Operating the Power System in Great Britain: Forecast Development and Challenges

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National Grid ESO

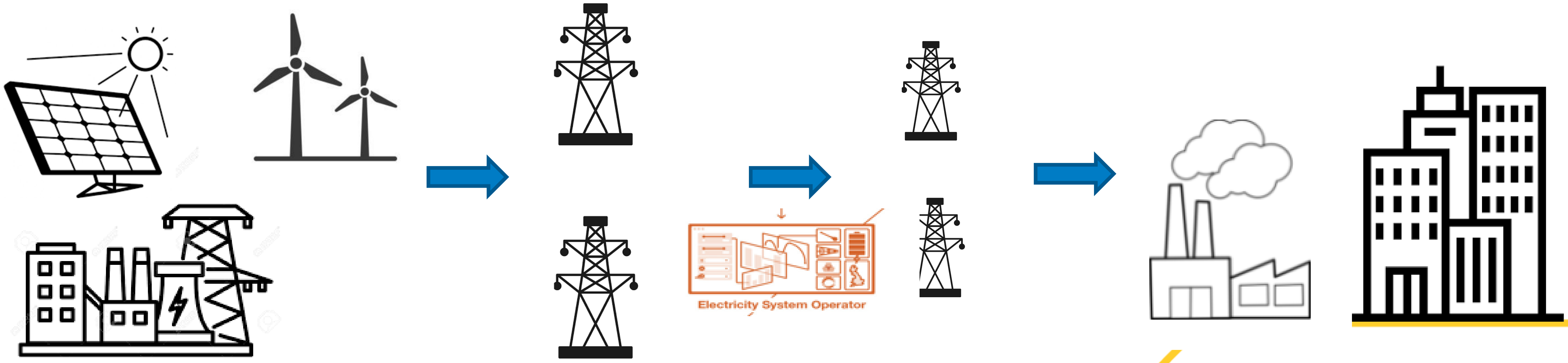
Once generated, electricity is then transported through the UK’s nationwide transmission network. We move the electricity to where it is needed, balancing supply and demand second by second, 24/7. We operate the system, but we are not responsible for the infrastructure, for example the pylons and cables, needed to carry the electricity.

Generation

Transmission network
(275 kV and 400 kV)

Distribution network
(132 kV and lower)

Consumer
demand



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Why forecast?

- To ensure the market has provided the correct amount of energy to operate the Electricity Network every minute of the day
- To know how much reserve to carry in case of a fault, loss of supply/ demand
- To calculate flows on the network to ensure constraints are not broken
- To plan ahead of time so that more economic solutions to solving issues can be found
- To operate the system reliably, economically and securely
- To provide the market with reliable forecasts so that other industry participants can plan their activities as economically as possible

https://data.nationalgrideso.com/

https://www.bmreports.com/bmrs/?q=help/about-us

Forecast timescales

Horizon	2 - 10 years	1 - 5 years	Up to 1 year	3-6 months	1 - 2 Week ahead	Day ahead	In-day
Purpose	Market signals: New build Generation and Interconnectors	Investment decisions on existing generation; Policy decisions on market design	Electricity market: Forward trades; Generator outage schedules; Network outage schedules	Seasonal preparedness Adjustments to outage plans	Market signals: Initial decisions on market position; Late decisions on outages Unplanned outages	Market position: Physical notifications to market; NG: Constraint planning Breakdowns	Final market positions; NG: Balancing actions

Outage and network set-up planning

Market and Operational planning

Real time management

Climatology

Weather forecast

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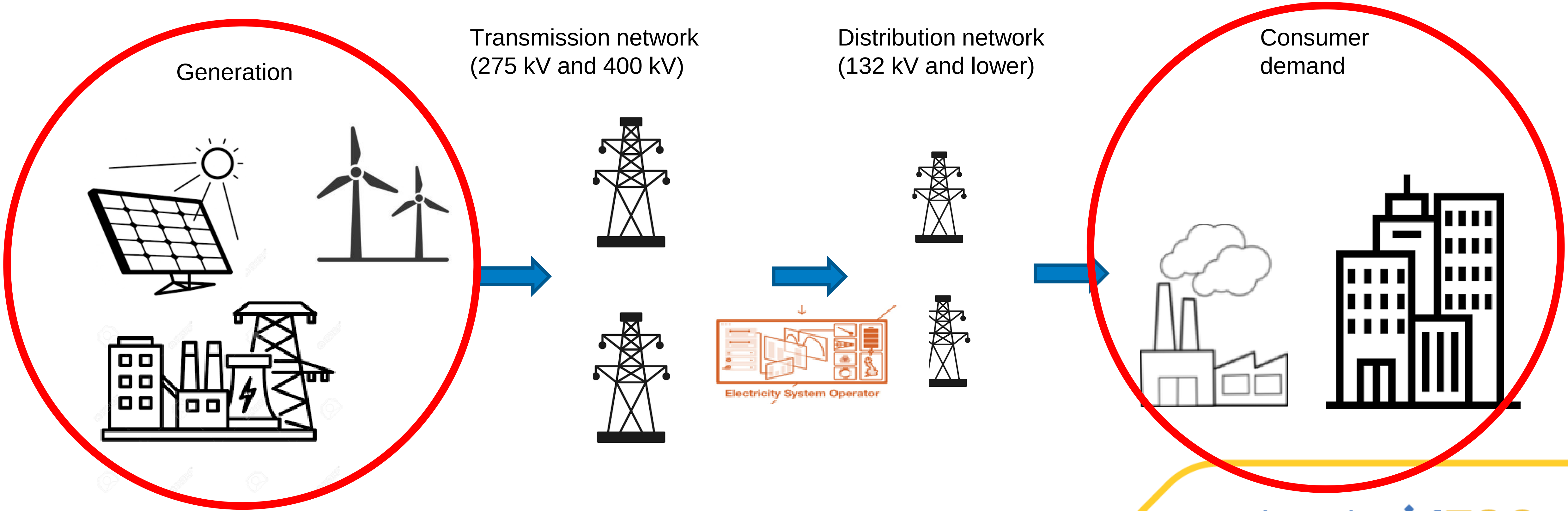
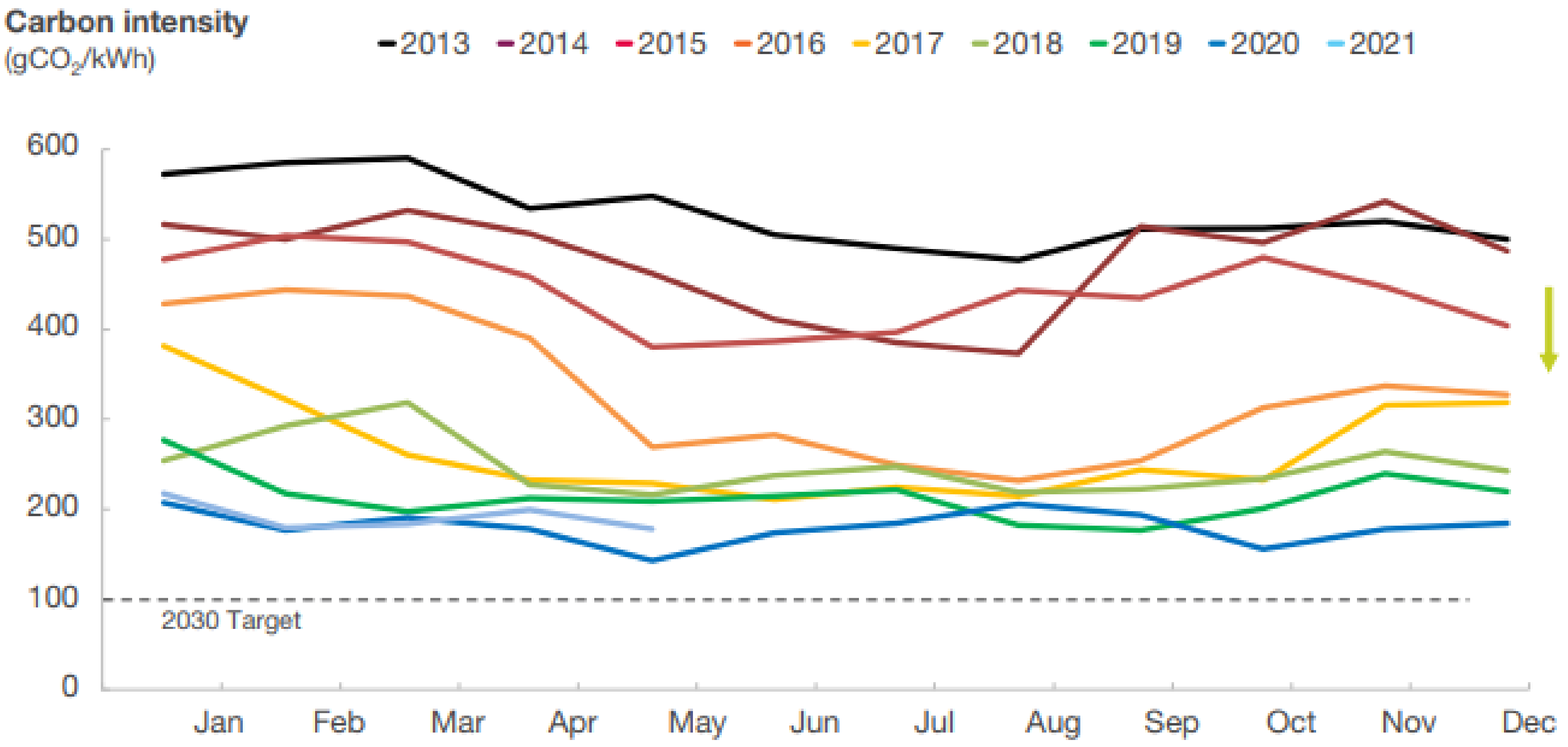
What we forecast

