January 2025

Distribution Future Energy Scenarios 2024

Results and assumptions report

South West licence area

nationalgrid DSO

Contents

Glossary

Short form	Definition	Short form	Definition
ACT	Advanced Conversion Technologies	**GW**	Gigawatt
AD	Anaerobic Digestion	**HGV**	Heavy Goods Vehicle
AONB	Area of Outstanding Natural Beauty	**HNDU**	Heat Network Delivery Unit
ASHP	Air Source Heat Pump	**HNIP**	Heat Network Investment Project
CCGT	Combined Cycle Gas Turbine	**HVO**	Hydrotreated Vegetable Oil
CCUS/CCS	Carbon Capture, Utilisation and Storage / Carbon Capture and Storage	**IDNO**	Independent Distribution Network Operator
CfD	Contract for Difference	**kW**	Kilowatt
CHP	Combined Heat and Power	**LA**	Local Authority
DEFRA	Department for Environment, Food and Rural Affairs	**LAEP**	Local Area Energy Plan
DESNZ	Department for Energy Security and Net Zero	**LCT**	Low Carbon Technology
DFES	Distribution Future Energy Scenarios	**LGV**	Light Goods Vehicle
DfT	Department for Transport	**LPG**	Liquefied Petroleum Gas
DNO	Distribution Network Operator	**LV**	Low Voltage
DSO	Distribution System Operator	**MCPD**	Medium Combustion Plant Directive
EfW	Energy from Waste	**MW**	Megawatt
EMR	Electricity Market Reform	**NGED**	National Grid Electricity Distribution
ENA	Energy Networks Association	**OCGT**	Open Cycle Gas Turbine
EPC	Energy Performance Certificate	**ONS**	Office for National Statistics
ESA	Electricity Supply Area	**OS**	Ordnance Survey
ESO	Electricity System Operator	**PHEV**	Plug-in Hybrid Electric Vehicle
EU	European Union	**PV**	Photovoltaic (solar)
EV	Electric Vehicle	**REMA**	Review Of Electricity Market Reform
FES	Future Energy Scenarios	**RIIO-ED3**	Revenue = Incentives + Innovation + Outputs – Electricity Distribution 3 (price control period)
FiT	Feed-in Tariff	**RHI**	Renewable Heat Incentive
GB	Great Britain	**STOR**	Short-Term Operating Reserve
GSHP	Ground Source Heat Pump	**TLO**	Technical Limit Offer
GSP	Grid Supply Point	**TMO4+**	Target Operating Model 4

Introduction to the National Grid Electricity Distribution DFES 2024

Background

The National Grid Electricity Distribution (NGED) Distribution Future Energy Scenarios (DFES) outline the range of credible futures for electricity load on the distribution network, providing granular scenario projections for:

- Distributed electricity generation, such as solar, wind, hydropower, fossil-fuelled generation and bioenergy
- Distributed electricity demand, such as heat pumps, electric vehicle chargers, new housing developments, business space and hydrogen electrolysers
- Distributed electricity storage, including electricity storage and domestic thermal storage
- For 2024, the DFES also models the future electricity demand connecting to the distribution network as a result of the decarbonisation and electrification of maritime, aviation, agriculture and rail sectors.

The DFES projections are directly informed by stakeholder engagement to reflect local and regional drivers, the ambitions of local authorities (including reviewing local area energy plans (LAEPs), where available) and national government targets and policies. The analysis is also influenced by the views of other sector stakeholders, such as project developers, technology companies, trade associations and community groups.

For NGED and other electricity distribution network companies, the DFES allows network planners to model and analyse different future load scenarios for their network. This data then informs integrated network planning and investment appraisal processes. The DFES also provides a key data resource and evidence base to enable NGED to appraise different investment options and develop the business case necessary to support future investment and regulated business plans. NGED and other networks are under way with their preparations for the RIIO-ED3 business planning process, and the data and evidence held within the DFES 2024 assessments will be one of the key inputs to NGED's ED3 business plan.

Scenarios

The NGED DFES uses the National Energy System Operator's (NESO) Future Energy Scenarios (FES) 2024 as a framework, adopting the same national-level societal, technological and economic assumptions as the FES: **Holistic Transition**, **Electric Engagement**, **Hydrogen Evolution** and the **Counterfactual**.

However, the DFES is a bottom-up analysis of a changing energy system at a more granular level, reflecting specific regional and local factors and the impact on the distribution network. The DFES seeks to recognise and reflect that distributed generation, demand and storage will develop in different ways, and at different paces, across the country.

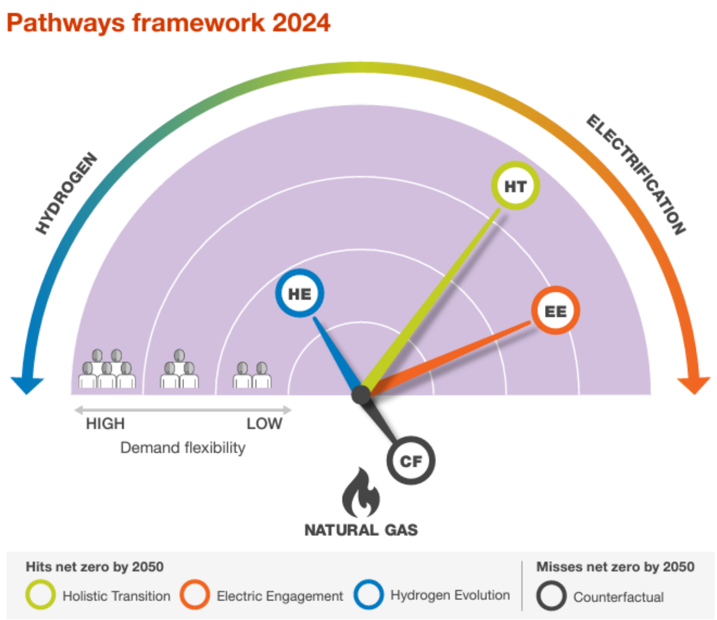


Figure 1 - The FES 2024 pathways framework

Scope

The NGED DFES 2024 scope encompasses technologies that directly connect to, or interact with, the distribution network in the four NGED licence areas: **South Wales**, **South West**, **East Midlands** and **West Midlands**. The scenario projections for these technologies are reported in standardised technology 'building blocks' developed by the Energy Networks Association (ENA).

The DFES scope does not include large-scale assets connecting directly to the National Grid electricity transmission system, such as conventional nuclear power, most offshore wind, large-scale pumped hydropower and many gas-fired power stations.

Annual cycle

The NGED DFES is produced annually, allowing scenario projections to be regularly updated to reflect the latest information available. The DFES is published around the end of the calendar year, following the release of the FES. This allows the DFES analysis to integrate the high-level scenario framework and assumptions from the latest FES and undertake a reconciliation between the FES and the DFES outcomes by technology, scenario and licence area. This annual cycle also allows for data sharing between the NGED DFES and the NESO FES teams, facilitating a continuous improvement of the data quality, processes and scenario modelling between both annual studies.

In addition to the FES, LAEPs produced by local authorities also interact with the DFES. LAEPs are used as a source of input data to feed into the DFES spatial analysis, reflecting specific local plans and ambitions. DFES data points are also being used to inform LAEPs when local authorities are planning for future energy generation, demand and storage.

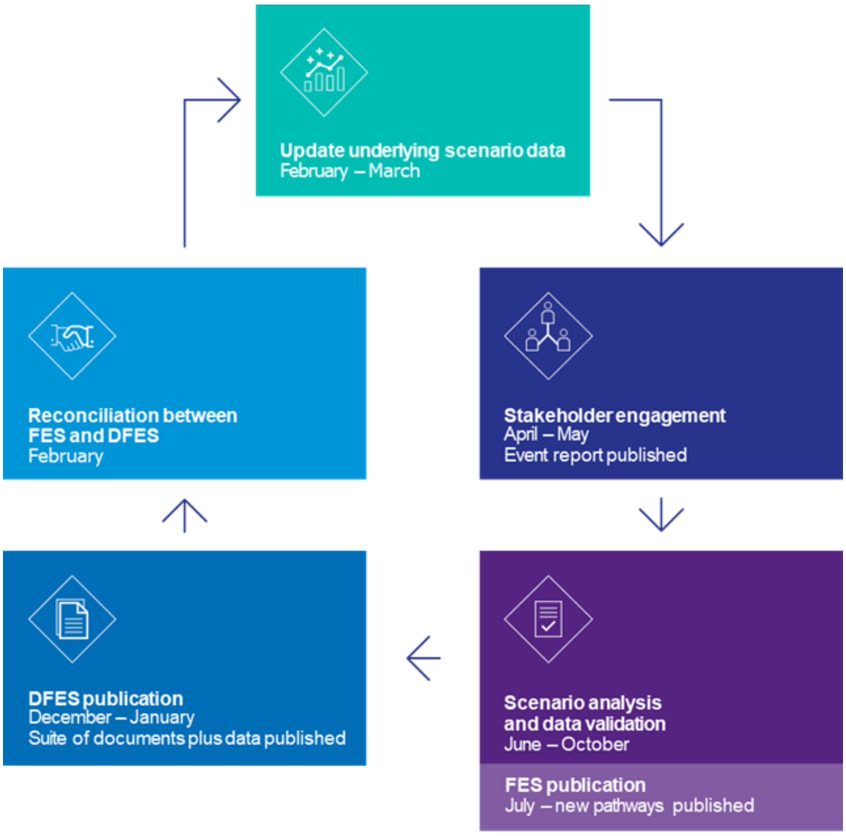


Figure 2 - The NGED DFES annual process

The annual DFES outputs also feed into wider NGED strategic planning processes, such as Network Development Plans and Distribution Network Options Assessments.

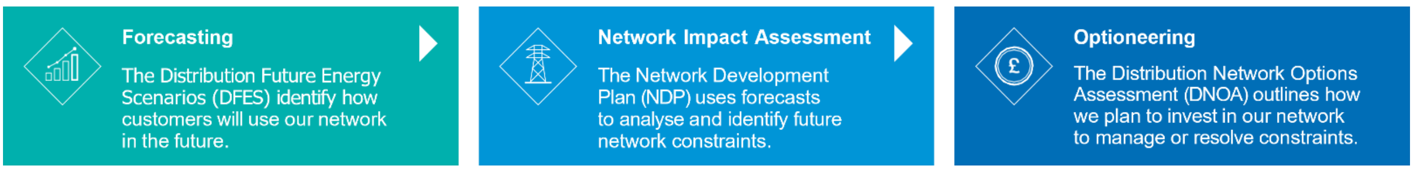


Figure 3 - NGED's strategic network planning process

Results

The NGED DFES 2024 analysis is produced to granular geographic areas known as Electricity Supply Areas (ESAs), of which there are four types:

- **Geographic ESA:** the geographic area fed by a primary substation providing electricity connections at the 11 kV or 6.6 kV level.
- **Single customer ESA:** reflecting a customer directly supplied at 132 kV, 66 kV, 33 kV or 25 kV (or by a dedicated primary substation). This also includes some large 11 kV customers, which require detailed modelling for electrical studies.
- **IDNO ESA:** an independent DNO which connects to the NGED network. These embedded customers generally do not hold a traditional connection agreement.
- **Low voltage ESA:** the geographic area fed by a low voltage transformer, providing electricity connections at less than 11 kV. In the NGED DFES 2024, domestic-scale rooftop PV and batteries, electric heating technologies and EV charger projections are produced at this highly granular level.

These ESAs are also split by local authority boundaries, allowing DFES data to be aggregated up to the local authority or primary substation level. This data can then be used for developing LAEPs and other local planning activities.

Depending on the technology building block, the DFES provides projections of electrical power capacity (MW) or installation numbers (e.g. number of EVs or heat pumps) but does not include analysis of network loads, load profiles, consumption or peak demand. This network load analysis is undertaken by NGED's System Planning team as a follow-on stage in the analysis process. The results of this process are published on the National Grid website.

The South West licence area

The key features of the South West licence area are detailed in the following table and depicted in Figure 4 and Figure 5.

Aspect	Characterisation
Geography	The NGED South West licence area contains a mixture of more populated areas, including Bristol, Exeter and Plymouth, alongside more sparsely populated rural areas, two national parks and hundreds of miles of coastline.
Distributed electricity generation	Distributed electricity generation in the area has increased significantly in recent years. Over 50% of generation capacity connected to the distribution network has connected since the beginning of 2015. Onshore wind and solar PV make up over 60% of the distributed electricity generation capacity, including the 66 MW Fullabrook onshore wind farm in North Devon – the largest generation site connected in the licence area.
Energy resources	The South West licence area has some of the highest levels of solar irradiance in the UK, and several areas of significant wind resource along the north coast of Devon and Cornwall. The licence area also has potential for other renewable technologies such as floating offshore wind, bioenergy and geothermal energy.
Distributed electricity demand	Currently, around 3% of registered vehicles in the South West are EVs, and around 2% of households have an electric heat pump.

Major energy users	The South West has a number of industrial hubs, with a number of large energy-consuming customers, including Bristol Airport, Bristol Port, Plymouth Port and Imerys' china clay quarries and processing plants.
Policy and government	The South West licence area currently contains 18 local authorities, including city region councils like Bristol City Council, Exeter City Council and Plymouth City Council. The licence area also has the West of England Combined Authority, covering the local authorities of Bristol, South Gloucestershire, and Bath and Northeast Somerset.

South West licence area – Baseline Generation and Storage Connections

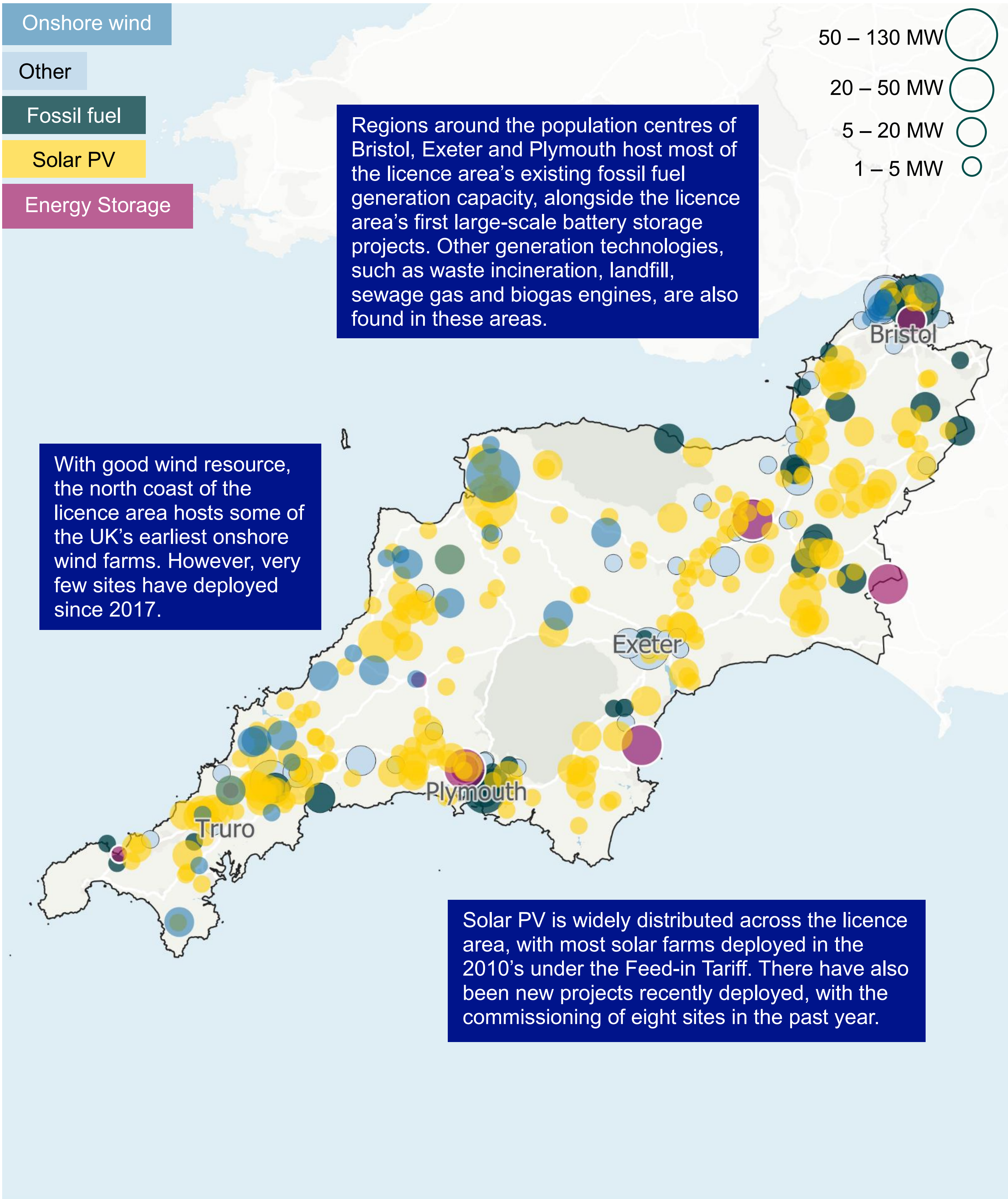


Figure 4: The NGED South West licence area, with the location of existing 'baseline' large-scale generation and storage sites.

South West licence area – Pipeline Generation and Storage Connections

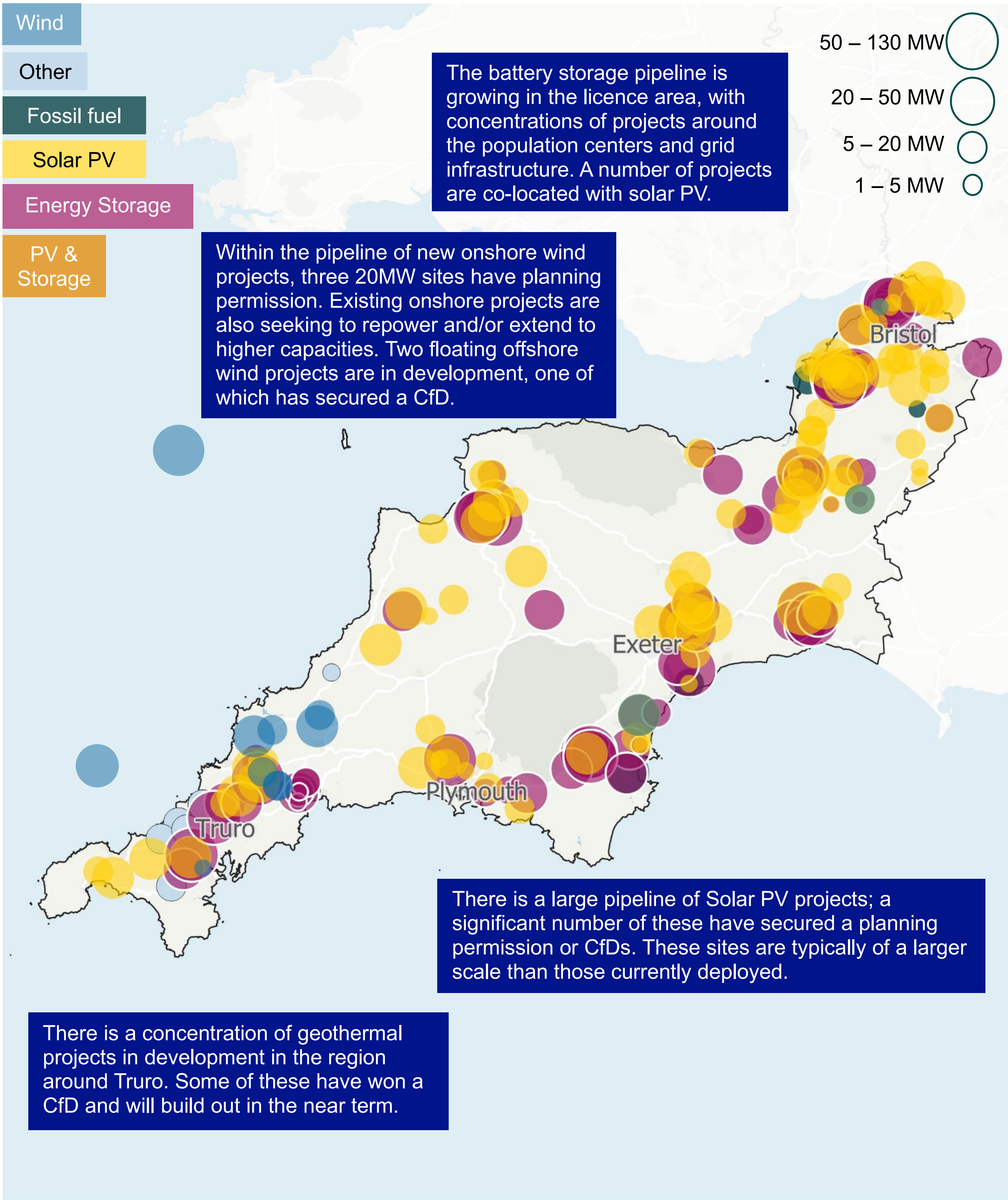


Figure 5: The NGED South West licence area, with the location of proposed 'pipeline' large-scale generation and storage sites.

Methodology

This report details the analysis, assumptions and scenario outcomes for each individual technology in the South West licence area. While a detailed methodology of the overall DFES process is available on the National Grid website, a high-level overview is described below.

DFES component	Characterisation
Baseline analysis	Existing generation, storage and demand connected to the distribution network is analysed to produce a baseline for the licence area. The 2024 baseline year represents the 2023/24 fiscal year, ending on 31 March 2024. This is based on NGED connection data, supplemented with project and energy subsidy programme registers, Department for Transport (DfT) statistics, planning data, EMR Delivery Body Capacity Market registers and other national datasets.
Pipeline analysis	Once a baseline is established, projects that are currently in development are assessed to understand the likely changes to generation and demand in the near term. This mainly comprises sites that have accepted a connection offer from NGED but that have not yet connected. The pipeline also includes sites that have other forms of development evidence, such as spatial planning approvals or applications, housing developments and proposed commercial development space identified in local authority planning documents.
Scenario projections	Key assumptions from the FES 2024 are combined with pipeline analysis, resource assessments, building stock analysis, local and sectoral stakeholder engagement and other modelling assumptions to produce scenario projections out to 2050 for the technologies included in the DFES scope for each ESA. These are detailed in the technology-specific sections of this report.

Local stakeholder influences

The development of the DFES has enabled NGED to take a more proactive approach to network planning. Stakeholders such as local authority planners, project developers, policymakers, energy technology companies, asset owners, major energy users, generation operators and community energy representatives are consulted via a series of consultation events, surveys and one-to-one engagements.

Stakeholder engagement	Description of how feedback is fed into the DFES
Consultation webinars	Four consultation events, one per licence area, were held online in June 2024. These webinars aimed to allow a wide range of local stakeholders to engage directly with NGED and Regen and to provide views on the regional analysis. Reports summarising how the feedback has been directly incorporated into the DFES analysis are available on the National Grid website.
Local authorities	An online data exchange was shared with local authorities to capture their decarbonisation plans and local plans for new housing and commercial developments. In addition, where LAEP reports were available, these were obtained and compared against the DFES scenarios to ensure the LAEP pathways were within the envelope of DFES scenario outcomes, where

	applicable. A separate overview of this comparison analysis was reviewed by NGED and Regen to inform the spatial distribution and uptake of relevant technology capacity projections within relevant local authority regions.
Developer engagement	Companies developing pipeline projects in NGED's licence areas were directly contacted, seeking views on the status and development timeline of key large-scale renewable energy, battery storage and hydrogen electrolysis projects.
Major energy user engagement	A selection of large energy-consuming customers connected to NGED's network were contacted to seek views around their plans regarding future electricity demand, onsite generation and storage, and areas where more information from their NGED could be of use. Eleven customers representing 20 sites across NGED's network responded to this call for input. Separately, Regen contacted the Energy Intensive User Group and Major Energy Users Council for input and insights. The sample size was small and based on site-specific circumstances, so wider trends should not be extrapolated. However, the responses provide anecdotal insight into the changes in energy use and generation for large energy users: ○ Several customers confirmed they will require supply capacity increases, driven mainly by EV charging and heat electrification ○ One customer indicated that a significant load currently met by behind-the-meter CHP would need to be met by an increased import capacity ○ Several customers have plans to install significant amounts of onsite solar generation to reduce grid electricity imports and energy costs and to meet their decarbonisation targets. Other customers are still developing their plans for onsite generation, considering a range of technologies. Key areas where more information was requested included: ○ Flexible network connections ○ Participation in and future of DSO flexibility services ○ Connections policy changes.

DFES-specific aspects

While the scenario framework and high-level assumptions are driven by the FES 2024, a number of specific aspects of the current energy system have been considered in the DFES 2024 analysis.

Aspect	Impact on DFES
Retained capacity for decommissioning assets	Across the four DFES scenarios, assets that are incompatible with net zero targets, such as unabated fossil fuel power generation, decommission by 2050. However, when an asset ceases operation, the connection agreement with NGED and the associated agreed export capacity held by the operator is not automatically relinquished. It is, therefore, likely that some sites will retain their connection capacity, either with a view to participating in network ancillary services such as reserve services or stability services, or for the potential future

	connection of an alternative generation or storage technology that is more compatible with a net zero energy system. To address this, the DFES analysis has assumed that any connection capacity 'freed up' by the mothballing of an existing fossil-fuel site, the removal of a generation asset or the significant reduction of onsite operating hours, is retained either for ten years or until a newly commissioned technology has been modelled to take its place. This assumption is based on direct engagement with stakeholders and internal system planning teams at NGED.
Reflecting upstream constraints on the transmission network	Across the transmission and distribution networks in GB, hundreds of GW of prospective electricity generation and storage projects have secured connection offers with the transmission and distribution network operators. A historic queue-based system for these projects has resulted in projects in some areas of the GB electricity grid being given connection dates well into the 2030s. Upstream constraints on the transmission network continue to impact the timescale of projects in the distribution network connection pipeline. This has been confirmed through discussions with project developers who are currently being directly impacted in NGED's licence areas. The DFES process typically seeks to model scenarios based on an unconstrained grid to allow unbiased future network planning to be undertaken. However, constraints on the transmission network, such as those identified via the Statement of Works process, are not within the remit or control of NGED or distributed generation developers. As such, these constraints have been reflected in the **Counterfactual** scenario. This allows the net zero scenarios to represent a range of potential future connections to the distribution network, including the fast-tracking of network investment and the early releasing of capacity headroom to enable connections.
Reflecting grid connections reform	In response to the impact of upstream transmission constraints on projects in the distribution network connection pipeline, a range of grid connections reform initiatives have been explored in the last 12 months. As part of the ENA's 3-step Action Plan for reforming grid connections, NGED DSO launched a Technical Limits initiative, giving DNOs the ability to accelerate the connection of generators subject to wider Transmission Reinforcement Works. Technical Limit Offers (TLOs) provide distribution customers with the option of an interim non-firm connection arrangement, enabling more agile and 'shovel-ready' customers to connect earlier. The DFES process typically seeks to model scenarios based on an unconstrained grid to allow unbiased future network planning to be undertaken. However, the near-term projections are impacted by current network constraints and proposed reforms, as these predominantly rely on the pipeline of accepted connections. As such, where pipeline sites have accepted a Technical Limit Offer, the updated connection date has been reflected in the scenario envelope as the earliest possible date of connection. NESO has also proposed a number of significant changes to help accelerate the connection queue. The revised approach is an enhanced version of their 'Target Operating Model 4' (TMO4+), which requires projects to meet certain criteria related to land rights and planning permission to be given a queue

	position. This could result in effective fast-tracking for projects that are 'shovel ready'. This reflects the existing DFES process used to assess the stage of development of pipeline sites.
Clean Power 2030 technology capacity requirements	Building on the reforms to manage the grid connections queue, the UK Government has published a detailed action plan for a Clean Power 2030 system and the requirements to enable it. This Clean Power 2030 plan discusses specific technology capacity requirements, including allocations to both regional and network tier levels. It also reinforces the significant reforms being proposed to connection application and queue management processes. Whilst these reforms will likely have a significant impact on the energy project pipelines in NGED's licence areas, the DFES 2024 has not directly modelled or reflected any specific Clean Power 2030 outcomes for any technologies. The DFES methodology and near-term load growth scenarios, particularly for energy generation and storage, has considered development evidence, developer feedback and site-specific information and timeframes around TLOs and Statement of Works.

Energy policy and wider context

Similar to the network planning consideration, several areas of energy policy and wider energy sector context have been considered in the DFES analysis. High energy prices driven by geopolitical factors and post-Covid economic recovery have resulted in a number of energy policy shifts and announcements. A new Labour Government in 2024 has also reframed energy, with the aforementioned Clean Power 2030 being one of the Government's core missions. Other policy developments, such as the Review of Electricity Market Arrangements (REMA), could also have a significant impact on energy project development and consumer adoption of low-carbon technologies.

The global energy crisis, driven by increased prices in oil, gas and electricity markets, is compounding an ongoing cost of living crisis in the UK. This is already impacting the uptake of DFES technologies, such as an increase in rooftop solar installations, and potentially creating challenges for consumers to adopt heat pumps and electric vehicles.

The DFES analysis is, in the near term, based on the current pipeline of projects, which reflects the current situation in the existing electricity market structure. Over the medium and longer term, the framework of four future scenarios aims to capture a range of credible energy system futures, which reflect changes to society, technology and the economy, in some cases markedly above and beyond current energy policy.

As a result, any immediate impacts of energy policy and the wider energy sector context are considered to be reflected in the detailed analysis of the known pipeline of potential connections, while the potential long-term impacts are assumed to be captured in this envelope of potential futures rather than being explicitly modelled in the DFES 2024.

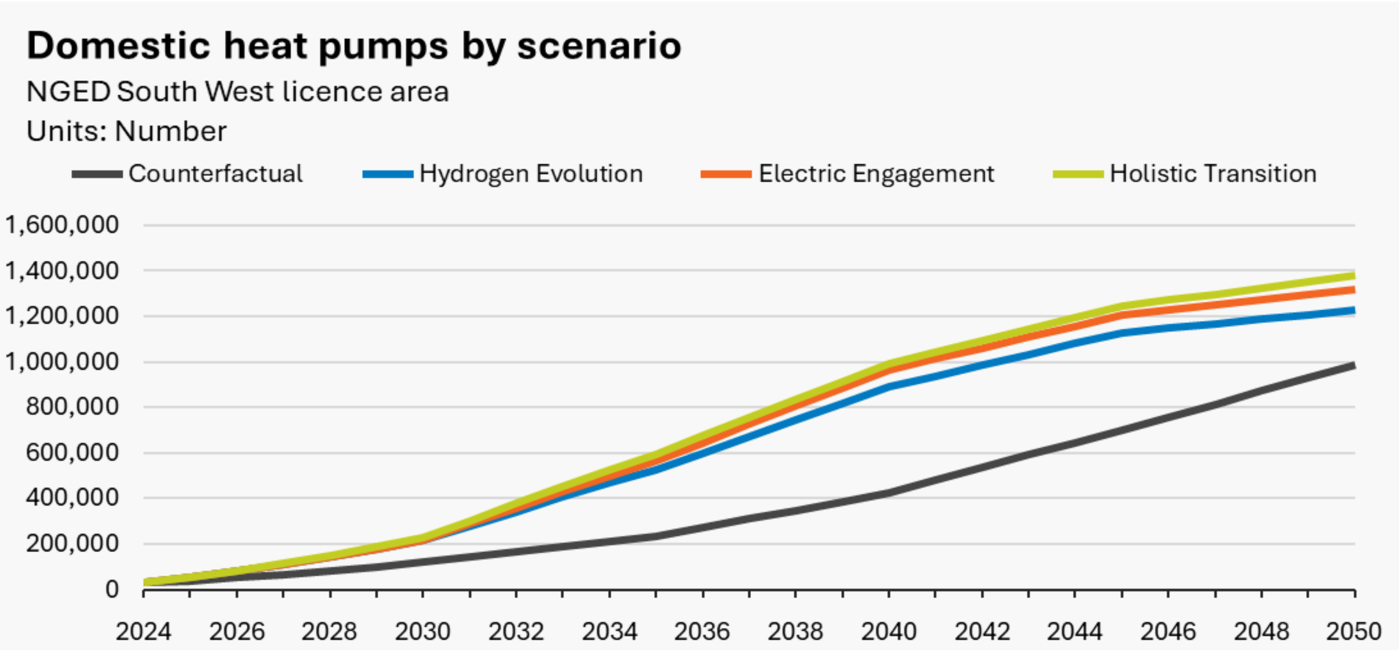
Demand technologies

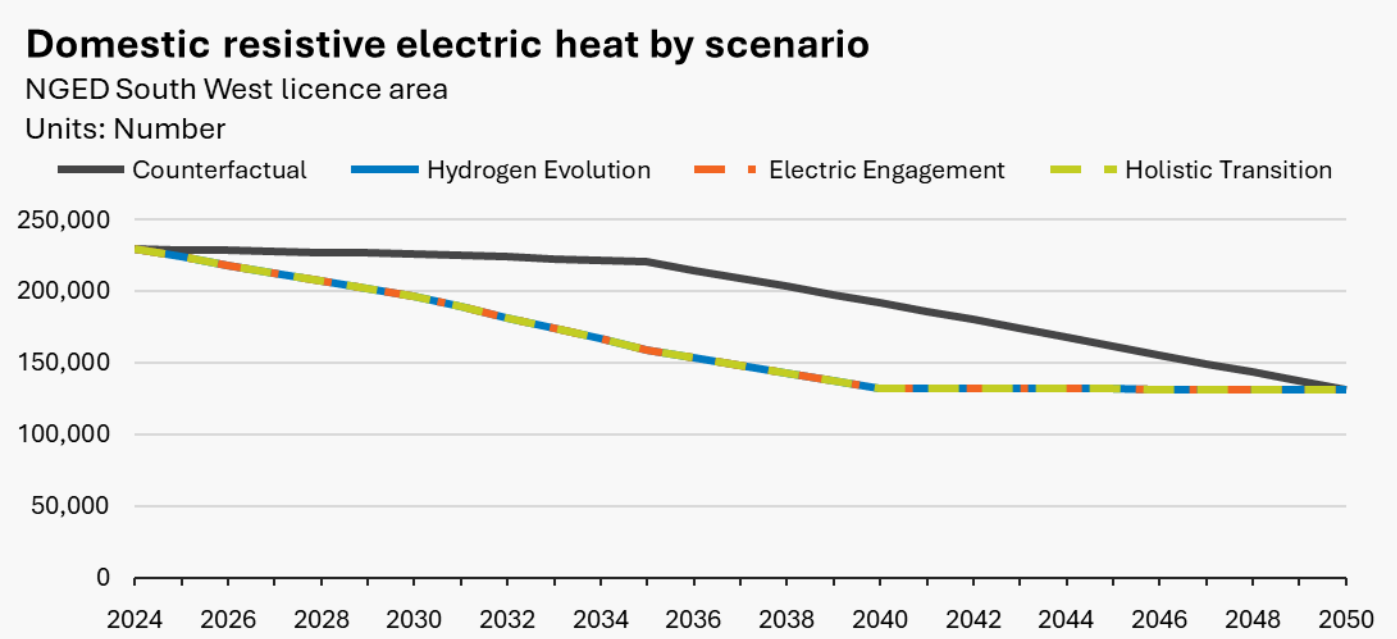
Results and assumptions

Domestic electric heat

Summary

- The South West licence area has a broad range of housing, from dense areas of on-gas houses and flats in built-up urban areas such as Bristol, to highly rural, off-gas areas across Devon and Cornwall. Overall, the licence area has a much higher proportion of off-gas homes than the GB average, resulting in an accelerated uptake of heat pumps in the near term.
- Under **Holistic Transition** and **Electric Engagement**, domestic heating is mostly decarbonised through heat pumps in the South West licence area in line with national trends. Initial uptake in the 2020s is modelled to occur more commonly in off-gas houses and new-build homes. This is a reflection of anticipated energy performance and new build housing regulations, which is in line with the UK government's target of 600,000 heat pump installations per year by 2028. In the medium and long term, a wider-scale rollout is modelled, with the majority of housing stock having heat pumps by 2050. This results in c. 1.3–1.4 million homes using a form of heat pump by 2050 in these scenarios.
- Under **Hydrogen Evolution**, domestic heating is driven primarily by low carbon hydrogen in the form of standalone hydrogen boilers or hybrid heat pumps. However, the higher proportion of off-gas homes in the South West results in higher uptake of non-hybrid heat pumps, as the availability of hydrogen from domestic heating is assumed to be in line with the current fossil gas heating. This results in 1.2 million homes using a form of heat pump by 2050 under this scenario.
- Under the **Counterfactual**, progress towards heat decarbonisation is slow despite some uptake of heat pumps in the late 2030s and 2040s. This results in c. 1 million homes using a form of heat pump by 2050.
- The number of households on resistive electric heating decreases in all scenarios, replaced by more efficient heat pumps and district heating. Direct electric heating, as the most expensive form of resistive electric heating, sees the greatest reduction in the near term. There is a shift from direct electric heating to storage heating in homes where a boiler or heat pump is less suitable.





Modelling assumptions and results

Baseline

Source: EPC certificates, MCS installations data and NGED connections data

	Heating technology	Number of homes	Description
Baseline	Non-hybrid heat pumps	30,000	Most heat pumps in existing homes in the South West licence area were supported by the Renewable Heat Incentive scheme, which ran from 2014 to 2022. This has since been succeeded by the Boiler Upgrade Scheme, which moves support to an upfront grant payment to reduce the capital costs of installing a heat pump. The RHI was particularly popular in the South West, with around 15% of heat pumps accredited by the RHI being in the South West licence area. This has resulted in approximately 2% of homes in the licence area now having a heat pump, which is slightly above the GB average. Resistive electric heating is much more common in the South West compared to the national average, heating nearly 16% of homes compared to around 10% nationally. This is due to a combination of rural areas not connected to the fossil gas network and dense urban areas such as Bristol, which features many blocks of flats with electric heating.
	Hybrid heat pumps	<1,000	
	Resistive electric heating	229,000	
	Connections to heat pump-driven district heat networks	<2,000	

Projections

Scenario	Description
Holistic Transition **Electric Engagement**	Homes are mostly decarbonised with heat pumps in the **Holistic Transition** scenario, with many of these heat pumps installed with thermal storage via either a conventional hot water tank or a more modern heat battery. Initial uptake in the 2020s is modelled to occur more commonly in off-gas houses and new-build homes due to anticipated energy performance and new-build housing regulations, before a wider-scale rollout is modelled on the majority of housing stock by 2050. In the South West licence area, this results in c. 1.4 million homes using a form of heat pump by 2050 under **Holistic Transition** and c. 1.3 million under **Electric Engagement**. Bristol, the largest population centre in the South West licence area, sees the roll-out of a number of planned heat-pump-driven heat networks under all scenarios, significantly influencing the uptake of district heat network heat pumps in the licence area in the near term. The adoption of district heat networks is expanded across Bristol and into other dense population centres in the licence area, such as Exeter and Plymouth. This results in 0.2 million homes connected to heat pump-driven heat networks by 2050 under these scenarios. The number of households on resistive electric heating decreases in all scenarios, replaced by more efficient heat pumps and district heating. Direct electric heating, as the most expensive form of resistive electric heating, sees the greatest reduction in the near term. There is a shift from direct electric heating to storage heating in homes where a boiler or heat pump is less suitable. However, around 60% of the baseline remains on resistive heating in 2050, particularly in smaller flats where a heat pump may not be suitable or economical.
Hydrogen Evolution	Homes are decarbonised primarily through low-carbon hydrogen options in the **Hydrogen Evolution** scenario, through the use of standalone hydrogen boilers or hybrid heat pumps. However, the higher proportion of off-gas homes in the South West results in higher uptake of non-hybrid heat pumps, as the availability of hydrogen from domestic heating is assumed to be in line with current fossil gas heating. This results in c. 1.2 million homes using a form of heat pump by 2050. District heating plays a role in domestic heat decarbonisation in urban areas across the South West especially after 2030. Where a district heat network area has been identified, the majority of flats and terraces, and a substantial proportion of semi-detached and detached homes, in the area are modelled to connect. New-build homes in district heat network areas are also projected to connect to the network in most cases. This results in c. 0.3 million homes connected to heat pump-driven heat networks by 2050 under this scenario. Resistive heating declines throughout the scenario timeframe due to the uptake of heat pumps and district heating. Direct electric heating, as the most expensive heating method, sees a greater reduction in the near term. There is a shift from direct electric heating to next-generation storage heating in homes where a boiler or heat pump is less suitable. However, around 60% of the baseline remains on resistive heating in 2050, particularly in smaller flats where a heat pump may not be suitable or economical.

