LCPDelta

Delivering a clean electricity system by 2030?

December 2022

Introduction

Delivering a clean electricity system by 2030?

- In the UK's **Net Zero Strategy** in October 2021**,** the government outlined its plans to meet Carbon Budget 6 (2033-37) including a commitment to **fully decarbonise the power sector by 2035, subject to security of supply.** This followed a similar, but subtly different recommendation from the Climate Change Committee (CCC) for an unabated gas phase out by 2035, also subject to security of supply.
- In light of rising energy prices, the government then published the **British Energy Security Strategy (BESS)** in April 2022, with the aim of reducing exposure to volatile gas prices, and increasing energy security through more home grown energy sources. While bringing forward and increasing many commitments/ambitions**, the Government did not bring forward the government's 2035 commitment** to fully decarbonise the power sector.
- At their party conference in September 2022, **Labour announced that if elected they would commit to a 'clean' electricity system by 2030,** which would appear to bring forward the government's commitment by 5 years. Although, it is not clear whether both commitments are targeting the same outcome.
- As a follow on to the LCP-SSE Net Zero Power Without Breaking the Bank' report published in July 2021 and the Impacts and implications of the British Energy Security Strategy (BESS) published with SSE's REMA consultation response in October 2022, **SSE commissioned LCP Delta to assess how a commitment to clean electricity could be defined and what level of increased ambition could be cost effectively delivered by 2030.**

Key current government commitments

Decarbonisation	**Fully decarbonise the power sector,** subject to security of supply by 2035 **(Net Zero Strategy)**.
Offshore Wind	Ambition to deliver up to **50GW of offshore wind by 2030**, with up to 5GW coming from floating offshore wind by 2030 **(BESS)**.
Nuclear	Ambition to reach up to **24GW of nuclear power capacity by 2050 (BESS)**.
Hydrogen	**2030 low carbon hydrogen production target of 10GW**, with electrolysers contributing at least 50% of this **(BESS)**.
Solar	Ambition to increase **solar capacity five-fold by 2035** to reach 70GW from 14GW today **(BESS)**
Networks	Plans to deliver the **transmission network** to meet the renewables ambition **(Electricity Networks Strategic Framework)**.
REMA	Launched **Review of Electricity Market Arrangements (REMA)** to assess how markets and mechanisms need to change in future

Defining a clean electricity ambition

Options to assess progress and drive ambition for electricity system decarbonisation

There is currently no clear definition as to what a 'clean electricity system' or 'fully decarbonised power sector, subject to security of supply' means and how this would be measured. There are 3 main options for defining this, which can be used in combination:

% Low Carbon or Full Unabated Gas Phase Out

The UK already has a coal phase out date, and an **unabated gas phaseout can be seen as a logical next step,** particularly if looking to encourage ambition globally. Likewise aiming for 100% low carbon is an easy target to communicate.

However, **a simple phaseout of unabated gas or 100% low carbon would not be cost effective by 2035,** which is why BEIS and the CCC included a caveat for security of supply. However, very high levels of ambition can be achieved.

Net Emissions Target

As with other sectors, residual emissions will remain in the electricity system for the foreseeable future, and so **the easiest target to conceptually put in place is a sectoral target for a Net Zero Electricity System**. This is a target recommended by the IEA for 2035 in advanced economies, and is both deliverable and measurable.

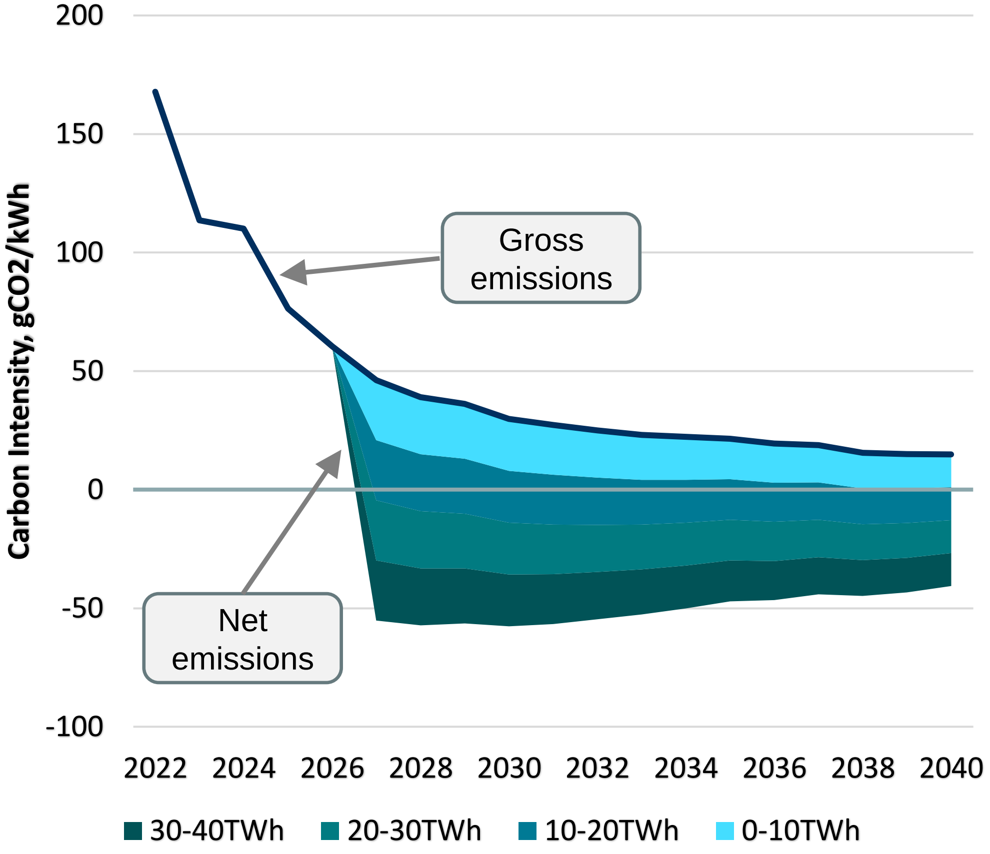
However, **sectoral emissions targets can mask more cost effective measures, and overly focus on Greenhouse Gas Removal (GGR) technologies**, such as BECCS rather than addressing residual emissions.

Gross Emissions Intensity

Setting a gross emissions intensity target can measure ambition and inform electricity system plans and the best use of GGR technologies across the economy. For Carbon Budget 5 (2028-32) set in 2016 the CCC recommended <100gCO2/kWh by 2030.

The CCC's Carbon Budget 6 report and the UK's Net Zero Strategy take this approach, setting sectoral ambition on a gross emission basis. Emissions from GGR technologies are counted against the economy wide target rather than in the sector they are operating in, which avoids these masking more cost effective measures.

