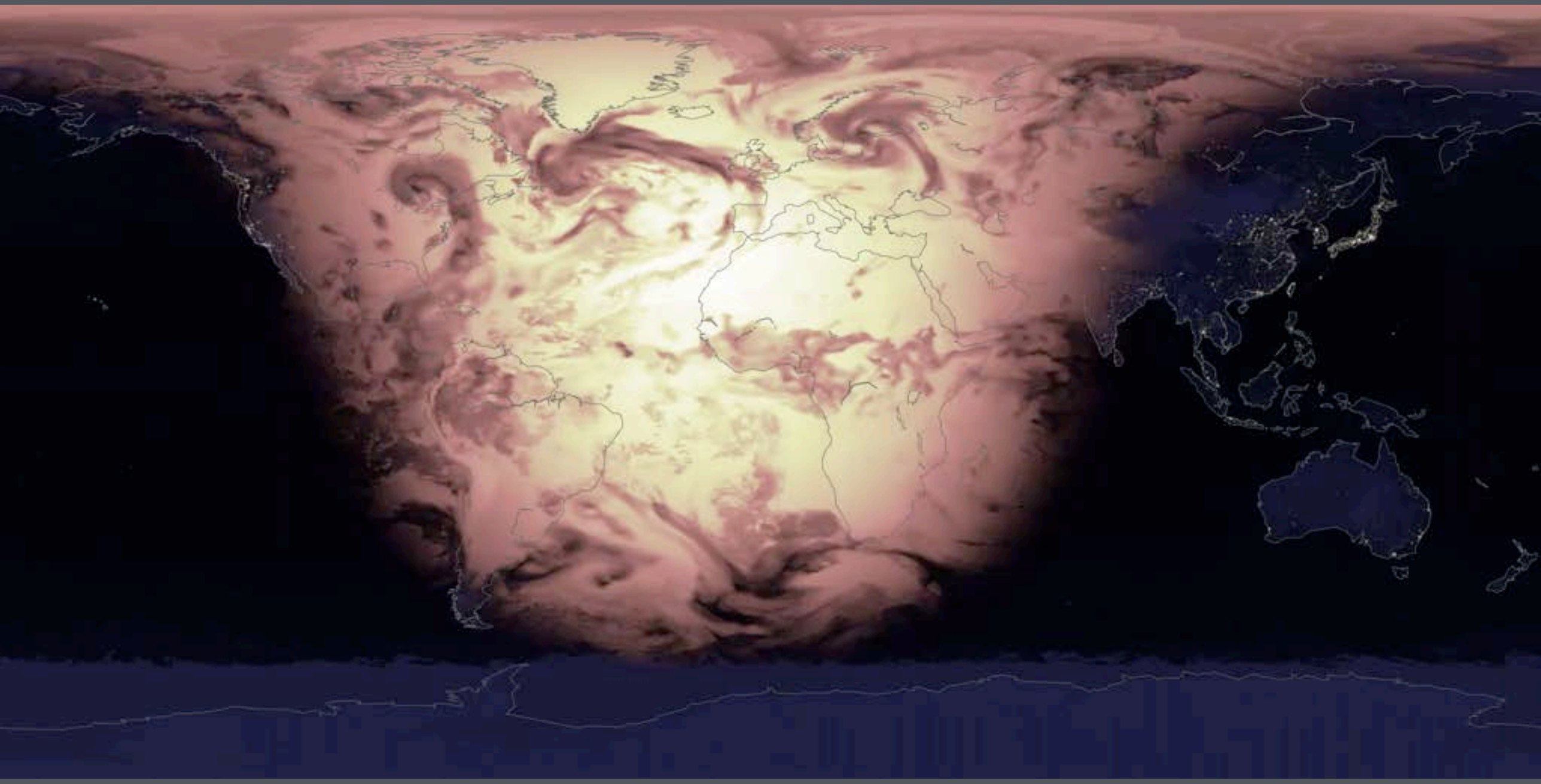
Using reanalysis and satellite data to model solar and wind power: challenges, applications, and lessons learnt



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Outline

1. Using reanalysis to simulate PV and wind, (and making the results available online)

2. Applications

3. Challenges and lessons learnt

PART 1

Using reanalysis to simulate PV and wind

How to simulate PV and wind output

- Measured meteo station data
  - Very limited geographical coverage, varying quality

- Satellite images
  - Limited geographical coverage
  - Directly applicable to photovoltaics (PV) only, not wind

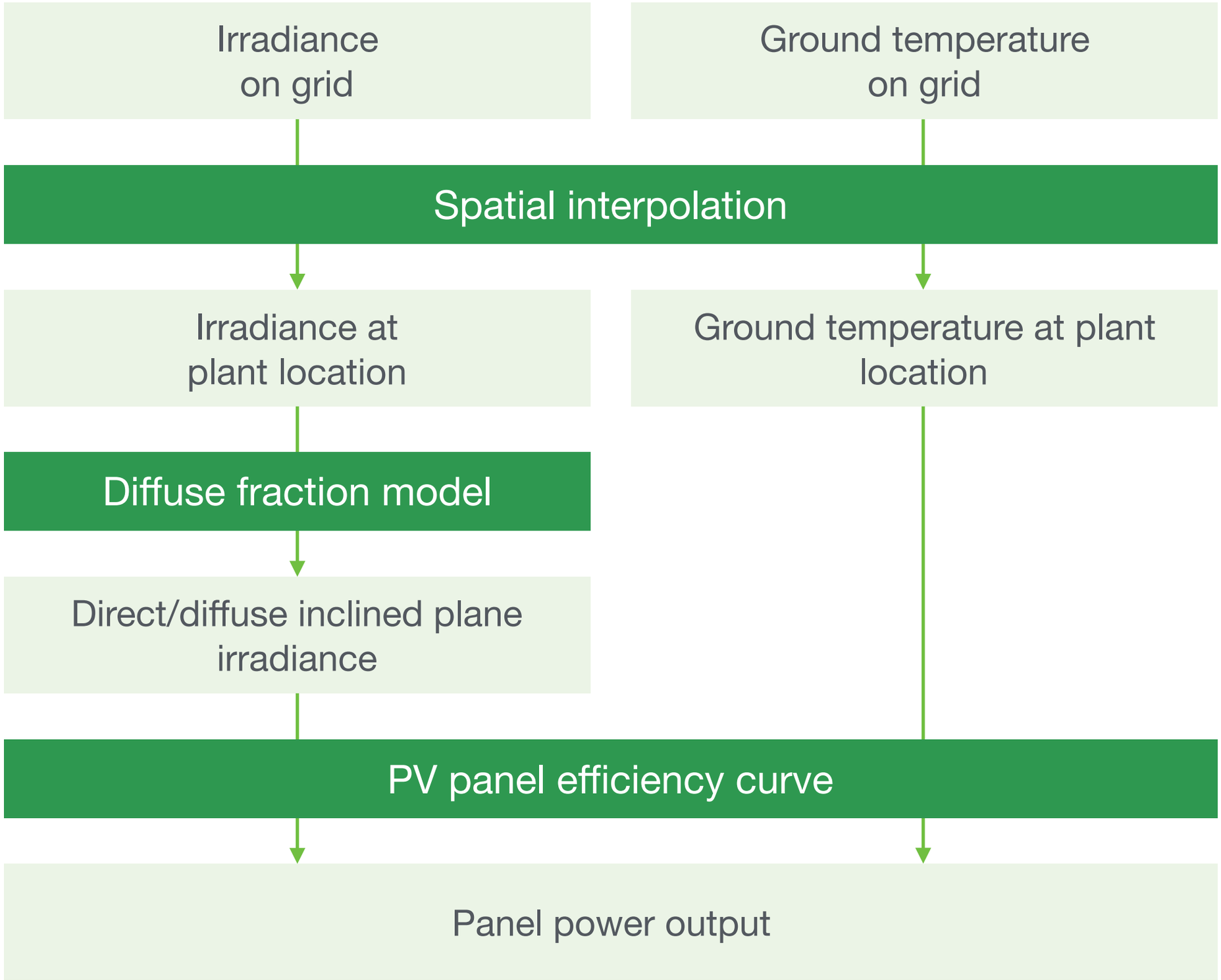
- Industry and project developers have other requirements
  - Investment-grade results = investment-grade costs

- Reanalysis data is an alternative **– but can it be trusted?**
  - Data is already cleaned and organised
  - Global coverage for the last 30 years
  - But… ‘measurements’ come from a coarse numerical model