We forecast generation and demand over a range of spatial (regional – national) and temporal scales (minutes – years ahead)

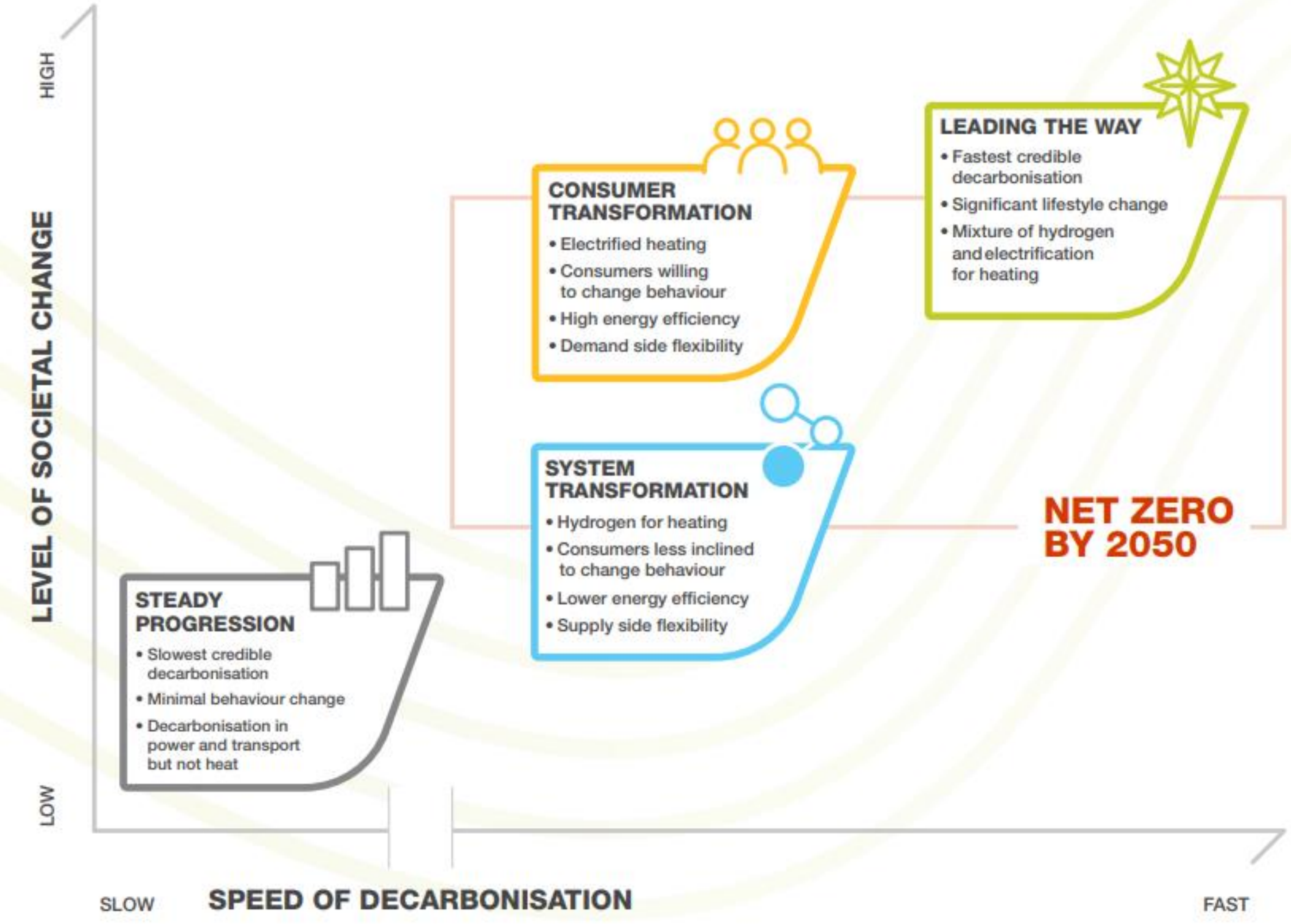


Carbon Intensity reduction



65.8% decrease
from 2013 to 2020

Future Energy Scenarios



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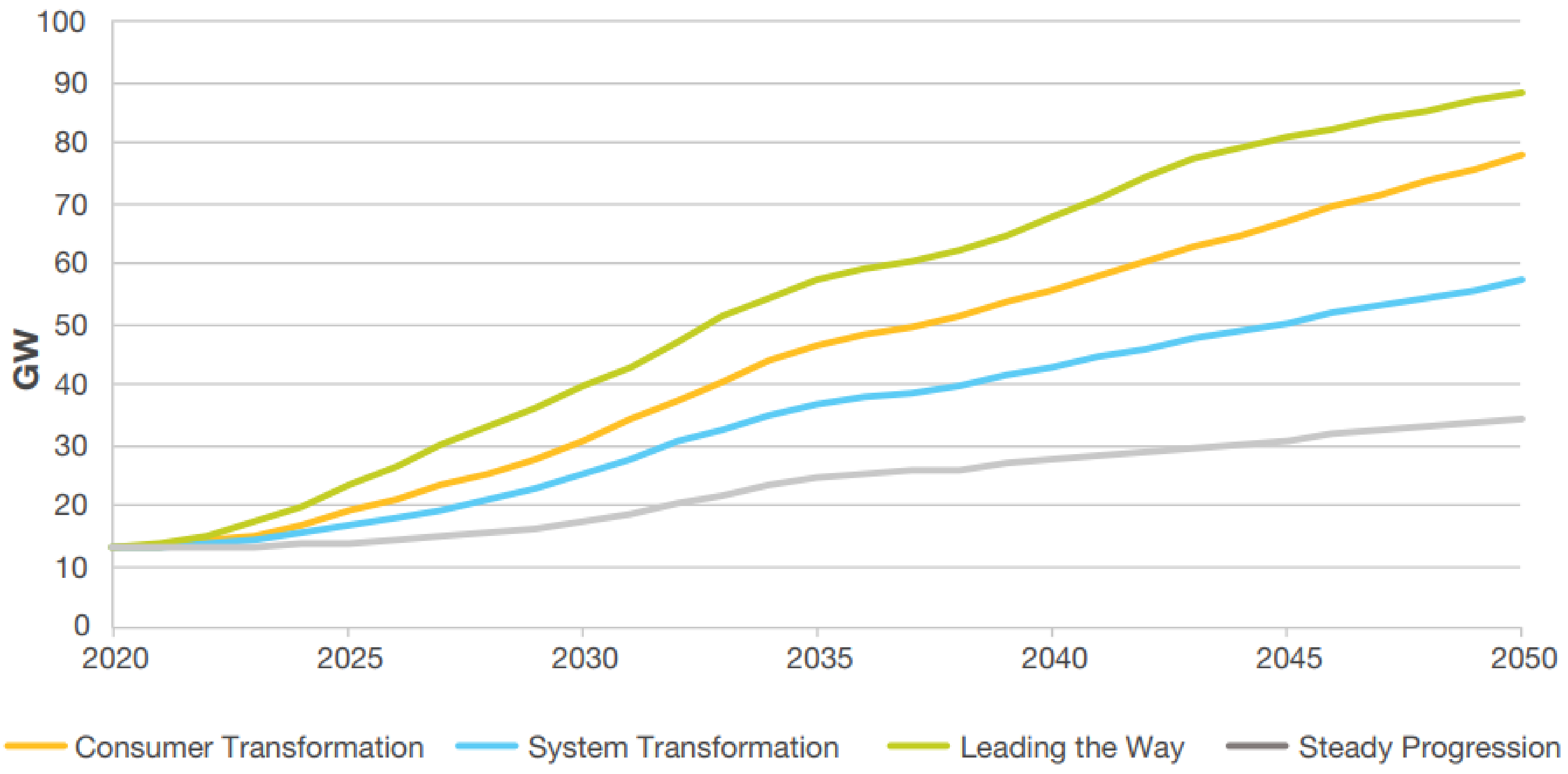
PV capacity