Impact on GB Power sector net emissions from difference levels of Biomass with Carbon Capture and Storage (BECCS) deployment

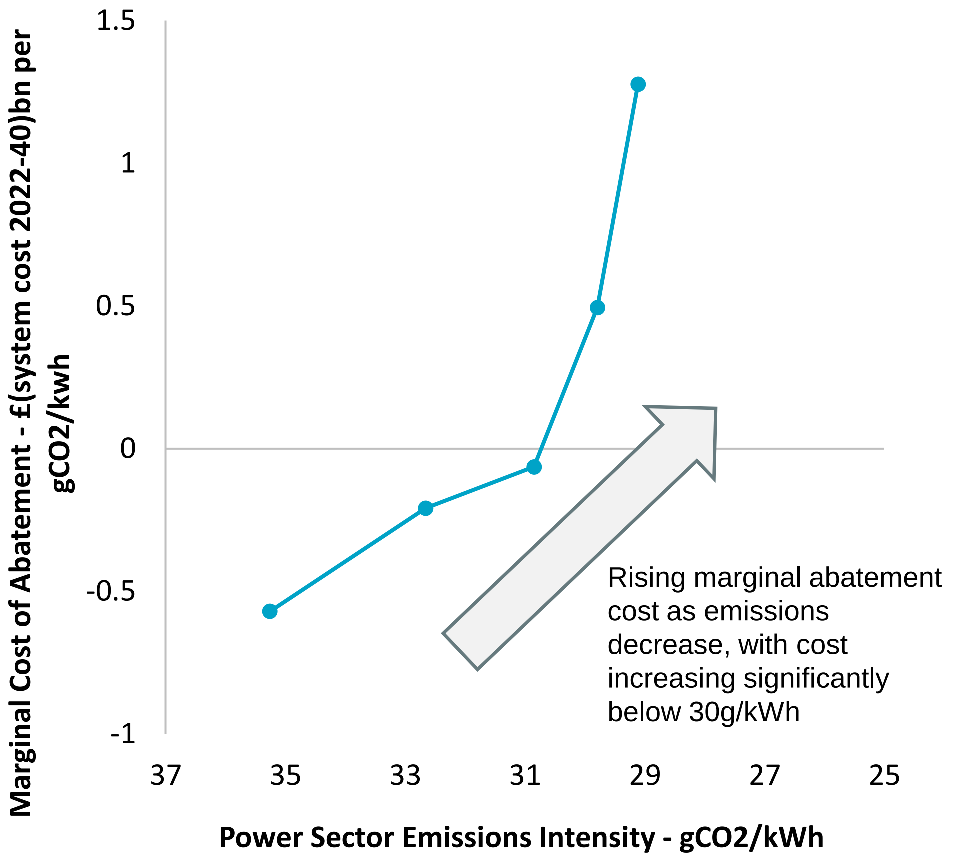


Setting a clean electricity ambition for 2030

Gross emissions savings towards absolute zero can become prohibitively expensive

- To some, an appropriate emissions target would mean gross emissions from the GB power sector being 0MT. However, **hitting 0MT in power is unlikely to be possible by even 2050, and certainly not economically desirable**.
- **As the power sector decarbonises, some residual emissions are likely to remain** from low carbon technologies such as Gas CCS and Energy from Waste while small amounts of generation from unabated gas plants for emergency situations will likely be more cost effective to ensure security of supply than building new low carbon assets.
- While it is understood that absolute zero emissions is neither feasible nor economic, there may be **merit in defining a gross emissions intensity trajectory on route to net zero**. This should be **set at a point where nearly all generation is coming from low carbon sources** other than small amounts needed for security of supply, whilst **ensuring that such a target is not prohibitively expensive**. This is similar to the approach taken by the Science Base Targets Initiative (SBTi) Net Zero Standard to ensure Corporates set long-term science-based targets which get their residual emissions down as low as possible before seeking to neutralise them with carbon removals.
- In this analysis an **emissions intensity below 30gCO2/kWh is the point where these criteria are reached so could be defined as a cost effective by 2030, on route to net zero electricity.** At this point around **97% of generation would be coming from low carbon sources** but the marginal cost of abatement to go to a lower level of emissions is extremely expensive with **an additional £1.3bn required for a 1gCO2/kWh emissions reduction below 30gCO2/kWh**.
- However, it should be noted that **setting a target in this way comes with risks**. Delivering incremental carbon savings in the electricity may be more expensive than other sectors, and risks ignoring the demand efficiencies that are also needed for a low cost, low carbon power sector.

Marginal Abatement Cost of decreasing emissions intensity around 30gCO2/kWh in 2030*



*Note that this marginal cost of abatement curve is based on the scenarios tested for this analysis. Other scenarios may exist with different marginal cost of abatement

Modelling Approach

A range of scenarios and sensitivities were modelled to test the impact of government policy and what could be done to accelerate ambition on power sector decarbonisation

Three core scenarios

Pre-BESS scenario

- Reflects govt commitment to fully decarbonise power by 2035, subject to security of supply
- Net Zero consistent but more build in later years.
- 40GW Offshore Wind by 2030.
- Gas CCS, onshore and solar ramp up over time.
- Sizewell C included but no further new nuclear.

BESS scenario

- All power sector measures from British Energy Security Strategy (BESS) from April 2022.
- 50GW Offshore Wind in 2030.
- 70GW Solar in 2035.
- 5GW of electrolysis in 2030.
- 15GW of nuclear by 2040 and 24GW by 2050.

BESS + CCS scenario

- Renewable and Nuclear technologies same as BESS scenario as assumed these are at maximum levels given network and planning limitations.
- Increased level of Gas CCS to 9GW by 2030 – requires available CO2 transport and storage infrastructure

Two sensitivities on BESS scenario

BESS with Slower nuclear deployment

- BESS with nuclear deployment consistent with Pre-BESS scenario.
- No further nuclear post Sizewell C, with this capacity replaced by Gas CCS.

BESS with Slower renewable deployment

- BESS with renewable deployment consistent with Pre-BESS scenario.
- 40GW Offshore Wind by 2030 and55GW solar in 2035.

Current high gas prices assumed to fall to lower levels in longer term

Demand based on BEIS Net Zero Lower Demand scenario

All scenarios Net Zero compliant and meet security of supply requirements

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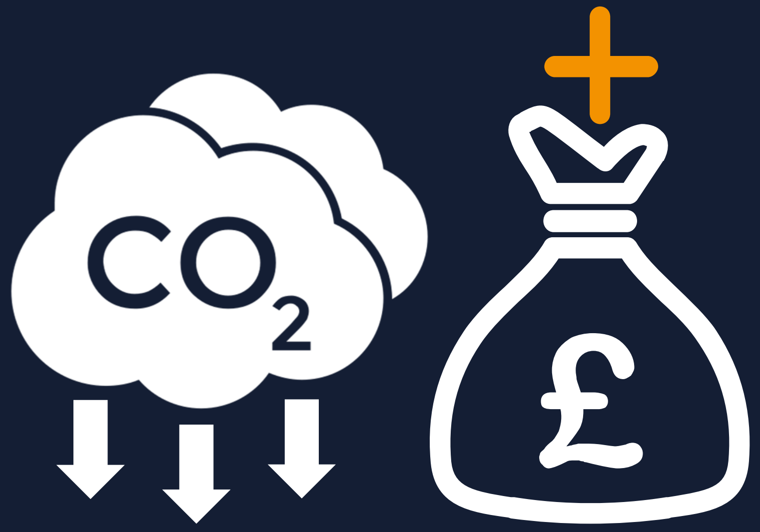
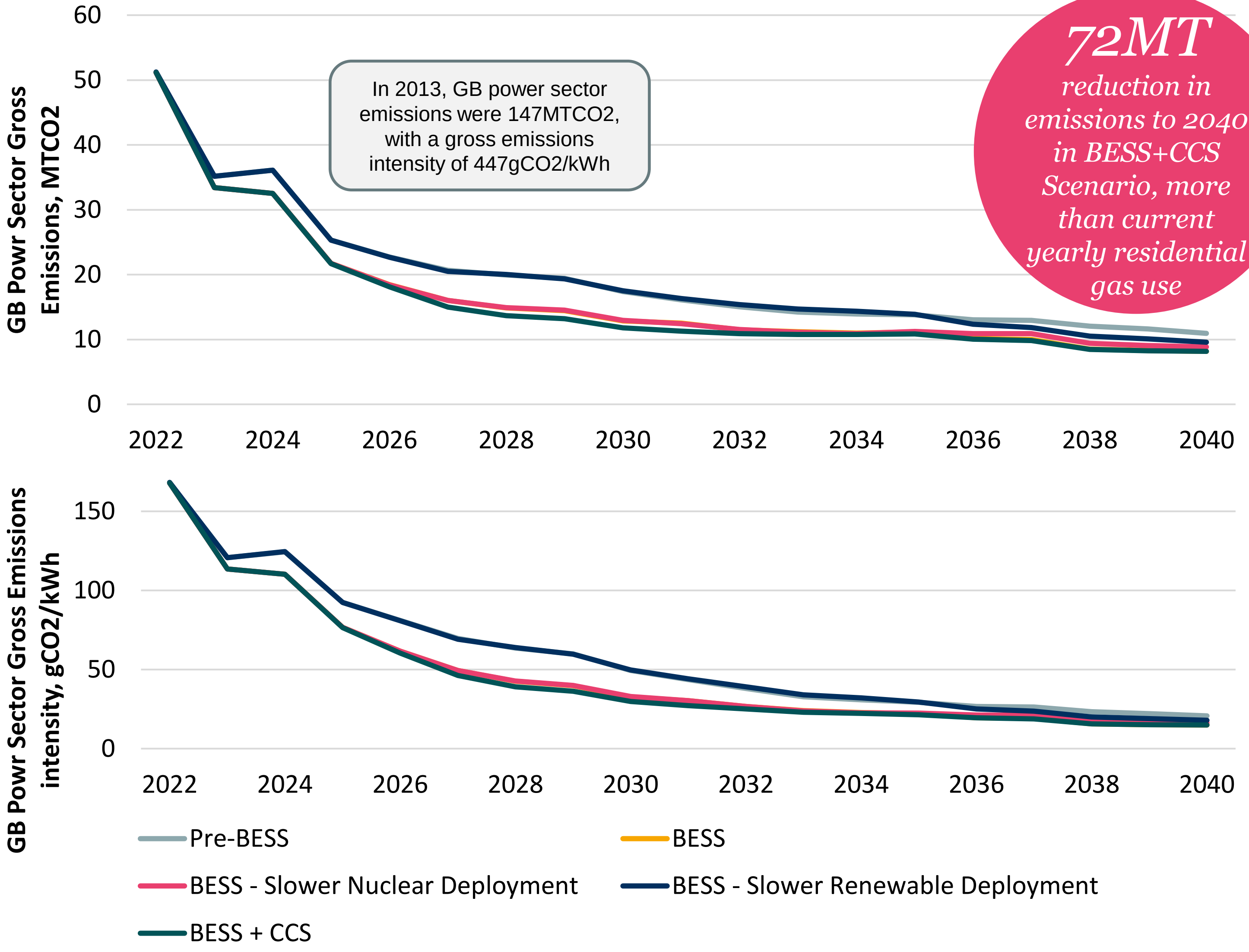
2030 decarbonisation: Impacts on emissions, gas use and costs



