The role of LDES in the UK Energy system

Model soft-linking to assess CP2030 and Net-Zero GHG by 2050 (initial results)

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LDES & Policy Context

- Strict GHG emissions reduction recommended by CCC CB7
  - 87% reduction by 2040 + NDC update to 81% reduction 2035
- Increasingly signaling that different durations of storage are fundamental
  - 35GW battery storage in 2050 deliver 139 GWh
  - 7GW medium duration in 2050 – excl. H2 caverns deliver 433GWh
  - 5-9 TWh H2 storage by 2050
- Recent shifts in policy structure in part mirror these dynamics
- LDES Cap & Floor (C&F) support for "Long duration"
  - 2.7 - 7.7GW storage by 2035
  - Sets minimum discharge @ 8hrs
  - Phased approach & Groups technology options
- Clean Power 2030 & NESO scenarios
  - 23 - 27 GW BESS
  - 4-6 GW LDES (6hrs-days)

Window 1 outcome for C&F

Technology type of asset	Count of Projects	Sum of Discharge capacity (GW)
Li-ion BESS	48	20.2
Pumped Storage Hydro	5	4.6
Vanadium Flow Battery/Zinc Battery	16	2.6
Vanadium Flow Battery	5	0.9
LAES & BESS Hybrid	2	0.4
Compressed Air Energy Storage	1	0.1
Grand Total	**77**	**28.7**

Research Questions

- What is the role of storage in the UK Energy System in 2050?
- What role do different systems play for CP2030 & NZ targets?
- What does “long duration” storage mean for the UK energy system?

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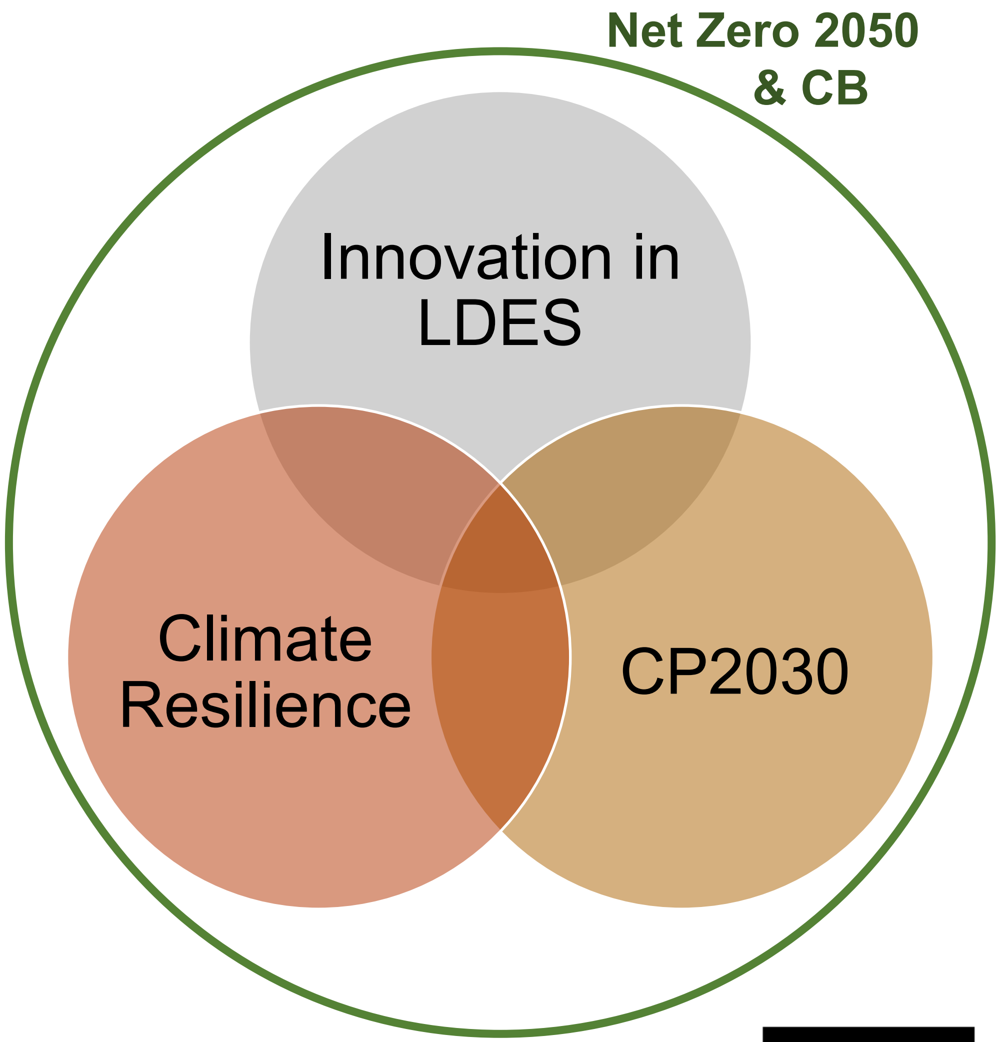
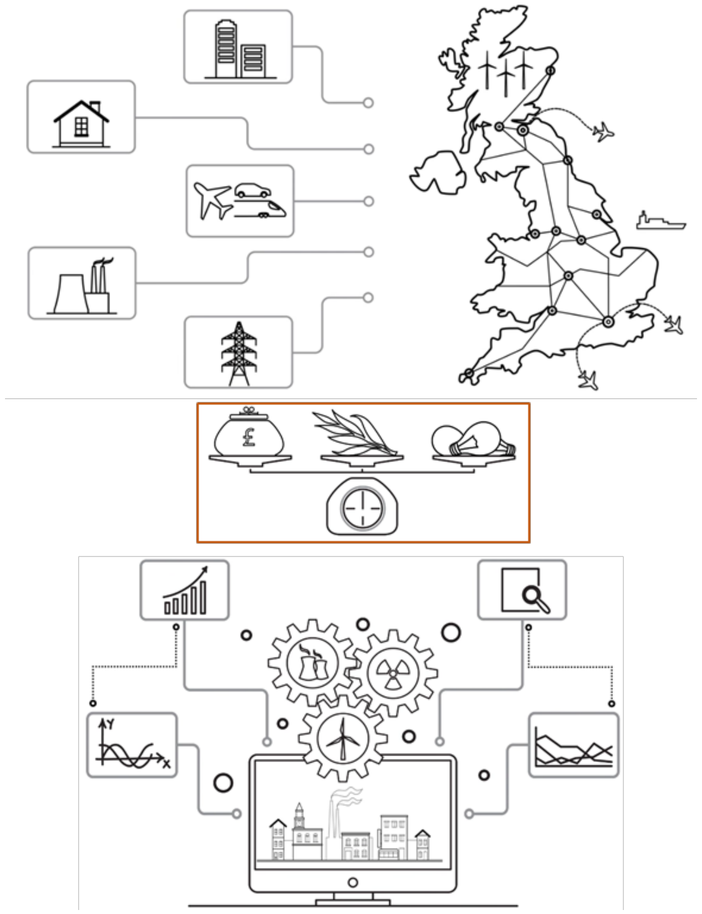
Modelling Framework – Scenario approach

