Security of supply challenges for a weather dependent GB electricity system

Risk and Resilience Day, March 13th 2025

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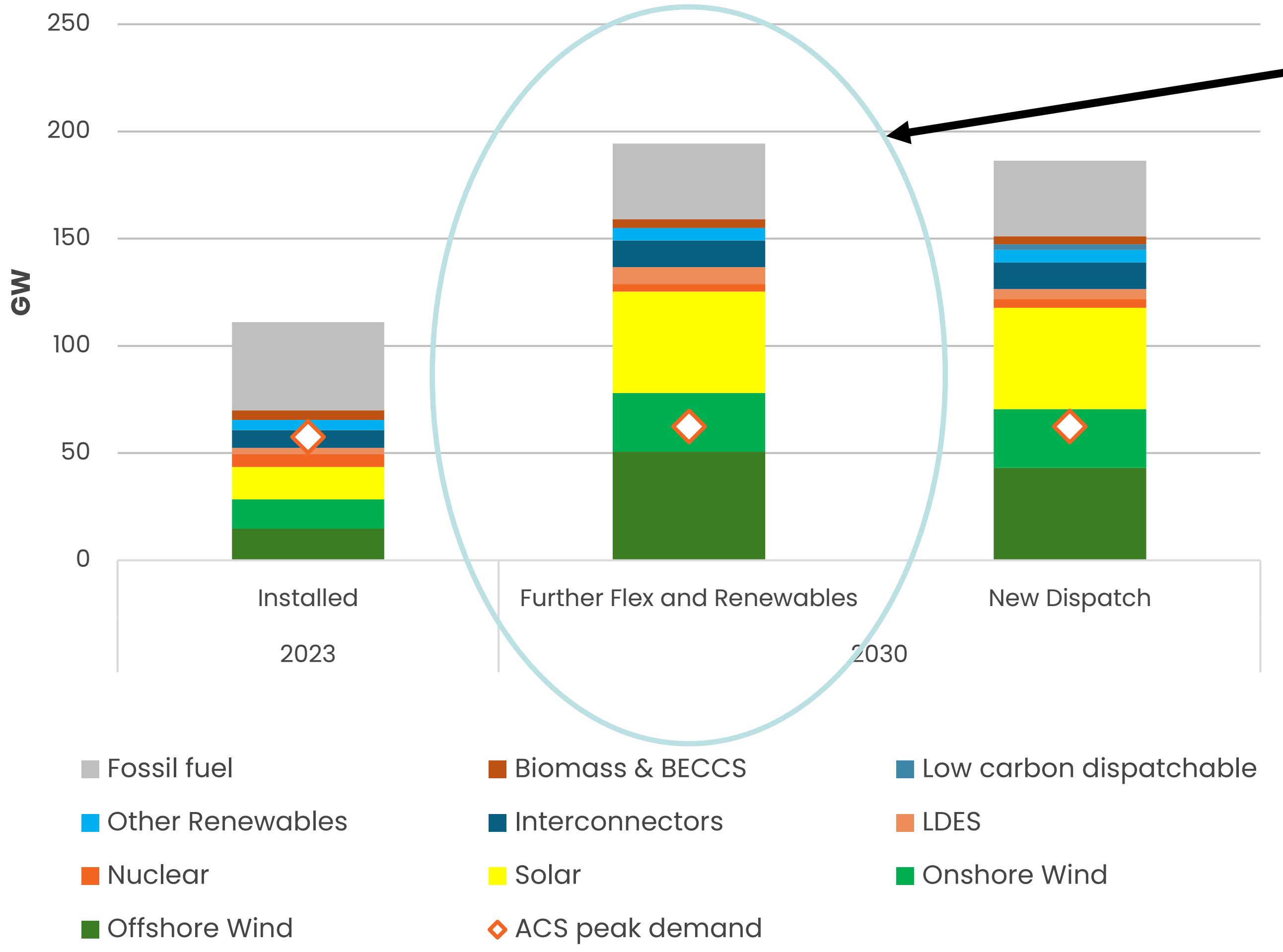
Clean Power by 2030 – What will it take?



Modelled in ‘SEEMM’

Installed generation capacity ↑~75%

Driven by new build renewables

- 3x ↑ offshore wind
- 2x ↑ onshore wind
- 3x ↑ solar

Clean Power by 2030 is a paradigm shift to a renewables dominated electricity system

It’s also the 1st step on the way to a fully decarbonised energy system by 2050.