GB electricity sector carbon emissions

BESS delivers significant emissions reductions but further 2030 ambition requires CCS



72MT *reduction in emissions to 2040 in BESS+CCS Scenario, more than current yearly residential gas use*

The Pre-BESS scenario reaches 50gCO2/kWh by 2030, and hits the 30gCO2/kWh in 2035 while BESS scenario reduces this to 2032

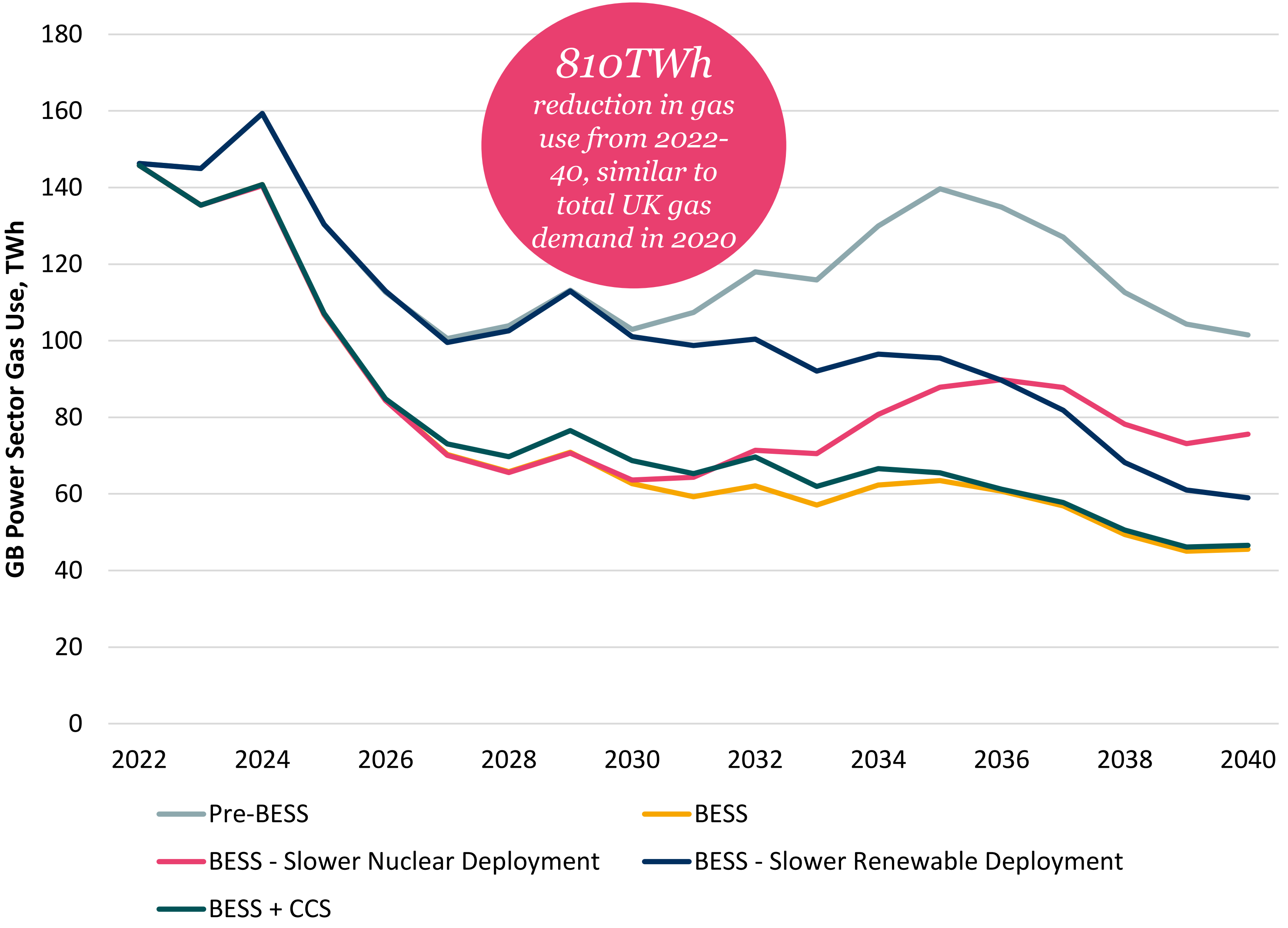
With the increased CCS ambition, **the BESS+CCS Scenario with 9GW of gas CCS gets gross emissions down to below 30gCO2/kWh by 2030**

Compared to the Pre-BESS scenario, the BESS+CCS scenario **reduces power sector emissions by 5.6MT in 2030** and a cumulative 72MT from now to 2040

Renewable energy deployment has a much bigger impact on emissions reduction than nuclear due to earlier deployment meaning it replaces unabated gas

GB electricity sector gas use

Increasing 2030 renewables ambition has significant impact on gas demand



The measures outlined in the BESS are effective at reducing gas use with **gas demand in the power sector reducing by 850TWh** from now to 2040 compared to the Pre-BESS scenario

