Delivering a reliable, decarbonised power system

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Climate Change Committee
March 2023

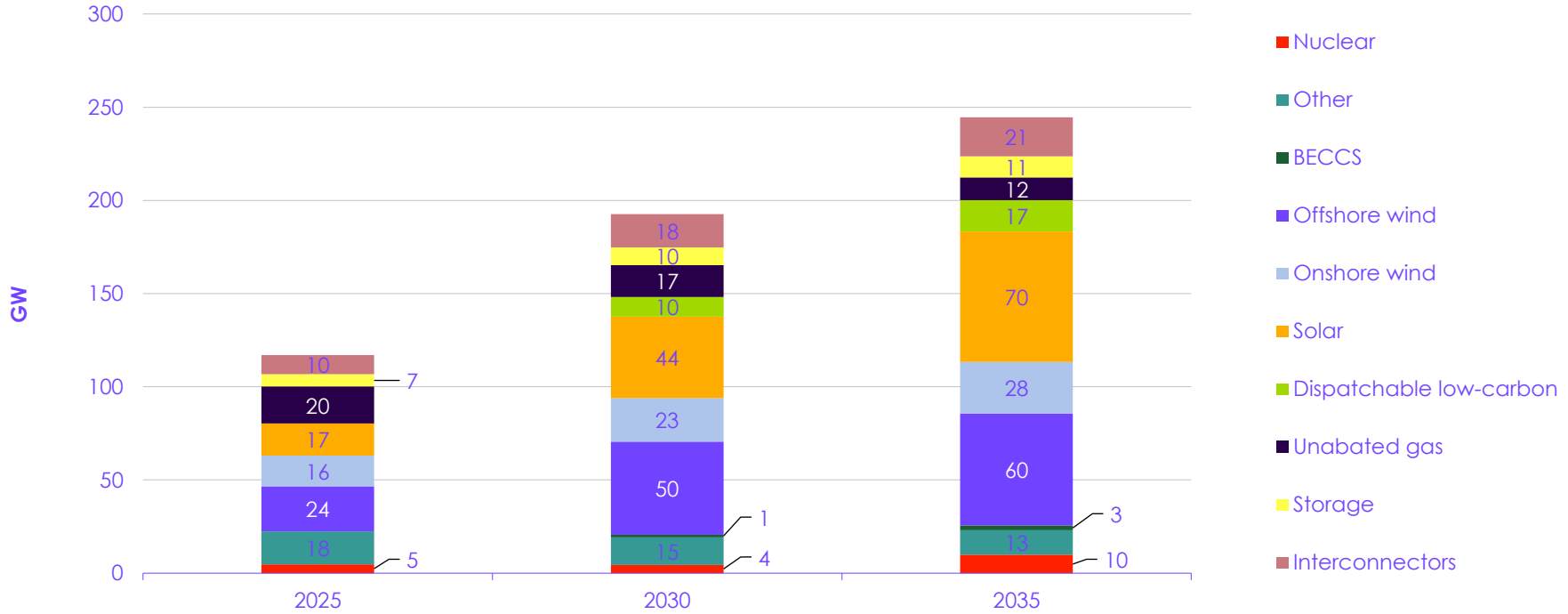
Delivering a reliable decarbonised power system
Our approach

New and detailed modelling, illustrating a realistic mix of solutions to achieve the Government's Energy Security Strategy, while operating a decarbonised GB electricity system based mainly on variable renewables.

- Uses historical weather data, including 2010's 'low-wind year' (a 1-in-50 year event) and an extreme 30-day period of wind drought.
- Considers wider enabling factors.
- Delivers new insights into hydrogen use and production and the infrastructure required to support it.
- Highlights climate-related risks to the energy system, given the increasing dependence on clean electricity.

Changes in electricity **capacity**

Low-cost variable renewables, especially offshore wind, the backbone of the future system, supplemented by complementary solutions



Source

AFRY (2023) *Net Zero Power and Hydrogen: Capacity Requirements for Flexibility.*

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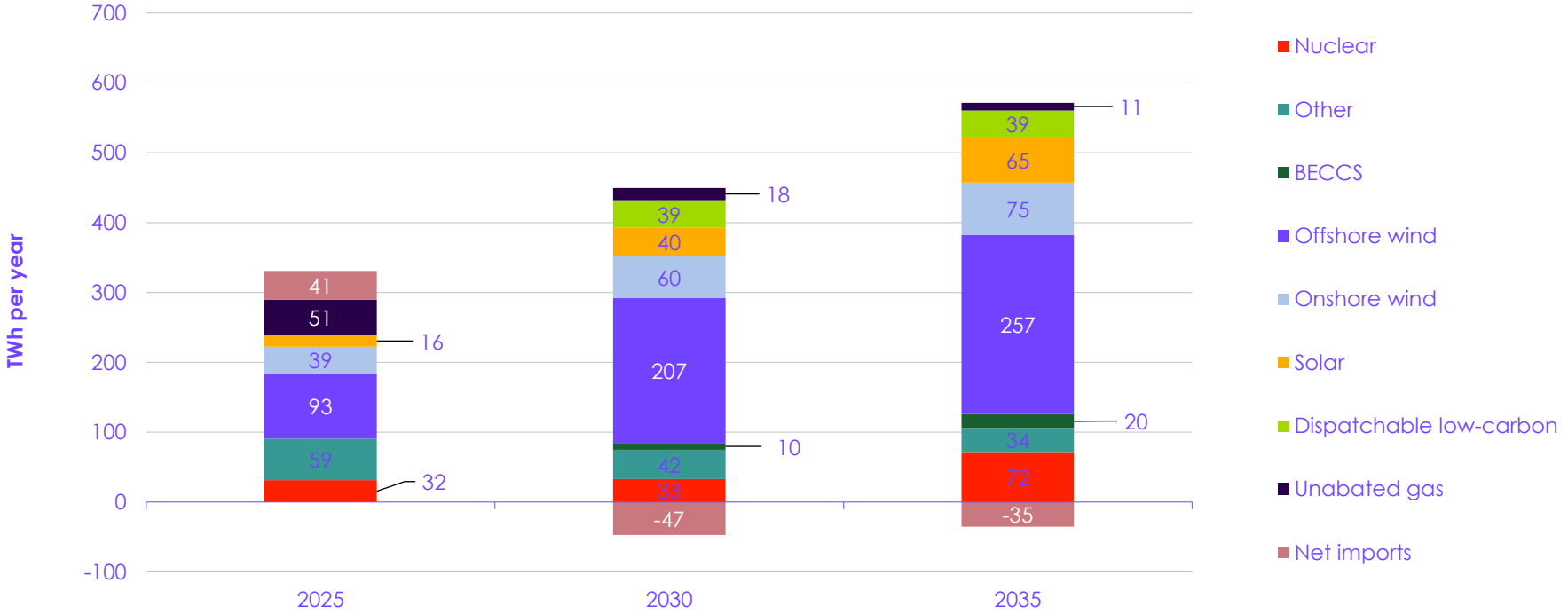