Source: NESO: Clean Power 2030 workbook https://www.neso.energy/publications/clean-power-2030

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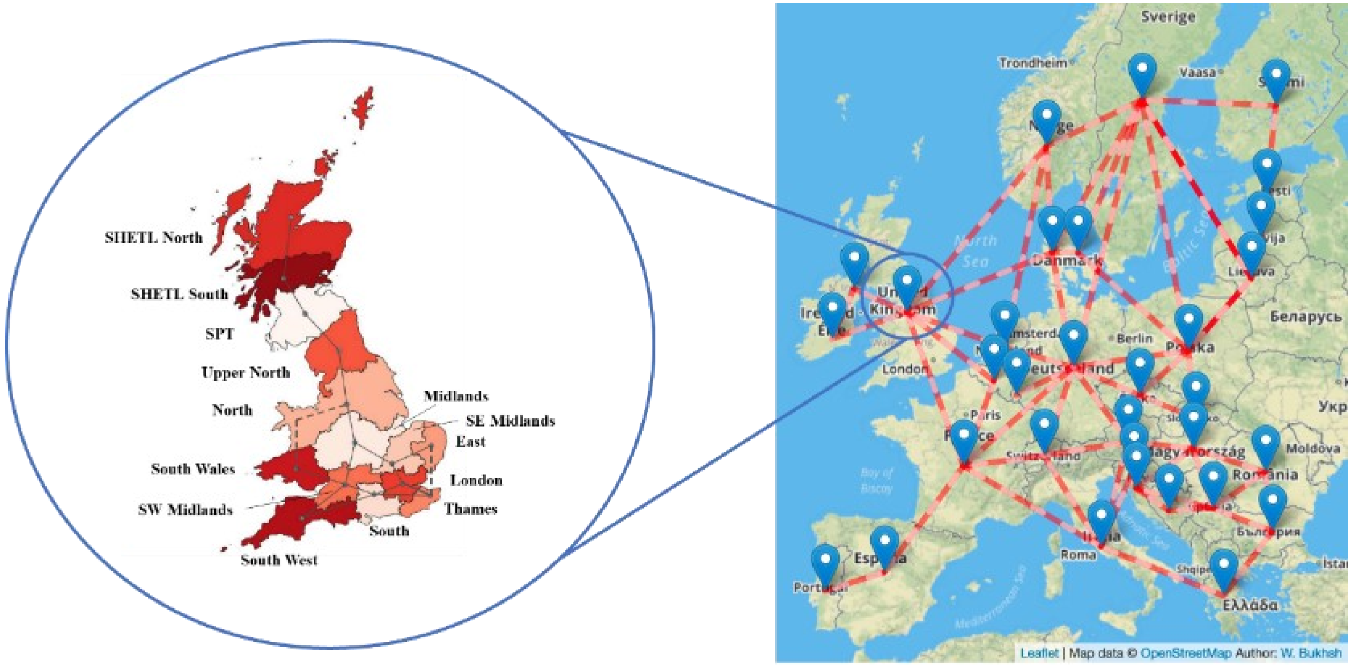
SEEMM – Strathclyde European Electricity Market Model

- Models generation and demand backgrounds across Europe and solves for lowest cost system dispatch for each hour of year
- GB disaggregated into 14 zones representing main transmission boundaries
- Requires spatially disaggregated wind, solar and demand profiles – important to examine different weather years
- Can examine future pathways for adequacy, emissions, curtailment, system cost, imports/exports etc



Useful tool for assessing the challenge facing the new government and sense checking their ambitions for ‘clean power’ by 2030!