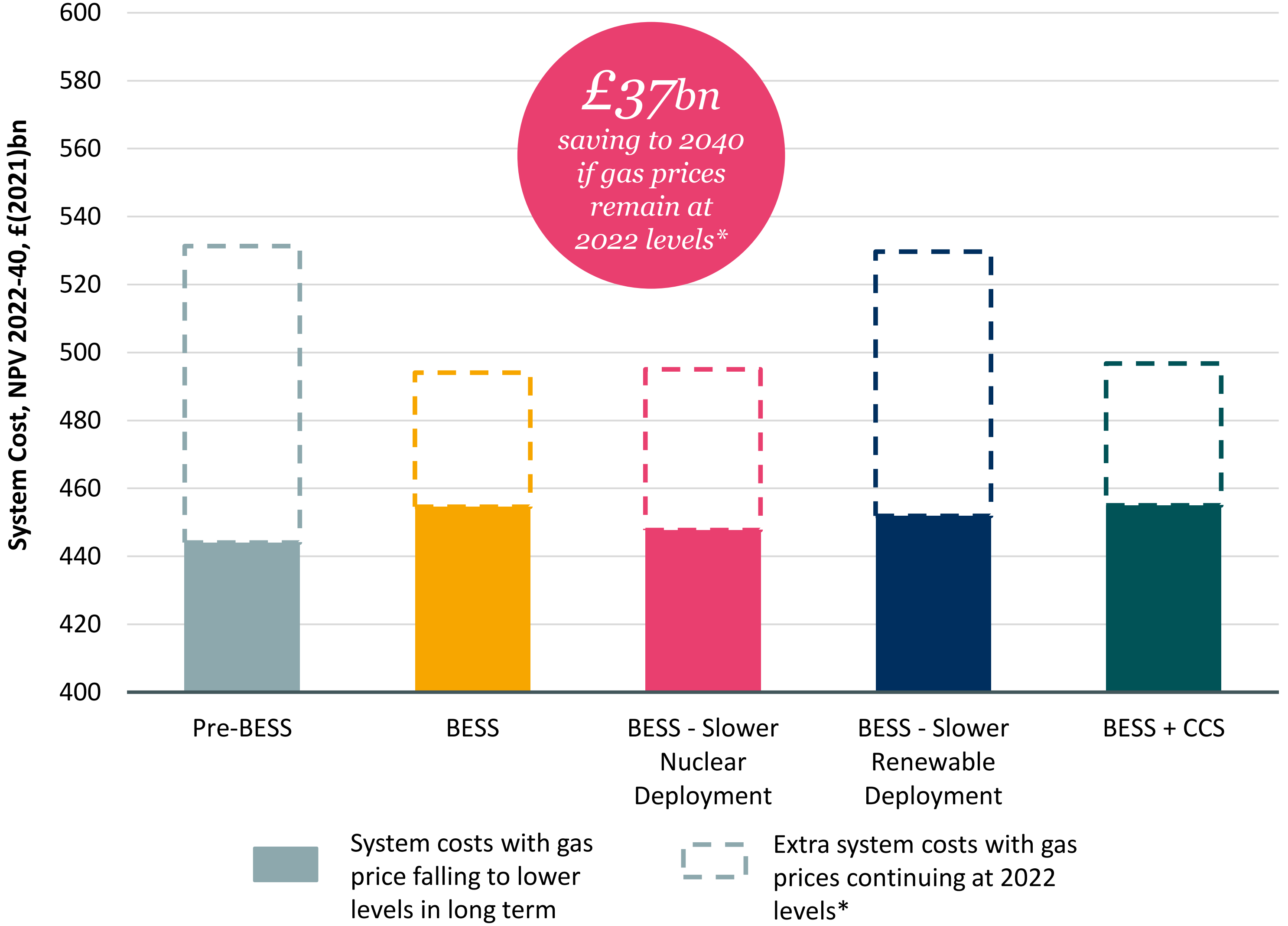
The BESS+CCS scenario **domestic gas use is on average 3TWh/year higher** compared to the BESS scenario. However, if **imports of electricity produced from gas power stations outside of GB** are taken into account then **change in gas use is minimal** between the two scenarios

By 2030, only 5% of GB power generation will be from unabated gas compared to 40% in 2021

Faster Renewable deployment outlined in BESS has the higher impact in the short to medium term with increased **Nuclear deployment reducing gas use from CCS in the longer term**

GB electricity sector system costs

Faster decarbonisation reduces exposure to volatile fossil fuel prices



If gas prices return to lower levels, BESS+CCS scenarios results in additional £11bn in system costs compared to the Pre-BESS Scenario.

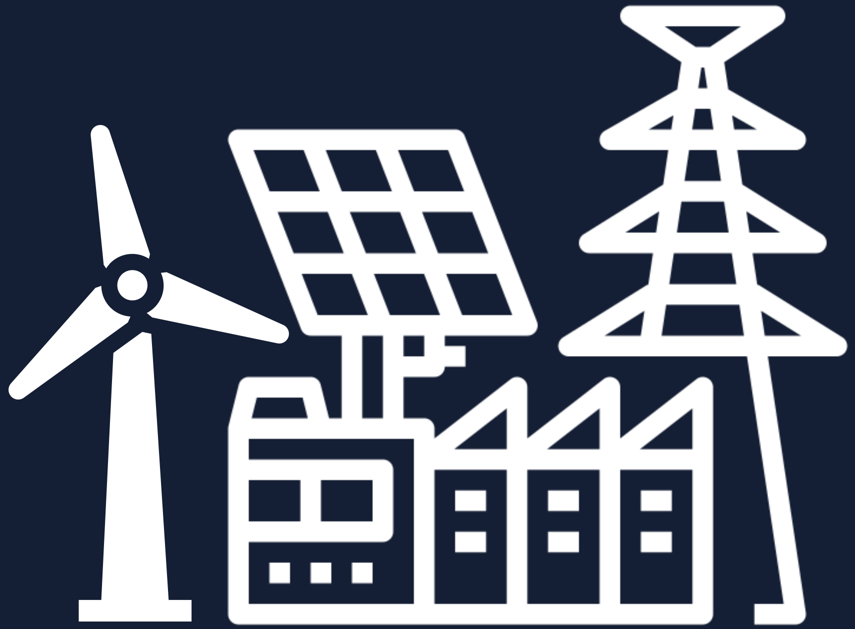
But **BESS measures are an insurance against very high gas prices** keeping total system costs £37bn lower if high gas prices remain.

Faster renewables deployment has a bigger impact on reducing system costs than increased Nuclear deployment. A BESS scenario with Nuclear has an additional cost of £4bn compared to without nuclear.

A BESS+CCS scenario could reduce system costs back inline with the BESS scenario by doing 7GW gas CCS in 2030, rather than 9GW. This would though have an emissions intensity above 30gCO2/kWh.

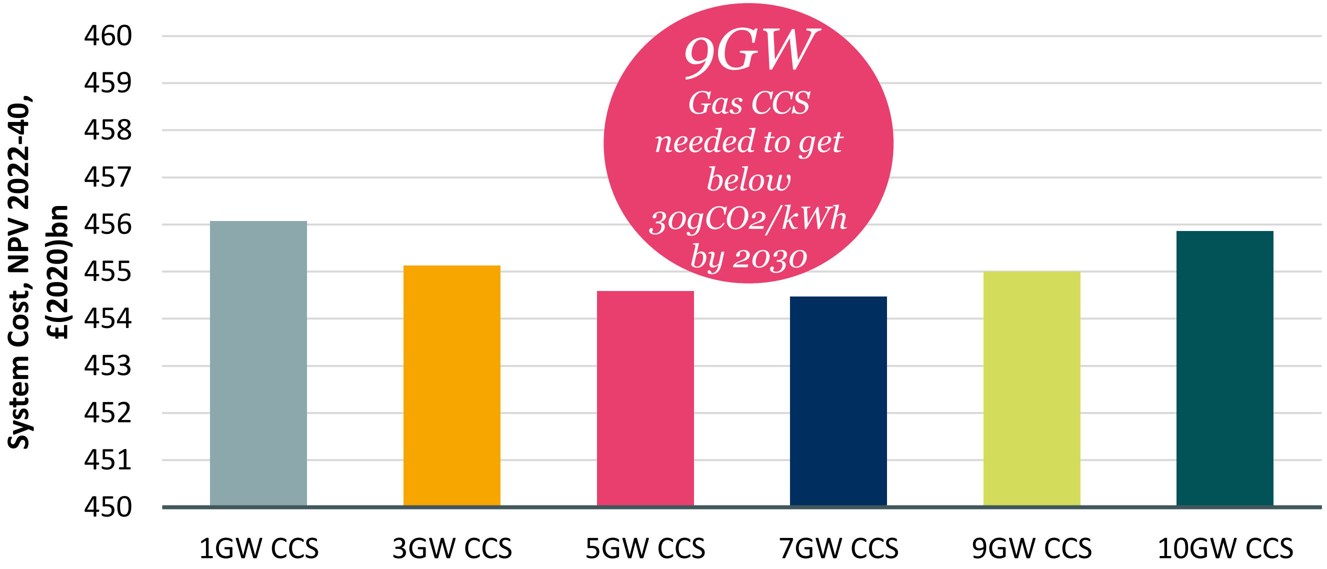
*2022 levels reflected GB forward prices from May 2022, which were at an average of 225p(2021)/therm for the year. Central gas price assumptions included in Annex