Pillar	Value / range	Description
Innovation	High Low	Contrast availability & cost of storage technology Consider varying rates of uptake / build-rate. Compare role of different storage durations
Climate Resilience	2010 2012	Stress test under varying weather years Shifts in weather condition variability Adjustments to operation and capacity.
CP2030	Enforced Removed	Apply "clean source" of power definitions Minimum clean contributions to GB Target C intensity of 50 gCO2e/kWh by 2050 Constrain electricity import ability



Modelling Framework – UK TIMES

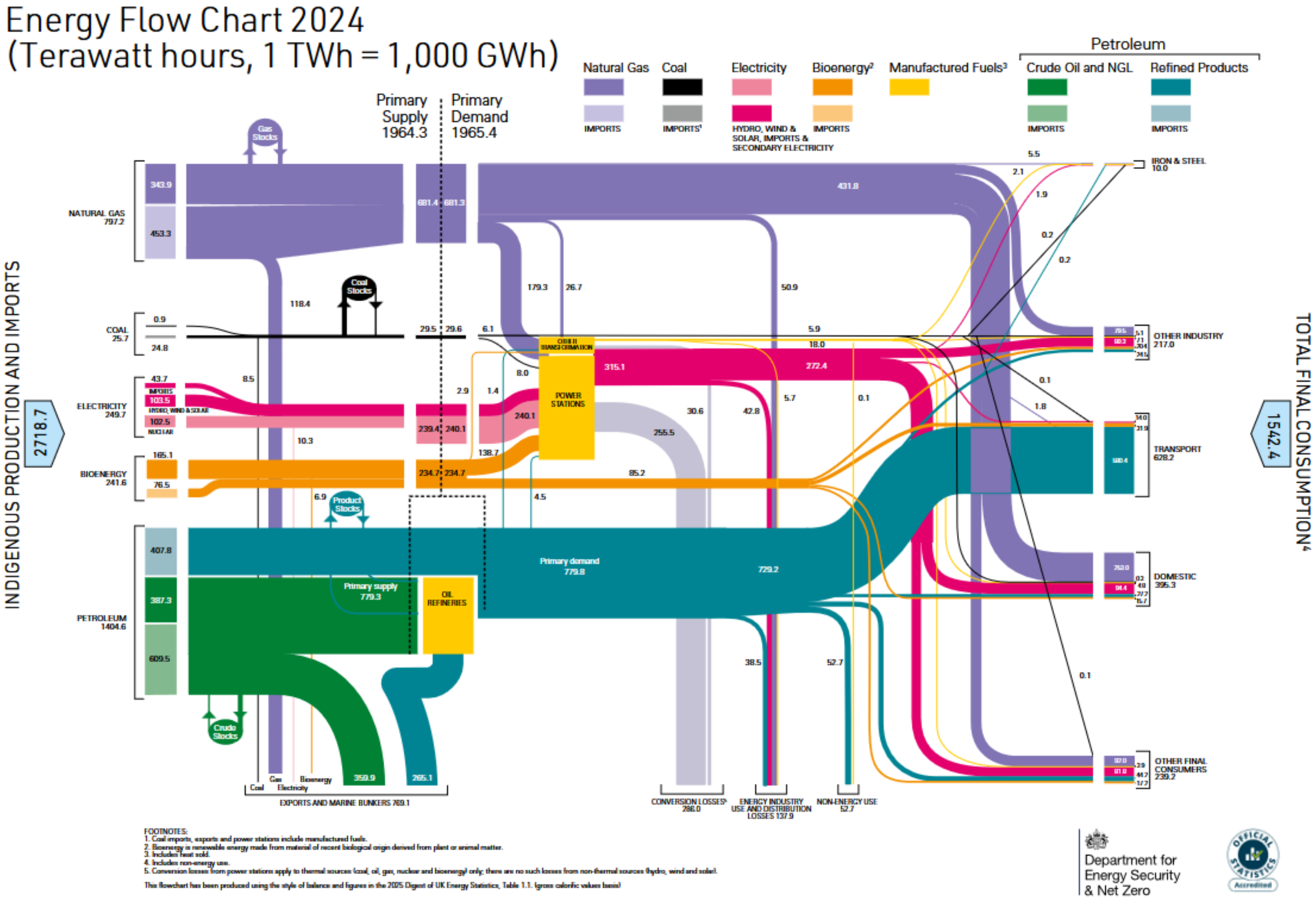


- **Least cost, long-term**, perfect foresight, single region, optimization, **bottom-up**, dynamic, **whole systems**, partial equilibrium, energy
- Technology rich
- Modelling time
  - 2010 base year, 5-year periods to 2050 (and beyond)
  - 16 time-slices – 4 seasons x 4 day-parts (variable: 1, 6, 192)
- End-use sectors
  - Transport, Industry, Services, Agriculture, Residential
  - Energy service demands
- Upstream processing, power and infrastructure
- Primary, intermediate, and final energy carriers
- GHG & Cost accounts consistent across all sectors

✓ Generating scenarios - Insights not numbers

✗ Predictions - Dynamic feedback

Modelling Framework – UK TIMES



Designed to assess **system-wide energy flows**

Builds **technology / commodity chains** connecting supply to **end-use**

Relies on energy statistics

- Calibrated to 2010 with updates to 2020.
- Digest of UK Energy Statistics (DUKES)
- … but also
    - Energy consumption in the UK (some demands)
    - English Housing Survey, National Travel Survey
    - National Household Model
    - National Grid and Exelon – high-resolution electricity and gas data
    - National Atmospheric Emissions Inventory (NAEI) – greenhouse gas emissions
    - …