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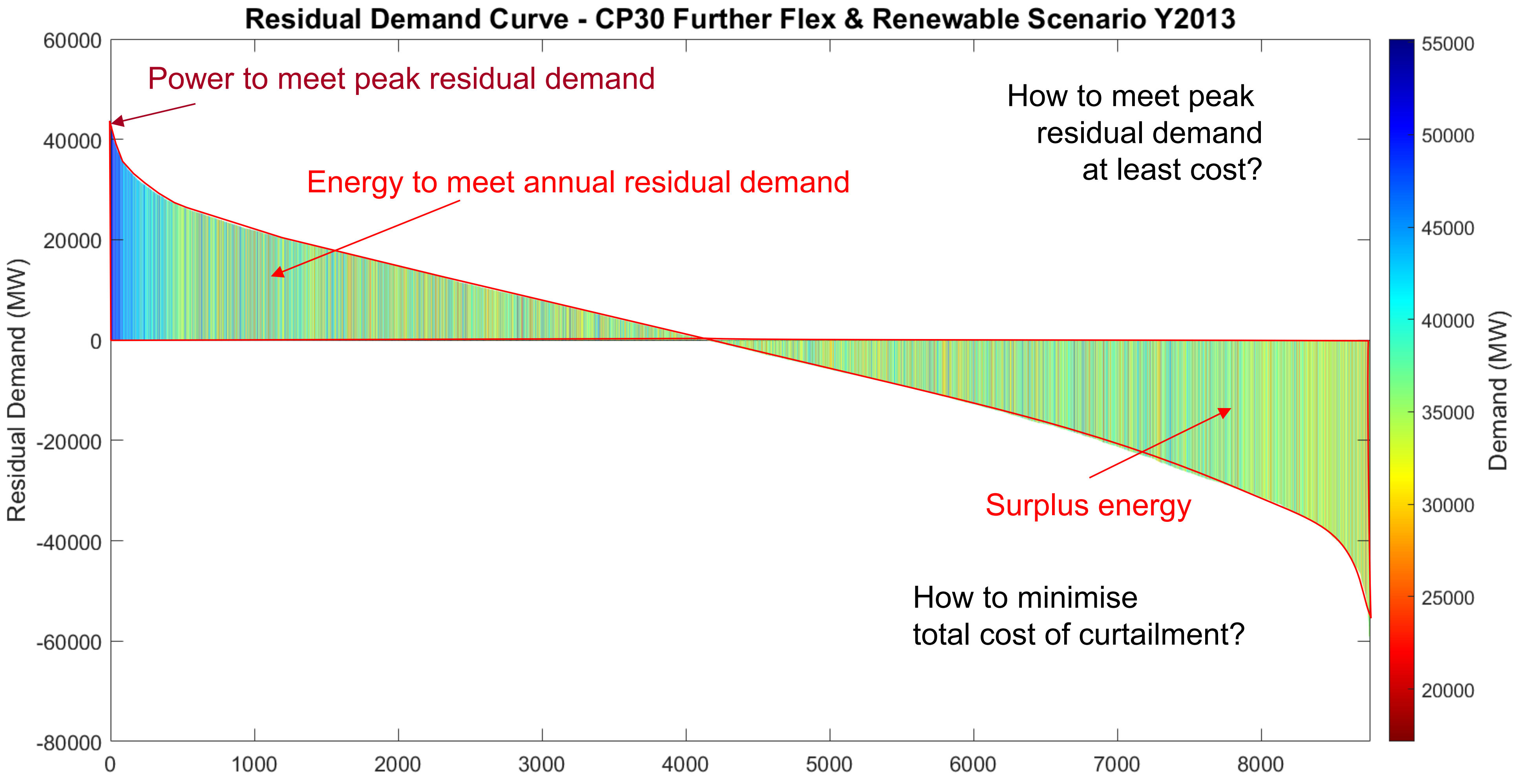
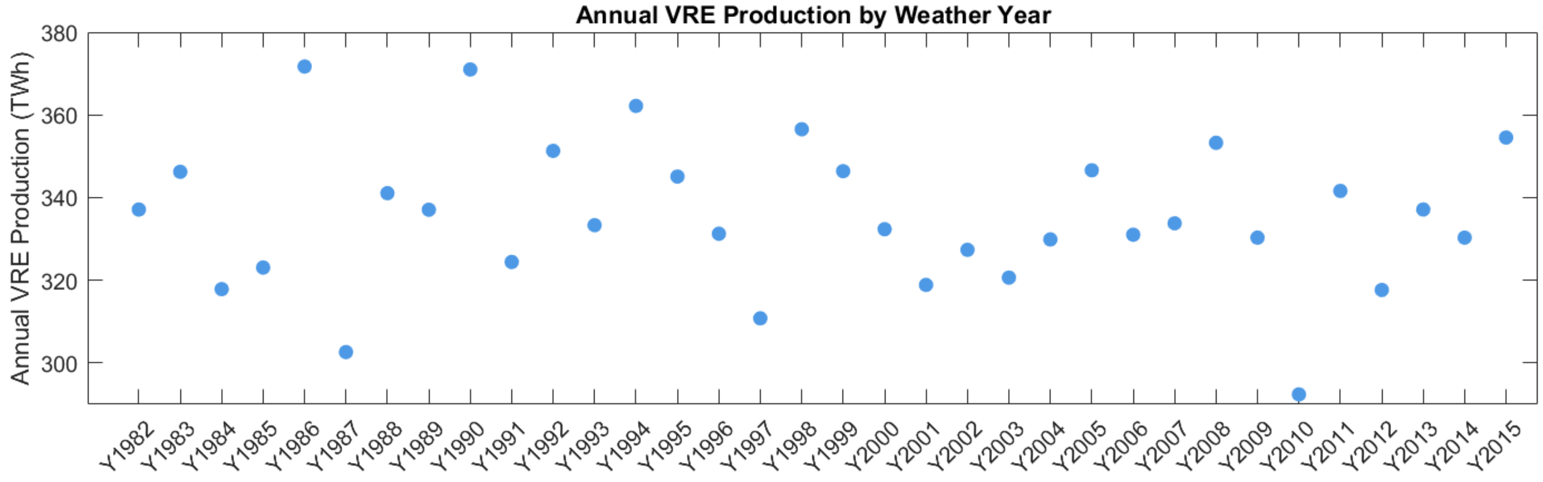