Counterfactual	Under the **Counterfactual** scenario, progress towards heat decarbonisation is slow, despite some uptake of heat pumps in the late 2030s and 2040s. In this scenario, many homes remain heated by fossil gas boilers in 2050, and the UK fails to meet its carbon emissions reduction targets. In the South West licence area this results in only c. 1 million homes using a form of heat pump by 2050. District heat networks also see lower uptake under this scenario, as progress towards net zero is slower. As a result, only c. 62 thousand homes are connected to a heat network by 2050 under this scenario. Resistive heating declines after 2035 due to the uptake of heat pumps and district heating. Direct electric heating, as the most expensive heating method, sees a greater reduction in the near term. There is a shift from direct electric heating to next-generation storage heating in homes where a boiler or heat pump is less suitable. However, around 60% of the baseline remains on resistive heating in 2050, particularly in smaller flats where a heat pump may not be suitable or economical.

Uptake modelling factors

The below factors are used to inform the overall uptake of domestic electric heating in the South West licence area.

Factor	Modelling impact	Source
New developments	Domestic heating in new homes has been modelled in line with The Future Homes and Buildings Standards: 2023 consultation, with heat pumps or district heating installed for the vast majority of new homes.[1]	Future Homes and Buildings Standards, DFES new developments projections
National uptake trends	The overall GB uptake of heating technologies modelled in the DFES reflects the overarching FES 2024 trends, such as a focus on electrified heat under **Holistic Transition** and **Electric Engagement** (which meet the UK government's target of 600,000 heat pump installations per year by 2028) and the availability of hydrogen for heating under **Hydrogen Evolution**.	FES 2024

Spatial factors

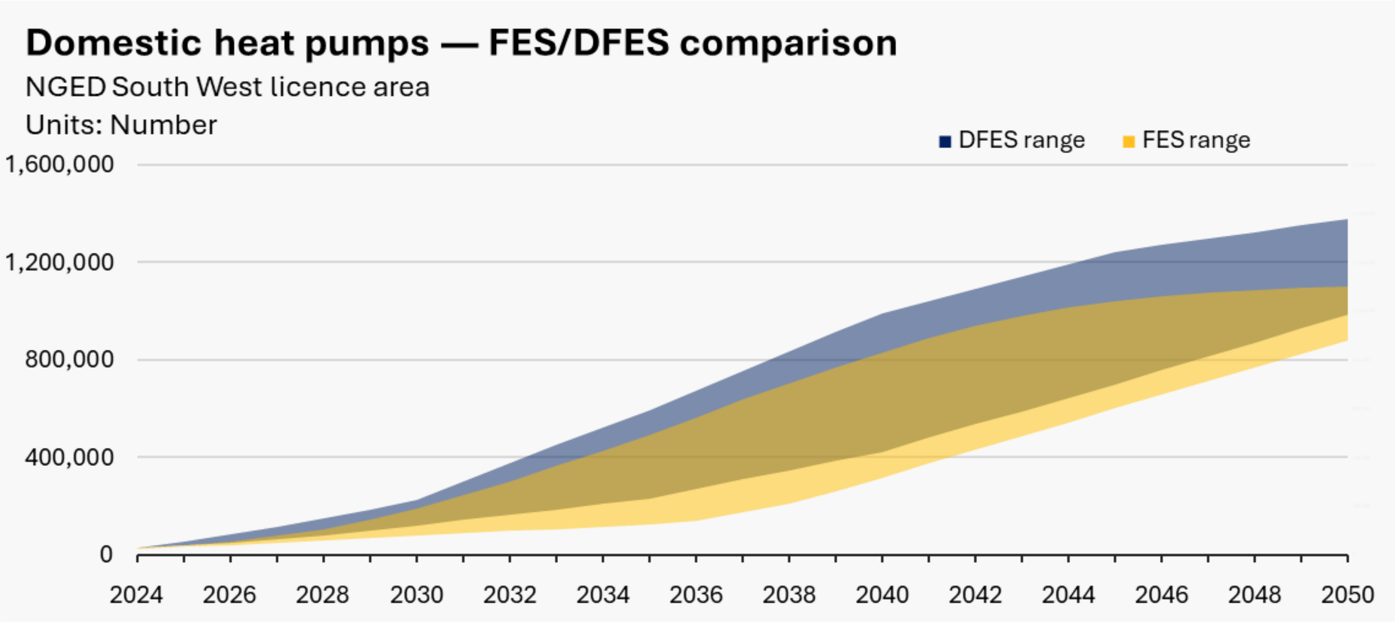
The below factors are used to inform the spatial distribution of domestic electric heating capacity across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Current heating technology	Current heating technology, categorised into on-gas, resistive electric heating and off-gas, affects when the uptake of decarbonised heating technology is projected to occur and what type of heating technology is likely to be installed.	EPC data, ONS Census

Building type	Building type, categorised into semi-detached, detached, terraced and flats, affects when the uptake of decarbonised heating technology is projected to occur and what type of heating technology is likely to be installed.	EPC data, ONS Census
Tenure	Tenure, categorised into owner-occupied, privately rented and socially rented, affects when uptake of decarbonised heating technology is projected to occur.	EPC data, ONS Census
Construction age band	Construction age band, categorised into pre-1930 and post-1930 construction, affects when the uptake of decarbonised heating technology is projected to occur and what type of heating technology is likely to be installed. This banding aligns with the findings of the NGED DEFENDER project.	EPC data
Areas with potential for district heat networks, or an existing heat network pipeline project	Areas with potential for district heat networks or an existing heat network pipeline project affects the likelihood of properties connecting to a district heat network as opposed to decarbonising with other heat technologies.	Heat network pipeline data, and Opportunity Areas for District Heat Networks in the UK - DESNZ
Hydrogen supply for domestic heating	In FES 2024, the **Holistic Transition** scenario features a small proportion of homes heated by hydrogen boilers or hydrogen hybrid heat pumps. The location of these homes has been modelled primarily on the east coast, in line with the East Coast Hydrogen project from Humber to Teesside, and the north west, in line with the HyNet North West project. Therefore, in this scenario, it is assumed that hydrogen supply for domestic heating does not extend to the South West licence area. Under **Hydrogen Evolution**, it is assumed that hydrogen supply follows the existing gas distribution network.	East Coast Hydrogen, HyNet North West, NESO FES engagement
Local Area Energy Plans	Data from Local Area Energy Plans has been obtained where available and reconciled against the DFES outcomes.	Local authority engagement

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.



- For all scenarios, the trend between the DFES outcomes and FES 2024 data for total heat pumps is comparable in the near-to-medium term. However, in the longer term there is a significant increase in the total numbers of homes modelled to have heat pumps or district heating in the DFES. This is due to a greater number of new build homes modelled in the DFES compared to FES, informed by our direct local authority engagement and data collection around new housing. The vast majority of new builds are modelled to be constructed with either a heat pump or district heating installed, as per The Future Homes and Buildings Standards: 2023 consultation.
- There is no regional level data in FES 2024 for resistive electric heating and, therefore, a direct comparison is not possible.

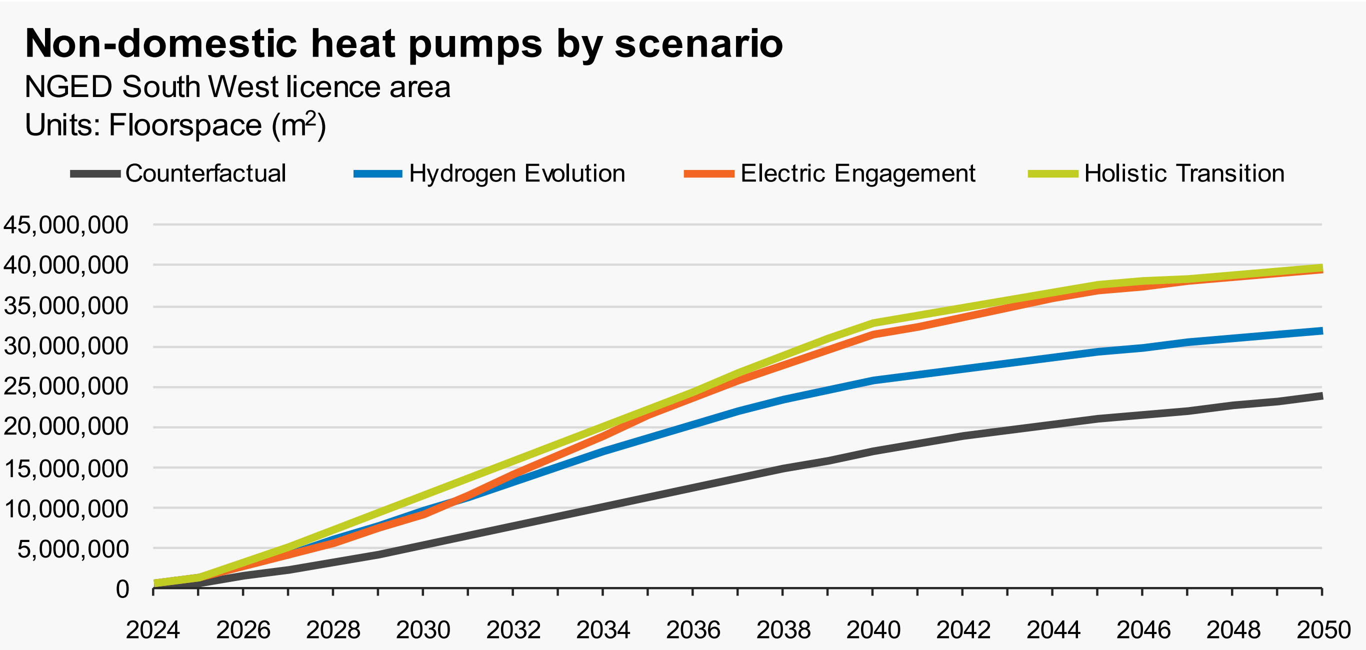
Comparison to DFES 2023

- The DFES 2024 scenario projections for **Hydrogen Evolution** scenario projection differ the most when compared to DFES 2023 System Transformation. This is due to an updated FES 2024 framework which has increased the number of heat pumps and reduced the amount of hydrogen for domestic heating under this scenario.
- The **Holistic Transition** and **Electric Engagement** scenario projections for heat pumps are lower than the projections from DFES 2023. For the **Holistic Transition** scenario, this is true until 2043 where the DFES 2024 projections start to overtake DFES 2023 projections. This is due to an updated FES 2024 framework which has reduced the uptake of heat pumps in the near term, reflecting current national uptake trends.
- The **Counterfactual** scenario is broadly aligned with the DFES 2023 projections, although slightly higher in the long term. This is due to the more ambitious uptake of heat at a national level modelled in FES 2024, which has been reflected in the DFES 2024 modelling.
- Resistive electric heating follows a similar trend in all scenarios in both DFES 2023 and DFES 2024. An earlier shift away from resistive electric heating, and matching outcomes in all three net zero scenarios, have been modelled to align with the national FES 2024 assumptions.

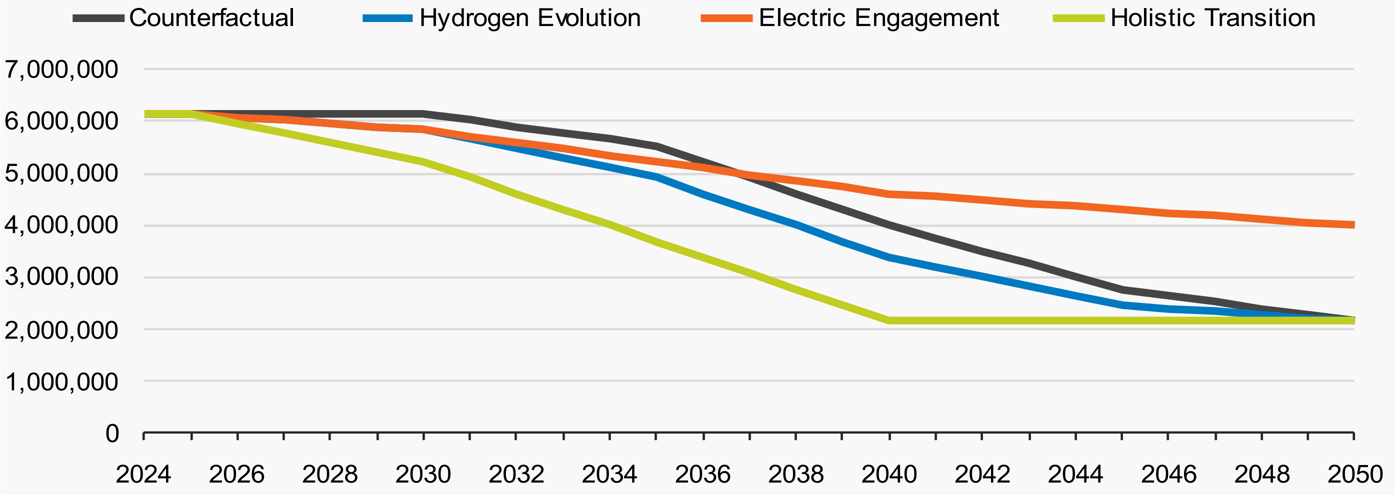
Non-domestic electric heat

Summary

- Heating in non-domestic buildings is currently dominated by gas-fired central heating, resistive electric heating and air conditioning for cooling.
- An evidence update from DESNZ on low-carbon heating and cooling in non-domestic buildings[2] found that non-domestic building decarbonisation pathways are strongly influenced by the existing heating system and HVAC environment.
- In all four scenarios, the near-term uptake of heat pumps in non-domestic buildings is focused on buildings heated with off-gas and direct electric heating systems due to the higher operational costs of these technologies.
- In the medium to long term, buildings currently heated by gas, oil or LPG are modelled to move to an air-source or ground-source heat pump, or connect to a district heat network, while most buildings with resistive electric heating are modelled to move to more efficient air-to-air heat pumps, operating similarly to air conditioners.
- Non-domestic buildings are primarily decarbonised with heat pumps in the three net zero scenarios, resulting in heat pumps heating 32-40 million sqm of floorspace by 2050.
- In all scenarios, resistive heating declines substantially from 2025 through to 2050 in non-domestic buildings, due to the uptake of more efficient heat pumps and district heating. Direct electric heating, as the most expensive heating method, sees a greater reduction in the near term. Under the **Electric Engagement** scenario, a higher proportion of non-domestic buildings remain on resistive electric heating in the long term due to the particularly strong focus on electrification of heat and limited low-carbon alternatives under this scenario.



Non-domestic resistive electric heat by scenario
NGED South West licence area
Units: Floorspace (m^2)



Modelling assumptions and results

Baseline

Source: NDEPC and DEC certificates and MCS installations data

	Heating technology	Total floorspace (million sqm)*	Description
Baseline	Heat pumps	0.5	Analysis of EPC and DEC data suggests that 7 million square meters of non-domestic floorspace is currently heated by resistive electric heating. This does not include buildings with air conditioning that are recorded as predominantly providing cooling.
	Resistive electric heating	6.1	EPC and DEC data does not record whether a building is heated by a heat pump. As a result, the heat pump baseline is informed by MCS installation data.

** This is a proportion of the total floorspace in non-domestic EPC and DEC data. This total includes unheated or air-condition-only properties, which make up around 25% of total floorspace.*

Projections

Scenario	Description
Holistic Transition	Non-domestic buildings are primarily decarbonised with heat pumps in the **Holistic Transition** scenario. Similar to heating in domestic buildings, near-term decarbonisation of heat in non-domestic buildings is focussed on buildings heated with off-gas and direct electric heating systems due to the higher operational costs of these technologies. In the South West licence area, this results in c. 40 million sqm of floorspace heated using a form of heat pump by 2050. Resistive heating declines sharply throughout the scenario timeframe from 2025 to 2040, due to the uptake of heat pumps and district heating. Around 35% of the baseline remains on resistive heating in 2050. Direct electric heating, as the most expensive heating method, sees a greater reduction in the near term.
Electric Engagement	Non-domestic buildings are primarily decarbonised with heat pumps in the **Electric Engagement** scenario. Similar to heating in domestic buildings, near-term decarbonisation of heat in non-domestic buildings is focused on buildings heated with off-gas and direct electric heating systems in the South West licence area, this results in c. 40 million sqm of floorspace heated using a form of heat pump by 2050. Resistive heating declines at a slower rate throughout the scenario timeframe, when compared to the other three scenarios resulting in a higher proportion of non-domestic buildings remaining on resistive electric heating in the long term. This is due to the particularly strong focus on the electrification of heat and limited low-carbon alternatives under this scenario. Around 65% of the baseline remains on resistive heating in 2050. Direct electric heating, as the most expensive and least flexible electric heating method, sees a greater reduction in the near term.
Hydrogen Evolution	Non-domestic buildings are primarily decarbonised with heat pumps in the **Hydrogen Evolution** scenario. Similar to heating in domestic buildings, near-term decarbonisation of heat in non-domestic buildings is focussed on buildings heated with off-gas and direct electric heating systems In the South West licence area, this results in c. 32 million sqm of floorspace heated using a form of heat pump by 2050. Resistive heating declines throughout the scenario timeframe from 2025 to 2050, due to the uptake of heat pumps and district heating. Around 35% of the baseline remains on resistive heating in 2050. Direct electric heating, as the most expensive and least flexible electric heating method, sees a greater reduction in the near term.
Counterfactual	Although to a lesser extent, non-domestic buildings are still primarily decarbonised with heat pumps in the **Counterfactual** scenario. Similar to heating in domestic buildings, near-term decarbonisation of heat in non-domestic buildings is focussed on buildings heated with off-gas and direct electric heating systems In the South West licence area, this results in c. 24 million sqm of floorspace heated using a form of heat pump by 2050. This is the lowest level of heat pump uptake in non-domestic buildings of the four scenarios, with a number of properties likely still remaining on fossil fuel heating systems by 2050. Resistive heating declines throughout the scenario timeframe from 2025 to 2050, due to the uptake of heat pumps and district heating. Around 35% of the baseline remains on resistive heating in 2050. Direct electric heating, as the most expensive and least flexible electric heating method, sees a greater reduction in the near term.

Uptake modelling factors

The below factors are used to inform the overall uptake of onshore wind in the South West licence area.

Factor	Modelling impact	Source
New developments	Heating in new non-domestic buildings has been modelled in line with The Future Homes and Buildings Standards: 2023 consultation, with heat pumps or district heating installed for the vast majority of new buildings.[1]	Future Homes and Buildings Standards, DFES new developments projections [1]
Existing baseline of non-domestic heat pump installations	Provides baseline numbers of non-domestic heat pump installations.	MCS installation data
National uptake trends	The overall GB uptake of heating technologies modelled in the DFES reflects the overarching FES 2024 trends, such as a focus on electrified heat under **Holistic Transition** and **Electric Engagement** and the availability of hydrogen for heating under **Hydrogen Evolution**, although the availability of hydrogen predominantly impacts domestic buildings.	FES 2024

Spatial factors

The below factors are used to inform the spatial distribution of onshore wind capacity across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Current building environment of non-domestic buildings (heating, cooling and ventilation requirements)	Current building heating environment including heating, cooling and ventilation requirements, affects when uptake of decarbonised heating technology is projected to occur and what type of heating technology is likely to be installed. This is based on DESNZ's 'Evidence update of low carbon heating and cooling in non-domestic buildings'.[3]	NDEPC and DEC data
Current heating technologies of non-domestic buildings	Current heating technology affects when uptake of decarbonised heating technology is projected to occur and what type of heating technology is likely to be installed. This is also based on DESNZ' 'Evidence update of low carbon heating and cooling in non-domestic buildings'.	NDEPC and DEC data
Areas with potential for district heat networks, or an existing heat	Areas with potential for district heat networks or an existing heat network pipeline project affects the likelihood of properties connecting to a district heat network as opposed to decarbonising with other heat technologies.	Heat network pipeline data, Opportunity Areas for District Heat Networks in the UK - DESNZ

network pipeline project		
Areas with potential for hydrogen zones	Areas with potential for hydrogen zones around industrial clusters affects when the uptake of decarbonised heating technology is projected to occur and what type of heating technology is likely to be installed under **Holistic Transition** and **Hydrogen Evolution**.	East Coast Hydrogen, HyNet North West, NESO FES engagement

Large-scale heat pumps for district heating

Once the buildings connecting to the heat network in the baseline and into the future under the different scenarios have been identified, peak heating demand assumptions are applied, and a COP of 3 is assumed to calculate the size of heat pump that would be installed to support the demand of the heat network customers. Where heat network zones exist, it is assumed that energy centres are located in these zones and serve neighbouring areas. Where heat network zones do not exist, it is assumed that energy centres will be located in areas with the highest district heating demand and serve neighbouring areas.

Reconciliation to FES 2024

As the FES non-domestic heat outputs are reported in number of installations rather than heated floorspace, it is not possible to directly reconcile the DFES with it. The modelling aims to mirror the high-level outcomes from non-domestic heating in each of the four FES scenarios.

Comparison to DFES 2023

- For all four scenario projections prior to 2028, DFES 2023 outcomes were higher than DFES 2024 numbers. This is due to reallocation of building environments using air conditioning for cooling only, rather than for heating and cooling, to not be classified as heat pumps in the baseline.
- After 2028, DFES 2024 scenario projections begin to overtake and increase compared to DFES 2023 projections. This is due to the implementation of assumptions from the Future Homes and Buildings Standard 2023 consultation, which specifies heat pumps or district heating will be required in the vast majority of new non-domestic buildings. Prior to the publication of this consultation, at the time of the DFES 2023 modelling, the assumptions had a wider range of potential low-carbon heating technologies in new non-domestic buildings, including resistive electric heating, bioenergy and hydrogen.

EVs and EV chargers

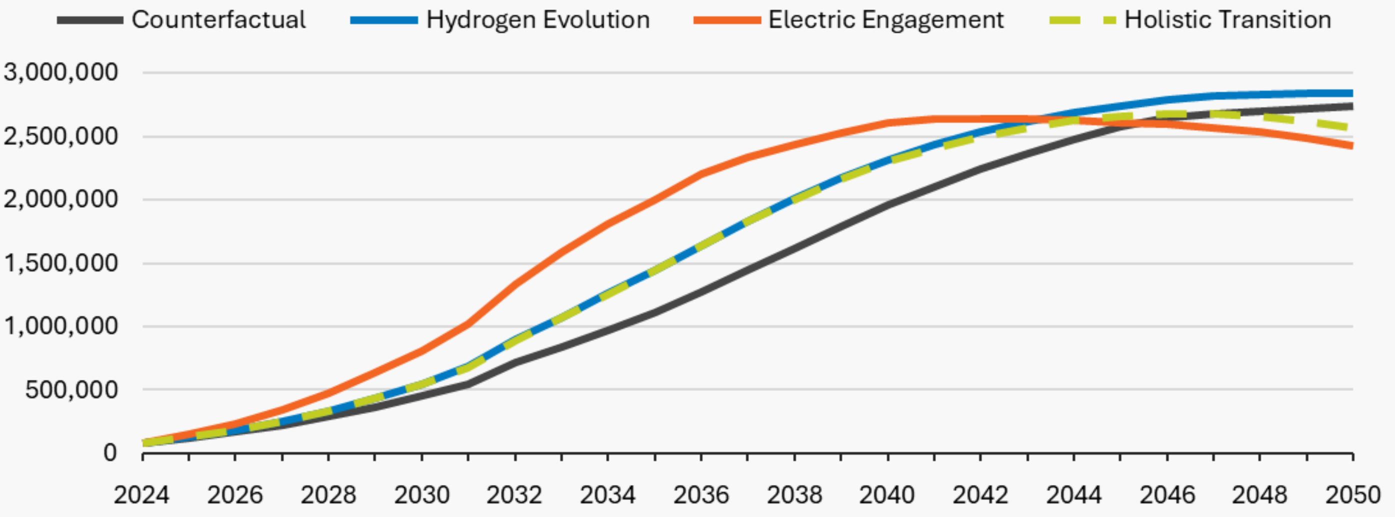
Summary

- Around 3% of vehicles in the South West licence area are currently battery electric or plug-in hybrid. This is anticipated to increase substantially under every scenario, as the UK looks to decarbonise the transport sector through electrification.
- In **Hydrogen Evolution** and **Holistic Transition**, the electrification of vehicles reflects the current Zero Emission Vehicle (ZEV) mandate of no new petrol or diesel cars to be sold after 2035.[4]
- Under **Electric Engagement**, EV uptake has been modelled to align with an accelerated ZEV mandate, with no new petrol or diesel cars sold after 2030, which has been discussed but has not yet been legislated.[5] Under this scenario, passenger vehicles such as cars and LGVs are rapidly electrified over the 2020s and the early 2030s. Non-passenger vehicles, such as HGVs and buses, follow suit, though over a longer timeframe. By 2050, almost all road vehicles are electrified – with the vast majority of EVs being fully battery electric.
- A greater availability of low-carbon hydrogen, including in cities, under the **Hydrogen Evolution** scenario results in harder-to-electrify vehicles, such as buses and HGVs, adopting hydrogen-fuelled alternatives, resulting in a more limited EV uptake.
- The electrification of transport is slowest overall under the **Counterfactual** scenario; however, the vast majority of vehicles are still electrified by 2050.
- **Electric Engagement** and **Holistic Transition** both see a fall in overall vehicle ownership as car sharing, active travel and greater use of public transport reduce the need for private vehicle ownership.
- Regen's DFES transport model determines the charger that is capacity required for the number of vehicles projected under each of the four DFES scenarios. This future charger requirement is split across a number of different domestic and non-domestic charger types, such as domestic off-street chargers, rapid en-route chargers and chargers in public car parks. eHGV chargers are also modelled, with deployment centred around HGV service stations along major highways.
- The near-term deployment of EV chargers is representative of the pipeline of commercial EV charging points which have an accepted connection offer from NGED. In the South West, this totals 111 MW, the majority of which is categorised as en-route chargers.
- The scenarios see the greatest variation in the medium term, with between 4.6 GW and 8.7 GW of EV charging capacity connected in the licence area in 2035. The scenarios converge in the longer term as road transport electrification progresses, resulting in a minimal range of outcomes around 10 GW by 2050.

Electric cars, LGVs and motorcycles by scenario

NGED South West licence area

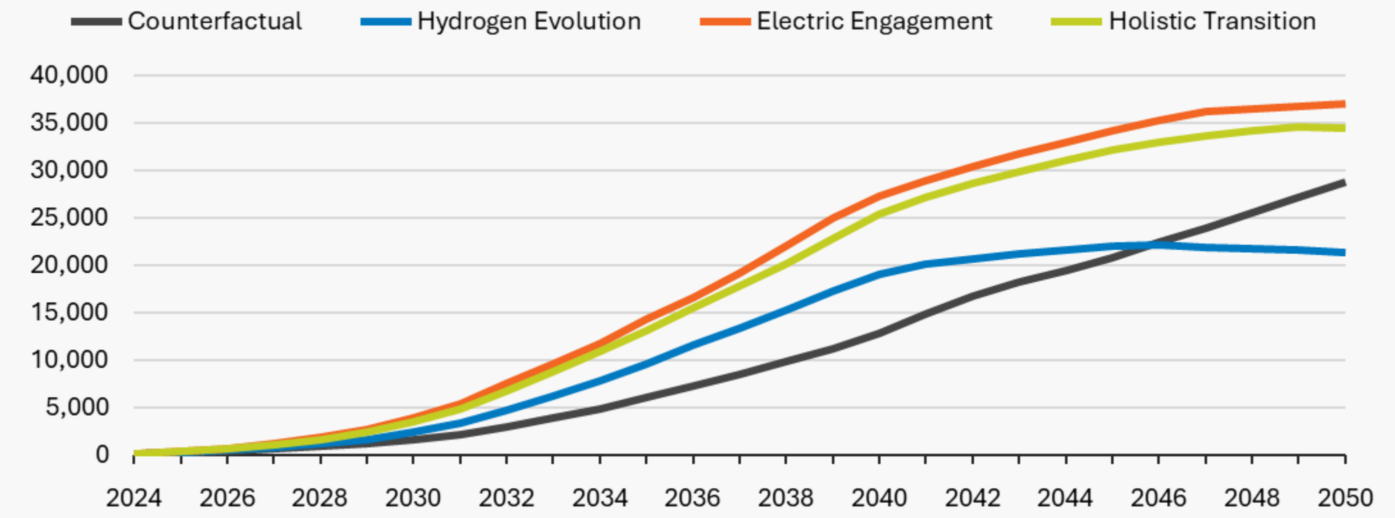
Units: Number

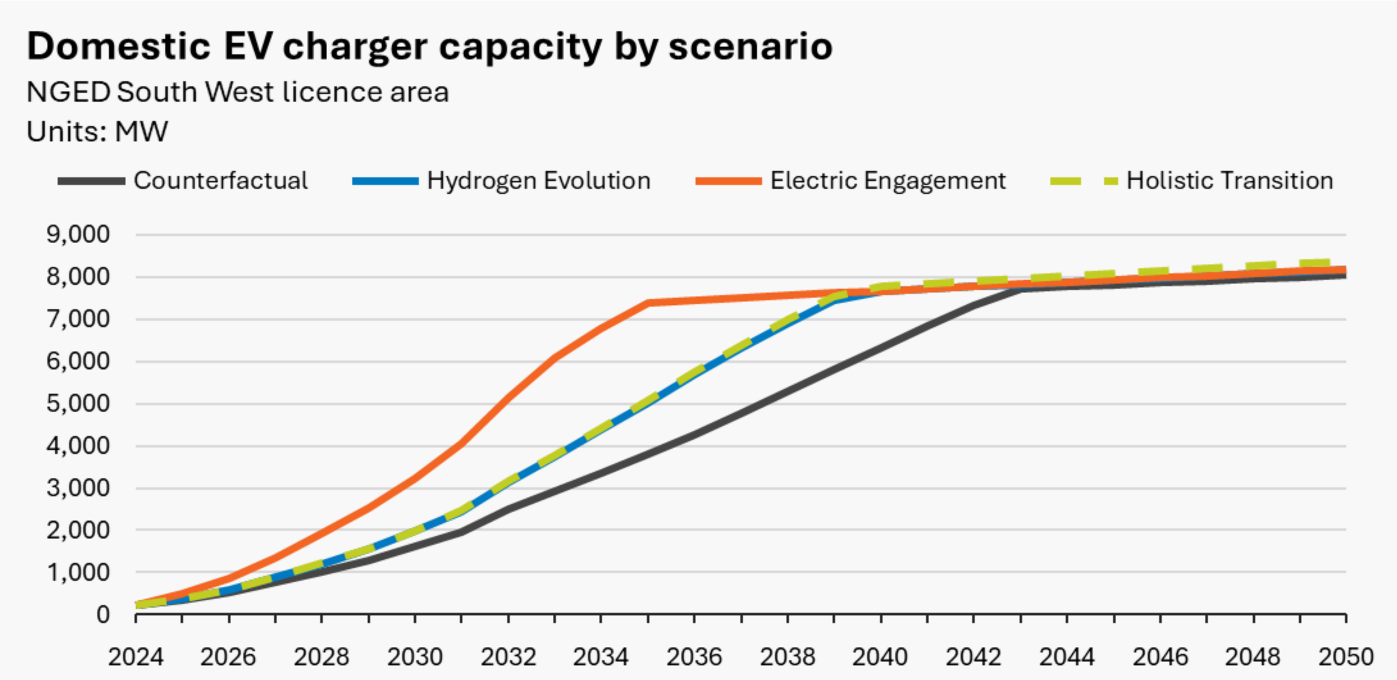


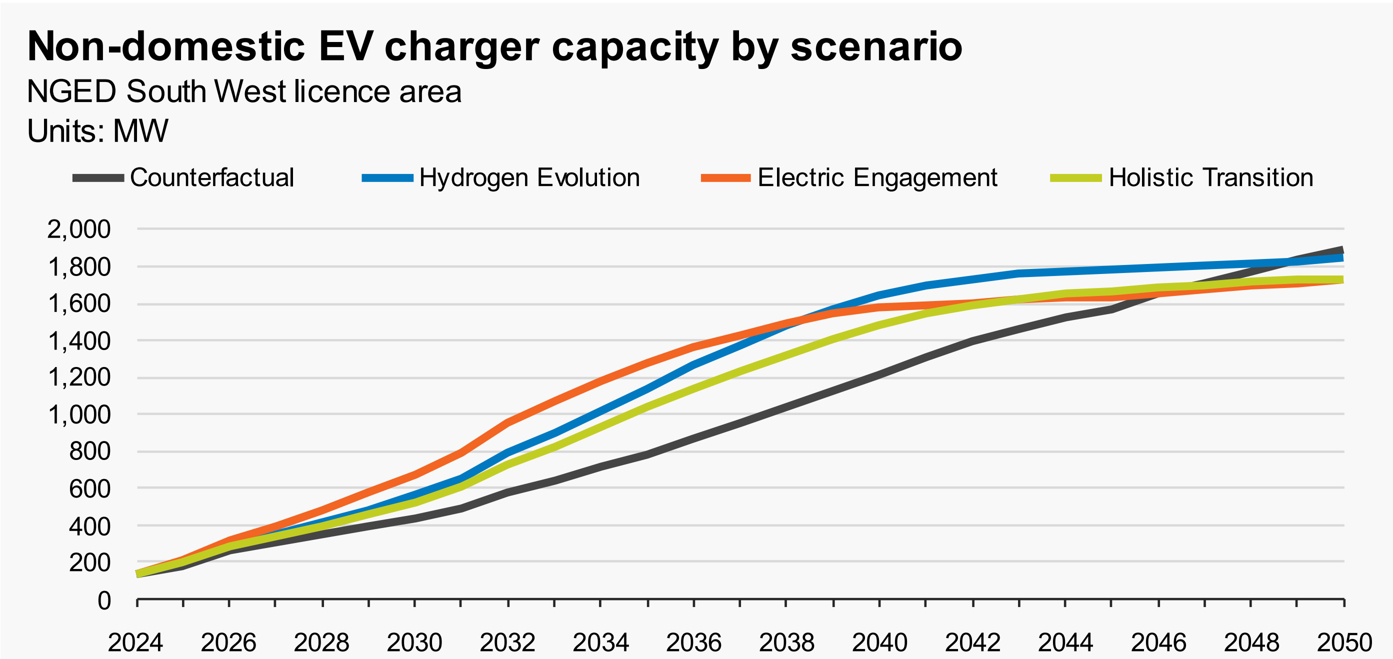
Electric buses, coaches and HGVs by scenario

NGED South West licence area

Units: Number




Domestic EV charger capacity by scenario
NGED South West licence area
Units: MW
Counterfactual
Hydrogen Evolution
Electric Engagement
Holistic Transition
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2024
2026
2028
2030
2032
2034
2036
2038
2040
2042
2044
2046
2048
2050


Non-domestic EV charger capacity by scenario
NGED South West licence area
Units: MW
Counterfactual
Hydrogen Evolution
Electric Engagement
Holistic Transition
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
2024
2026
2028
2030
2032
2034
2036
2038
2040
2042
2044
2046
2048
2050

Modelling assumptions and results

Baseline and pipeline

Source: DfT data, OpenChargeMap data, Workplace Charging Scheme data, NGED connections data

	Type	Vehicles (000s)/ Capacity (MW)	Description
Electric vehicles			
Baseline	Pure electric car	53	The uptake of EVs across the UK has been steadily accelerating. The current EV baseline represents just over 3% of all vehicles registered in the South West licence area, up from 2.3% in DFES 2023. This has been due to a number of factors, including favourable tax benefits and grant funding support, increasing consumer confidence and the electrification of commercial vehicle fleets. While the vast majority of EV uptake in the South West licence area has centred on cars, sales of electric buses and coaches have also significantly increased over the past year, from only six in DFES 2023 to just over 200 in DFES 2024.
	Plug-in hybrid car	25	
	Pure electric LGV	3	
	Other EVs	1	
EV chargers			
Baseline	Domestic	234	As the number of EVs has increased, the number and capacity of installed EV chargers has also risen. In addition to most domestic EV owners having a home charger, non-domestic chargers in the form of car park chargers, workplace chargers and rapid en-route chargers at forecourts have also seen an increased rollout in recent years. There is currently 234 MW of domestic EV chargers and 114 MW of non-domestic EV chargers operating in the South West licence area. Due to a lack of high-granularity data for domestic EV charger installations, baselines were calculated based on the number of EVs and the housing stock within the licence area. The non-domestic EV charger baseline was calculated using OpenChargeMap data and data from the Workplace Charging Scheme, supplied by NGED.
	Non-domestic	114	

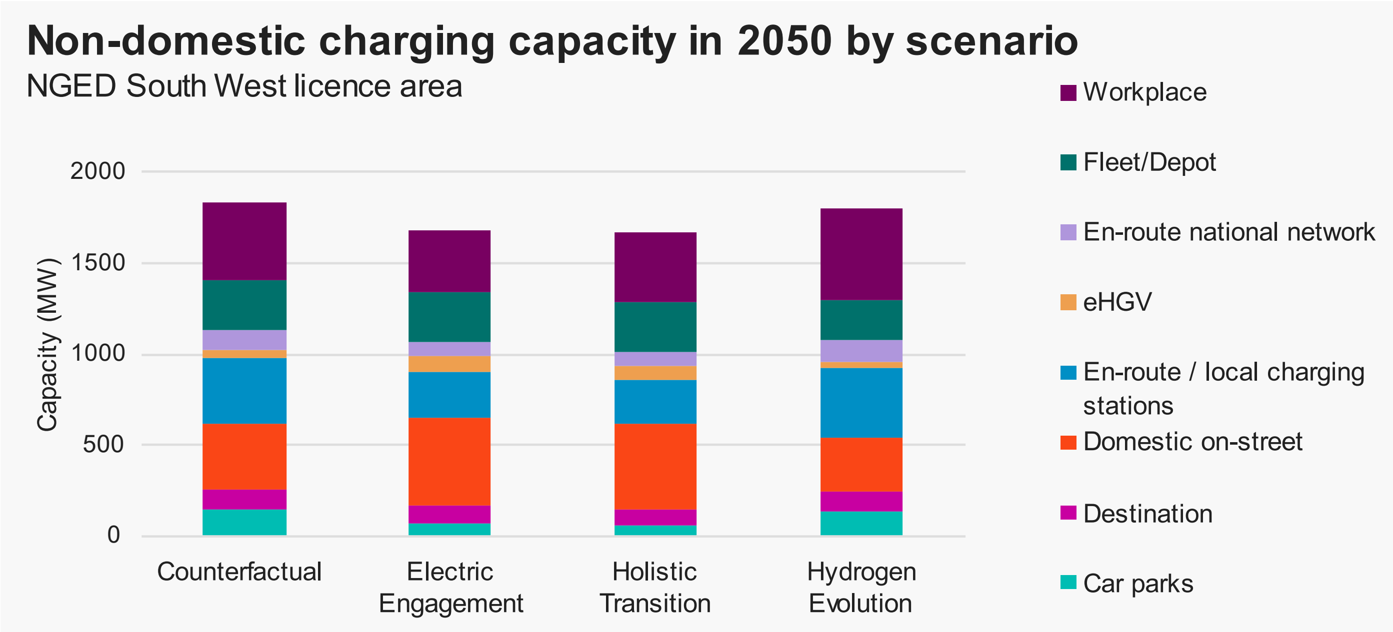
Pipeline	Domestic	n/a	Domestic EV charger installations often commission quickly and, therefore, are unlikely to hold their connection offer for long before being installed. In addition, NGED has recently introduced a ‘connect and manage’ scheme for domestic low-carbon installations, which means that households do not need to apply for a grid connection ahead of installing EV chargers. Therefore, no clear view of the pipeline of domestic EV chargers has been considered to inform the DFES projections.
	Non-domestic	110	The pipeline of new EV chargers therefore comprises entirely commercial EV charging points which have an accepted connection offer with NGED. There are currently 32 sites within the South West licence area, totalling 110 MW. The majority of this capacity is associated with en-route chargers. This pipeline is modelled to connect between 2025 and 2027, depending on the scenario and when the connection offer was accepted.