Data sources used

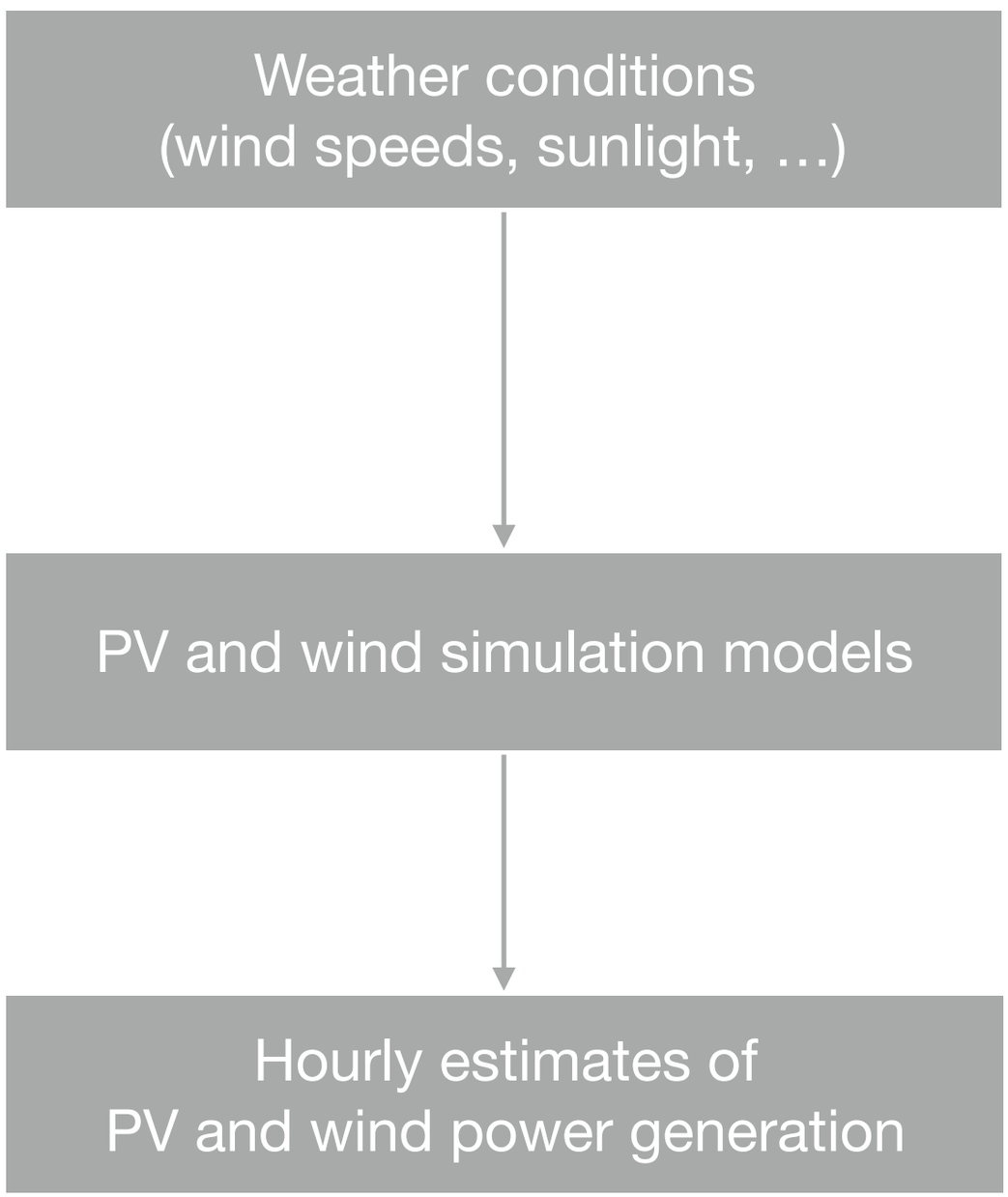
	PV	Wind
Reanalysis	MERRA	MERRA
	MERRA-2	MERRA-2
Satellite	SARAH (CM-SAF)	

PV simulation model



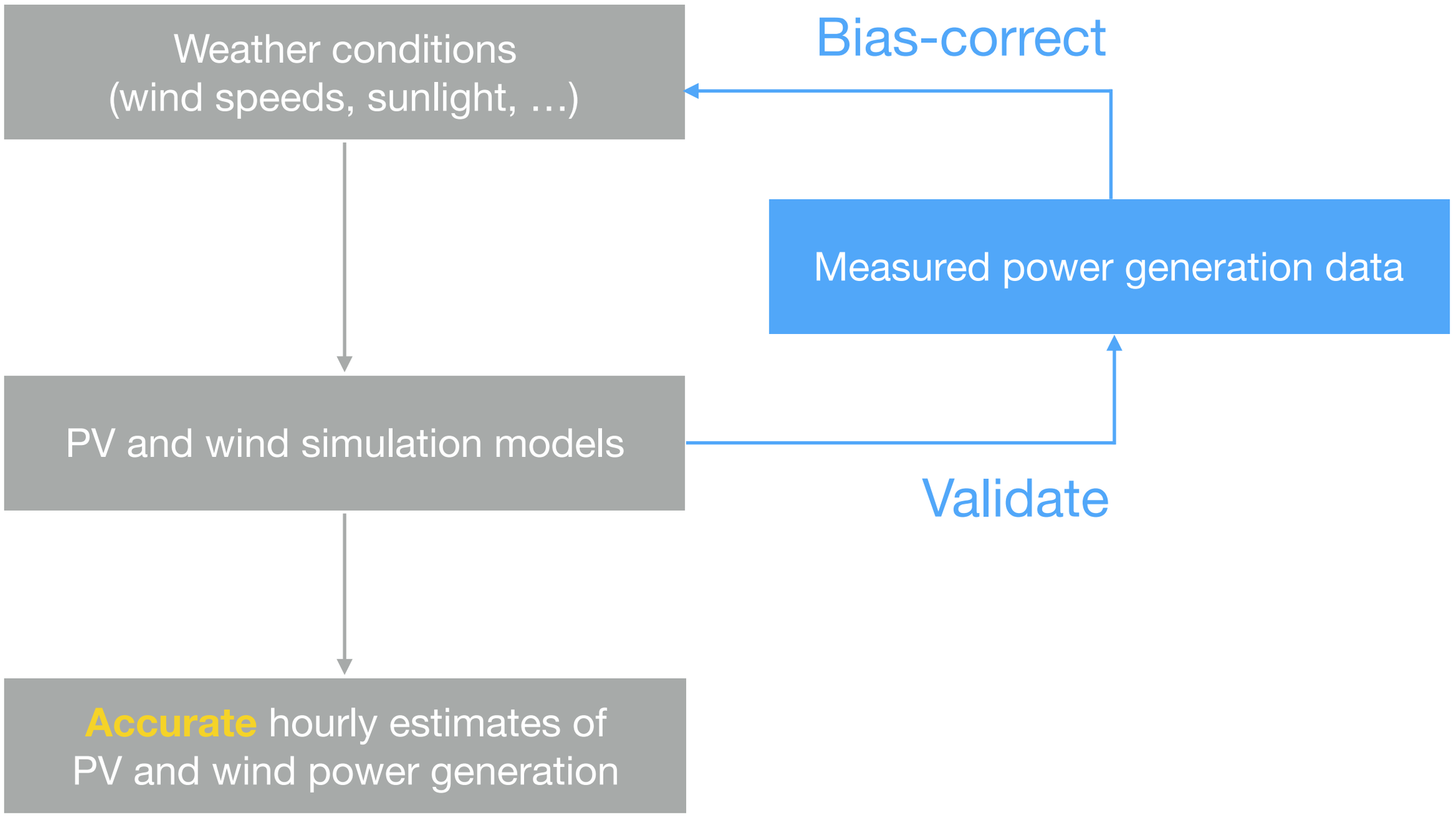
Pfenninger and Staffell (2016)

Main challenge & key innovation: bias correction



Pfenninger and Staffell (2016), Staffell and Pfenninger (2016)