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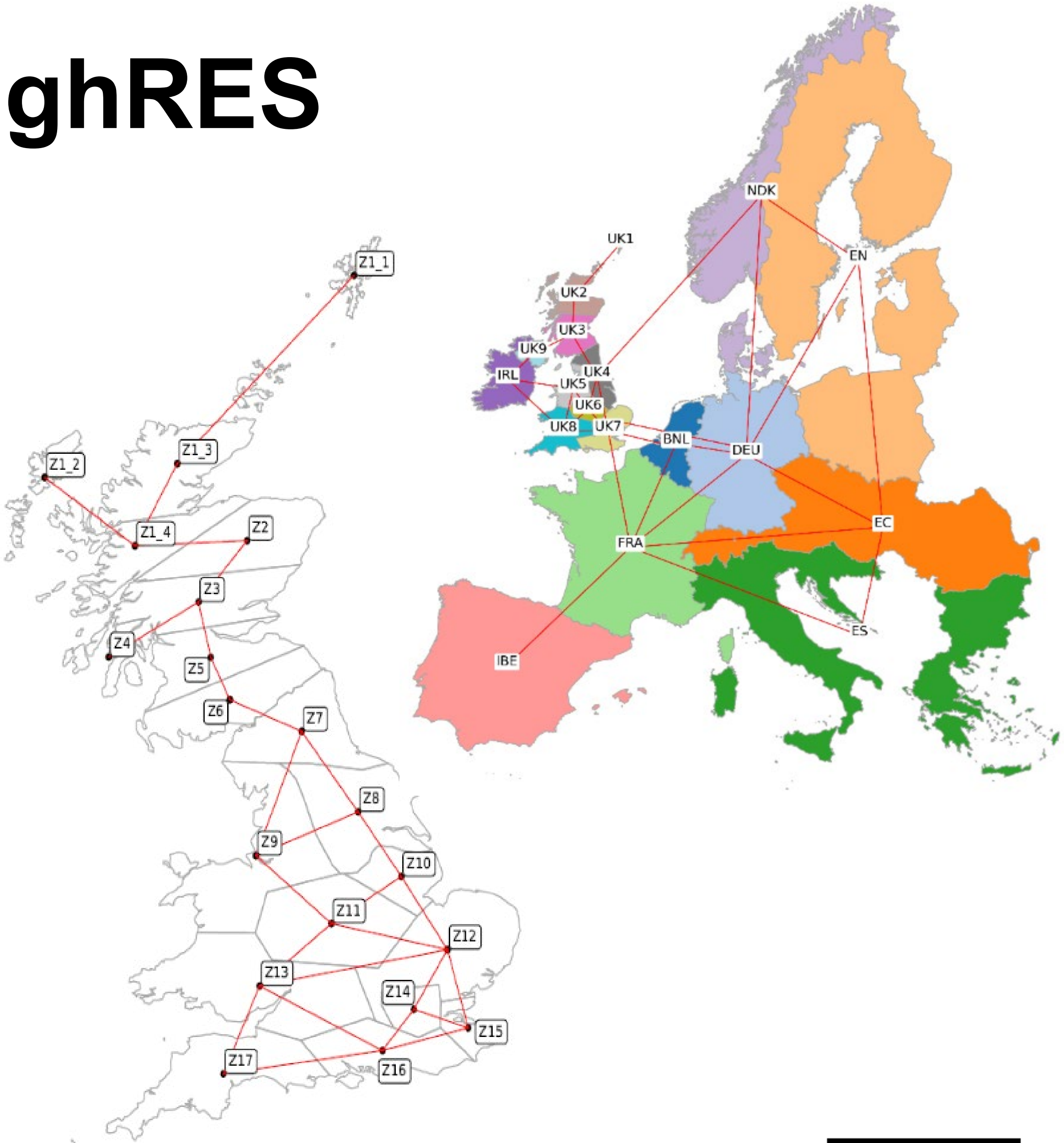
Modelling Framework – highRES

high spatial and temporal **r**esolution **e**lectricity **s**ystem model

- Single snapshot year at **full hourly resolution** (8760).
- Exists as GB, UK in Europe, or Europe
- Least cost – Simultaneous **capacity planning & operational decisions**
- Supply & demand balanced hourly under consistent weather conditions
- Trades-off different flexibility options:
  - A range of storage options
  - Interconnector and transmission reinforcement
  - Low carbon dispatchable power (nuclear, BECCS, NGCCS)
- Represents system reserves and inertia requirements
- Open-source code and data



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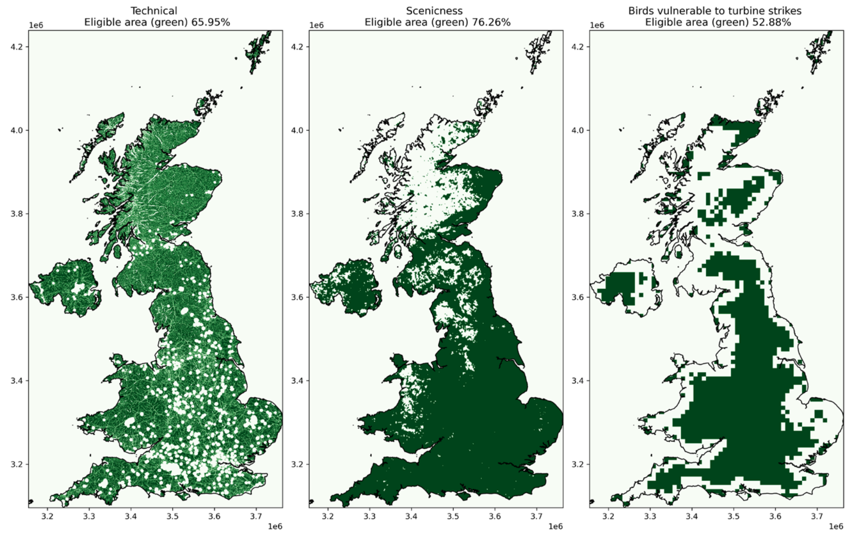
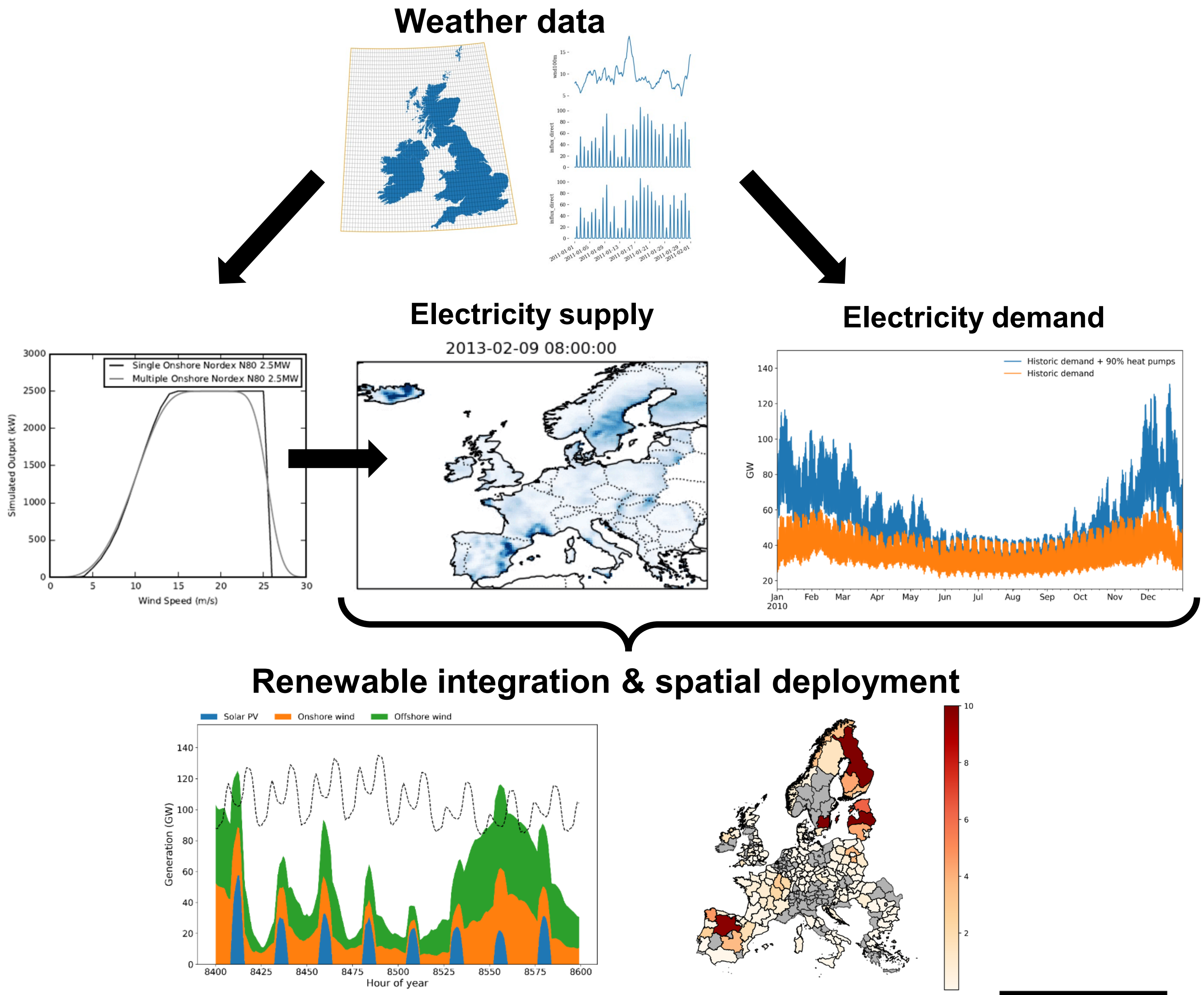
highRES