Projections

- The acceleration in the uptake of EVs seen over the past few years is anticipated to continue under every scenario, particularly between the mid-2020s and 2040.
- In the longer term under the three net zero scenarios, EV adoption approaches saturation and the sale of new EVs slows in most areas. Harder-to-electrify vehicles, such as HGVs, that saw lower uptake in the near term, see a higher uptake out to 2050.
- The total number of EVs reduces in some scenarios in the long term, reflecting a lower level of car ownership and higher use of public transport.
- EV charger uptake is closely tied to EV adoption, with domestic and non-domestic chargers continuing to be installed to meet demand. This is augmented by the known pipeline of accepted connections for non-domestic EV charger installations connecting to the NGED distribution network, predominantly in the form of en-route charging hubs at service stations on major motorways and A roads.
- By 2035, the installation rate of EV chargers slows. It is assumed that homes with multiple EVs don’t purchase a second charger at the same rate as their first, leading to a levelling out of domestic EV charger capacity under all scenarios. The demand for additional public charging also reduces, as the majority of vehicles are electrified by this point. It is also assumed that, while EV numbers may reduce in the 2040s under some scenarios, installed EV chargers will remain in place, but with lower utilisation as the overall number of vehicles on the road decreases.

Scenario	Description
Holistic Transition	A high proportion of new car and LGV sales are EVs in the late 2020s and early 2030s. Harder-to-electrify vehicles, such as buses and HGVs, see some uptake in the

Hydrogen Evolution	medium-term, but hydrogen-fuelled alternatives also begin to be adopted, limiting EV uptake for these as heavier vehicles, particularly under **Hydrogen Evolution**. Plug-in hybrid vehicles see moderate uptake under both scenarios, with battery electric vehicles being the dominant EV technology across all vehicle classes. While domestic charging is most common, rapid en-route charging also sees significant uptake under these scenarios. Car ownership falls under **Holistic Transition** in the mid-2040s as car sharing via autonomous vehicles, active travel and greater use of public transport reduce the need for private vehicle ownership. By 2050, under **Holistic Transition**, there are 2.6 million EVs, and an associated charger capacity of 10.1 GW. By 2050, under **Hydrogen Evolution** there are 2.9 million EVs and an associated charger capacity of 10.0 GW.
Electric Engagement	EVs dominate new car and LGV sales from the late 2020s under this scenario and from 2030 almost all new cars are electric. Harder-to-electrify vehicles, such as buses and HGVs, also see uptake in the medium-term, with the majority of all road vehicles electrified by 2040. With such a rapid shift toward battery electric vehicles, plug-in hybrid vehicles see relatively low uptake, and the number of hybrid vehicles declines in the late 2030s. EV uptake is facilitated by a widespread rollout of domestic and non-domestic charging. This includes 350 kW and 1 MW eHGV chargers at major service stations. Overall vehicle ownership falls in the mid-2040s, as car sharing via autonomous vehicles, active travel and greater use of public transport moderately reduces private vehicle ownership. By 2050, there are 2.5 million EVs, and an associated charger capacity of 9.9 GW.
Counterfactual	A high proportion of new car and LGV sales are EVs by the early 2030s. Harder-to-electrify vehicles, such as buses and HGVs, see limited uptake in the medium-term. Plug-in hybrid vehicles see moderate uptake, but battery electric vehicles remain the dominant EV technology across all vehicle classes. There is a much lower rate of domestic off-street charging under this scenario, with a higher number of car park, workplace and local charging stations being rolled out in the 2030s. By 2050, there are 2.8 million EVs, and am associated charger capacity of 9.9 GW.



Uptake modelling factors

The below factors are used to inform the overall uptake of EVs and EV charger capacity in the South West licence area.

Factor	Modelling impact	Source
Current number of EVs and petrol/diesel vehicles	The baseline of existing EVs and the total number of all vehicles in the licence area strongly informs the projected uptake of EVs.	DfT statistics
New developments	EV charging points in new domestic homes have been modelled in line with The Future Homes and Buildings Standards: 2023 consultation, with EV charging points installed in 75% of new build properties with parking provision.	Future Homes and Buildings Standards, DFES new developments projections

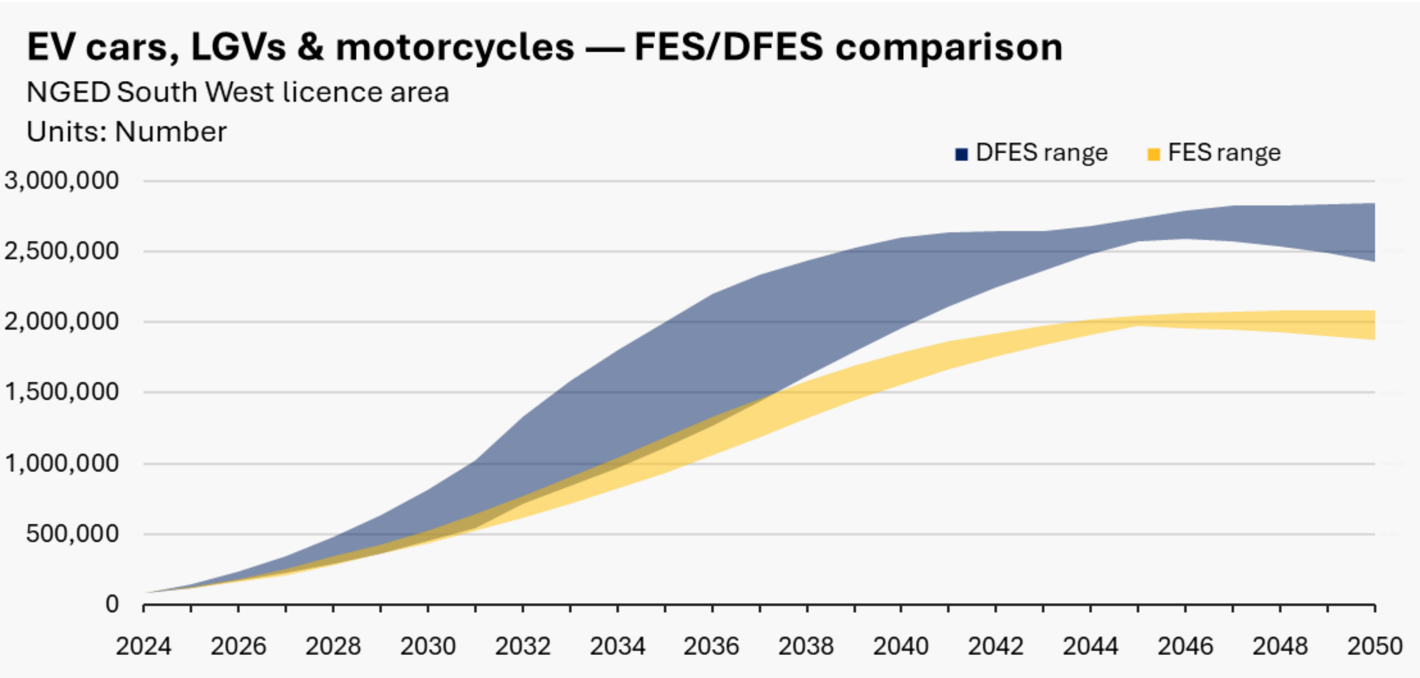
Spatial factors

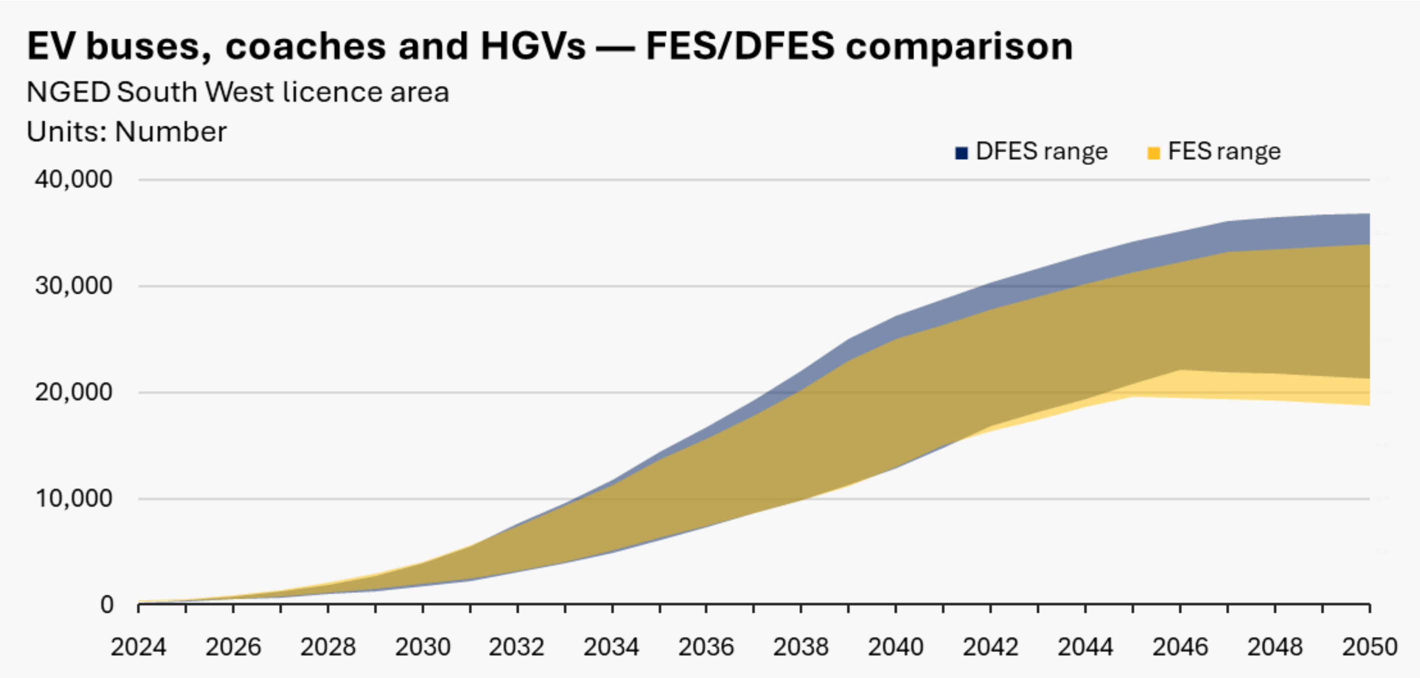
The below factors are used to inform the spatial distribution of EVs and EV charger capacity across the South West licence area, down to LV and 11 kV ESAs.

Factor	Modelling impact	Source
Access to off-street and on-street parking, affluence and rurality	These factors influence the near-term location of EVs and the associated off-street and on-street domestic EV chargers.	ONS Census data
Location of petrol/diesel fuelling stations	The location of petrol/diesel fuelling stations are used to indicate the location for projected en-route EV chargers.	OS Addressbase
Location of car parks, workplaces and fleets/depots	The location of car parks, workplaces and fleets/depots are used to indicate the projected location of car park, workplace and fleet/depot chargers.	OS Addressbase
Ambition of local authority	Local authorities which indicated having a low carbon transport plan in the local authority survey are assumed to have a slightly accelerated uptake of electric buses and coaches, as well as en-route / local charging stations. Specific LAEP targets for the rollout of EV charger capacity have also been reviewed and incorporated where available and where possible.	Regen DFES local authority survey LAEP publications

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.





- As the uptake of EVs and provision of EV charging infrastructure are heavily driven by national trends and factors, the DFES projections for EVs and EV chargers in the licence area strongly mirror the national FES 2024 outcomes. The exception to this is **Electric Engagement**, which has an accelerated uptake for cars and vans, tailored to reflect recent policy uncertainty around the ZEV mandate being applicable in 2030 or 2035. This creates a larger envelope of scenario outcomes in the DFES, compared to FES.
- Overall, vehicle uptake is lower in the FES compared to the DFES, with the 2050 end points differing by around 20%. The reason for this variance is unclear, but is likely due to differences in the modelled existing vehicle stock. The DFES modelling uses DfT vehicle licencing data to inform the overall number of different vehicle types in the licence area, which subsequently guides the future uptake of EVs. As the adjoining West Midlands licence area sees an opposite divergence from FES, it is possible that the discrepancy is due to the allocation of vehicles on the border of the South West and West Midlands licence areas, around Bristol and South Gloucestershire.
- The different EV charger technologies are not broken down in the FES 2024 data at a GSP, licence area or national level. As such, reconciliation of EV charger capacity in the licence area is not possible. However, FES assumptions on vehicle efficiencies, mileage and vehicle numbers are used to inform the DFES analysis where possible.

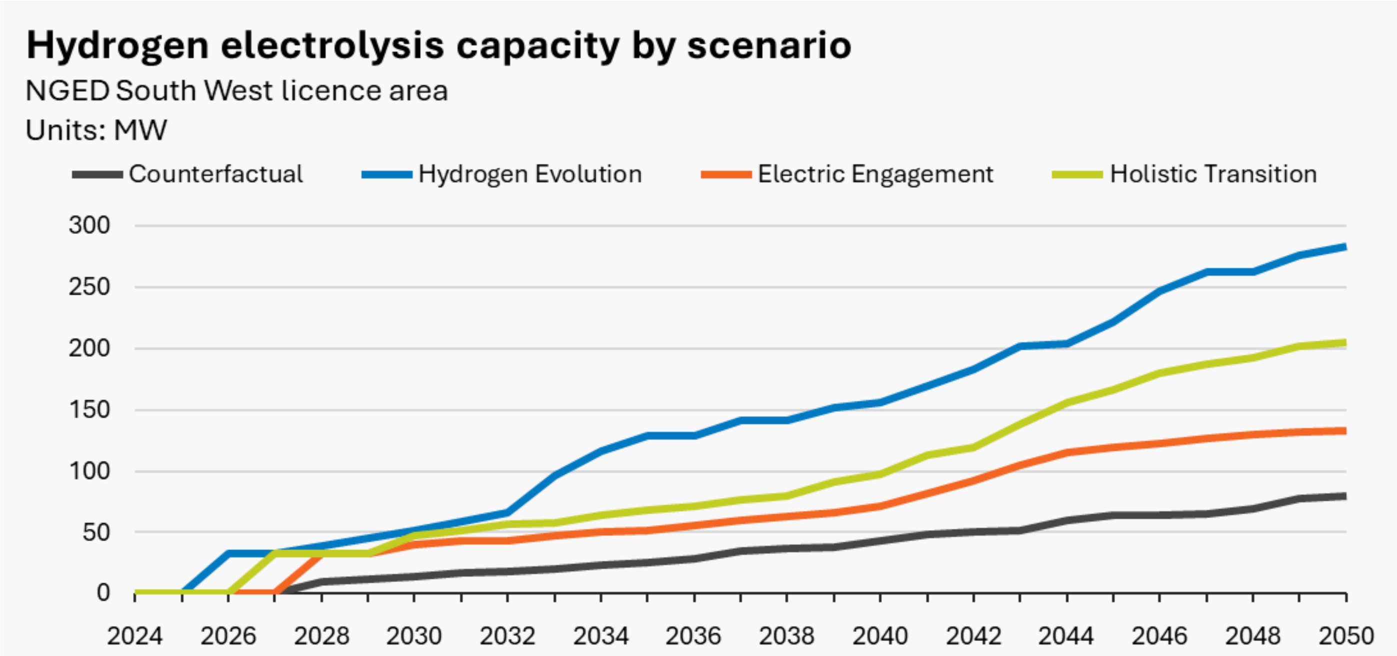
Comparison to DFES 2023

- The envelope of values remains broadly similar to DFES 2023, with the overall methodology remaining unchanged. A key difference this year is the divergence of **Electric Engagement** from FES 2024, in order to reflect a proposed change to the ZEV mandate. Any other changes reflect the updated projections from FES 2024, which includes a more ambitious uptake of EVs in the **Counterfactual** and greater alignment between **Hydrogen Evolution** and **Holistic Transition**.

Hydrogen electrolysis

Summary

- Whilst some development is starting to emerge, hydrogen electrolysis is still an emerging technology with uncertainty around its future role in the energy system. The extent to which hydrogen electrolysis will scale-up and make use of transmission connections is one such uncertainty. This results in a wide range of projections at the licence area level.
- The 2022 British Energy Security Strategy outlined a target of 10 GW of low-carbon hydrogen production by 2030, of which 5 GW is to be from electrolysis (also known as 'green hydrogen'). In addition, the government has set an interim aim for 1 GW of electrolytic production capacity to be in construction or operation by 2025.
- Funding has been committed in support of this target:[6]
    - 11 electrolysis projects are receiving funding through the first Hydrogen Allocation Round (HAR 1), totalling 125 MW of green hydrogen production capacity
    - 875 MW of additional hydrogen production capacity will be supported through the second allocation round (HAR 2), with winning projects announced in the first half of 2025
    - An additional 1.5 GW of hydrogen production capacity will be funded across both HAR 3 and HAR 4, launched in 2025 and 2026, respectively
    - Subsequent allocation rounds will be held annually between 2025 and 2030.
- Engagement with electrolyser developers and hydrogen industry groups has highlighted the importance of these allocation rounds in enabling the near-term deployment of commercial-scale projects. The development of commercial electrolysis projects outside of this support mechanism is not considered feasible in the near term. The results of HAR 2, and subsequent allocation rounds, will give greater certainty to the near-term development of hydrogen electrolysis capacity in the licence area and across GB.
- In the South West, there are two sites in Somerset and North Devon, which have accepted connection offers from NGED, totalling 17 MW. These are modelled to build out in all scenarios other than the **Counterfactual**, at the earliest in 2026 under **Hydrogen Evolution.**
- Beyond the known pipeline, the potential for additional new capacity out to 2050 is based on FES 2024 projections for national networked electrolysis, paired with a regional analysis of potential supply and demand drivers for hydrogen
- Compared to other regions, the South West has relatively little existing gas-fired electricity generation capacity and low industrial demand. National Gas' proposed future hydrogen backbone transmission network, Project Union, does not run through the licence area, and is another locational factor within the analysis.[7] This results in relatively low projections for hydrogen electrolysis in the licence area.
- By 2050, under the most ambitious scenario, **Hydrogen Evolution**, 280 MW of hydrogen electrolysis is modelled to be deployed in the licence area. In the least ambitious scenario, the **Counterfactual**, 80 MW is deployed.



Modelling assumptions and results

Baseline and pipeline

Source: NGED connections data and desktop research

	Development status	Capacity (MW)	Description
Baseline	Operational	0	There is currently no electrolyser capacity connected to the distribution network in the South West licence area.
Pipeline	Accepted to connect	17	Two electrolyser sites, totalling 17 MW have accepted connection offers with NGED. While there is no evidence of either of these sites progressing through planning, projects do not need to have prior planning permission to be eligible for HAR support. Due to sector engagement indicating the importance of HAR support for near-term commercial viability, an assumption has been made that these sites will be applying for HAR support and subsequently secure planning permission. HAR 2 requires projects to demonstrate they can become commercially operational by between 2026 and 2029. This range of dates has been reflected in the DFES scenarios. The sites see deployment in 2026 under **Hydrogen Evolution**. 2027 under **Holistic Transition** and 2028 under **Electric Engagement**. Failure to build out is reflected in the **Counterfactual**. This scenario order aligns with FES assumptions for electrolysis project buildout timeframes.

Other	10	Exeter Hydrogen Hub is under development and is aiming have a 10 MW plant operational by 2026 to supply hydrogen HGVs and ground vehicles at Exeter airport[8]. The project has applied for funding through HAR 2 and is modelled to connect under all scenarios, between 2026 and 2028. Langage Green Hydrogen has secured funding through HAR 1 and is aiming to have 10 MW[9] of hydrogen electrolysis in operation by 2028. Engagement with the developer has confirmed that the site will make use of on-site generation. As a result, is not modelled to deploy on the distribution network.

Projections

Scenario	Description
Hydrogen Evolution	Under this scenario, a major driver for the growth of hydrogen electrolysis capacity in the medium term is the high-levels of hydrogen blending through the gas network. This means the coverage of the existing gas network infrastructure is an important regional supply consideration. Demand from industrial decarbonisation in the licence area is also a key medium-term driver. In the long term, a core hydrogen transmission network is built out and links with regional distribution networks, such as those proposed by HyNet and Hyline Cymru.[10,11] This reduces the need for demand and production to be so locally tethered and allows hydrogen production sites to be developed in areas that are most suitable. This results in a balance between the proximity to any future hydrogen gas network, renewable energy projects (including for co-location) and sources of low-carbon hydrogen demand. As a result, by 2050, 280 MW of hydrogen electrolysis is deployed in the South West licence area.
Holistic Transition	Under this scenario, high-levels of hydrogen blending means that the coverage of the existing gas network infrastructure is an important regional consideration for the development of hydrogen electrolysis projects. Demand from industrial decarbonisation is also a key medium-term driver. A core hydrogen transmission network is developed, but to a lesser extent than seen under **Hydrogen Evolution**, and without regional distribution networks. This makes the route of the core transmission network an important locational factor for electrolysis, alongside existing gas-fired electricity generation and industrial activity. By 2050, 210 MW of hydrogen electrolysis is deployed in the South West licence area under this scenario.
Electric Engagement	With less hydrogen blending, the demand from industrial decarbonisation, heavy transport and existing gas-powered electricity generation are the main medium-term drivers for electrolysis development under this scenario. A core hydrogen transmission network is developed, but to a similarly lesser extent than **Hydrogen Evolution**, as seen in **Holistic Transition**, including no regional distribution networks. This makes the route of the core transmission network an

	important locational factor, alongside existing gas-fired electricity generation and industrial activity. By 2050, 130 MW of hydrogen electrolysis is deployed in the South West licence area under this scenario.
Counterfactual	Hydrogen production and demand are more directly matched at a regional level, as hydrogen networks are not developed. Electrolyser projects are therefore limited and only developed close to hydrogen demand. In the medium and long term, this demand is primarily driven by the industrial sector, heavy road transport and power generation. By 2050, only 80 MW of hydrogen electrolysis demand is deployed in the South West licence area under this scenario.

Uptake modelling factors

The below factors are used to inform the overall uptake of hydrogen electrolysis in the South West licence area.

Factor	Modelling impact	Source
Proportion of hydrogen electrolysis projects that connect to the distribution network	A number of anomalies within the FES 2024 GSP level projections for hydrogen electrolysis have led to them being removed as an input to the DFES model. As a result, post-pipeline projections for distribution network-connected electrolysis are based upon the FES 2024 GB total networked electrolysis projections, with an assumed ratio of deployment on the distribution network. This ratio is 20% within **Hydrogen Evolution**, **Holistic Transition**, and **Electric Engagement** and 60% under the **Counterfactual**, where the industry does not scale-up and deploy transmission network scale connections.	FES 2024
Hydrogen distribution factors	An assessment of hydrogen supply and demand factors for all GB licence areas was completed. These factors were used to inform the level of electrolytic hydrogen production and projected capacity of hydrogen electrolysis in the licence area by scenario. These factors include the presence of: • Industrial energy demand • Heavy transport demand • Planned hydrogen network coverage • Gas distribution network coverage • Gas-fired electricity generation • Hydrogen innovation projects • Aviation activity • Existing grey hydrogen production • Renewable energy generation	Various

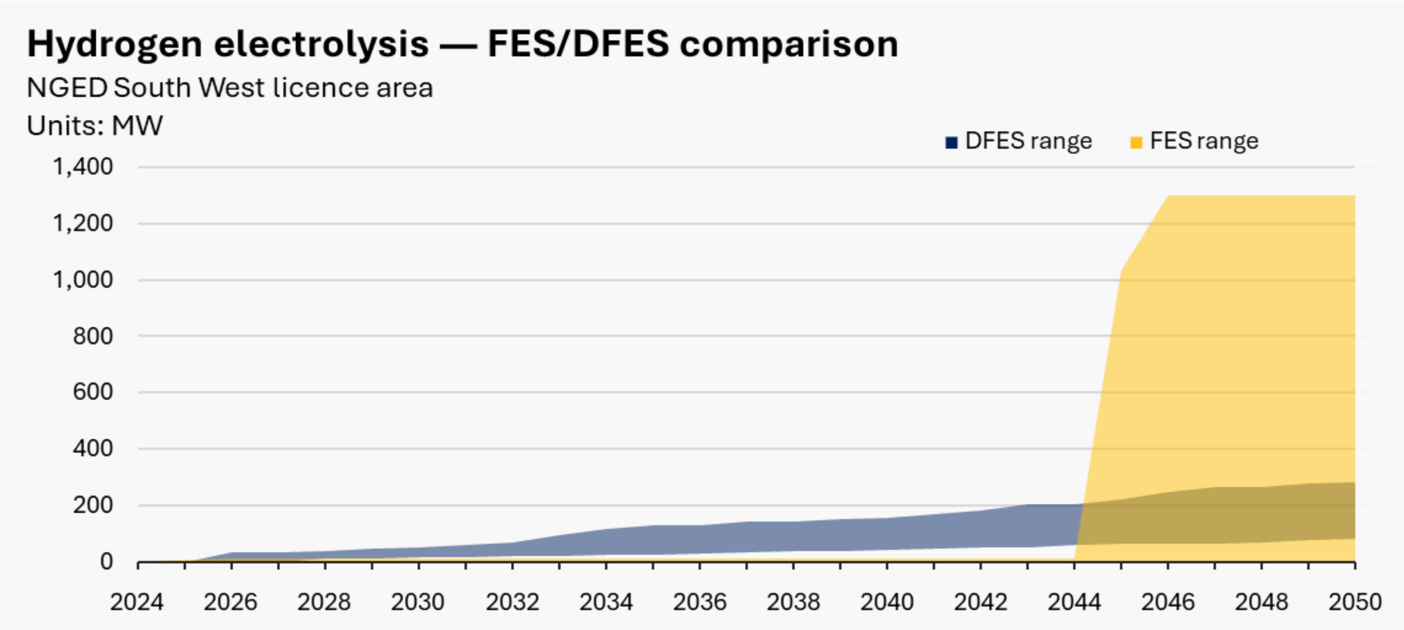
Spatial factors

The below factors are used to inform the spatial distribution of hydrogen electrolysis capacity across the South West licence area, down to 11 kV electricity supply areas (ESAs).

Factor	Modelling impact	Source
Industrial sites	Post pipeline capacity is assigned to areas surrounding industrial energy users, in line with plans for a core hydrogen network.	OS Addressbase
Local authority ambition	Local authorities that have hydrogen strategies or targets in place are assigned a greater proportion of post-pipeline capacity.	DFES local authority engagement survey

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.



- FES 2024 doesn't project any hydrogen electrolysis capacity deploying on the distribution network in the South West until 2045, when 1.3 GW connects over two years. The basis of this surge of growth is unclear and has been queried with the FES team.
- The DFES 2024 reflects the overall increase in national electrolysis projections seen in the FES 2024, as well as regionally-specific project input and distribution factors. Relative to other licence areas, the South West has low levels industrial demand, existing gas generation and does not contain a section of Project Union hydrogen transmission network.

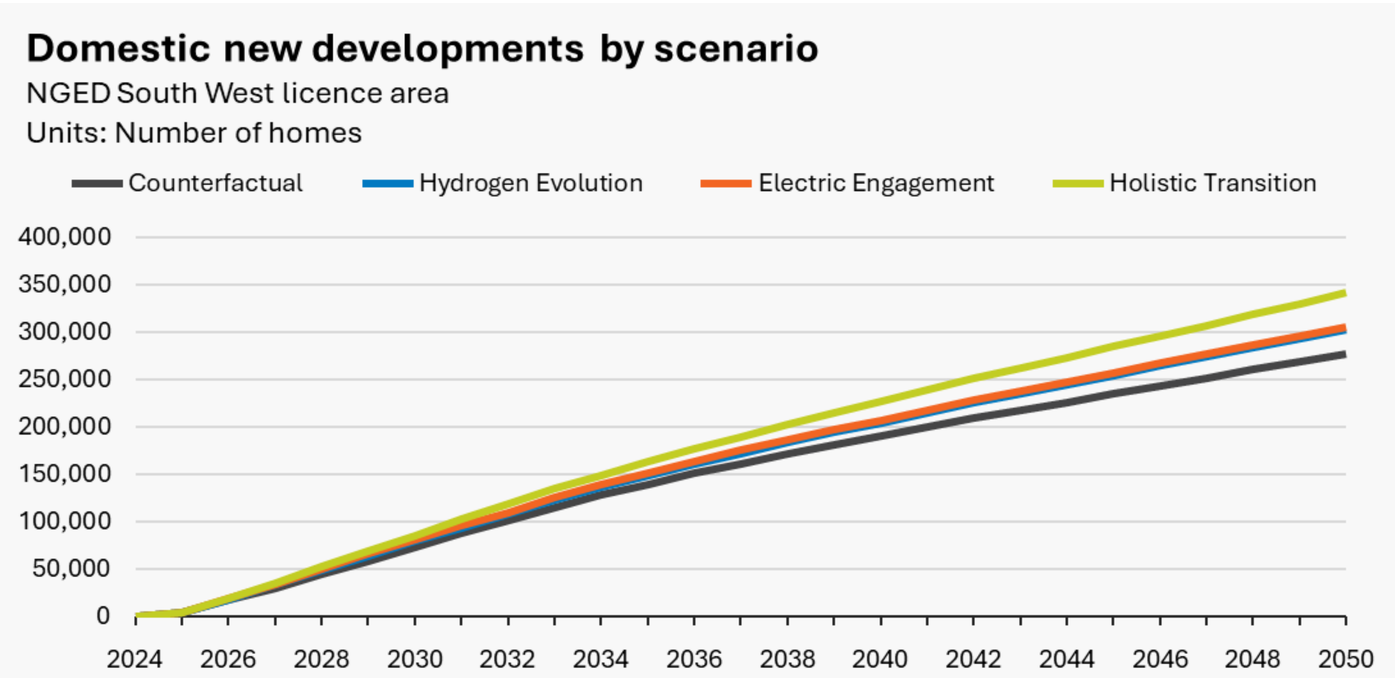
Comparison to DFES 2023

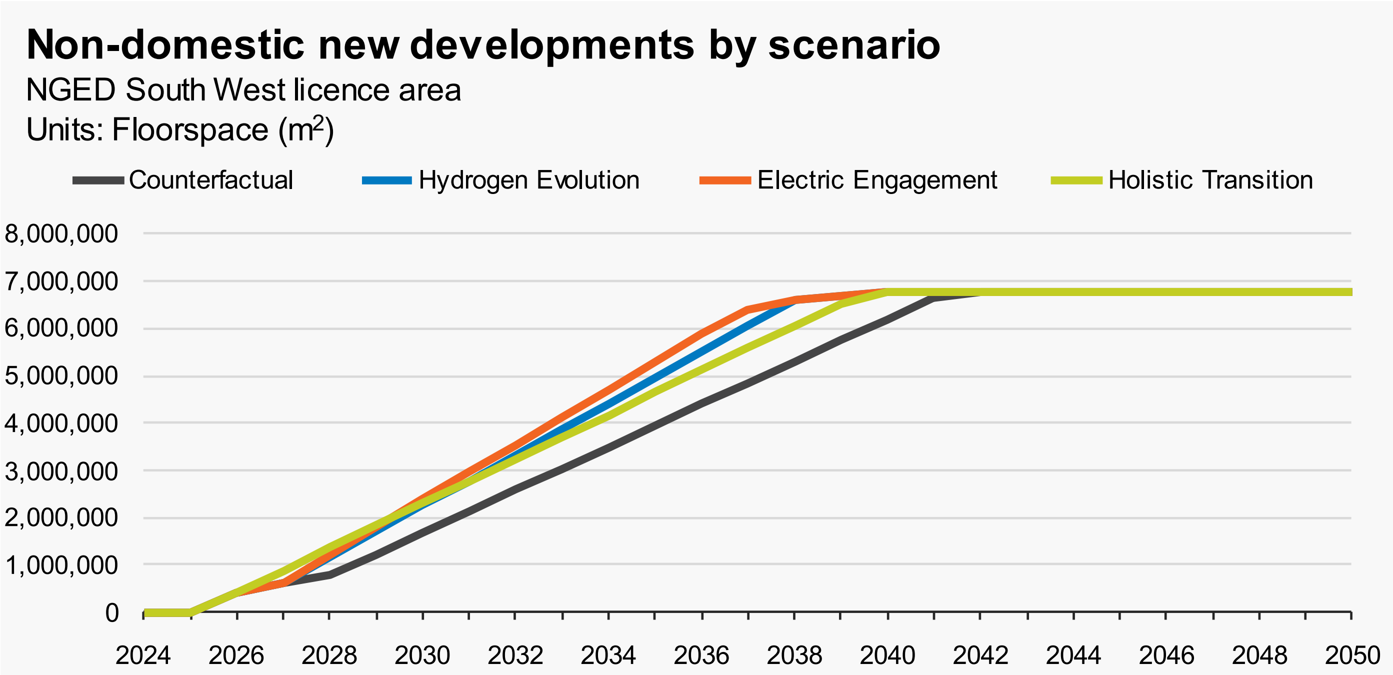
- Compared to DFES 2023, DFES 2024 projects more distribution network connected electrolysis in the licence area across the period to 2050.
- This is driven by significant increases in the FES projections for networked electrolysis capacity in the medium and long term.
- The DFES 2024 projections also reflect changes to how electrolysis is supported in the FES 2024 scenario framework. **Hydrogen Evolution** is now the most ambitions scenario for grid-connected hydrogen electrolysis, followed by **Holistic Transition**, **Electric Engagement** and finally the **Counterfactual**, which sees limited development.

New developments

Summary

- The new developments modelling within the DFES is based on direct engagement with local authority planning departments and an analysis of local planning documents submitted to Regen.
- Over the last three years, Regen has received domestic datasets from 72% of local authorities across NGED's licence areas, and non-domestic datasets from 44% of local authorities. Half of local authorities updated their domestic datasets for this year's modelling and a quarter of non-domestic datasets.
- The domestic data is supplemented with information from local planning portals and updated local development plans for local authorities that have not engaged in the last four or more years.
- By 2050, the domestic modelling results in between 277,000 and 340,000 new homes in the South West licence area across the scenarios, representing a 17-21% increase in the number of domestic houses, compared to today.
- By 2050, an additional 6.8 million square meters of non-domestic floorspace is also modelled in the licence area under each DFES scenario.
- The UK government is currently consulting on a new methodology to establish localised housing targets. While the impact that this may have on future new developments is recognised, this has not been directly reflected in the analysis, as it is still in the consultation phase. The DFES modelling does, instead, use the most recently compiled ONS housing projections and historical buildout rates for each scenario.
- Somerset (25,511), Cornwall (18,698) and the City of Bristol (11,664) have the most new homes projected by 2050.
- Notable non-domestic sites included Gravity[12] a new smart campus and home to one of Europe's largest gigafactory (Somerset), SkyPark[13] new business park near the Exeter airport and a Cribbs Causeway[14] new neighbourhood on the edge of Bristol that will include non-domestic properties.





Modelling assumptions and results

Baseline and pipeline

Source: Local Authority engagement and local planning portals

Pipeline	Development status	Number of domestic sites (homes)	Number of non-domestic sites (sqm)	Description
Baseline	As the scope of the new developments analysis in the DFES is focused on future additional/new domestic and non-domestic buildings, no baseline is defined for this technology. There are currently around 1.6 million customers and 172 thousand non-domestic customers in the South West licence area.			
Pipeline	Buildout Provided	699 (116,816)	4 (27,000)	These sites are modelled according to the buildout rate provided by the local authority. The only exception to this is that only sites that are under construction or those that hold an accepted connection offer agreement are modelled to connect in DFES Year 1 (2025).
	Sites with no buildout provided			
Pipeline	Block Loads	17 (3,017)	41 (895,572)	These sites have an accepted grid connection offer with NGED and connect in 2025 under all scenarios.

Under Construction	2 (251)	137 (1,141,079)	Sites that have been identified as under construction are modelled to begin energization in 2026 under all scenarios.
Granted	86 (8,395)	331 (2,121,239)	Approved planning permission is strong evidence that a site is moving toward construction. All sites which have been granted planning permission are modelled to connect between 2027 and 2029.
Outline or Reserved Matter	0	60 (160,870)	Outline planning applications are less detailed than a full planning application. While outline planning may be approved a developer will need to get approval on the missing details, which are referred to as reserved matters. Once all reserved matters are approved the site is considered to have full planning approved. These sites are modelled to connect between 2028 and 2030.
Submitted	3 (94)	1 (88,466)	A submitted planning application demonstrates a site has been identified and progressed but is waiting for approval from the local authority. These sites are modelled to connect between 2030 and 2033.
Allocated/ Pre-planning	57 (8,699)	206 (1,866,904)	Allocated sites and pre-planning sites are those typically identified by local authorities as areas for development. As allocated sites are often not yet at the planning stage, they are the last sites modelled to connect, doing so between 2031 and 2034.
No Information	0	55 (484,869)	As all data is provided by local authorities, sites with no development stage information are modelled to connect between 2030 and 2032.

Projections

- Projections are only modelled for domestic new developments due to no reliable data sources for non-domestic targets. The ONS household projections provide a baseline to model domestic housing.