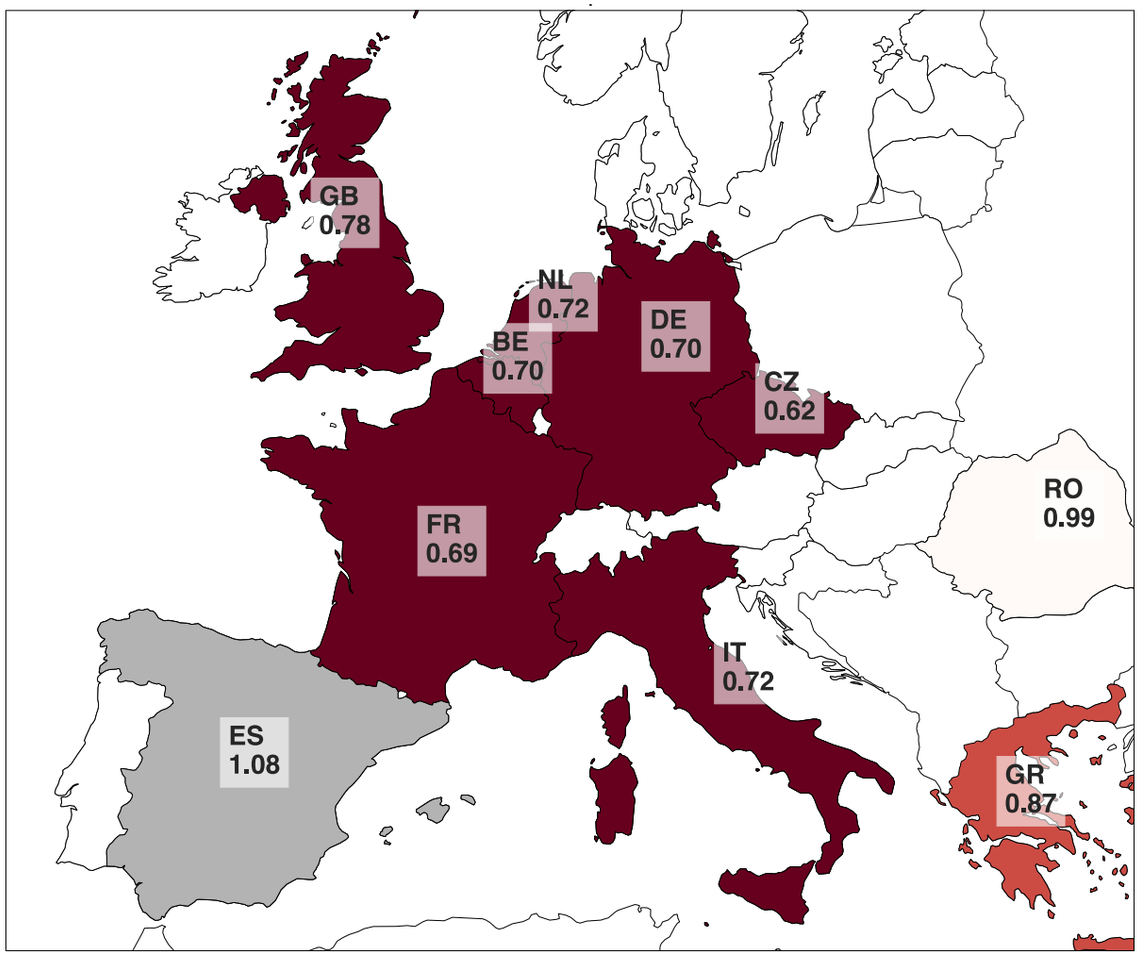
Main challenge & key innovation: bias correction



Pfenninger and Staffell (2016), Staffell and Pfenninger (2016)

Bias correction is not optional

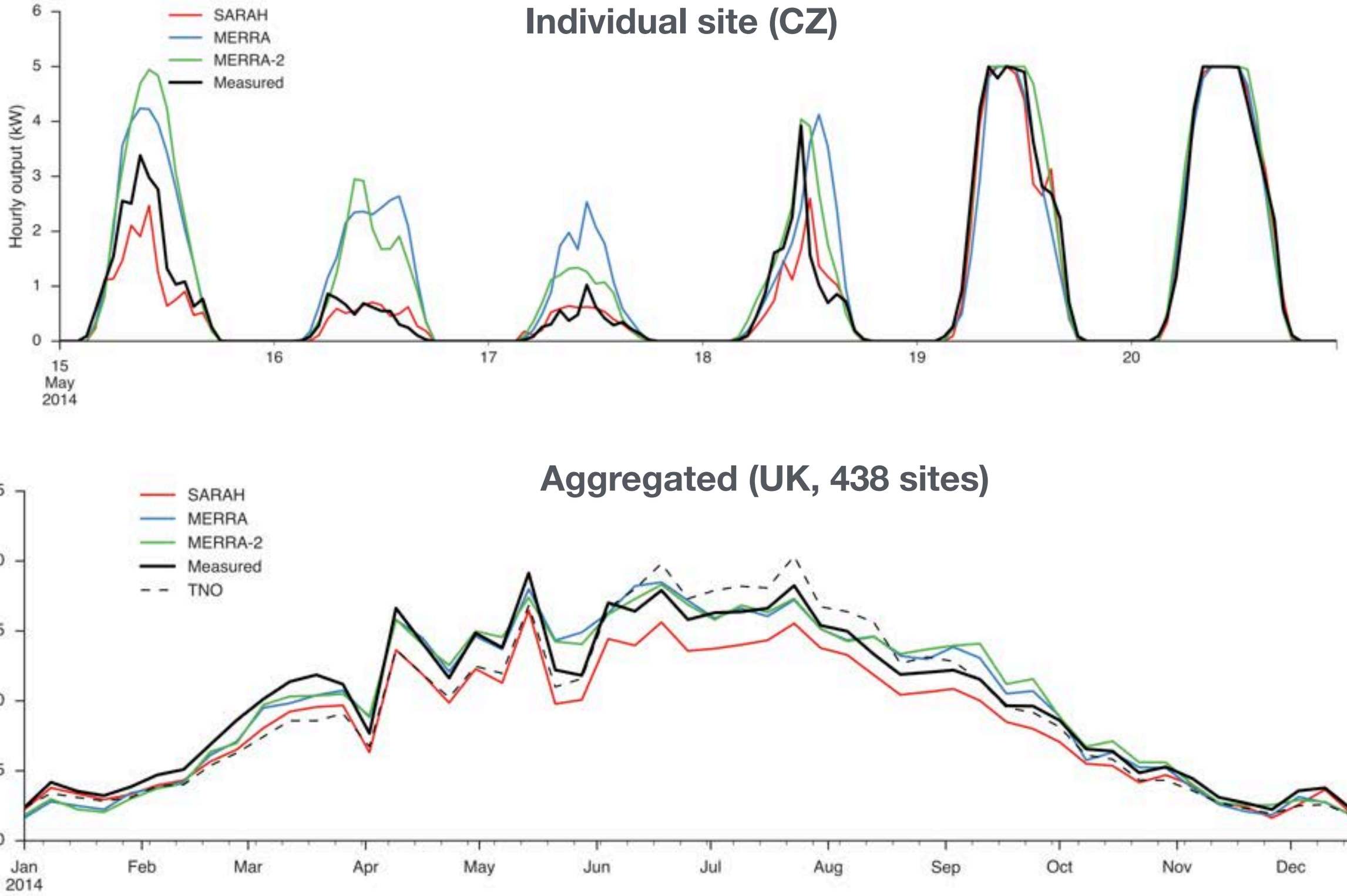
- Reanalysis without calibration *will* get it wrong!
- Adjust wind speed / irradiance resource data up or down
- Q: But… with ±40% adjustment, ***what's the point?***
- A: Bias-corrected simulations are surprisingly accurate



Actual / simulated capacity factor

Staffell and Pfenninger (2016)

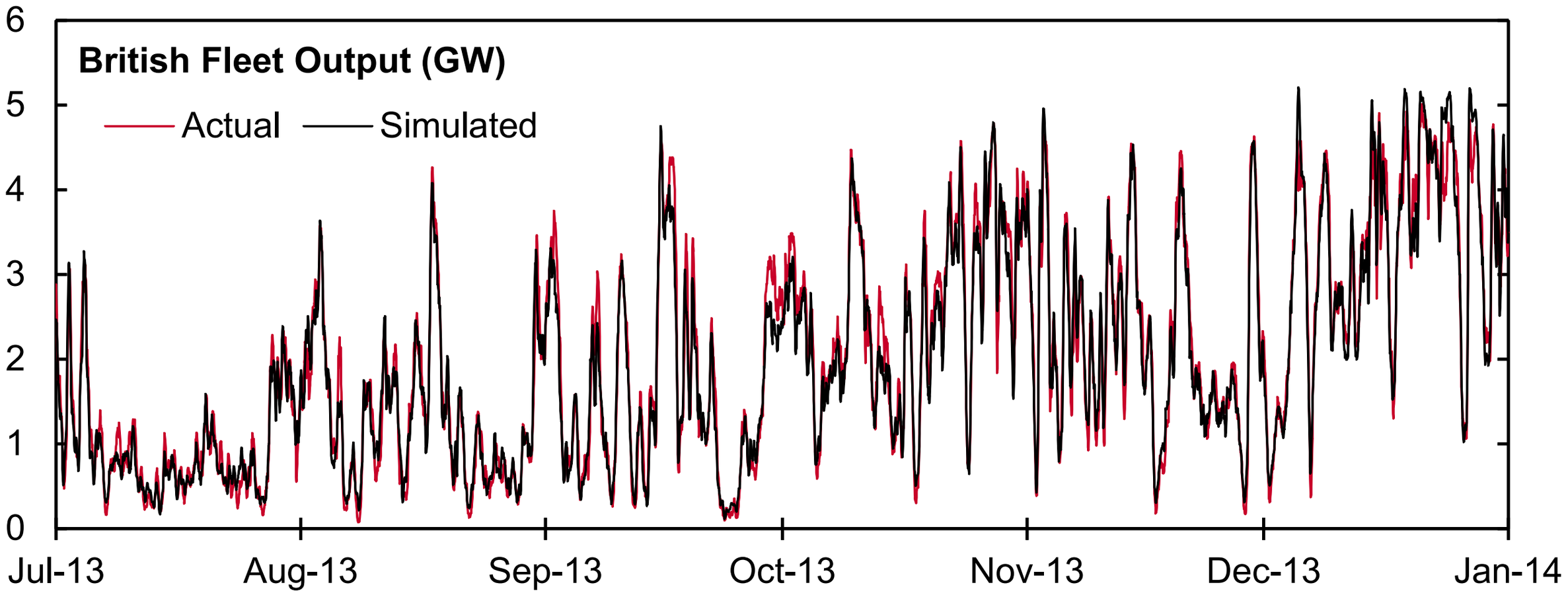
Bias-corrected simulations



Pfenninger and Staffell (2016)