- Internally consistent weather data included in balancing supply / demand
- VRE siting – using GIS datasets to exclude areas they either cannot or probably won't be placed.





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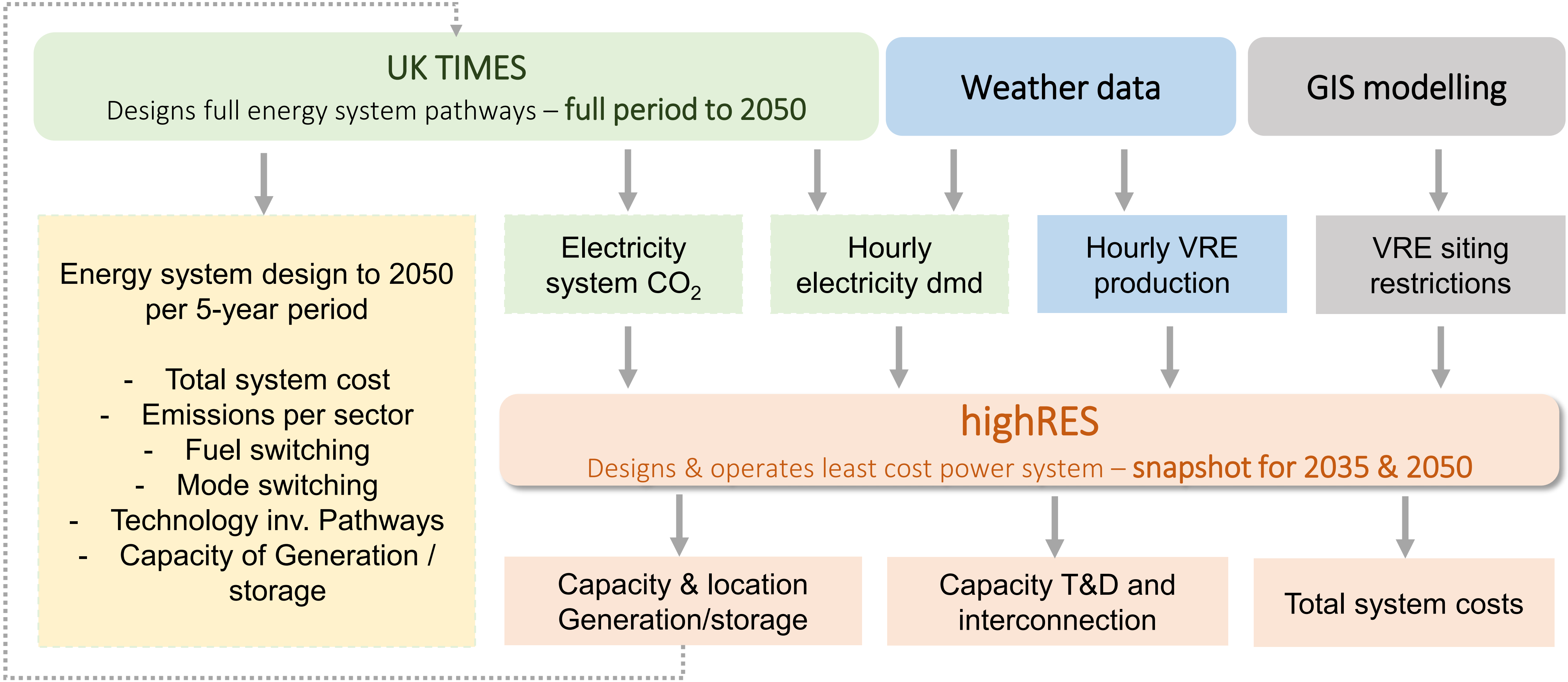
Modelling framework - highRES & UK TIMES



Scenario implementation

Pillar	Value	Both models	Additional constraints: UK TIMES	Additional constraints: highRES
Innovation	High	• CAPEX & OPEX 4h, 8h, 24h storage • Focus on Li-ion & CAES		
	Low		• Advanced battery storage options switched off • Deployment limits for 8h, 24h storage based on NESO FES	
Climate Resilience	High		n.a. will be run on iteration	2010 weather year (T°C, wind s, solar r)
	Low			2012 weather year (T°C, wind s, solar r)
CP2030	Enforced	• Past FID* capacity included • 95% electricity from CP • Net imports ≤ 0	• NESO expected investments in VRE included	2035 • past FID capacity • maximum gCO2/kW 2050 • maximum gCO2/kWh • 2035 VRE and transmission capacities • Free trade
	Removed	Past FID* capacity included		