Scenario	Description
Holistic Transition	Under this scenario, sites are modelled to connect at the earliest possible date based on their development stage. In addition to the planned development sites, ONS household projections from 2018 are used to uplift the long-term projections. A 16% increase over the yearly ONS projections is added to this scenario, based on analysis of building rates over the last 10 years. This scenario is also modelled to dampen ambitious developer data and maintain yearly buildouts to below the 3rd quartile of historic yearly builds. This reflects the increase in low-carbon technologies (including EV chargers, rooftop solar and heating technologies) that is expected to occur at new developments under this scenario.
Electric Engagement **Hydrogen Evolution**	These two scenarios are modelled in the middle of the connection range for each development type. The **Electric Engagement** scenario uses the fastest build-out rate, the same as **Holistic Transition**. In addition to the planned development sites, ONS household projections from 2018 are used to uplift the long-term projections. This scenario is also modelled to dampen ambitious developer data and maintain yearly buildouts to below the average of historic yearly builds. This reflects the increase in low-carbon technologies (including EV chargers, rooftop solar and heating technologies) that are expected to occur at new developments under the **Electric Engagement** scenario. **Hydrogen Evolution** uses a slower build-out rate, i.e. fewer homes connected per year.
Counterfactual	This scenario models sites to connect at the slowest buildout rate and in the last year of the connection range. In addition to the planned development sites, ONS household projections from 2018 are used to uplift the long-term projections. A 22% decrease over the yearly ONS projections is added to this scenario, based on analysis of building rates over the last 10 years. This scenario is also modelled for unforeseen delays in developer data and maintain yearly buildouts to below the 1st quartile of historic yearly builds. This scenario is the only one that does not connect every home or all floorspace provided by local authorities, with some allocation sites not assumed to be completed by 2050.

Uptake modelling factors (domestic only)

The below factors are used to inform the overall uptake of domestic new developments in the South West licence area.

Factor	Modelling impact	Source
Known local authority developments	Regen and NGED's Strategic Engagement Officers engages with all local authorities within the South West licence area to acquire data on known new developments, both domestic and non-domestic.	Local authority SharePoint
Residual developments*	These are small-scale developments of less than 20 homes, which are not included in the data collection from local authorities. Analysis of previous new housing suggests that these developments could account for c.5% of total new-build housing. As a result, a 5% uplift is applied to the planned projections throughout the scenario timeframe.	Local authority SharePoint

Post-plan developments	This accounts for housing developments that could occur in the medium and long term, beyond the current timescales of local authority planning. As planned developments tail off in the 2030s, post-plan developments are modelled to account for additional future housebuilding out to 2050. These projections are tailored to each local authority, based on ONS household data.	2018 ONS Household projections by local authority
Historical new development builds benchmark	The timeline and build-out rate of new developments are key sources of uncertainty. Regen applies scenario-specific delay factors to allow for these uncertainties in the completion of local authority plans. This data set is used as the scenario benchmark, using the 1st quartile, mean and 3rd quartile to capture unforeseen delays and to damper ambitious development numbers.	Ministry of Housing, Communities and Local Government: Net Additional Dwellings, Table 122

**Residual developments of 5% of the total new builds are added to all scenarios except Year 1.*

Spatial factors

The below factors are used to inform the spatial distribution of domestic new developments across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Planned sites	Planned sites are located based on their address or the description of their location, and directly assigned to the ESA that they fall within.	Local Authority SharePoint
Housing density	Modelled sites (domestic houses only) are distributed across all areas, weighted to areas with moderate housing density such as town and city suburbs, as analysis of historic housing development shows these areas see higher levels of housebuilding than denser city centres or highly rural areas.	Census 2021
NGED customer count	The customer count is used along site census data to determine the customer density (domestic only).	NGED connections data

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.

- There is no variation for future housing growth under the four FES scenarios. In contrast, the DFES models a range of projections for future housing. This aids distribution network planning, as new domestic customers can represent key bulk loads of conventional demand on the network.
- Non-domestic floorspace is not detailed in the FES 2024 data.
- As a result of these factors, the new developments outputs have not been reconciled against the FES 2024 data.

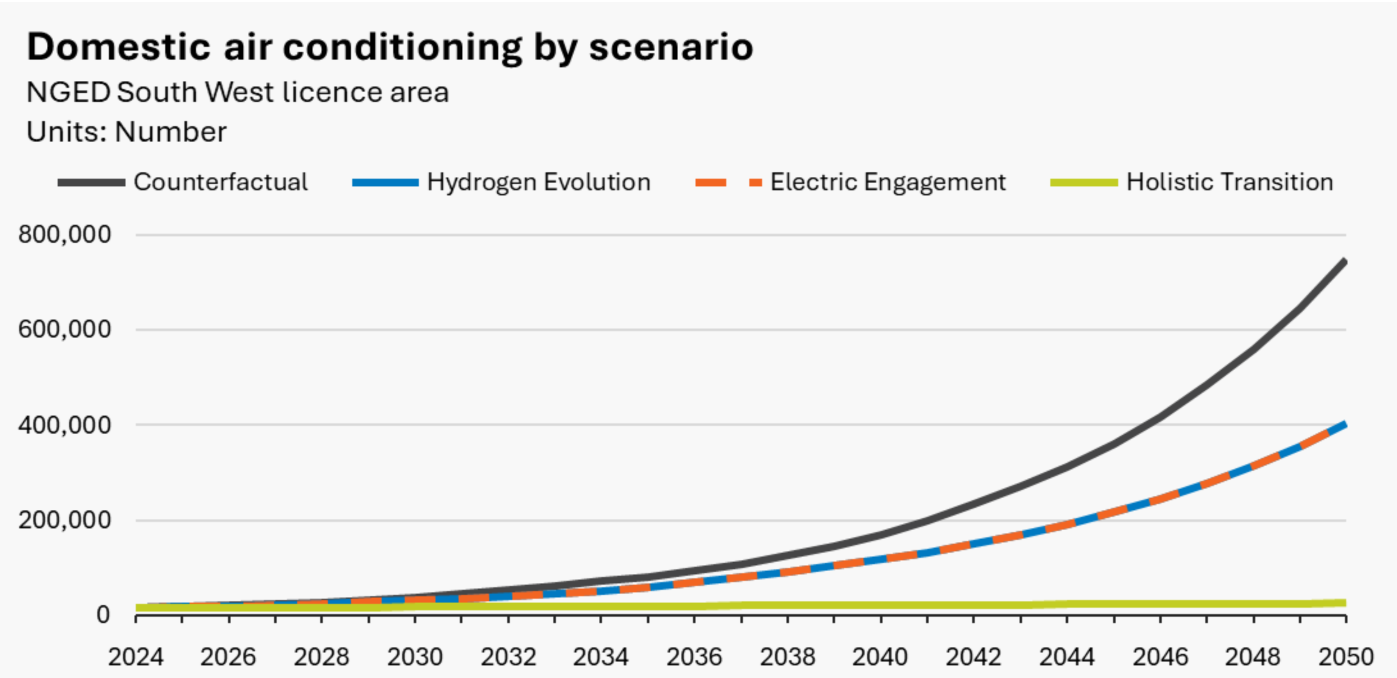
Comparison to DFES 2023

- The DFES 2024 housing projections have decreseased by up to 28% compared to DFES 2023. This is in part due to a error in DFES 2023 when considering planned local authority developments in comparison to housing projections from ONS. The modelling has been further refined in DFES 2024 to better reflect these ONS housing projections and additional checks have been included in the analysis and modelling process.
- There are several contributing factors to the decreased numbers, including updated SharePoint data and modelling improvements:
    - For DFES 2024, the only sites that have been modelled to connect in Year 1 (2025) are those with an accepted connection offer or those identified by local authorities as being under construction. In addition, no residual or projected sites are modelled in Year 1.
    - DFES 2024 has changed the method of assigning scenarios to local authority provided data. DFES 2023 did not use a range of connection years, based on the sites development status, but rather scenario assignment occurred later in the modelling process where we have used historical build-out rates to benchmark future development. For sites where no buildout data was provided DFES 2024 used development status to assign the year building would commence and better relfects the method used to assign generation technologies connection years.
    - Domestic new developments use the three historical new development builds benchmarks (1st quartile, average, and 3rd quartile. This is because known developments result in a higher annual buildout rate than historically experienced, and delay factor has been applied. However, this is mostly applied to sites which have a lack of evidence, rather than all sites being delayed as it was in DFES 2023.

Domestic air conditioning

Summary

- Domestic air conditioning (A/C) is not currently common in the UK - an estimated 1% of UK homes are thought to have an installed domestic A/C unit. As no public or DNO register of domestic A/C installations has been found, the regional baseline has been modelled as a proportion of the FES 2024 figures for current domestic A/C across GB.
- Increased summer temperatures and extended heat waves are likely to result in an increased uptake of domestic A/C in the future. The UK building stock is not optimised around passive cooling, which could see the uptake of A/C increase more significantly under scenarios with limited retrofit.
- Given the limited visibility of the baseline and high-level of uncertainty around how homes in the UK will be cooled in the future, there is a broad range of scenario outcomes. Uptake is modelled to be more prevalent in urban areas due to the 'heat island effect' under which denser urban areas experience higher temperatures than less built-up areas.
- By 2050, over 0.7 million domestic A/C units are installed under the **Counterfactual** scenario. This is equivalent to 50% of existing homes in the South West, although there is the potential for some homes to have multiple units. Minimal domestic A/C units are installed under **Holistic Transition** by 2050, with effective passive cooling measures being much more prevalent across homes.



Modelling assumptions and results

Baseline and pipeline

Source: FES 2024

	Development status	Total units	Description
Baseline	Connected	15,119	There is limited baseline data on domestic A/C levels in the UK. The DFES modelling aligns with FES 2024's estimate of 370,000 domestic air conditioners in GB in 2024.
Pipeline	n/a	n/a	There is no pipeline for domestic A/C.

Projections

Scenario	Description
Holistic Transition	Uptake is minimal, with households opting for passive cooling methods such as shading, ventilation and insulation. This results in the equivalent of just 2% of homes having A/C in 2050 under this scenario.
Electric Engagement **Hydrogen Evolution**	Uptake accelerates, particularly in urban areas due to heat island effects and the prevalence of smaller dwellings such as flats that may be more susceptible to overheating. However, uptake and awareness of passive cooling methods mean that active cooling via A/C remains relatively uncommon. This results in the equivalent of 27% of homes having A/C in 2050 under this scenario.
Counterfactual	Increasing frequency of heat waves and low uptake and awareness of passive cooling methods leads to high uptake of A/C to achieve comfortable internal temperatures in homes. This results in the equivalent of 50% of homes having A/C in 2050 under this scenario.

Uptake modelling factors

The below factors are used to inform the uptake of domestic A/C in the South West licence area.

Factor	Modelling impact	Source
FES 2024 domestic air conditioning demand	Total GB domestic A/C electricity demand is converted into total units using kW rating and operating hours assumptions per A/C unit detailed in the FES 2024 data workbook. These calculations dictate the overall trend under each scenario.	FES 2024
Population density	Domestic A/C uptake is modelled to occur more commonly in regions with denser urban areas.	Census 2021
Cooling demand	Domestic A/C uptake is modelled to occur more commonly in regions with higher cooling demand, such as South East England and the Midlands, using data on cooling degree days.	Met Office

New-build homes	UK government statutory guidance stipulates that mechanical cooling can only be used to meet building regulations where passive cooling and mechanical ventilation are not sufficient to avoid overheating. As a result, there is no A/C uptake modelled in new-build homes under any scenario.	Overheating: Approved Document O

Spatial factors

The below factors are used to inform the spatial distribution of A/C installations across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Population density	Domestic A/C uptake occurs in all types of household, but is distributed towards denser urban areas in towns and cities.	Census 2021

Reconciliation to FES 2024

- FES 2024 does not detail domestic A/C projections by region, so no direct comparison could be made.

Comparison to DFES 2023

- There are no major differences between DFES 2023 and DFES 2024 modelling methods or outcomes

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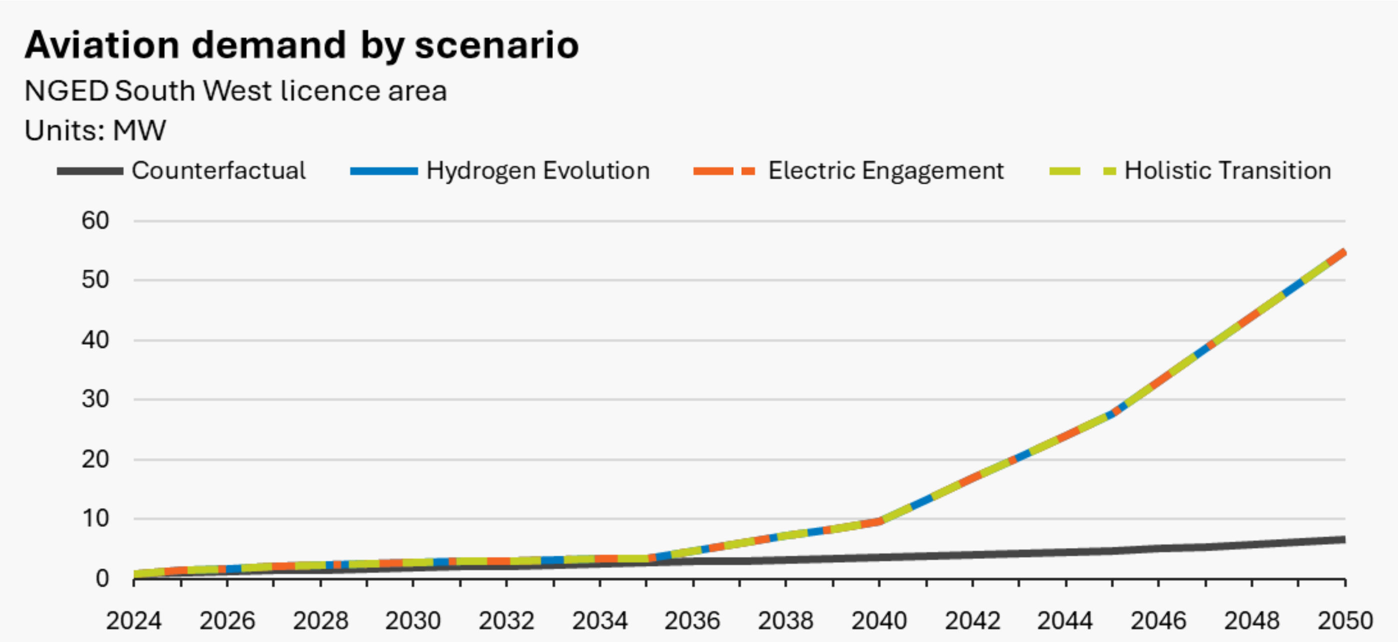
Aviation

Summary

- The decarbonisation of the aviation sector, and its resultant impact on the distribution network, is a new area of modelling for DFES 2024. Electricity demand associated with on-site buildings and passenger EV charging is already modelled in the DFES, as well as on-site solar generation.
- UK aviation emissions have doubled since 1990, representing 7% of the UK's total emissions. The aviation sector is considered to be 'hard to decarbonise', due to the vast amount of energy required to fuel aircraft. There are a range of technological pathways to reduce aviation emissions, including sustainable aviation fuels, hydrogen or hydrogen derivatives, and electric aircraft. However, there is no single solution to decarbonising the aviation sector yet confirmed. Any potential solution is likely to have implications for electricity demand at airports, but not until the 2030s at the earliest.
- The DFES analysis has been informed by work completed by IBA, an aviation intelligence and advisory company, that was commissioned by National Grid Group to explore electricity use at UK airports.[15] The DFES modelling focuses on electricity demand from airport vehicles, aircraft ground power, aircraft charging and on-site hydrogen liquefaction.
- There are five commercial airports operational in the South West licence area: Bristol International Airport, Cornwall Airport Newquay, Exeter Airport, Isles of Scilly (St Mary's) Airport and Lands End (St Just) Airport. The projections for airports in the South West licence area have been developed and adapted based on these individual airports, incorporating data on existing electricity demand, specific decarbonisation plans and direct engagement with airports.
- Under the three net zero scenarios, peak electricity demand at airports in the South West increases slowly from a baseline of c. 0.9 MW in 2024 to c. 3.5 MW by 2035, before rapidly increasing in the 2040s to reach c. 55 MW by 2050 due to the liquefaction and storage of hydrogen onsite. Under the **Counterfactual** scenario, onsite hydrogen liquefaction does not occur until after 2050, hence peak electricity demand only reaches c. 6.5 MW by 2050. This still represents a 700% increase.
- The airport with the highest electricity demand is Bristol, due to its size and higher proportion of international flights. Newquay and Exeter also have considerable demand by the 2040s.



Modelling assumptions and results

Baseline

Source: NGED connections data

	Development status	Capacity (MW)	Description
Baseline	Peak capacity	0.92	The South West licence area has a total of 920 kW of peak electricity demand at airports for charging airport vehicles and providing aircraft ground power. This is included within existing NGED connection agreements at airports.

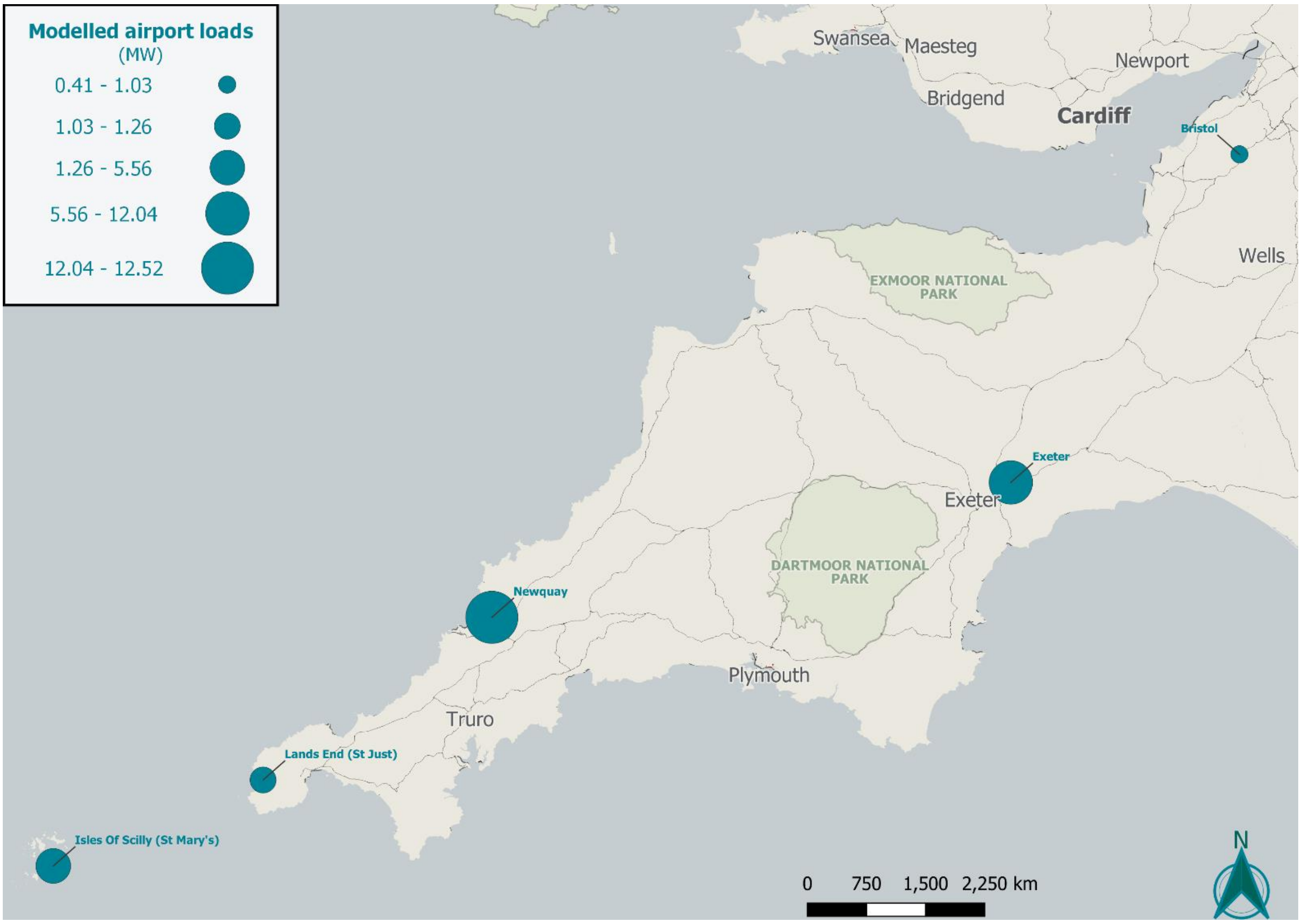
Projections

The IBA modelling archetypes airports as either 'local', 'regional', 'large international' or 'major international'.

- Bristol, Newquay and Exeter have average annual aircraft movements of 69,000, 46,000 and 44,000, respectively, classed as 'regional airports'.
- St Mary's Airport on the Isles of Scilly and St Just Airport in Cornwall have average annual aircraft movements of 12,000 and 11,000, respectively, classed as 'local airports'.

Scenario	Description
Holistic Transition Electric Engagement Hydrogen Evolution	The net zero scenarios abide by the UK government's net zero targets for aviation by 2050, as published by the DfT Jet Zero Road Map. Commercial aviation traffic grows in line with the DfT's central scenario, but is constrained by no new runways at London Heathrow or London Gatwick. This scenario represents strong political and social support and technology development for zero-emission technology for large commercial aviation. This also reflects stated ambitions of ATI's FlyZero, Rolls-Royce, Airbus, ZeroAvia and Universal Hydrogen aircraft that are in development. In particular, the Airbus NB hydrogen aircraft is modelled to enter service by 2035. In the near term, an increase in electricity demand at airports will be driven by additional electricity usage from terminal buildings and ground infrastructure, in line with many airport's targets to be 'operationally net zero' by 2030, including Bristol and Newquay. This will include EV charging provision for airport vehicles. In the longer term, regional airports are likely to switch to sustainable aviation fuels and liquefied hydrogen for aircraft. This will result in significant electricity demand at airports for on-site hydrogen liquefaction and storage. These are energy-intensive processes, requiring 13.33 kWh/kg of hydrogen. In comparison, local airports are more likely to favour electric aircraft as the majority of their operations are general aviation or small passenger aircraft. However, some local airports, including St Mary's and St Just, are looking at gaseous hydrogen, which has been reflected in the modelling. This results in a higher overall electricity demand than for other local airports, as the storage of hydrogen is an energy-intensive process. Under the three net zero scenarios, peak electricity demand at airports in the South West increases slowly from a baseline of c. 0.9 MW in 2024 to c. 2.2 MW by 2035, before rapidly increasing in the 2040s to reach c. 55 MW by 2050, linked to the liquefaction and storage of hydrogen onsite. This represents an increase in electricity demand of over 6000%. The onsite production and use of some low carbon hydrogen will require onsite storage, which could require significant land space on site.

Counterfactual	UK aviation growth follows DfT's central forecast, with modest development of the advanced air mobility market, with large zero-emission turboprop aircraft not expected to enter service until between 2040 and 2045. This scenario assumes a new runway is built in 2030 at either London Heathrow or London Gatwick and that annual aircraft traffic movements increase. Under this scenario, significant decarbonisation doesn't happen until after 2050, therefore, electricity demand up until this point is mostly through airport vehicles and some aircraft charging. This is directly proportional to the size of the airport, based on its archetype and annual aircraft traffic movements. By 2050, peak electricity demand from airports in the South West licence area reaches c. 6.5 MW.



Map of electricity demand impacting the distribution network at key airport locations in the licence area in 2050.
Note: Size of circles represent the scale of future capacity.

Uptake modelling factors

The below factors are used to inform the decarbonisation of aviation in the South West licence area.

Factor	Modelling impact	Source
IBA UK Airport Power demand projections	IBA's analysis has been used to inform airport archetyping, the underlying scenario assumptions and projected power demand by airport classification. IBA's analysis identified seven areas of electricity demand in airports: buildings, surface access vehicles, on-site solar PV, airport vehicles, aircraft ground power, aircraft charging and hydrogen liquefaction and storage. The first three categories are already modelled as part of existing DFES technologies and, therefore, do not form part of this aviation electrification analysis.	IBA study for National Grid
Aircraft traffic movements	IBA's projections have been scaled based on the average annual aircraft traffic movements of individual airports in the licence area.	UK Civil Aviation Authority annual airport data, 2019
Current grid connection arrangements	The current electricity demand for different end uses has been calculated from IBA's analysis scaled to individual airports' grid connection with NGED.	NGED connections data
Desk-based research of airport decarbonisation plans	Where information has been identified, the projections for that airport have been tailored to reflect their net zero plans.	Airport websites and press releases
Engagement with airports	The analysis has been tested and modified through direct engagement with individual airports. Where feedback has been received, the projections for that airport have been tailored to reflect their net zero plans.	St Mary's Airport, St Just Airport, Bristol Airport and Cornwall Airport Newquay

Spatial factors

The below factors are used to inform the spatial distribution of electricity demand at airports across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Location of commercial airports	DFES aviation modelling is done on a site-specific basis, engaging directly with relevant airports and scaled to the air traffic movements of each airport.	UK Civil Aviation Authority annual airport data, 2019

Reconciliation to FES 2024

- Aviation is not modelled within the FES, but is considered within its total energy demand modelling.

- In **Holistic Transition**, **Electric Engagement** and **Hydrogen Evolution**, the FES assumes that aviation emissions are aligned to the CCC's Balanced Pathway.[16] The CCC models a smaller role for hydrogen aircraft in the timeframe to 2050, assuming that even if hydrogen aircraft were commercialised in the 2040s, it would be challenging to immediately achieve a large share of aircraft sales and is unlikely to lead to a significant fleet penetration before 2050. This differs from the Net Zero scenario modelled by IBA, which reflects the stated ambitions of some of the largest aircraft manufacturers.
- In the **Counterfactual**, aviation emissions are modelled based on the FES 2023 Falling Short scenario, representing a world where decarbonisation takes place, but at a slower pace than required to achieve net zero and the carbon budgets.

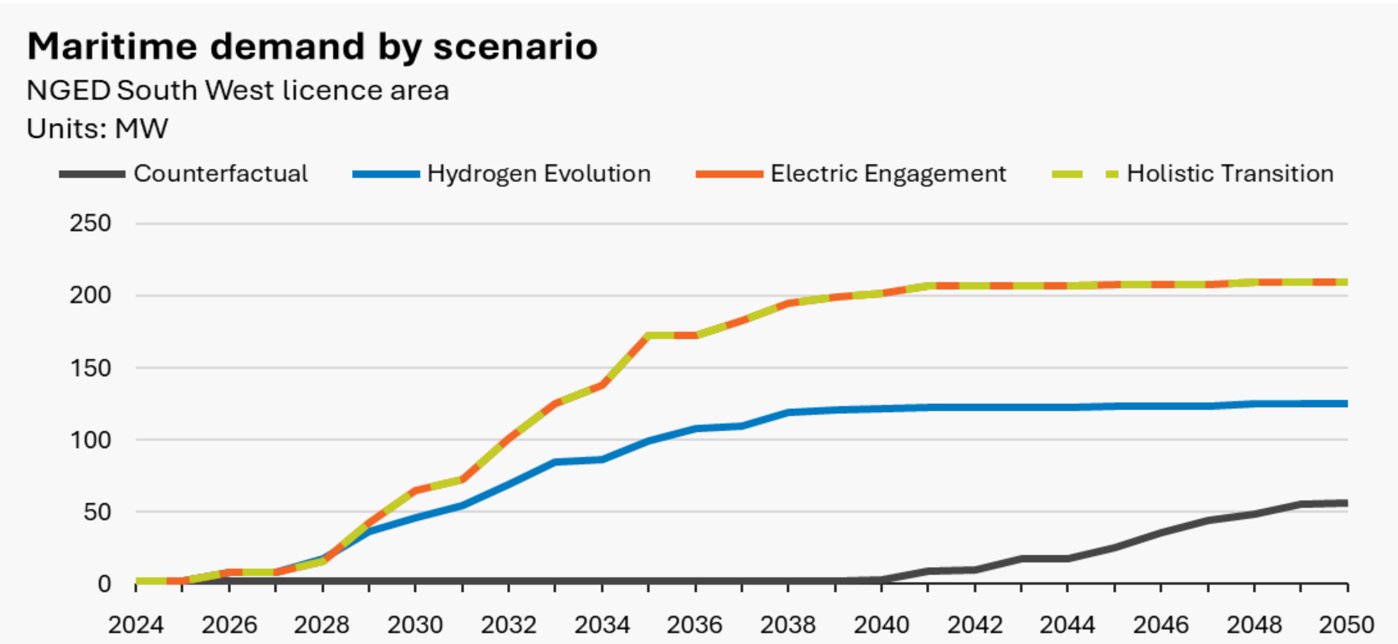
Comparison to DFES 2023

- Aviation was not modelled in DFES 2023.

Maritime transport

Summary

- The decarbonisation of the maritime sector, and its resultant impact on the distribution network, is a new area of modelling for DFES 2024. This includes shore power requirements, vessel charging and the electrification of other port operations. Electricity demand associated with on-site buildings and passenger EV charging is already modelled in the DFES, as well as on-site solar generation.
- The International Maritime Organization (IMO) has agreed to reduce global international shipping emissions by at least 50% by 2050, compared to 2008 levels.[17] There are a range of technological pathways to reduce maritime emissions, including hydrogen or hydrogen derivatives, and battery-electric propulsion. However, there is currently no single solution favoured for the whole sector.
- Electricity will primarily be used in ports to provide shore power, also known as 'cold ironing', where ships temporarily connect to the local grid to power onboard systems when docked. Container, passenger and cruise ships are most likely to be shore-power ready in the near term.
- As a net zero propulsion option, electricity is estimated to play a much smaller role than that of alternative fuels, mainly adopted by vessels that operate short voyages, such as short ferry routes.
- In 2023, the EU set out an agreement that container and passenger ships will be obliged to use onshore power supplies for all electricity needs while moored at the quayside in major EU ports, as of 2030. This will also apply to the rest of EU ports as of 2035.[18] The UK has no equivalent policy.
- There are 11 commercial ports operational in the South West licence area, including Bristol (Avonmouth and Portbury Docks), Plymouth and Falmouth. Smaller docks and marinas, such as Dartmouth, have not been included in this analysis, due to a lack of DfT's port-level data/statistics.
- Under **Holistic Transition** and **Electric Engagement**, peak electricity demand at ports in the South West increases rapidly from a baseline of c. 2 MW in 2024 to 170 MW by 2035 and 210 MW by 2050. Under **Hydrogen Evolution**, vessels are expected to favour hydrogen fuel cell technology, and less electricity is modelled to be required for shore power, resulting in 125 MW by 2050.
- Under the **Counterfactual** scenario, full maritime decarbonisation does not occur until after 2050, so peak electricity demand only reaches 56 MW by 2050. This still represents a 2800% increase.



Modelling assumptions and results

Baseline and pipeline

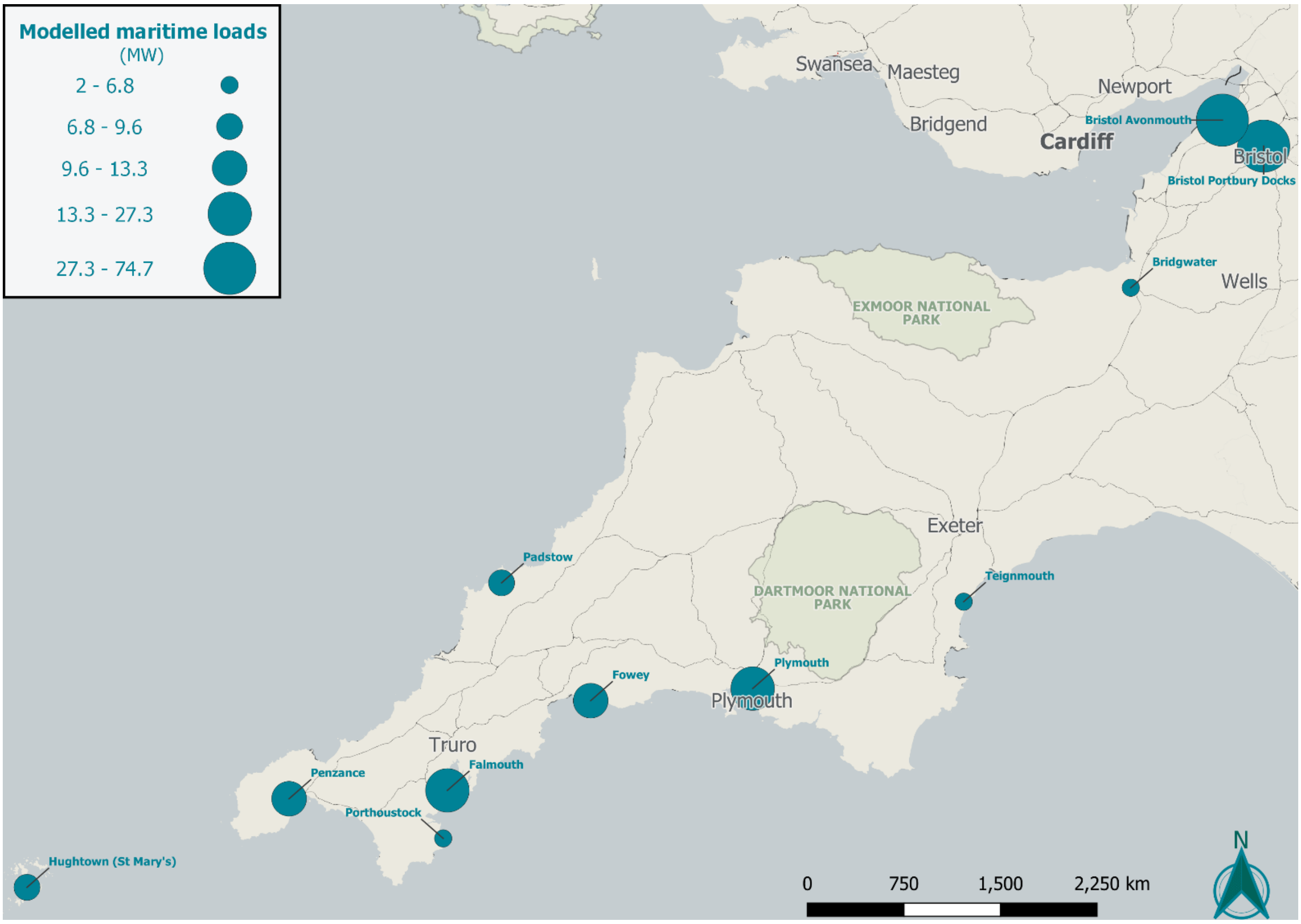
Source: NGED connections data

	Development status	Capacity (MW)	Description
Baseline	Peak capacity	1.97	The South West licence area has c. 2 MW of peak electricity demand at ports for onsite operations. This has been calculated as a percentage of the overall peak demand of these ports via their existing connection agreements with NGED. This includes the world's first 150 kW maritime vessel charging facility at Mount Batten, the UK's first 75 kW site at Queen Anne's Battery and a 25 kW installation at the Barbican landing stage – all in Plymouth in south Devon.[19]
Pipeline	In development	6	There is a 6 MW ferry charger at Millbay Docks in Plymouth that holds a connection offer with NGED. This is part of a partnership between Plymouth City Council, Millbay Docks and Brittany Ferries, which includes a focus on meeting shore power requirements.[20] This site is modelled to connect in 2026 in the three net zero scenarios, but is delayed to the 2030s under the **Counterfactual**.

Projections

Scenario	Description
Holistic Transition **Electric Engagement**	These scenarios abide by the UK government's Clean Maritime Plan and reflect the ambition of EU policies, which are assumed to be replicated by the UK.[21] In the near term, an increase in electricity demand at ports will be driven by shore power which, under these scenarios, is modelled to be in place at major ports for container ships, passenger ferries and cruise ships by 2030. This also reflects the plans of key operators like Brittany Ferries.[22] Shore power provision for other vessels is modelled to be in place at major ports by 2035 and minor ports by 2040. This results in an increased uptake of shore power as one of the first emissions reduction options. In addition to shore power, a shift to electric propulsion is modelled for short-hop ferries and small vessels under these scenarios. This is intended to represent an illustrative upper-bound estimate of the potential demand for electricity to charge electric vessels at key ports in the licence area. The UK Emissions Trading Scheme opened a consultation[23] around the inclusion of emissions from the maritime sector. This could drive further policy and commercial impetus to the decarbonisation and electrification of maritime vessels Under **Holistic Transition** and **Electric Engagement**, peak electricity demand at ports in the South West increases rapidly from a baseline of c. 2 MW in 2024 to 170 MW by 2035 and 210 MW by 2050.
Hydrogen Evolution	Similar timescales for decarbonisation and shore power provision are modelled under **Hydrogen Evolution**, but with lower overall projected capacity. This represents fewer vessels using battery-electric propulsion technology, in favour of hydrogen fuel cells,

	and less demand for shore power, potentially in favour of more innovative hydrogen-based solutions, like the one being developed by the Port of Leith.[24] This results in peak electricity demand at ports in the South West increasing to 99 MW by 2035 and 125 MW by 2050 under this scenario.
Counterfactual	Under this scenario, significant decarbonisation of the maritime transport sector doesn't happen until after 2050. As a result, electricity demand before 2050 mostly comes from onsite operations and some limited shore power provision. Passenger ferries are the first vessels to be shore-power-ready, by 2040, followed by container and cruise ships by 2045. This scenario is intended to represent an illustrative lower-bound estimate of the potential demand for electricity from vessels at key ports. By 2050, peak electricity demand from ports in the South West licence area reaches 56 MW, mainly driven by shore power demand for cruise ships, for which the South West is a popular destination and hosts active commercial ports.



Map of electricity demand impacting the distribution network at key port locations in the licence area in 2050.
Note: Size of circles represent the scale of future capacity.

Uptake modelling factors

The below factors are used to inform the decarbonisation of ports in the South West licence area.

Factor	Modelling impact	Source
Current grid connection arrangements	The current electricity demand for different end uses has been calculated by interrogating the existing grid connections held by key ports. This informs the potential future electricity demand for onsite operations.	NGED connections data
Annual port ship arrivals	For the ports that are in scope for this analysis, the number of ship arrivals, the breakdown of these by vessel type and the categorisation of each port (major or minor) are obtained from DfT's PORT data. This data is analysed and used to inform the potential future shore power requirements at these port locations.	DfT PORT data
Number of berths	The projections for electricity demand at ports are based directly on the number of berths and the type of vessels these serve.	Desk-based research, individual port websites
Average power demand per vessel	Various data sources have been compiled, comparing shore power and charging requirements for different vessel types at different ports. These have been used to represent a low, medium and high estimation of shore power requirement by vessel type.	Desk-based research and academic studies [25] [26] [27] [28] [29]

Spatial factors

The below factors are used to inform the spatial distribution of electricity demand at ports across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Location of commercial ports	DFES maritime modelling is done on a site-specific basis, scaled to the number of berths and vessel movements of each airport.	DfT PORT data

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.

- Maritime decarbonisation is not modelled within the FES, but is considered within its total energy demand modelling.
- In **Holistic Transition**, **Electric Engagement** and **Hydrogen Evolution**, the FES assumes that maritime emissions are aligned to the CCC's Balanced Pathway.[30] The CCC expects that the shipping sector can achieve very close to full decarbonisation by 2050. Electricity is used in a limited number of niche hybrid and full electric propulsion vessels (using onboard batteries and motors), and more widely used to provide shore power. This has generally been reflected in the DFES modelling, however an augmented view of **Hydrogen Evolution** has been considered, whereby maritime

decarbonisation is partially delivered through low-carbon hydrogen propulsion systems, hydrogen fuel cells or other hydrogen derivatives.

- In the **Counterfactual**, maritime emissions are modelled based on the FES 2023 Falling Short scenario, representing a world where decarbonisation takes place, but at a much slower pace than required to achieve net zero and the carbon budgets.