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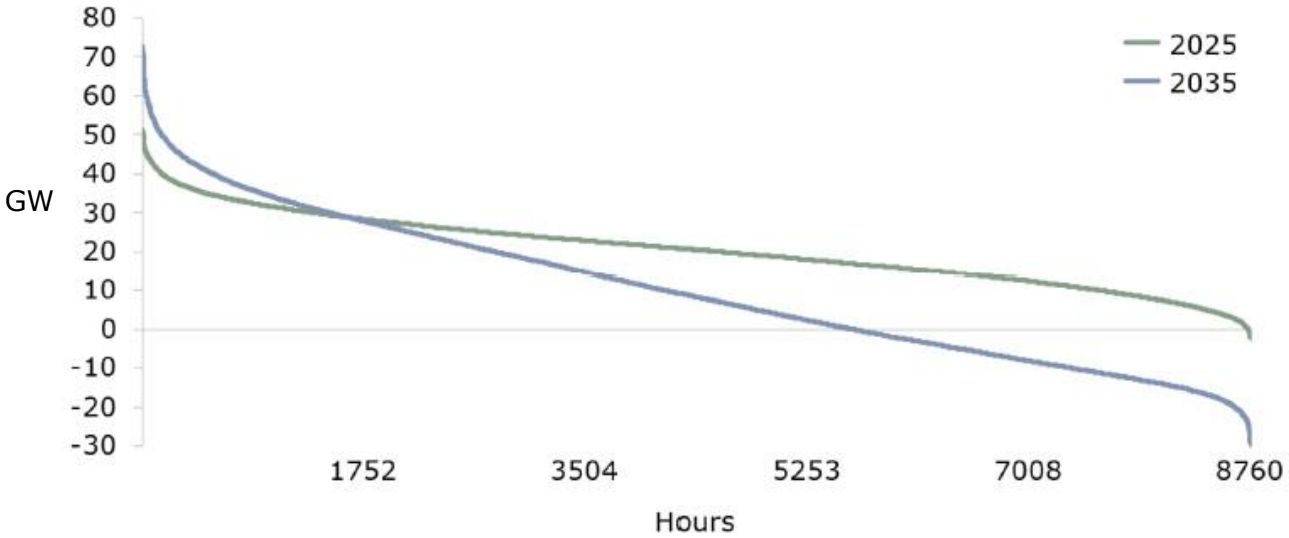
Residual demand (GW)

