Feasibility analysis for achieving a net zero power grid in Great Britain by 2030

A report by AFRY Management Consulting for Offshore Energies UK

JULY 2024

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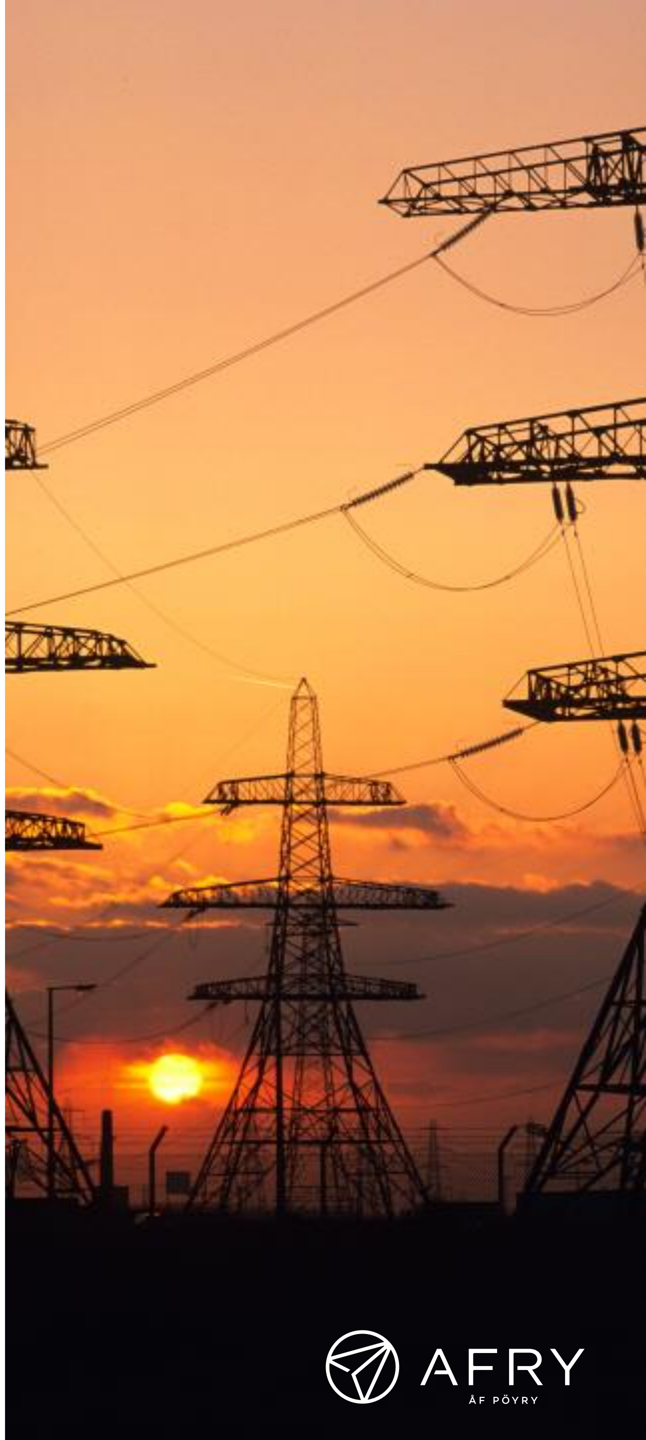

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AFRY has carried out a feasibility analysis of what would be required to deliver a net zero carbon power sector in Great Britain by 2030

BACKGROUND

In October 2021, the UK Government published its Net Zero Strategy[1], which introduced a new ambition to 'fully decarbonise our power system by 2035, subject to security of supply'. This was followed in April 2022 by the British Energy Security Strategy (BESS), which introduced additional technology-specific targets, including 50GW of offshore wind by 2030, 70GW of solar PV by 2035 and 10GW of low carbon hydrogen (including 5GW of electrolysis) by 2030, while retaining the 2035 ambition for decarbonised power.

Ahead of the 2024 UK General Election, the Labour Party published a policy document on energy, which includes a target to achieve a 'zero-carbon electricity system by 2030'[2] - which would effectively bring the current target forward by 5 years.

The policy document also identifies barriers to address to make the 2030 target achievable:

- delays in the planning system for renewable projects ("reduce the time projects take in planning from years to months");
- delays to transmission grid reinforcement; and
- delays in grid connection (including delays caused by "zombie projects").

OBJECTIVE

Offshore Energies UK (OEUK) is the trade association for the offshore energy industry in the UK, representing oil, gas, renewable energy and hydrogen companies active offshore, as well as companies involved in the supply chain.

OEUK has commissioned AFRY to carry-out a strategic 'what-if' analysis of what would be required to achieve a net zero carbon power grid in Great Britain by 2030, focussing on required rates of technology deployment, planning consents, award of Government support contracts and grid connections.

The analysis includes a quantitative and qualitative assessment of key drivers[4], but excludes:

- fundamentals power market modelling;
- analysis of supply chain feasibility;
- whole system costs analysis; and
- assessment of the feasibility / challenges of electrification of demand, and any impacts this might have on delivering a net-zero power sector[3].

The analysis assumes:

- there are no changes to market arrangements

1. HM Government 'Net Zero Strategy: Build Back Greener', October 2021
2. 'Missions for a Better Britain - Make Britain a Clean Energy Superpower'
3. e.g. competition for funding, flexibility from new demand sources, etc.
4. Analysis for this report was carried January – March 2024

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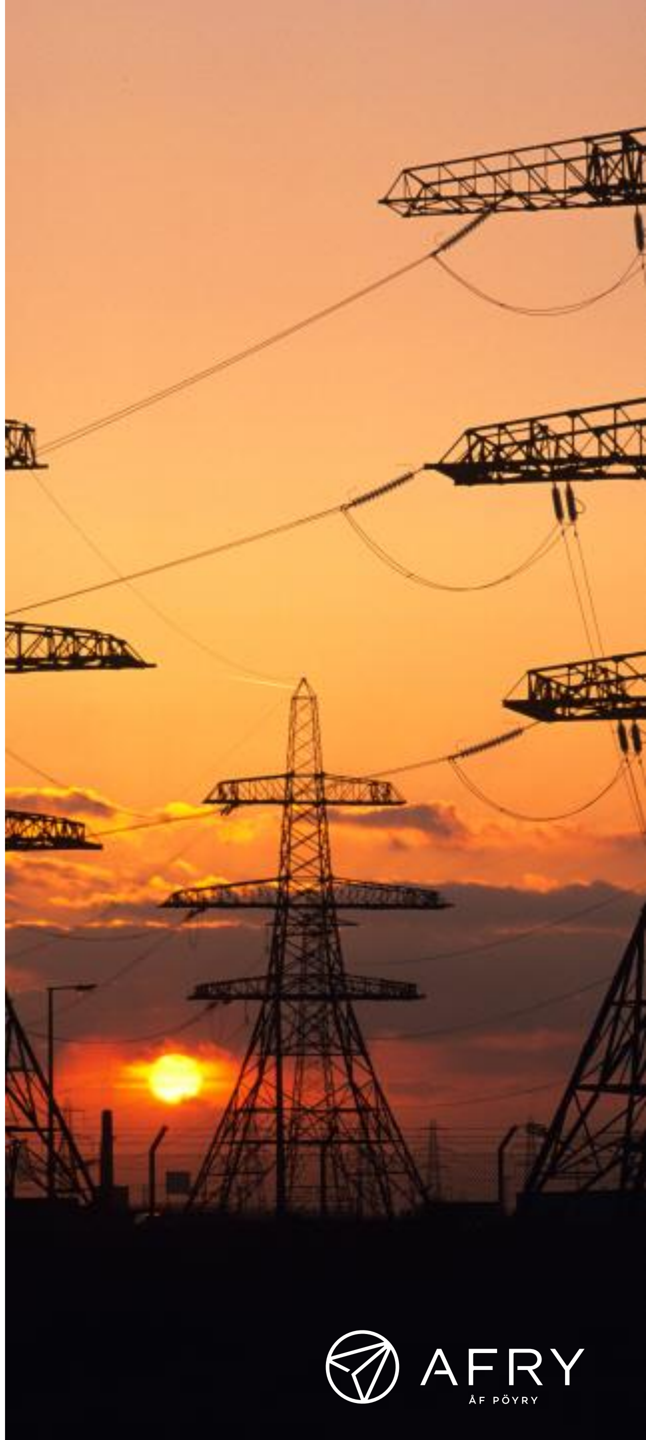


The Net Zero Power (NZP) scenario requires over 90GW of new generation capacity to be deployed by 2030

While overall renewable and storage deployment requirements are broadly in line with growth paths for 2035 net-zero scenarios, there are key differences in low-carbon thermal capacity and the associated infrastructure requirements

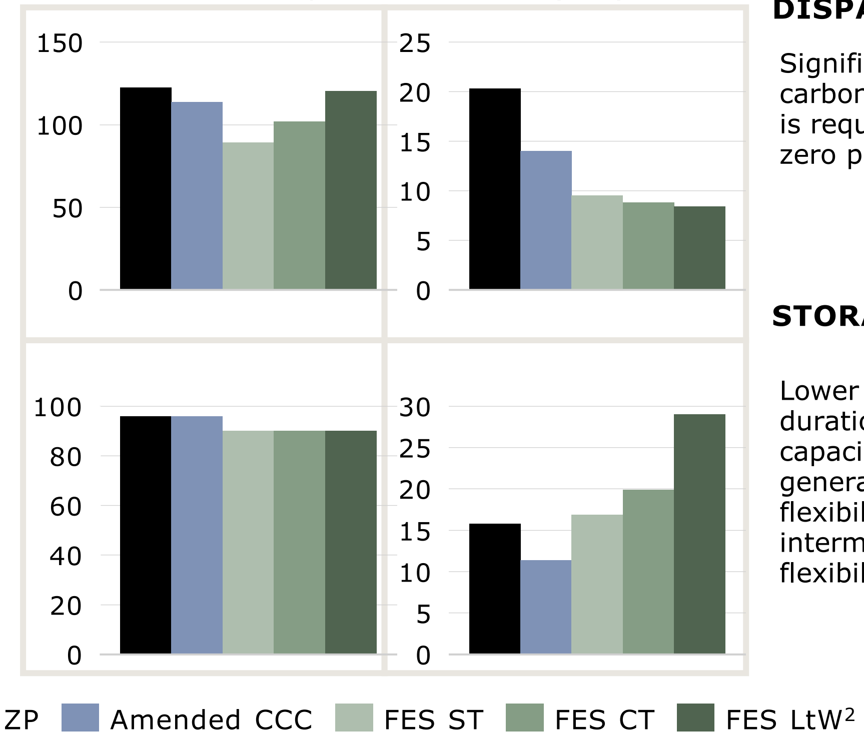
INTERMITTENT RENEWABLES

Around 80GW of new intermittent renewable capacity needs to be deployed compared to today's levels. Although challenging, this is similar to the most ambitious scenarios which reach net zero power by 2035.

TRANSMISSION NETWORK

There is slightly more additional transmission build in the NZP scenario than the FES scenarios, and the locations of the reinforcements are slightly different. However, we do not think this this represents a material enough difference in activity levels for this analysis.

Installed capacities in 2030 (GW)[1]



DISPATCHABLE LOW CARBON

Significantly increased growth in dispatchable low carbon generation and corresponding infrastructure is required compared to scenarios that reach net zero power by 2035.

STORAGE

Lower levels of storage, and particularly long-duration storage, partly reflect the higher capacities of low carbon dispatchable power generation and interconnection. Some form of flexibility is required for a system with high levels intermittent renewables but there is some flexibility in the exact form.

1. Installed capacities (intermittent renewables, dispatchable low carbon and storage); or total transmission boundary capabilities summed for 9 key network boundaries (transmission network)
2. NZP – Net Zero Power scenario; Amended CCC – Amended CCC Balanced Pathway scenario; FES (Future Energy System scenarios 2023) ST - System Transformation; CT – Consumer Transformation; and LtW - Leading the Way

Achieving net zero power in Great Britain by 2030 is possible but very challenging

MAJOR EFFORT NEEDED IN MANY AREAS	Delivering net zero power in 2030 will require fast, effective and co-ordinated effort in several areas, with little contingency available
DEPLOYMENT MUST BE ACCELERATED	Deployment rates for mature techs would need to match or (greatly) exceed historical annual peaks every year until 2030 and new technologies would need to be deployed at scale
POLICY ACTION IS REQUIRED	Planning processes will need to be streamlined to ensure a sufficient pipeline of projects, and support schemes will need to be scaled up or implemented
LIMITED MITIGATIONS ARE AVAILABLE	There are no obvious mitigations that could reduce the risks of accelerating the delivery of net zero power by five years to 2030

Net zero power in 2030 requires fast, effective and coordinated effort

- Accelerating the pace of decarbonisation means technologies with long lead times (e.g. nuclear power) cannot make a material additional contribution by 2030.
- Much more effort must be made to expand and expedite the project pipelines for the current portfolio of low-carbon technologies.
- For many technologies (e.g. solar PV, onshore wind, offshore wind) this would involve sustaining activity at historical peak rates. For others (e.g. gas-fired generation with CCUS and hydrogen-fuelled generation) it means much more rapid commercialisation of an emerging technology.
- A large majority of the new capacity required is linked to revenue support schemes; policymakers have scope to increase utilisation of these schemes to rapidly ramp-up deployment.
- The planning system needs sufficient additional capacity to cope with an immediate expansion of applications for some technologies (e.g. offshore wind), while simultaneously expediting existing project pipelines.
- Some agreed dates for network connections would also need to be immediately brought forward from post-2030, to give sufficient time for any necessary enabling works.
- Coordinated action would be required to ensure bottlenecks on deployment are removed rather than shifted to a different point.
- **Delivering net zero power in 2030 will require fast, effective and co-ordinated effort in several areas, with little contingency available.**

Step changes in deployment would be needed across the board

- Over and above already ambitious deployment paths to achieve a fully decarbonised grid by 2035, a credible pathway to net zero carbon power in 2030 requires deployment of:
  - over double the current capacity of solar PV and onshore wind;
  - more than three times today's capacity of offshore wind; and
  - **around 15GW of entirely new types of low-carbon dispatchable capacity** (gas-fired generation with CCUS and hydrogen-fuelled generation), together with the associated storage and network infrastructure.
- For each renewable technology, the **maximum historical annual deployment would have to be repeated or exceeded every year** to 2030, including:
  - 5.2GW/year for offshore wind;
  - 2.8GW/year for onshore wind; and
  - 4GW/year for solar PV.
- For both gas-fired generation with CCUS and hydrogen-fuelled generation, capacity equivalent to close the entire visible pipeline of projects conceivably deliverable by 2030 need to be built.
- Major grid reinforcements are also required (although current ambition on these to enable 50GW of offshore wind by 2030 could be close to sufficient).
- Achieving simultaneous scale-up in all technologies including grid reinforcement would be major challenge.

Revenue support schemes and planning pose particular challenges

- To achieve net zero power by 2030, a large majority of new generation capacity required is anticipated to be covered by some form of Government revenue support.
- For existing renewable technologies, while the framework for Contract for Difference (CfD) allocation rounds support is well-established**, CfD award rates (GW/year) need to approximately double for each of offshore wind, onshore wind and solar PV.**
- **For new dispatchable low carbon technologies, revenue support frameworks are much less mature. Urgent attention is needed** to ensure they are finalised in time for around 15GW of gas-fired generation with CCUS and hydrogen-fuelled generation to receive awards by 2027.
- **Across all intermittent renewables, rates of planning consent need to be maintained at peak levels,** which may require current processes to expedited.
- However, for offshore wind, even if these rates are maintained, there is currently insufficient capacity in the planning process to meet the 51GW requirement, meaning:
  - **7.6GW of offshore wind capacity needs to enter the planning system in 2024** (the historical maximum is 7.2GW in one year); and
- Grid connections are also a significant challenge for offshore wind: **around 6GW of grid connection agreements for offshore wind need to rapidly be brought forward to 2030**, to allow sufficient time for any required network enabling works.

Mitigations for deployment risk are are limited in scope

- The Net Zero Power scenario has been defined to accelerate the types of capacity most scalable at speed given existing project pipelines and existing or developing policy.
- Given the challenges, achievement of the target will depend on:
  - **building on existing policy levers** - as the legal framework for the required policies exists, extending or implementing them more quickly is within the Government's remit;
  - **committing sufficient revenue** support for generation capacity; and
  - **committing greater resources to enable swift consenting**.
- **On deployment, there is limited scope for contingency to mitigate risks.** Failure to deliver in one area would generally lead to greater effort in an area which is more difficult to scale. However, there may be some contingency around the exact generation mix to reach net zero carbon power by 2030.
- Increased ambition for long duration energy storage (LDES) could decrease the need for 15GW of gas-fired generation with CCUS and hydrogen-fuelled generation. However, the LDES support regime is not yet in place.
- Greater biomass-fired generation with CCUS is potentially deliverable by 2030, offering additional negative emissions (Lynemouth and two further units at Drax). However, revenue support is currently unclear
- Current efforts to halve the time take to deliver transmission reinforcement projects to around 7 years will not be implemented in time to help with grid build by 2030.

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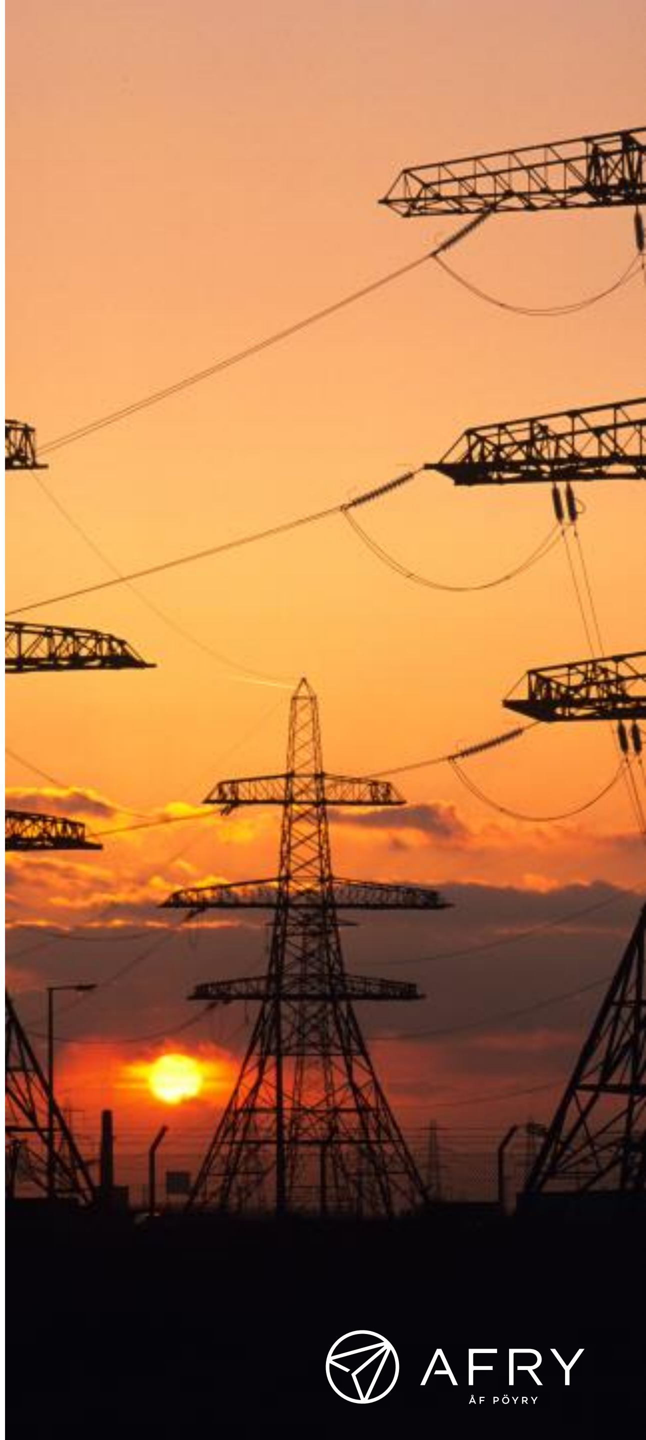

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4. Analysis for this report was carried out January – March 2024

We have split the project into three parts – scenario definition; 'what if' analysis; and reporting

AFRY'S APPROACH

1 **Scenario definition**

Defined a scenario that achieves a net zero power grid by 2030. We have called this the *Net Zero Power scenario*.

2 **'What if' analysis**

Carried out a semi-quantitative analysis of the key requirements for the key technologies to reach the Net Zero Power scenario.