Comparison to DFES 2023

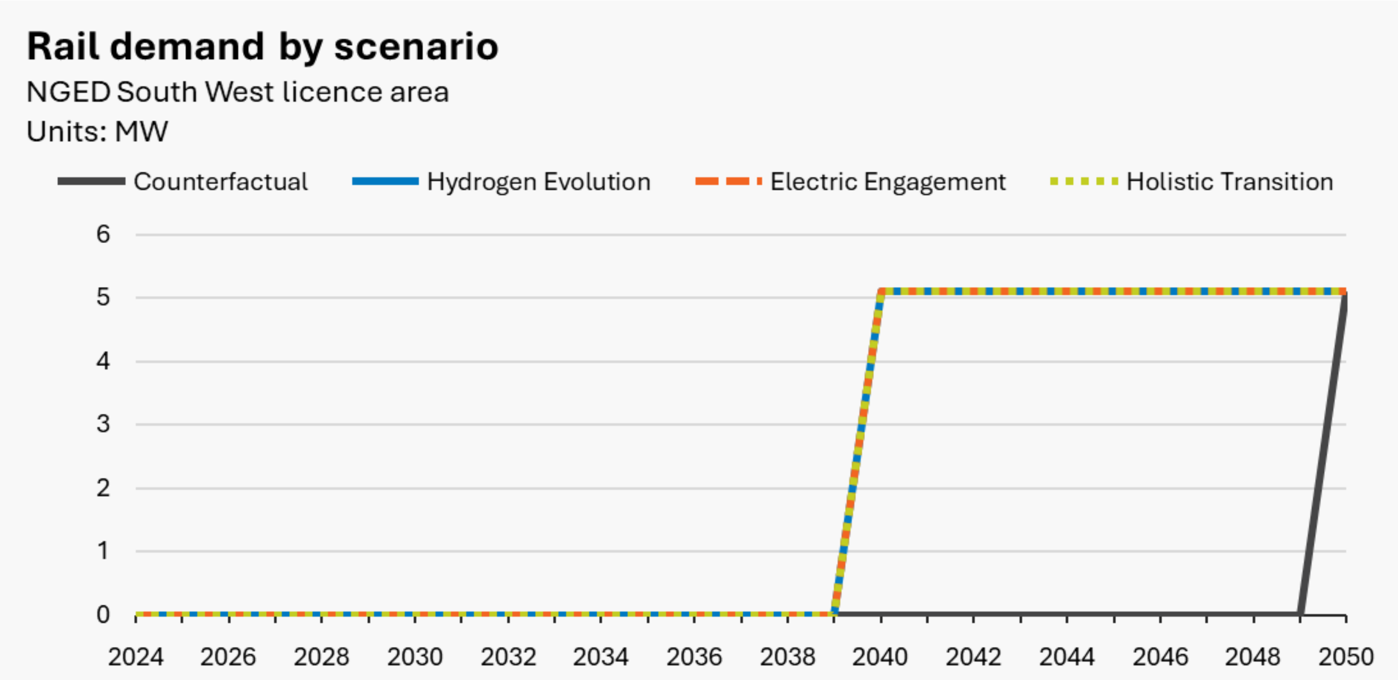
- Maritime decarbonisation was not modelled in DFES 2023.

Rail

Summary

- The decarbonisation of the rail sector is a new area of modelling for DFES 2024.
- 6,000 kilometres of railway are currently electrified across the UK, accounting for 38% of the total rail network by length. Power supply for existing electrified rail infrastructure has historically been fed by transmission connections, with some exceptions.
- There are two decarbonisation targets for the rail sector, both of which will have a direct impact on future electricity requirements[31]:
  - By 2040, all diesel-only trains will be removed from the network
  - By 2050, the railway will have net zero emissions
- In 2020, Network Rail published the Traction Decarbonisation Network Strategy (TDNS), an interim business case outlining its plan for a fully decarbonised railway. The TDNS identified decarbonisation solutions for each route on the network and recommended over 11,700 single-track kilometres of Overhead Line Electrification (OLE). Since then, Network Rail has developed further region-specific decarbonisation strategies which allocate the routes into sequenced delivery tranches.
- Four Network Rail regions overlap with NGED's licence areas: Eastern, North West & Central, Southern and Wales & Western.
- It is estimated that, by 2050, 5.1 MW of additional capacity for traction demand will be connected to the distribution network in the South West. This additional capacity is modelled to connect in 2040 in the three net zero scenarios, and 2050 in the **Counterfactual**. The capacity comes online at the same time as all routes are in the same delivery tranche (Western Tranche 5).
- The additional capacity comes from the battery electrification of five routes in Cornwall and Devon:
  - Truro to Falmouth (2.1 MW)
  - Par to Newquay (1.0 MW)
  - Liskeard to Looe (0.8 MW)
  - St Erth to St Ives (0.7 MW)
  - St Budeaux to Gunnislake (0.6 MW)
- The capacity projections presented here only include demand anticipated to connect to the distribution network. Significant further grid capacity is likely to be required by the rail sector for OLE connecting to the transmission network.

Note: These projections carry a high degree of uncertainty due to the significant unknowns surrounding rail decarbonisation.



Modelling assumptions and results

Baseline and pipeline

Source: NGED connections data

	Development status	Capacity (MVA)	Description
Baseline	Operational	3.3	The South West licence area currently has 3.3 MVA of Network Rail demand connections on NGED's 11 kV and LV networks. The largest site is a 1.8 MVA 11 kV connection in Bristol. *Note: The scenario projections under this technology only consider future additional MW capacity requirements and do not include this baseline figure.*

Projections

Scenario	Description
Holistic Transition **Electric Engagement** **Hydrogen Evolution**	In the net zero scenarios, all routes are assumed to have infrastructure enabling a net zero railway by 2050. In addition, the infrastructure enabling the removal of diesel-only trains is modelled to be in place by 2040. This additional requirement brings forward the decarbonisation of branch lines, compared to the **Counterfactual**. The projection shown under these scenarios is focused on battery electrification lines connecting to the distribution network as a focused tranche of work. Overall, rail electrification is likely to be a phased process, both in time and geographically, as Network Rail and rail line operators coordinate on capital projects. Also, various aspects of rail electrification works will be subject to local and national planning regimes, so planning timelines could be variable by region.

Counterfactual	In this scenario, electrification is assumed to progress at a slower rate with projects delivered c. 10 years later than in the net zero scenarios. Full decarbonisation of the GB rail network is achieved, however, not under the 2040 or 2050 timescales currently set out by the DfT.

Route	Route length (km)	Trains per day	Net Zero scenario delivery year	Counterfactual delivery year	Estimated load (MW)
Truro to Falmouth	20	60	2040	2050	2.1
Par to Newquay	34	16	2040	2050	1.0
Liskeard to Looe	14	30	2040	2050	0.8
St Erth to St Ives	7	56	2040	2050	0.7
St Budeaux to Gunnislake	17	18	2040	2050	0.6

Map of additional rail sector loads on the distribution network in 2050. Size of circles represent the scale of capacity required.

Uptake modelling factors

The below factors are used to inform the decarbonisation of rail in the South West licence area.

Factor	Modelling impact	Source
Route identification	52 routes within NGED's licence areas requiring decarbonisation were identified.	Network Rail Traction Decarbonisation Network Strategy
Route decarbonisation solutions	For each route, solutions were identified from Network Rail's regional decarbonisation strategy documents, which classified routes as requiring Overhead Line Electrification (OLE) or an alternative solution. Alternative solutions include battery-electric (including those powered in part or wholly by overhead lines) or hydrogen-fuelled traction. Routes requiring an alternative solution with lengths less than 200 km were assumed to use battery-electric solutions.	Wales and Western Regional Traction Decarbonisation Strategy Engagement with Network Rail
Delivery sequence	Decarbonisation sequencing was sourced from Network Rail's strategies. Since delivery dates weren't published, Regen set approximate completion dates to align with rail decarbonisation targets.	Wales and Western Regional Traction Decarbonisation Strategy
Network connection	For routes needing OLE, spatial analysis determined whether a connection would be made to the transmission or distribution network based on two criteria: • Routes within 10 km of a transmission substation are assumed to connect to transmission. • Transmission feeders are assumed to power trains 100 km in both directions.	Autotransformer Fed Traction Power Supply System: Analysis, Modelling and Simulation
Energy requirement	The energy required by all trains travelling on each route per day was calculated from the route distance, number of trains travelling each day and specific energy consumption of battery trains. Key assumptions included: • Specific energy consumption for battery trains: 6 kWh per train km • Maximum battery electric train range: 240km	Table 8, IET Onboard energy storage in rail transport Economic, environmental and grid-resilience benefits of converting diesel trains to battery-electric
Charging period	Charging capacity was derived assuming energy needs are met in four hours of charging per day (in motion or whilst stopped).	Desk research
Location of railway routes	The estimated capacity was allocated to locations at either end of branch lines.	Desk research

Spatial factors

The below factors are used to inform the spatial distribution of electricity demand for rail across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Location of railway routes	DFES rail modelling is done on a bottom-up, route-specific basis and so the locations of modelled loads are defined by the location of each route. For the branch lines in the South West, the trains are assumed to charge at either end of the line.	Network Rail

Reconciliation to FES 2024

- FES includes projections of annual rail electricity demand (TWh). Under **Holistic Transition**, GB demand more than doubles over the period from around 5 TWh in 2023 to 10.6 TWh in 2050.
- FES does not publish projections of grid capacity used by the rail sector or regionally-specific projections, so reconciliation was not possible.

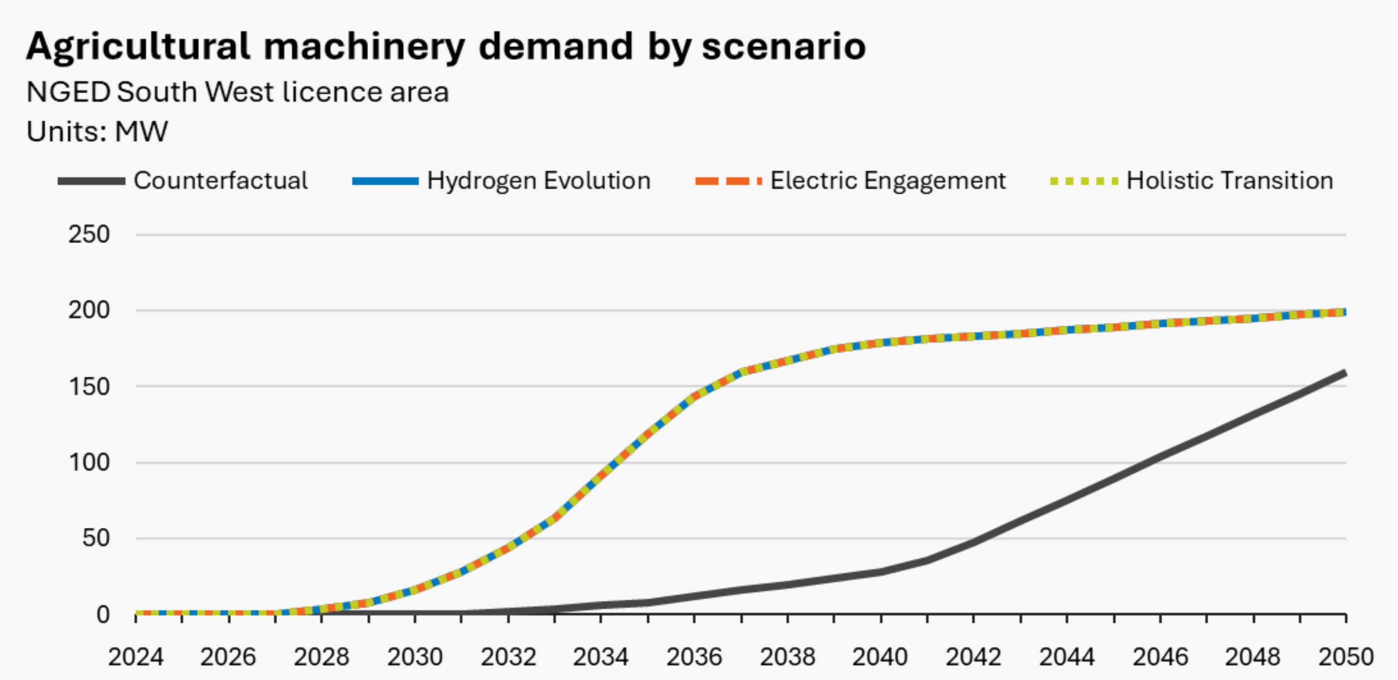
Comparison to DFES 2023

- Rail was not modelled in DFES 2023.

Agricultural machinery

Summary

- The decarbonisation of agricultural machinery, and its resultant impact on the distribution network, is a new area of modelling for DFES 2024. On-site solar generation, fossil fuel electricity generation and anaerobic digestion electricity generation, which may all be located at farms, are already reflected as separate technologies in the DFES, as is building heat and road transport.
- Stakeholder engagement revealed that electrification of agricultural machinery is at a very early stage, especially for mobile machinery such as farm vehicles. This is reinforced by vehicle registrations data from the DfT, encompassing vehicles registered for use on public roads, which suggests that there are currently less than 100 electric agricultural vehicles in the South West licence area. This equates to 0.2% of registered agricultural vehicles, the vast majority of which are currently fuelled by diesel.
- The FES 2024 does not include agricultural energy demand within its modelling, instead deferring to the decarbonisation pathways presented in the CCC's Sixth Carbon Budget.[32] The DFES scenarios have been modelled based on the CCC's Balanced Pathway, which assumes that the majority of agricultural machinery will be fuelled by hydrogen or bioenergy, rather than electricity, by 2050.
- Stakeholder engagement aligned with these Balanced Pathway assumptions, with stakeholders highlighting some limitations of electrification, such as the impact of increased vehicle weight on farmland for larger machinery and requirements for long ranges/operating hours on peak days during key harvest seasons.
- Stakeholders felt that agricultural machinery electrification is most likely to be limited to smaller 'utility' tractors and telehandlers, with larger farm machinery likely to employ biodiesel, biomethane or hydrogen solutions to decarbonise. Stakeholders identified that farms with typically smaller machinery and denser operations are more likely to adopt electric agricultural machinery, including fruit and vegetable farming, dairy herds, pigs and poultry.
- The South West licence area has proportionally a higher presence of dairy farming and beef cattle compared to England and Wales as a whole. These are seen as types of farm that may be more suited to deeper levels of electrification. However, the licence area also features a high proportion of grassland agriculture due to upland areas and hillier terrain, which is potentially at odds with some electric farm machinery and vehicles.
- To calculate potential future demand on the distribution network, the national demand for electricity for agricultural machinery under the CCC's Balanced Pathway has been disaggregated to local authority level. This has been based on the presence of the farm types that could be suited to electrification in the near term, as identified by stakeholders, combined with current petroleum consumption for agriculture as a longer-term driver. Future demand capacity connecting to the network has been determined using electrical energy demand, peak day requirements and assumptions around charging windows for machinery and vehicles.
- Under **Holistic Transition**, **Electric Engagement** and **Hydrogen Evolution**, capacity connected to the distribution network in the South West licence area reaches 200 MW by 2050, with the majority of capacity connecting in the 2030s.
- Under the **Counterfactual** scenario, agriculture sector electrification progress is slower and occurs mostly in the 2040s, reaching just under 160 MW by 2050.



Modelling assumptions and results

Baseline and pipeline

Source: DfT Vehicle Statistics

	Development status	Capacity (MW)	Description
Baseline	Operational	n/a	The installed capacity of electric agricultural machinery would be comprised of chargers for mobile farm machinery and direct connections for non-mobile machinery. Data for this is not currently available, due to it being a very specific subset of wider farm grid connections and equipment. Stakeholder engagement highlighted that the electrification of agricultural machinery is at a very early stage, especially for mobile machinery. This is reinforced by vehicle registrations data from the DfT, encompassing vehicles registered for use on public roads, which suggests that there are less than 100 electric agricultural vehicles in the South West licence area. This equates to 0.2% of registered agricultural vehicles, the vast majority of which are instead currently fuelled by diesel.

Projections

The three net zero scenarios are modelled based on the outcomes for agricultural machinery electrification in the CCC's Sixth Carbon Budget Balanced Net Zero Pathway. This states that "*completely decarbonising the agricultural sector is not possible (on current understanding) due to the inherent biological and chemical processes in crop and livestock production*". Of the current and projected emissions associated with agriculture, machinery decarbonisation is small compared to reducing food waste, changing diets and implementation of low-carbon farming measures (see below).

Based on this CCC analysis and Energy Consumption in the UK data, agricultural machinery currently consumes c. 12 TWh of fuel per year, mainly in the form of diesel and other petroleum products, with a small contribution from bioenergy.[33] In the CCC's Balanced Pathway, the majority of agricultural machinery is decarbonised via bioenergy in the near term and via low carbon hydrogen in the longer term, with electricity providing only 11% of final energy demand by 2050.

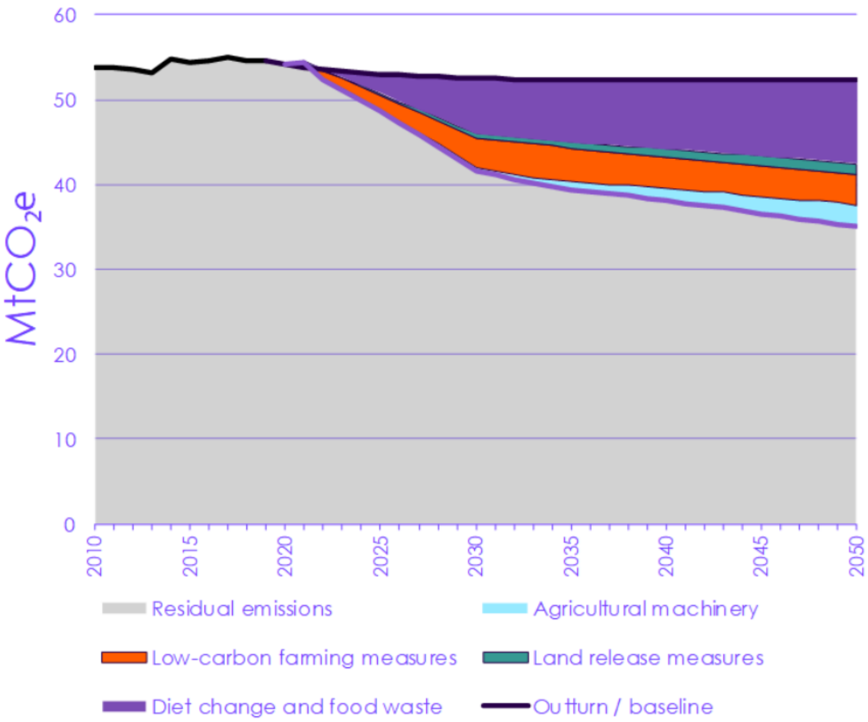


Figure 6 - Sources of abatement in the Balanced Net Zero Pathway for the agriculture sector, CCC Sixth Carbon Budget Report, Dec 2020

This outcome was tested with industry stakeholders, including agricultural machinery sector experts, local authorities and a consultancy with experience in rural decarbonisation studies. Two major limitations for the electrification of agricultural machinery were identified. Firstly, the greater weight of battery electric vehicles would be expected to make electrification of larger tractors, combine harvesters and other large mobile machinery unfeasible due to the resultant soil compaction and impact on farmland. Secondly, the requirements of agricultural machinery on peak days, such as during harvest season, can require up to 16 hours of continual use for a single piece of machinery over a single day. Current electric agricultural machinery, and foreseeable developments in the near term, are not expected to address these excess weight or charge duration/range barriers, thus limiting uptake.

As a result, stakeholders felt that agricultural machinery electrification is most likely to be limited to smaller 'utility' tractors and telehandlers, with larger machinery likely to employ biodiesel, biomethane or low carbon hydrogen solutions. This is particularly likely where farms can produce their own biofuel on-site. Current developments in the agricultural vehicle market are focused on these biofuels, with many new agricultural vehicles currently being delivered with biodiesel fuel capabilities included.

To calculate potential future demand on the distribution network, the national demand for electricity from agricultural machinery under the CCC's Balanced Pathway has been disaggregated to local authority level. This has been based on the presence of suitable farm types in the near term, as identified by stakeholders, combined with current petroleum consumption for agriculture in the longer term. This electrical energy demand has then been converted to a potential network connection capacity, calculated using the proportion of annual consumption that may be required on a peak day and an assumed eight-hour charging window.

The electrification of specific agricultural machine 'implements', such as irrigators, was identified as an area of current development. However, these implements are expected to be powered by a generator fuelled by diesel, biodiesel or hydrogen rather than a battery. As a result, this specific aspect equipment electrification would not result in any distribution network facing demand.

Potential future evolutions in agricultural practices, such as using fleets of autonomous 'drone' machinery for crop spraying and seeding, or controlled-environmental vertical farming, could be highly suited to electrification. However, the trajectory for these technologies is currently highly uncertain. As a result, the DFES modelling and subsequent projections are based on a continuation of conventional farming practices and machinery requirements between now and 2050. Depending on how this area develops over the coming years, a 'deep electrification' scenario projection may be justified.

Overall, the South West hosts 12% of total farmed area in England and Wales, and has proportionally a higher presence of dairy farming and beef cattle compared to the rest of England and Wales. These are seen as prospective types of farm for electrification. However, the licence area also features a high proportion of grassland agriculture due to upland areas and hillier terrain, which is a challenge to highly electrified heavy vehicle fleets.

Scenario	Description
Holistic Transition **Electric Engagement** **Hydrogen Evolution**	Stakeholders suggested that the CCC Balanced Pathway for agricultural electrification, published in 2020, was overly ambitious in the near term compared to current uptake and developments in the agricultural machinery market. As a result, the DFES projections are based on a slightly delayed uptake in the near term, with the majority of electrification occurring from the 2030s onwards. Under the net zero scenarios, this results in c. 200 MW of capacity of agricultural machinery connected to the distribution network by 2050 in the South West licence area. These projections carry a high degree of uncertainty due to a very wide range of potential outcomes for the decarbonisation of the agricultural sector in the UK.
Counterfactual	This scenario is intended to represent an illustrative lower-bound estimate of the potential demand for electricity from agricultural machinery. Uptake is delayed by approximately ten years compared to the net zero scenarios, as progress on transport electrification and wider carbon emissions reductions measures are more limited under this scenario. By 2050, this results in c. 160 MW of capacity of agricultural machinery in the South West licence area, with the majority of electrification occurring in the 2040s.

Uptake modelling factors

The below factors are used to inform the overall uptake of electrified agricultural machinery in the South West licence area.

Factor	Modelling impact	Source
Trajectory and magnitude of UK agricultural machinery electrification	The Balanced Net Zero pathway from the CCC's Sixth Carbon Budget has been used to guide the overall uptake of agricultural machinery electrification under the three net zero scenarios.	CCC Sixth Carbon Budget
Typical annual and peak day operating hours for utility tractors and telehandlers	To estimate the connection capacity required to meet annual electricity consumption for agricultural machinery presented in the CCC Sixth Carbon Budget, a number of assumptions have been made based on engagement with sector stakeholders and reinforced by desk research. For a smaller utility tractor of under c. 100 horsepower or telehandler, annual operating hours can vary significantly but average around 300 hours per year. Due to the timing necessities of agricultural work, a peak day during harvest season could require at least 12	Stakeholder engagement

	hours of machinery use for a small tractor or telehandler, and up to 16 hours for larger machinery. As a result, the connection capacity has been calculated based on 4% of annual demand being delivered in an eight-hour overnight charging period before or after a significant harvest day, driving peak utilisation. This is likely to be a conservative estimate and does not account for top-up charging of vehicles within the peak day or rotation of equipment during the day. Using these assumptions, the utilisation factor of the connection capacity is just over 2%. There is potential for greater utilisation of this capacity through smart charging, autonomous machinery and vehicle-to-grid technology.	
Land use, crop areas and livestock populations by local authority	Stakeholder engagement identified that farms with typically smaller machinery and denser operations are more prospective for electric agricultural machinery, as the market currently stands. This includes fruit and vegetable farming, dairy herds, pigs and poultry. In contrast, other arable crops, cereals, grassland and sheep/lamb farming were seen as less suited to significant levels of electrification. The near-term uptake of electric agricultural machinery has been based on the presence of these farm types by local authority. This aims to reflect the potential development of the electric agricultural machinery market over time to tackle a wider variety of uses. The focus of capacity towards specific farm types is reduced in the longer term, as other farm types consider some degree of electrification.	DEFRA structure of the agricultural industry data[34]
Current petroleum consumption for agriculture by local authority	The uptake of electric agricultural machinery has been based on current agricultural petroleum consumption by local authority. This aims to reflect the potential development of the electric agricultural machinery market over time to tackle a wider variety of uses.	DESNZ sub-national total final energy consumption data[35]

Spatial factors

The below factors are used to inform the spatial distribution of electrified agricultural machinery capacity across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Land use, crop areas and livestock populations by local authority	Mirroring its use as an uptake factor, local authority data on farm type, informed by hectares of crops and numbers of livestock, is used to model the locations for agricultural electrification, particularly in the near and medium term.	DEFRA structure of the agricultural industry data[36]
Current petroleum consumption for agriculture by local authority	Mirroring its use as an uptake factor, local authority data on current petroleum consumption from the agricultural sector, down to local authority level, is used to model the locations for agricultural electrification in the longer term.	DESNZ sub-national total final energy consumption data[37]
Location of agricultural premises	Following the distribution to local authorities through the two factors above, the location of agricultural premises, identified through analysis of OS Addressbase use classes, has been used to distribute local authority projections down to individual 11 kV ESAs.	OS Addressbase

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.

- Agricultural machinery is not modelled within the FES.
- The FES uses emissions pathways from the CCC Balanced Pathway for sectors that are not modelled, such as agriculture. This has been reflected in the DFES in the three net zero scenarios, alongside delayed progress under the **Counterfactual** scenario.

Comparison to DFES 2023

- Agricultural machinery was not modelled in DFES 2023.

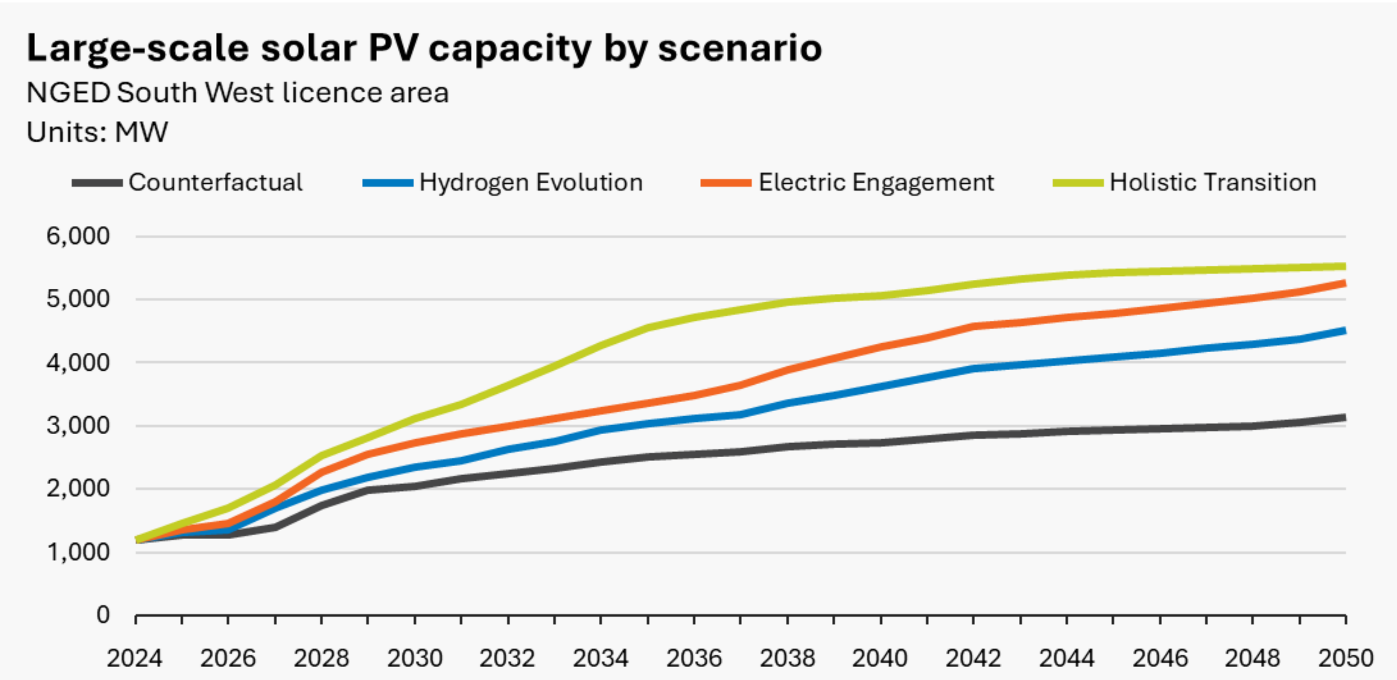
Generation technologies

Results and assumptions

Large-scale solar

Summary

- Solar power is one of the critical enablers for a net zero electricity system, with the UK government aiming to treble solar generation as part of its plan to achieve 'Clean Power' by 2030, from 15 MW to 47 MW. Under this plan, the distribution networks will play a key role in the deployment of new solar projects, expected to account for 90% of solar capacity by 2030.[38]
- The South West licence area has historically seen a moderate level of large-scale solar PV deployment, with 1.2 GW MW of capacity connected over the past decade. In the past year alone, 124 MW of new projects have connected in the licence area.
- In addition to this, there is currently 2.9 GW of large-scale solar PV, across 119 projects, with an accepted connection offer in the South West licence area. This is an increase, 50 MW, over the last 12 months. 64% of these sites have planning evidence, with 32% having been granted full planning permission.
- The Contract for Difference Allocation Round 6 awarded to twelve sites in South West with contracts, totalling 437 MW of installed capacity.
- The South West is host to a significant amount of suitable land for solar farm development, moderately high solar irradiance and a history of planning friendliness by regional local authorities. Therefore, the installed capacity of large-scale solar in the South West is projected to increase substantially out to 2050 in all scenarios.
- By 2050, the capacity of large-scale solar PV in the South West ranges from 3.1 GW under the **Counterfactual** scenario, over two and a half times the current baseline, to 5.5 GW under **Holistic Transition**, nearly four times the baseline.



Modelling assumptions and results

Baseline and pipeline

Source: NGED connections data

	Development status	Capacity (MW)	Description
Baseline	Connected/ operational	1203	124 MW of large-scale solar has connected in the South West licence area in the last year. This is the most large-solar added in a single year since 2017. This increase is contributed to eight sites, the largest site in South West the Lower Litchardon Solar Park a 57.6 MW.
Contract for Difference Allocation Round 6		437	Twelve sites (437 MW) were identified as having been awarded a Contract for Difference in Allocation Round 6. All sites were modelled to connect by the delivery years (2026/28), except for those that are in areas of grid constraint. These sites were modelled to connect by the delivery year under **Holistic Transition** and **Electric Engagement** modelled to connect by the year that statement of works upstream network reinforcement is set to complete under **Hydrogen Evolution** and **Counterfactual**.
Pipeline	Granted	579	In addition, there are 35 sites, totalling 579 MW which have granted planning permission. This includes 10 sites that are individually greater than 20 MW. The largest site is the Peradon Solar Farm Limited (53 MW) in Cullompton. There are also four sites that are 49.9 MW.
	Submitted	386	There are 17 sites in the South West licence area, totalling 386 MW, that have submitted planning applications. Two sites were awarded CfDs (89 MW). Of these, seven sites are modelled to connect, in the mid to late 2020s, under **Holistic Transition**. Under **Electric Engagement**, 15 sites with installed all with capacity less than 40 MW were modelled to connect in the late 2020s early 2030s, except the two CfD sites. Nine site was modelled to connect in the late 2020s early 2030s. under **Hydrogen Evolution** based on an analysis of the level of local ambition and historic planning permission. Under the **Counterfactual** scenario, only sites in areas with a CfD or high-levels of historic planning success for large-scale solar PV are modelled to connect.

Pipeline	Pre-planning	507	Pre-planning includes sites with evidence of pre-development beyond an accepted connection offer, such as a screening opinion for the need for an environmental impact assessment (EIA) or early-stage community engagement. Sites in the pre-planning stages are only modelled to connect under the three net zero scenarios. Under **Electric Engagement** and **Hydrogen Evolution**, 25% of the 507 MW capacity is modelled to connect based on local ambition and historic planning permission success rates. Under **Holistic Transition**, this is increased to 50%.
	No information	1061	There are a number of sites with no evidence of development. While this could be an indication that the site is unlikely to connect, many of these sites have only recently accepted a connection offer with NGED. Therefore, 30% of these sites are modelled to connect under **Holistic Transition** and **Electric Engagement**.
	Rejected/withdrawn /expired/abandoned	281	Sites that have been rejected in planning (281 MW), withdrawn their planning applications or have abandoned development are not modelled to connect under any scenario.

Projections

Scenario	Description
Holistic Transition	This scenario sees the largest growth in large-scale solar PV, driven by a high proportion of the known pipeline being modelled to connect. Baseline sites are modelled to repower with an additional 50% capacity at the end of a 20-year operational life. Solar capacity resultantly reaches over 5.5 GW by 2050 in the licence area under this scenario.
Electric Engagement	Solar PV deployment increases substantially under this scenario, reaching 5.3 GW by 2050. Repowering of baseline sites at the end of a 25-year operational life is modelled to increase capacity by 25%.
Hydrogen Evolution	Solar PV deployment increases steadily under this scenario, driven by high-levels of local ambition, reaching over 4.5 GW by 2050. Repowering of baseline sites at the end of a 25-year operational life is also modelled to increase capacity by 25%.

Counterfactual	Whilst the least ambitious of the four scenarios for renewable energy development, the DFES still models a capacity increase of nearly two and a half times the baseline by 2050. This is driven by the high proportion of known sites with granted planning permission connecting with longer development timelines, pushing development up to the late 2030s, where growth in new connected solar capacity levels off, reaching 3.1 GW by 2050. Repowering is assumed to have a minimal impact under this scenario, with most site owners choosing to extend the life of their existing panels rather than increase capacity.

Uptake modelling factors

The below factors are used to inform the uptake of large-scale solar PV in the South West licence area.

Factor	Modelling impact	Source
Existing and prospective projects with grid connections	The number, location and capacity of projects currently connected or with a connection offer in NGED's South West licence area are used to model the near-term projections.	NGED connections data
Planning progress	The development status of individual projects, including their status within the local planning authority, is used to inform which of these projects are modelled to connect under which scenarios and on what timeline.	Renewable Energy Planning Database, Contracts for Difference auctions, public consultations, desk research
Repowering assumptions	Baseline sites > 5 MW are modelled to repower at the end of their operational life with +25% capacity in **Electric Engagement** and **Hydrogen Evolution** and +50% in **Holistic Transition**.	Developer engagement
Historical planning friendliness	The proportion of solar sites that have received planning approval with relevant local planning authorities is used to help determine which projects with planning status submitted or pre-planning are modelled to connect.	Renewable Energy Planning Database
Local ambition	Similar to historical planning friendliness for **Electric Engagement** and **Holistic Transition**, local planning authorities who have explicitly stated local ambition in solar power (through LAEPs or stated targets) are used to determine which projects are modelled to connect.	DFES local authority energy strategy survey Local Area Energy Plans

Technical limits offers	Where a project has accepted a technical limit offer with NGED, this anticipated energisation date is used as the minimum year of connection for that project under any scenario.	NGED connections data
Statement of Works transmission reinforcement timelines	Where a project is impacted by a transmission-level Statement of Works, the anticipated completion year this is used as the minimum year of connection for that project under the **Counterfactual**.	NGED connections data

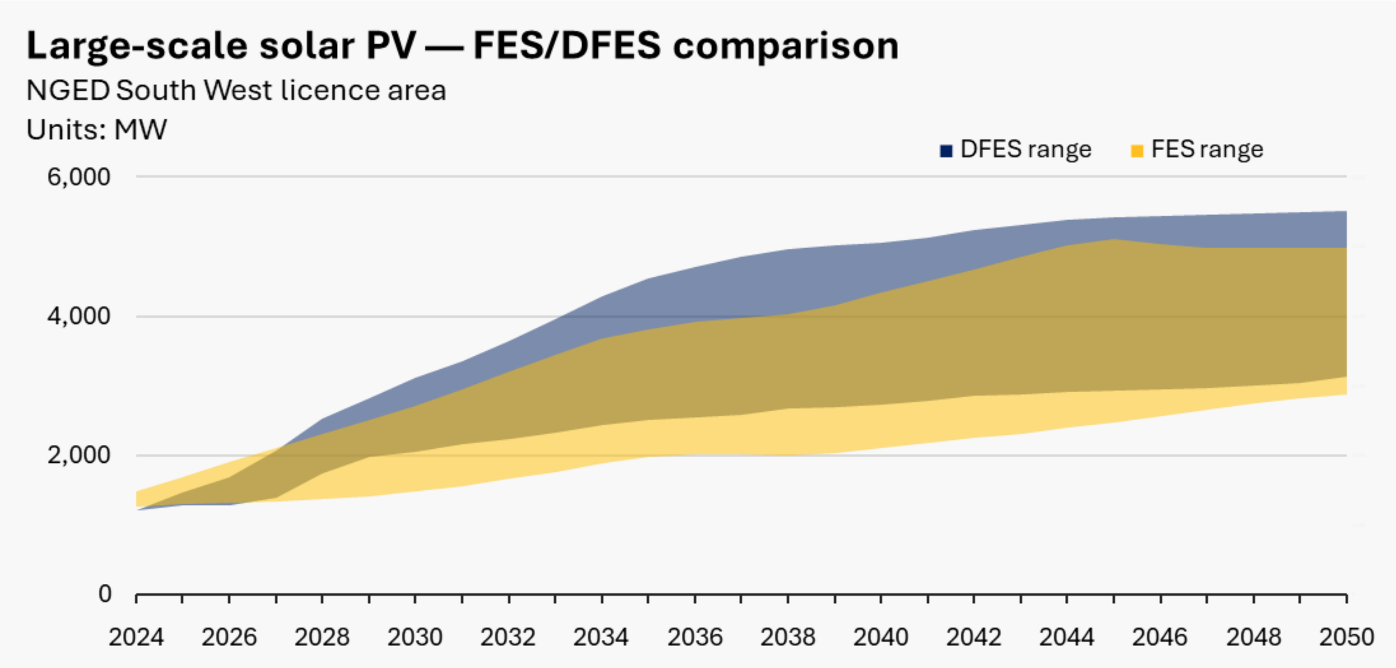
Spatial factors

The below factors are used to inform the spatial distribution of large-scale solar capacity across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Solar resource assessment	Regen's in-house resource assessment, taking into consideration solar resource, land availability and planning constraints in the licence area, is used to identify potential future areas for large-scale solar development.	Solar irradiance data, Natural England, OS Addressbase
Local ambition	Local ambition, including the local authority policy landscape and commitment to renewable energy and net zero goals, is reflected in the large-scale solar projections at a local authority level.	Climate Score Cards, DFES local authority energy strategy survey, Local Area Energy Plans

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared against the FES 2024 projection for the same licence area.



- The FES 2024 baseline is around 75 MW higher than the DFES 2024 baseline for the South West licence area. This could be due to erroneous assignment of solar farms to GSPs on the edge of the licence area in the FES data.
- Over the scenario timeframe beyond the baseline, the FES and DFES projections are closely aligned.