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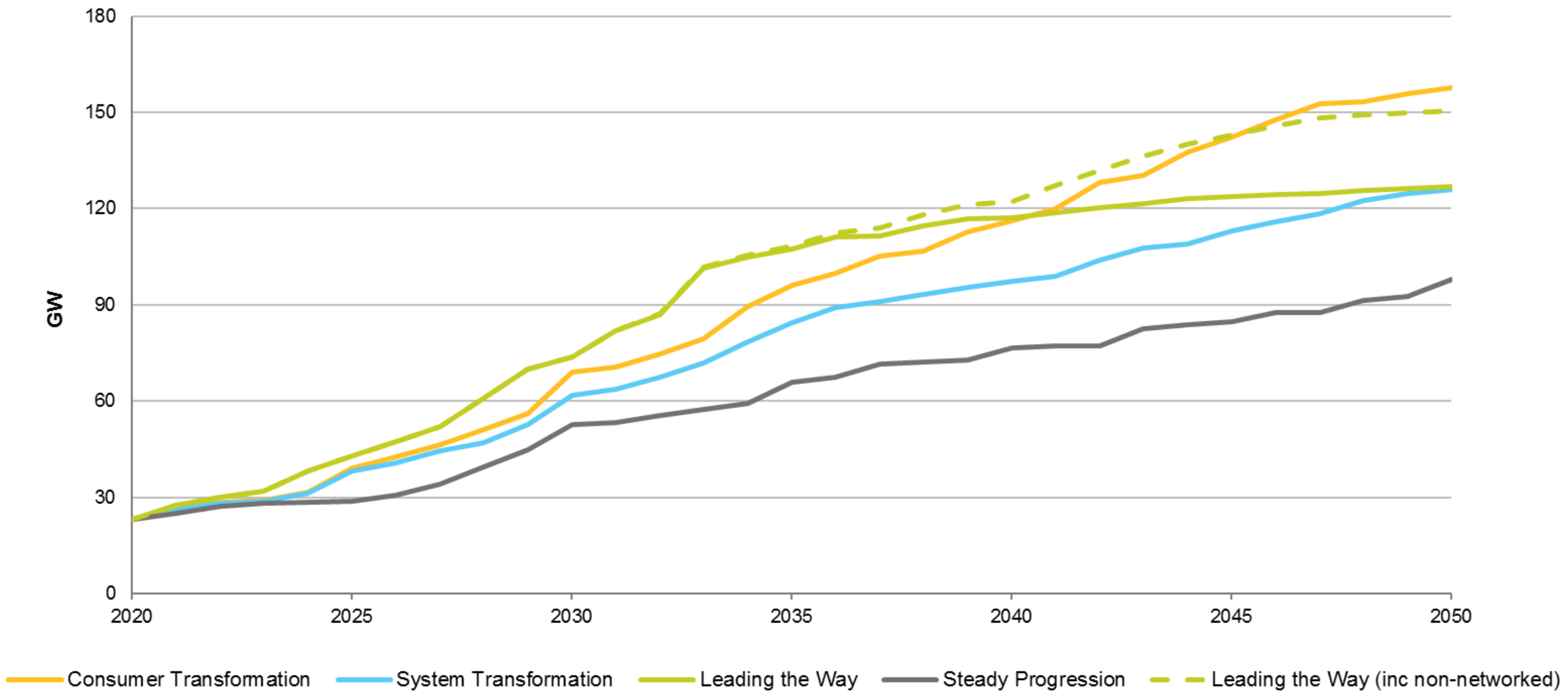
Wind capacity



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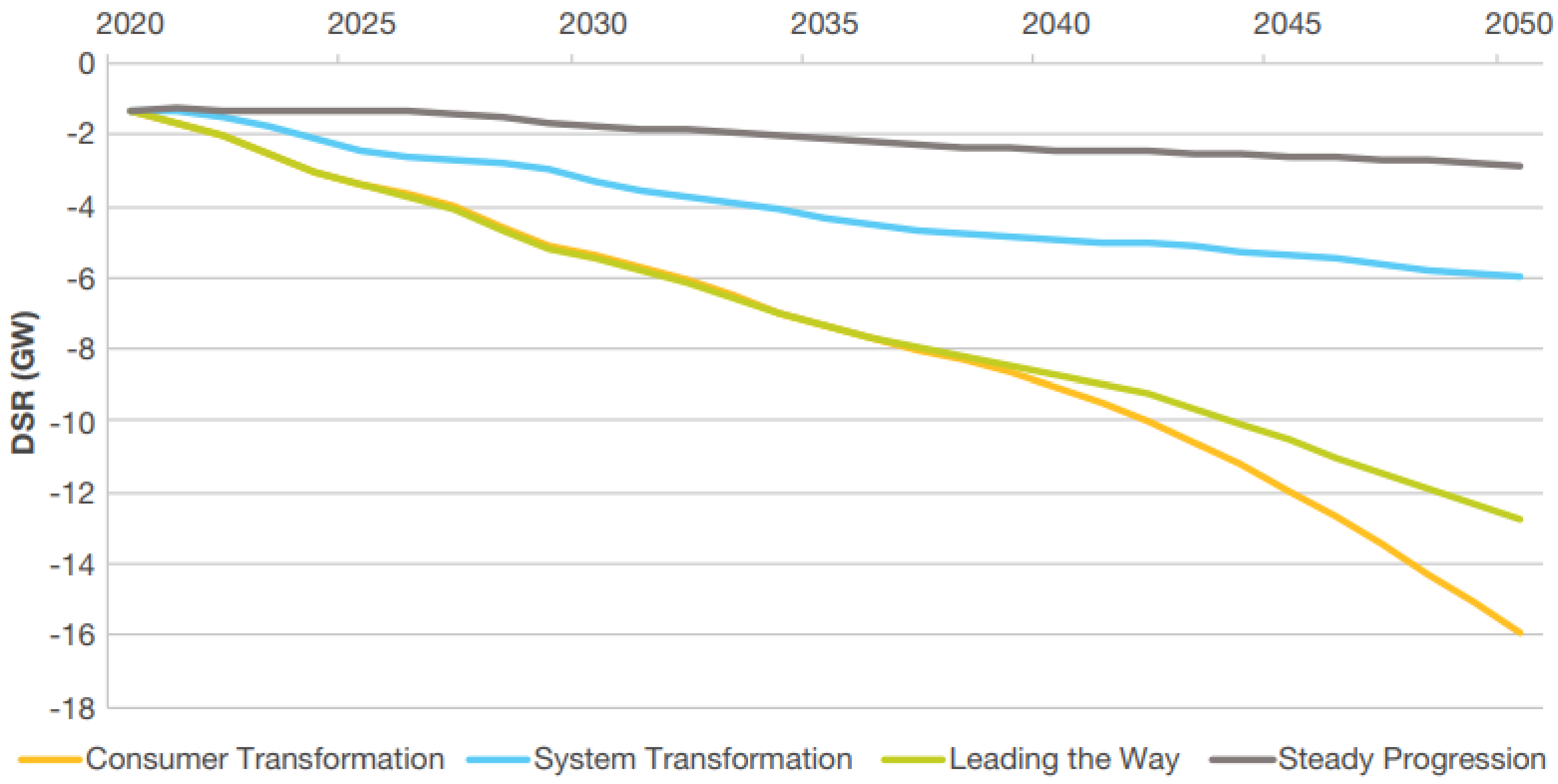
Demand Side Response