3 **Implications and mitigations**

Assessed the feasibility of the requirements and considered actions that may reduce the substantial challenge of accelerating power sector decarbonisation.

1. Scenario definition:

- Reaching a net zero carbon power grid by 2030 requires rapid development of low carbon technologies.
- The Net Zero Power scenario is one possible pathway to reach a net zero carbon power grid by 2030.
- This scenario is based on accelerating an existing scenario which reaches net zero by 2035, and then adjusting any features which are not feasible to bring forward by 5 years while still achieving a net zero power grid. It is not an economically optimised modelled scenario.

2. 'What if' analysis

- For the key technologies, we have analysed the requirements to meet the Net Zero Power scenario focusing on required rates of technology deployment, planning consents, award of Government support contracts and grid connections.

3. Implications and mitigations

- We have compared the requirements identified in the 'what if' analysis above to historical rates and current policy to understand the feasibility.

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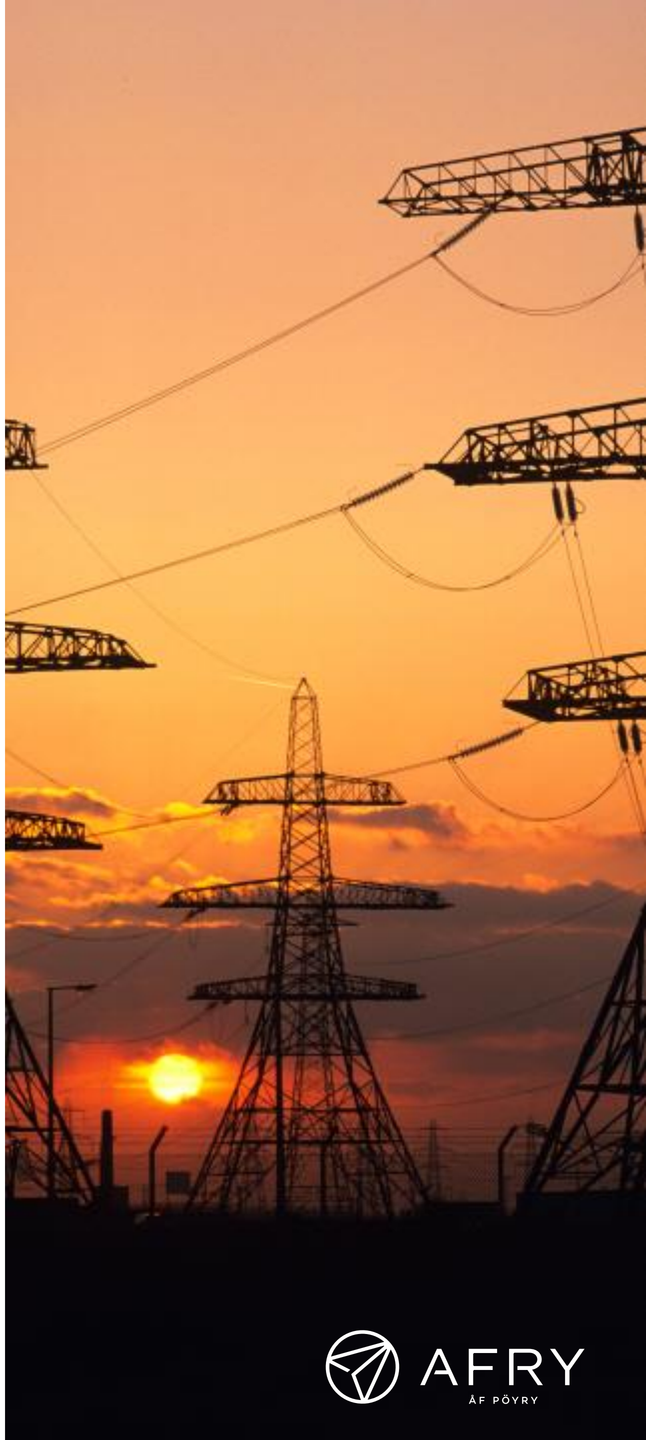

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The Net Zero Power scenario was developed by adapting a scenario that achieves net zero power in Great Britain by 2035

METHODOLOGY TO DEFINE A SCENARIO ACHIEVING NET ZERO POWER BY 2030

1	Select a public scenario achieving net zero power by 2035	The CCC Balanced Pathway scenario was selected. This been amended to reflect the targets in the British Energy Security Strategy (BESS) and some additional detail added to allow for modelling. In this report, this is referred to as the **Amended CCC Balanced Pathway scenario[1] (Amended CCC)**. The scenario has 5MtCO_2/year of gross power sector emissions by 2035.
2	Accelerate this scenario to achieve net zero power by 2030	We have brought electricity generation capacity and demand forward from 2035 to 2030 to create an **Accelerated scenario** that achieves net zero power by 2030.
3	Assess the feasibility of the accelerated scenario	We have examined key metrics in the Accelerated scenario and compared these with other public scenarios. Key metrics include deployment of intermittent renewables, low carbon dispatchable power, storage, and transmission build. Based on this comparison we have categorised areas as (1) infeasible (2) very challenging (3) challenging but plausible.
4	Alternative pathways for non-credible metrics	For metrics that have been labelled as infeasible or very challenging, we have developed alternative pathways. We have ensured alternatives pathways retain an energy-demand balance, and that gross carbon emissions in the power sector remain very low.
5	2030 net zero power scenario	This has resulted in the **Net Zero Power scenario (NZP)**. In terms of metrics assessed, this is a challenging but feasible scenario which achieves net zero power (and very low gross power emissions) by 2030. We have run the scenario for 2030 through our fundamentals market model to check supply and demand balancing, and emissions.

1. The Amended CCC Balanced Pathway scenario is based on the Central scenario used in the report: Net Zero Power and Hydrogen: Capacity Requirements for Flexibility, March 2023, AFRY https://www.theccc.org.uk/publication/net-zero-power-and-hydrogen-capacity-requirements-for-flexibility-afry/

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We compared the accelerated scenario to public scenarios which reached net zero power by 2030 to assess the feasibility of key metrics

Metric	2030 Accelerated scenario[1]	Feasibility	Justification
Demand	485TWh	Red	The highest comparison scenario reaches 382TWh by 2030. It is unlikely that electricity demand growth will accelerate with accelerated emission reductions in generation.
Offshore wind	55GW	Green, Amber	Slightly greater than the most ambitious comparison scenario and current Government targets (50GW offshore wind by 2030) which are already challenging.
Onshore wind	28GW	Green	In line with the most ambitious comparison scenario.
Solar PV	70GW	Amber	The highest comparison scenario only reaches 44GW by 2030. However, due to the modular nature, smaller project sizes, and quicker development timelines of solar PV, we have categorised this as ‘very challenging’.
Nuclear	9.8GW	Red	The highest comparison scenario reaches 4.6GW by 2030. Given the long lead time to build nuclear generators, an additional 5.2GW of nuclear by 2030 was deemed infeasible.
Generation with CCS	11GW	Green, Amber	Highest comparison scenario reaches 3.5GW by 2030 and a lot of infrastructure is required to be built in the next 6 years. However, there is a significant pipeline of projects.
Hydrogen-fuelled generation	5GW	Green, Amber	Highest comparison scenario reaches 4.7GW by 2030 but a lot of infrastructure is required to be built in the next 6 years.
Transmission	N/A	Red	Given the long lead times for transmission build, we do not think accelerated transmission reinforcements beyond the already ambitious plans set out by the system operator are feasible.
Storage	16GW	Green	Lower than comparison scenarios.

Red: Infeasible Amber: Very challenging Green: Challenging but plausible

1. To assess feasibility, we have compared the 2030 values in the Accelerated scenario to those in the following comparison scenarios: Amended CCC; and FES 2023 ST, CT and LtW.

We have adjusted infeasible and very challenging metrics to create a challenging but feasible scenario – the Net Zero Power scenario

Direction of change	Metric	Accelerated scenario[1]	Net Zero Power scenario[1]	Approach to adjustments
↓	Demand	485TWh	383TWh	2030 demand in the Net Zero Power scenario is amended to be in line with 2030 demand in the Amended CCC scenario. Main reductions were in base demand (59TWh) and electric vehicle (EV) demand (25TWh).
↓	Solar capacity	70GW (~65TWh)	44GW (~41TWh)	Reduced solar capacity to be in line with 2030 capacity in the Amended CCC scenario. Demand reductions allow for some reduction in generation.
↓	Offshore wind	55GW (~246TWh)	51GW (~228TWh)	Reduced offshore wind capacity to be in line with Amended CCC scenario. Demand reductions allow for some reduction in generation. Capacity removed from areas with large volumes of curtailment.
—	Onshore wind	28GW (~93TWh)	28GW (~93TWh)	No change in total capacity, but around 2GW of new onshore wind relocated from areas with a lot of curtailment (i.e. Scotland) to areas with less (i.e. England and Wales). This requires a change in planning regulations.
↓	Transmission reinforcement			Reduced to Amended CCC 2030 grid reinforcements. To try and reduce the impact this will have on curtailment, we have re-located some of the wind capacity (see above).
↓	CCS	12GW (~51TWh)	11GW (~41TWh)	Demand reductions allow for some reduction in generation. Biomass CCS is generally a base generation and so likely to have a similar generation pattern to base demand.
↓	Nuclear capacity	9.8GW (~73TWh)	4.5GW (~34TWh)	Demand reductions allow for some reduction in generation. Nuclear likely to have similar generation patterns as base demand.

1. Generation is approximate based on the following assumed load factors: Solar - 11%; Offshore wind - 51%; Onshore wind - 38%; CCS gas - 37%; CCS biomass - 88%; nuclear - 85%.

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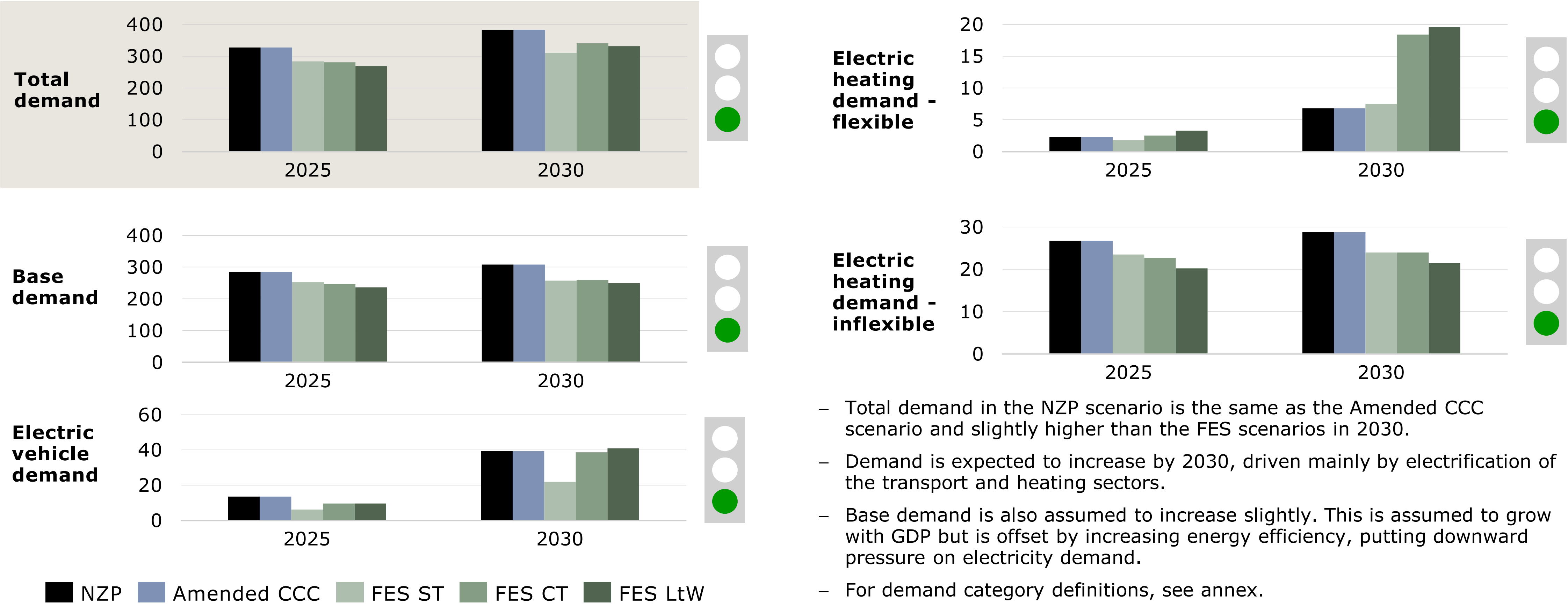
In the NZP scenario, power demand growth by 2030 is in line with the Amended CCC scenario

POWER DEMAND (TWh)



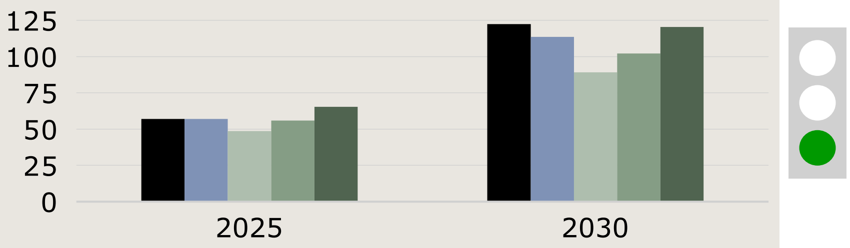
- Total demand in the NZP scenario is the same as the Amended CCC scenario and slightly higher than the FES scenarios in 2030.
- Demand is expected to increase by 2030, driven mainly by electrification of the transport and heating sectors.
- Base demand is also assumed to increase slightly. This is assumed to grow with GDP but is offset by increasing energy efficiency, putting downward pressure on electricity demand.
- For demand category definitions, see annex.

Note: Traffic light indicators reflect the scale defined previously on p.18.

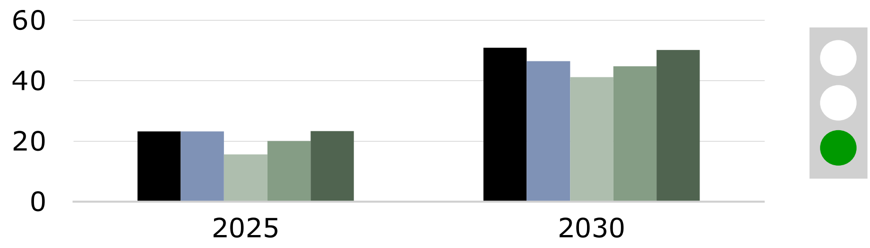
In the NZP scenario, intermittent renewable capacity growth is comparable to the most ambitious FES scenario

INSTALLED CAPACITY (GW)

Intermittent renewables



Offshore wind capacity



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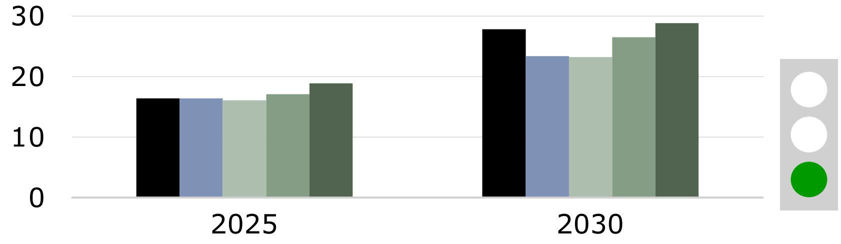
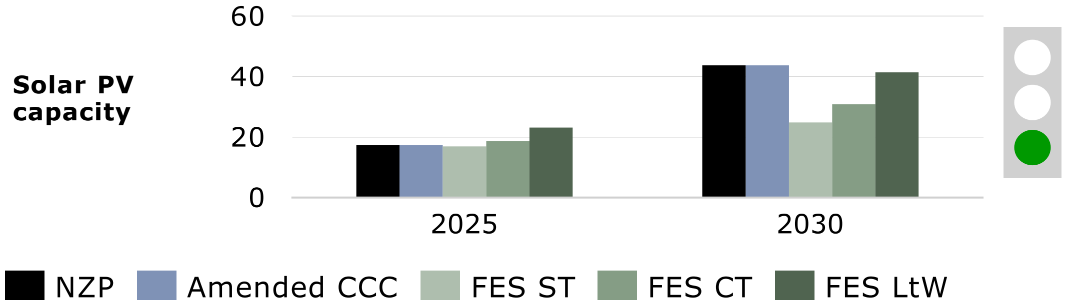


Solar PV capacity

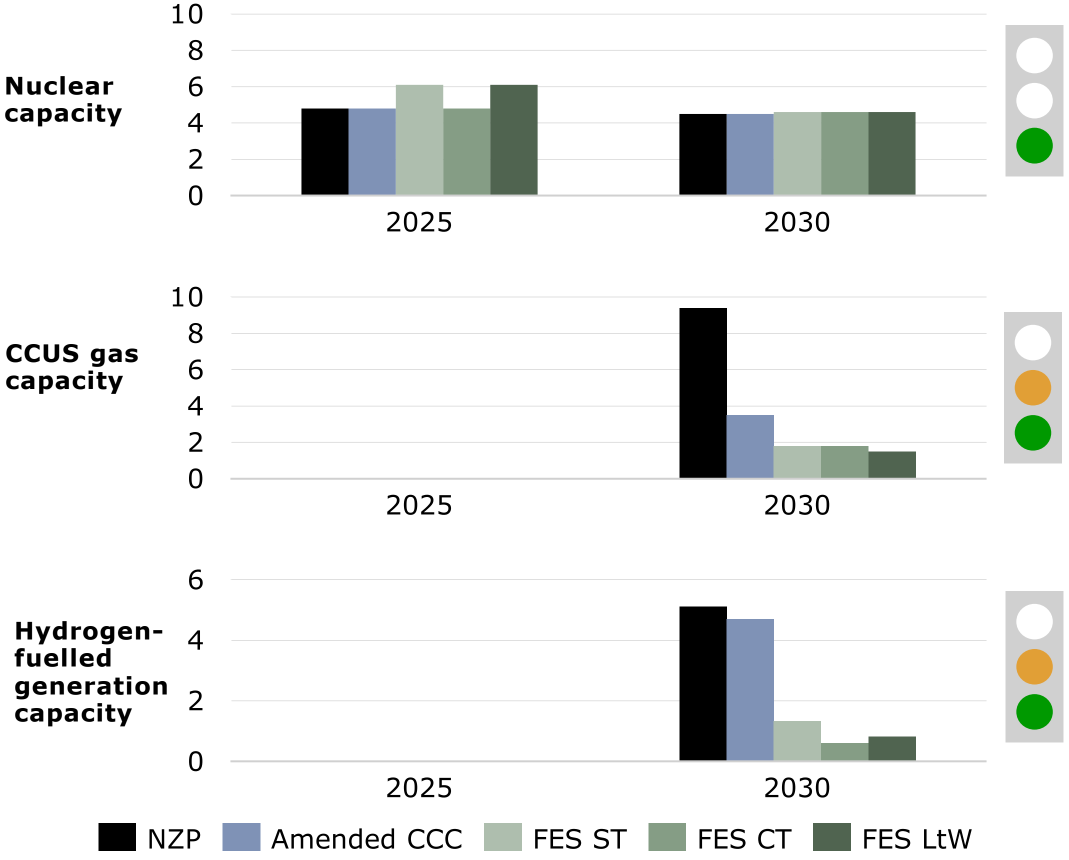


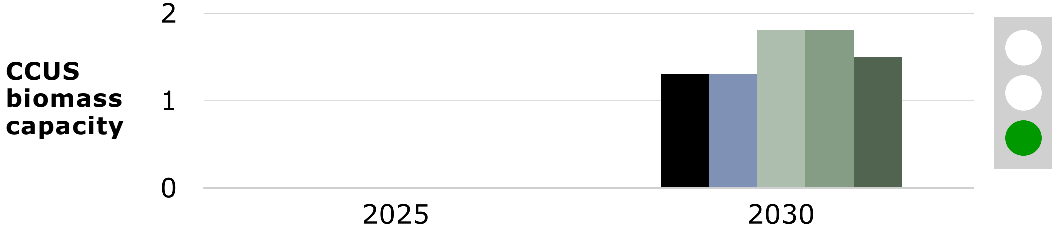
- **Intermittent renewable capacity growth is challenging but comparable to the most ambitious scenarios and targets.** 2030 capacities are comparable to the FES LtW scenario.
- **The fastest growth is required in offshore wind.** Operational offshore wind capacity more than triples from today's installed capacity by 2030. 51GW is just over the current target of 50GW.
- **Onshore wind capacity is around double the operational capacity installed today**, and slightly lower than FES LtW.
- **Significant growth is also required in solar PV capacity**. 2030 capacity is slightly greater than the FES LtW scenario and almost triple the operational capacity installed today.
- **Achieving this growth simultaneously across all technologies will be challenging.**

Note: Traffic light indicators reflect the scale defined previously on p.18.