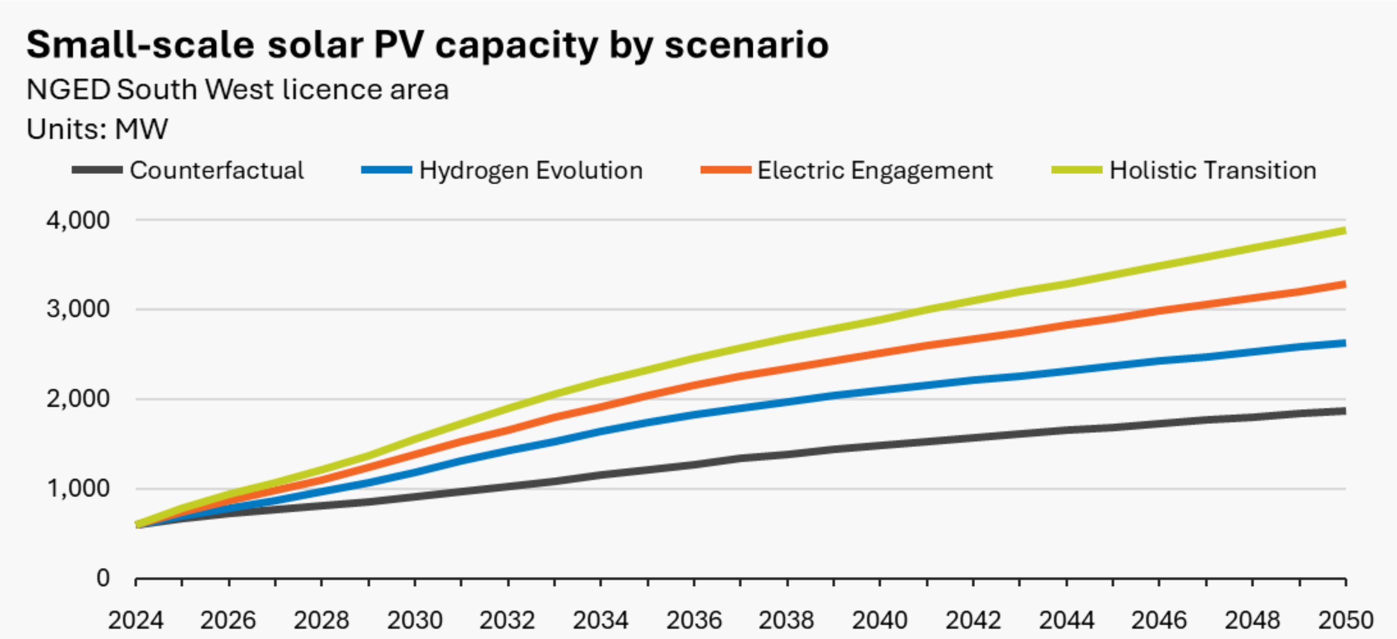
Comparison to DFES 2023

- There are no major differences between DFES 2023 and DFES 2024 outcomes.

Small-scale solar

Summary

- High energy prices over the past few years have resulted in an increase in small-scale solar PV deployment across GB, reaching its highest level in over a decade. The South West baseline now totals nearly c.600 MW, with two thirds of this capacity originating from domestic rooftop solar.
- This trend is projected to continue as solar panel and installation costs continue to fall and domestic solar generation remains attractive for households and businesses, especially when paired with a domestic battery or EV.
- High electrification of transportation and heating drives the uptake of small-scale solar in homes and businesses under the net zero scenarios. By 2050, 3.8 GW of small-scale solar PV capacity connects in **Holistic Transition**, 3.3 GW **Electric Engagement** and 2.6 GW **Hydrogen Evolution**.
- The **Counterfactual** reflects lower levels of electrification but still shows significant growth in small-scale solar, with c. 1.9 GW of capacity deployed by 2050 under this scenario.



Modelling assumptions and results

Baseline and pipeline

Source: NGED connections database and MCS installations data

	Installation type	Capacity (MW)	Description
Baseline	Domestic rooftop (<10 kW)	385	The majority of small-scale solar was deployed in the FiT era in the 2010s, with over 360 MW connecting during this period. The South West is currently seeing consistently high ongoing deployment of small-scale solar, with 59 MW of new capacity connecting in the last year. This growth is driven by a number

	Commercial rooftop (10 kW – 1 MW)	186	of factors, including continued high electricity and gas prices and a recent decrease in solar installation costs.
Pipeline	Domestic rooftop (<10 kW)	0.3	The majority of small-scale solar sites with accepted connection offers with NGED are commercial rooftop arrays of between 10 kW and 1 MW. There is only 300 kW of domestic rooftop capacity with equivalent accepted connection offers. All pipeline sites are modelled to connect in 2025 under all scenarios, due to the small scale and clear evidence of ongoing solar deployment– many of which are under permitted development, not requiring planning approval. Domestic solar sites often commission quickly and, therefore, are unlikely to hold their connection offer for long before being installed. In addition, NGED has recently introduced a 'connect and manage' scheme for domestic low-carbon installations, which means that households do not need to apply for a grid connection ahead of installing rooftop solar.
	Commercial rooftop (10 kW – 1 MW)	28	

Projections

Scenario	Description
Holistic Transition	Very high-levels of consumer engagement with smart electricity usage, dynamic electricity tariffs and high green ambition help boost small-scale solar deployment under the **Holistic Transition** scenario. This is augmented by solar deployment on new-build homes, which is modelled to occur on 80% of new homes and a high proportion of new non-domestic buildings. This is in line with the Future Homes Standard, once it is fully implemented. This results in 3.8 GW of small-scale solar by 2050 under this scenario.
Electric Engagement	High-levels of consumer engagement with smart electricity usage, dynamic electricity tariffs and high-level green ambition help to boost small-scale solar deployment under the **Electric Engagement** scenario. This is augmented by solar deployment on new-build homes, which is modelled to occur on 80% of new homes and a high proportion of new non-domestic buildings. This is in line with the Future Homes Standard, once fully implemented. This results in 3.3 GW of small-scale solar by 2050 under this scenario.
Hydrogen Evolution	With the need to decarbonise electricity demand quickly to meet carbon reduction targets, solar PV uptake is also high under the **Hydrogen Evolution** scenario. However, due to customers being less engaged and an overall lower level of electrification of heat and transport, uptake of rooftop PV is not as high as in the other net zero scenarios. This is augmented by solar deployment on new-build homes, which is modelled to occur on 80% of new homes and a high proportion of new non-domestic buildings, in line with Future Homes Standard, once fully implemented.

	This results in 2.6 GW of small-scale solar by 2050 under this scenario.
Counterfactual	Reflecting a lower uptake of low carbon technologies, smart tariffs and less engaged customers, the **Counterfactual** scenario results in lower demand for small-scale solar. This is augmented by solar deployment on new-build homes, which is modelled to occur on around 50% of homes and a moderate proportion of new non-domestic buildings by the 2030s. This results c.1.9 GW of small-scale solar by 2050 under this scenario.

Uptake modelling factors

The below factors are used to inform the overall uptake of onshore wind in the South West licence area.

Factor	Modelling impact	Source
Recent small-scale solar PV uptake trends	Nearly 600,000 solar installations have occurred in GB since January 2020. With such a large sample size, the DFES has modelled uptake trends at a regional level based on the uptake of small-scale solar PV in the region relative to the national uptake over the past four years.	MCS Data Dashboard
New-build housing	New-build housing is modelled to include rooftop solar PV in line with the Future Homes Standard consultation. As such, the outputs of the DFES new housing projections directly influence the location of future small-scale solar PV installations.	DFES new developments projections, Future Homes Standard consultation

Spatial factors

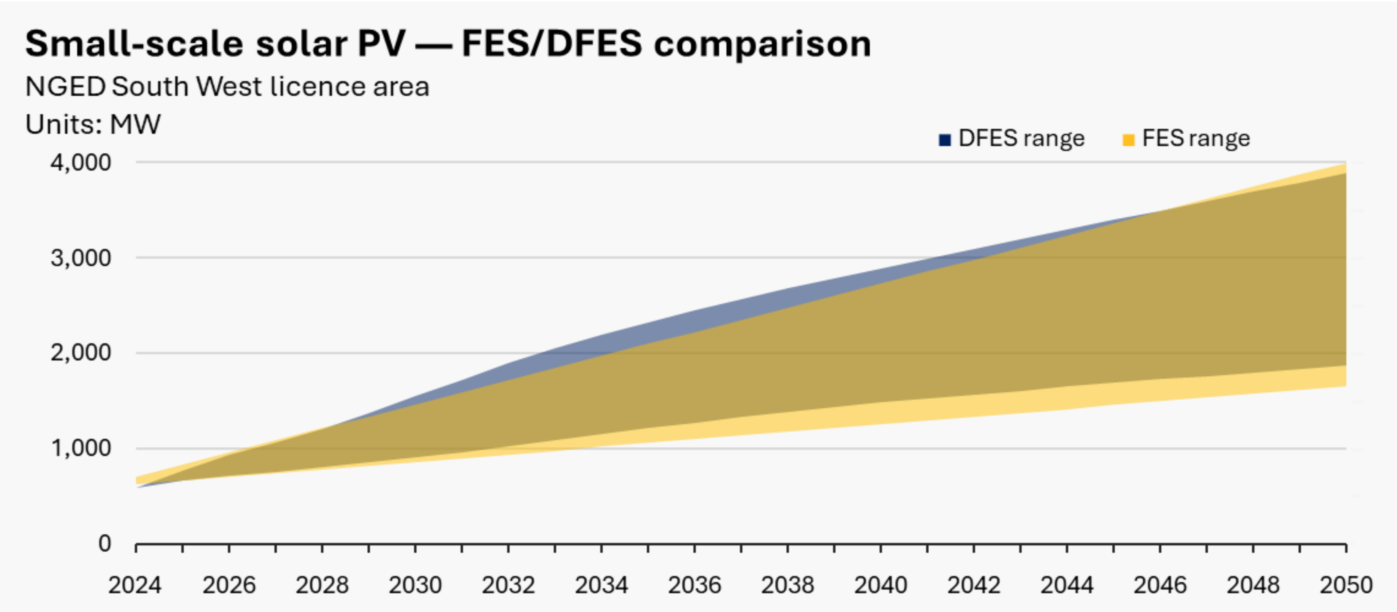
The below factors are used to inform the spatial distribution of onshore wind capacity across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Building type	The building type of domestic homes, such as detached, terraced and flats, is the primary distribution factor for domestic rooftop solar PV, used as a proxy for available roof space.	ONS Census
Tenure	The tenure of domestic homes, such as owner-occupied, social-rented or private-rented, is a secondary distribution factor for domestic rooftop solar PV, with more uptake on owner-occupied and social-rented homes.	ONS Census
Affluence	Affluence plays a minor role in the distribution of domestic solar PV in the near term, as stakeholder	ONS Census

	feedback and analysis of baseline trends show that the cost of solar PV is still a major contributing factor to uptake. Affluence is modelled using the ONS census Socio-economic Classification (NS-SEC) variable.	
Non-domestic buildings with potential for rooftop solar PV	Based on engagement with stakeholders, we have identified existing non-domestic buildings with potential for rooftop solar to be included in the modelling. This includes schools, universities, warehouses, hospitals, shopping centres and offices.	OS Addressbase

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.



- The DFES 2024 projections are highly comparable to the FES 2024. In the other three NGED licence areas, the DFES 2024 projections for small-scale solar are generally above the FES projections for that licence area, due to how the Future Homes Standard has been reflected. The Future Homes Standard has been similarly reflected in the South West licence area. However, this has been counteracted by the fact that FES regional projections for small-scale solar are mainly based on historic uptake, for which the South West licence area is more heavily weighted, while the DFES aims to represent a more distributed uptake across the country, as has been seen in more recent years.

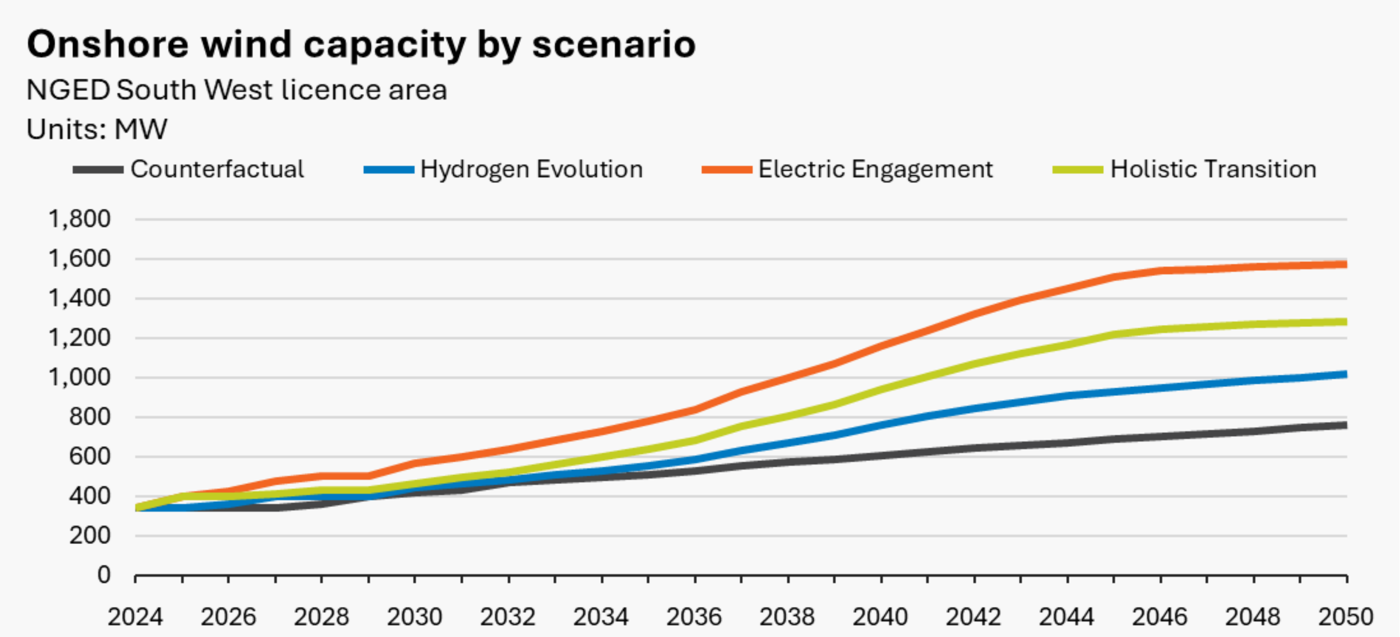
Comparison to DFES 2023

- The DFES 2024 projections are broadly comparable to DFES 2023 projections, though similarly have a higher overall projected capacity out to 2050. This is due to an increase in the number of new-build homes and non-domestic properties that have solar PV deployed, reflecting with the Future Homes Standard consultation, which was published in late 2023, meaning it was not directly reflected in DFES 2023 modelling.

Onshore wind

Summary

- Home to some of the UK's first wind farms, the South West licence area currently hosts 338 MW of distribution network connected onshore wind capacity. Around half of this capacity connected before 2012, including some under the Feed in Tariff (FiT) scheme.
- There is substantial onshore wind resource in the South West, with areas of high wind speeds and suitable land. However, deployment has been heavily restricted for many years, due an unsupportive planning policy regime in England, which was in force between 2015 and 2024.
- In July 2024, the incoming UK government revised onshore wind planning policy, as set out in the 'Policy statement on onshore wind', removing this barrier to deployment in the national planning policy framework.[39] While the full effect of this reform is yet to be seen in the pipeline of in-development onshore wind projects in England, the impact of this policy change has been reflected in an increase to the lower bounds of the DFES projections for onshore wind, relative to previous years' analysis.
- There are 18 sites with an accepted connection offer in the licence area, totalling 154 MW. Four of these sites, over 80 MW in total, have applied for or received planning permission and are modelled to build out before 2030 in all scenarios. The remaining, less well evidenced sites are assumed to build by 2030 in only the most ambitious scenario, **Electric Engagement.**
- Engagement with the onshore wind sector has confirmed that development of new onshore wind capacity is expected to be limited before 2029. Long connection queues and uncertainty around the impact of aforementioned planning reforms are cited as remaining barriers to near-term deployment.
- A renewed deployment of new onshore wind sites is projected in all scenarios post-2029. The repowering of existing sites at the end of their operational life at increased capacities also contributes to continued growth through the 2040s.
- This results in 1.6 GW deployed across the licence area by 2050 under the most ambitious scenario, **Electric Engagement**, with 800 MW deployed under the same timeframe in the least ambitious scenario, the **Counterfactual**.



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Modelling assumptions and results

Baseline and pipeline

Source: NGED connections data

	Development status	Capacity (MW)	Description
Baseline	Operational	338	83% of installed onshore wind capacity in the South West comes from 36 sites that are 1 MW or greater. Cornwall hosts 14 of these larger-scale sites, totalling 114 MW. The largest site in the licence area is the 66 MW Fullabrook Windfarm in North Devon. The vast majority of the baseline was constructed between 2010 and 2015 though support schemes such as the Feed-in Tariff and Renewables Obligation. Subsequently, a restrictive English planning regime has meant that just 19 MW of installed capacity, across nine sites, has been installed in the South West since 2017.
Pipeline	Planning permission granted	60	Three 20 MW onshore wind sites have secured planning permission in the licence area. These are modelled to deploy in 2025 in **Electric Engagement** and **Holistic Transition**, with delays to 2026/7 and 2028/9 modelled in **Hydrogen Evolution** and the **Counterfactual** respectively.
	Planning application submitted	23	The Bears Down windfarm is a proposed repowering of an existing windfarm in Cornwall. It is modelled to build out in all scenarios, specifically in 2028 in **Electric Engagement,** and in 2032 in the **Counterfactual** scenario.
	Pre-planning	11	Scoping opinion requests have been submitted for a 10 MW extension to the Imerys Wind site in Cornwall and a 900 kW repowering of an existing turbine, also in Cornwall. These are modelled to deploy in 2027 and 2030 under **Electric Engagement** and **Holistic Transition**, respectively.
	No information	93	Twelve sites of varying scales from 80 kW to 30 MW have accepted connection offers, but no evidence of progressing though the planning system. These are modelled to buildout only under **Electric Engagement**, between 2025 and 2030.

Projections

Scenario	Description
Holistic Transition	The modelling under this scenario assumes a renewed deployment of onshore wind in the licence area through the 2030s and 2040s. Existing sites larger than 5 MW are also modelled to repower with an additional 40% capacity, reflecting more efficient and larger turbines when these sites reach the end of their operational life. This results in an additional 181 MW of capacity in the licence area by 2050.

	This scenario sees significant overall growth in installed capacity, with nearly 1.3 GW deployed by 2050.
Electric Engagement	The modelling under this scenario assumes a renewed deployment of onshore wind in the licence area through the 2030s and 2040s. Existing sites larger than 5 MW are also modelled to repower with an additional 50% capacity due to more efficient and larger turbines at the end of their operational lifetimes. This results in an additional 202 MW of capacity in the licence area by 2050. This scenario sees the largest growth in onshore wind capacity, with just under 1.6 GW deployed by 2050 – five times the existing baseline
Hydrogen Evolution	This scenario sees a greater focus on transmission network-connected electricity generation to achieve net zero targets, resulting in limited onshore wind deployment on the distribution network. Despite this, a renewed deployment of new onshore wind sites is projected post-2029 due to an improved planning environment. Repowering of baseline sites with an additional 25% capacity results in an additional 101 MW connecting at these sites in the 2030s and 2040s. By 2050, just over 1 GW of onshore wind capacity is deployed in the licence area under this scenario.
Counterfactual	As the least ambitious scenario, the **Counterfactual** has the least amount of growth in onshore wind capacity. However, due to the improved planning environment, a renewed deployment of onshore wind still is considered in the licence area, resulting in 750 MW deployed by 2050, over double the current baseline.

Uptake modelling factors

The below factors are used to inform the overall uptake of onshore wind in the South West licence area.

Factor	Modelling impact	Source
Accepted connection offer	The number, location and capacity of projects currently with a connection offer in the licence area form the basis of near-term projections.	NGED connections data
Technical limits offers	Where a project has accepted a technical limit offer with NGED, this anticipated energisation date is used as the minimum year of connection for that project under any scenario.	NGED connections data
Statement of Works transmission reinforcement timelines	Where a project is impacted by a transmission-level Statement of Works, the anticipated completion year this is used as the minimum year of connection for that project under the **Counterfactual**.	NGED connections data

Planning progress	The status of a project within local, regional and/or national planning processes, alongside the results of CfD auctions, is used to inform when a project is modelled to connect and under which scenarios.	Local authority planning platforms, CfD auction results.
Repowering assumptions	Baseline sites over 5 MW are modelled to repower at the end of their operational life with additional capacity in all scenarios. This is modelled as 50% in **Electric Engagement**, 40% in **Holistic Transition**, and 25% in **Hydrogen Evolution** and the **Counterfactual**.	Network connections data, desktop research

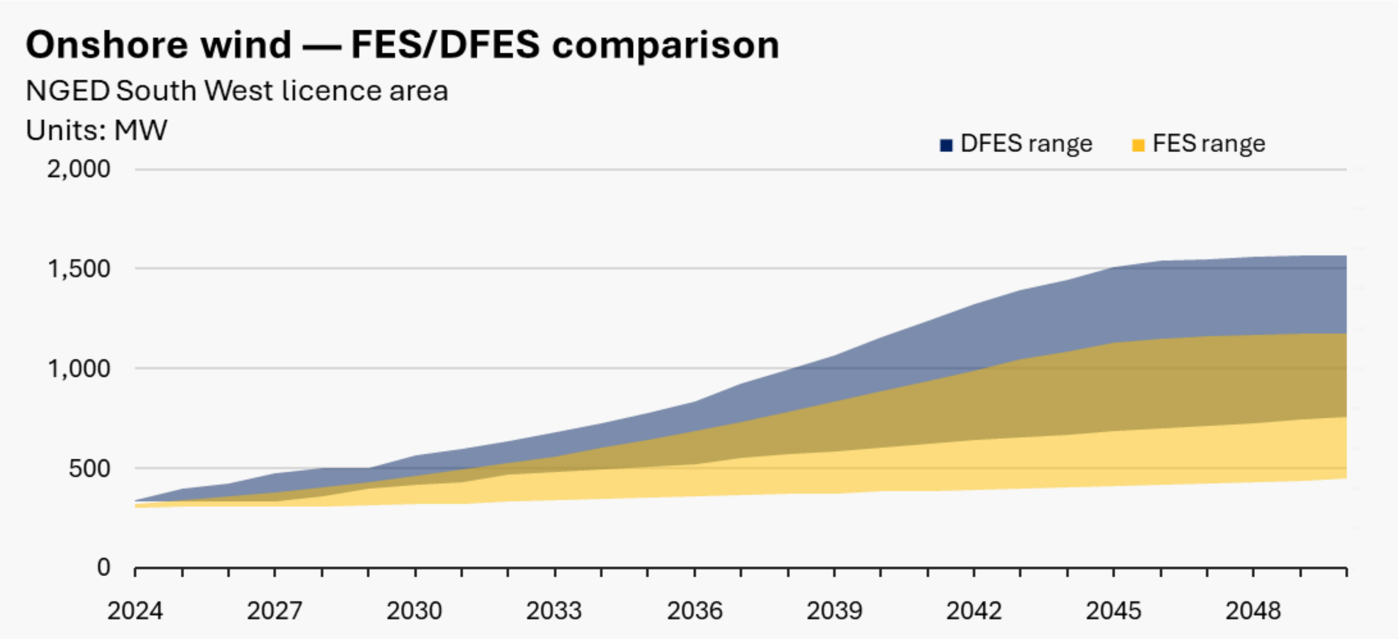
Spatial factors

The below factors are used to inform the spatial distribution of onshore wind capacity across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Wind resource assessment	Regen's in-house resource assessment, taking into consideration wind resource, land availability and planning constraints in the licence area, is used to inform the distribution of post-pipeline capacity.	Numerical Objective Analysis of Boundary Layer (NOABL) wind speed data, Natural England, OS Addressbase
Local ambition factors	Local ambition, including the local authority policy landscape and commitment to renewable energy and net zero goals, is reflected in the distribution of post-pipeline capacity. Explicitly stated local targets for wind power (through LAEPs or otherwise) inform the distribution of post-pipeline capacity. DFES projections are checked against these targets to ensure they are captured within the envelope of scenarios where applicable.	Climate Score Cards, DFES local authority energy strategy survey, LAEPs

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.



- The reported baseline of 308 MW in FES 2024 aligns relatively closely with the 338 MW reported in DFES 2024.
- Relative to FES 2024, DFES 2024 projects higher near-term deployment of new onshore wind to 2030. The DFES near term projections are based on existing sites with accepted connection offers and evidence around progress through planning for individual projects.
- Under the more ambitious scenarios, **Electric Engagement** and **Holistic Transition**, DFES 2024 projects more long-term capacity deployment than FES 2024. This is likely due to the consideration of repowering at existing sites, adding significant capacity in the 2030s and 2040s. The DFES also reflects the strong wind resource and land availability in the South West licence area.
- The less ambitious DFES scenarios, **Hydrogen Evolution** and the **Counterfactual**, both project higher long-term growth than the FES 2024 equivalents. This is due to the reflection of recent onshore wind planning reform in the DFES 2024 modelling. The FES 2024 was published prior to the announcement of this reform.

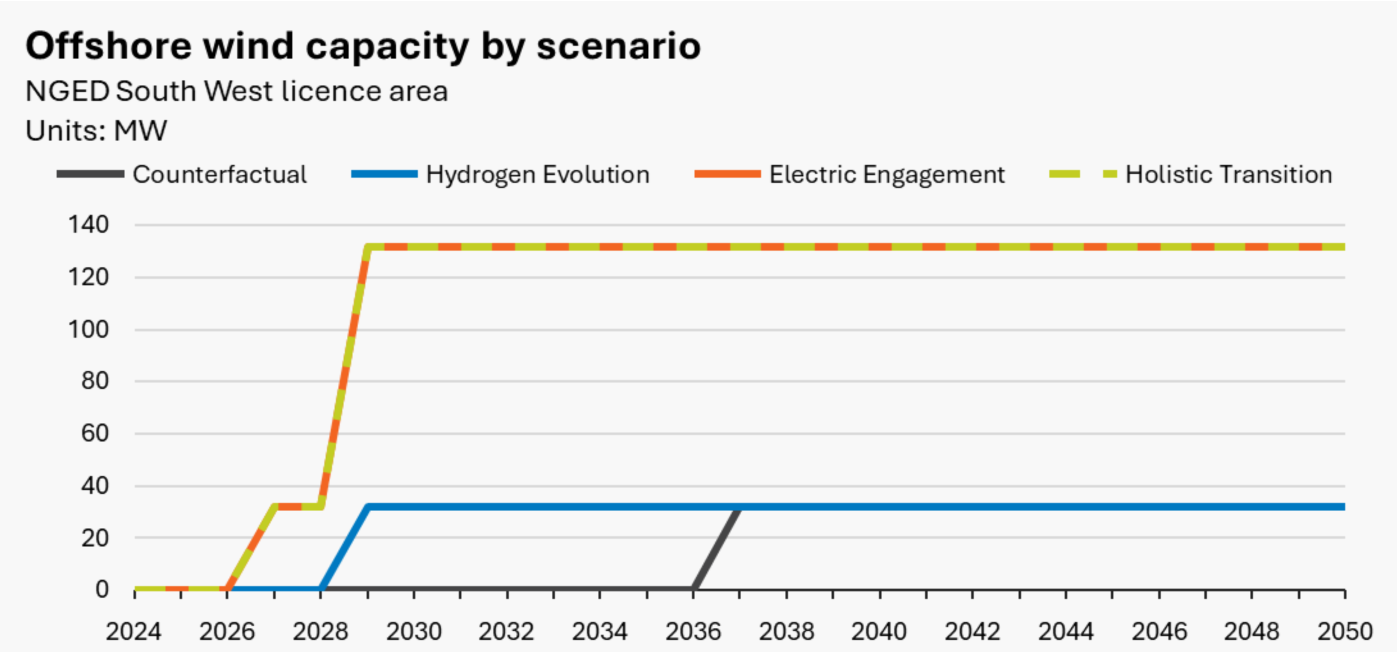
Comparison to DFES 2023

- There is close alignment between the most ambitious **Electric Engagement** scenario and the most ambitious scenario within DFES 2023.
- The **Holistic Transition** scenario has approximately 100 MW less pre-2030 growth in connected capacity relative to its equivalent scenario within DFES 2023. This is due to updated planning evidence. Post-2030 growth rates are well aligned, so this difference is maintained out to 2050.
- The less ambitious DFES scenarios, **Hydrogen Evolution** and the **Counterfactual**, both project higher long-term growth than the DFES 2023's less ambitious scenarios. This is due to the reflection of recent onshore wind planning reform in the DFES 2024 modelling.

Offshore wind

Summary

- There are no operational offshore wind projects in the South West licence area. However, there is an active pipeline of floating offshore wind projects at both distribution and transmission network level.
- Two floating offshore wind projects, the 32 MW TwinHub project and the 100 MW White Cross wind farm, have secured connection offers and offshore leases from The Crown Estate. TwinHub has also secured a CfD from the government in Allocation Round 4 for delivery in 2026/27.[40]
- Beyond this known pipeline, additional floating offshore wind projects are expected to connect at the transmission level in the licence area.
- Under the net zero scenarios, distributed offshore wind is expected to have slower deployment than onshore renewables as offshore wind requires more complex construction. By 2050, 132 MW of offshore wind is modelled under **Holistic Transition** and **Electric Engagement**, all connected before 2030. **Hydrogen Evolution** and the **Counterfactual** assume less offshore wind is required on the distribution network due to a greater focus on thermal generation, only modelling 32 MW to connect by 2050.



Modelling assumptions and results

Baseline and pipeline

Source: NGED connections data

	Development status	Capacity (MW)	Description
Baseline	Operational	n/a	There are no operational offshore wind projects connected to the distribution network in the South West licence area.

Pipeline	Granted planning permission	32	The TwinHub demonstration project, at the former WaveHub site off the coast of Hayle in Cornwall, secured a CfD as part of Allocation Round 4, for which the contractual arrangement begins in 2026/27. This project is modelled to connect under this timeline in **Holistic Transition** and **Electric Engagement**, but is slightly delayed in **Hydrogen Evolution** and the **Counterfactual**. This is based on industry engagement around a challenging environment for offshore wind due to delays in spatial planning, grid connections and supply chain constraints.
	Submitted planning application	100	The White Cross test and demonstration offshore wind farm submitted its marine licence and consent application to the Marine Management Organisation in 2023. It is aiming to connect in the mid-2020s, dependent on securing a CfD in a future Allocation Round. The project has, therefore, been modelled to connect in 2029 in **Holistic Transition** and **Electric Engagement**, but does not move through to development in **Hydrogen Evolution** and the **Counterfactual** scenario. This is based on industry engagement around a challenging environment for offshore wind due to delays in spatial planning, grid connections and supply chain constraints.

Uptake modelling and spatial distribution factors

The below factors are used to inform the overall uptake and spatial distribution of offshore wind in the South West licence area.

Factor	Modelling impact	Source
Existing baseline sites	The projections are based solely on the known operational sites.	NGED connections data

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.

- FES 2024 projects no distribution-connected offshore wind capacity in the South West licence area under any scenario.
- The DFES projections are based on known projects with accepted connection offers, clear evidence of development and engagement with the floating offshore wind sector in the South West.

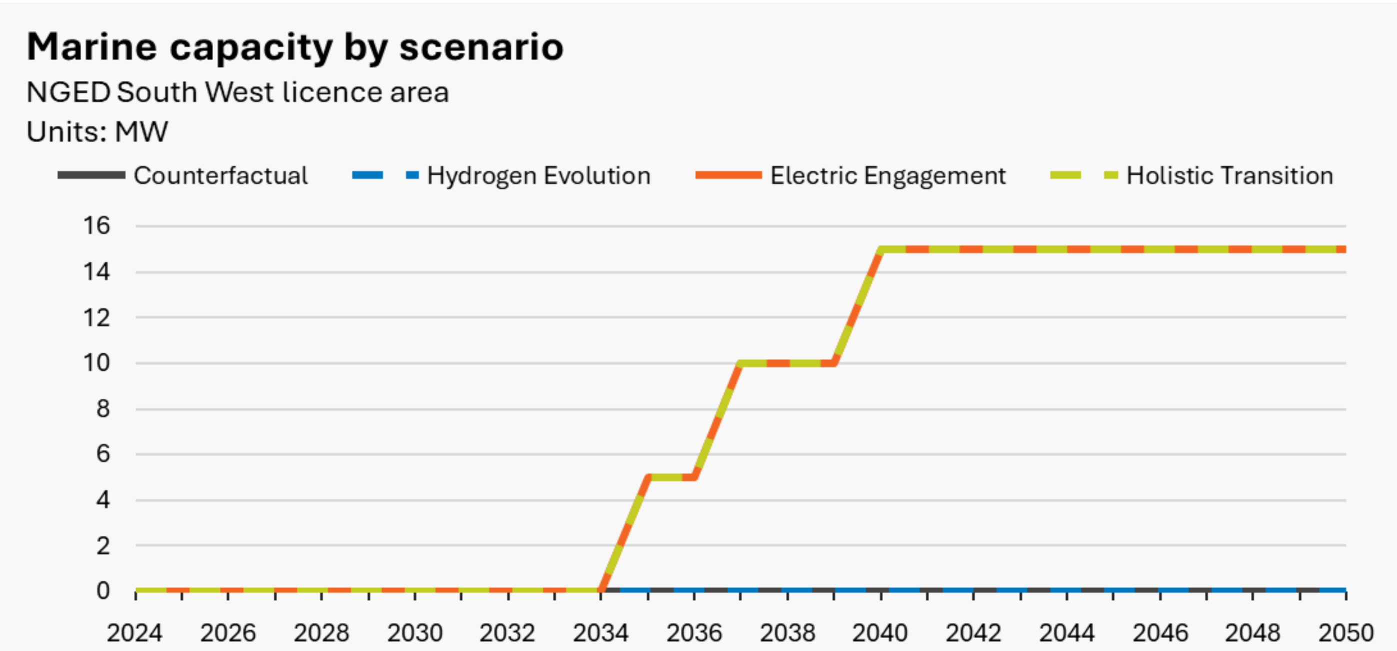
Comparison to DFES 2023

- The DFES 2024 projections are slightly below the DFES 2023 projections, due to the removal of a modelled extension at the TwinHub site. Based on latest industry engagement, this is not considered likely as floating offshore projects are increasing in size, focused on gigawatt-scale developments on the transmission network.

Marine

Summary

- This analysis covers the technologies of wave energy, tidal stream and tidal range, however, tidal range projects are expected to exclusively connect to the transmission network.
- There are no operational grid-connected marine energy projects in the South West licence area.
- In the early 2010s, the South West developed a number of wave and tidal demonstration sites, including Wave Hub in Hayle, Cornwall. However, a lack of government funding resulted in stalled deployment of these technologies, beyond testing.
- The Cornwall Council-owned Wave Hub site has now been sold to the floating offshore wind developer Hexicon and is home to the TwinHub floating offshore wind demonstrator, planned to come online in 2026/27.
- No future wave capacity is modelled to connect in the licence area, under any scenario, due to a lack of clear routes to market, as well as test and demonstration sites being focused in northern Scotland.
- 15 MW of tidal stream capacity has been modelled to connect in the North Devon Demonstration zone under **Holistic Transition** and **Electric Engagement**. While there are no projects being developed in the area yet, it has been identified as an area of significant tidal stream resource. The success of tidal projects in West and Scotland securing CfDs in recent Allocation Rounds has boosted industry confidence and accelerated the development timeline of tidal stream technology.[41]



Modelling assumptions and results

Baseline and pipeline

	Development status	Capacity (MW)	Description
Baseline	Operational	n/a	There are no operational marine energy projects connected to the distribution network in the South West licence area.
Pipeline	In development	n/a	There are no marine energy projects with an accepted connection offer with NGED in the South West licence area.

Projections

Scenario	Description
Holistic Transition **Electric Engagement**	While there are no tidal stream projects in the connection pipeline, the North Devon Tidal Demonstration Zone off the coast of Lynmouth was previously identified as having potential for tidal stream projects. 15 MW of tidal stream capacity has been modelled to connect by 2050 under **Holistic Transition** and **Electric Engagement**, as three 5 MW phased developments, between 2035 and 2040. With the Wave Hub site being repurposed for the TwinHub floating offshore wind demonstration project, there are no utility-scale wave projects in development in the South West licence area. Engagement with developers and sector representatives did not identify any prospective wave energy projects off the coast of the South West licence area, despite good wave energy resource. No wave energy capacity has been modelled to connect under any scenario. Engagement with developers also highlighted the potential for tidal and wave energy deployment off the Isles of Scilly. This is currently not reflected under any of the scenarios due to the early stage of development for this resource and uncertainty over whether this would be connected to the NGED distribution network on the island.
Hydrogen Evolution **Counterfactual**	No future marine energy capacity is modelled to connect to the distribution network in the South West licence area under **Hydrogen Evolution** or the **Counterfactual**. These scenarios represent a lower drive for decarbonisation and emerging or distributed sources of renewable electricity generation, such as marine technologies.

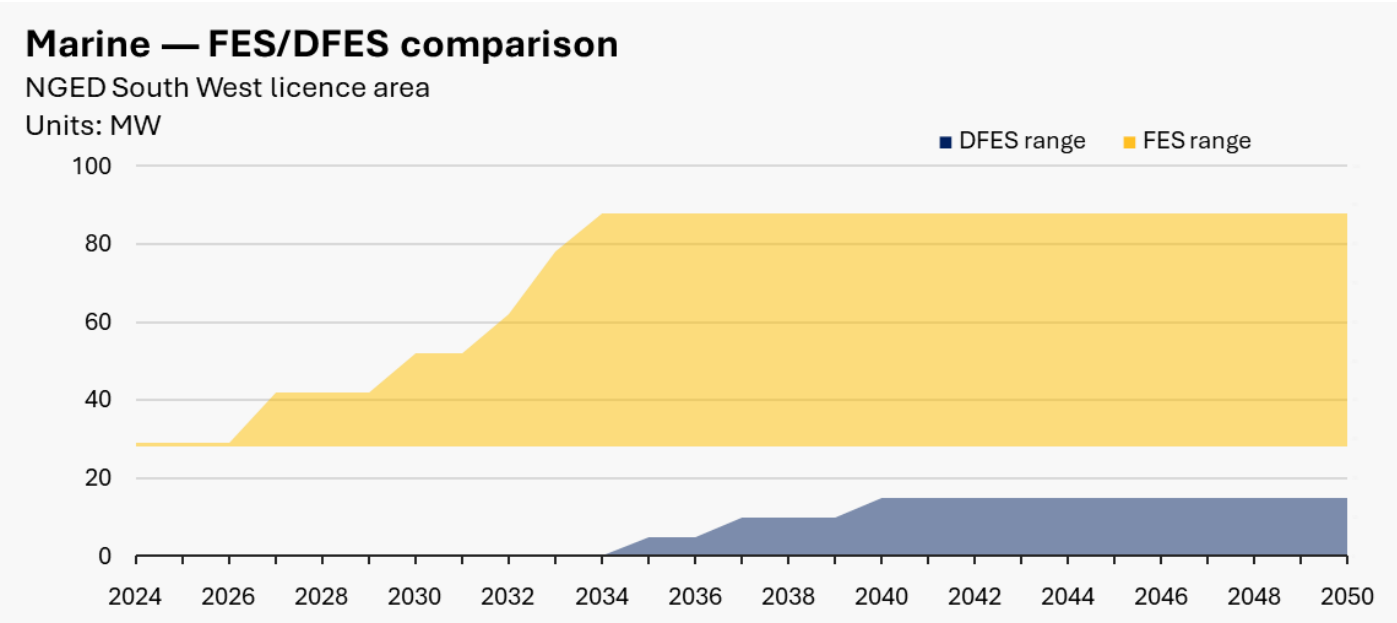
Uptake modelling and spatial distribution factors

The below factors are used to inform the overall uptake and spatial distribution of marine energy capacity across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Locations of potential future sites	The overall uptake and spatial distribution of future capacity are wholly modelled based on the location of potential future sites identified through desk research and extensive developer engagement.	Desk research, developer engagement, engagement with sector representatives

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.