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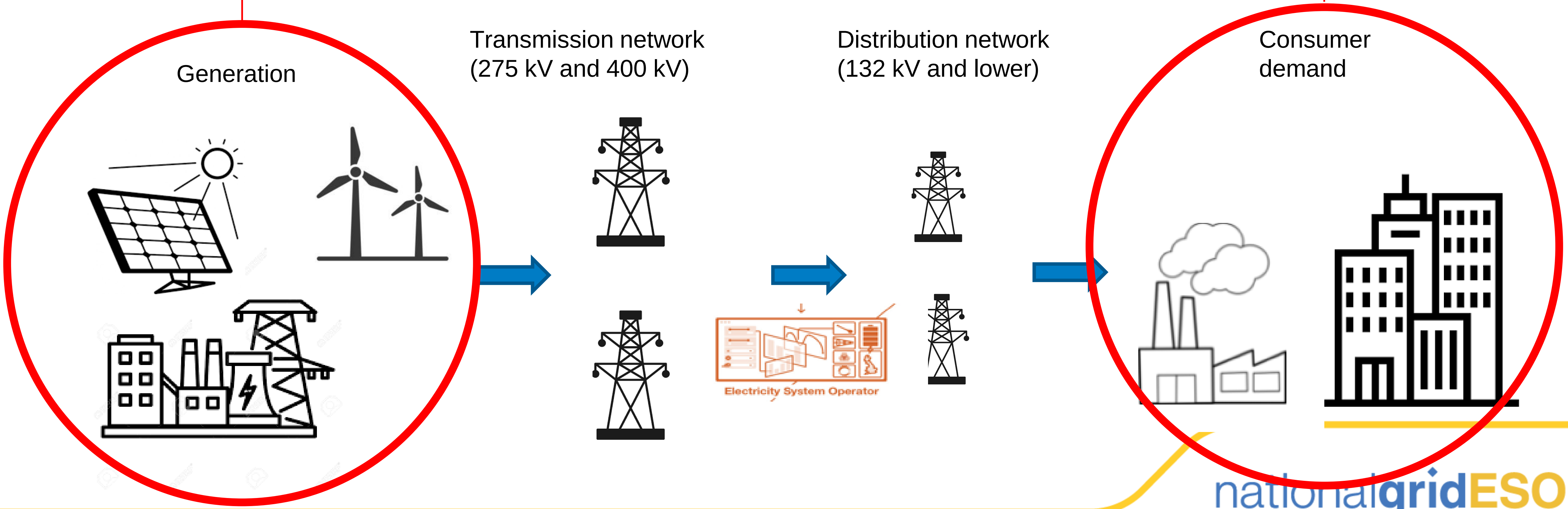
What we forecast

- Growing number of small generators
- Increasing proportion of weather-dependent generation

- More demand side response
- More embedded generation



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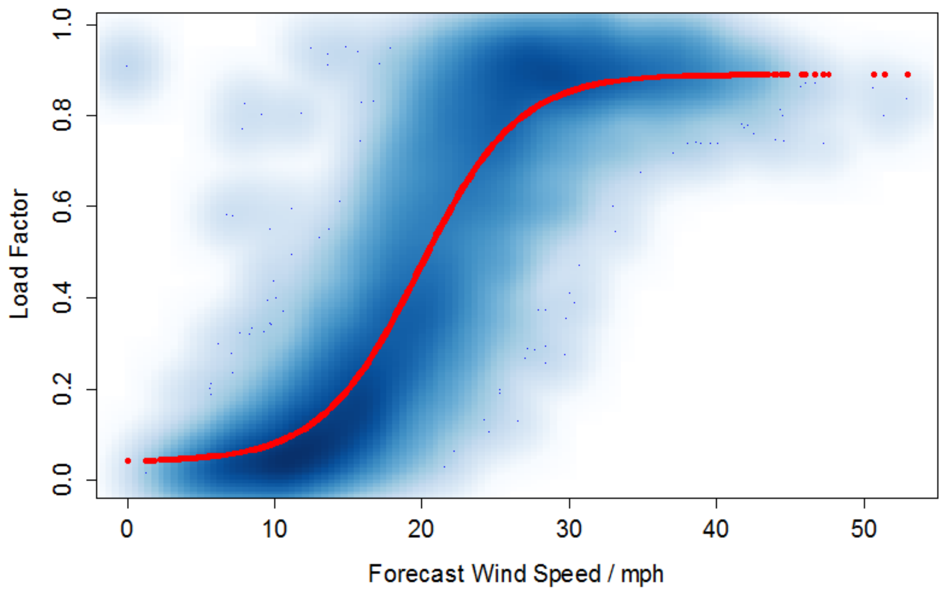
Wind power

Forecast metered and unmetered wind

Metered wind:

- Each wind farm mapped to one of ~100 weather stations
- Derive power curve from historical output



Unmetered wind:

- do not provide metering to the ESO;
- variable generation, depending on local weather conditions
- suppresses National Demand
- Capacity and location found from range of sources
- Use generic power curve

Weather variables

- **U:** Wind speed at hub height

Run the forecast for wind speed deciles to provide representation of uncertainty.

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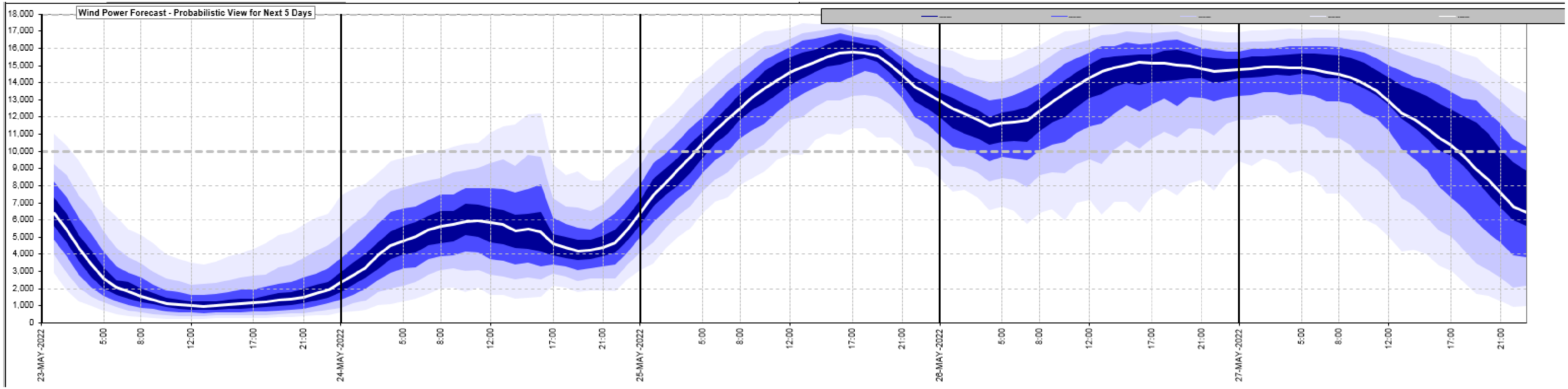
Example forecast