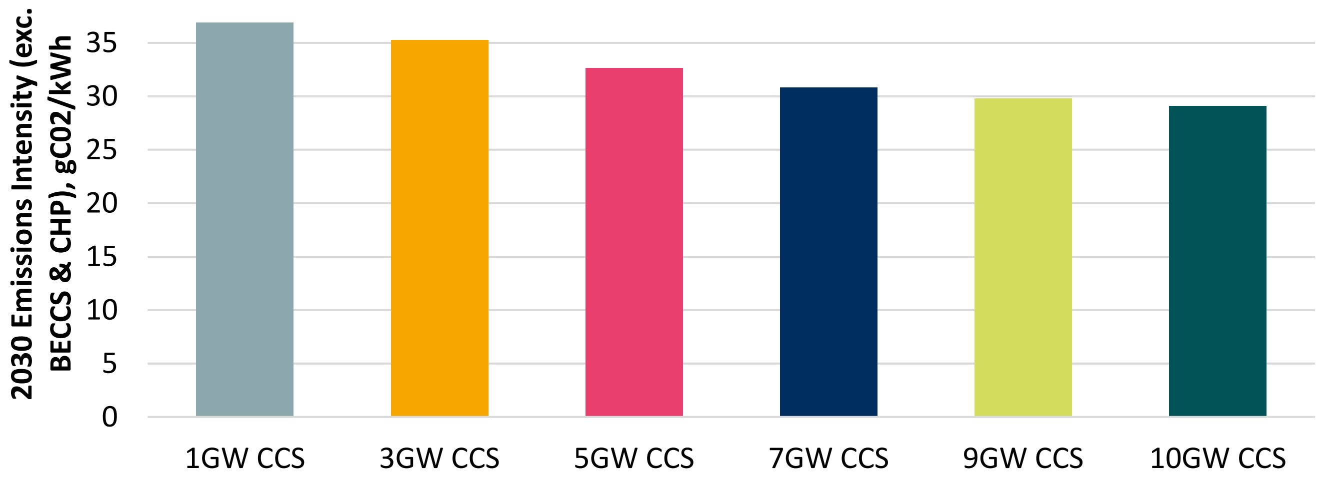
2030 decarbonisation: Deepdives



The role of Power CCS in delivering increased 2030 ambition

Deploying 7GW gas CCS by 2030 is cost optimal for the system in a BESS scenario but reaching 9GW can reduce emissions under 30gCO2/kWh





To reach an **emissions intensity of 30gCO2/kwh by 2030 in the BESS+CCS scenario requires 9GW of Gas CCS by 2030**, on top of the measures outlined in the BESS. With hydrogen power unlikely to be available in large volumes by 2030, new nuclear unable to be built before this point and renewables already deployed to maximum levels, then **alongside energy efficiency, additional CCS is one of the only ways to deliver an increased 2030 ambition.**

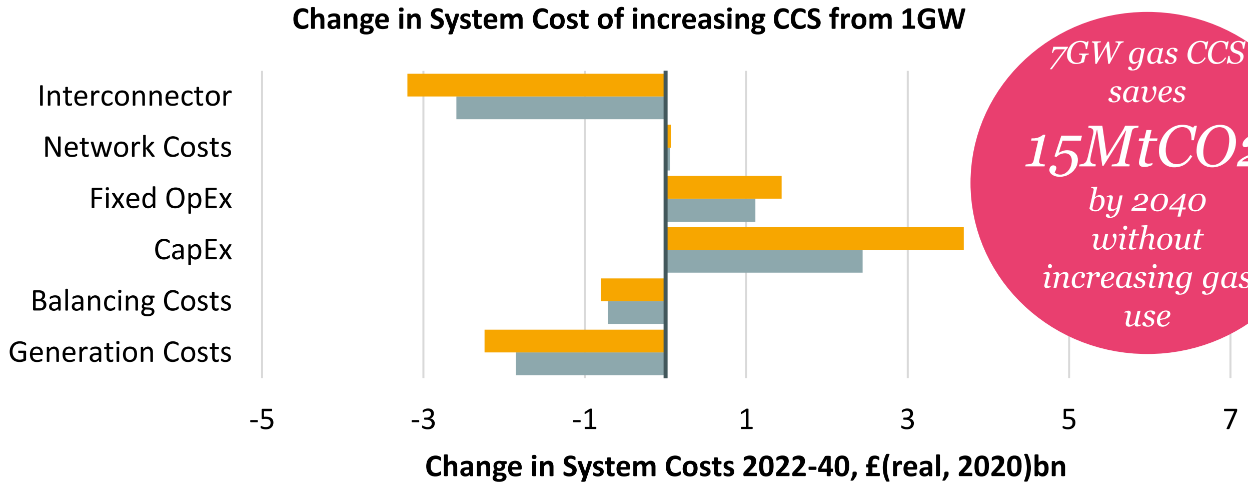
Aiming to **deploy CCS and indeed all technologies to maximum levels by 2030 can also bring benefits in terms of reducing delivery risk** for low carbon capacity as Gas CCS can provide a safety net for gas used for non-delivery of renewables or nuclear.

Deploying additional Gas CCS can reduce emissions without increasing total gas use across GB and interconnected countries. While deploying 9GW is needed to reduces emissions below the 30gCO2/kWh, this does increase costs by up to £0.5bn from now to 2040 compared to the lowest cost CCS deployment scenario.

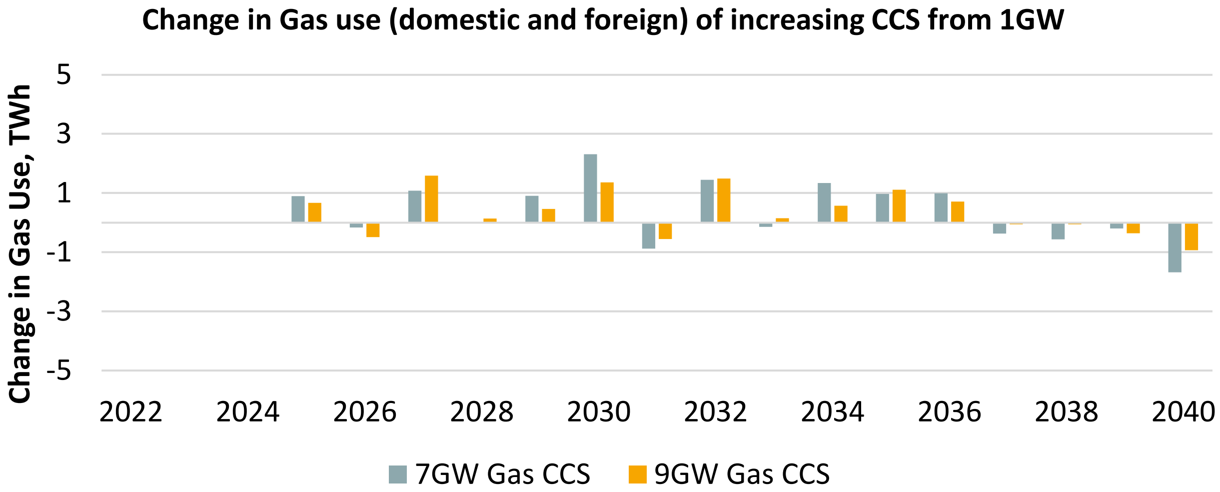
Of the different Gas CCS levels tested, **7GW by 2030 has the lowest system costs**. As **such building 7GW of Gas CCS is likely to be low regrets** and can support the deployment of carbon and hydrogen infrastructure in industrial clusters around the UK's ports. However, **the availability of CO2 transport and storage infrastructure will be a limitation on the amount of CCS that is deliverable** by 2030.