Residual demand = demand – power available from renewables

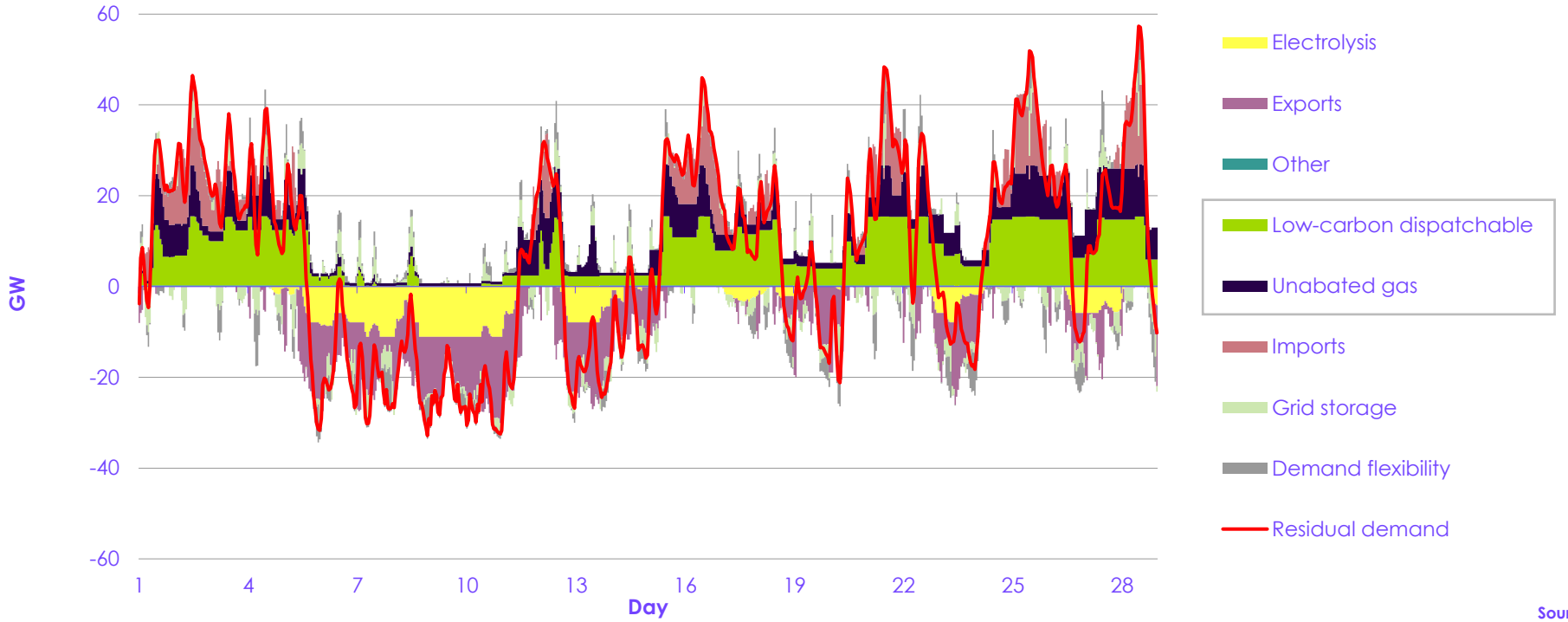


Notes: Central scenario and 2012 weather patterns
Source: AFRY Analysis

Source
AFRY (2023) Net Zero Power and Hydrogen: Capacity Requirements for Flexibility; CCC analysis.

Tools to complement variable renewables and nuclear

Portfolio of low-carbon flexibility solutions to bridge the gap in 2035 – four-week period of **highest** residual demand



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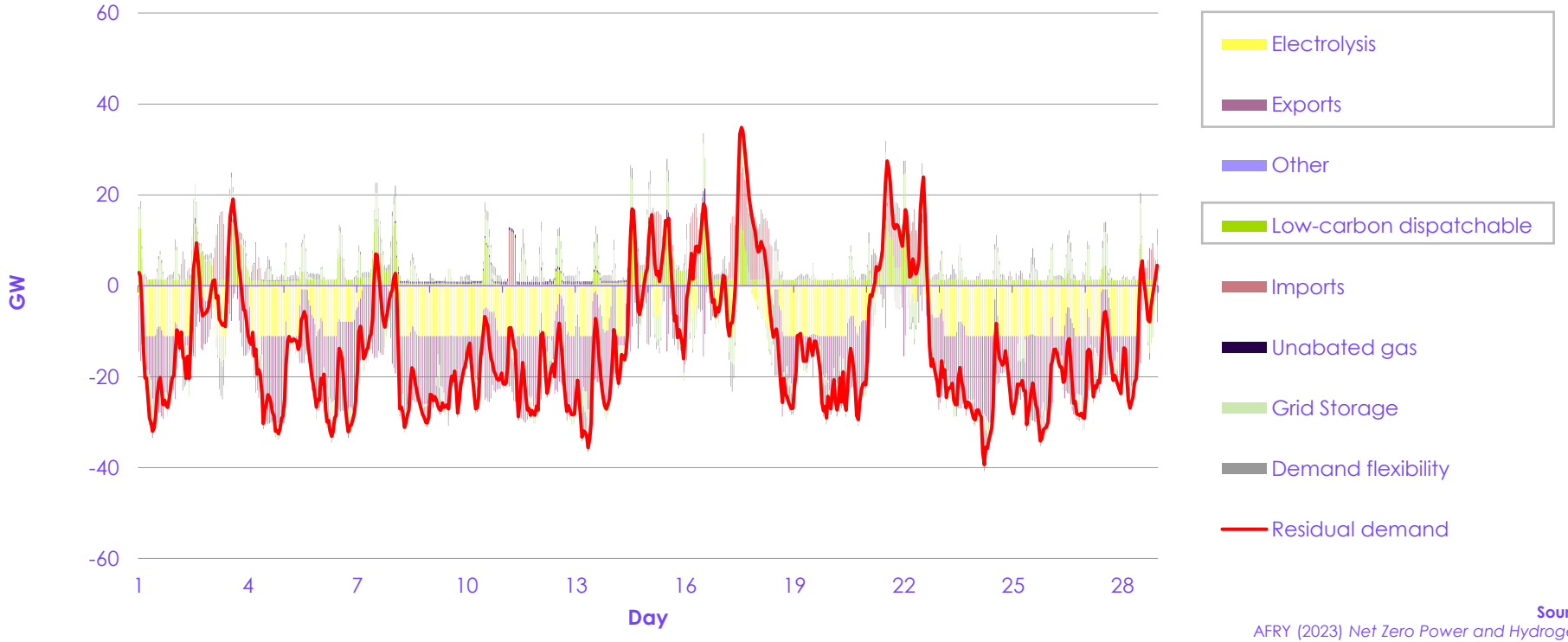
Tools to complement variable renewables and nuclear

Portfolio of low-carbon flexibility solutions to bridge the gap in 2035 – four-week period of **lowest** residual demand



Source
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The need for climate resilience

Potential impacts on the energy system due to climate trends & extreme weather events in the UK

Climate hazard	Expected change by 2050
Heatwaves	~50% chance of 2018 summer each year (around 10-25% currently)
Flooding (river, surface and coastal)	~5% wetter winters on average (compared to 1981-2000) ~10% increased intensity of heavy rainfall 10 – 30 cm increase in average sea levels (above 1981-2000 levels)
Drought	~10% drier summers on average (than over 1981 – 2000)
Wind strength and wind regimes	Highly uncertain
Storminess and occurrence of storm events	Highly uncertain
Snow and ice	Decreasing but still possible