Bias-corrected simulations

Simulating the UK wind fleet: $R^2 = 0.95$



Staffell and Pfenninger (2016); actual data from Elexon & National Grid

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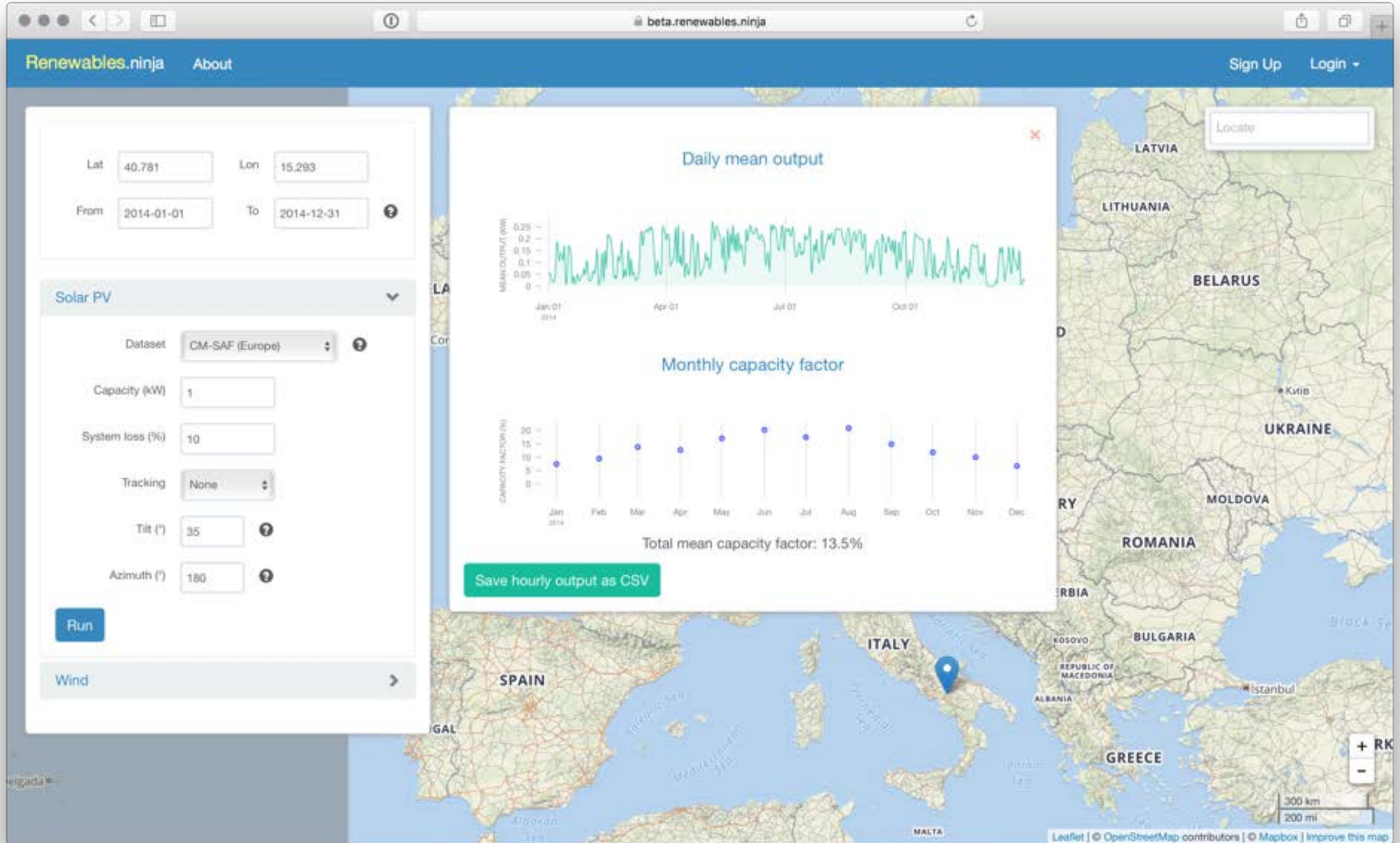
Goal: provide easy access to our bias-corrected wind and PV simulations.

>650 users from >210 institutions in 60 countries.

Pfenninger and Staffell (2016). *Energy*; Staffell and Pfenninger (2016). *Energy*

www.renewables.ninja



Pfenninger and Staffell (2016), Staffell and Pfenninger (2016)

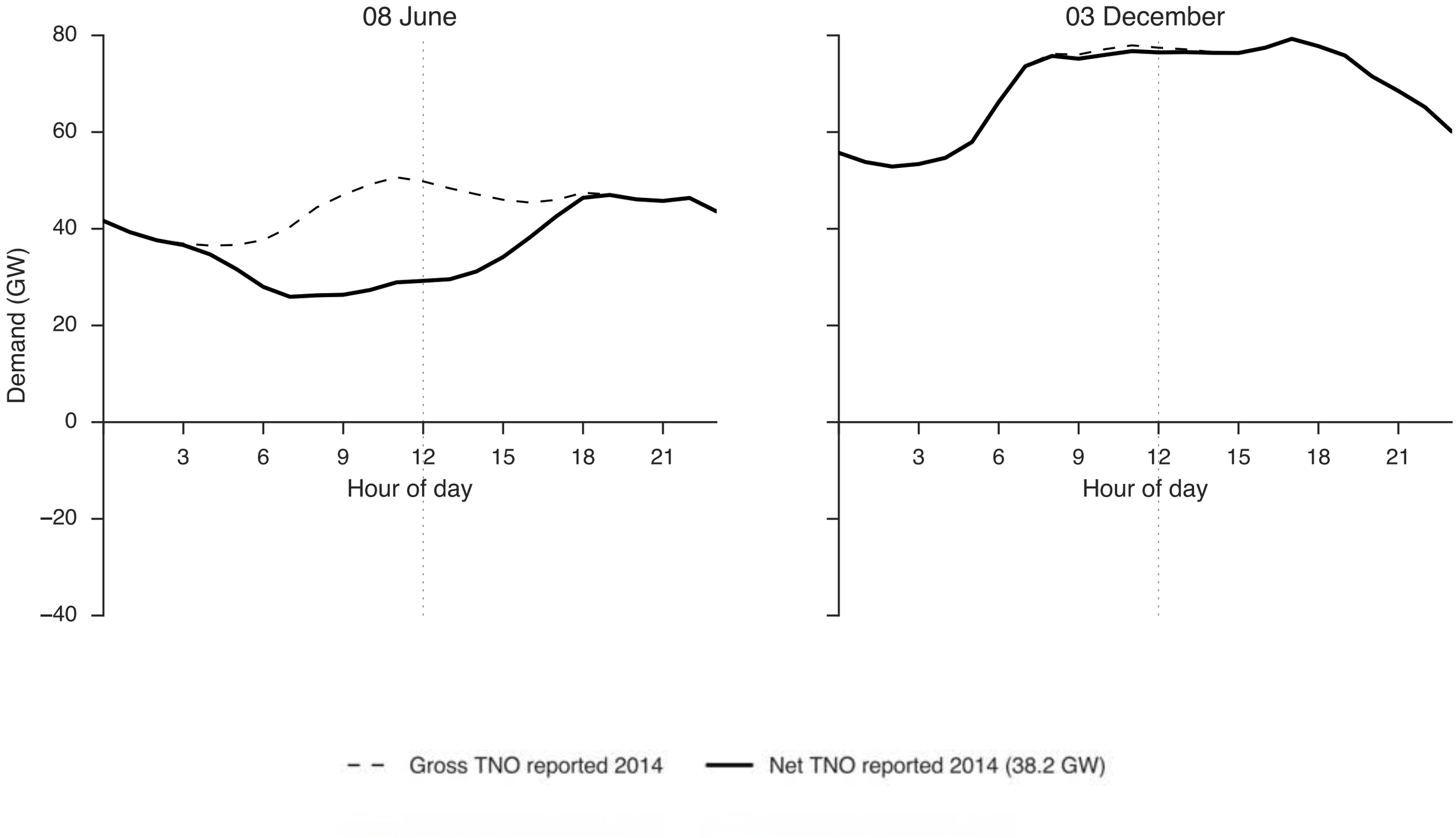
PART 2

Applications

Application 1:

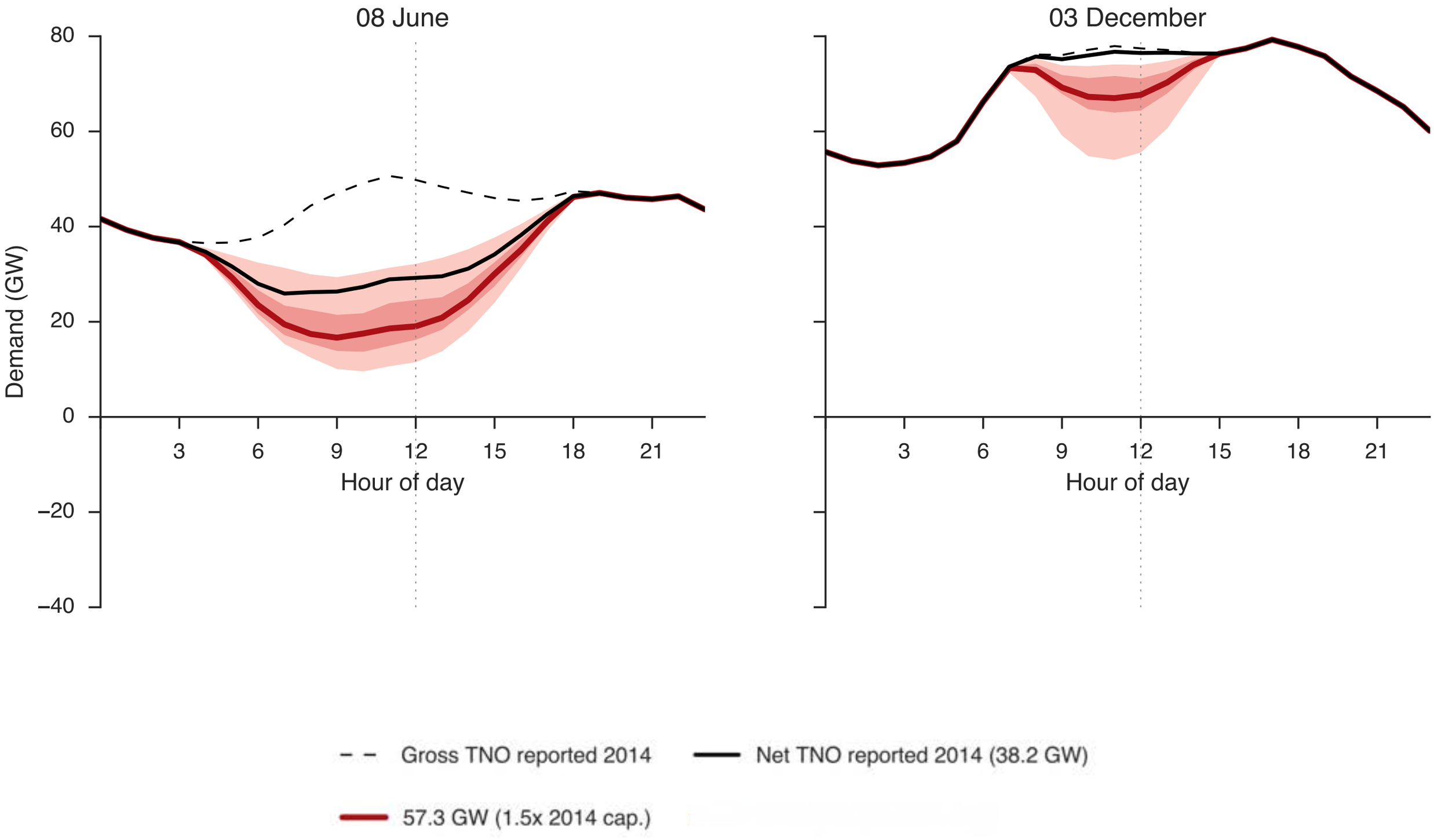
Net demand impact by increasing PV penetration

Demand net of PV in Germany



Pfenninger and Staffell (2016)

Demand net of PV in Germany



Pfenninger and Staffell (2016)

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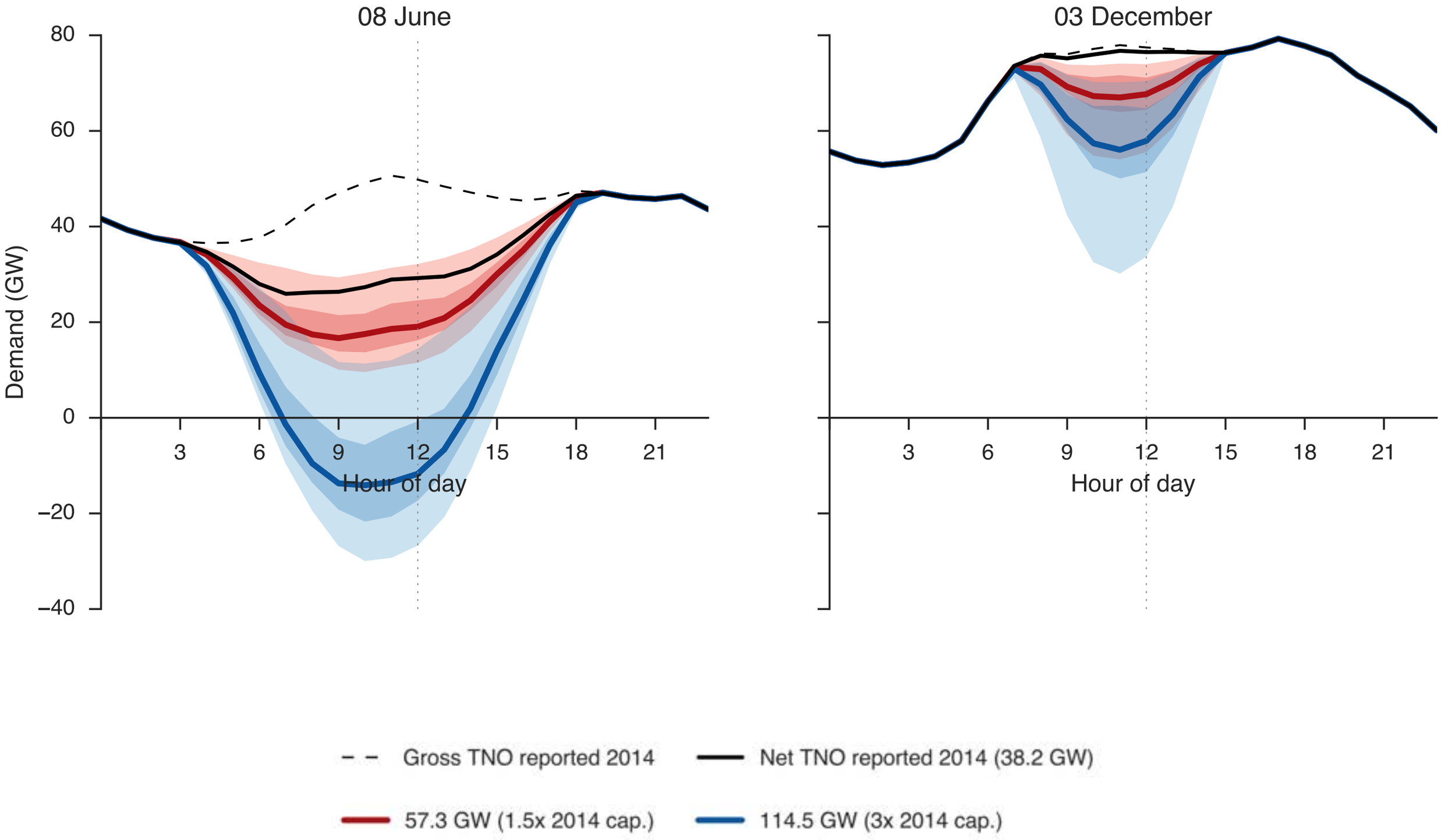


Pfenninger and Staffell (2016)

Application 2:

Understanding weather regimes: more stable European wind power

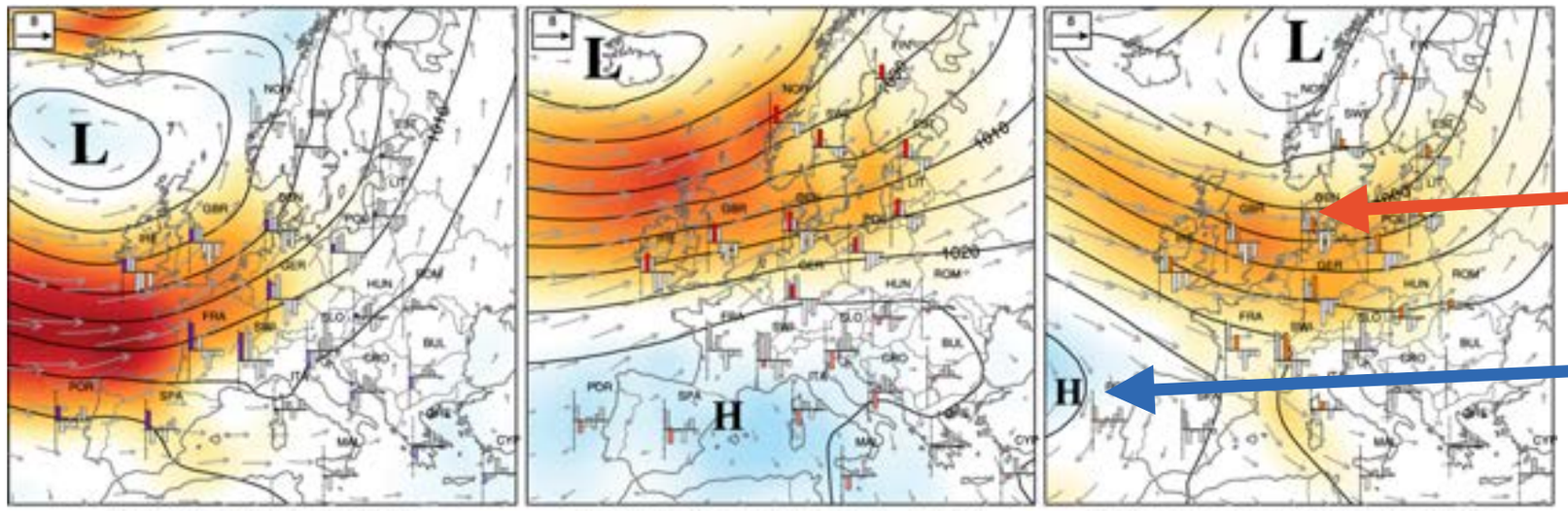
Weather regimes

Atlantic Trough
AT

Zonal
ZO

Scandinavian Trough
ScTr

Cyclonic



red shading:
high wind

blue shading:
low wind

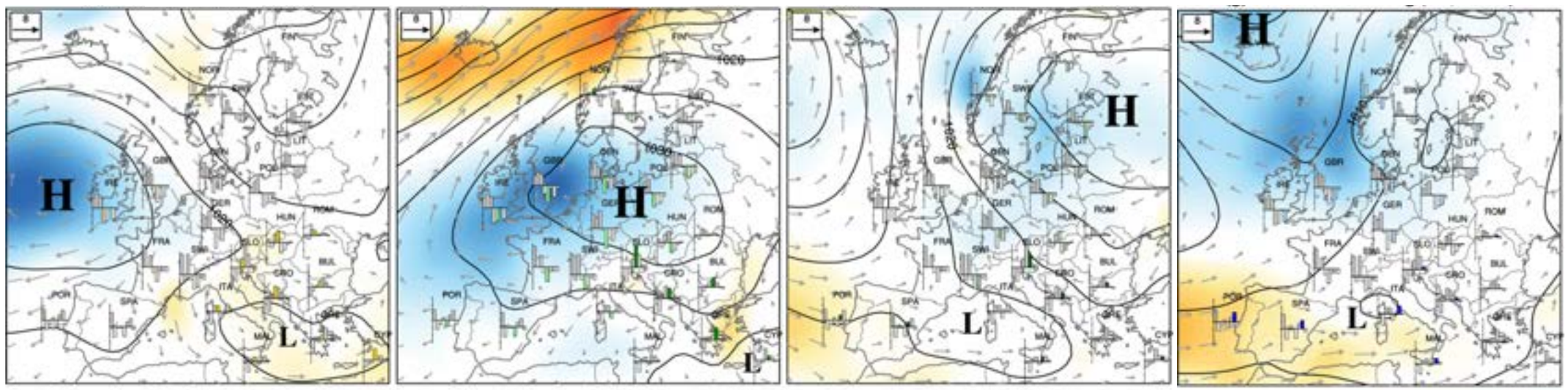
Atlantic Ridge
AR

European Blocking
EuBL

Scandinavian Blocking
ScBL

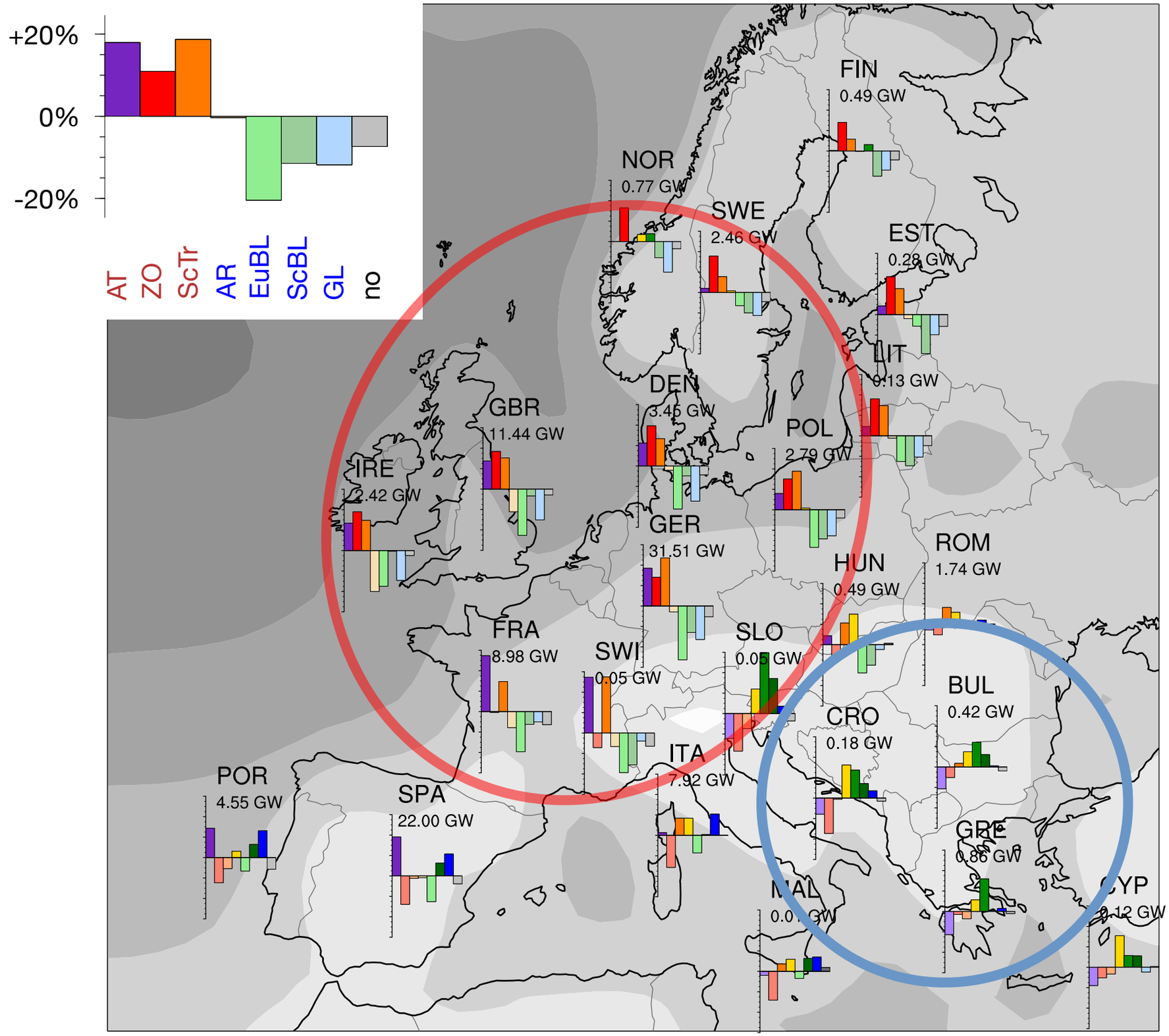
Greenland Blocking
GL

Blocked



Grams, Beerli, Pfenninger, Staffell and Wernli. *Nature Climate Change* (accepted - under press embargo)

Mean EU-wide wind output



Grams, Beerli, Pfenninger, Staffell and Wernli. *Nature Climate Change* (accepted - under press embargo)

Existing:

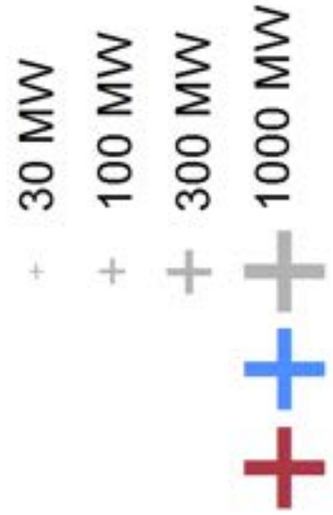
+ 135 GW

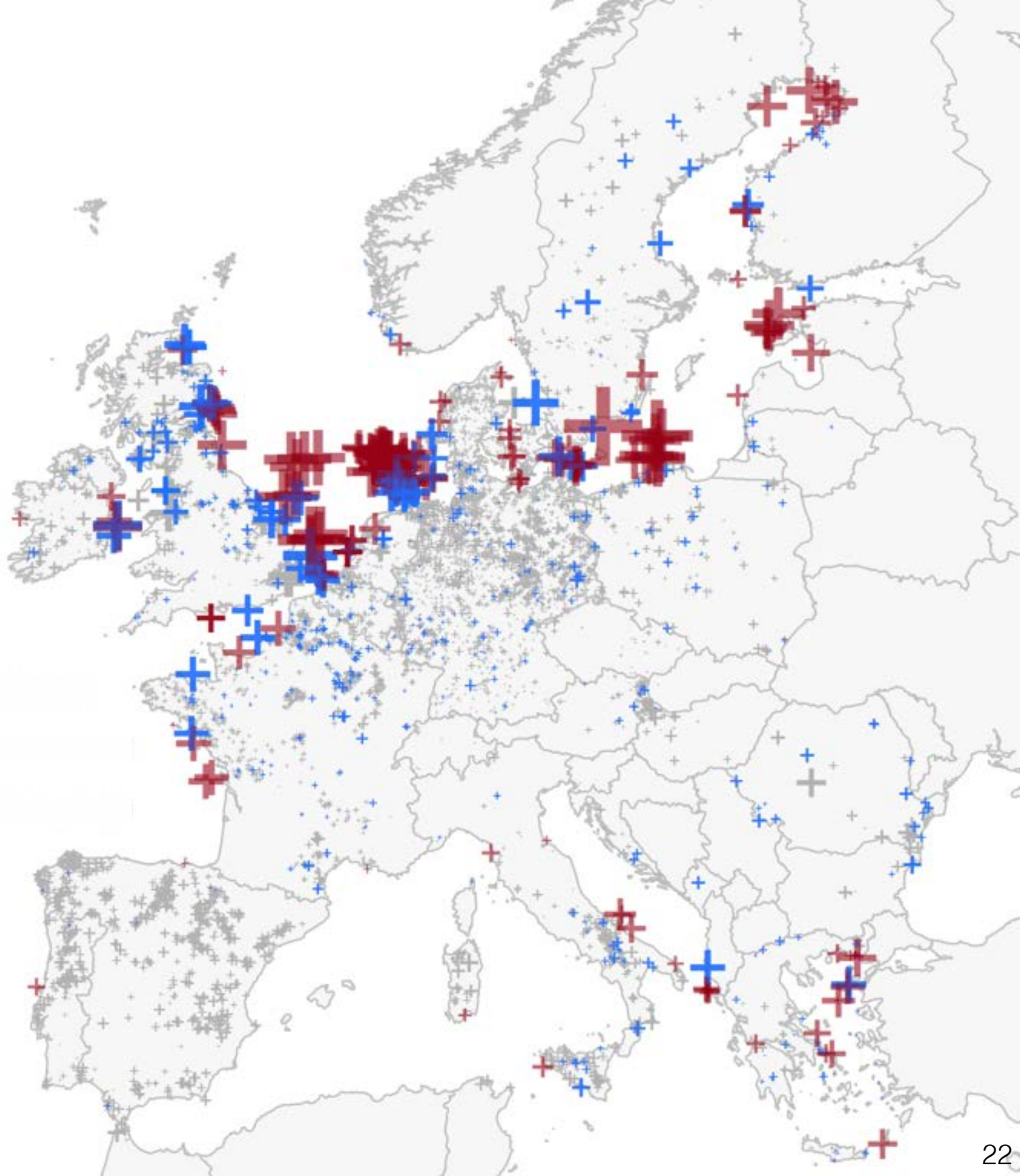
Under construction:

+ 44 GW

Planned:

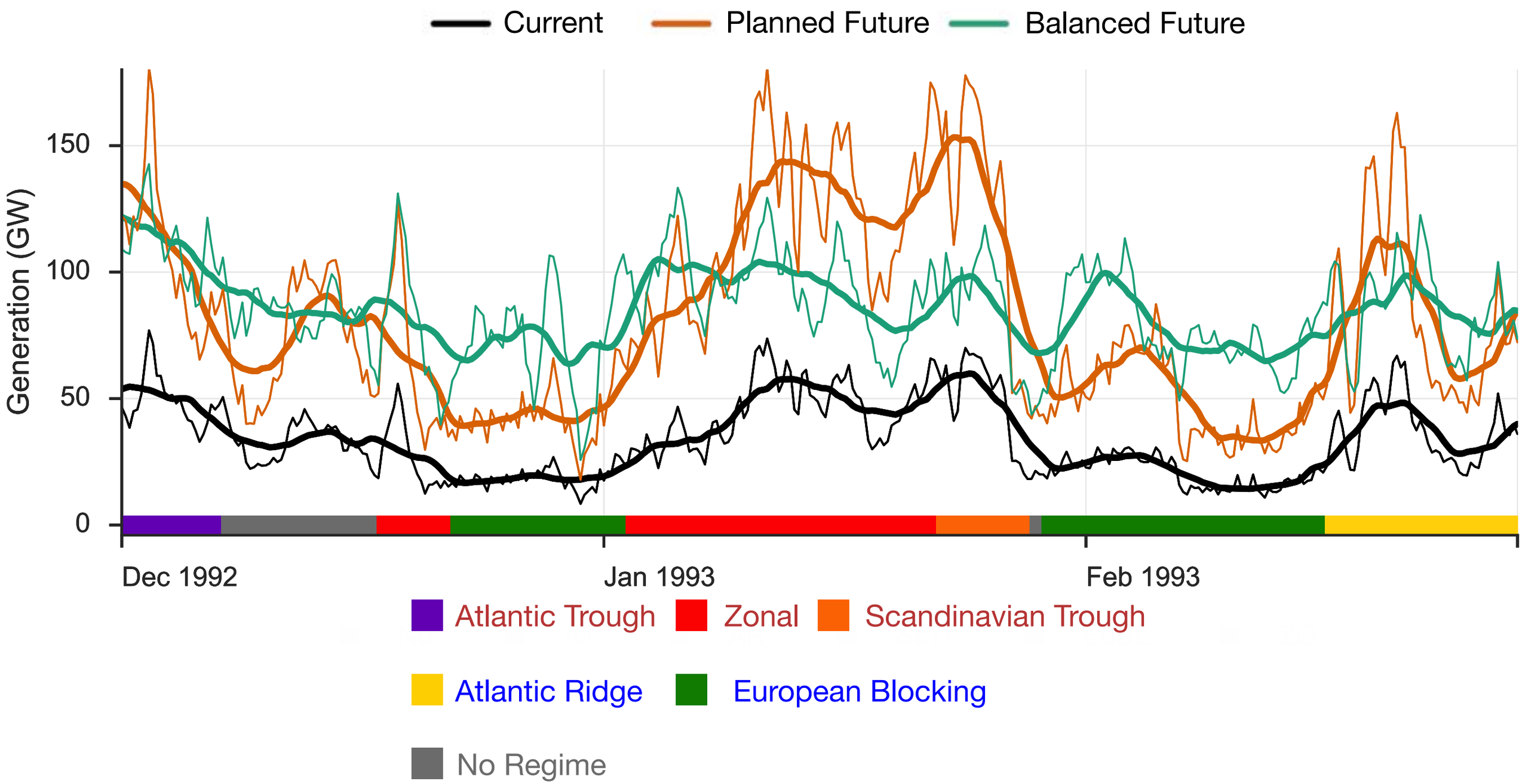
+ 93 GW





Staffell and Pfenninger (2016). *Energy*

Balanced deployment of wind



Grams, Beerli, Pfenninger, Staffell and Wernli. *Nature Climate Change* (accepted - under press embargo)