The impact of Power CCS on gas use

Deploying 7-9GW gas CCS by 2030 not only saves on carbon and costs, but does so without increasing gas use



7GW gas CCS saves
15MtCO2
by 2040 without increasing gas use



Deploying 7-9GW Gas CCS capacity by 2030 rather than 1GW by 2030 would reduce cumulative emissions to 2040 by 15-18Mt and system costs by £1.1-1.6bn compared to a scenario consistent with current government strategy of 1 CCS plant by 2030.

Maybe counterintuitively, **a scenario with higher levels of gas CCS uses a similar level of gas compared to 1GW due to the efficiency gains of newer turbines displacing older existing gas generation in GB and importing over the interconnectors***, even including the energy used for carbon capture.

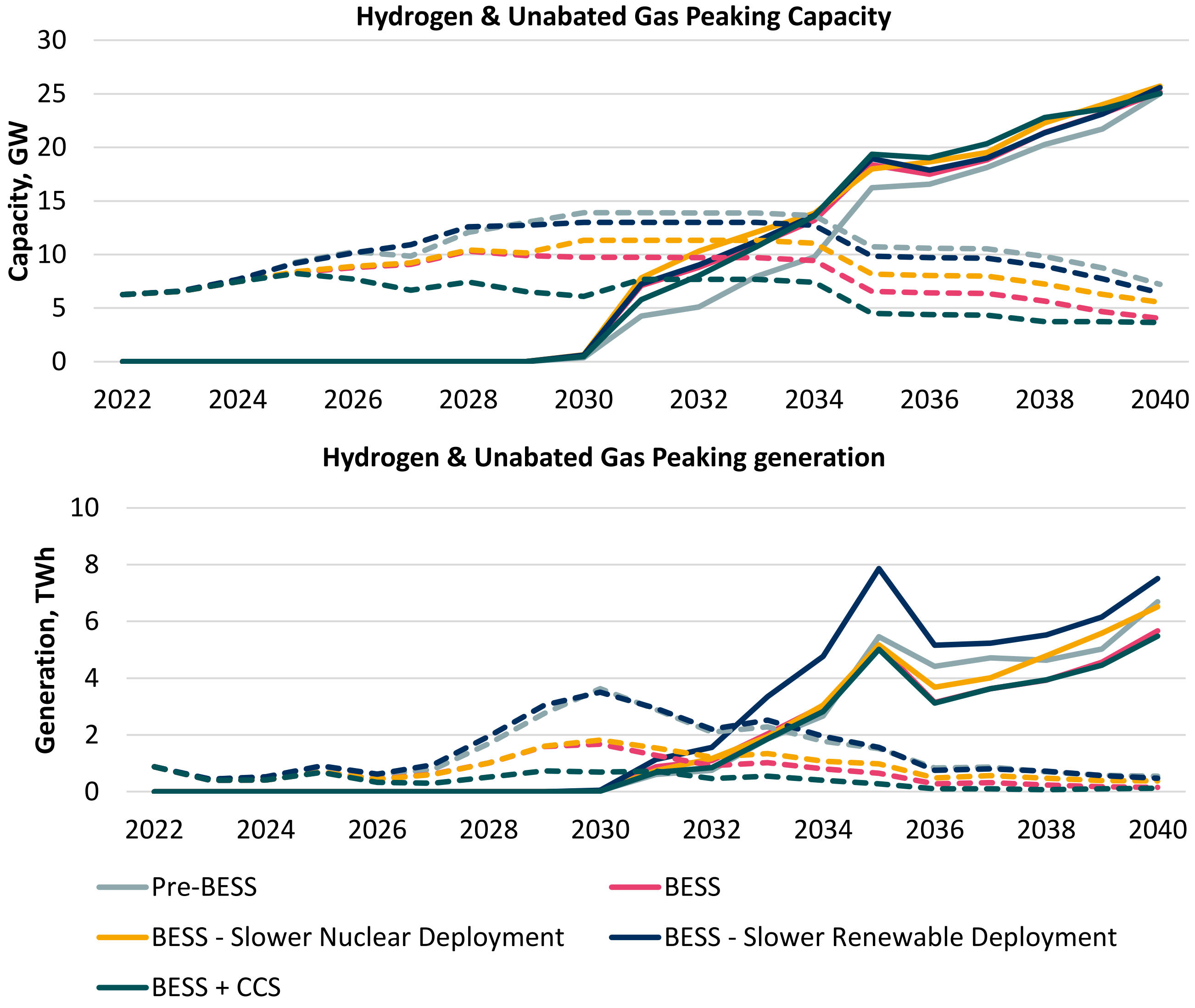
Under a 7GW gas CCS scenario gas consumption in the GB electricity system is on average 0.8TWh per year higher from 2025 to 2030, and 0.1TWh for the 2030s. For comparison, UK gas consumption was 861TWh in 2021.

Additionally, while deployment of renewables will provide the most significant protection**, Gas CCS capacity can assist in protecting consumers from price shocks,** much in the way gas-to-coal fuel switching has today across Europe**.** While clearly not desirable, 7-9GW gas CCS by 2030 provides policymakers with flexibility to utilise the higher efficiency gas power units without capturing the CO2 if needed, thus reducing gas use compared to older, less efficient unabated gas plants.

*Assumes inefficient gas-fired generation being imported as marginal generator

The emergence of hydrogen power stations

Hydrogen power generation can displace unabated gas capacity and output



With electricity sector demand set to double between now and 2050 and different types of demand being added to the system, **increased levels of peaking capacity operating at low load factors will likely be needed to ensure security of supply.**

In all our scenarios, this **peaking capacity* reaches up to 30GW in 2040 generating up from 6GW today.** Although this capacity generates less than 10TWh per year with load factors of less than 4%. Requirements for unabated gas peaking capacity are reduced by 8GW by 2030 in the BESS+CCS scenario due to increased Gas CCS.