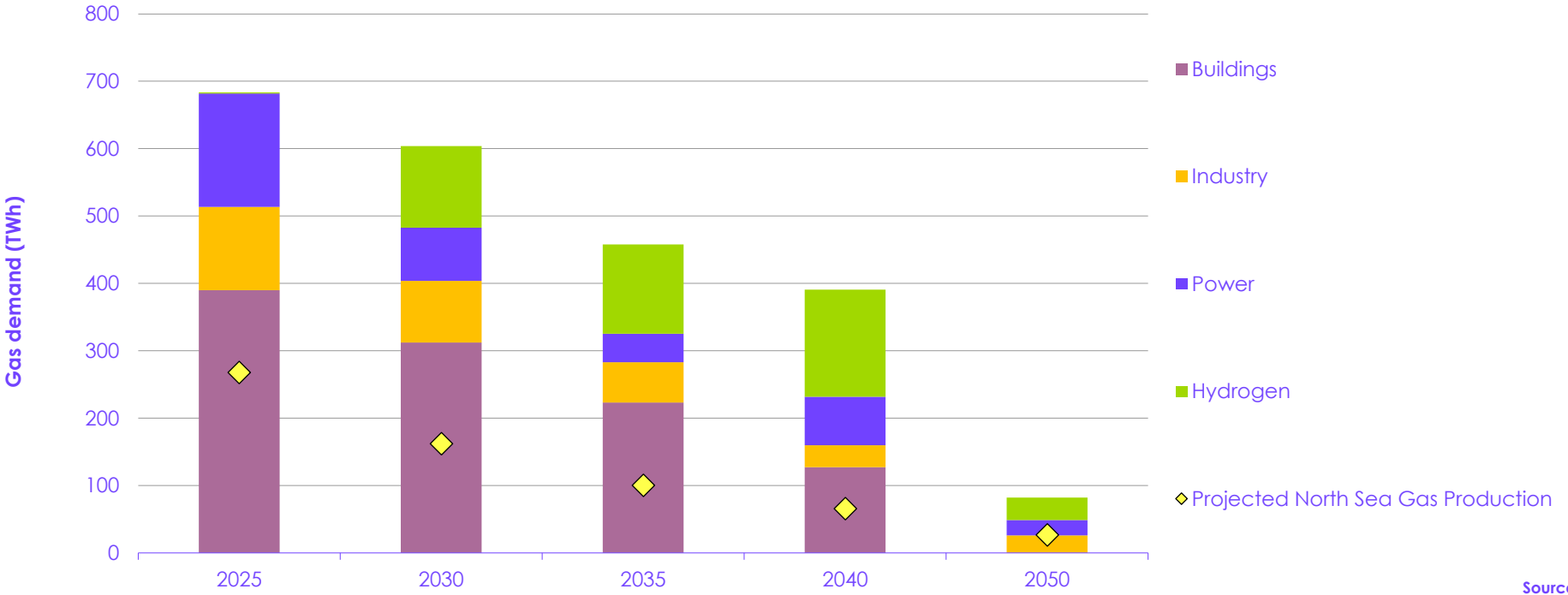
Summer:
- Are thermal ratings appropriate?

Winter:
- Assets resilient to flood risk?
- Unknown whether storms are becoming worse or more frequent
- However, dependency on electricity increasing

Source
UKCP18 Projections; summarised in CCC (2021) Independent Assessment of UK Climate Risk

Annual GB gas usage declines rapidly

Falling demand for fossil gas as we decarbonise power, buildings, industry – but imports still required

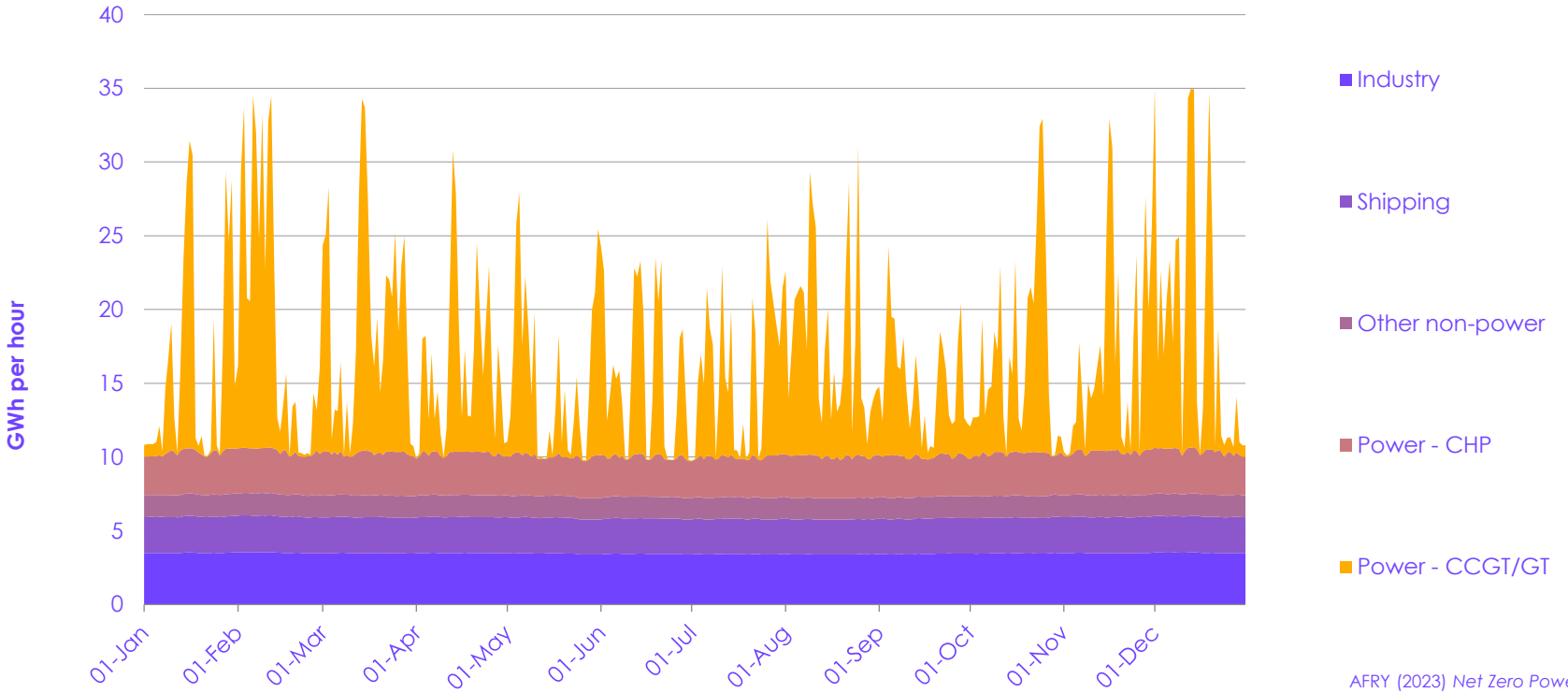


Source

AFRY Central Scenario, CCC (2020) *Sixth Carbon Budget Balanced Pathway*; NSTA (2022) *August 2022 oil and gas production projections*