The growth in low carbon thermal technologies is one of the most ambitious features of the NZP scenario

INSTALLED CAPACITY (GW)



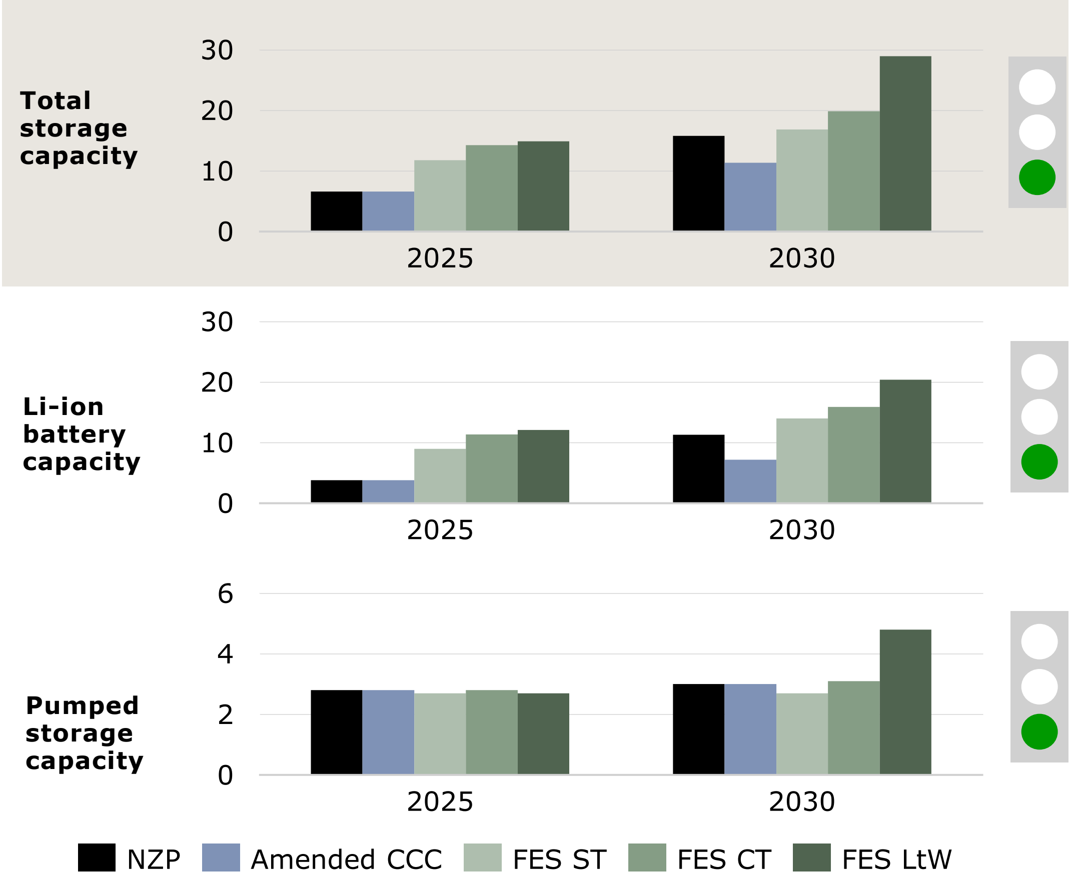


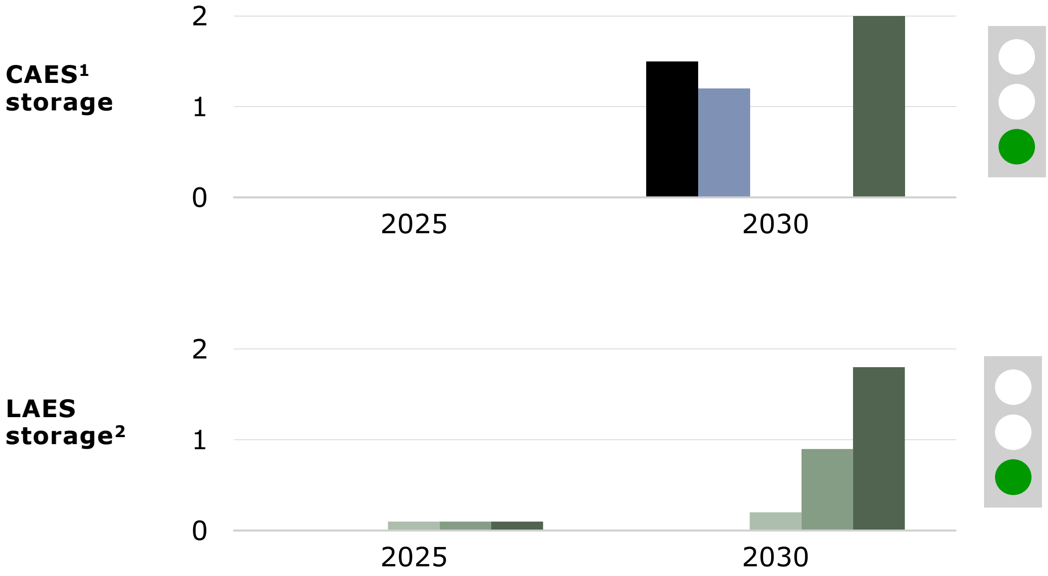
- **Gas-fired generation with Carbon Capture Utilisation Storage (CCUS) is much more ambitious than any of the comparison scenarios,** reaching 9.4GW by 2030. In addition, there is a large growth in hydrogen-fuelled generation capacity.
- **Both generation with CCUS and hydrogen-fuelled generation will require significant infrastructure to be built in the next 6 years**. Generation plants will need to be built or retrofitted; carbon and hydrogen will need to be transported; and the carbon will require storage facilities. We think this is very challenging.
- **There is flexibility in the split of capacity between gas-fired generation with CCUS, biomass-fired generation with CCUS and hydrogen-fuelled generation.** All technologies can provide the flexibility required in the electricity system. Biomass CCUS has the benefit of additional negative emissions, allowing for continued use of some unabated gas.

Note: Traffic light indicators reflect the scale defined previously on p.18.

Electricity storage levels in 2030 are generally lower than the most ambitious FES scenarios for both long and short duration storage

INSTALLED CAPACITY (GW)





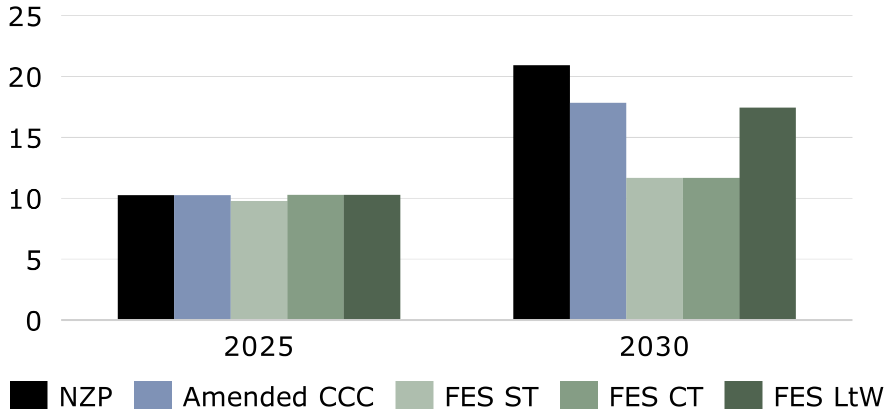
- **Storage capacity is lower than in most of the comparison scenarios.**
- **Lower levels of storage, and particularly long-duration storage, may partly reflect the higher capacities of low carbon dispatchable power generation and interconnection.** Some form of flexibility is required for a system with high levels of intermittent renewables but there is some flexibility in the exact form.

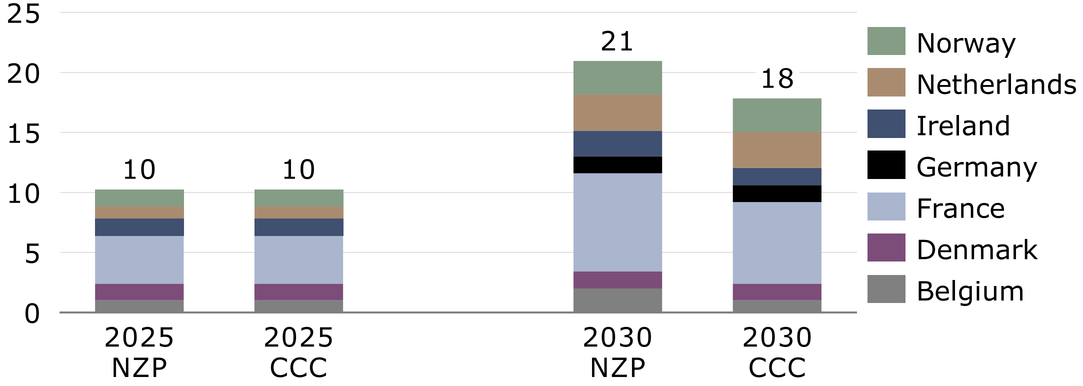
1. CAES: Compressed Air Energy Storage.
2. LAES: Liquid Air Energy Storage.

Note: Traffic light indicators reflect the scale defined previously on p.18.

The NZP scenario has around 3GW of additional interconnection compared to the Amended CCC scenario

TOTAL INTERCONNECTOR CAPACITY (GW)



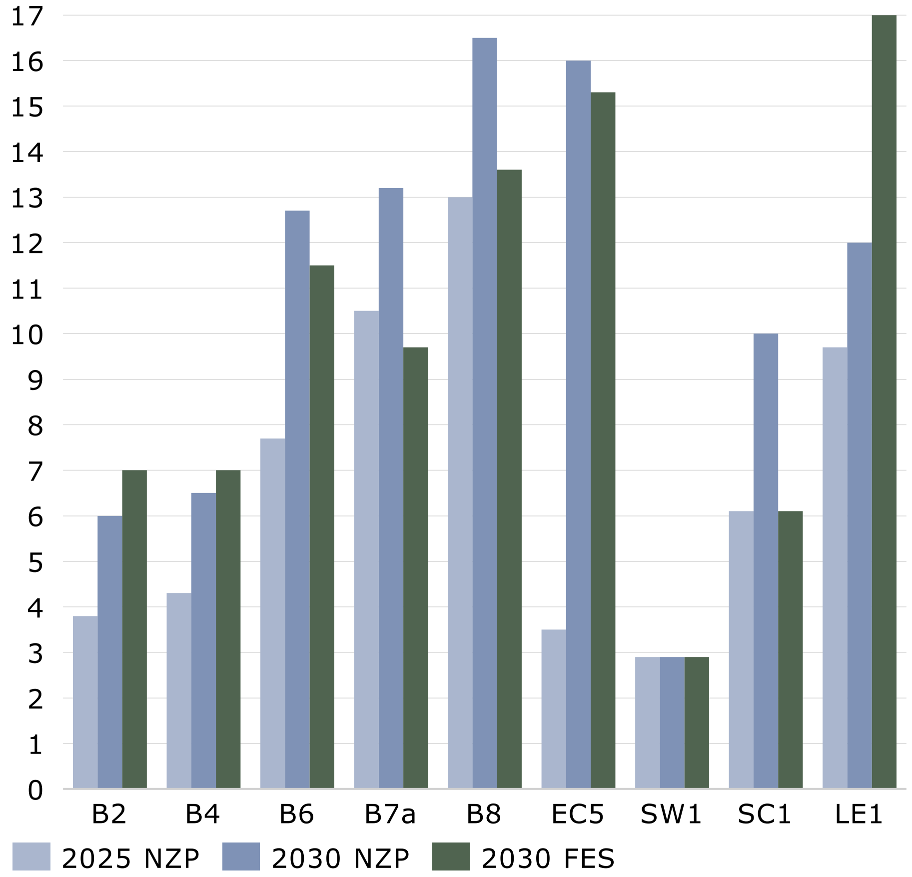


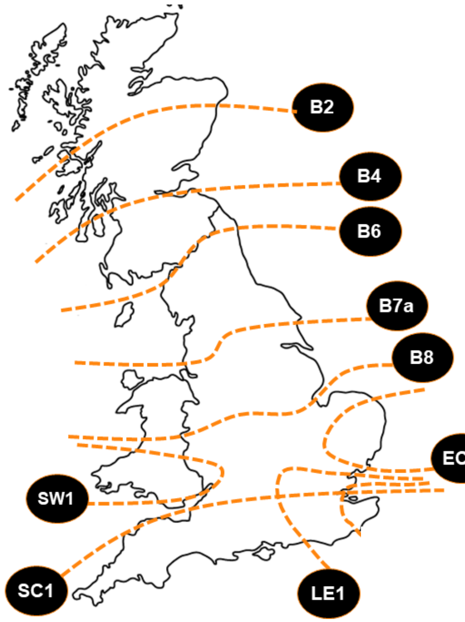
- **The Amended CCC scenario is bullish on future electricity connection to other markets**, matching the capacity in LtW.
- **The NZP scenario assumes a further 3GW of interconnection** (additions in interconnection to Ireland, France and Belgium).
- Ofgem's recent minded to decisions on applicants for Window 3 of the Cap and Floor regime is minded to approve two interconnectors (2.6GW) of the seven projects that applied[1]. Delays in interconnector capacity build may place additional requirements on storage solutions.

1. Initial Project Assessment of the third cap and floor window for electricity interconnectors, Ofgem, March 2024.

Transmission boundary capabilities in the NZP scenario are broadly similar to those in the FES 2023 scenarios

TRANSMISSION BOUNDARY CAPABILITIES (GW)



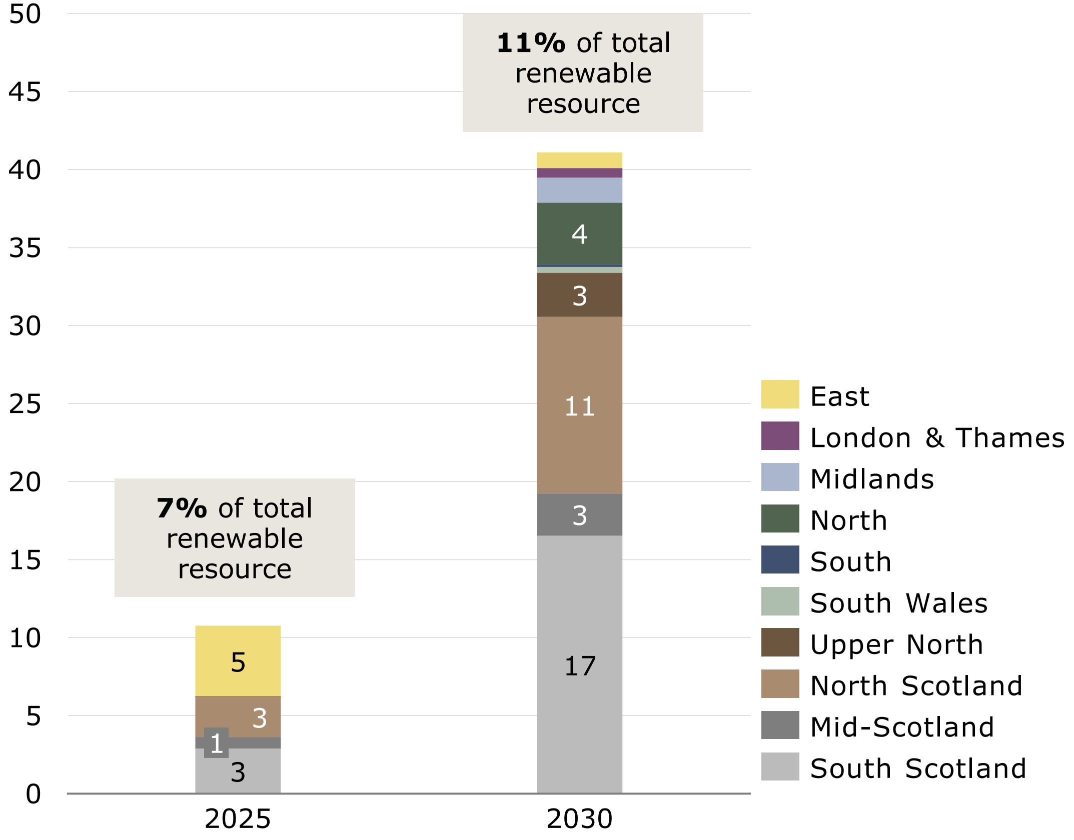


- National Grid Electricity System Operator (NG ESO) communicates the nature of transmission constraints to the market via the concept of boundaries.
- These are fictional lines across the country, which are assigned MW transfer capacities corresponding to their thermal capability.
- Whilst NG ESO identifies dozens of boundaries, we have shown nine major boundaries. These capture major transmission constraints that have a significant impact on the overall operation of the GB system.
- The NZP scenario assumes significant transmission reinforcements, particularly across areas expecting high wind capacity growth, such as the EC5 boundary and the B2, B4 and B6 boundaries.
- There is slightly more additional transmission build in the NZP scenarios than the FES scenarios, and the locations of the reinforcements are slightly different. However, we do not think this this represents a material enough difference in activity levels for this analysis.
- Work is currently ongoing to reduce the time to build transmission infrastructure from 12-14 years to 7 years[1]. As 2030 is 6 years away, we do no think further transmission reinforcements are feasible.

1. Transmission Acceleration Action Plan: Government Response to the Electricity Network Commissioner's report on accelerating electricity transmission network build, DESNZ, November 2023.

Renewables see high economic and transmission-based curtailment in 2030

INTERMITTENT RENEWABLE CURTAILMENT NZP SCENARIO (TWh)



– **Renewable curtailment is around 11% of the total renewable resource in the NZP scenario**. This includes both economic curtailment, and curtailment due to transmission constraints. Economic curtailment occurs when there is less demand than low marginal cost generation at the day-ahead stage, meaning renewables are out of merit.

– **These curtailment volumes are a conservative estimate.** These levels are dependent on being able to locate some new onshore wind on the less congested areas of the network. This requires 2GW of new onshore wind to be developed in England and Wales. Under current regulation, it is very difficult for onshore wind to secure planning permission in England.

– **We expect some of this curtailment to be transitory as network reinforcement is expected to continue beyond 2030.**

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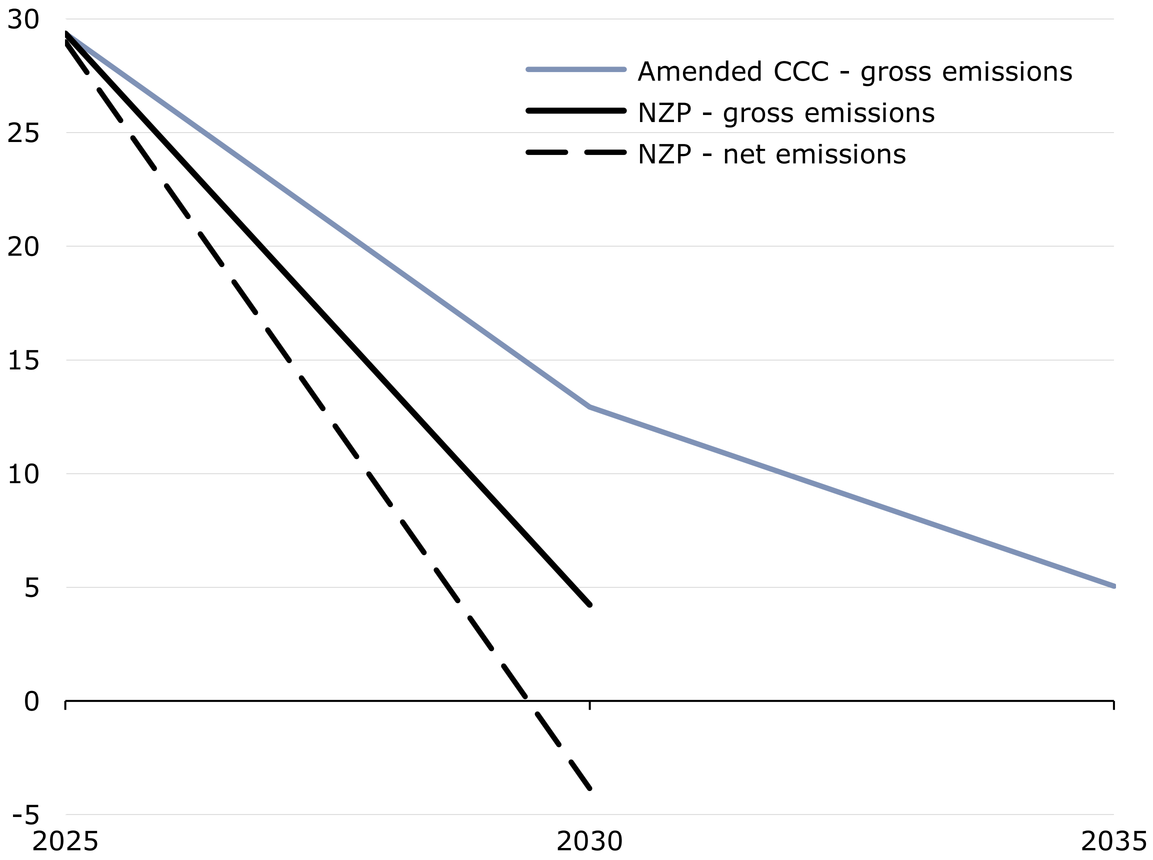
The Net Zero Power scenario reaches very low emissions by 2030

POWER SECTOR CARBON EMISSIONS ($MtCO_2$/year)



– **Gross power sector emissions (excluding negative emissions[1]) in the scenario, reach around 4mtCO_2/year in 2030.** This equates to a gross emissions intensity of around 10gCO_2/kWh.