**includes nuclear Hinkley C & Sizewell B*

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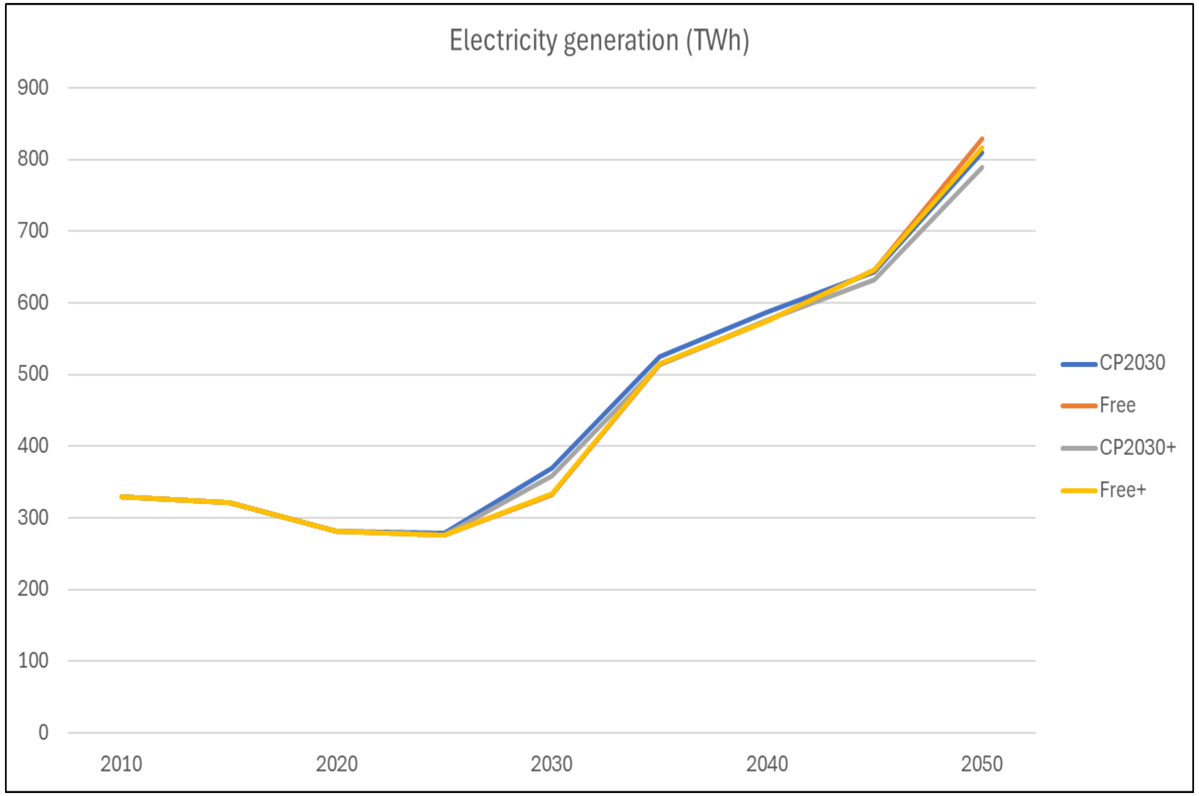
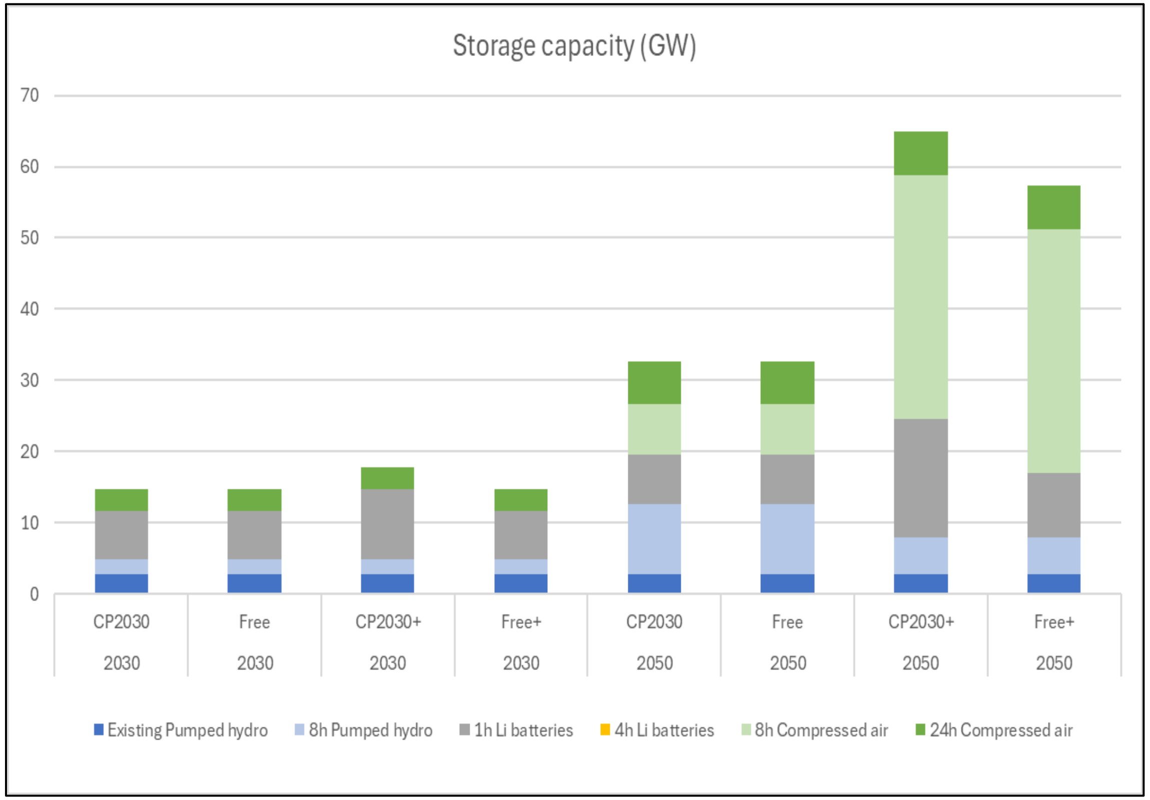
Scenario implementation

- 4 core scenarios run in UK TIMES
- 8 combinations run in highRES, one for each weather year
- 2 modelling iterations developing results in highRES

Scenario #	Name	Innovation	CP2030	Weather years
1	CP2030	LOW	YES	BOTH
2	Free	LOW	NO	BOTH
3	CP2030+	HIGH	YES	BOTH
4	Free+	HIGH	NO	BOTH

Initial results – UK TIMES – Electricity generation & storage





- Electricity generation increases by factors of 2.8-2.9
- Independent of scenario assumptions

- High innovation boosts increase in 2050 storage capacity with a focus on 8h option
- Consistent but limited role for 24h CAES options
- Consistent role for BESS, particularly in near term.