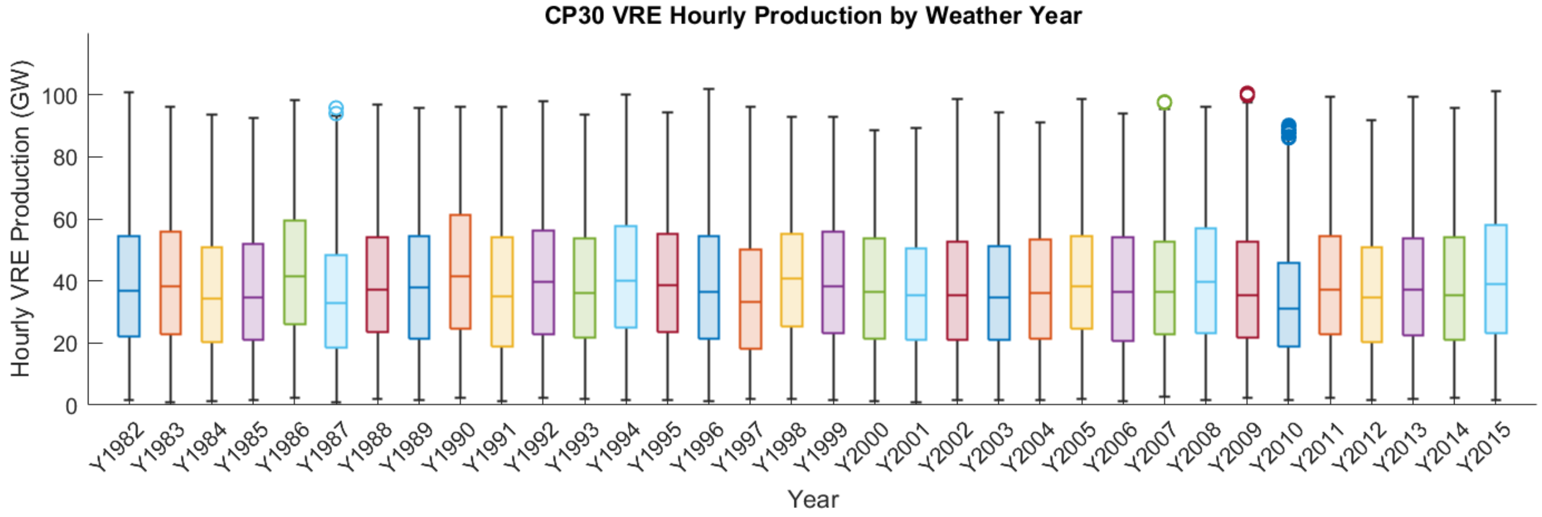
New paradigm: System no longer demand driven – ‘residual demand’ key metric