– **These gross emission levels are consistent with the point where nearly all generation is coming from low carbon sources other than small amounts needed for security of supply.** This is consistent with the current target for all electricity to be fully decarbonised, subject to security of supply[2], but achieved in 2030 rather than 2035.

– **Net power sector emissions (accounting for negative emissions) in 2030 are -3.9mtCO_2/year**, demonstrating that the NZP scenario is net zero. The source of negative emissions is generation from the 1.3GW of biomass-fuelled generation with CCUS by 2030.

1. Net Zero Strategy: Build Back Greener, October 2021, Department for Energy Security and Net Zero and Department for Business, Energy & Industrial Strategy.

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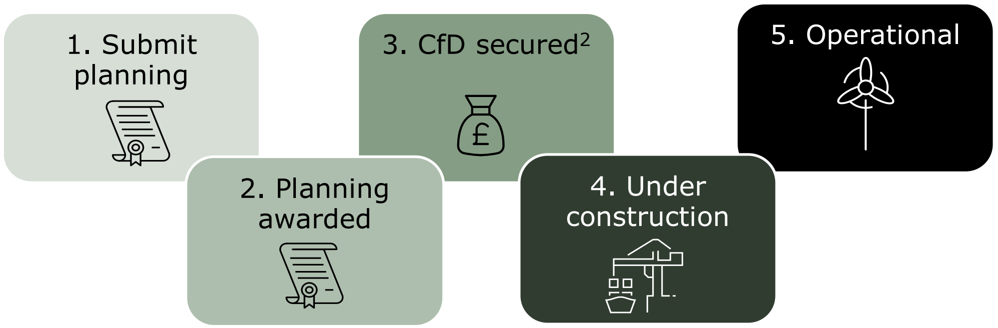
We have used the current pipeline of generation technologies to assess required annual rates for consents, subsidies and deployment

METHODOLOGY[1]

To assess the requirements to achieve net zero power in 2030, we have:

- Made assumptions on the time to operation from various development milestones (see annex for assumptions). These assumptions are based on industry data.
- Based on this and the current capacities of projects at each development milestone, we have determined the average annual rate capacity is required to reach each milestone. This is an annual average and does not consider when plants already in the development pipeline will be ready to reach the next stage.
- We have also assessed the annual rates for consents, subsidies and deployment to each net zero by 2035 as a comparison – see annex.

EXAMPLE DEVELOPMENT MILESTONES



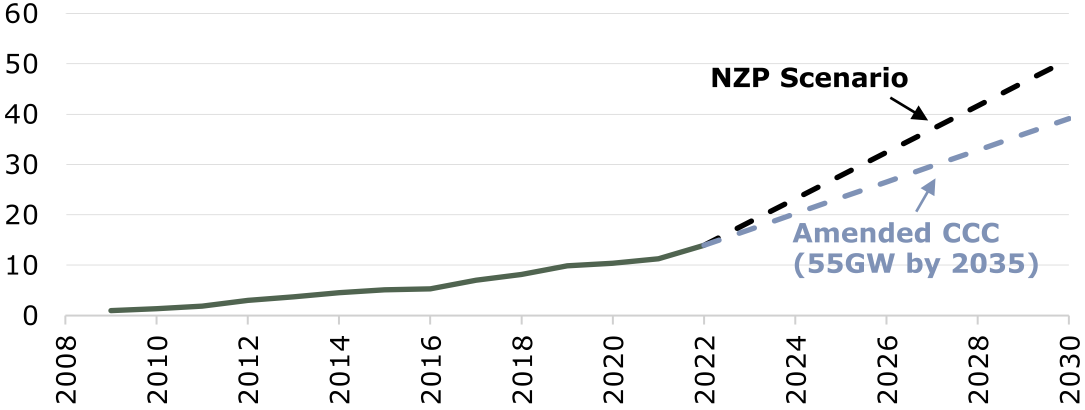
RENEWABLE ASSUMPTIONS

- For offshore wind, onshore wind and solar PV we have assumed 6, 6 and 4 years respectively from planning submitted to operation.
- For offshore wind, timelines assumed are slightly faster than average historical development timelines in Great Britain. To reach 50GW by 2030, some offshore wind capacity still needs to submit planning. These plants only have 6 years to reach operation by 2030.
- For solar PV, these timelines are slightly extended compared to historical averages. There are two reasons for this:
    - We are assuming most plants require a CfD. CfD auctions are annual, and so may extend development timelines compared to historical timelines when subsidies could be accessed throughout the year.
    - Generally, we expect individual solar PV plants to be larger than historically. Larger plants may have longer development timelines due to more complex planning.

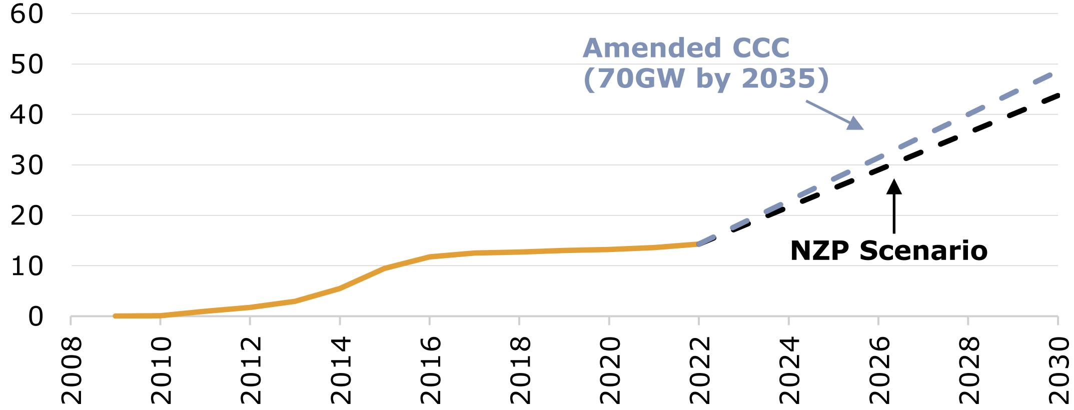
1. For full methodology, see Annex.
2. Based on delivery years for solar PV of Allocation Round 6 CfD.

All intermittent renewables need to achieve and maintain deployment rates comparable to or higher than historical maximum deployment rates

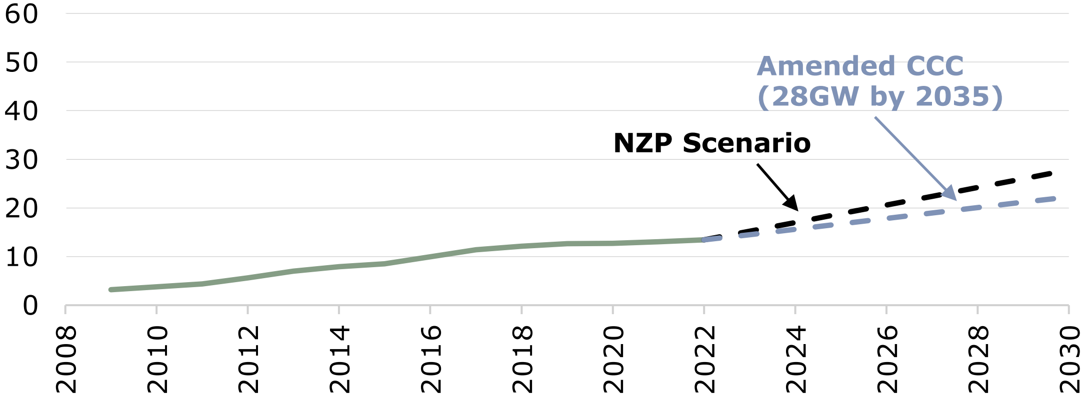
GB OFFSHORE WIND GROWTH VS HISTORICAL[1] (GW)



GB SOLAR PV GROWTH VS HISTORICAL[1] (GW)



GB ONSHORE WIND GROWTH VS HISTORICAL[1] (GW)



- **More than 10GW of intermittent renewables will need to be deployed per year.** Average deployment rates for all intermittent renewables will need to be comparable or higher than the maximum observed historically and built simultaneously.
- **Offshore wind deployment rates will need to almost double 2022's peak.** Almost 5GW / year is required whereas a record of 3GW became operational in 2022.
- **Required deployment rates for onshore wind and solar PV are broadly in line with the peak industry has achieved historically.** However, these have not been sustained over long periods

1. Renewable electricity capacity and generation (ET 6.1 – quarterly), Department for Energy Security and Net Zero, December 2023.

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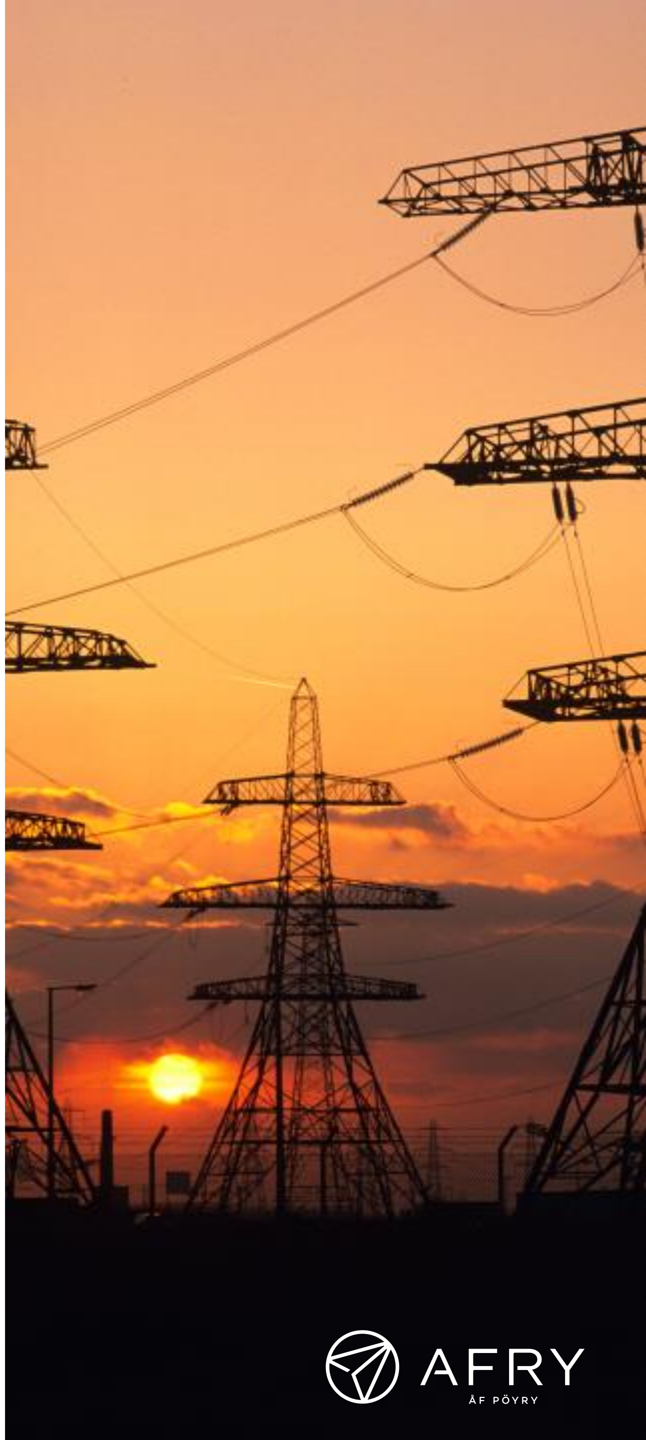
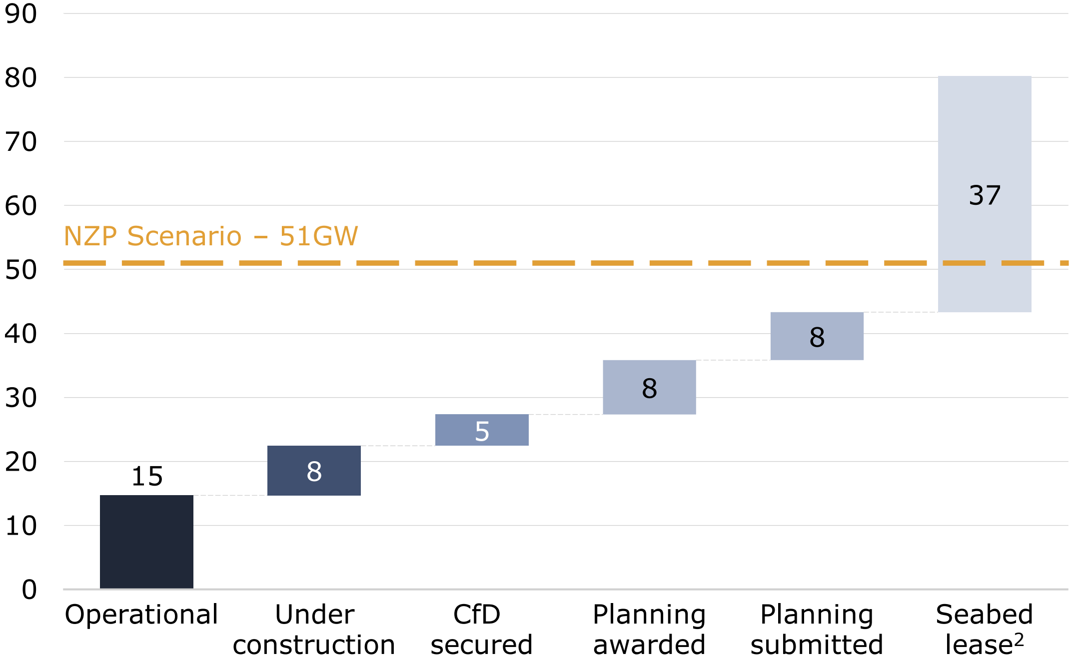


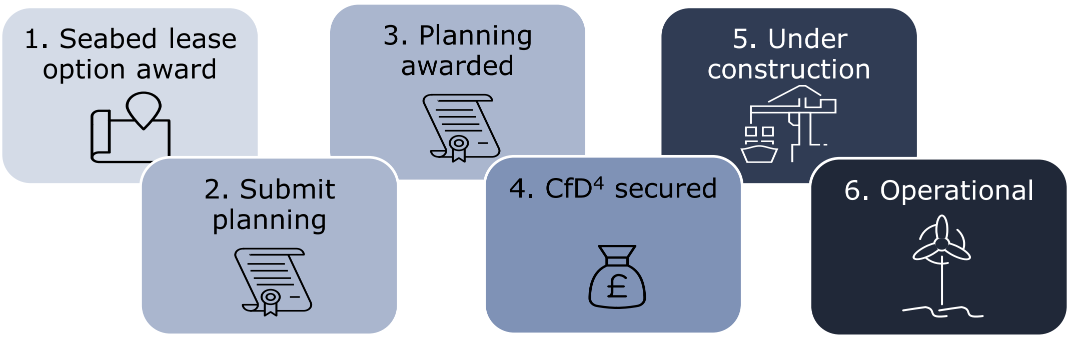
To achieve 51GW of offshore wind by 2030, rapid development of the offshore wind pipeline is required

CURRENT PIPELINE OF OFFSHORE WIND PROJECTS IN GREAT BRITAIN[1] (GW)



Historical avg. years until fully operational[3]	Under construction	CfD secured	Planning awarded	Planning submitted	Seabed lease
	~2		~5	~7	

KEY MILESTONES FOR MOST OFFSHORE WIND DEVELOPMENT



– **An additional 36GW of offshore wind must be operational by 2030.** There is currently 15GW operational and the Net Zero Power scenario achieves 51GW by 2030.

– **Development timelines are expected to be the main barrier.** There is currently a large pipeline of offshore wind projects – around 80GW[2] in total. However, historically offshore wind can take over 10 years to be fully operational from seabed lease.

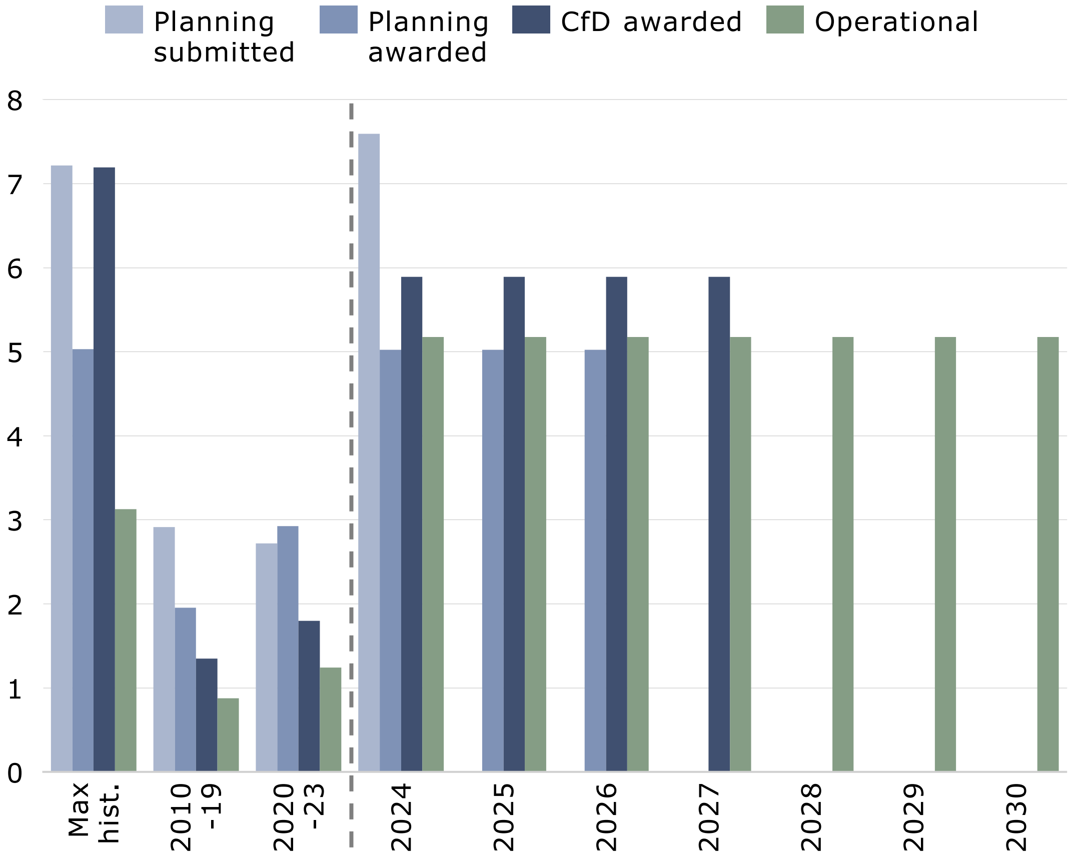
– **At least 7.6GW of projects are required to submit planning applications this year.** If all projects that have submitted planning are operational by 2030, this will only deliver a total installed capacity of 43GW by 2030.

1. Source: Renewable Energy Planning Database: quarterly extract, January 2024, DESNZ.
2. Projects which have been awarded a seabed lease option award. This does not include projects that received a seabed lease option through the INTOG seabed leasing round.
3. Weighted by capacity and based on all operational plants in the Renewable Energy Planning Database: quarterly extract, October 2023, DESNZ. Note this includes projects pre-dating the CfD.
4. CfD – Contract for Difference. This is currently the main subsidy for new offshore wind plants in GB.