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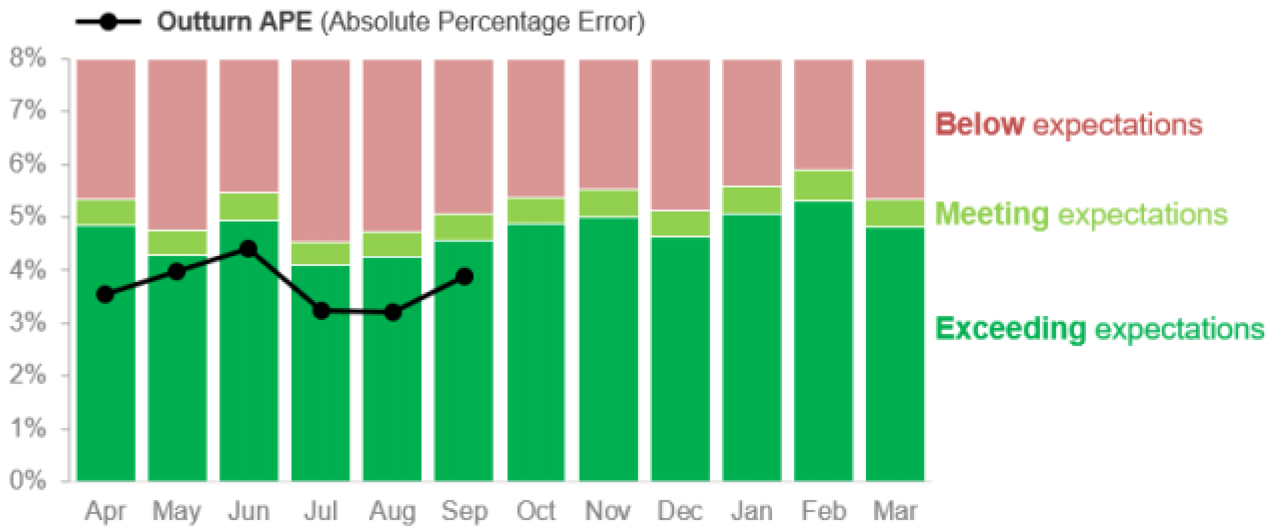
Wind forecast performance

Day-ahead forecast error approximately 5%

Largest errors (~20%) tend to be associated with mis-timing ramping events

Figure 3: BMU Wind Generation Forecast APE vs Indicative Benchmark (2021-22)



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Solar power

Entire GB solar fleet is embedded, this means:

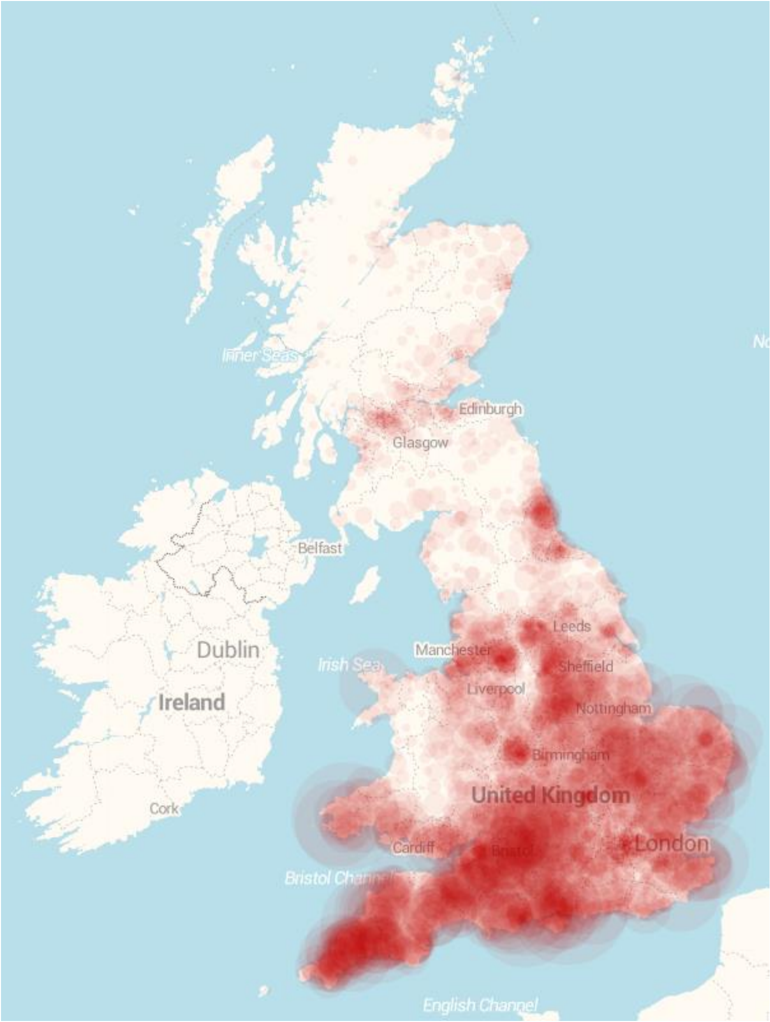
- do not provide metering to the ESO;
- do not participate in the BM.
- variable generation, depending on local weather conditions
- suppresses National Demand and network demands

Capacities & locations found from BEIS/Subsidy/public databases

- Approx. half is domestic solar!