- In each hour residual demand = demand – (wind + solar)
- Does not include electrolysis demand

What is the impact of weather variability?

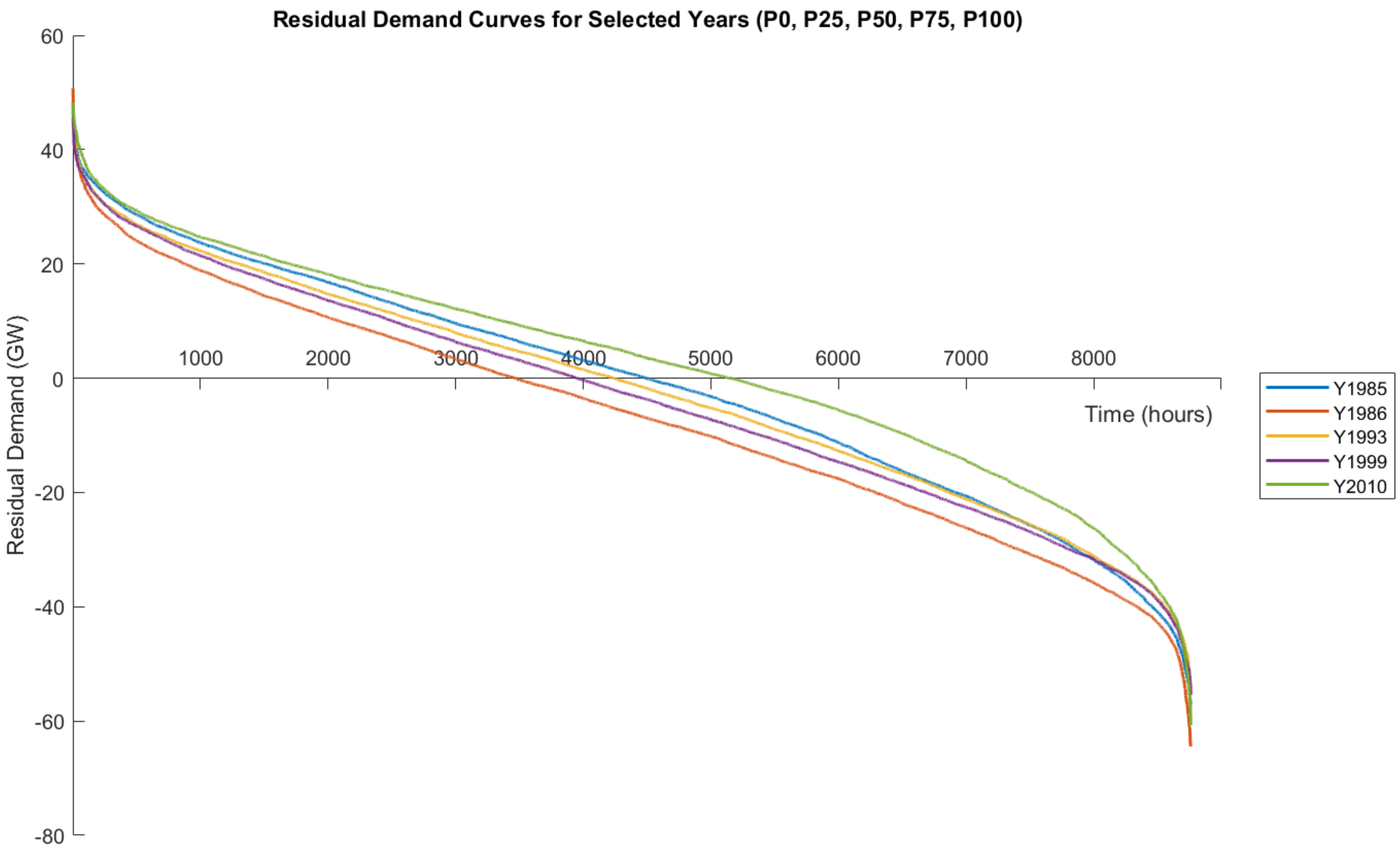




- Variable renewable energy output in GB modelled based on CP30 FFR scenario for 34 weather years (1982-2015)
- Builds on historical re-analysis data for wind and solar availability and heating demand by H. Bloomfield [1]
- Augmented with own view on EV and electrified heating profiles and with capacity factors matched to NESO
- Headlines:
  - Total VRE output on average similar to annual demand
  - But ~80 TWh variation in annual output
  - Large variation hour by hour between ~1 GW and ~100 GW

[1] H. Bloomfield, D. Brayshaw, and A. Charlton-Perez, “Era5 derived time series of european country-aggregate electricity demand, wind power generation and solar power generation,” https://doi.org/10.17864/1947.272, 2021

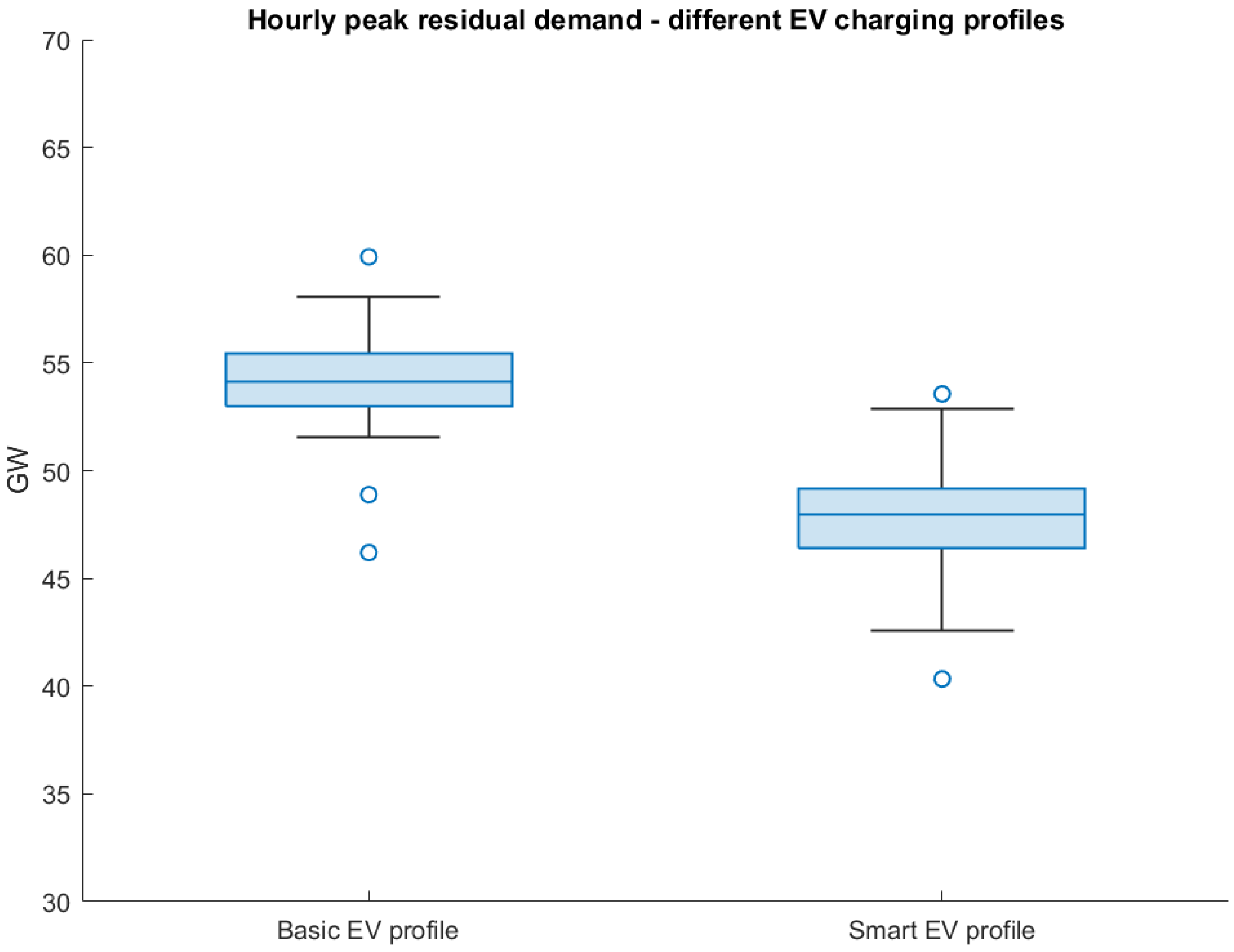
Impact of weather on residual demand?