Development timelines and the scale of construction are both ambitious to reach 51GW offshore wind by 2030

51GW BY 2030 (NZP SCENARIO)[1]

Average additional capacity required to enter development stage (GW/year)



1. Source: Renewable Energy Planning Database: quarterly extract, January 2024, DESNZ. Where partial plant capacities are awarded a CfD, the capacity shown 'CfD awarded' relates to the nameplate capacity.

- The timelines for submitting planning applications, consenting and securing a subsidy remain as serious bottlenecks for offshore wind.
- **7.6GW of offshore wind submitting planning applications this year is possible**. Based on data from the Planning Inspectorate website, more than 8GW of Leasing Round 4 and extension projects are expected to submit planning applications in 2024.
- **The average planning consent rate since 2020 needs to almost double for offshore wind**. Historically, the planning consent rate has been ~3GW per year. In the Net Zero Power scenario, over 5GW of planning approvals are required per year until 2027. This consenting rate has been seen historically, but not consistently.
- **Capacity awarded through the CfD will need to more than double.** Around 5.9GW needs to clear in each of the next 4 annual auctions (AR6 – AR9). From 2014 to 2022, an average of around 2.3GW offshore wind have cleared per year (although auctions were previously held biennially).
- **Future unsuccessful auctions are a risk but mitigated by Government increasing strike price caps.** In the latest CfD auction held in 2023 (AR5), no offshore wind cleared due to low strike price caps. However, for AR6, strike price caps have been revised upwards significantly. Based on the budget notice for AR6, 3GW offshore wind is the minimum likely to clear.

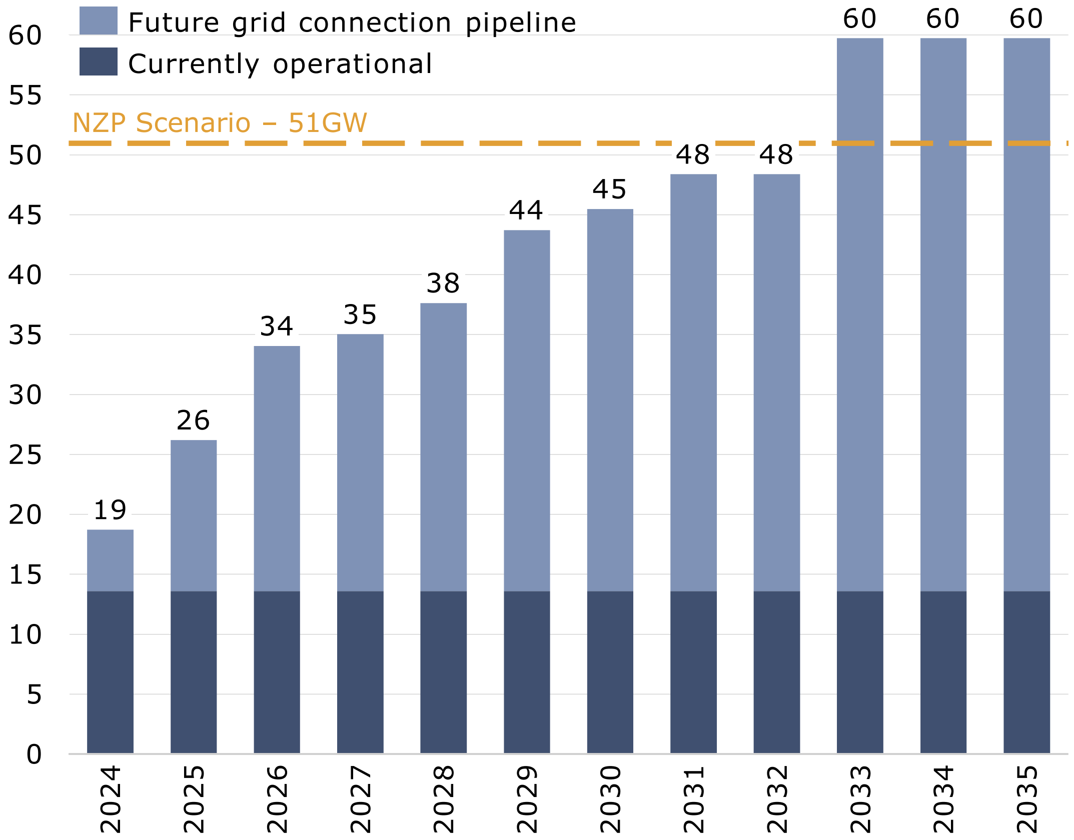
OFFSHORE WIND CFD AWARD RESULTS TO DATE[2] (GW)

FIDeR (2014)	AR1 (2015)	AR2 (2017)	AR3 (2019)	AR4 (2022)	AR5 (2023)
3.2	1.2	3.2	5.5	7.0	0.0

2. Years in brackets state the year when auction results were published. Where partial capacities are awarded CfDs, the capacities show only the partial capacity awarded a CfD. AR: Allocation Round. FIDeR: Final investment Decision enabling for Renewables.

Only 45GW of offshore windfarms currently being developed have grid connections by 2030 – a minimum of 6GW will need to be brought forward

CUMULATIVE GRID CONNECTION DATES OF OFFSHORE WIND IN THE PLANNING PIPELINE (GW)



- Currently, only 45GW of offshore windfarms in the pipeline have grid connection agreements by 2030.
- **At least 6GW of projects grid connections will need to be brought forward to achieve 51GW.** In reality, grid connections for projects totalling more than 6GW will need to be brought forward as many projects are likely to encounter delays due to planning, construction, and being unsuccessful in the CfD.

Sources: Transmission Entry Capacity (TEC) register, National Grid ESO; Renewable Energy Planning Database: quarterly extract, October 2023, DESNZ.

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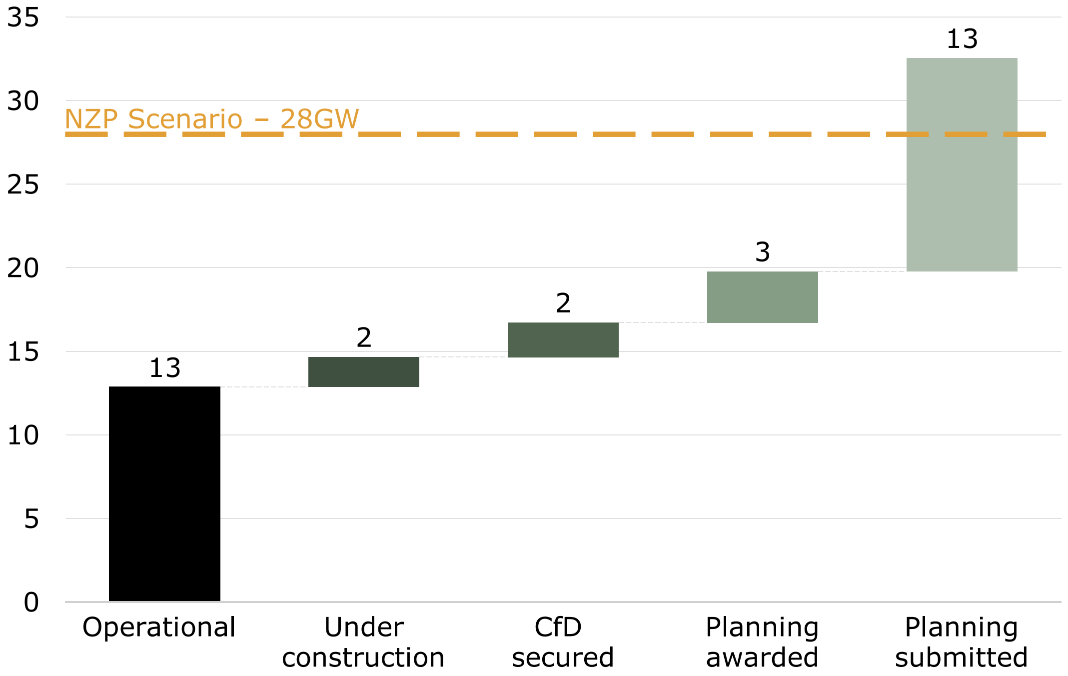
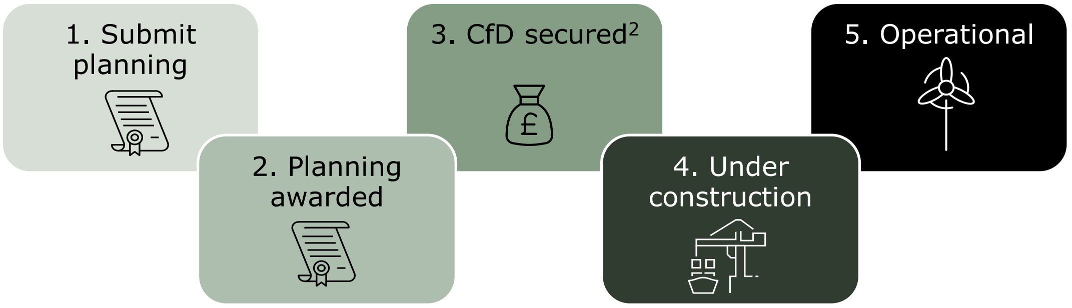
To achieve 28GW of onshore wind by 2030, a significant proportion of the planning applications submitted will need to be approved

CURRENT PIPELINE ONSHORE WIND PROJECTS IN GREAT BRITAIN[1] (GW)



Historical avg. years until fully operational[2]	Under construction / CfD secured	Planning awarded	Planning submitted
	~1-2	~4	~6

KEY MILESTONES FOR ONSHORE WIND DEVELOPMENT



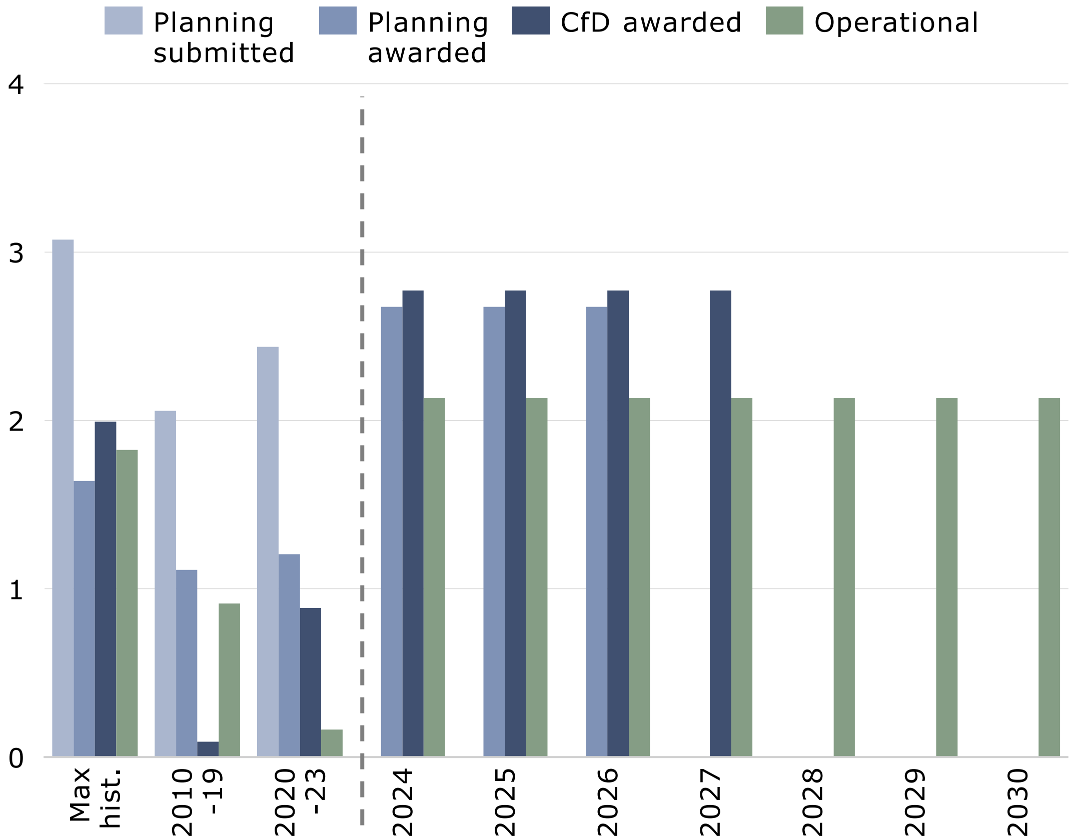
- **An additional 15GW of onshore wind needs to be operational by 2030.**
- As shown in the figure, **there is sufficient capacity already within the planning process to exceed this requirement.**
- **The major risk is approval rates and speed of award of the 13GW with planning submitted.** Around 60% of those with planning submitted will need to have planning awarded by the end of 2026. Historically, approval rates for onshore wind have been around 40%[3].

1. Renewable Energy Planning Database: quarterly extract, January 2024, DESNZ.
2. Weighted by capacity and based on all operational plants in the Renewable Energy Planning Database: quarterly extract, October 2023, DESNZ. Note this includes projects pre-dating the CfD.
3. Based on data from the REPD, 40% of onshore wind projects that have submitted planning are now operational, under construction, or awaiting construction. This does not include potential reductions in capacity due to planning restrictions.

The consenting process is the main bottleneck for onshore wind, CfD auctions will also need to increase the capacity procured in each auction

28GW BY 2030 (NZP SCENARIO)[1]

Average additional capacity required to enter development stage (GW/year)



- **The biggest bottleneck for onshore wind is increasing the planning consenting rates.** The average planning consenting rate will need to more than double compared to the rate from 2020-2023. An average of over 2.6GW of planning applications need to be approved each year. Since 2020, only ~1.2GW of onshore projects have received planning consents per year.
- **Over 2.7GW of onshore wind capacity also needs to clear each of the next four CfD auctions**, assuming most projects require a CfD to reach financial close. Since the inception of the CfD scheme, AR5 has been the most successful for onshore wind, with ~1.7GW of projects clearing.

ONSHORE WIND CFD AWARD RESULTS TO DATE[2] (GW)

AR1 (2015)	AR2 (2017)	AR3 (2019)	AR4 (2022)	AR5 (2023)
0.7	N/A	0.3	1.5	1.7

1. Source: Renewable Energy Planning Database: quarterly extract, January 2024, DESNZ. Where partial plant capacities are awarded a CfD, the capacity shown for ‘CfD awarded’ relates to the nameplate capacity.
2. Years in brackets state the year in which auction results were published. Where partial capacities are awarded CfDs, the capacities show only the partial capacity awarded a CfD.

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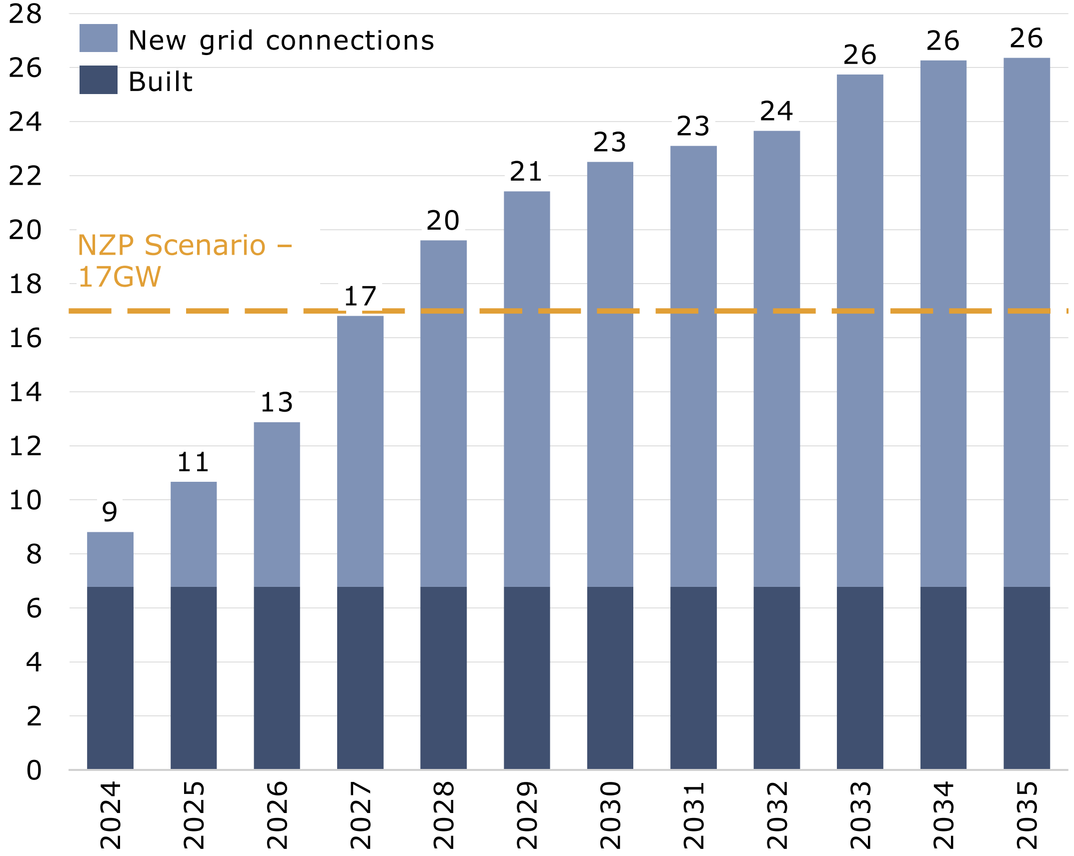
There is enough cumulative capacity of grid connections for transmission connected onshore wind, but these are unlikely to be for the correct projects

CUMULATIVE ONSHORE WIND GRID CONNECTION DATES WITH NATIONAL GRID ESO (GW)



- Operating onshore wind is either connected to the transmission grid or the distribution grid. Windfarms connected to the distribution grid may not have a bilateral connection agreement with National Grid ESO. Around 75% of operating onshore wind capacity in Scotland, and 5% of capacity in England and Wales have direct agreements with National Grid ESO[1].
- **There may be sufficient transmission grid connection contracts, but these are unlikely to be for the correct projects.** The graph shows the capacity of onshore windfarms with contracts with the ESO (either directly connected to the transmission network or making use of it). Assuming the historical ratio for new capacity requiring contracts with the ESO is the same as the ratio of operational plants, around 17GW (existing and new) require a connection agreement with National Grid ESO in the NZP scenario for 2030 or before. However:
  - these connections may not be associated with the plants that are progressing through the development pipeline; and
  - as onshore wind projects get larger, a greater proportion may be required to have connection agreements with National Grid ESO.
- **It remains uncertain whether the remaining 5GW of new windfarms under development assumed to be seeking agreements with the distribution network operators will be able to connect by 2030**.

1. Based on the capacity of built grid connections in the Transmission Entry Capacity register (February 2024), NGESO, and the capacity of operational projects in Renewable Energy Planning Database: quarterly extract, January 2024, DESNZ.