Hydrogen's essential role 2035

Hydrogen provides 'on-demand' power to meet peaks and back-up renewables – requiring significant hydrogen storage



Source

AFRY (2023) *Net Zero Power and Hydrogen: Capacity Requirements for Flexibility*; CCC analysis.

Will we have enough domestic green hydrogen?

Unlikely that all hydrogen demand in 2035 can be met from domestic non-fossil fuel production

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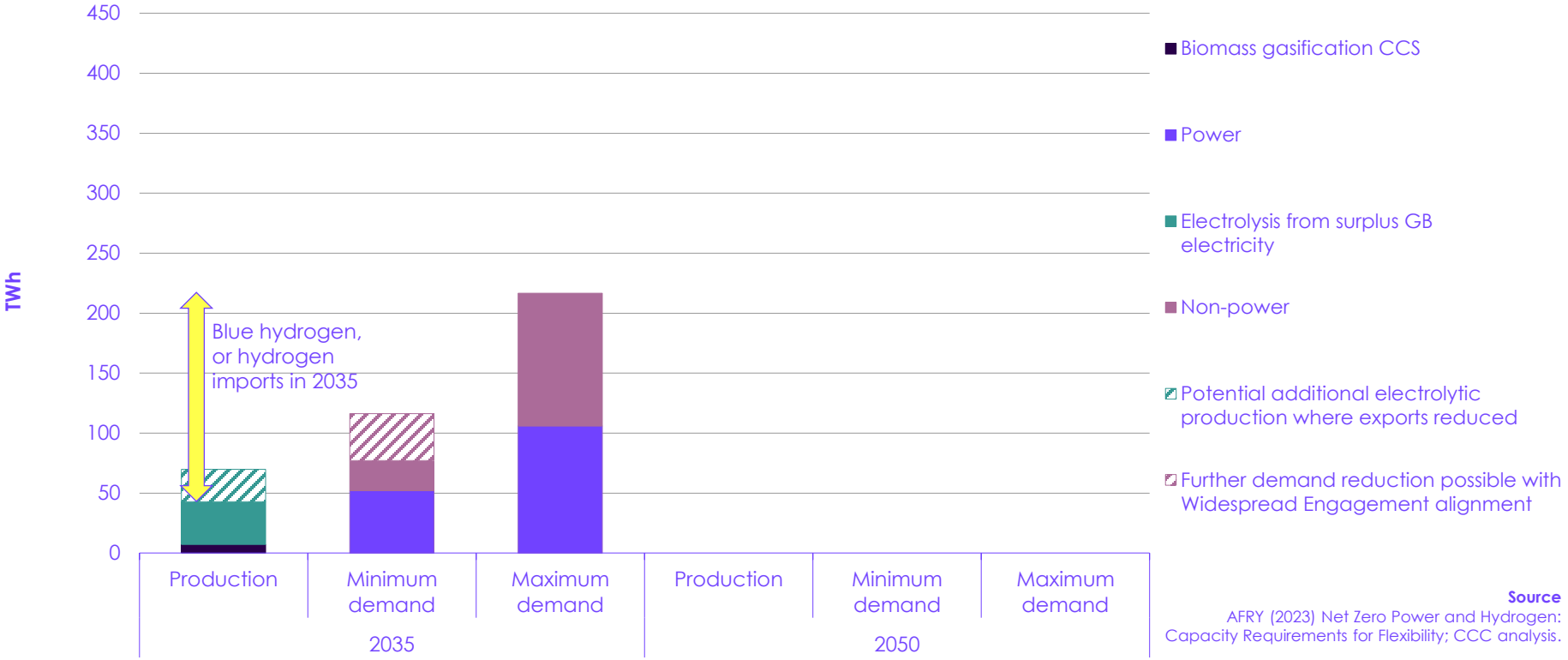