Solar output is an estimation, +/- 10% error

- https://www.solar.sheffield.ac.uk/pvlive/



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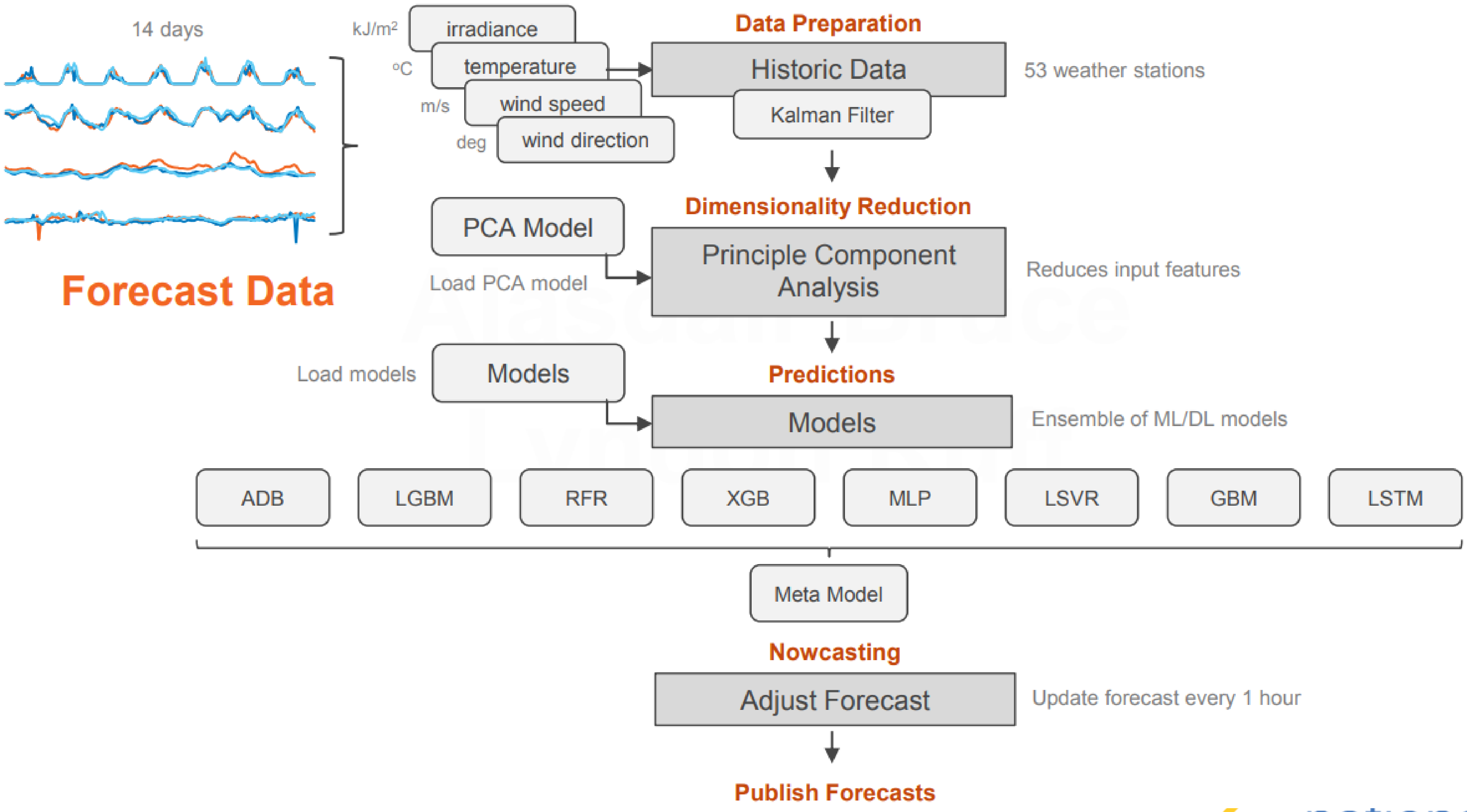
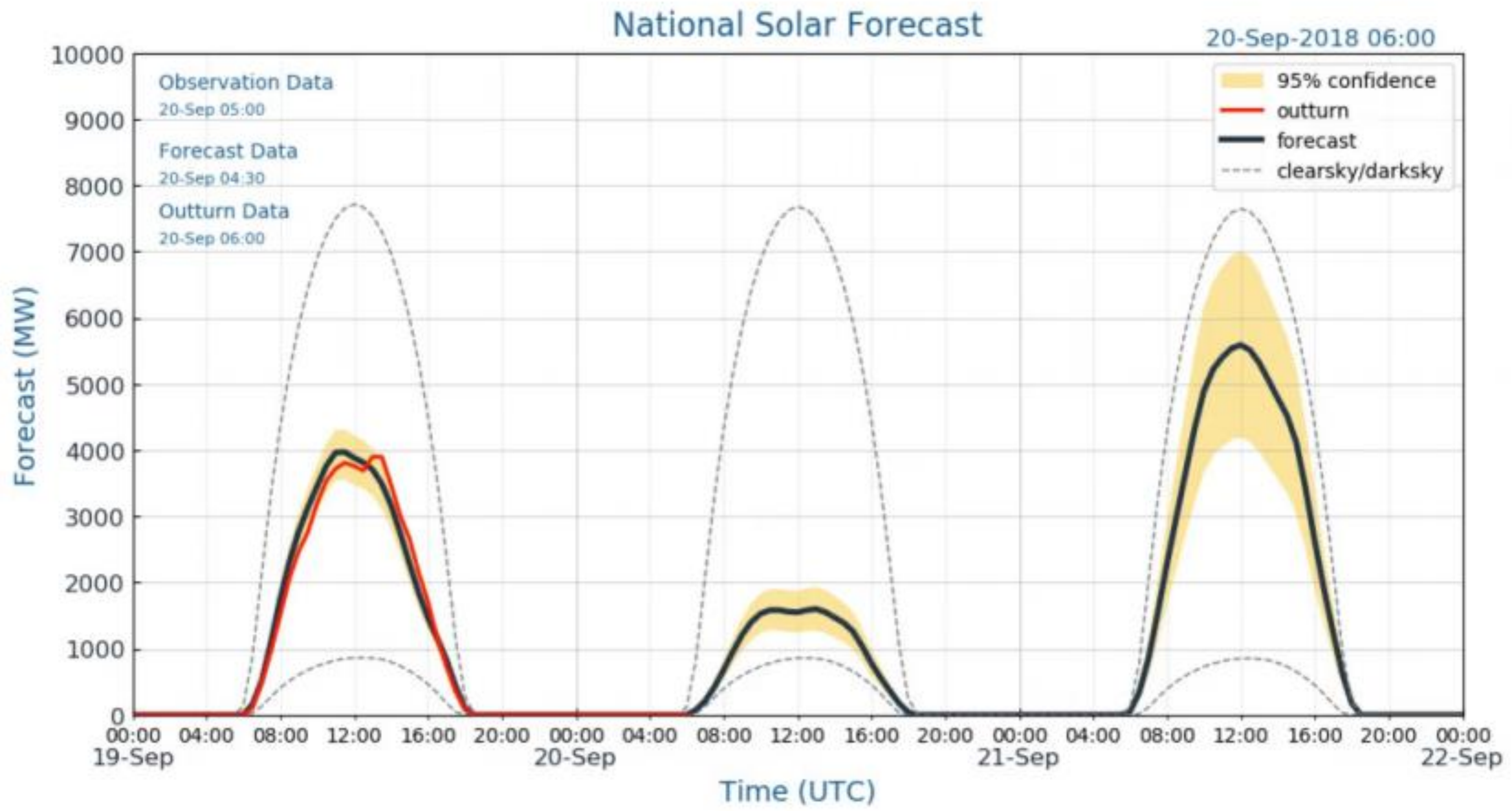
Solar power forecast