- Taking P0, P25 … P100 VRE weather years shows significant variation in the resulting residual demand curves
- System operator must be able to plan for multiple outturn scenarios, not just a central case

How does this translate at different timescales?

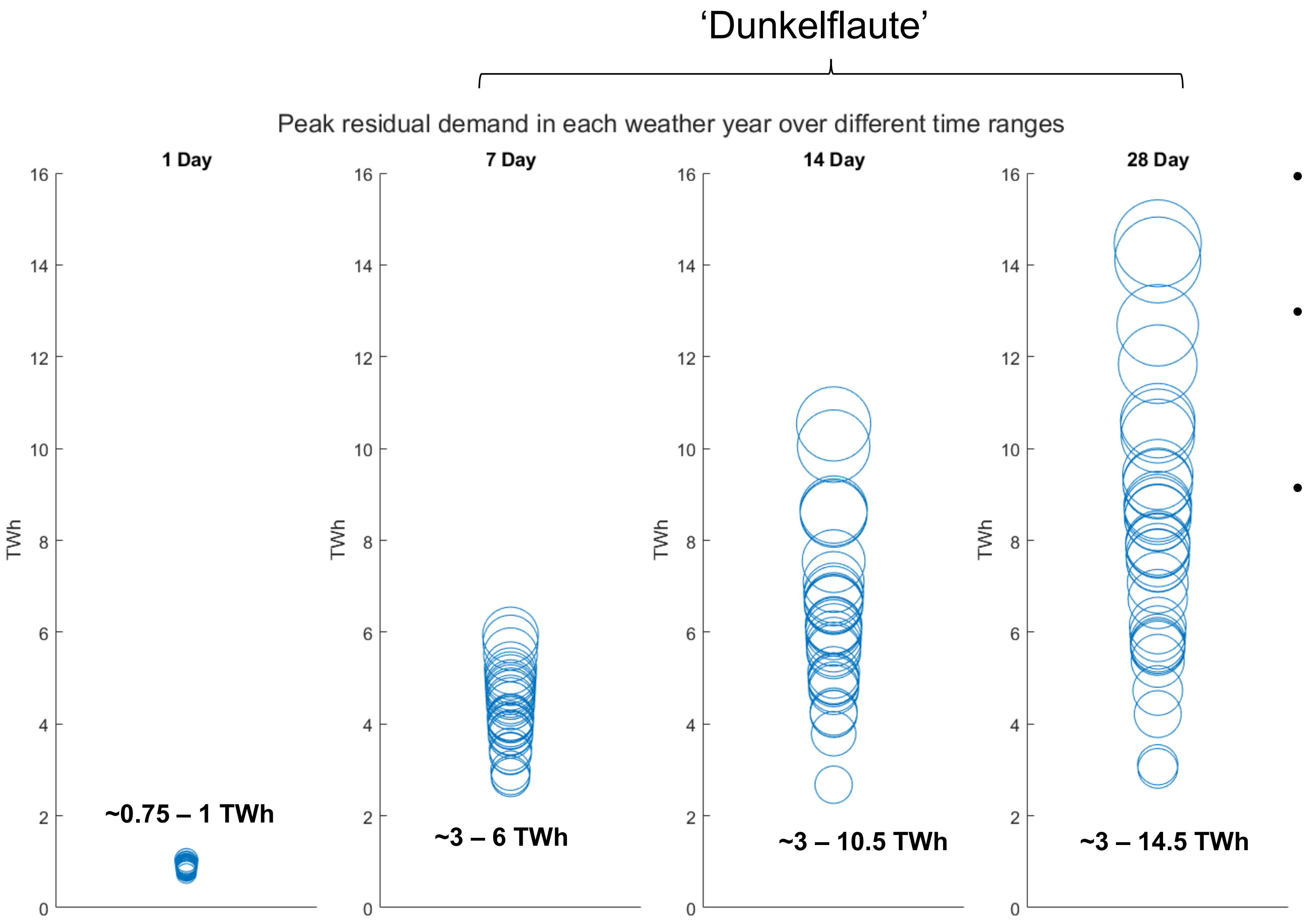
Peak hourly residual demand



- Critical for informing system dispatchable capacity needs
- ~15GW variation in peak hourly residual demand
- Overlap between low VRE periods and high demand periods varies significantly year on year
- Covering for a 'normal' year not enough