- The DFES projections are lower than the FES in all scenarios. This is due to the FES modelling 28 MW of operational marine energy capacity in the licence area, likely to be the previous Wave Hub site in Cornwall. This site holds a grid connection agreement with NGED, but this will be used to host a floating offshore wind project, which has been reflected in DFES modelling.
- Beyond the baseline, the FES models an additional 60 MW of distributed marine energy capacity in the South West. Other than potential tidal stream development off the coast of Lynmouth in North Devon, engagement with regional sector representatives did not identify any further potential marine energy projects that could connect to the distribution network in the South West licence area. In general, developer focus has shifted strongly towards floating offshore wind.

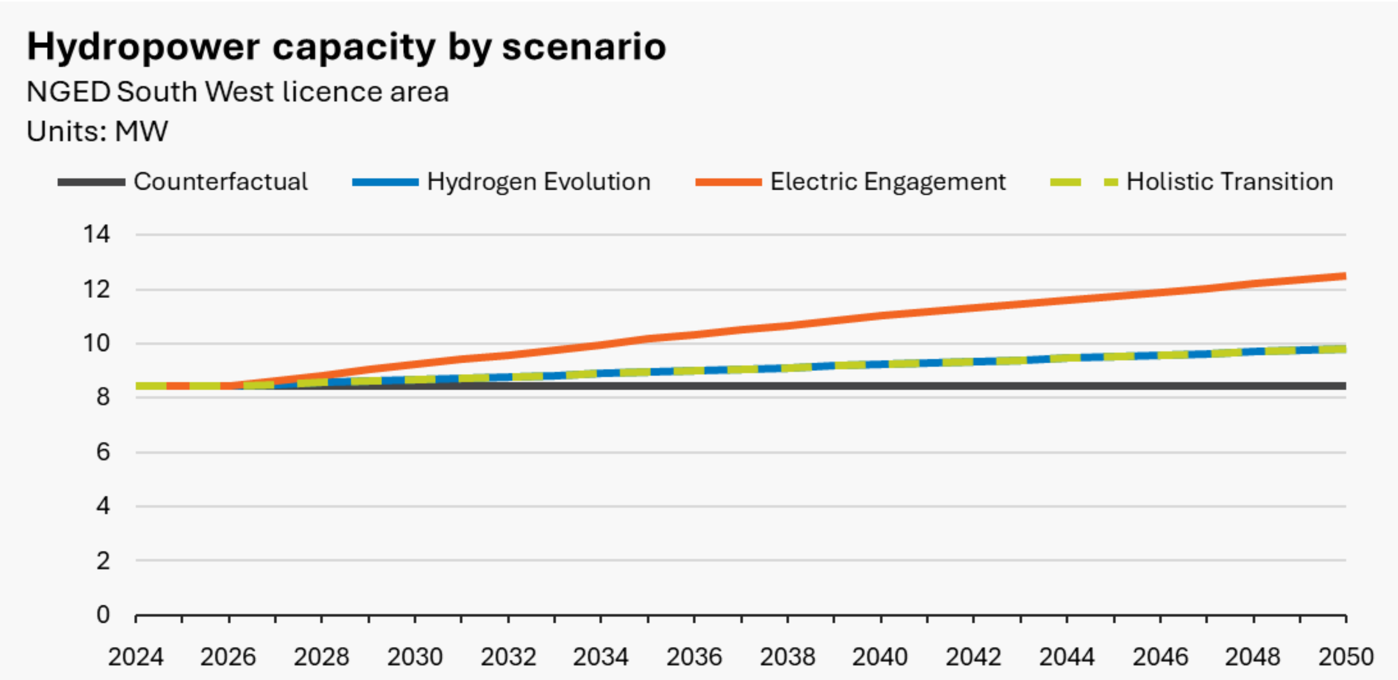
Comparison to DFES 2023

- The outcomes and modelling methods for marine energy are similar between DFES 2023 and DFES 2024. However, the DFES 2024 has 10 MW additional capacity projected in the North Devon Demonstration Zone than was considered in DFES 2023. This is based on industry engagement and continued industry confidence, off the back of multiple successful CfD rounds.

Hydropower

Summary

- While the South West licence area does not contain the topography for large-scale hydropower generation, there are a number of operational small-scale hydropower sites around elevated areas such as Dartmoor, totalling 8.5 MW.
- Following the closure of the FiT scheme in 2019, deployment of small-scale hydropower has stalled. There are currently no hydropower pipeline sites in the South West licence area.
- Due to this lack of subsidy support and increased abstraction licencing costs, the deployment of new hydropower is limited the licence area under all scenarios out to 2050.[42] Some additional capacity is modelled to connect in the licence area, representing existing sites repowering at a larger capacity, thought to be between 10% and as much as 30% of current installed capacity.[43]
- The scenario with the highest deployment, **Electric Engagement**, sees an additional 4.1 MW of hydropower modelled to connect, reaching 12.5 MW by 2050.
- Due to a lower drive for decarbonisation and distributed sources of renewable electricity generation, such as hydropower, the **Counterfactual** does not project any additional capacity by 2050.



Modelling assumptions and results

Baseline and pipeline

Source: NGED connections data

	Development status	Capacity (MW)	Description
Baseline	Operational	8.5	Over half of the hydropower capacity in the licence area (4.8 MW from four sites) is at reservoirs and water treatments owned by South West Water. The majority of this capacity connected to the distribution network in the 1990s or earlier, including Mavy Tavy Power Station in Devon, which is one of the oldest hydro sites in the UK, commissioned in the 1930s. The remaining capacity was almost entirely developed through the financial support of the FiT scheme in the 2010s. These small-scale sites are located across Devon, Cornwall and Somerset.

Projections

- Hydropower deployment in the South West has stalled in recent years, with no projects in the pipeline. High abstraction licence costs in England and a lack of subsidy support result in limited deployment of hydropower in the licence area, across all scenarios.

Scenario	Description
Holistic Transition	1.4 MW of additional capacity is modelled to connect under this scenario, reflecting the repowering of existing sites with up to 15% extra capacity.
Electric Engagement	**Electric Engagement** represents a focus on distributed sources of renewable energy technologies, such as hydropower. Therefore, an additional 4.1 MW is modelled to connect by 2050, reflecting the repowering of existing sites with up to 30% extra capacity and new capacity at other developable locations with an appropriate head difference for hydropower deployment.
Hydrogen Evolution	Only 1.4 MW of additional capacity is modelled to connect under this scenario, reflecting the repowering of existing sites with up to 15% extra capacity.
Counterfactual	Due to a lower drive for decarbonisation and distributed sources of renewable electricity generation, such as hydropower, the **Counterfactual** does not project any additional hydropower capacity in the licence area by 2050.

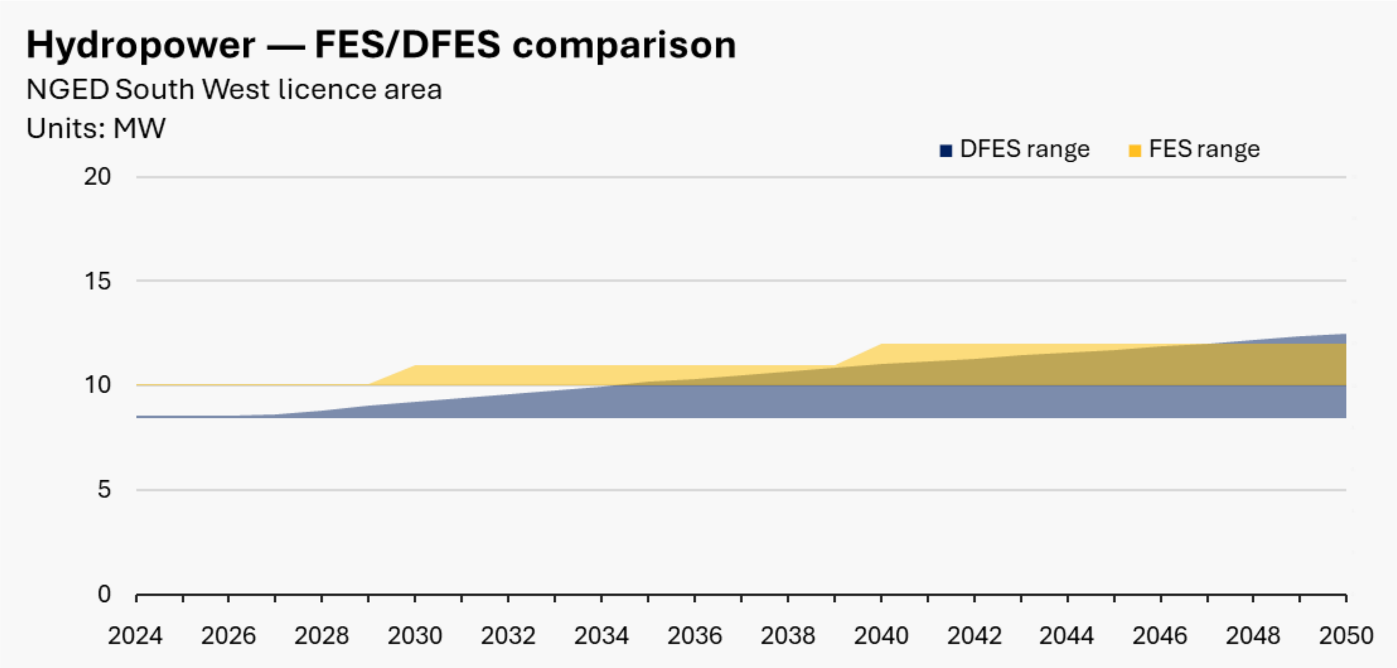
Uptake modelling and spatial distribution factors

The below factors are used to inform the overall uptake and spatial distribution of hydropower capacity across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Existing operational sites	Known hydropower projects in the licence area are used to inform the likelihood of future site capacity being developed. Where additional capacity is projected, this is distributed to existing sites to reflect future repowering and to represent watercourses with an appropriate head difference for hydropower deployment.	NGED connections data

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.



- The DFES and FES projections for hydropower in the South West are closely aligned, though the FES has a moderately higher baseline than the DFES. The FES baseline aligns with last year's DFES baseline, however, the capacity at certain sites has been updated since then.

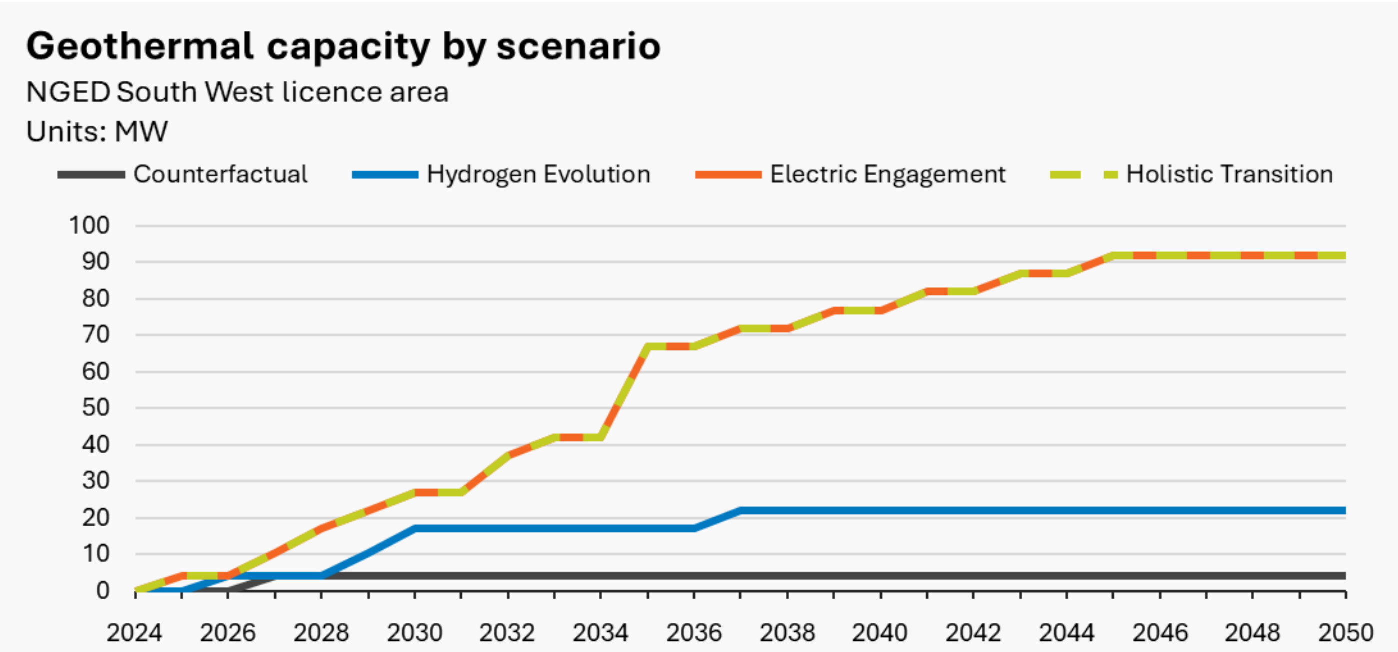
Comparison to DFES 2023

- The DFES 2024 baseline is slightly lower than the DFES 2023 baseline, due to updated data on the operational capacity of sites. The 2050 projections are well aligned overall, with **Electric Engagement** showing the largest increase in capacity to reach c. 13 MW by 2050.

Geothermal

Summary

- The South West is recognised by the British Geological Survey as one of the best places in the UK for deep geothermal electricity and heat generation, owing in particular to Cornwall and Devon's hot granitic bedrock, which brings geothermal resource closer to the surface than anywhere else in the UK.[44]
- A number of projects across the South West are already producing heat from geothermal, however, no electricity has been generated to date. Electricity generation from geothermal in the wider licence area could soon begin however, with the United Downs Deep Geothermal Power Project due to come online in 2024.
- There is a notable pipeline of geothermal projects in the South West, including a number of sites developed by Geothermal Engineering Ltd., which have received government support through the CfD scheme in Allocation Round 5.
- The business case for geothermal power has historically proved challenging, with projects facing high costs, long lead times and lengthy permitting processes. However, the recent success of projects under development near Redruth and St Austell has had a major impact on geothermal development and potential future deployment in the South West licence area. The scale of this future development remains uncertain, however.
- As a result of these factors, the scenario results for geothermal electricity generation in the South West represent a broad range of outcomes in both the near term and the long term, ranging from 4 MW by 2050 in the **Counterfactual** scenario, to 92 MW by 2050 in **Holistic Transition** and **Electric Engagement**.



Modelling assumptions and results

Baseline and pipeline

Source: NGED connections data

	Development status	Capacity (MW)	Description
Baseline	Operational	0	There are no geothermal sites currently producing electricity in the South West licence area. Whilst the United Downs site in Cornwall has drilled production wells and has completed the majority of testing, the commissioning of the power generation plant is not expected until the end of 2024.
Pipeline	Under Construction	4	The 4 MW United Downs site is expected to begin power generation at the end of 2024. This project was awarded a CfD in Allocation Round 5 for 2 MW to come online by 2026/27. The rest of the output is expected to be used to power a local hospital and housing development.[45] This is modelled to connect in all four scenarios, with staggered connection years modelling potential delays to operation.
	Granted planning permission	18	Two sites (6.5 MW each), developed by Geothermal Engineering Ltd., achieved planning permission in late 2023 and early 2024, respectively, and both won a Contract for Difference in Allocation Round 5. These projects, therefore, have target delivery years of 2027/28 and have been modelled to connect in all three net zero scenarios. They have not been modelled to connect under the **Counterfactual** due to a lower drive for decarbonisation and lower support for emerging technologies in this scenario. The Eden Project, near St Austell in Cornwall, is also developing geothermal heat and power generation. In 2023, the project started generating heat, becoming the UK's first operational deep geothermal project in 37 years.[46] It is now looking to secure investment to progress its second phase – producing electricity. This is currently affected by grid connection delays and is, therefore, only modelled to start producing electricity in the 2030s in the net zero scenarios.
	Submitted planning application	4.9	One further Geothermal Engineering Ltd. site (4.9 MW) submitted a planning application in January 2024. This site has been modelled to connect under **Holistic Transition** and **Electric Engagement** in the late 2020s as scenarios that reflect more development for emerging/novel renewable energy generation technologies. Reduced deployment of geothermal in **Hydrogen Evolution** and the **Counterfactual** means that this site is not modelled to connect under these scenarios.

Withdrawn planning application	13	Two additional Geothermal Engineering Ltd. sites withdrew planning applications. It is understood that this means Geothermal Engineering Ltd. are no longer progressing developments at these sites. Therefore, these have not been modelled to connect under any scenario.

Projections

- Beyond the current pipeline, developer engagement has suggested further geothermal projects could be developed in Cornwall and Devon.
- In the long term, deployment of geothermal heat and power capacity will depend on a viable business model. This could include private wire agreements with neighbouring industrial heat and power off-takers, ringfenced CfD funding for geothermal or the ability for geothermal power producers to obtain revenue from participating in markets such as the Capacity Market or commercial balancing and reserve services. Lithium extraction from geothermal brines could also provide an additional revenue stream for geothermal heat and power producers in the South West.[47]
- The high-level of uncertainty around these policy and business case considerations, alongside the need to secure planning permission and mineral rights at each site, result in a wide range of scenario outcomes for geothermal power out to 2050.

Scenario	Description
Holistic Transition **Electric Engagement**	All ten sites (totalling 65 MW) identified from developer engagement have been modelled to come online between 2030 and 2045. This includes a potential nine additional sites developed by Geothermal Engineering Ltd. across Cornwall, and a prospective geothermal site on the eastern edge of Dartmoor in Devon, being developed by Angus Energy.[48]
Hydrogen Evolution **Counterfactual**	No further geothermal sites beyond the known pipeline of development projects are modelled to connect in either the **Hydrogen Evolution** or the **Counterfactual** scenario. These scenarios represent a lower drive for decarbonisation and emerging or distributed sources of renewable electricity generation.

Uptake modelling factors

The below factors are used to inform the overall uptake of geothermal in the South West licence area.

Factor	Modelling impact	Source
Known pipeline of sites in development	The known pipeline of sites in development from NGED's connection database is used to inform near-term growth in geothermal capacity.	NGED connections data
Planning status	The connection timeline for known pipeline sites is modelled based on its planning status.	Local authority planning records

Government CfD awards	Sites that have received government support through the CfD scheme are modelled to connect by, or close to, their target delivery years.	CfD results
Developer engagement	Beyond the known pipeline of sites in NGED's connection database, developer engagement has been used to gather information on long-term development sites.	Various

Spatial factors

The below factors are used to inform the spatial distribution of geothermal capacity across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Pipeline sites	Sites already in the NGED connections pipeline or identified through developer engagement.	NGED connections data, developer engagement
Geothermal resource areas	The location of future geothermal sites is based on subsurface heat flows, with prospective geology around Penzance and Redruth.	British Geological Survey

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.

- There is no distribution-connected geothermal capacity in the South West licence area in FES 2024, despite the high-levels of project development underway in the region.
- The DFES projections have been modelled based on known projects and direct engagement with geothermal developers, specifying intentions to move towards producing and exporting electricity to the network, when grid connections are available.

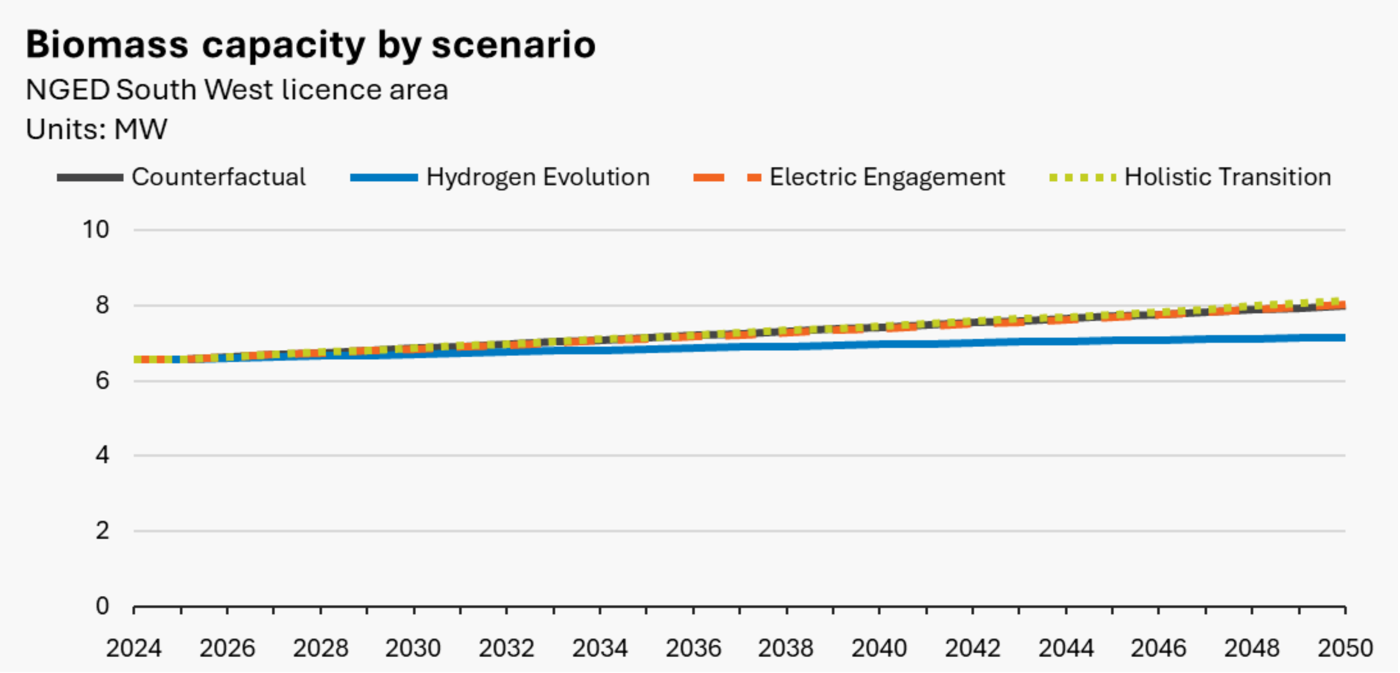
Comparison to DFES 2023

- The outcomes and modelling methods for geothermal are similar between DFES 2023 and DFES 2024. There is slightly less geothermal capacity projected in DFES 2024, compared to DFES 2023 (13 MW). This represents the two sites which have withdrawn their planning applications in 2024.
- In DFES 2024, **Holistic Transition** and **Electric Engagement** share very similar outcomes, whereas DFES 2023 had a wider range in projected capacity by 2050. This reflects changes in the FES 2024 framework, which has more directly aligned outcomes for geothermal generation across GB under these scenarios.

Biomass

Summary

- Biomass power generation in the South West consists entirely of small-scale sites of under 5 MWe. This includes sites providing Combined Heat and Power (CHP) at a china clay extraction and processing site, a business park and a supermarket distribution centre.
- Small-scale biomass CHP sees limited growth in all four scenarios as a means of decarbonising local heat and industrial energy. **Hydrogen Evolution** sees lower uptake compared to the other three scenarios due to the greater availability of hydrogen for CHP in this scenario.



Modelling assumptions and results

Baseline and pipeline

Source: NGED connections data

	Development status	Capacity (MW)	Description
Baseline	Operational	7	There are seven operational biomass baseline sites in the South West, which all appear to use biomass for CHP. This includes a 3 MWe Imerys kaolin clay extraction and processing site at Lee Moor and a 1.3 MWe supermarket distribution centre in Bristol.
Pipeline	n/a	0	There are no biomass pipeline sites with accepted connections in the South West licence area.

Projections

Scenario	Description
Holistic Transition Electric Engagement Hydrogen Evolution Counterfactual	None of the four scenarios see a major role for distribution connected biomass in heat decarbonisation. As shown by the lack of pipeline and minimal biomass generation deployment in the South West licence area to date, there is limited potential for growth in biomass generation capacity. However, there is still some deployment, particularly for heating at business parks and industrial sites. **Hydrogen Evolution** sees slightly uptake compared to the other three scenarios due to the greater availability of hydrogen for CHP in this scenario.

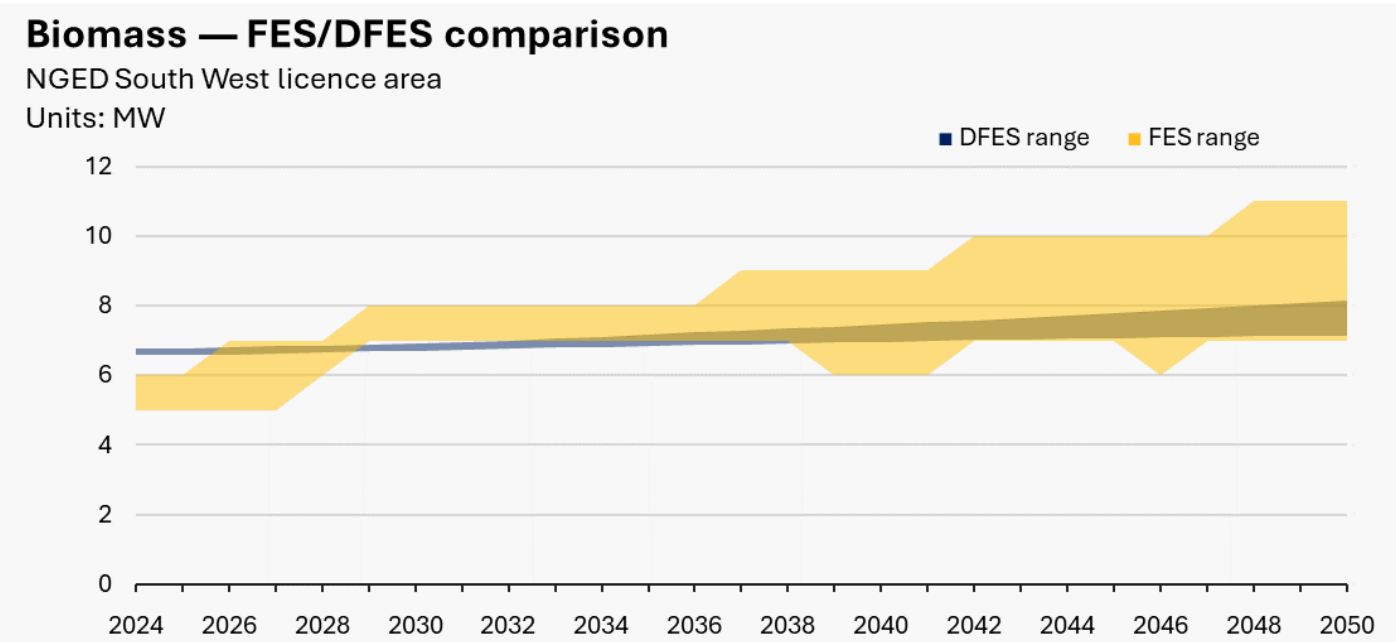
Uptake modelling and spatial distribution factors

The below factors are used to inform the overall uptake and spatial distribution of biomass capacity across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Existing baseline and pipeline sites	Alongside the existing baseline, growth in small-scale biomass CHP capacity is distributed to existing small-scale biomass connections.	NGED connections data

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.



- The DFES and FES baselines and scenario outcomes are closely aligned, albeit with the DFES having a slightly narrower capacity outcomes by 2050, reflecting limited biomass development.

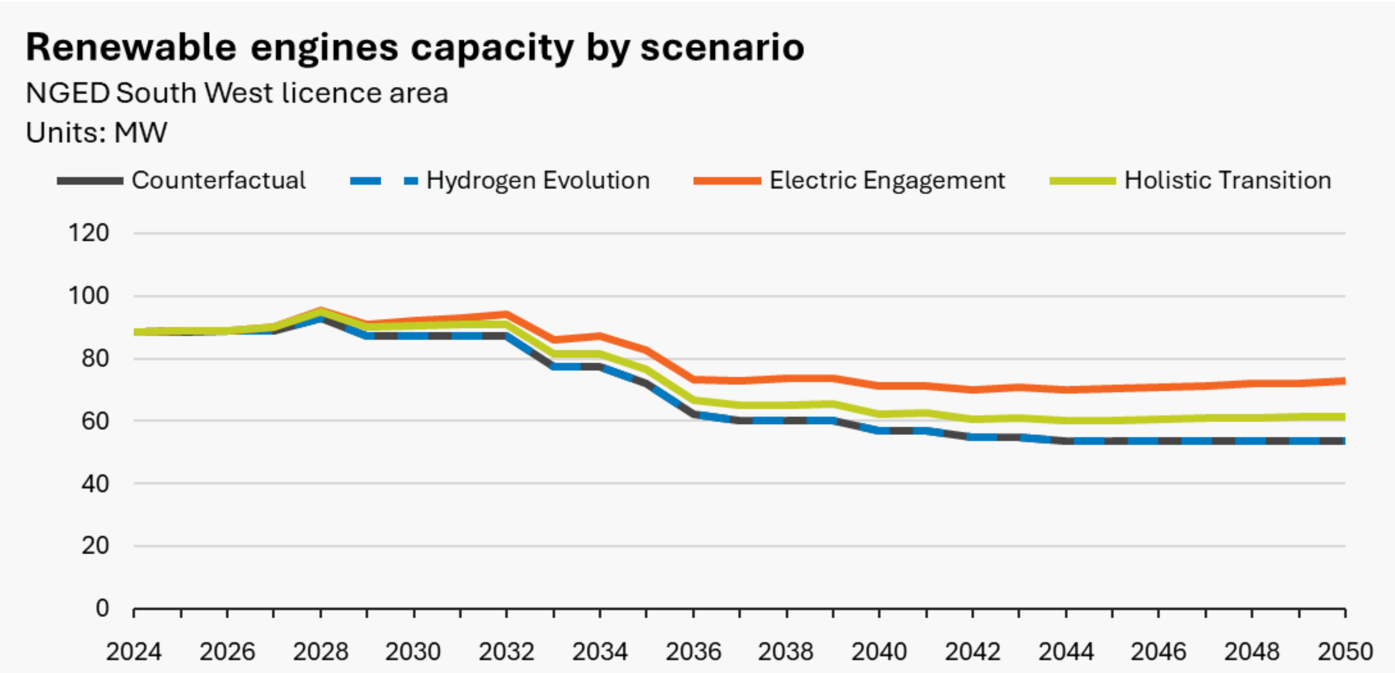
Comparison to DFES 2023

- The outcomes and modelling methods for biomass are similar between DFES 2023 and DFES 2024.

Renewable engines

Summary

- Renewable engines as a technology sector is divided into three types of sites: landfill gas, the anaerobic digestion of farm and food waste, and sewage gas at sewage treatment plants.
- Landfill gas, which makes up just under half of the baseline capacity in the South West, is modelled to decommission over time in every scenario, as the UK moves towards more sustainable waste treatment and an overall reduction in the volume of waste produced as a society.
- Anaerobic digestion, accounting for around one-fifth of the renewable engines baseline capacity, is projected to increase under the **Electric Engagement** and **Holistic Transition** scenarios. However, bioenergy resource is prioritised where possible in all scenarios for harder-to-decarbonise sectors such as industry, aviation and shipping, thereby limiting its role in electricity generation.
- Sewage gas, which makes up just under one-third of the baseline capacity, is assumed to remain relatively stable in all scenarios, with much of the sewage gas resource already being captured and used for electricity and CHP generation at sewage treatment works.
- Combining these trends results in an overall reduction in renewable engines capacity in the South West licence area, from 88 MW currently operational to between 74 MW in **Electric Engagement** and 54 MW in the **Hydrogen Evolution** and **Counterfactual** scenarios.



Modelling assumptions and results

Baseline and pipeline

Source: NGED connections data

	Development status	Capacity (MW)	Description
Baseline	Operational	88	The landfill gas baseline, totalling 39 MW across 15 sites, consists of sites near urban areas. Landfill gas generation capacity was mostly deployed in the licence area in the late 1990s and early 2000s. The majority of anaerobic digestion baseline sites, which total 17 MW across 22 sites, are individually less than 2 MW and typically located in rural parts of the licence area. The sewage gas baseline, totalling 32 MW across 18 sites, consists of generation at Wessex Water and South West Water sewage treatment works. The vast majority of these sites connected in the 1990s and 2000s, supported by the Renewables Obligation incentive scheme, with only one new sites connecting since 2011.
Pipeline	Accepted to connect	5.3	There are just three renewable engine projects in the pipeline, ranging from 0.5 MW to 4 MW. The largest of these sites, a 4 MW Wessex Water sewage gas site in Bristol, has been granted planning permission and is expected to take several years to construct. This project is projected to connect in 2028 in all scenarios. The remaining two pipeline sites are small-scale anaerobic digestion projects, at 0.4 MW and 0.5 MW. One site is already under construction and the other is an extension to an existing facility. As a result, both are modelled to connect in the coming year under all four scenarios.

Projections

Scenario	Description
Holistic Transition **Electric Engagement**	Landfill gas sites that are operational or in development are modelled to have an operational lifespan of 30 years under every scenario, after which point the site is decommissioned. This reflects desk research on landfill gas availability and output over the lifetime of a generation project. Sewage gas sites that are operational or in development are modelled to remain connected at a consistent capacity out to 2050 under every scenario, reflecting these assets being embedded within water industry sludge management and

Hydrogen Evolution	decarbonisation strategies. The lack of new projects being developed indicates there is low potential for growth in future sewage gas capacity but that existing sites have long operational lifespans and repowering of existing generators. Previous engagement with water companies suggested that further development of sewage gas resources would be focussed on on-site heat and power generation rather than exporting to the grid.
Counterfactual	The South West has a high potential for anaerobic digestion deployment due to the amount of farmland, particularly in the more rural parts of the licence area. Under **Electric Engagement** and **Holistic Transition**, anaerobic digestion sees a small amount of deployment throughout the scenario timeframe, whereas under **Hydrogen Evolution** and **Counterfactual** there is no further deployment beyond the pipeline. This results in a range of outcomes for renewable engines capacity in the licence area by 2050, from 54 MW under the **Counterfactual** and **Hydrogen Evolution** to 74 MW under **Electric Engagement**, compared to the 88 MW baseline.

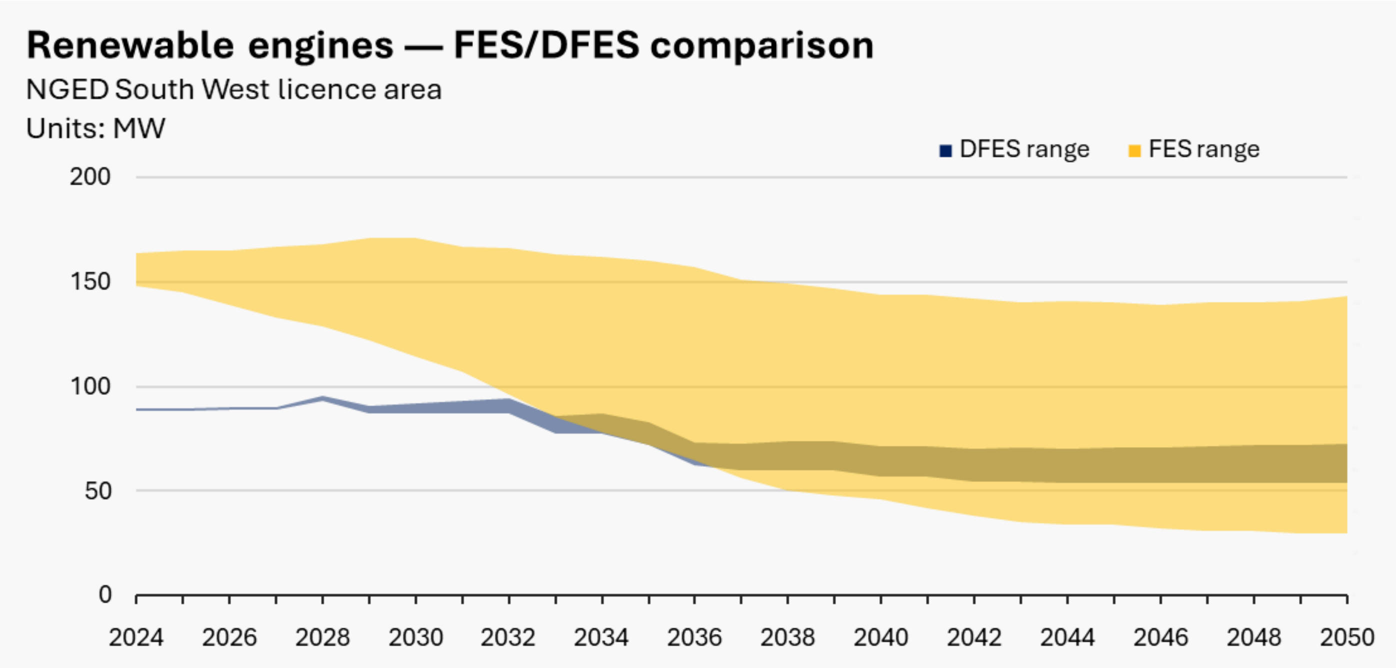
Uptake modelling and spatial distribution factors

The below factors are used to inform the overall uptake and spatial distribution of renewable engines capacity across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Existing baseline and pipeline sites	The baseline, pipeline and decommissioning are modelled directly on a site-by-site basis. Growth in anaerobic digestion capacity is distributed to existing anaerobic digestion sites.	NGED connections data

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.



- The FES and DFES baselines in the South West are not well aligned, with the FES baseline nearly double the DFES baseline. The reason for this is unclear, but could be related to differences in technology classifications.
- The majority of the renewable engines baseline in the South West is landfill gas and sewage gas, which share the same assumptions under all four scenarios in the DFES modelling. This results in the DFES outcomes presenting a much narrower range of possible outcomes than the FES, as the only variance between the four DFES scenarios is the level of anaerobic digestion capacity growth.
- The lack of pipeline for this technology and requirements for bioenergy in other harder-to-decarbonise sectors results in the projected growth in anaerobic digestion in the DFES not reflecting the amount projected in the higher FES scenarios.

