significant change in risk of low production



## CLIMATE CHANGE EFFECTS – HIGH SHORTFALL

- ▶ Further global climate change decreases winter energy demand
- ▶ Reduced risk of high shortfall

**CAUTION** Energy demand model based on the temperature-demand relationship as in 2006-2015, this is expected to change