Example forecast



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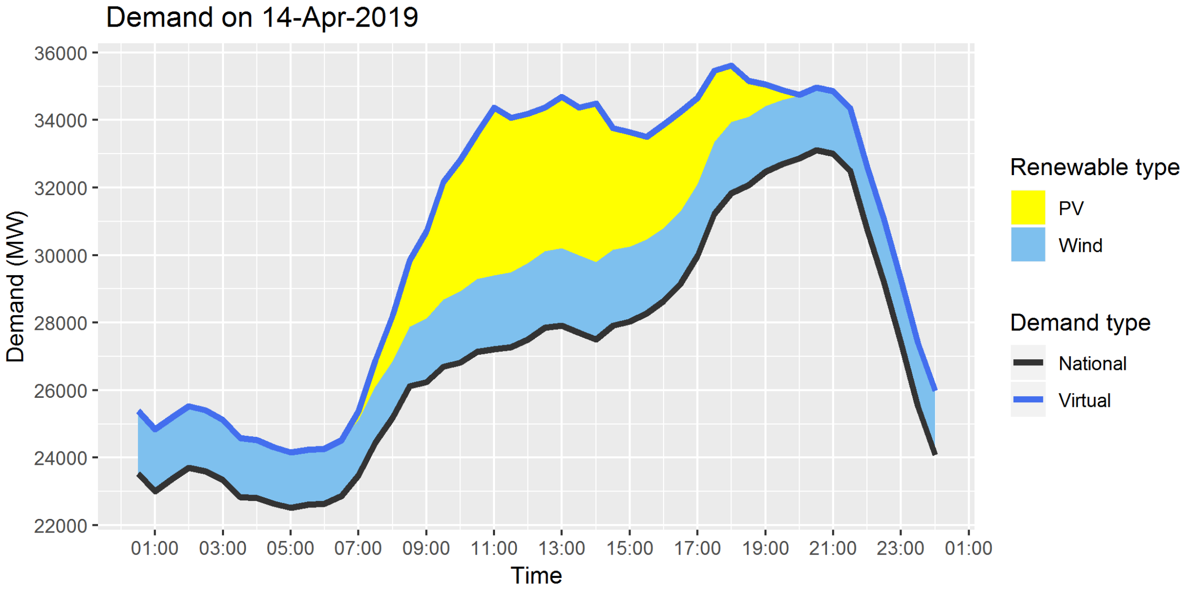
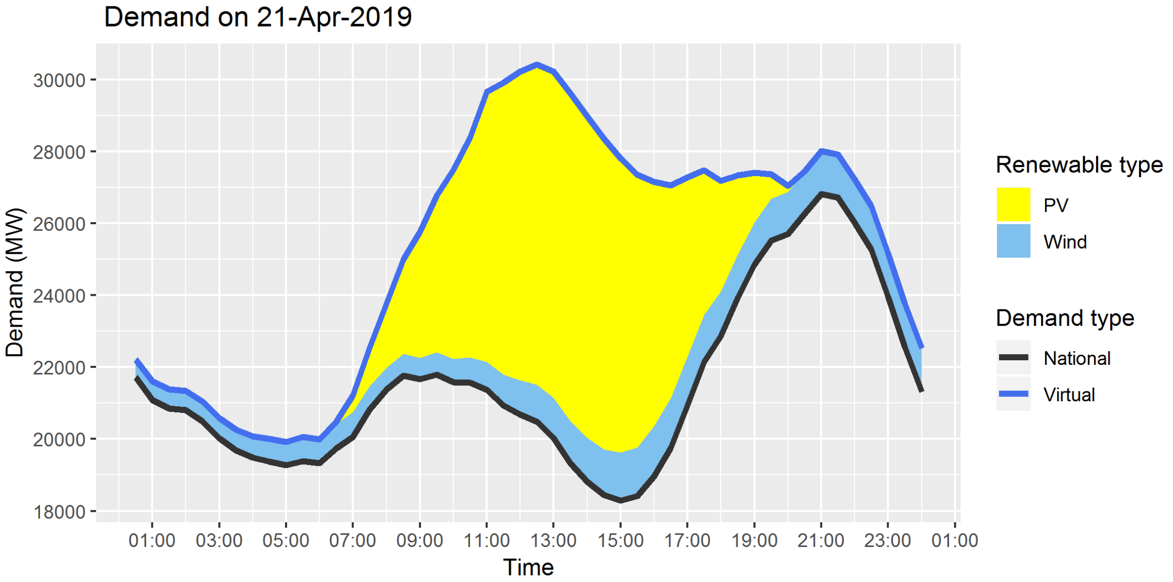
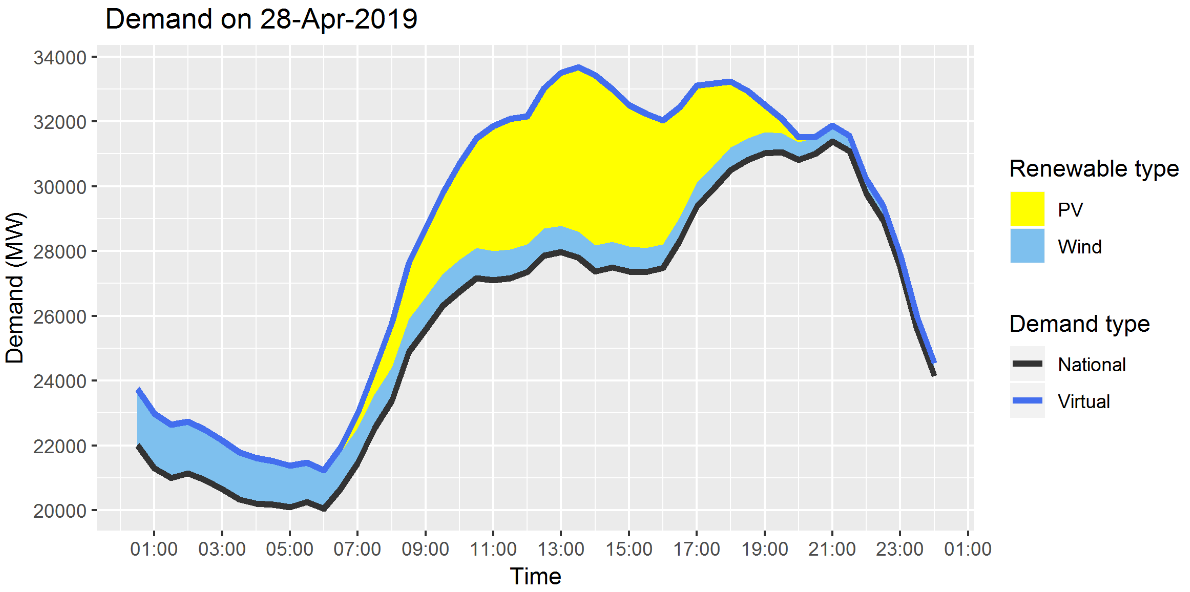
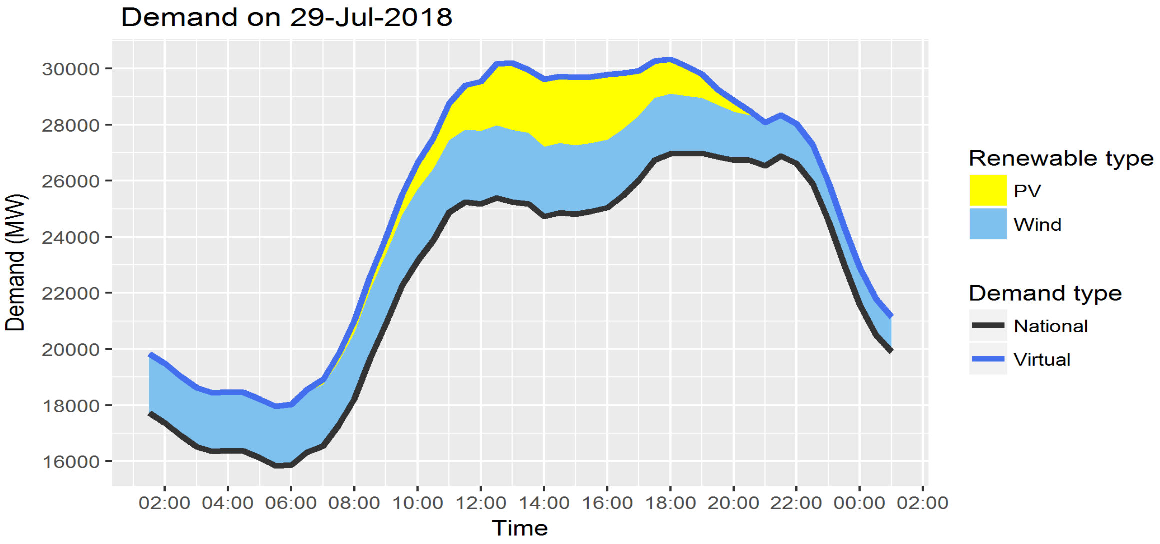
Embedded renewables









Drivers of demand variability

Weather	Time of Year	Day of Week	Time of Day
Bank Holidays & Special Events	School Holidays	Embedded Solar & Wind	Other Embedded Generation
TV pickups	Triad avoidance	COVID	

Drivers of demand variability

Weather

Bank Holidays & Special Events

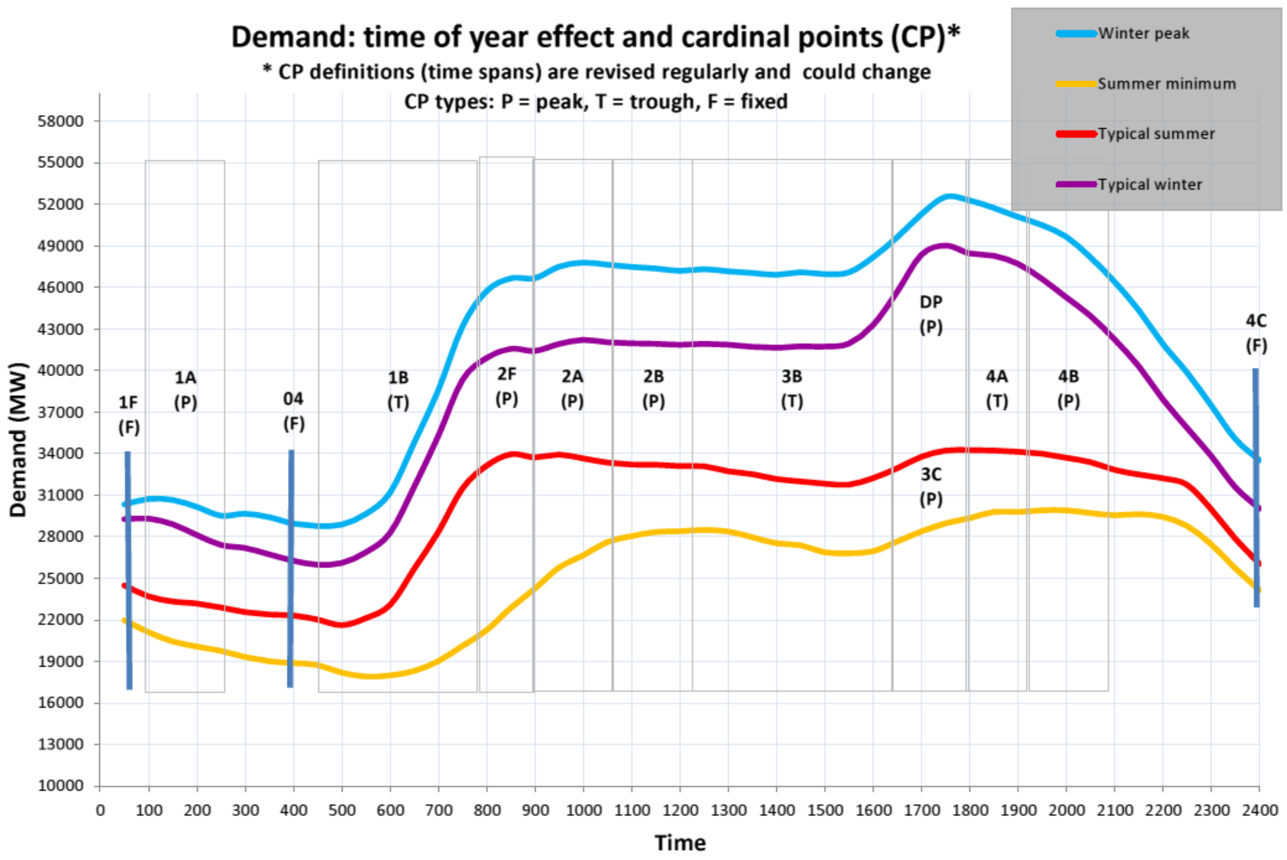
TV picku

Weather variables

- **TO**: Observed temperature in ˚C. Average of last four hours Air Temperature
- **TE**: Effective temperature in ˚C. Average of TO today and TE yesterday. Captures the lag effect of warming and cooling of buildings.
- **EI**: Effective Illumination. Logarithmic transformation of solar flux
- **WS**: Wind Speed. Measured in knots. Average wind speed over previous 10 minutes
- **CP:** a component that responds to how cold people feel in the wind