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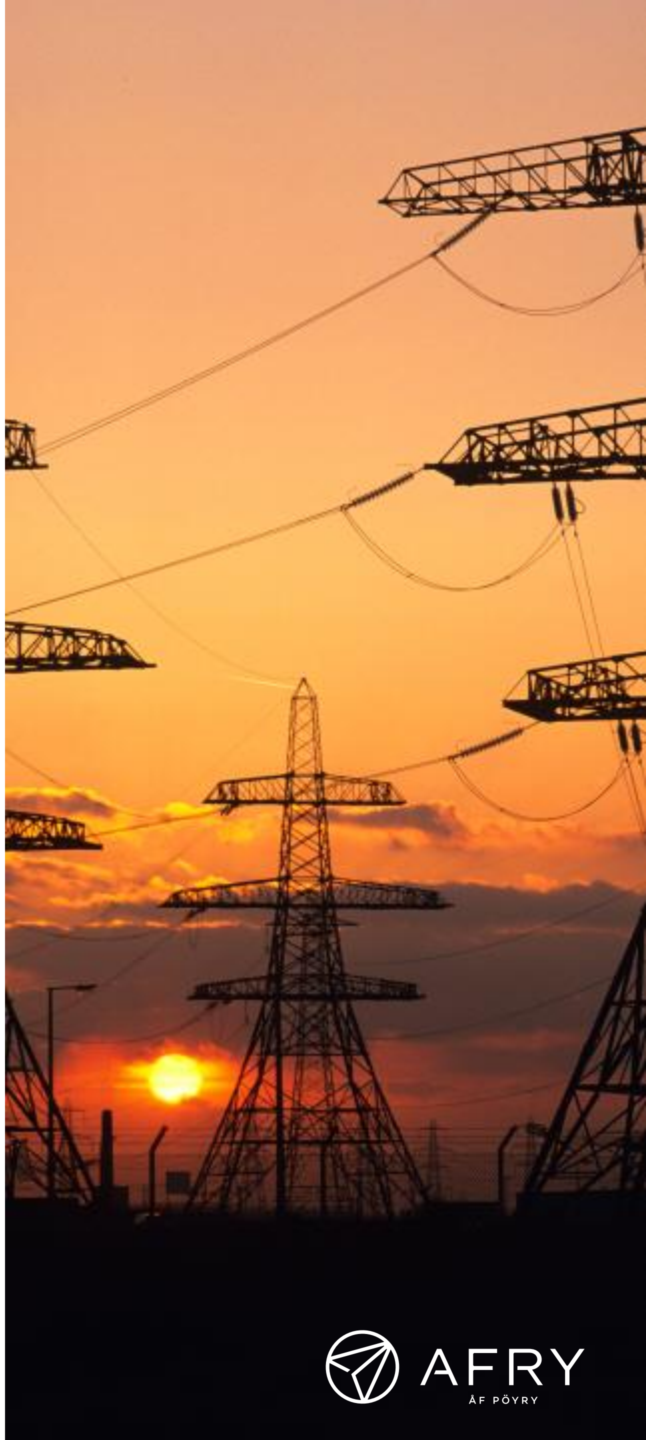
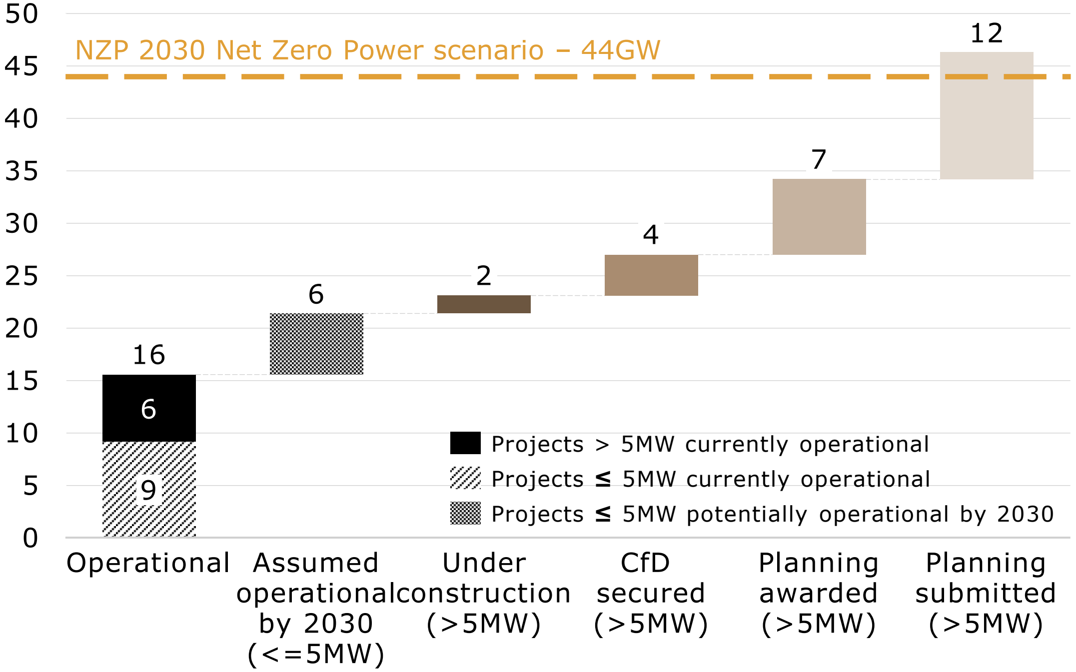


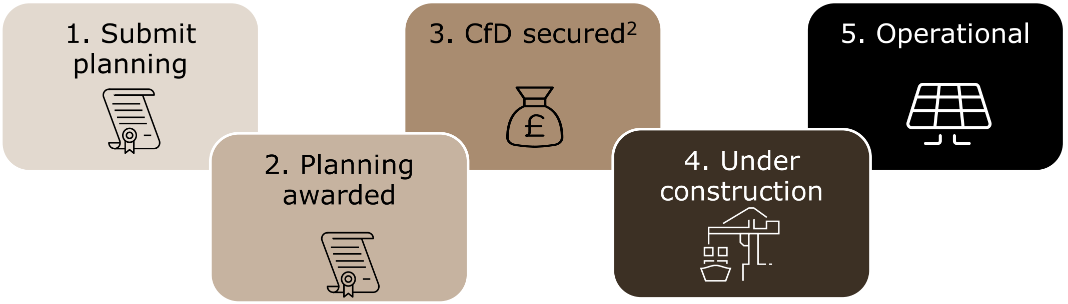
There is sufficient solar PV under development to reach 44GW by 2030, but a high rate of small-scale solar PV deployment must be maintained

CURRENT PIPELINE SOLAR PV PROJECTS IN GREAT BRITAIN[1] (GW)



Historical avg. years until fully operational[2]	<1	~1	~2

KEY MILESTONES FOR SOLAR PV DEVELOPMENT



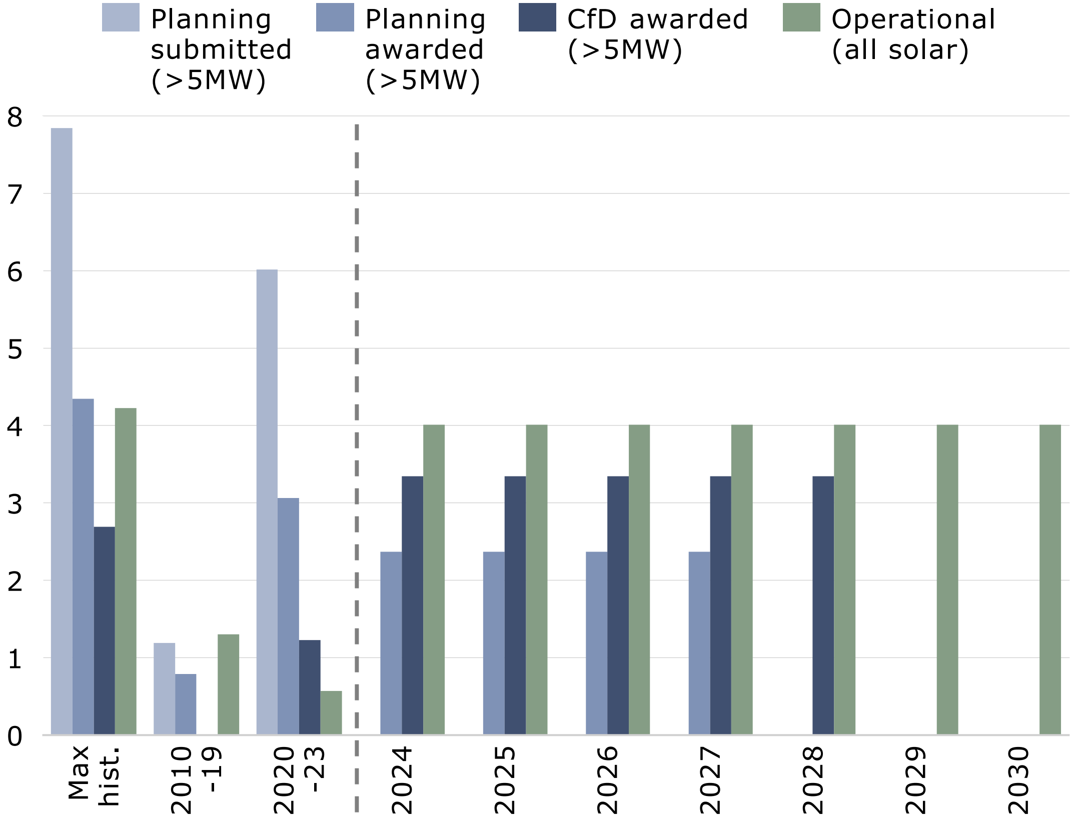
- **An additional 28GW of solar PV needs to be operational by 2030.**
- **There is sufficient capacity already within the planning process to exceed this requirement.** As solar PV has relatively fast development timelines, further solar projects can also submit planning applications.
- **A high installation rate for small-scale solar PV (≤5MW) must be maintained (~800MW / year).** This was observed in 2023 but was much higher than previous years. There is a risk this rate of solar deployment is not maintained as high electricity prices in 2023 may have increased the rate of small-scale solar deployment.
- Historically, development timelines for solar PV have been relatively fast and so are expected to be less of hurdle. However, future timelines may increase, as assumed in this analysis. The average capacity of plants with planning submitted is 55MW compared to 17MW for operational plants. Larger plants may have more complex planning which could increase development timelines.

1. Source: Renewable Energy Planning Database (REPD), January 2024; Solar Photovoltaics Deployment, DESNZ, January 2024.
2. Weighted by capacity and based on operational plants >5MW in the Renewable Energy Planning Database: quarterly extract, October 2023, DESNZ. Note this includes projects pre-dating the CfD.
3. We have no clear view on the pipeline of solar PV projects under 5MW. Assumed addition of 6GW by 2030 assumes the annual capacity addition in 2023 repeats each year.

The main bottleneck for solar PV is increasing the capacity awarded contracts in the CfD allocation rounds

44GW BY 2030 (NZP SCENARIO)[1]

Average additional capacity required to enter development stage (GW/year)



– **The greatest challenge for solar PV deployment is increasing the capacity awarded contracts in the CfD.** Over 3GW[2] of solar PV must be awarded contracts in each of the next 5 allocation rounds. Historically, the maximum capacity of solar PV awarded contracts in one CfD round is 2.2GW in AR4.

– **The current consenting rate of planning applications should be continued.** The consenting rate over the last 3 years is in line with the rate required for the next 4 years.

SOLAR PV CFD AWARD RESULTS TO DATE[3] (GW)

AR1 (2015)	AR2 (2017)	AR3 (2019)	AR4 (2022)	AR5 (2023)
0.07	N/A	N/A	2.2	1.9

1. Source: Renewable Energy Planning Database: quarterly extract, January 2024, DESNZ. Where partial plant capacities are awarded a CfD, the capacity shown for 'CfD awarded' relates to the nameplate capacity.
2. Assuming all solar PV requires a CfD to reach financial close. In reality, some plants may acquire corporate PPAs, or trade as merchant plants instead.
3. Years in brackets state the year in which auction results were published. Where partial capacities are awarded CfDs, the capacity shown is the partial capacity awarded a CfD.

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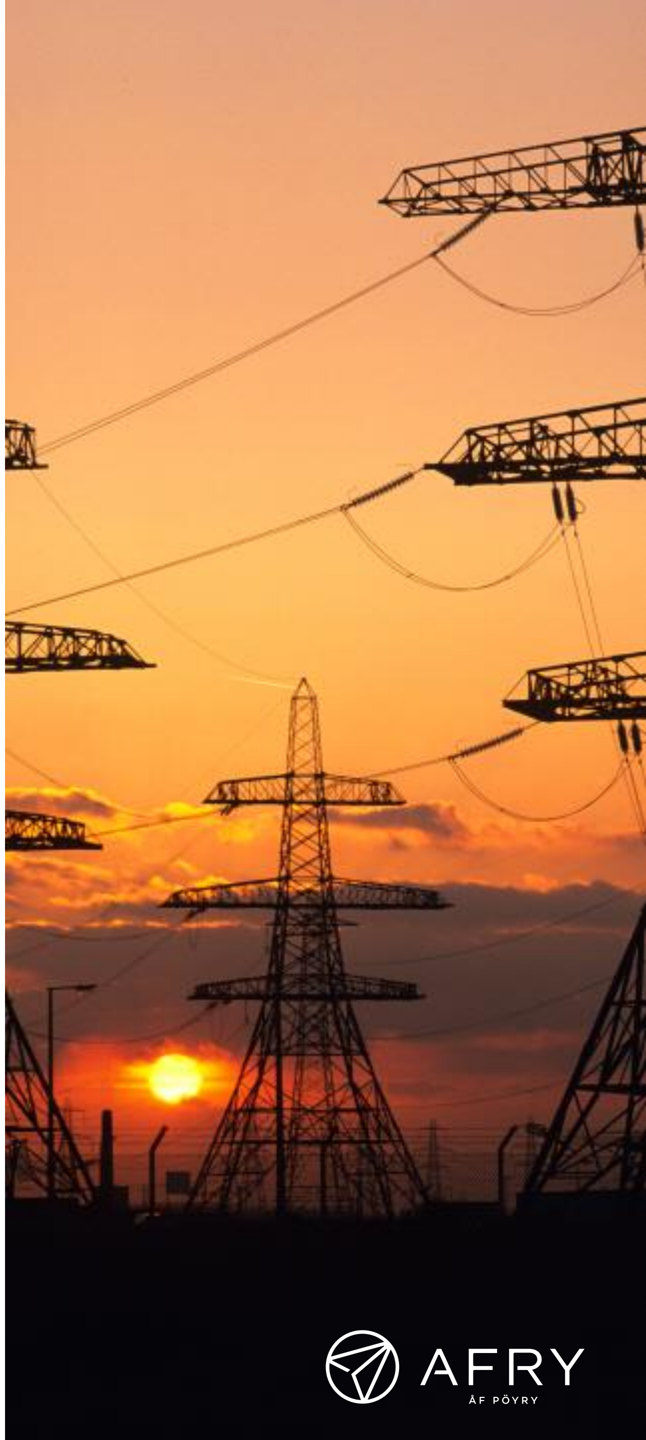
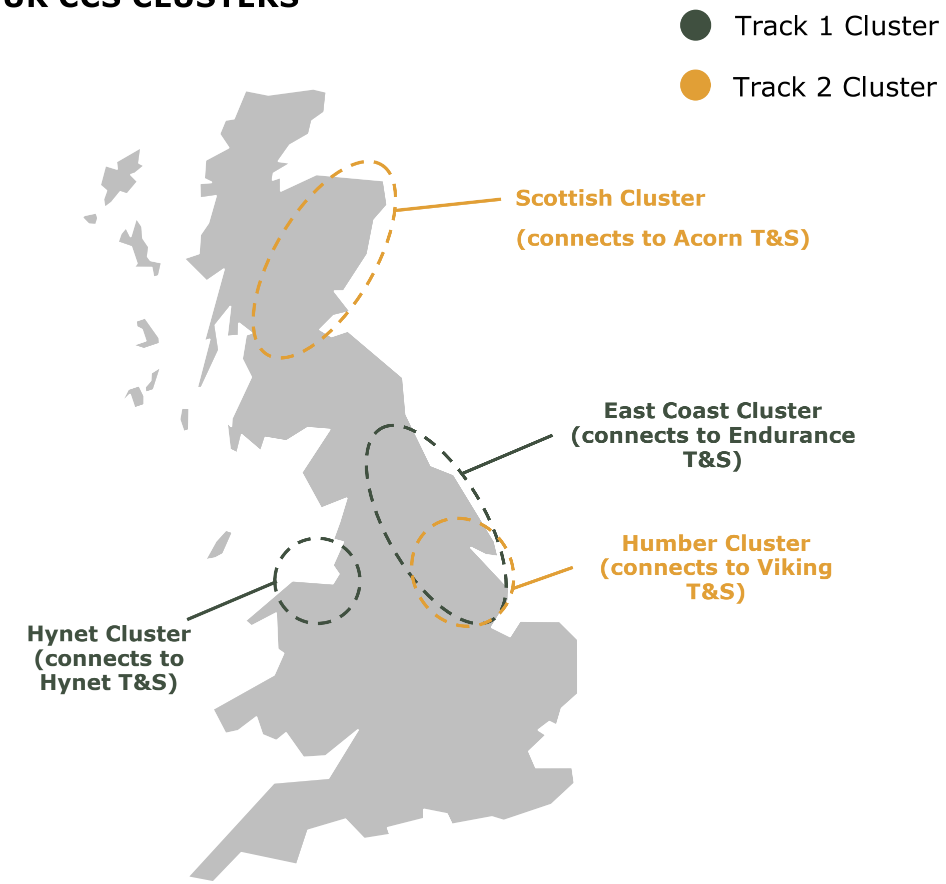


Current Government policy on Carbon Capture Usage and Storage (CCUS) is based on delivering four CCUS clusters by 2030

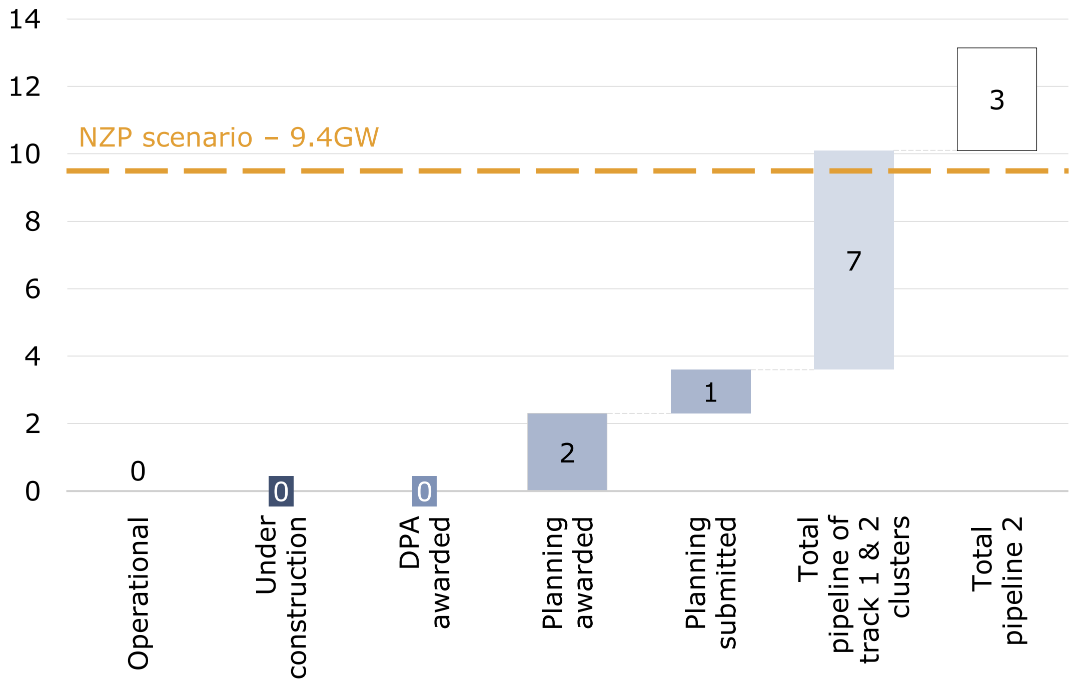
THE FOUR CCS CLUSTERS



- The NZP scenario CCUS power generation requirements depend on successful development of the industrial cluster schemes.
- The current roadmap sees development of these through a twin track process. Current UK Government targets for CCUS include:
  - Delivery of 2 CCUS clusters by the mid-2020s (Track 1 clusters) and 2 more by 2030 (Track 2 clusters); and
  - A capture rate of 20-30MtCO_2/year by 2030.
- Negotiations for Track 1 clusters are underway and Track 2 applications are expected to open in 2024.
- Government's ambition is to start supporting Track 1 clusters by the mid-2020s and Track 2 by 2028/29.
- Currently, only one power generation CCUS project is under negotiation (see annex).

To achieve 9.4GW of gas-fired generation with CCUS by 2030, rapid development of the power CCUS pipeline is required

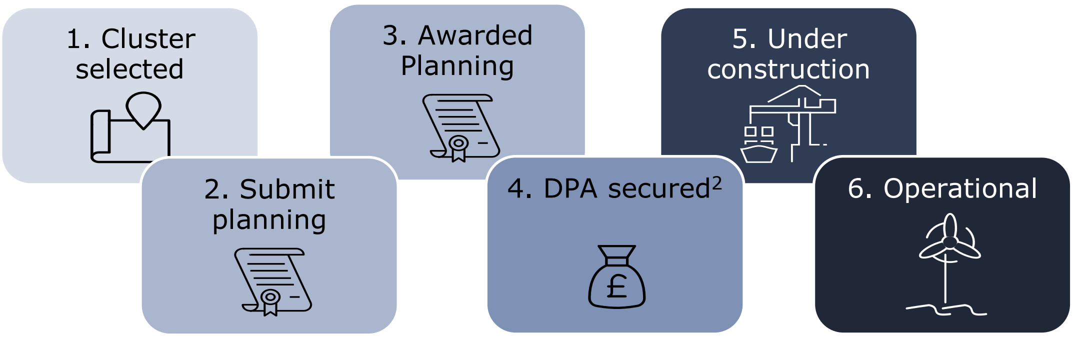
CURRENT PIPELINE OF GAS-FIRED GENERATION WITH CCUS PROJECTS IN GREAT BRITAIN (GW)



Years until fully operational[1]	~2	~3	~4-5	~6-7

1. Source: Developer websites.
2. The additional 3GW completing the total pipeline relates to projects not in Track 1 or Track 2.