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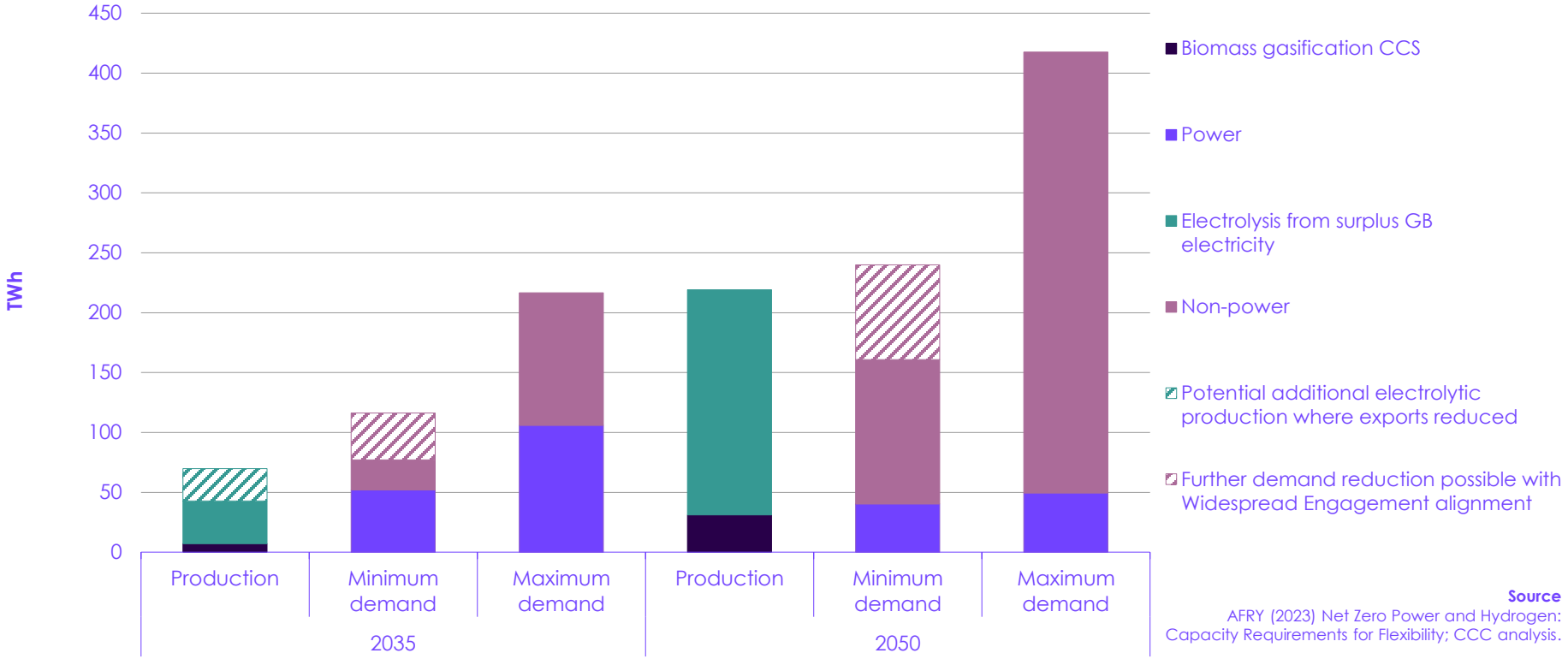

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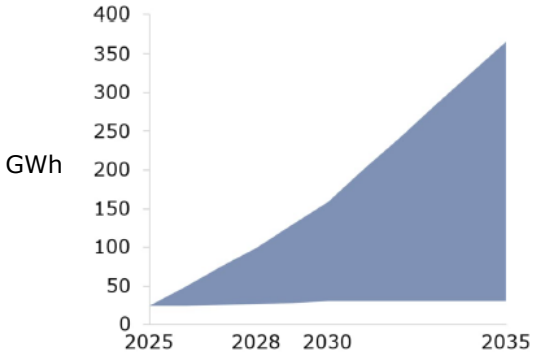
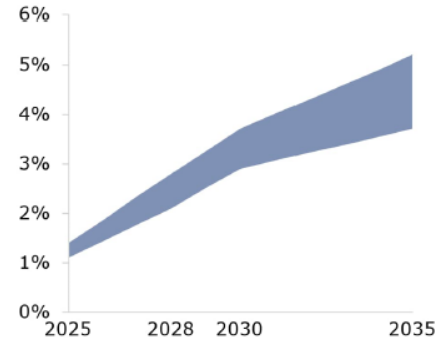
Energy storage capacity and shiftable domestic demand

"Grid storage" capacity



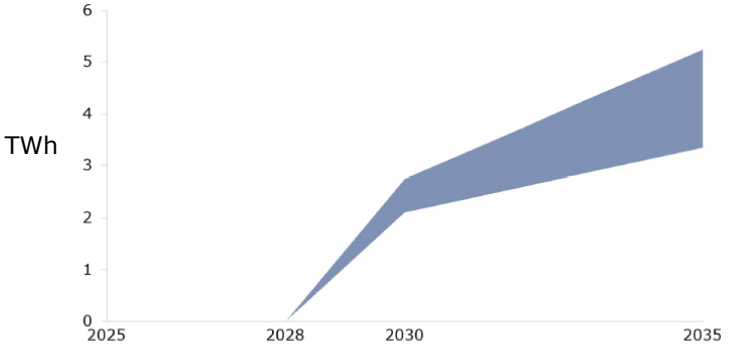
Notes: The total amount of energy that can be stored in grid storage technologies (Batteries, CAES/LAES and PS).

Flexibility of demand



Notes: The fraction of total domestic demand that is shifted or avoided.

Hydrogen storage capacity



Notes: The total amount of hydrogen that can be stored in Salt Caverns and Pressurised Tanks.

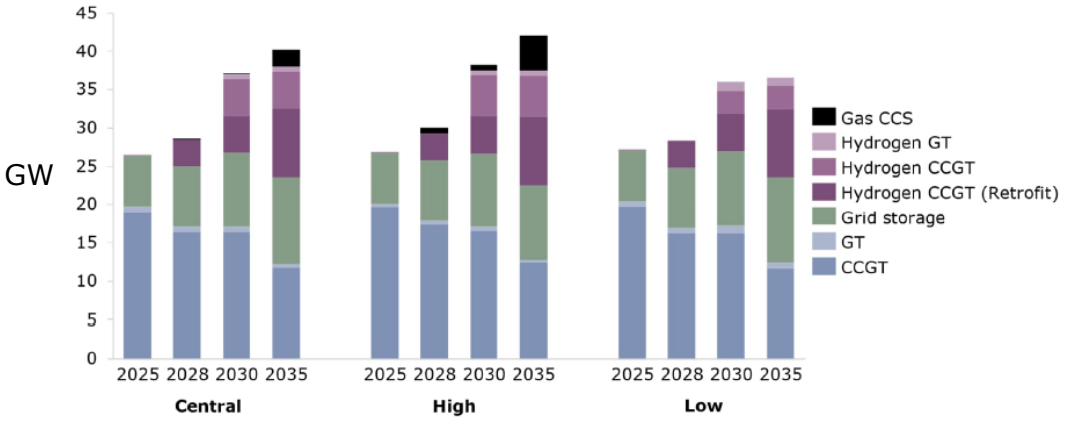
Source

AFRY (2023) Net Zero Power and Hydrogen: Capacity Requirements for Flexibility; CCC analysis.