Modelling approach

- Demand is forecast at Cardinal Points: points on the demand curve that carry significant meaning, typically turning points or inflection points on the curve.
- Demands for half hour settlement periods in between Cardinal Points are interpolated using a well-chosen historical curve
- Demand forecasting models have been using a technique called generalized additive models



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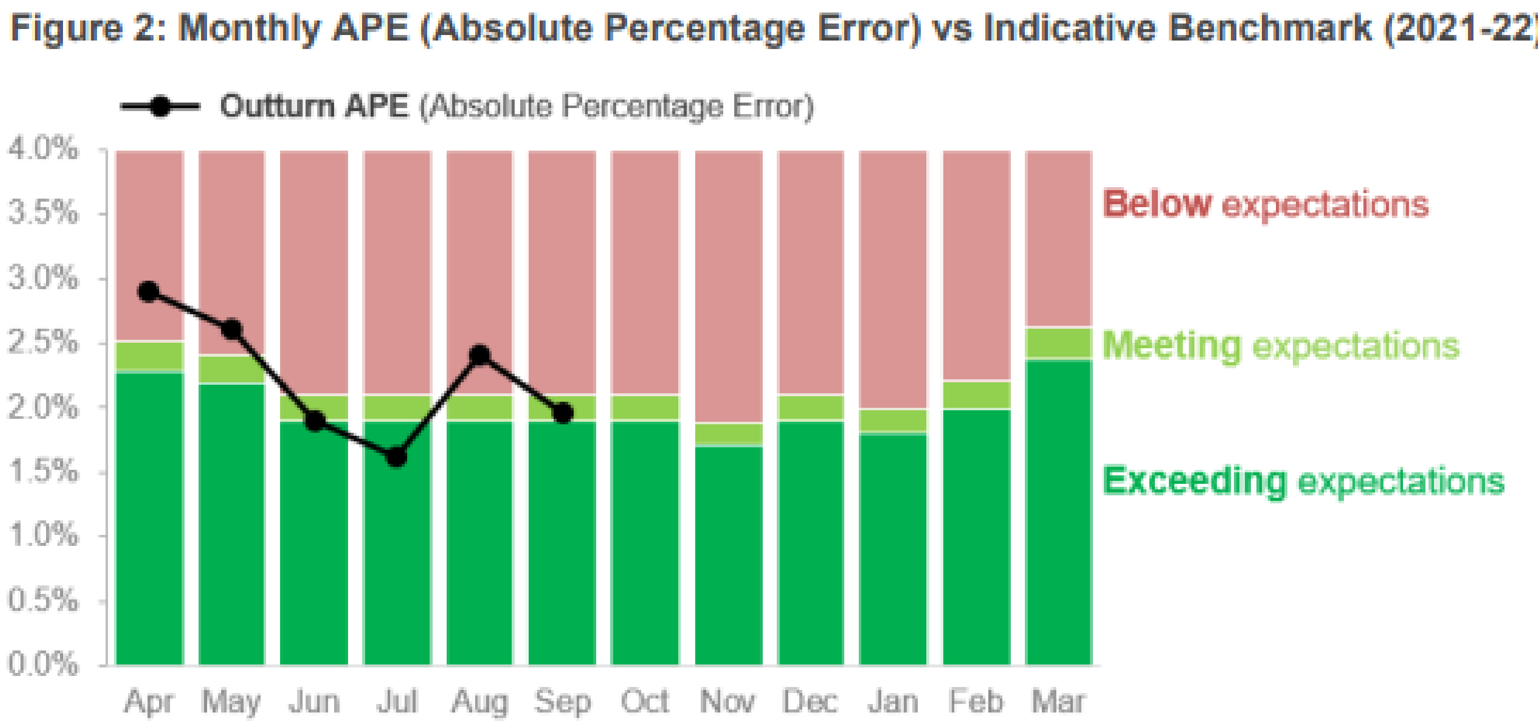
Demand forecast performance

Day-ahead forecast error approximately 2%



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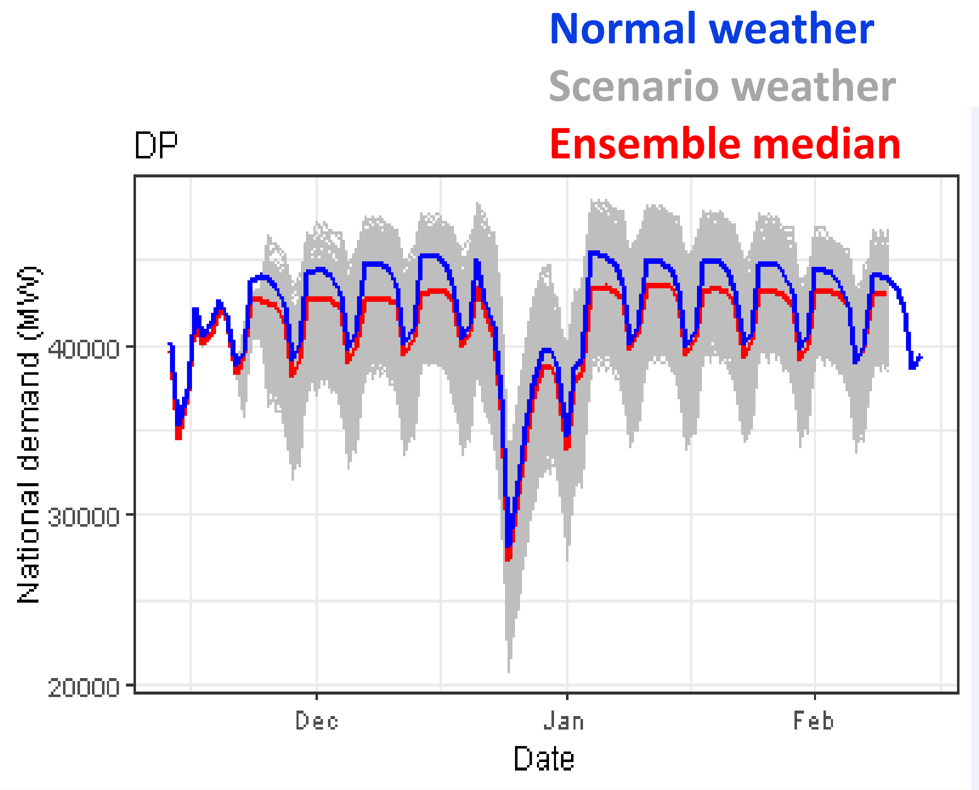
Long-term forecasts

For long-term forecasts (beyond 14 days) we forecast using scenarios generated from historic weather data (MERRA2 reanalysis).

Example of winter forecast.

- Hourly weather variables
- Coherent time series
- Generate ~1000's scenarios
- Range of possible demands
- Combined with:
  - Coherent wind power forecast
  - Modelled time series of available generation



Challenges

WIND

- Increased wind capacity: Errors scale with capacity? Largest errors 4 GW → 8 GW
- Clusters of large offshore farms: Errors in regional forecasts?

SOLAR PV

- Increased solar PV capacity: Large errors typically linked to weather forecast (cloud cover, radiation)
- Embedded: No metering – working with an estimate of outturn.

DEMAND

- Increased embedded generation: Small generation (wind, PV, batteries)
- Changes in demand patterns (Electric vehicles, heating)
- Price signal demand side response

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