- Demand assumptions also key
- basic fleet EV charging profile adds
- If 'smart' charging shifts demand off-peak, reduces the dispatchable capacity requirements significantly

Residual demand at different timescales



- Large variation in 'worst case' energy requirements over longer timescales year on year
- Uncertainty over extent to which demand destruction would reduce burden in extreme periods
- High prices may lead to turn down of some industrial demand (total industrial demand ~7.5 TWh / month in 2030)

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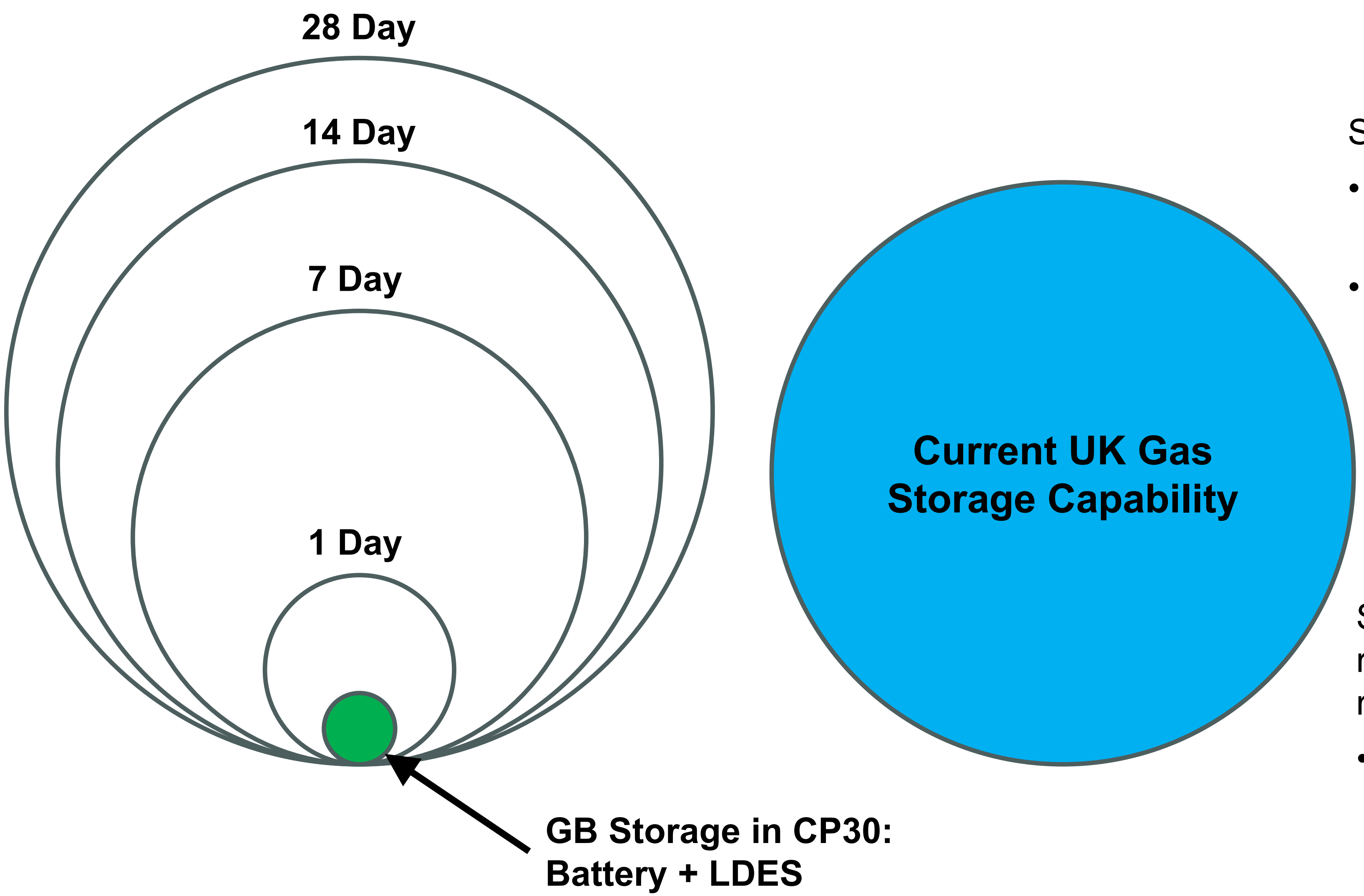
Energy requirements to ‘meet the peak’



Short term storage:

- Great for near term flexibility
- Won’t solve long term energy deficits

Seasonal scale storage or readily accessible fuel sources required:

- Key role for Gas + CCS or Hydrogen power in future

Modelling of NESO’s CP30 FFR scenario by Magnus Jamieson with Callum MacIver and Shanay Skellern at University of Strathclyde using the Strathclyde European Electricity Market Model (SEEMM)