KEY MILESTONES FOR GAS CCS POWER DEVELOPMENT



- Based on Track 1 and Track 2 projects, **there is a sufficient pipeline of projects to reach 9.4GW.**
- However, based on project websites, **most of these projects have not entered the planning system.** An expedited development timeline will be required for these projects.
- **No gas-fired generation with CCUS has secured support to date.** Most projects will require a DPA[3] to reach financial close. Only one project (0.9GW) entered negotiations for a DPA in the initial round, although eight projects were considered eligible (see annex). To achieve the NZP scenario, negotiations must be efficient and timely.

3. DPA – Dispatchable Power Agreement, the current support arrangement for power CCUS.

Rapid development of planning applications and funding needs to be achieved to reach 9.4GW of gas-fired generation with CCUS by 2030

> 9.4 GW BY 2030 BY 2030 (NZP SCENARIO)

Average additional capacity required to enter development stage (GW/year)

- **On average, 1.3GW of gas-fired generation with CCUS will need to be constructed per year[1].** However, given the current development status of power CCUS projects, this will be significantly weighted towards greater construction volumes in the years approaching 2030.
- **Awarding the DPA will be a significant challenge.** An average of 2.4GW of DPA awards is required every year until 2027. This is a new business model and to date, no DPAs have been awarded. Agreeing contracts for 9.4GW of gas-fired generation with CCUS will therefore be challenging.
- **Around 7.3GW need to submit planning applications in 2024.**

1. This includes both retrofitting existing gas-fired generation plants and entirely new power plants.

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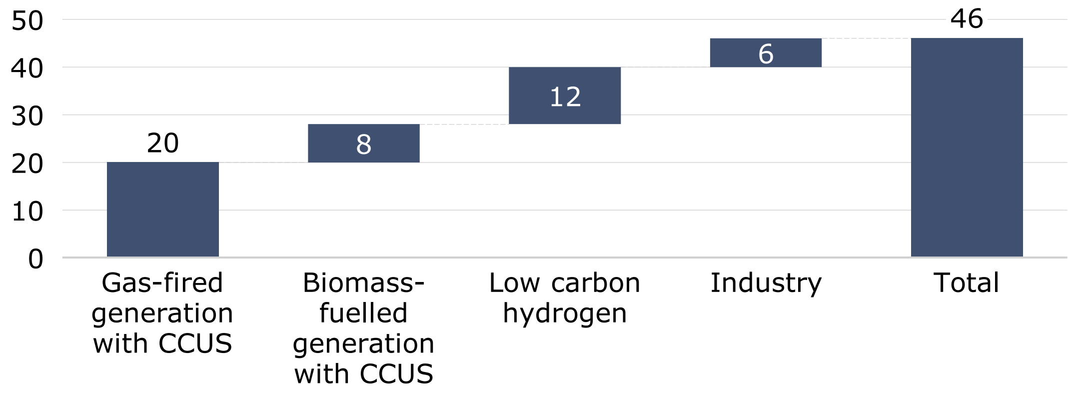
Carbon transportation and storage projects would need to scale from current policy ambition, with ramping up of injection rates a key challenge

GB CARBON TRANSPORTATION & STORAGE PIPELINE

Project	Potential injection rates 2030 ($MtCO_2$/year)	Potential injection rates 2035 ($MtCO_2$/year)	Total storage volume ($MtCO_2$)
Acorn	5	>20	240
Viking	10	15	300
Endurance	10	23	450
Hynet	10	?	113
Total	**35**	**>58**	**1,103**

NZP 2030 CARBON STORAGE REQUIREMENTS[1] ($MtCO_2$/year)



- As well as generation projects, carbon transport and storage projects need to be developed for the carbon captured.
- **A storage rate of around 46$MtCO_2$/year is required** in 2030 in the NZP scenario.
- **Current plans for transport and storage by 2030 are insufficient.** An additional 11$MtCO_2$/year of additional transport and storage over what is already planned for 2030 is required. Storage can be increased with increased injection rates of CO_2.
- **A clear and sustained Government vision backed by sufficient funding and coordination will be required** to achieve an injection rate of around 46$MtCO_2$/year through the four transportation and storage projects already under development for the Track 1 and Track 2 clusters.

1. Biomass-fuelled generation with CCUS based on 2 units of Drax converting; 6$MtCO_2$ of industrial CCUS based on Government targets; and 12$MtCO_2$ low carbon hydrogen based on project pipelines.

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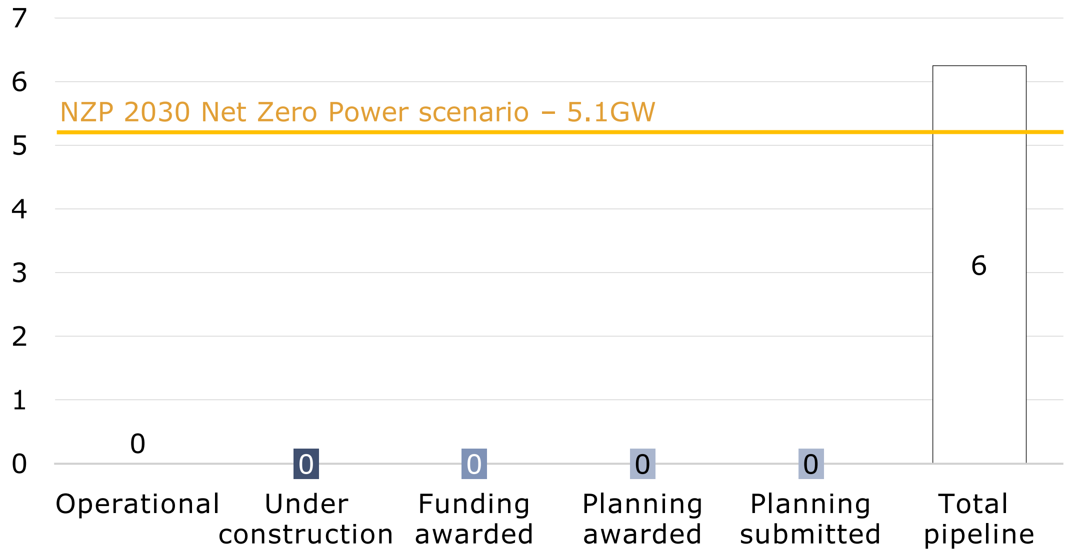
To achieve 5.1GW of hydrogen-fueled power generation by 2030, rapid development of a support mechanism is required

CURRENT PIPELINE OF HYDROGEN-FUELED POWER GENERATION PROJECTS IN GREAT BRITAIN (GW)



KEY MILESTONES FOR HYDROGEN POWER DEVELOPMENT

- **The NZP scenario requires 5.1GW of hydrogen-fueled power generation by 2030.** The total visible pipeline of projects in GB is 6.2GW[3].
- **There is no defined support mechanism, which is a major risk** for getting 6GW of hydrogen-fueled generation through the development pipeline**.** Government are currently consulting and intend to publish a response to the consultation in Q2 2024[4].
- **Support for hydrogen production is also required to provide fuel for the power stations**. The NZP scenario assumes 5GW electrolytic hydrogen by 2030. Government have recently concluded Hydrogen Allocation Round 1 (HAR1), through which 125MW of electrolytic hydrogen production will receive support from the Hydrogen Production Business Model. HAR2 is aiming to support 875MW. This was increased to account for 125MW less capacity than expected securing support through HAR1. Regular allocation rounds will be required to reach 5GW electrolytic hydrogen production by 2030.
- Some generating stations may also rely on blue hydrogen production, at least until electrolytic hydrogen capacity has increased.
- Projects in the pipeline are mainly based near CCUS clusters and so will be near hydrogen production. However, there are some generating stations located outside these areas. These projects will rely on local hydrogen production facilities and so may be higher risk. However, the electrolytic hydrogen allocation rounds are not restricted to clusters and so electrolytic hydrogen is expected to be constructed across the country.

1. Full planning application may not be required for operational projects looking to blend H_2.
2. A standardised support mechanism for hydrogen for power is still under development.

3. Pipeline and information on status, funding and planning are gathered from developer websites available in the public domain and may no be an exhaustive list.
4. Hydrogen to Power: market intervention need and design, December 2023, DESNZ.

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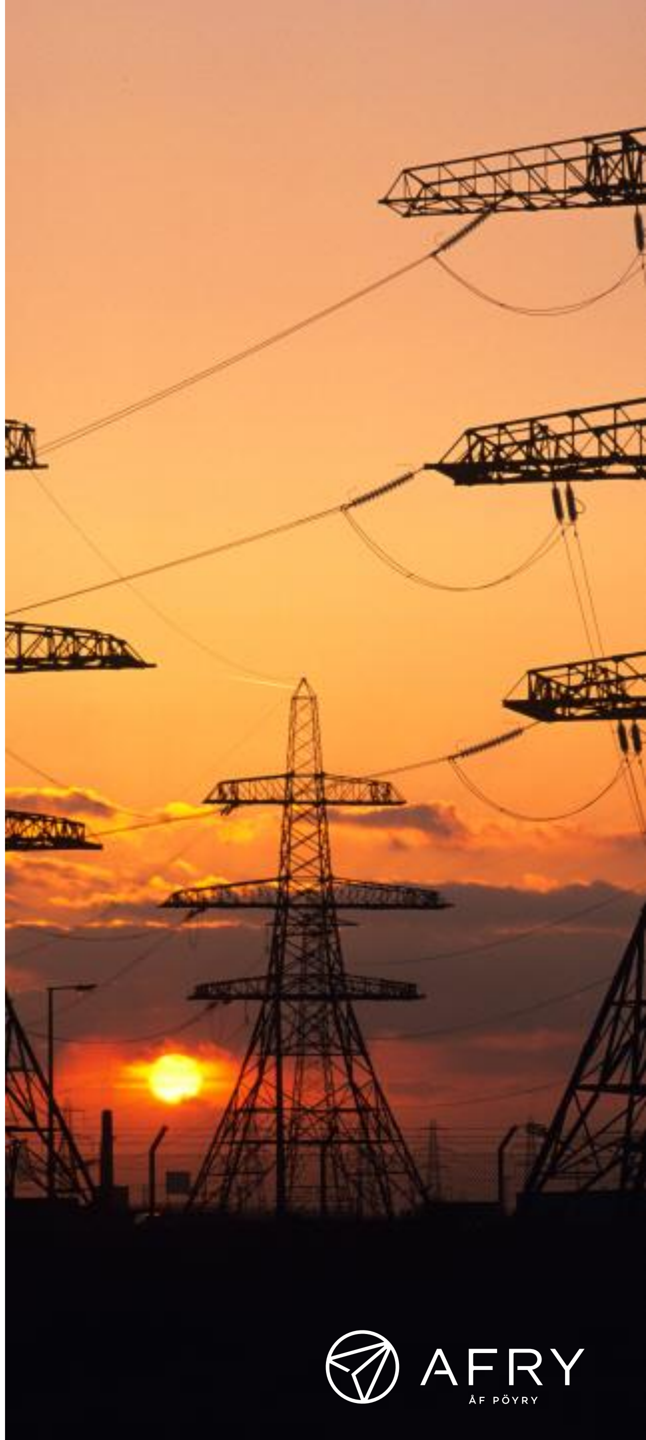
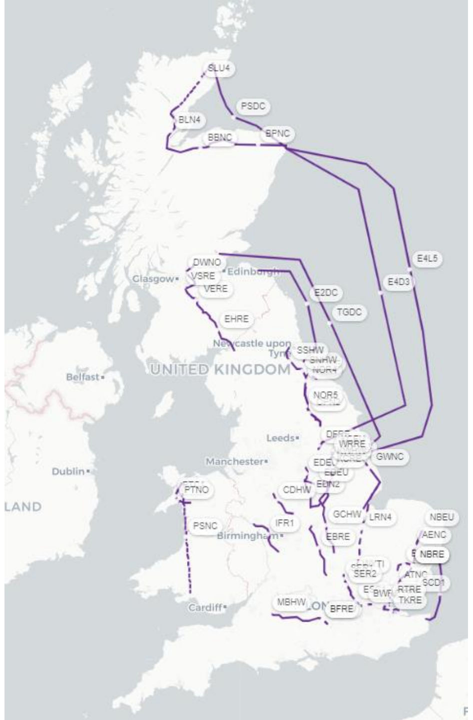


There is significant work being implemented to half the time to build transmission infrastructure

2024 GB TRANSMISSION CIRCUIT LINES[1]

NOA NEW CIRCUITS AND UPGRADES BY 2030[1]



COMMENTARY

– **There are ambitious plans to upgrade the transmission grid by 2030** to reach Government 2030 targets, such as connecting 50GW offshore wind to the grid.

– The Electricity Network Commissioner's recent report[2] noted that **the current process for building transmission infrastructure takes 11-14 years.** This also identified a **need to reduce this to 7 years.**

– The Transmission Acceleration Action Plan[3] was published by the Government in response to this and responds to over 40 of the recommendations to be implemented to achieve this acceleration. These cover strategic spatial planning, design standards, regulatory approval, planning approval, supply chains and communities and engagement.

– This is in addition to existing regulatory incentive frameworks for transmission build which form part of the RIIO-T2 price control, such as the Large Onshore Transmission Investment (LOTI) and the Accelerated Strategic Transmission Investment (ASTI) framework.

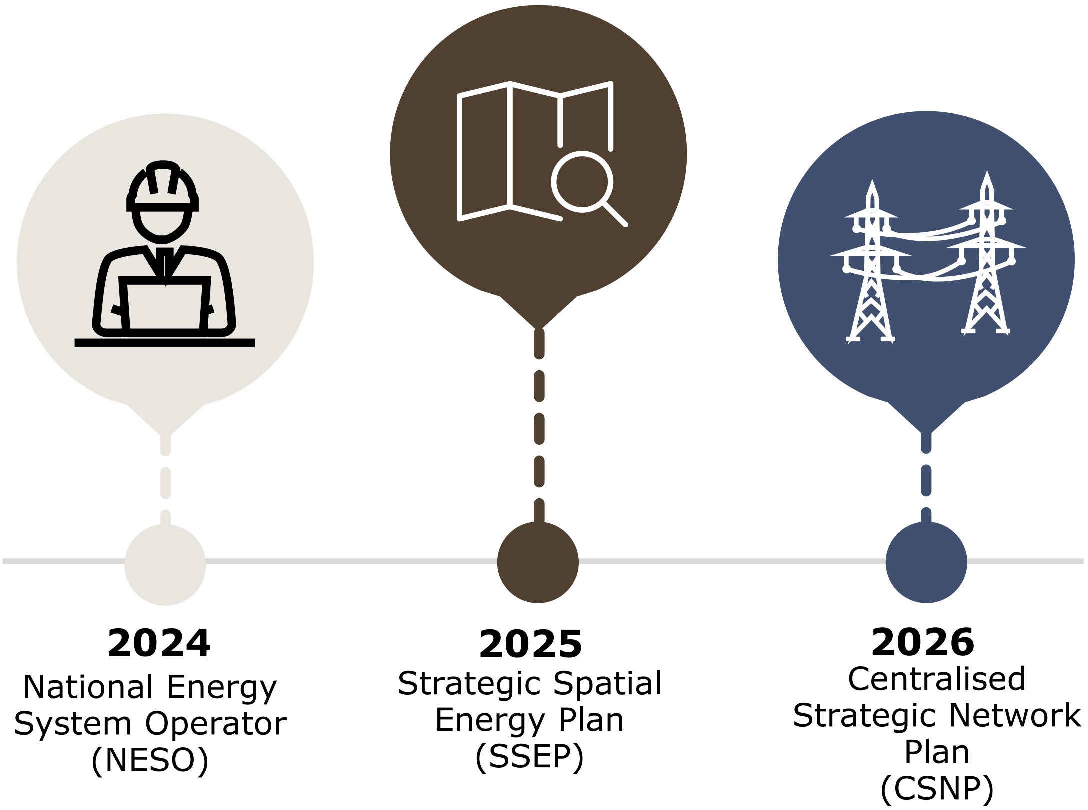
– The ASTI framework was designed to fund the large strategic onshore transmission projects required to deliver the Government's 2030 ambitions. The ASTI framework will initially apply to 26 projects and £20billion of transmission network investment.

1. National Grid ESO interactive map, March 2024, https://www.nationalgrideso.com/future-energy/pathway-2030-holistic-network-design/holistic-network-design-offshore-wind/our-interactive-map The map on the right shows the development of new circuits and upgrades to existing circuits identified in the Networks Options Assessment (NOA) by 2030.

2. Electricity Networks Commissioner's principal areas of recommendation, UK's Electricity Networks Commissioner, August 2023.
3. Electricity Networks: transmission acceleration action plan, DESNZ, November 2023.

Plans to shorten the time to deliver transmission build projects will not be implemented in time to impact 2030 transmission build

TIMELINE FOR DELIVERY OF THE CENTRALISED STRATEGIC NETWORK PLAN



- One recommendation in the Electricity Networks Commissioner's report[1] and subsequent Government response[2] was **to create a Strategic Spatial Energy Plan (SSEP), which will be the foundation of future network planning**. The purpose of the SSEP is to coordinate generation and transmission infrastructure in time and space. This will bring more timely system wide regulatory approval and anchor network plans in current energy policy.
- The reports also recommended a **Centralised Strategic Network Plan (CSNP) to provide independent, coordinated and longer-term network planning.** This is intended to help make quicker funding decisions. This will provide a firm delivery pipeline of transmission build for the first 12 years, and a longer-term pathway over the next 25 years. The CSNP will be informed by the SSEP.
- **The National Energy System Operator (NESO) will be responsible for producing the CSNP and the SSEP.** The NESO will be an independent public body responsible for planning the electricity and gas network and operating the electricity system.
- **The timelines for the CSNP are too long to impact grid build by 2030.** Current timelines[3] suggest the NESO will be set-up by summer 2024; the SSEP is expected late in the 2024/25 financial year; and the first long-term CSNP will be delivered in 2026. The earliest we expect new grid build as recommended in the CSNP is therefore 2033.

1. Electricity Networks Commissioner's principal areas of recommendation, UK's Electricity Networks Commissioner, August 2023.
2. Transmission Acceleration Action Plan, DESNZ, November 2023.
3. Decision on the framework for the Future System Operator's Centralised Strategic Network Plan, December 2023.

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Achieving net zero power in Great Britain by 2030 is possible but very challenging

MAJOR EFFORT NEEDED IN MANY AREAS	Delivering net zero power in 2030 will require fast, effective and co-ordinated effort in several areas, with little contingency available
DEPLOYMENT MUST BE ACCELERATED	Deployment rates for mature techs would need to match or (greatly) exceed historical annual peaks every year until 2030 and new technologies would need to be deployed at scale
POLICY ACTION IS REQUIRED	Planning processes will need to be streamlined to ensure a sufficient pipeline of projects, and support schemes will need to be scaled up or implemented
LIMITED MITIGATIONS ARE AVAILABLE	There are no obvious mitigations that could reduce the risks of accelerating the delivery of net zero power by five years to 2030

CONCLUSIONS – KEY MESSAGE 1 - MAJOR EFFORT IN MANY AREAS

Net zero power in 2030 requires fast, effective and coordinated effort

- Accelerating the pace of decarbonisation means technologies with long lead times (e.g. nuclear power) cannot make a material additional contribution by 2030.
- Much more effort must be made to expand and expedite the project pipelines for the current portfolio of low-carbon technologies.
- For many technologies (e.g. solar PV, onshore wind, offshore wind) this would involve sustaining activity at historical peak rates. For others (e.g. gas-fired generation with CCUS and hydrogen-fuelled generation) it means much more rapid commercialisation of an emerging technology.
- A large majority of the new capacity required is linked to revenue support schemes; policymakers have scope to increase utilisation of these schemes to rapidly ramp-up deployment.
- The planning system needs sufficient additional capacity to cope with an immediate expansion of applications for some technologies (e.g. offshore wind), while simultaneously expediting existing project pipelines.
- Some agreed dates for network connections would also need to be immediately brought forward from post-2030, to give sufficient time for any necessary enabling works.
- Coordinated action would be required to ensure bottlenecks on deployment are removed rather than shifted to a different point.
- **Delivering net zero power in 2030 will require fast, effective and co-ordinated effort in several areas, with little contingency available.**

Step changes in deployment would be needed across the board

- Over and above already ambitious deployment paths to achieve a fully decarbonised grid by 2035, a credible pathway to net zero carbon power in 2030 requires deployment of:
  - over double the current capacity of solar PV and onshore wind;
  - more than three times today's capacity of offshore wind; and
  - **around 15GW of entirely new types of low-carbon dispatchable capacity** (gas-fired generation with CCUS and hydrogen-fuelled generation), together with the associated storage and network infrastructure.
- For each renewable technology, the **maximum historical annual deployment would have to be repeated or exceeded every year** to 2030, including:
  - 5.2GW/year for offshore wind;
  - 2.8GW/year for onshore wind; and
  - 4GW/year for solar PV.
- For both gas-fired generation with CCUS and hydrogen-fuelled generation, capacity equivalent to close the entire visible pipeline of projects conceivably deliverable by 2030 need to be built.
- Major grid reinforcements are also required (although current ambition on these to enable 50GW of offshore wind by 2030 could be close to sufficient).
- Achieving simultaneous scale-up in all technologies including grid reinforcement would be major challenge.