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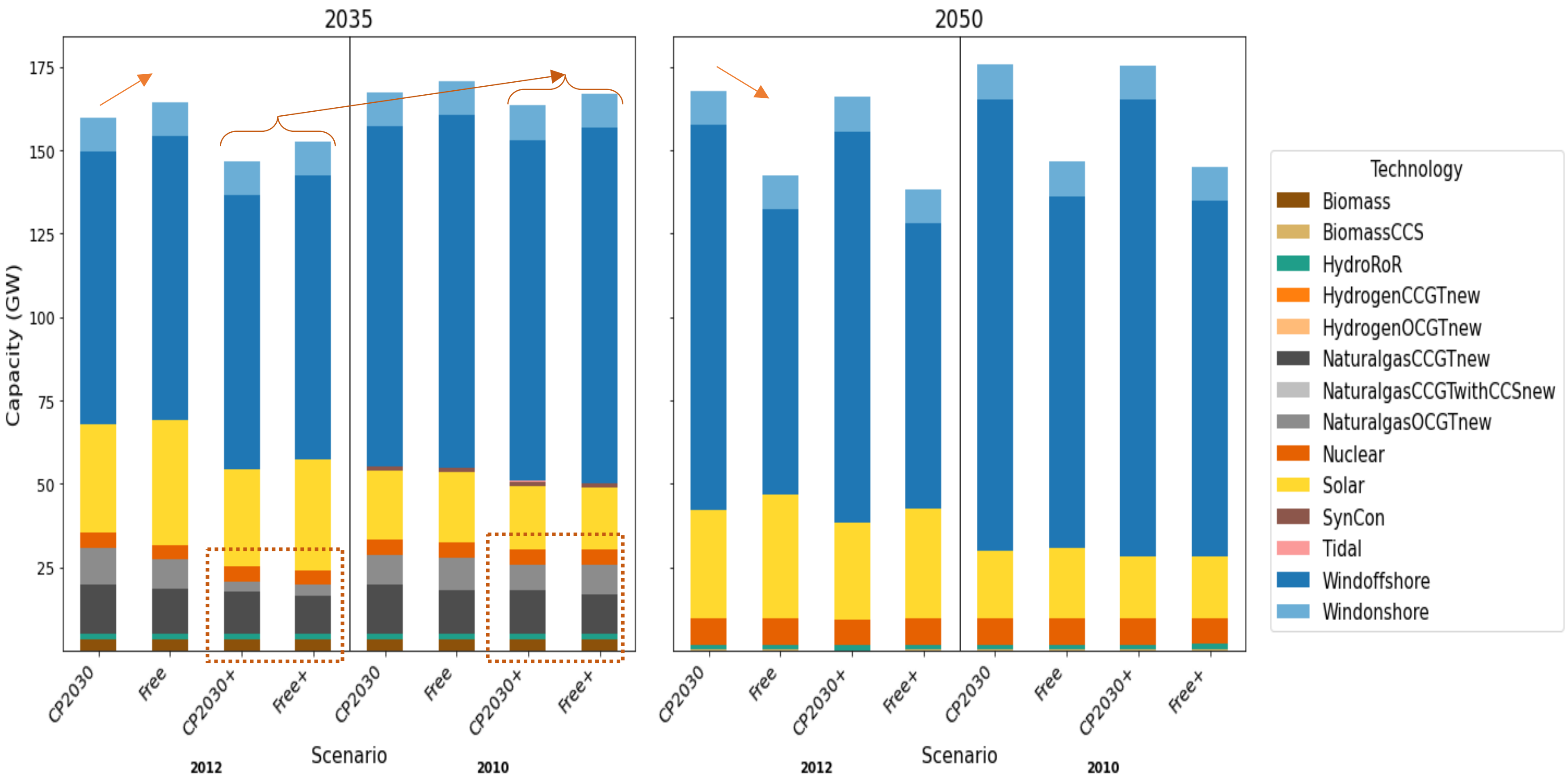
Initial results – highRES – installed generation capacity



Near term to 2035

- Removing CP2030 leads to comparatively higher VRE and lower spinning fossil / lock-in.
- Higher innovation in LDES goes the other way, reducing system size

Long term to 2050

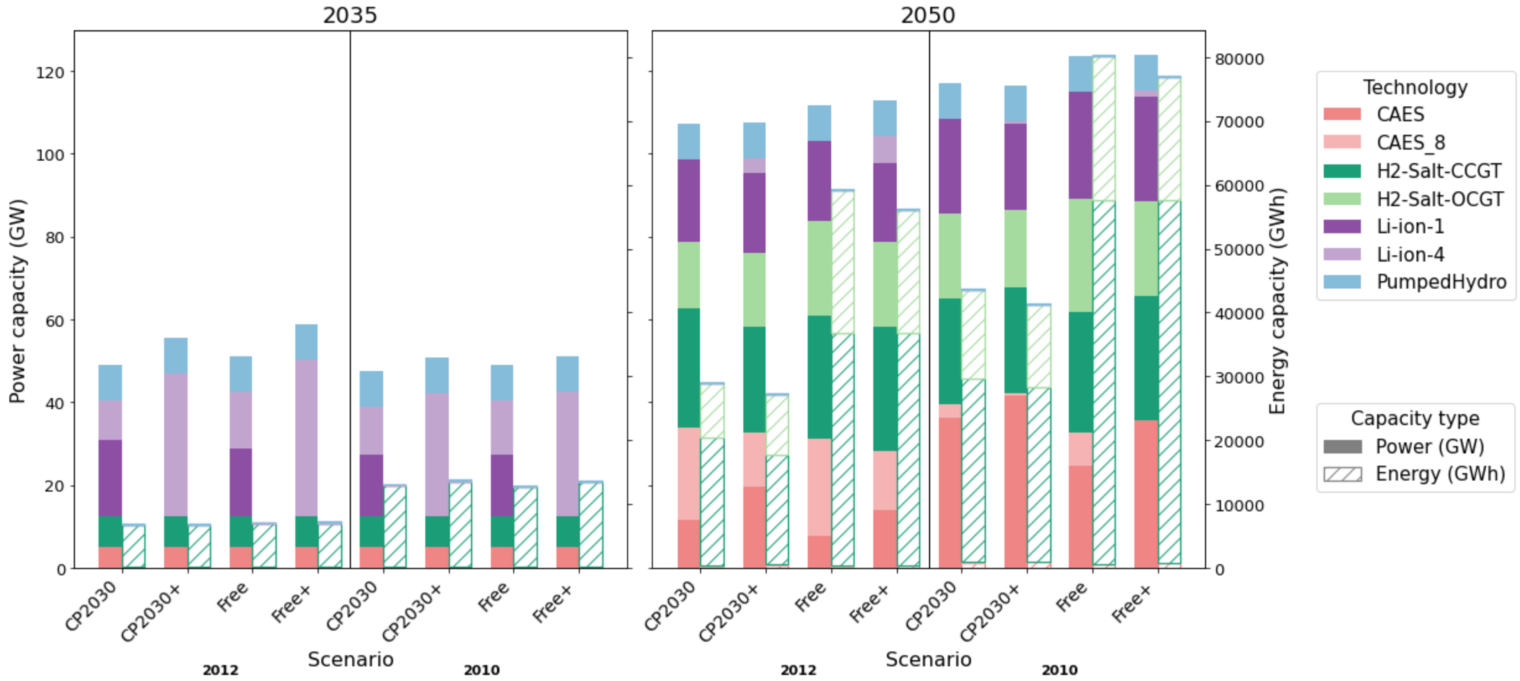
- Allowing the system to import electricity reduces power system size.
- Fossil is completely absent.