PART 3

Challenges and lessons learnt

Renewables.ninja provides open data

- Leads to collaboration, and allows unexpected innovation
- Permits more transparent research on the energy transition

nature
International weekly journal of science

WORLD VIEW *A personal take on events*

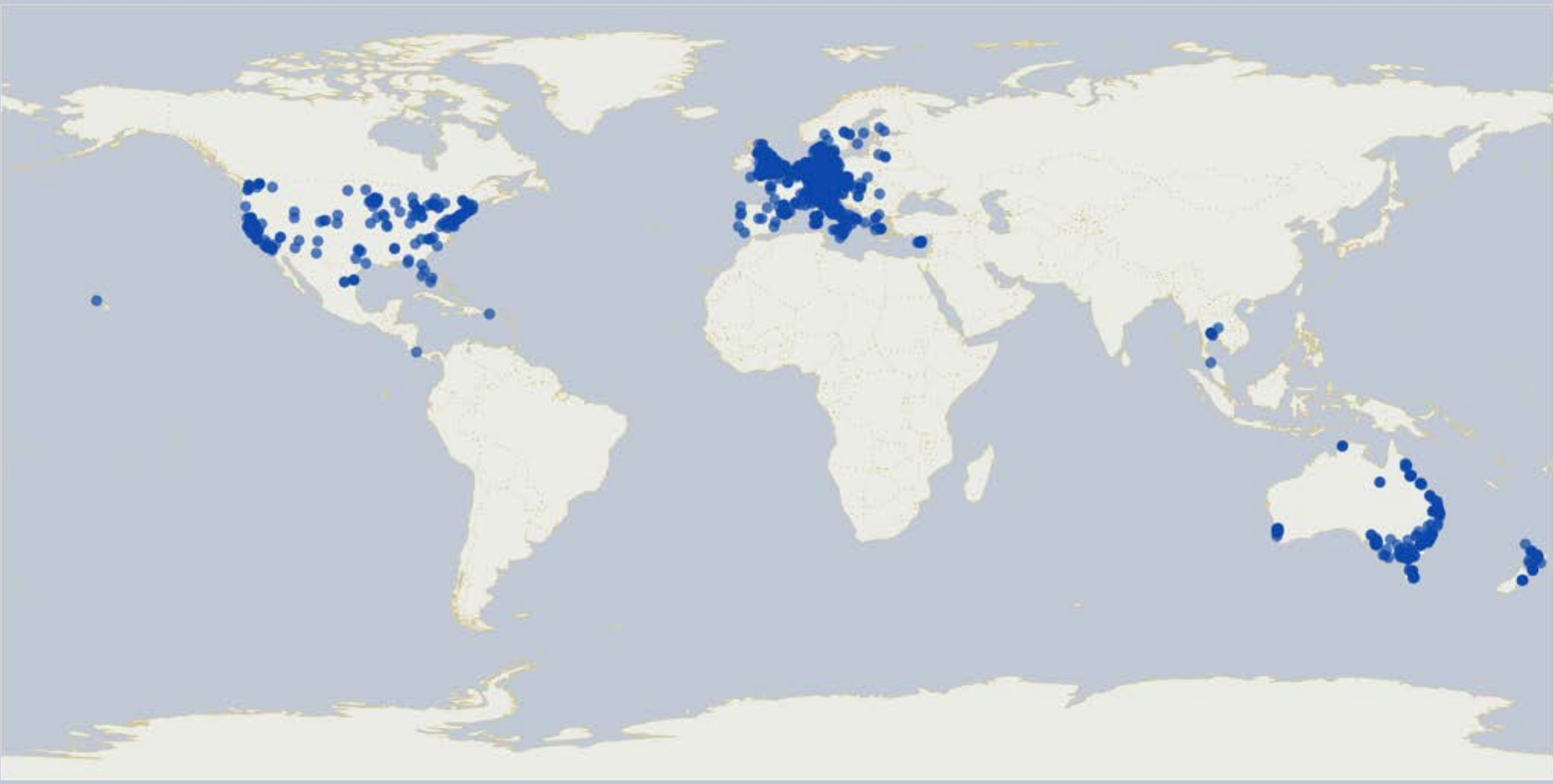
ANDREA VEDOVO

Energy scientists must show their workings

Public trust demands greater openness from those whose research is used to set policy, argues **Stefan Pfenninger**.

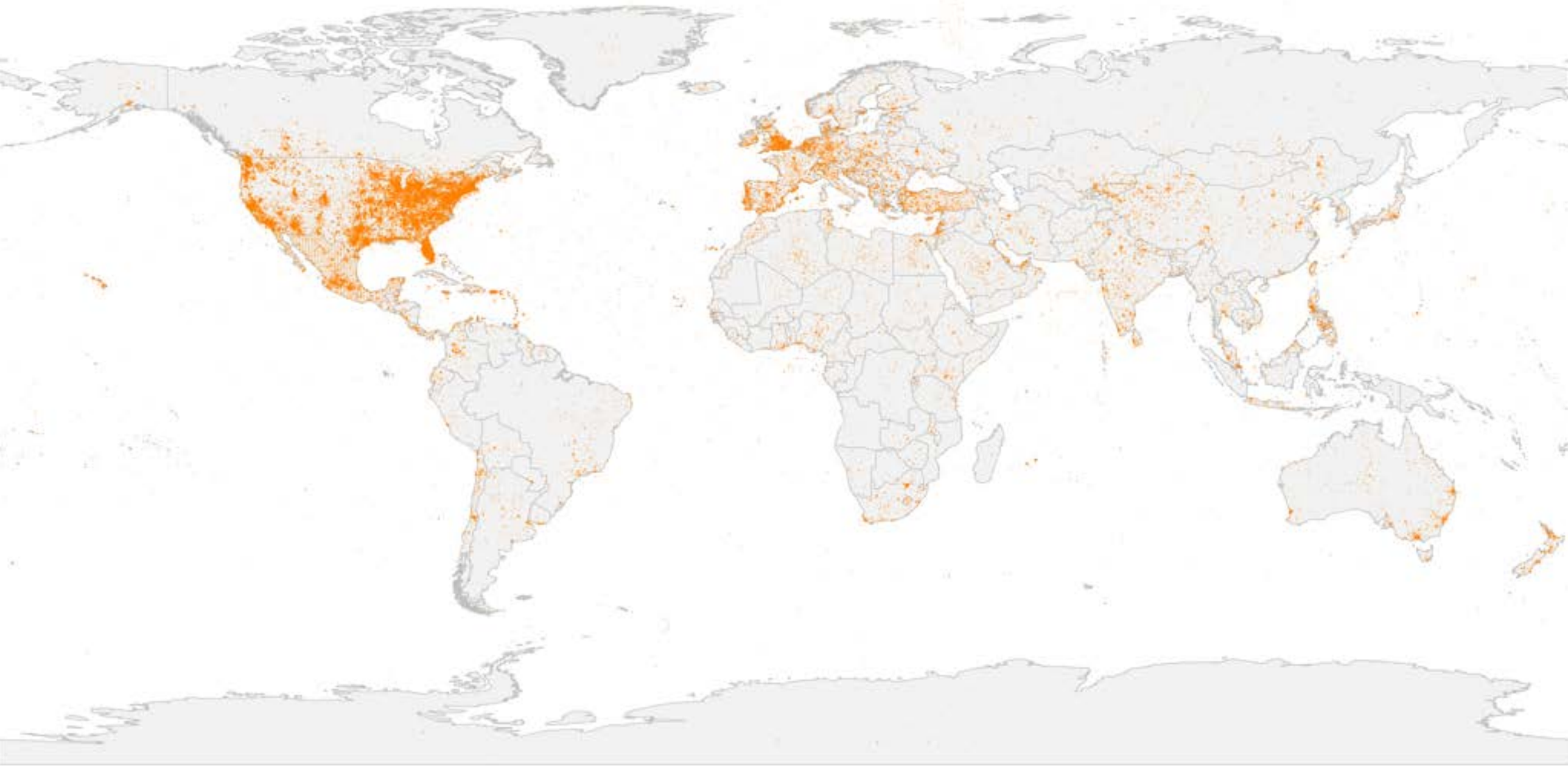
Pfenninger (2017). *Nature*

Extending our initial approach globally is challenging



Site-specific PV generation data gathered so far; work in preparation

But demand for data globally



We are working on globally validated/corrected simulations.
Sign up on www.renewables.ninja to be notified when ready.

Thanks for your attention

- Reanalysis works to simulate wind and PV globally, but only if you correct for bias in the weather data.
- Renewables.ninja is a free platform that lets you model wind and solar easily, and get on with your research. Global validation in progress and coming soon.
- Making data available allows innovation to happen

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www.renewables.ninja www.callio.pe www.pfenninger.org

- Pfenninger and Staffell (2016). Long-term patterns of European PV output using 30 years of validated hourly reanalysis and satellite data. *Energy* 114, pp. 1251-1265. doi: 10.1016/j.energy.2016.08.060
- Staffell and Pfenninger (2016). Using Bias-Corrected Reanalysis to Simulate Current and Future Wind Power Output. *Energy* 114, pp. 1224-1239. doi: 10.1016/j.energy.2016.08.068
- Pfenninger (2017). Energy scientists must show their workings. *Nature* 542, 393. doi: 10.1038/542393a