Revenue support schemes and planning pose particular challenges

- To achieve net zero power by 2030, a large majority of new generation capacity required is anticipated to be covered by some form of Government revenue support.
- For existing renewable technologies, while the framework for Contract for Difference (CfD) allocation rounds support is well-established**, CfD award rates (GW/year) need to approximately double for each of offshore wind, onshore wind and solar PV.**
- **For new dispatchable low carbon technologies, revenue support frameworks are much less mature. Urgent attention is needed** to ensure they are finalised in time for around 15GW of gas-fired generation with CCUS and hydrogen-fuelled generation to receive awards by 2027.
- **Across all intermittent renewables, rates of planning consent need to be maintained at peak levels,** which may require current processes to expedited.
- However, for offshore wind, even if these rates are maintained, there is currently insufficient capacity in the planning process to meet the 51GW requirement, meaning:
  - **7.6GW of offshore wind capacity needs to enter the planning system in 2024** (the historical maximum is 7.2GW in one year); and
- Grid connections are also a significant challenge for offshore wind: **around 6GW of grid connection agreements for offshore wind need to rapidly be brought forward to 2030**, to allow sufficient time for any required network enabling works.

Mitigations for deployment risk are are limited in scope

- The Net Zero Power scenario has been defined to accelerate the types of capacity most scalable at speed given existing project pipelines and existing or developing policy.
- Given the challenges, achievement of the target will depend on:
  - **building on existing policy levers** - as the legal framework for the required policies exists, extending or implementing them more quickly is within the Government's remit;
  - **committing sufficient revenue** support for generation capacity; and
  - **committing greater resources to enable swift consenting**.
- **On deployment, there is limited scope for contingency to mitigate risks.** Failure to deliver in one area would generally lead to greater effort in an area which is more difficult to scale. However, there may be some contingency around the exact generation mix to reach net zero carbon power by 2030.
- Increased ambition for long duration energy storage (LDES) could decrease the need for 15GW of gas-fired generation with CCUS and hydrogen-fuelled generation. However, the LDES support regime is not yet in place.
- Greater biomass-fired generation with CCUS is potentially deliverable by 2030, offering additional negative emissions (Lynemouth and two further units at Drax). However, revenue support is currently unclear
- Current efforts to halve the time take to deliver transmission reinforcement projects to around 7 years will not be implemented in time to help with grid build by 2030.

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We have used the current pipeline of generation technologies to assess average annual rates required to reach each development milestone

METHODOLOGY

To assess the requirements to achieve net zero power in 2030, for key technologies we have analysed the development status of the current project pipeline. Our approach is:

1. Identify the status of the current pipeline and capacity at each development milestone. For intermittent renewables this is based on analysis of the Renewable Energy Planning Database.[1]

2. Define assumptions for the number of years to reach operation from each development milestone. This is loosely based on historical timelines (see assumptions to the right).

3. Calculate the capacity of the technology that needs to reach each development milestone, and by when, using the current pipeline (from 1) and timelines (from 2).

4. Calculate the average annual rate at which plants need to reach each development milestone. This is an annual average and does not consider when plants already in the development pipeline will be ready to reach the next stage. We therefore expect some years with a greater annual rate, and some with a lower annual rate.

5. Compare these average annual rates to rates observed historically.

6. Review the Transmission Entry Capacity (TEC)[2] register to gain an idea of grid connections for wind. We have not reviewed grid connections to the distribution network.

ASSUMED YEARS UNTIL OPERATION FROM DEVELOPMENT MILESTONE

	Offshore wind	Onshore wind	Solar PV	Gas-fired generation with CCUS
Planning submitted	6	6	4	6
Planning awarded	4	4	3	5
Subsidy awarded	3	3	2[3]	3
Under construction	2	2	1	2

1. Renewable Energy Planning Database: quarterly extract, January 2024 / October 2023, DESNZ
2. Transmission Entry Capacity (TEC) register, National Grid ESO (February 2024)

3. Based on delivery years for solar PV of Allocation Round 6 CfD

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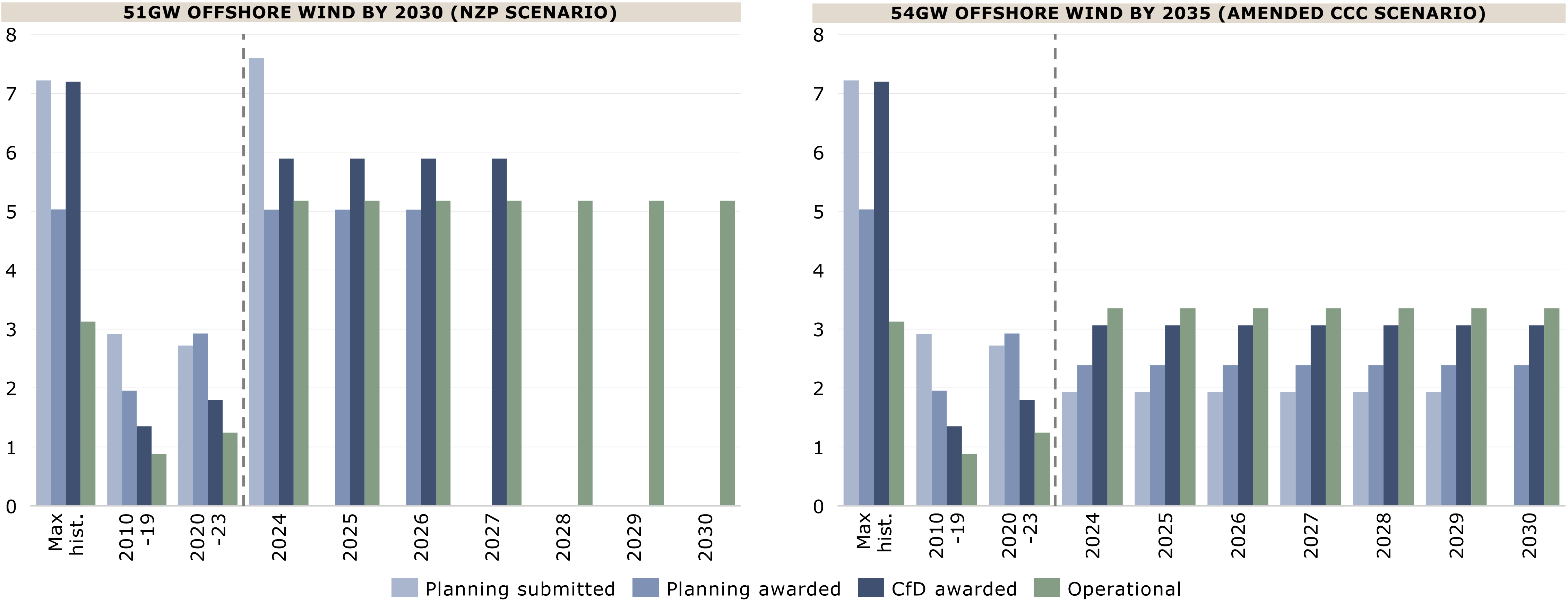
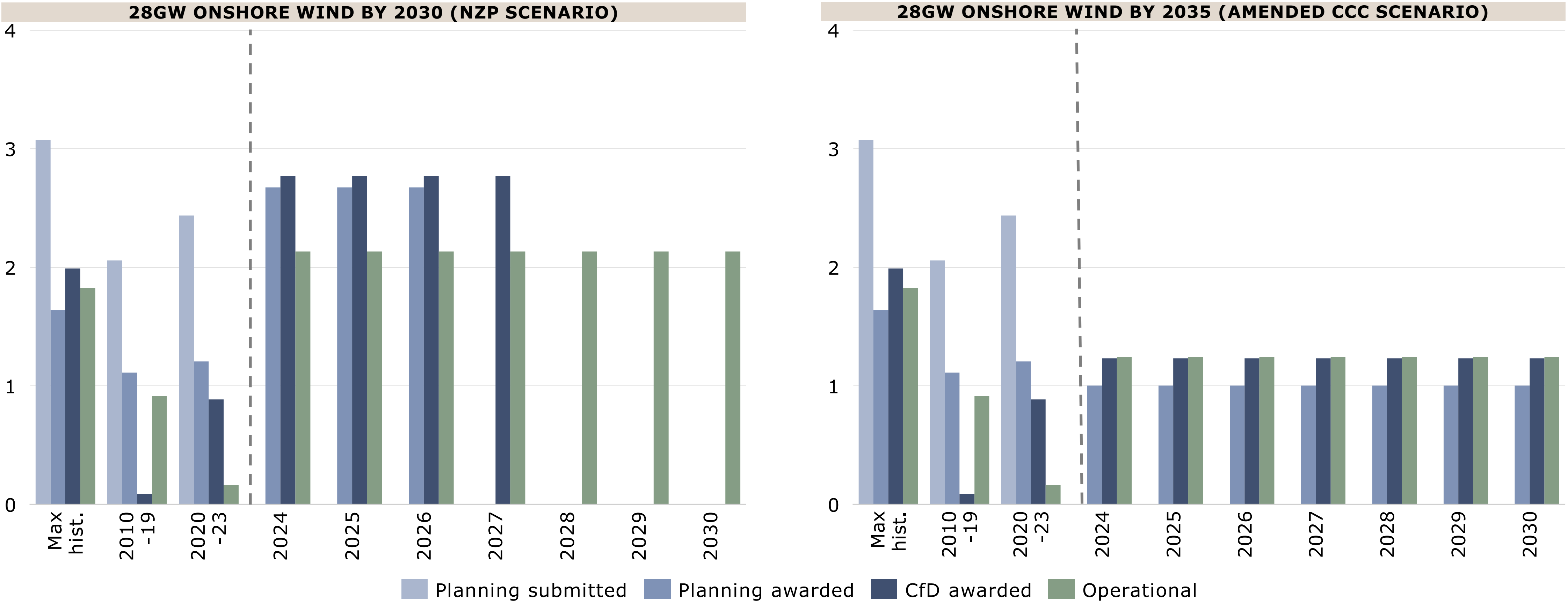
Offshore wind consenting rates required in the NZP scenario are around double those required in the Amended CCC scenario

Average additional capacity required to enter development stage (GW/year)



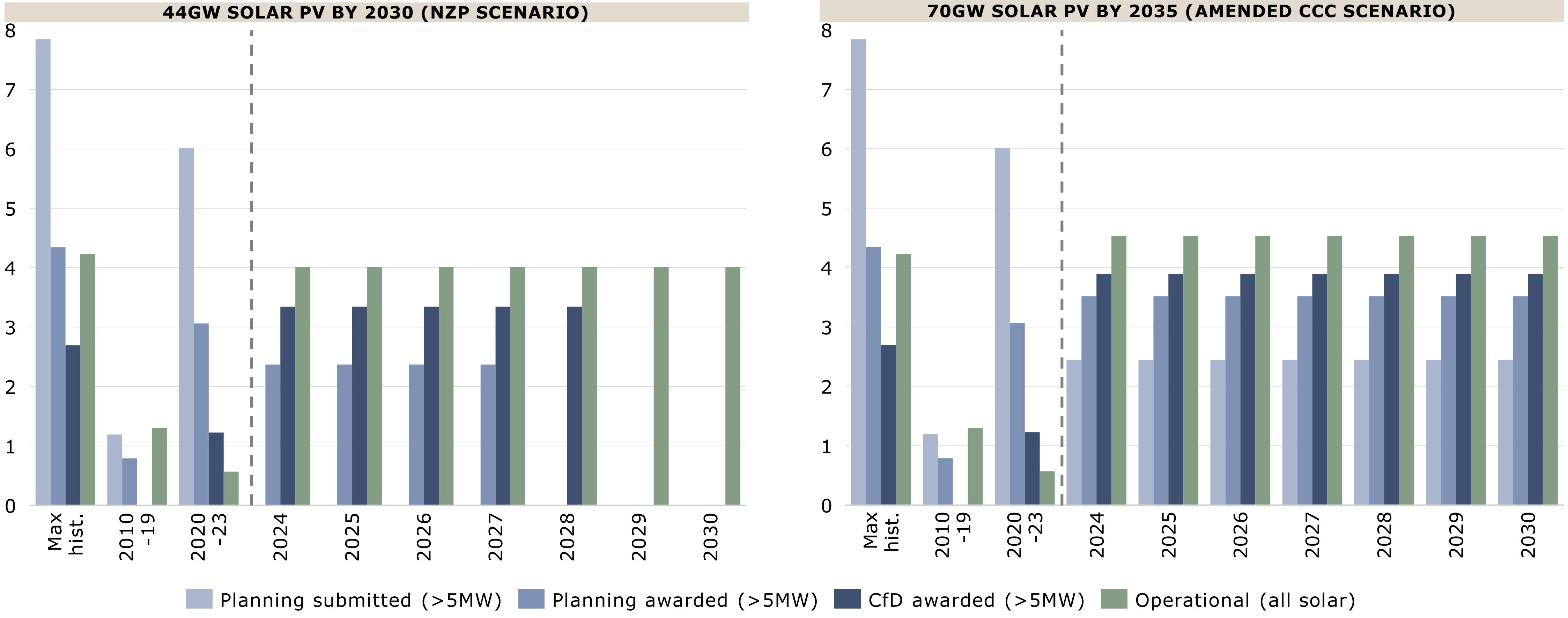
Onshore wind consenting rates required in the NZP scenario are around two and half times those required in the Amended CCC scenario

Average additional capacity required to enter development stage (GW/year)



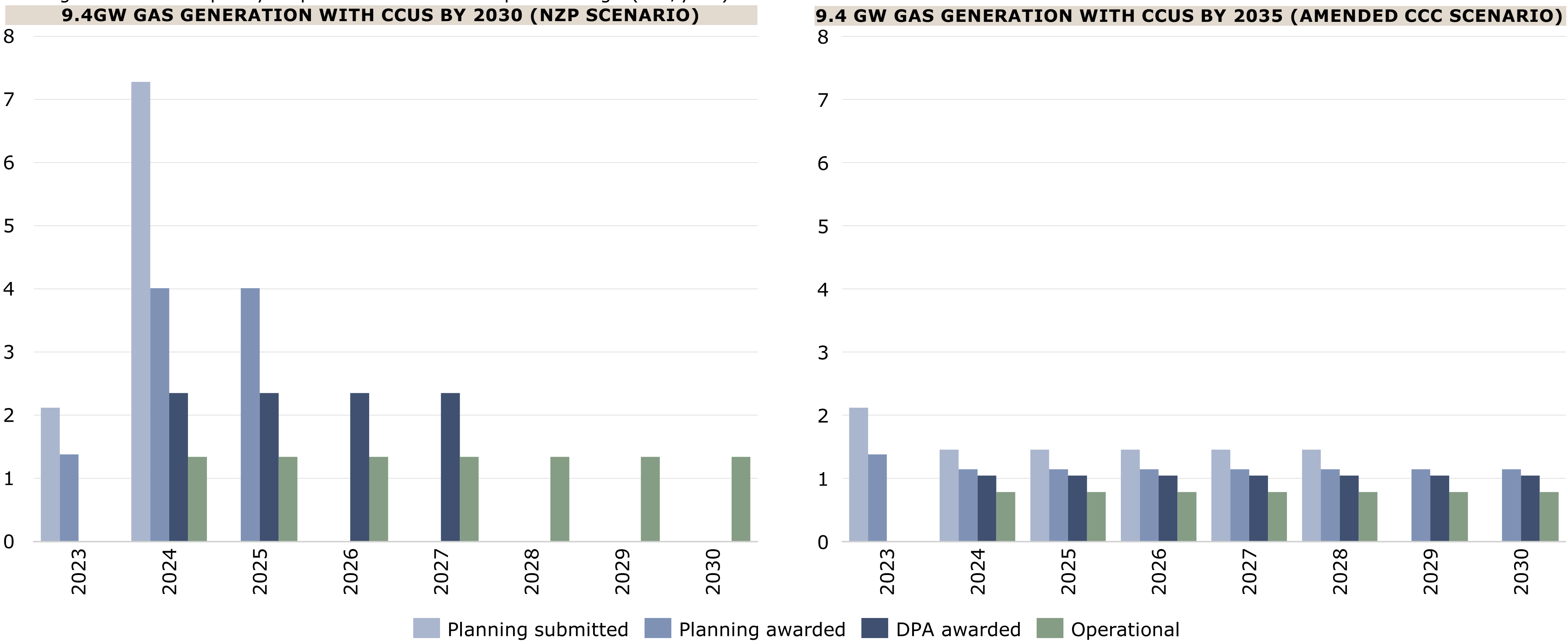
Average deployment rates for solar PV to 2030 are greater in the Amended CCC scenario, as the average rate to reach 70GW in 2035 is higher

Average additional capacity required to enter development stage (GW/year)



Around 1GW/year of gas-fired generation with CCUS is required in the amended CCC scenario

Average additional capacity required to enter development stage (GW/year)



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The total current pipeline of Track 1 and Track 2 gas-fired generation with CCUS projects is 10.1GW

Track	CCS Cluster	Project	Funding status[1]	Capacity (GW)[2]	Carbon capture ($mtCO_2$/year)
Track 1	East Coast	Net Zero Teesside	Negotiation	0.9	2
		Whitetail clean energy	Eligible	0.4	0.8
		Alfanar CCGT		0.2	0.4[3]
		Keadby 3		0.9	1.5
		C.GEN Killingholme		0.5	1.0
		VPI Immingham Humber Zero		1.2	2.4[3]
	Hynet	Grain	Eligible	1.3	2
Track 2	Acorn	Peterhead	Eligible	0.9	1.5
	Viking	West Burton	None	1.3	2.6[3]
		Staythorpe retrofit		1.7	4
		Stallingborough		0.8	2
Total				**10.1**	**20.2**

1. Cluster sequencing Phase 2: eligible projects (power CCUS, hydrogen and ICC), March 2022 & Cluster sequencing Phase 2: Track 1 project negotiation list, March 2023, DESNZ. 'Eligible' projects met the eligibility criteria as part of the phase 2 cluster sequencing process for Track 1 projects
2. Based on information collected from project websites
3. Estimated based on power capacity to carbon capture ratio of other plants

The demand categories referenced in this report are defined below

Demand category	Definition
Base demand	Comprises: 1. Total residential customer demand excluding residential heating and residential EV charging. 2. Total commercial sector demand excluding demand from heating and EV charging 3. Total industrial demand excluding electrolysis and district heating
Electric vehicle demand	Total residential and commercial EV demand
Heat demand (flexible)	Total residential and commercial heating demand, with a profile reflecting dynamic time of use tariffs
Heat demand (inflexible)	Residual residential and commercial heating demand, plus industrial district heating demand

Glossary of abbreviations

AR	Allocation Round
Amended CCC scenario	Amended Climate Change Committee Balanced Pathway scenario
BESS	British Energy Security Strategy
CCUS	Carbon Capture Utilisation and Storage
CSNP	Centralised Strategic Network Plan
CAES	Compressed Air Energy Storage
CT	Consumer Transformation
CfD	Contract for Difference
DESNZ	Department for Energy Security and Net Zero
DPA	Dispatchable Power Agreement
ESO	Electricity System Operator
FIDeR	Final Investment Decision Enabling for Renewables
FES	Future Energy Scenarios

GB	Great Britain
HAR	Hydrogen Allocation Round
INTOG	Innovation and Targeted Oil & Gas
LtW	Leading the Way
LAES	Liquid Air Energy Storage
NESO	National Energy System Operator
NZP Scenario	Net Zero Power scenario
OEUK	Offshore Energies UK
PV	Photovoltaic
REPD	Renewable Energy Planning Database
SSEP	Strategic Spatial Energy Plan
ST	System Transformation
TEC	Transmission Entry Capacity

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