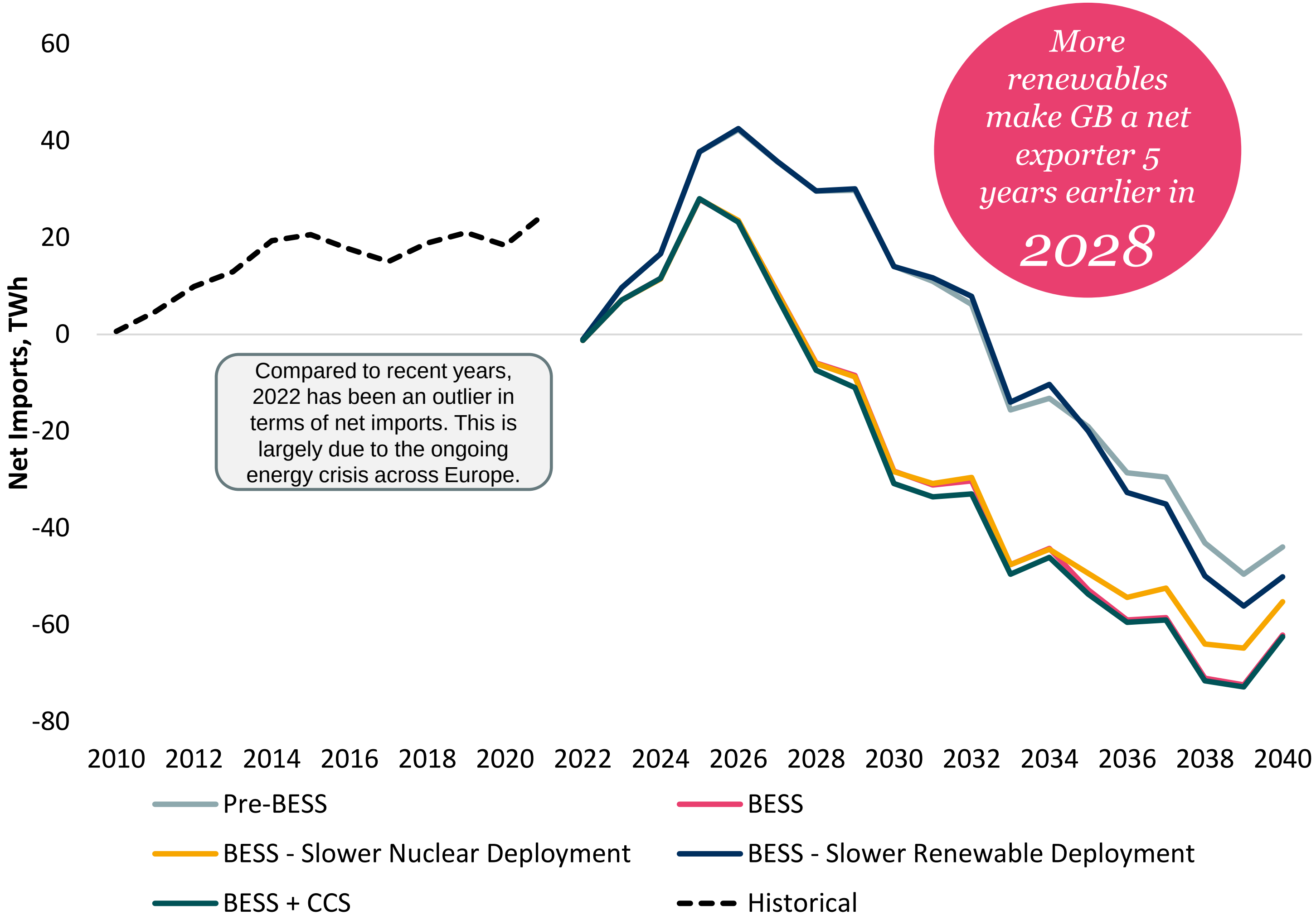
To decarbonise the electricity system cost effectively, **new peaking gas generation built by 2030, or earlier, should be able to utilise 100% hydrogen** and be located within industrial clusters with emerging hydrogen network and storage infrastructure, to ensure low carbon hydrogen will be available. Additional deployment of power CCS in the 2020s to achieve <30gCO2/kWh could help to kickstart, then transition to, a hydrogen economy due to the synergies between CCS and hydrogen.

This hydrogen power generation capacity could save up to 15MtCO2 over the 2030s compared to this generation coming from unabated gas.

* Peaking capacity includes Open Cycle Gas/Hydrogen Turbines (OCGT/OCHT) and below.

GB becomes a net exporter of electricity

Faster decarbonisation makes GB a net exporter by 2028



Increases in renewable and interconnector capacity will **support GB in its objective to be a net exporter of electricity ahead of the government target date of 2040**.

The Government is aiming to have 18GW of interconnector capacity with other countries to by 2030, up from 7.4GW today. Whilst interconnectors face questions over their impact during concurrent capacity issues as seen this winter, they certainly **help integrate large levels of renewable capacity** onto the system allowing GB to export excess wind and solar energy to Europe during high renewable low demand periods.

The measures in the BESS and BESS+CCS scenario to increase renewable capacity mean that GB becomes a net exporter in the late 2020s rather than the early 2030s. In 2021, GB was a net importer from Europe with net electricity imports of 24TWh. This changes significantly by 2040 with GB becoming a net exporter and net exports being up to 70TWh, which would be **worth £1bn/year in net exports to UK plc over the 2030s**.

Conclusions

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Delivering a clean electricity system by 2030?

Delivering accelerated 2030 ambition

Achieving accelerated ambition for 2030 can be achieved cost effectively, but will require new policies and commitments

Setting a gross emissions intensity goal for 2030 can help assess progress towards net zero and drive ambition.

Getting to <30gCO2/kWh in 2030 would mean nearly all (97%) generation is low carbon without costs rising too high and be on track for a net zero power sector in mid-2030s.

The measures outlined in **the British Energy Security Strategy (BESS) accelerate emissions reductions** reducing emissions by 64MTCO2 by 2040.

However **these measures are not enough to get below** <30gCO2/kWh in 2030.

With renewables already deployed at maximum levels, **further deployment of other technologies is needed beyond BESS levels** to accelerate decarbonisation ambition.

Gas CCS is the most feasible option to accelerate ambition by capturing emissions during periods of low wind and sun.

All technologies delivering at maximum levels by 2030 to achieve **clean power carries a significant delivery risk.**

Hydrogen power generation can displace unabated gas capacity and output so effort should be made to **deploy hydrogen in power by at least 2030.**

Impacts of accelerated 2030 ambition

Accelerated 2030 ambition will reduce gas use and emissions whilst acting as an insurance against volatile gas prices.

Accelerating 2030 ambition for electricity is a **£4-11bn insurance against very high gas prices.**

If prices stay at current levels then BESS measures reduces costs by £37bn by 2040.

Achieving 2030 clean power results in a **significant reduction in gas usage.**

Faster low carbon deployment can save 810TWh of gas use through to 2040 in the power sector alone.

Deploying additional **Gas CCS by 2030 can reduce costs and carbon without increasing gas use**.

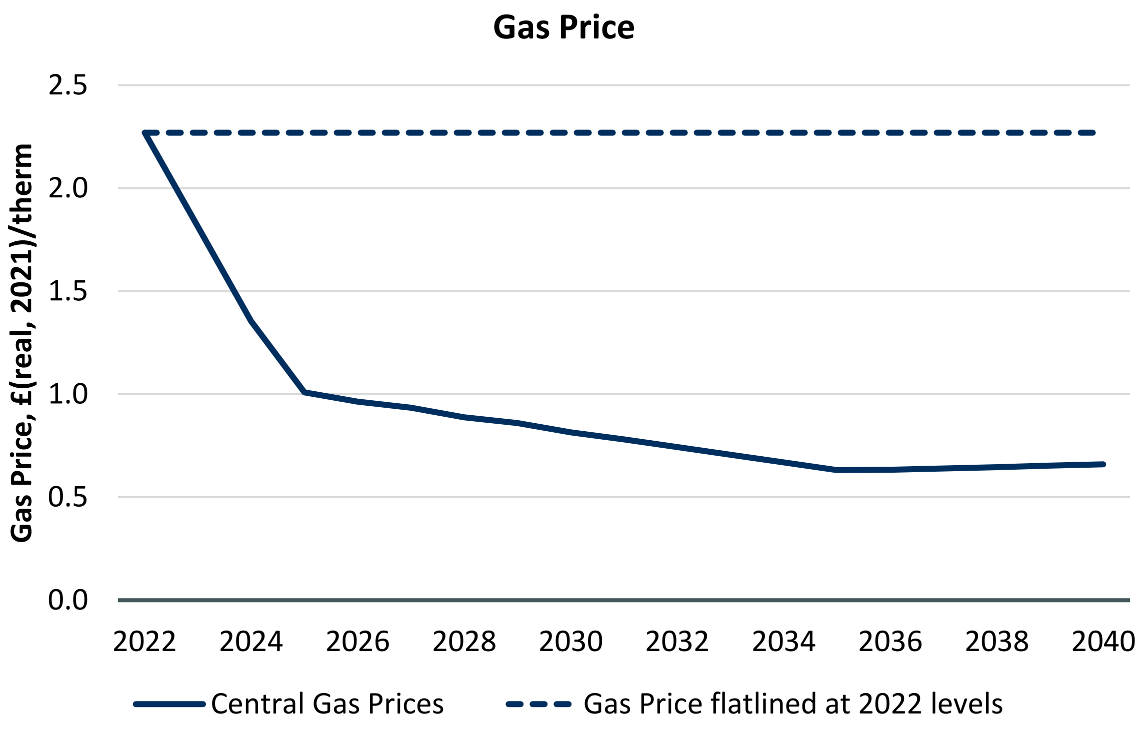
Deploying **7GW gas CCS by 2030 is cost optimal** for the system in a BESS scenario but **reaching 9GW can reduce emissions below 30gCO2/kWh by 2030**.