Energy production capacity
Results of AFRY analysis

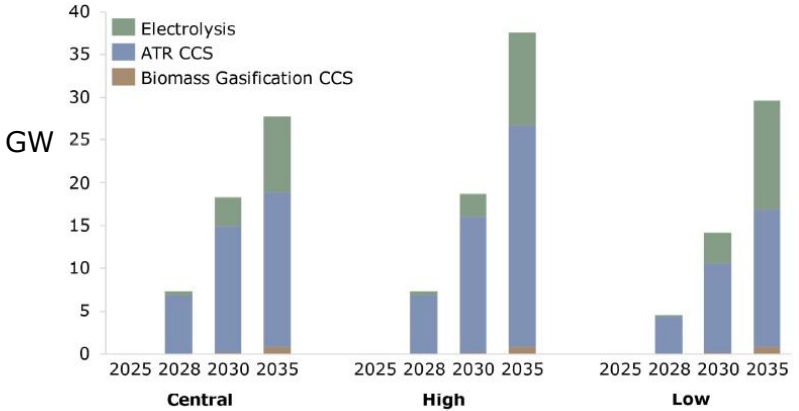
Central: CCC 6th Carbon Budget Balanced Pathway
High: CCC 6th Carbon Budget Widespread Innovation
Low: CCC 6th Carbon Budget Headwinds

‘Flexible’ generation and storage power capacity



Notes: This excludes Gas CCGT capacity that is mothballed ahead of anticipated conversion to hydrogen operation.

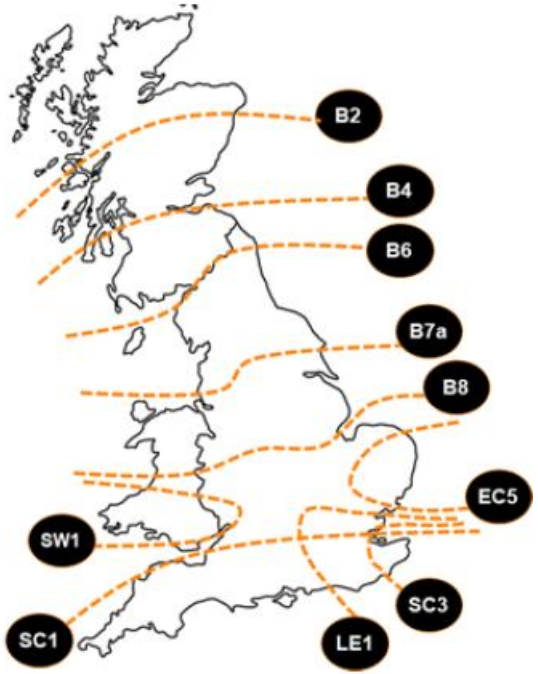
Hydrogen production capacity

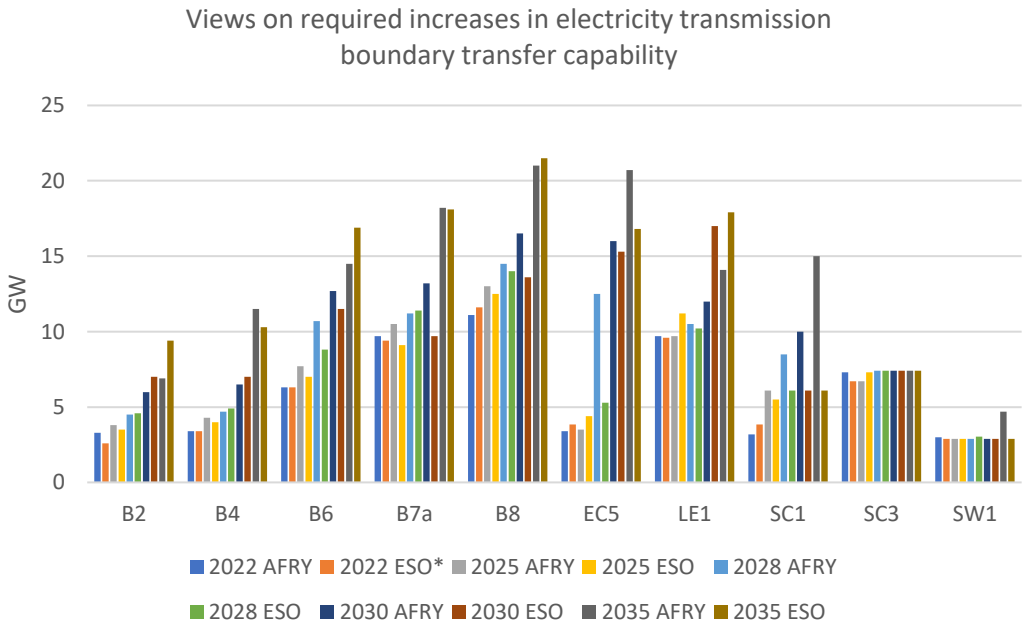


Source
AFRY (2023) Net Zero Power and Hydrogen: Capacity Requirements for Flexibility