Across all scenarios

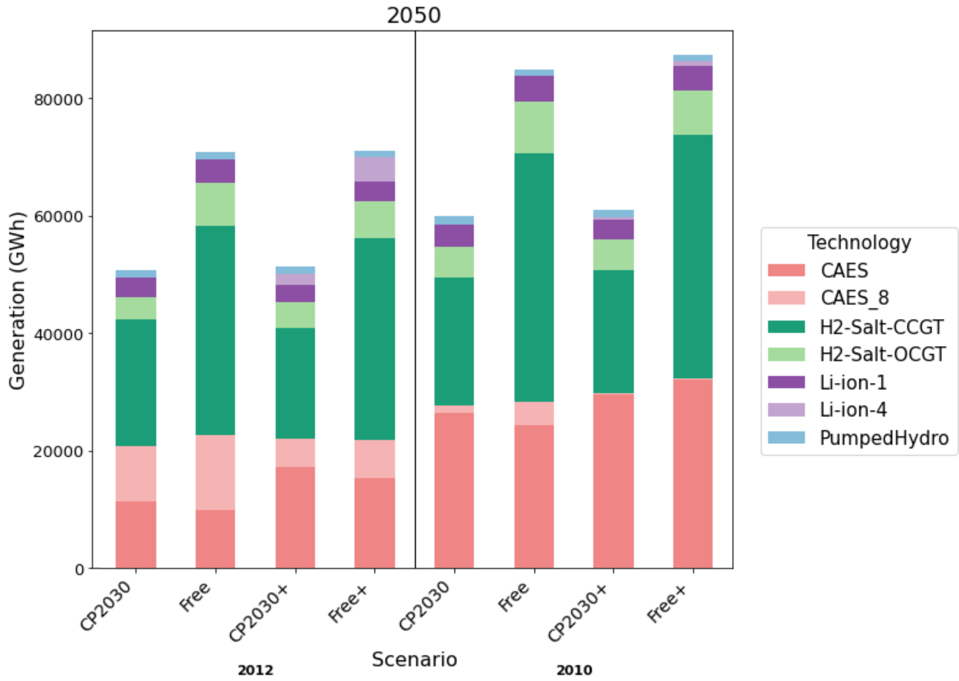
- Poor weather characteristics lead to larger power systems, and near-term higher reliance on gas.

Initial results – highRES – Storage Capacity and Discharge

Power & Energy storage capacity

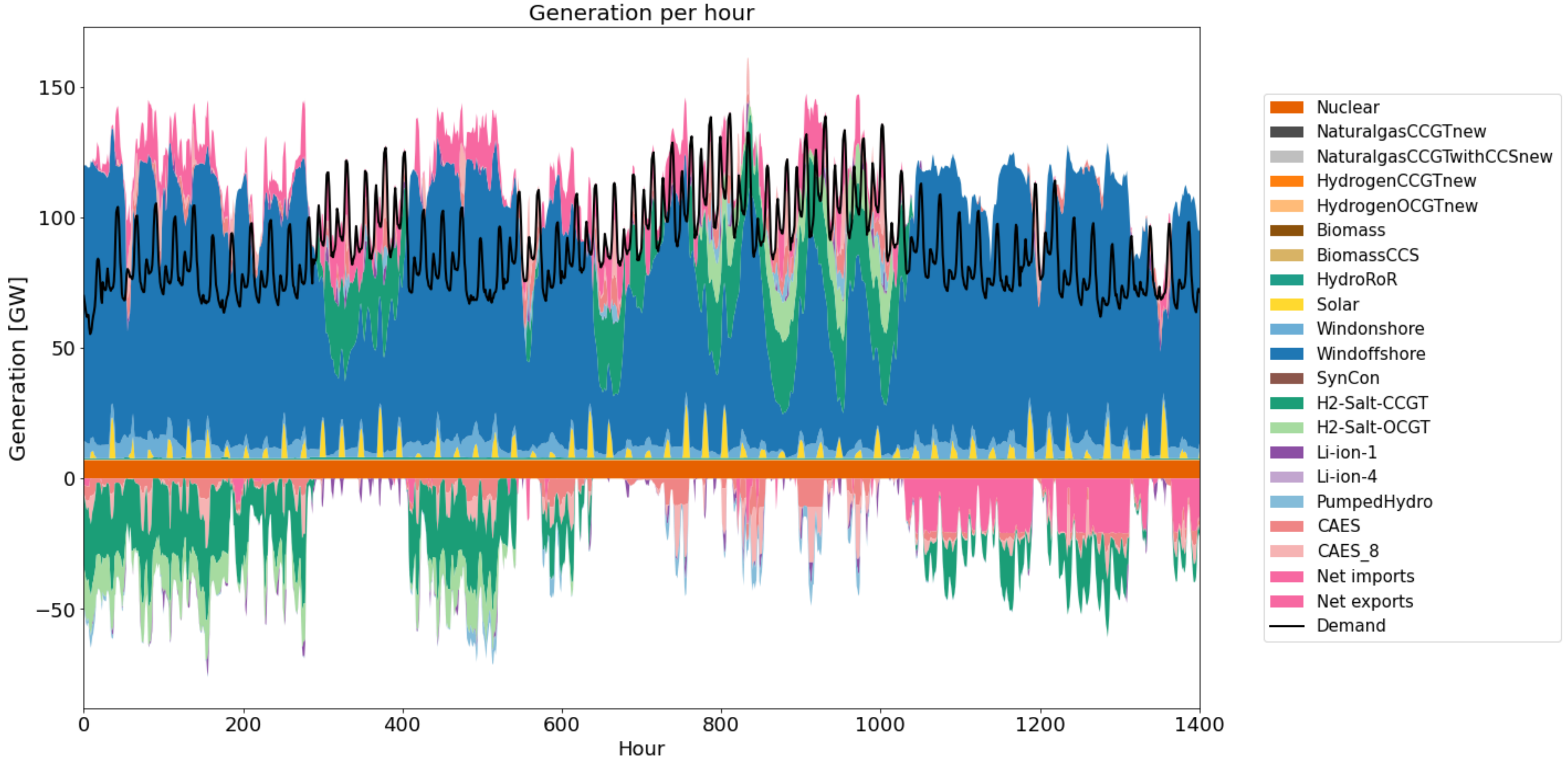


Annual storage discharge



- Role to play for all storage durations – but H2 caverns provides significant energy storage in 2050.
- H2 caverns provide **26 - 80 TWh** energy – in theory … this translates to **1210 - 2778 hours** of discharge at full capacity
- **Weather year characteristics** significantly impacts the need for LDES – in 2050 – **increasing H2 energy capacity 35% - 51%**
- Favourable innovation assumptions shift distribution of short duration options without really affecting H2 LDES (power capacity)