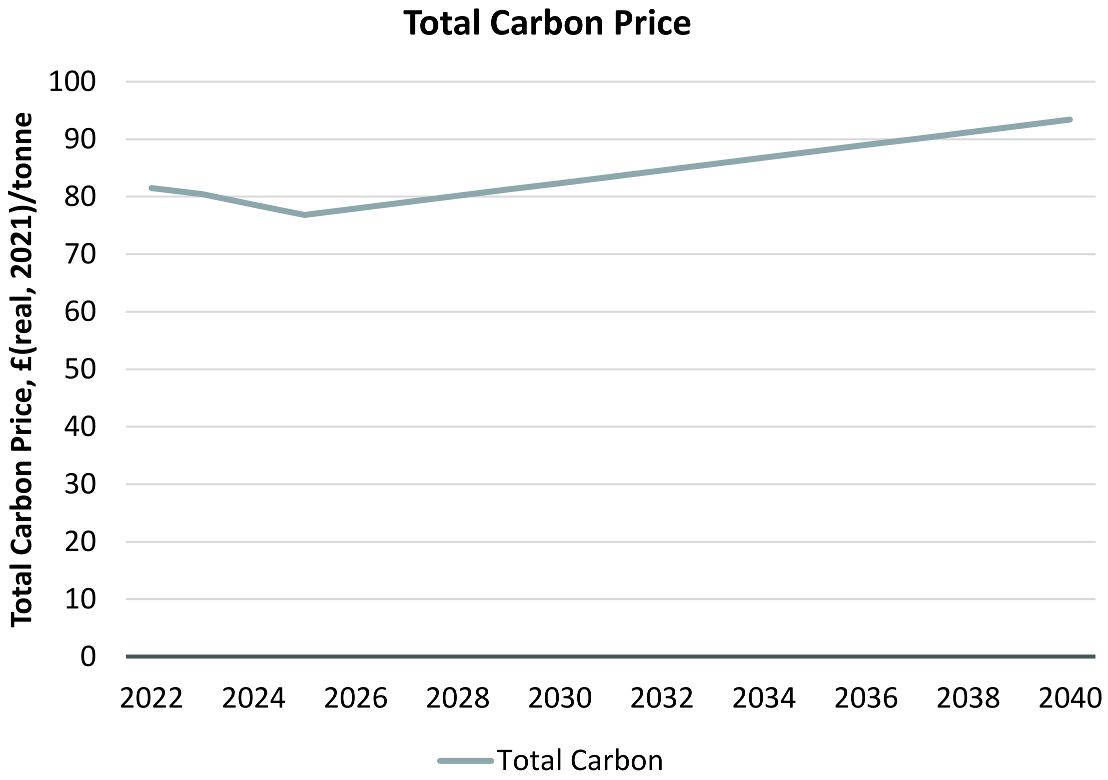
Achieving 2030 clean power can make **GB a net exporter of electricity by late 2020s.**

Net exports could reach up to 70TWh in 2030s, worth £1bn/year in exports to UK plc.

Annex

Annex: Assumptions
Commodity prices





Gas and Carbon Prices are based off forward look curves of gas price for 2025 from May 2022.

Prices are then interpolated from this point to reach FES2021 levels in 2035 in central gas price and carbon price.

Annex: Assumptions

Other Assumptions

Assumption	Status Quo	BESS	BESS – Slower Nuclear Deployment	BESS – Slower Renewables Deployment	2030 Clean Power
Demand	Demand aligns with BEIS Net Zero Lower Demand scenario rising from 305TWh in 2022 to 460TWh in 2035 and 490TWh in 2040				
Peak demand	Peak demand is scaled from FES Consumer Transformation scenario to be consistent with total demand. Peak demand rises from 58GW in 2022 to 95GW in 2040.				
Coal retirements	All retired by 2024				
Nuclear	Hinkley Point C and Sizewell C live by 2028 and 2034. No further Nuclear capacity added	Hinkley Point C and Sizewell C live by 2028 and 2034. Further 6GW added to reach 15GW by 2040 on the way to reaching 24GW ambition in 2050	Hinkley Point C and Sizewell C live by 2028 and 2034. No further Nuclear capacity added	Hinkley Point C and Sizewell C live by 2028 and 2034. Further 6GW added to reach 15GW by 2040 on the way to reaching 24GW ambition in 2050	Hinkley Point C and Sizewell C live by 2028 and 2034. Further 6GW added to reach 15GW by 2040 on the way to reaching 24GW ambition in 2050
Solar	Rising from 15GW in 2022 to 40GW in 2035.	Rising from 15GW in 2022 to 70GW by 2035 in line with BESS ambition.	Rising from 15GW in 2022 to 70GW by 2035 in line with BESS ambition.	Rising from 15GW in 2022 to 40GW in 2035.	Rising from 15GW in 2022 to 70GW by 2035 in line with BESS ambition.
Onshore wind	Rising from 13GW in 2022 to 19GW by 2030 and 36GW by 2040	Rising from 13GW in 2022 to 30GW by 2030 and 48GW by 2040	Rising from 13GW in 2022 to 30GW by 2030 and 48GW by 2040	Rising from 13GW in 2022 to 19GW by 2030 and 36GW by 2040	Rising from 13GW in 2022 to 30GW by 2030 and 48GW by 2040
Offshore wind	Rising from 13GW in 2022 to meet previous 40GW target in 2030 and 75GW in 2040. 5GW of floating offshore wind in 2030	Rising from 13GW in 2022 to meet previous 40GW target in 2030 and 75GW in 2040. 5GW of floating offshore wind in 2030	Rising from 13GW in 2022 to meet previous 40GW target in 2030 and 75GW in 2040. 5GW of floating offshore wind in 2030	Rising from 13GW in 2022 to meet previous 40GW target in 2030 and 75GW in 2040. 5GW of floating offshore wind in 2030	Rising from 13GW in 2022 to meet previous 40GW target in 2030 and 75GW in 2040. 5GW of floating offshore wind in 2030
CCS new build	Rising to 5GW in 2030 and reaching 15GW by 2040	Rising to 5GW in 2030 and reaching 8,5W by 2040	Rising to 5GW in 2030 and reaching 15GW by 2040	Rising to 5GW in 2030 and reaching 8,5W by 2040	Rising to 9GW by 2030
Electrolysis Capacity	Rising to 0.5GW by 2030 and then reaches 40GW by 2040	Rising to 10GW by 2030 and then reaches 50GW by 2040			
Biomass CCS Capacity	0.5GW in 2030 rising to 2.5GW by 2040				
Peaking Capacity	Additional peaking capacity built as required to meet security of supply. This role is fulfilled by Gas Recips pre-2030 with Hydrogen peakers being built after this point				
Technology Costs	All technology costs (opex and capex) taken from BEIS Generation Costs report 2020 with exception of Storage costs taken from Mott Mcdonald report on storage. Floating offshore wind costs based on OREC floating offshore wind report.				