Electricity transmission capacity

Results of AFRY modelling compared with ESO view



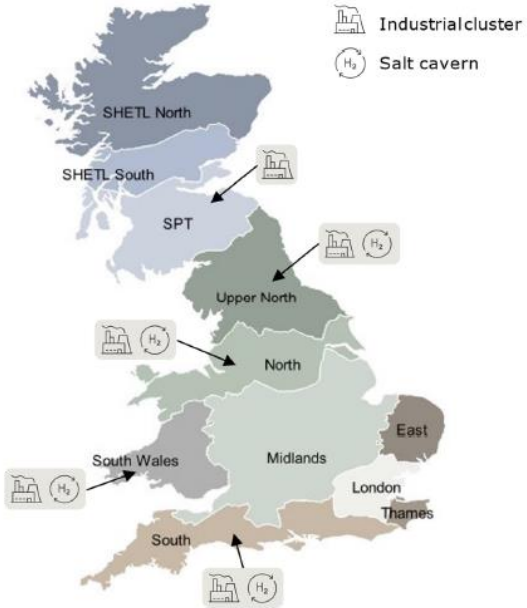


Source
AFRY (2023) Net Zero Power and Hydrogen: Capacity Requirements for Flexibility

Sources
AFRY (2023) Net Zero Power and Hydrogen: Capacity Requirements for Flexibility, NGESO, Electricity Ten Year Statement 2022, January 2023

Hydrogen transmission capacity

Results of AFRY modelling: H2 to complement the electricity system; access to H2 storage and demand



Capacity (GW)

0.0 — 7.3

	2028	2030	2035
SHETL_N - SHETL_S	0.0	0.4	1.3
SHETL_S - SPT	0.0	1.7	2.6
UpperNorth - SPT	0.0	1.3	2.8
North - UpperNorth	0.0	1.0	3.0
Midlands - North	0.0	6.0	7.3
East - Midlands	0.0	0.6	0.7
London - Midlands	0.0	3.1	3.7
London - South	0.0	2.5	3.0
London - Thames	0.0	0.2	0.4
Midlands - SWales	0.0	0.2	0.5

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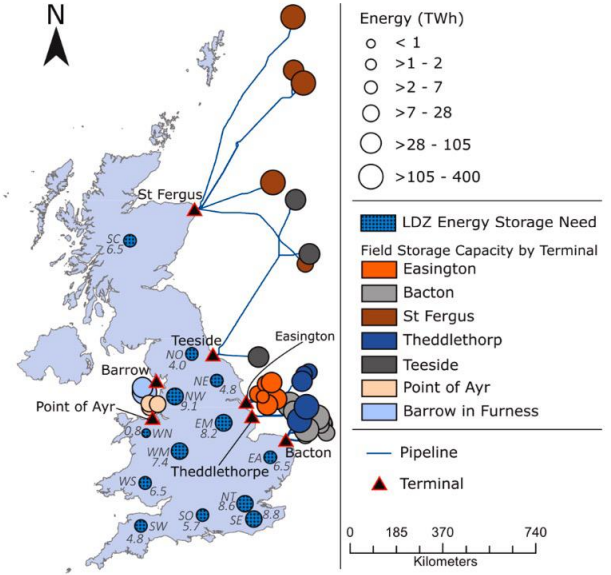

Julien Mouli-Castillo, Niklas Heinemann, Katriona Edlmann, Mapping geological hydrogen storage capacity and regional heating demands: An applied UK case study (2021). Applied Energy, 283, 116348, https://doi.org/10.1016/j.apenergy.2020.116348

Delivering a reliable decarbonised power system
Key findings

It is credible to deliver a reliable, resilient and secure decarbonised electricity system by 2035. The modelled 2035 system

- **meets higher electricity demands;**
- **rapidly reduces our dependence on imported oil and gas;**
- **reduces our exposure to volatile international energy prices.**

Build rates, for generation and network capacity, must far exceed what has been achieved historically in a number of areas.

A number of processes – including planning, consenting and connections – are not fit for purpose. These must be urgently reformed to deploy infrastructure at sufficient speed.

The production, storage and use of low-carbon hydrogen plays an essential role in achieving the 2035 goal of a reliable, resilient decarbonised power system, but there are choices.

Government must set strategic direction for power and non-power uses of hydrogen – low-regret hydrogen infrastructure investments must proceed immediately.

It is unlikely that all UK hydrogen demand can be met from domestic 'green hydrogen' production by 2035, given likely limits on the rate at which renewable generation capacity can feasibly be built.

For the wider Net Zero goal, availability of low-carbon hydrogen is a key risk to Government plans for high levels of hydrogen use outside of the power system (e.g. hydrogen for heat in buildings)

The climate risks to the electricity system are currently underplayed. Climate-related impacts will multiply as we rely increasingly on electricity for heat and transport needs.

Given the level of investment needed, we must not miss the opportunity to build in system- and asset-level resilience from the start.

Delivering a reliable decarbonised power system
Key Recommendations

- Publish a **comprehensive long-term strategy for the delivery of a decarbonised, resilient, power system by 2035**.
- **Clarify urgently and formalise the institutional responsibilities of the Future System Operator, Ofgem and Ministers**, for strategic planning and delivery of the decarbonised, resilient system.
- **Conduct a review of governance arrangements for resilience to climate hazards in the energy system**, to ensure they are fit for the new expanded and more diverse low-carbon system given increasing societal reliance on electricity.
- **Identify a set of low-regret electricity and hydrogen investments that can proceed now**. **Finalise funding mechanisms and allocate funding** to support the development of 10 GW of low-carbon hydrogen production by 2030.
- **Fast-track the development of new business models for hydrogen transportation and storage infrastructure**, with a view to keeping options open for larger scale hydrogen use by 2030.
- **Create a Minister-led infrastructure delivery group**, advised by the new Electricity Networks Commissioner, to ensure enabling initiatives for energy infrastructure build are taken forward at pace, and necessary policy changes are implemented across the UK, to deliver a decarbonised and resilient power system by 2035.
- Through the existing Review of Electricity Market Arrangements, **develop a strategy as soon as possible on market design for the medium- to long-term for a fully decarbonised, resilient electricity system in the 2030s and onwards**.