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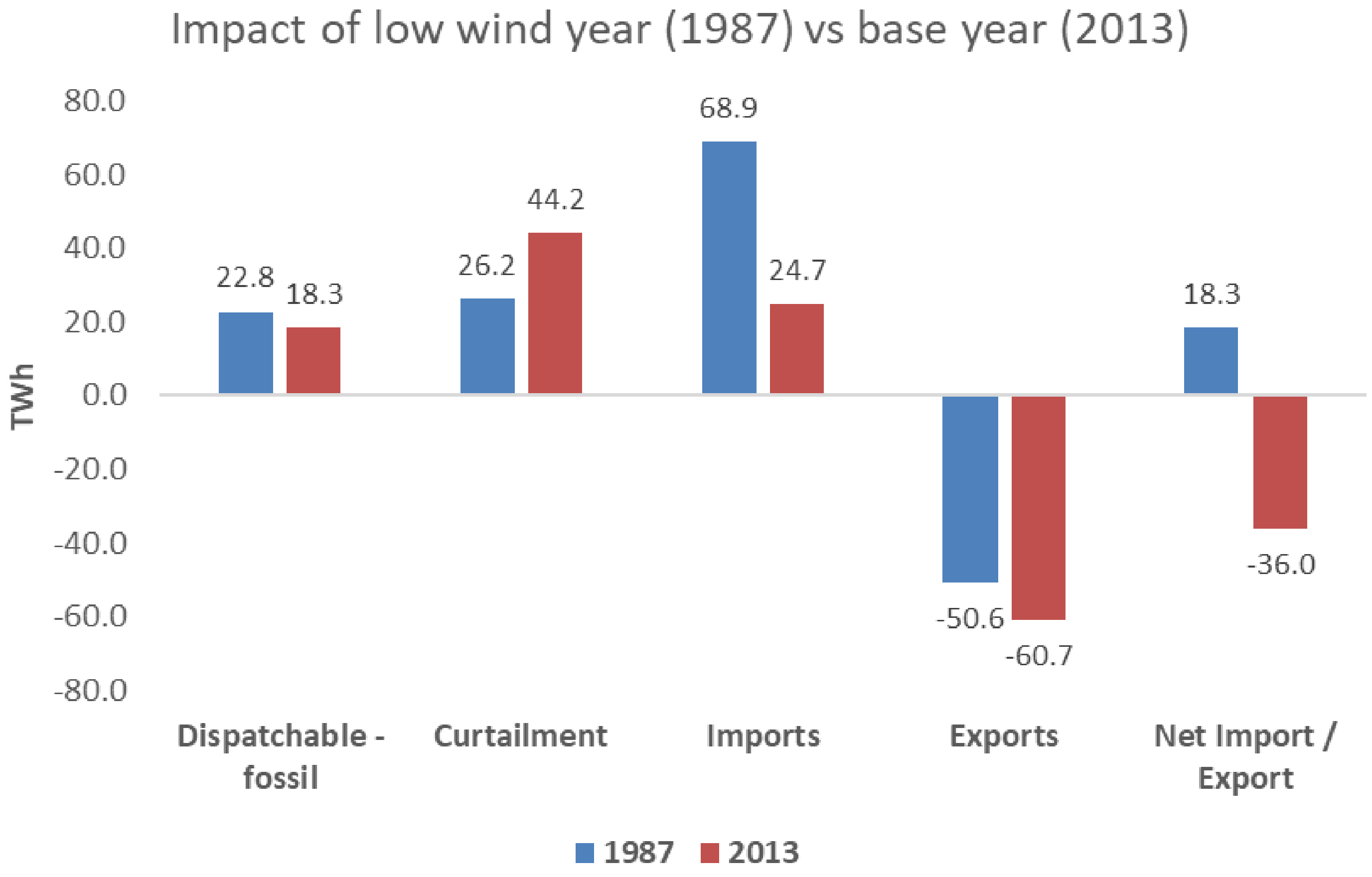
System Impact – low renewables year



- 25% increase in dispatchable gas burn
- Total emissions up 10%
- Curtailment down
- Imports up significantly (how clean?)
- Exports down
- GB net importer compared with large net exporter
- Large impact from interconnectors, driven by market prices and comparative renewables availability in rest of Europe.
- Recent history shows risks associated with reliance on imports.

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Conclusions

- Future GB electricity system to be dominated by weather dependent renewables
- Annual variability in renewable output can be large (> ±10% swings around the mean)
- Residual demand is key future metric
- Hourly peak determines requirement for instantaneous capacity
  - capacity market targets must account for more than a typical year or risk being undersupplied
- 7, 14, 28-day residual energy deficits indicate scale of required storage or readily accessible fuel sources
  - Role for clean 'dispatchable' power sources like Gas CCS or Hydrogen for Power to replace continuing reliance on unabated gas.
- Annual weather variations lead to significant changes in modelled system behaviour
  - Impact on level of fossil fuel generation
  - Impact on system prices and therefore interconnector flows
  - Territorial emissions at mercy of weather and economics of wider system
- <u>Key point: single year analysis not adequate to understand system challenges</u>