Initial results – highRES – the role of storage in 2050 dispatch

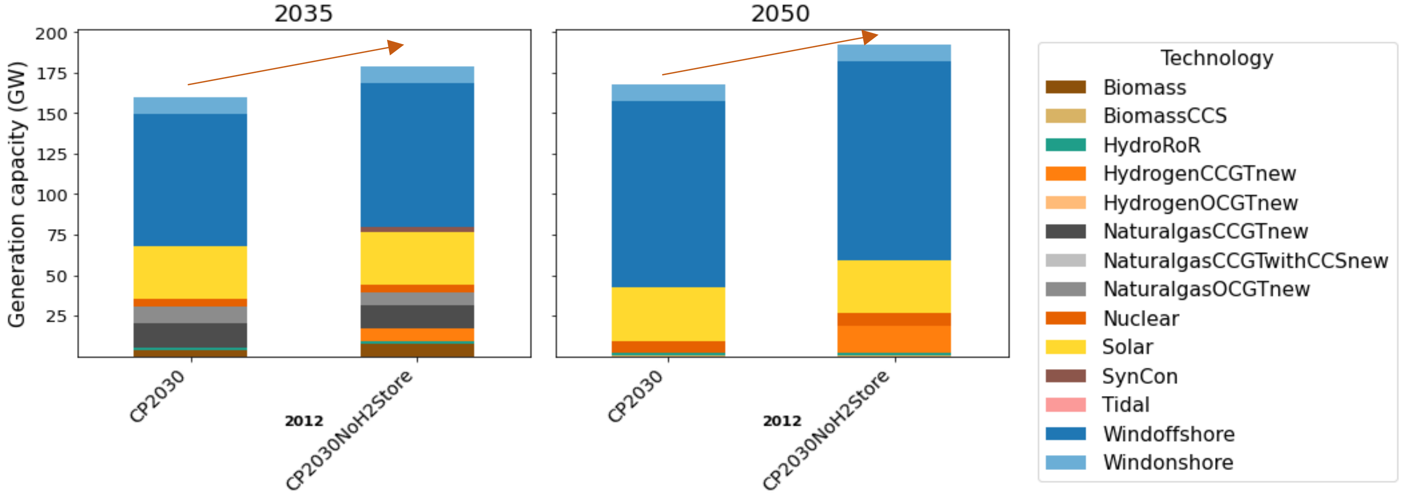


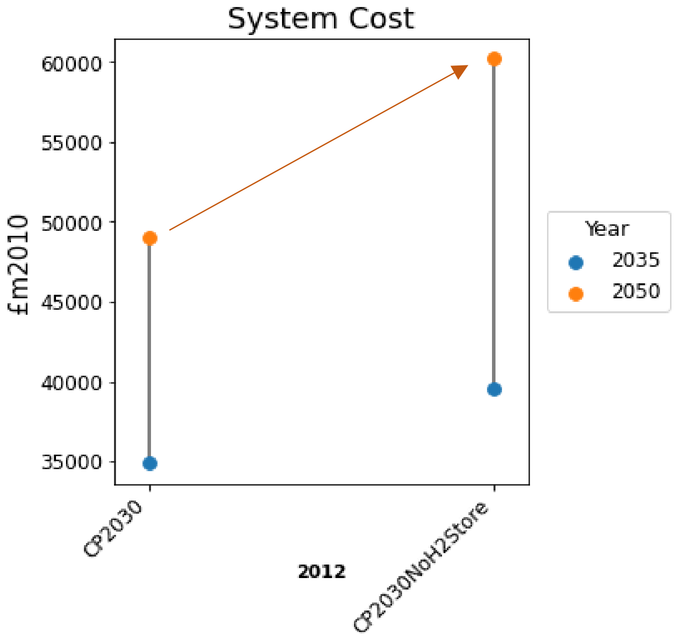
CP2030 – 2012 weather

- Jan-Feb hourly generation
- System balances across VRE, storage charge / discharge, and electricity trade.
- Significant role for H2 salt cavern storage (Greens)
- Integrated behaviour between trade / storage likely across different nodes.
- Some trade behaviour linked to CP2030 constraints

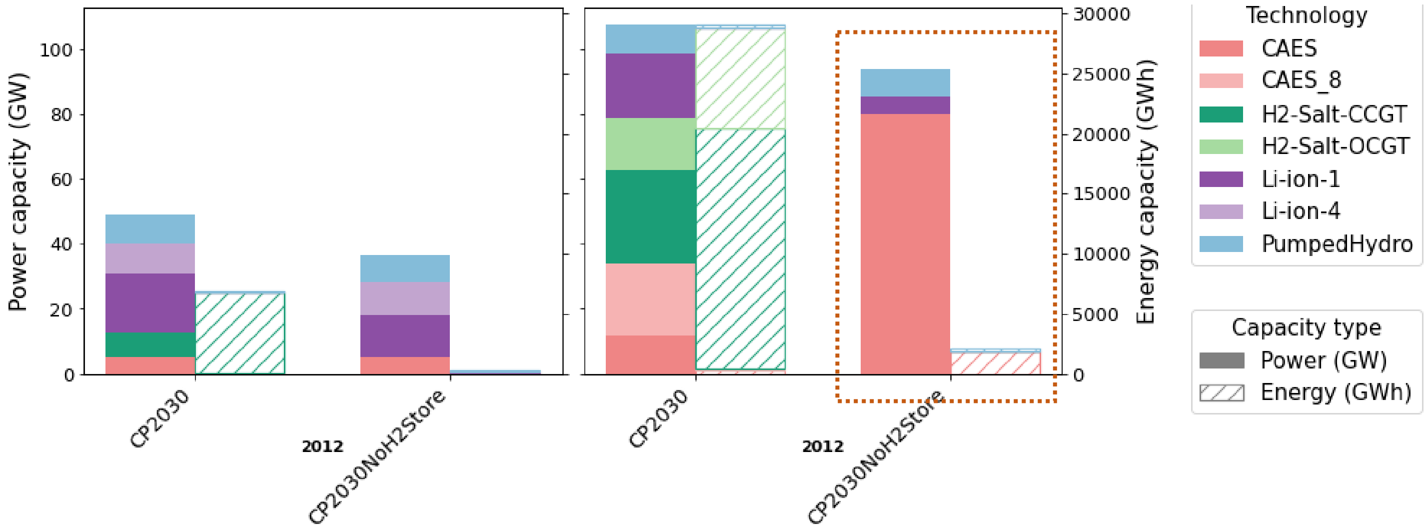
Initial results – highRES – the impact of removing H2 LDES

Power system capacity increase





Storage capacity shift to increase 24h option



+23% in total system cost in 2050

(note – this is for 2012 weather year, 2010 could be worse still)

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Overall

- Integrated whole system and power system modelling to investigate the role of different storage durations in the UK
- Modelled policy context including CP2030, CBx, and NZ, alongside possible innovation in storage technologies.
- Highlighted that all storage durations have a role to play in the system – both near and longer-term
- But demonstrated the need for up 10s TWh storage capacity to provide 1000s h dispatch capability.
- Highlighted this is particularly true under unfavourable weather conditions as we move to high (near 100%) VRE systems.

Thank you for your attention

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