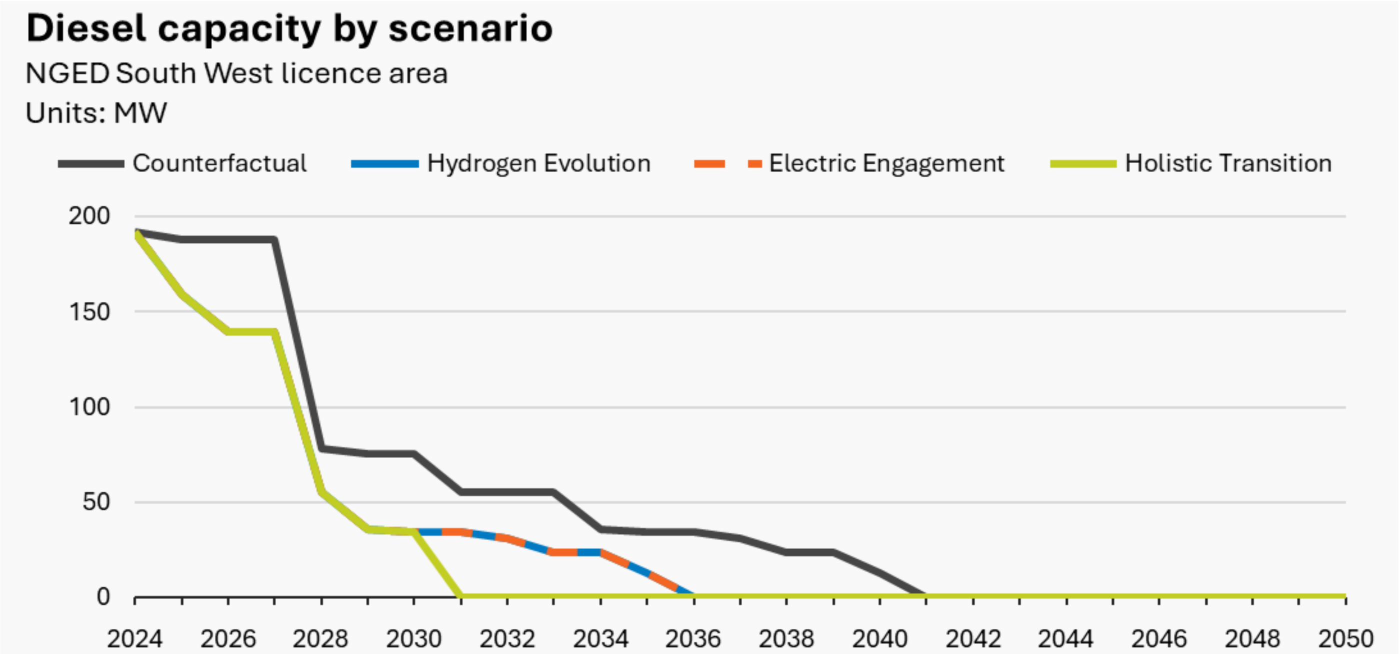
Comparison to DFES 2023

- The outcomes and modelling methods for renewable engines are similar between DFES 2023 and DFES 2024. The near-term growth in anaerobic digestion capacity under the three net zero scenarios has been reduced, reflecting the relatively small pipeline of developing projects.

Diesel-fired electricity generation

Summary

- As one of the most polluting forms of electricity generation, diesel electricity generation is being phased out across GB as generators respond to policies designed to minimise air pollution in the short term and meet carbon targets in the longer term. Overall diesel generation capacity has been decreasing across NGED's licence areas over the last few years.
- The operation of unabated diesel generation is at odds with net zero emissions targets and is restricted by the UK's implementation of the EU Medium Combustive Plant Directive (MCPD), which requires diesel generation plants with capacity over 5 MWth (c. 2 MWe) to adhere to stringent air quality limits unless they operate for 500 hours or fewer per year. Generators identified as being impacted by the MCPD are modelled to decommission after 2025 in all three net zero scenarios.
- Backup diesel generators are expected to remain connected to the network for longer under all scenarios, as they are unlikely to meet the MCPD threshold of 500 hours of operation. These backup generators are modelled to decommission later in the scenario timeframes, by 2031 under **Holistic Transition** and 2036 under **Electric Engagement** and **Hydrogen Evolution**.
- Under the **Counterfactual** scenario, commercial and backup diesel generation remains connected for longer, as progress towards low carbon flexibility and backup power solutions is slower.



Modelling assumptions and results

Baseline and pipeline

Source: NGED connections data

	Development status	Capacity (MW)	Description
Baseline	Operational (commercial)	53	Only three commercial diesel generation sites remain in the baseline, located near major population centres.

	Operational (backup)	139	The majority of sites and capacity in the licence area baseline has been classified as backup diesel generation. This includes capacity at quarries, docks, universities and water treatment works.
Pipeline	n/a	0	There are no diesel generation projects in the pipeline.

Projections

Scenario	Description
Holistic Transition **Electric Engagement** **Hydrogen Evolution**	The MCPD was passed into UK law in 2019. This requires plants with a thermal capacity of over 5 MWth (c. 2 MWe) to adhere to stringent air quality limits through environmental permitting, unless they operate for fewer than 500 hours per year. Unabated commercial diesel generation falls within this regulation and, therefore, will no longer be able to operate after 2025 without exhaust abatement technologies, such as catalytic reduction technology. The combination of high diesel prices and the cost of fitting exhaust abatement has made diesel generation financially unattractive. As a result of the MCPD, commercial diesel baseline sites are modelled to decommission by 2026 at the latest under all three net zero scenarios. Backup diesel generators are exempt from these environmental permit requirements, due to their limited operational hours. Additionally, backup generators are allowed to extend their annual operating hours to 1,000 hours if needed in an emergency. Engagement with major energy users also suggests that biodiesel such as hydrotreated vegetable oil (HVO) may be used as a transition fuel to decarbonise backup power generation. These backup generators are modelled to decommission later in the scenario timeframes, either at the end of their assumed operational life of 20 years or by 2031 at the latest under **Holistic Transition** and 2036 under **Electric Engagement** and **Hydrogen Evolution**. The technology that replaces these assets varies, depending on the scenario. This could be a form of bioenergy generator or an electricity storage technology.
Counterfactual	This scenario assumes less stringent emissions limits and less ambitious decarbonisation strategies for generators. Commercial diesel falling under the MCPD is not modelled to decommission until 2030, unless its operational life is reached before this point, and backup diesel remains connected into the 2040s.

Uptake modelling factors

The below factors are used to inform the overall uptake of diesel generation in the South West licence area.

Factor	Modelling impact	Source
Medium Combustion Plant Directive	The MCPD dictates the decommissioning timescales for commercial diesel plants, from 2026 under the net zero scenarios and 2031 under the **Counterfactual**.	Environment Agency DEFRA

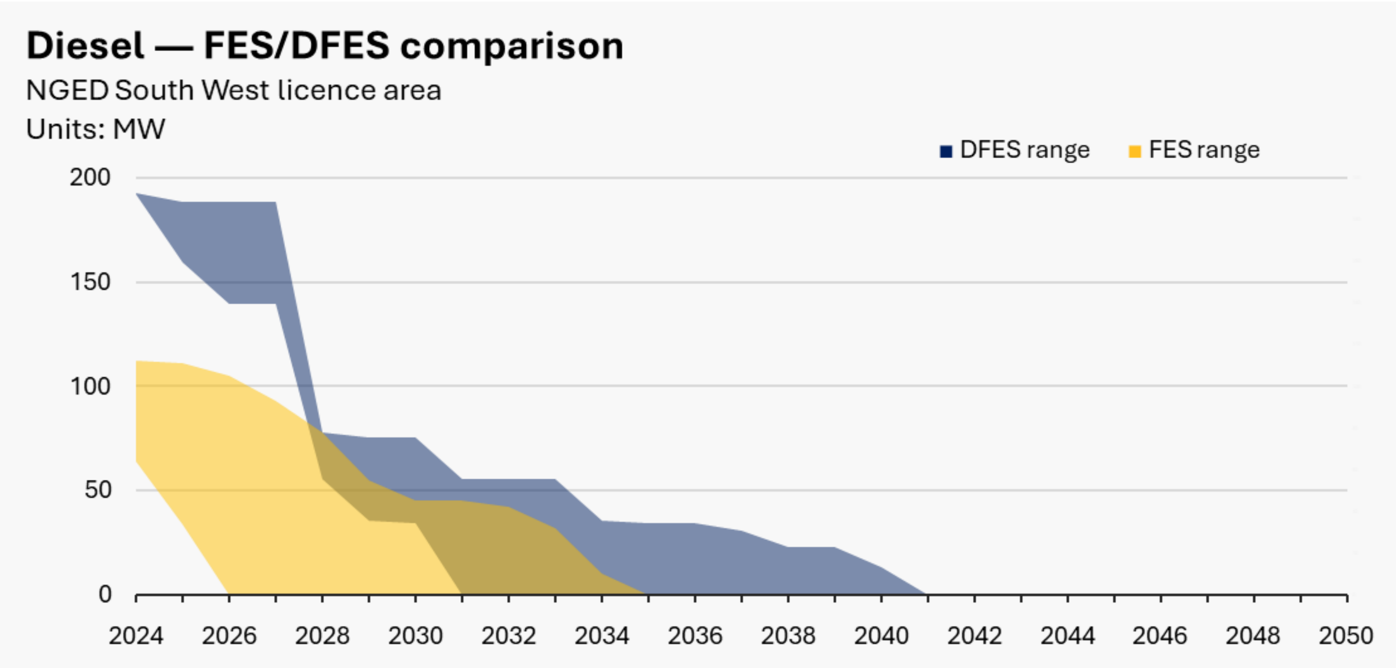
Spatial factors

The below factors are used to inform the spatial distribution of diesel generation capacity across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Existing baseline and pipeline sites	The DFES projections are modelled directly on a site-by-site basis.	NGED connections data

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.



- There is a considerable difference between the FES and DFES baseline for diesel. This may be due to the high proportion of backup diesel generation in the licence area, which is often more difficult to identify and categorise. In the DFES analysis, these sites have been individually assessed where possible. The FES and DFES baselines for diesel are well aligned. Note that the FES data has a variance between scenarios in 2024 due to the FES 2024 baseline year being 2023.
- The assumptions applied in the DFES modelling result in diesel generation decommissioning over a longer timescale than in the equivalent FES pathways. This is likely due to the explicit modelling of backup generation that is not anticipated to be impacted by the MCPD, as there is no clear driver for these sites to decommission in the short term.

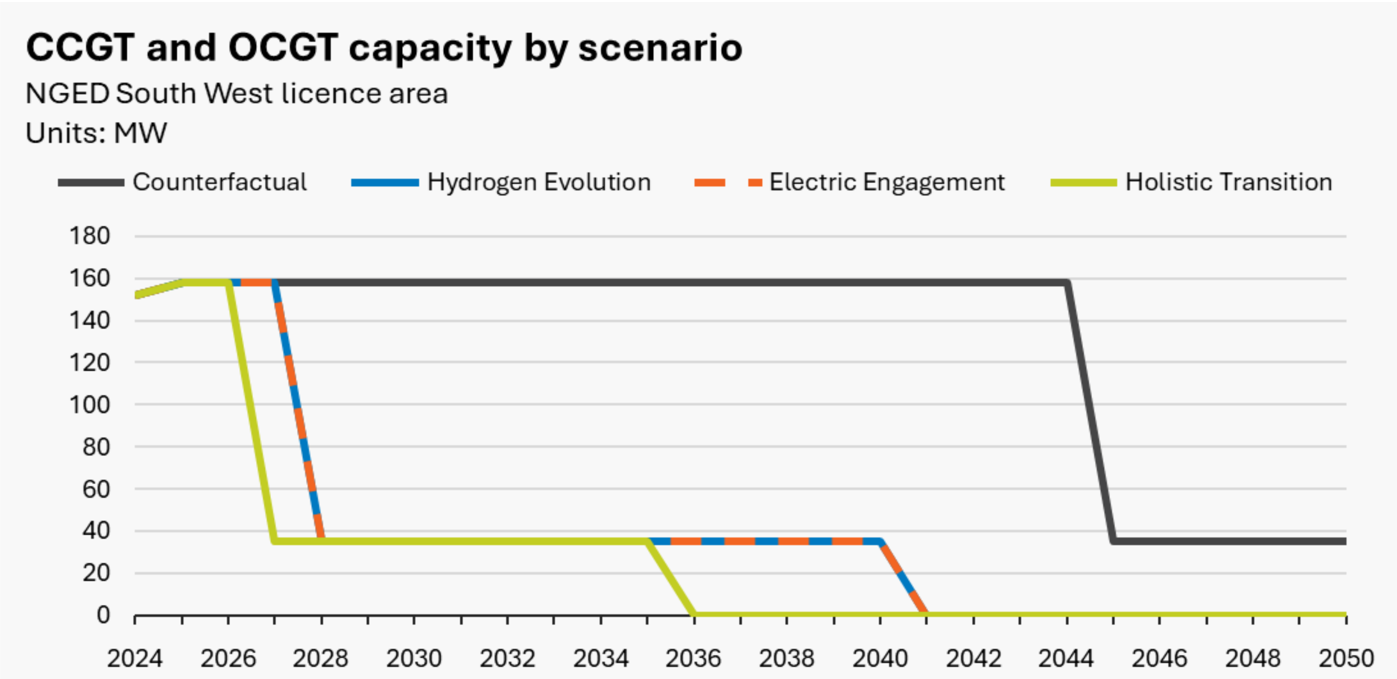
Comparison to DFES 2023

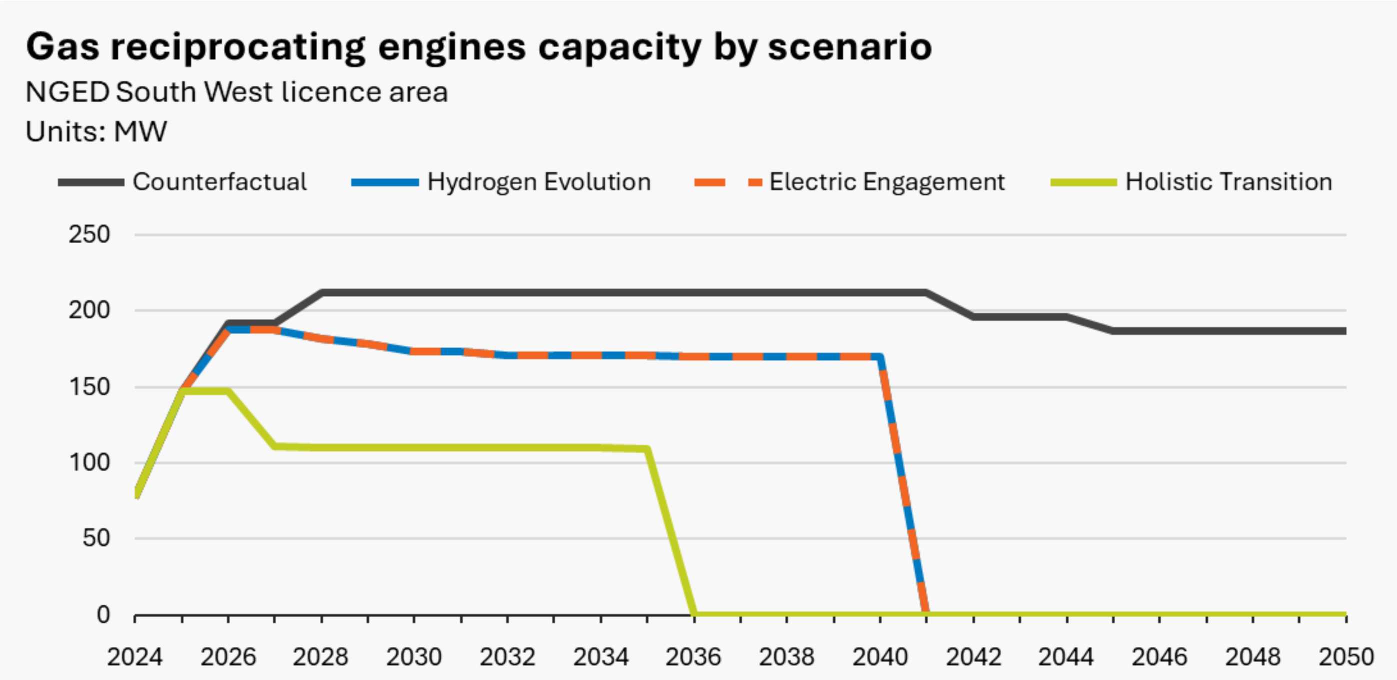
- The outcomes and modelling methods for diesel generation are similar between DFES 2023 and DFES 2024. However, backup diesel has been modelled to remain connected for longer into the medium term under all scenarios in DFES 2024, following desktop research and stakeholder engagement around the operational life of backup diesel plant and use of alternative fuels such as HVO/biodiesel.

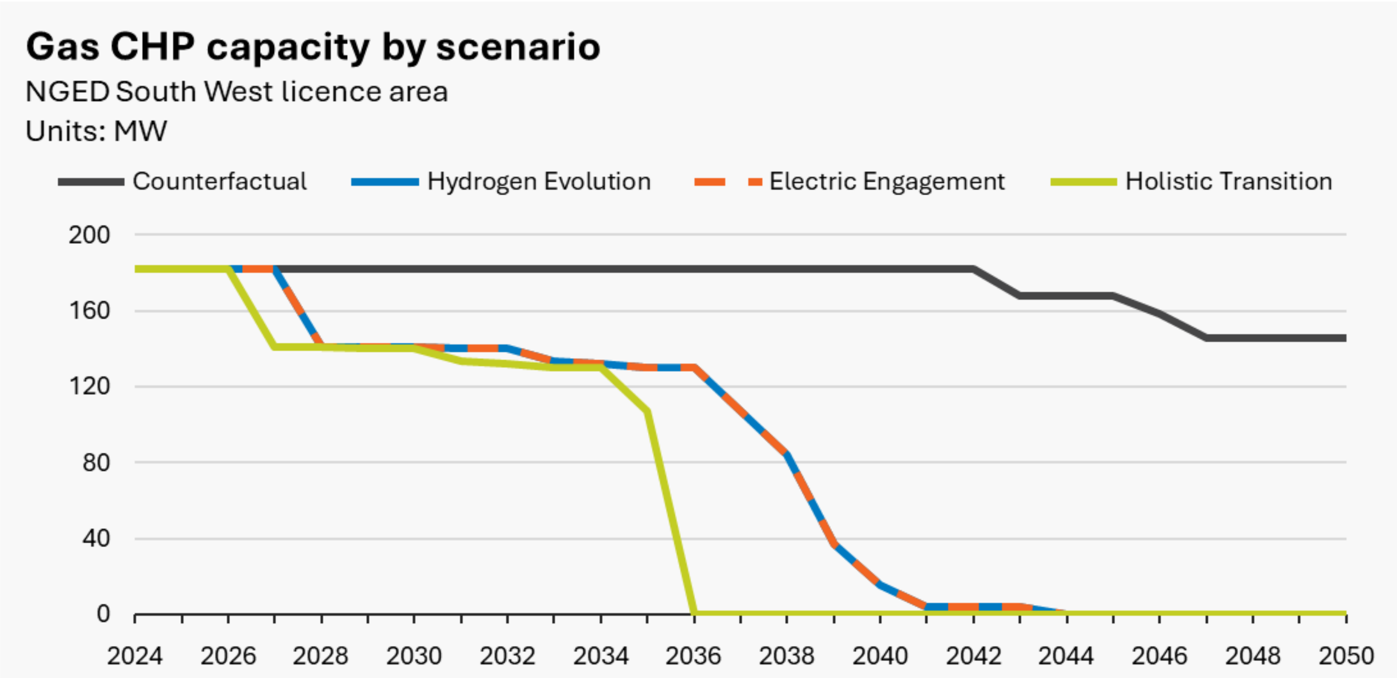
Fossil gas-fired electricity generation

Summary

- There is over 400 MW of fossil gas-fired electricity generation capacity in the South West licence area, split across OCGTs, reciprocating engines and gas CHPs.
- Deployment of gas-fired generation is slowing overall as GB looks to decarbonise its electricity system. There are only ten fossil gas projects, totalling 141 MW of capacity, with an accepted connection offer with NGED. The majority this capacity has planning approval and positive Capacity Market activity, and has therefore been modelled to progress under every scenario.
- In the net zero scenarios, fossil gas generation capacity is modelled to decrease across the late 2020s and 2030s as GB moves to lower carbon forms of dispatchable generation such as batteries, hydrogen-fuelled generation and bioenergy, alongside demand-side flexibility. This aligns with the FES 2024 scenario framework, under which the three net zero scenarios achieve net zero power by 2035 at the latest (though some gas-fired power remains connected for backup purposes).
- All three net zero scenarios model some fossil gas sites to repower as hydrogen-fuelled generation plants, particularly under **Hydrogen Evolution** where hydrogen is most readily available across GB.
- Under the **Holistic Transition** scenario all fossil-gas generation is decommissioned by 2036, and by 2041 under **Electric Engagement** and **Hydrogen Evolution**, as GB moves to net zero power. Note that this aligns with 2035 and 2040 years in FES 2024 respectively, due to NGED's DFES modelling financial years.
- Slower progress towards decarbonisation results in most gas-fired electricity generation capacity remaining online beyond 2050 under the **Counterfactual** scenario.




Gas reciprocating engines capacity by scenario
NGED South West licence area
Units: MW
Counterfactual
Hydrogen Evolution
Electric Engagement
Holistic Transition
250
200
150
100
50
0
2024
2026
2028
2030
2032
2034
2036
2038
2040
2042
2044
2046
2048
2050


Gas CHP capacity by scenario
NGED South West licence area
Units: MW
Counterfactual
Hydrogen Evolution
Electric Engagement
Holistic Transition
200
160
120
80
40
0
2024
2026
2028
2030
2032
2034
2036
2038
2040
2042
2044
2046
2048
2050

Modelling assumptions and results

Baseline and pipeline

Source: NGED connections data

	Technology type	Capacity (MW)	Description
Baseline	CCGT	0	There are 65 operational fossil gas generation sites in the South West licence area. This includes two large-scale OCGTs at 58 and 65 MW respectively, installed in 1999. Just over half of this baseline capacity has been installed since 2010, mainly reciprocating engines and CHP sites.
	OCGT	152	
	Reciprocating engines	77	
	CHP	182	
Pipeline	CCGT	0	Five sites have been granted planning permission or are under construction alongside positive Capacity Market activity, such as winning a Capacity Agreement or prequalifying for an auction. These sites are modelled to go ahead in every scenario.
	OCGT	6	Three sites have been granted planning permission but were not found to be active in the Capacity Market. These are modelled to go ahead under all scenarios except **Holistic Transition**.
	Reciprocating engines	135	
	CHP	0	The two remaining sites were not found in planning or the Capacity Market, and as such are only modelled to progress under the **Counterfactual**.

Projections

Scenario	Description
Holistic Transition	Fossil gas generation capacity decommissions quickly in the late 2020s and early 2030s as GB looks to achieve a rapidly decarbonised electricity system. Sites are modelled to decommission at the end of their operational life, ranging from 15 years for reciprocating engines to 20 years for OCGTs, or by a backstop date of 2036.
Electric Engagement / **Hydrogen Evolution**	Fossil gas generation capacity decommissions in the late 2020s and throughout the 2030s as GB looks to achieve a rapidly decarbonised electricity system. Sites are modelled to decommission at the end of their operational life, ranging from 20 years for reciprocating engines and CHPs to 25 years for OCGTs, or by backstop dates of 2041 for electricity-only generation and 2046 for gas CHPs.
Counterfactual	Fossil gas generation remains online as progress towards net zero is slow and low-carbon alternatives to fossil gas generation see low uptake. Only older projects reaching the end of an extended operational life are modelled to decommission, resulting in a limited reduction in fossil gas capacity in the 2040s.

Uptake modelling factors

The below factors are used to inform the overall uptake of fossil gas generation in the South West licence area.

Factor	Modelling impact	Source
Operational life of fossil gas plant	The operational life of a fossil gas plant informs the logic used to model site-by-site decommissioning for baseline and pipeline sites.	Desk research, analysis of previous baseline sites
Backstop decommissioning dates	The overall timeframe for the decommissioning of unabated fossil gas generation under each scenario has been mirrored from the FES 2024 scenario framework.	FES 2024

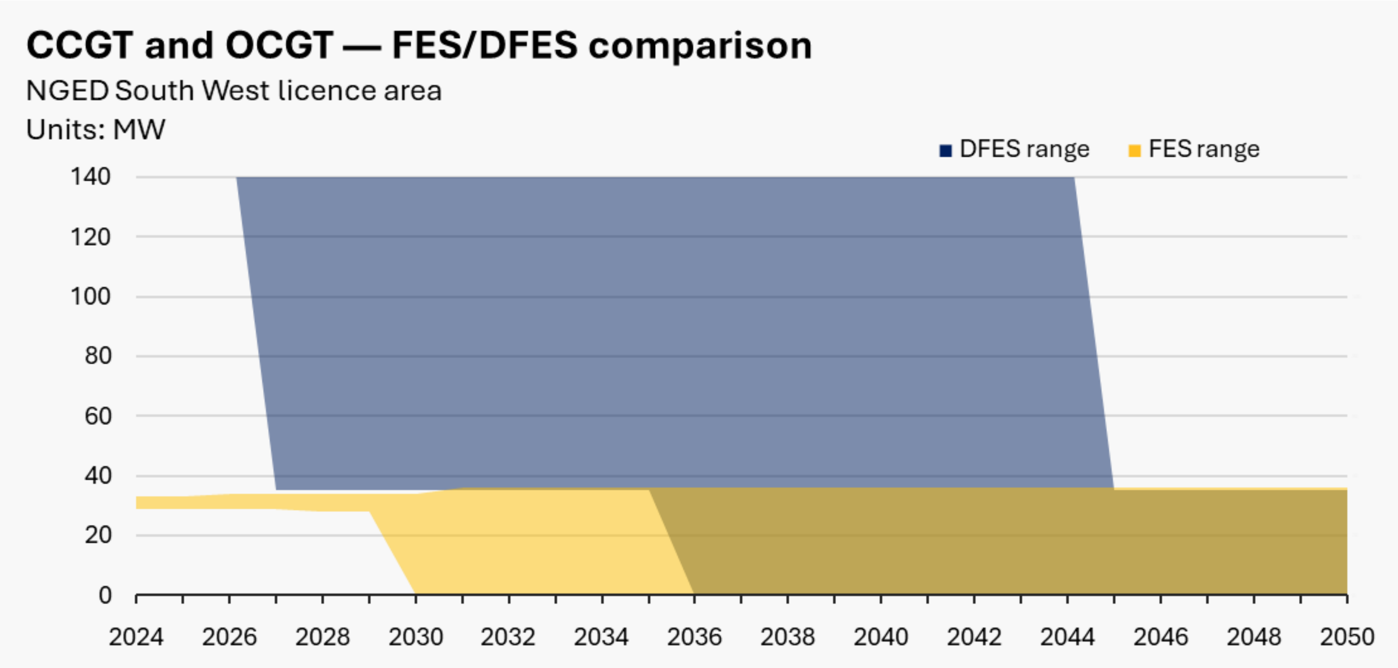
Spatial factors

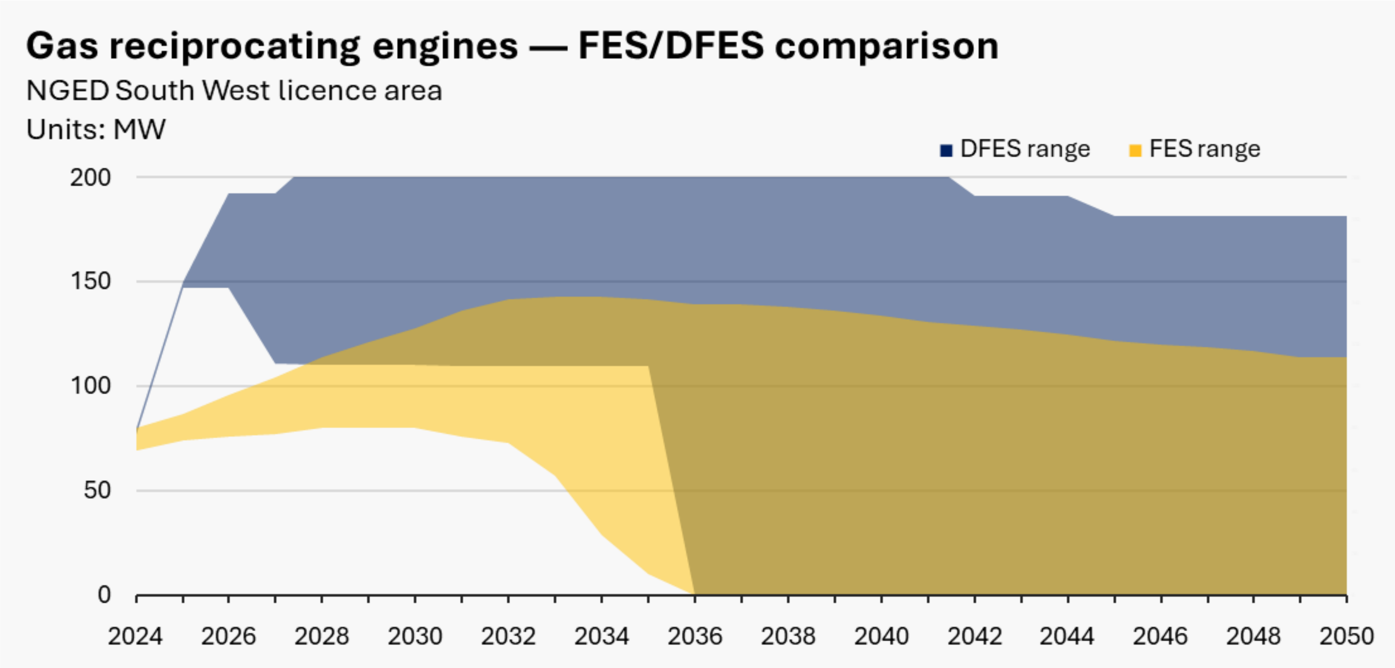
The below factors are used to inform the spatial distribution of fossil gas generation capacity across the South West licence area, down to 11 kV ESAs.

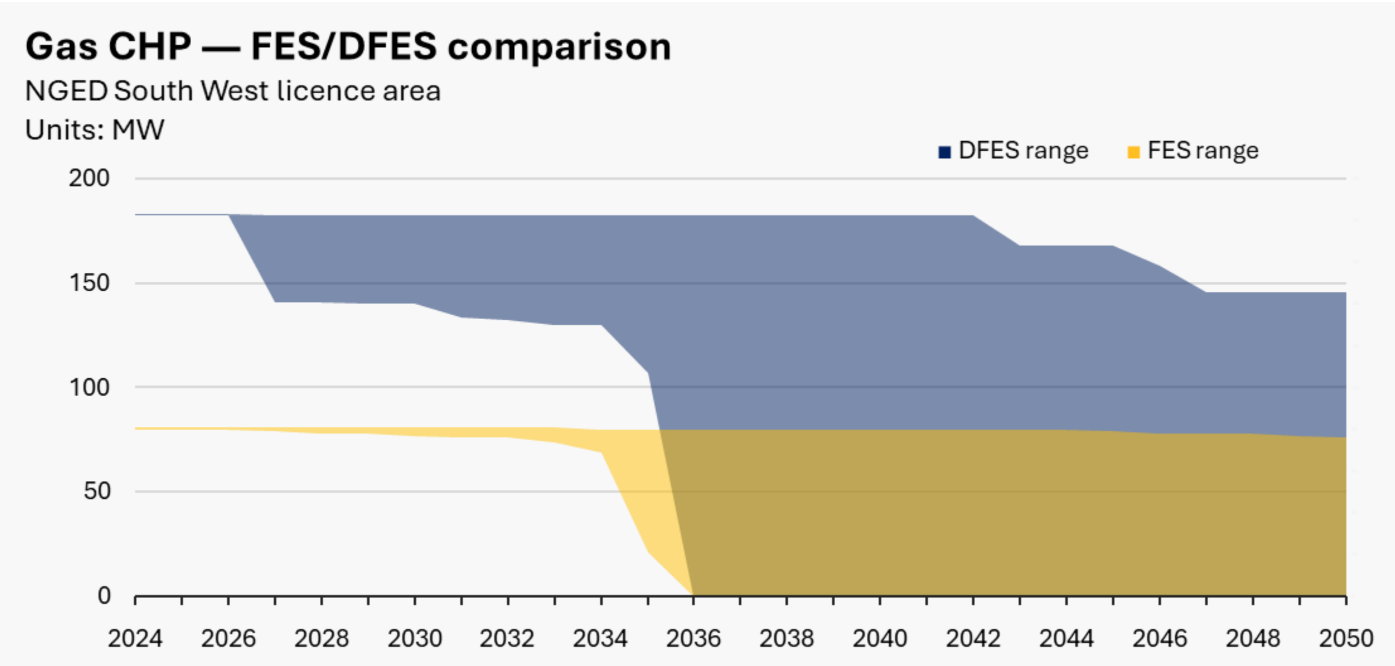
Factor	Modelling impact	Source
Existing baseline and pipeline sites	The DFES projections are modelled directly on a site-by-site basis.	NGED connections data

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.







- Overall, the DFES follows similar trends to the FES for fossil gas generation, as the final decommissioning year for each technology type is inherited from the FES 2024 framework.
- The baselines for the DFES, especially for OCGT and CHP subtechnologies, are substantially higher than FES. The reason for this is unclear, but may be due to classification differences or the DFES having greater visibility of behind-the-meter generation, especially with regards to CHP.
- For gas reciprocating engines in particular, there is a greater but shorter near-term increase in capacity. This is due to the site-by-site analysis of the pipeline revealing a number of well advanced projects, either already under construction or holding planning permission and with a Capacity Market contract to be delivered in the next few years. Ongoing policy reforms being implemented by

NESO suggest that the development of new unabated fossil fuel generation could be very limited, which reinforces the limited, pipeline-based DFES projection.

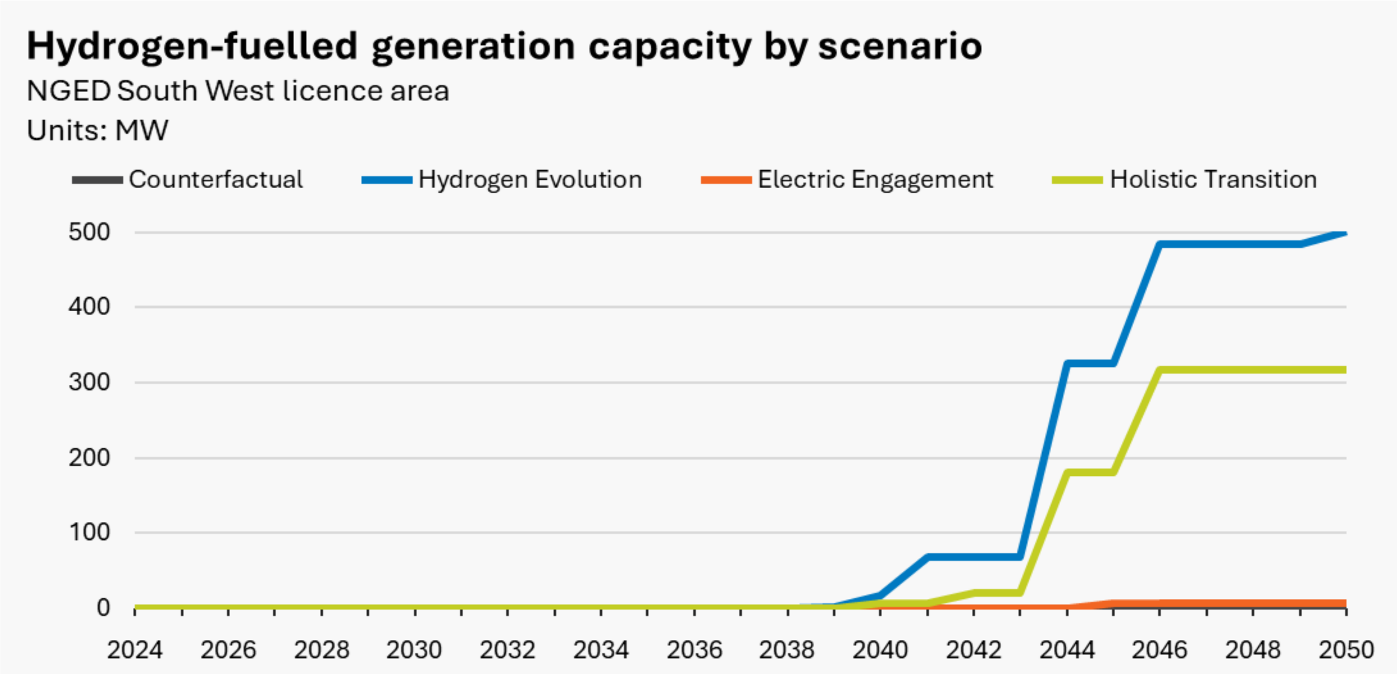
Comparison to DFES 2023

- The outcomes and modelling methods for fossil gas are similar between DFES 2023 and 2024.
- 2028 has been considered as the earliest possible decommissioning year for fossil gas generation in the DFES 2024 modelling process. This is to reflect the current trends around some new fossil gas generation being deployed rather than significant decommissioning.
- Compared to DFES 2023, the assumed operational lifespan of each technology type has been extended to reflect the likelihood of gas plants remaining online at very low load factors during the transition to net zero power. As a result, more capacity decommissions at the 'backstop years' for each net zero scenario in DFES 2024, rather than the more gradual decline modelled in DFES 2023.

Hydrogen-fuelled electricity generation

Summary

- Hydrogen-fuelled electricity generation is modelled based on the conversion of existing operational and in-development fossil gas generation sites to hydrogen-fuelled generation. This is modelled based on an analysis of if and when low-carbon hydrogen becomes regionally and locally available under each of the four scenarios.
- In 2023, the UK Government consulted on hydrogen-to-power business model support, publishing their response in late 2024. This proposed commercial support to enable hydrogen power generation through a 'dispatchable power agreement' arrangement and enabling hydrogen power generation to bid into the Capacity Market. This support could endorse the development of hydrogen power generation in the UK, in line with the three net zero scenarios.
- Dispatchable low-carbon electricity supply such as hydrogen-fuelled generation is seen as a key component in achieving a net zero power system based predominantly on variable renewables like solar PV and wind power, which occurs under all three net zero scenarios.
- Hydrogen becomes widely available in the 2030s and 2040s across GB under the **Hydrogen Evolution** scenario, resulting in a high proportion of existing and pipeline fossil gas generation sites converting to hydrogen-fuelled generation in the longer term. By 2050, 500 MW of hydrogen-fuelled generation capacity is projected in the South West licence area under this scenario.
- Under **Holistic Transition**, hydrogen only becomes widely available in and around industrial clusters rather than across most of GB. Even lower levels are available under **Electric Engagement**. This results in less hydrogen-fuelled generation both nationally and in the licence area under these scenarios.
- Relative to other licence areas, the South West sees later uptake of hydrogen-fuelled generation due to the lack of proximity to planned hydrogen networks, such as National Gas' Project Union, or planned hydrogen clusters such as East Coast Hydrogen or HyNet.
- There is no distribution-scale hydrogen-fuelled electricity generation anywhere in GB under the **Counterfactual** scenario as progress towards decarbonisation is slow under this scenario.


Hydrogen-fuelled generation capacity by scenario
NGED South West licence area
Units: MW
Counterfactual
Hydrogen Evolution
Electric Engagement
Holistic Transition
500
400
300
200
100
0
2024
2026
2028
2030
2032
2034
2036
2038
2040
2042
2044
2046
2048
2050

Modelling assumptions and results

Baseline and pipeline

Source: NGED connections data

	Development status	Capacity (MW)	Description
Baseline	n/a	0	There are no baseline or pipeline hydrogen-fuelled generation projects in the licence area. For modelling purposes, the existing baseline and pipeline of fossil gas-fired generation projects are effectively used as a pipeline of prospective locations for future distributed hydrogen-fuelled power generation in the medium and longer term.
Pipeline	n/a	0	

Projections

Scenario	Description
Holistic Transition **Electric Engagement**	Operational and pipeline fossil gas-fired generation sites are modelled to convert to hydrogen once hydrogen is locally available and the gas-fired plant has been decommissioned. Hydrogen availability is modelled based on distance to an anticipated hydrogen or industrial cluster, such as the South Wales Industrial Cluster or Southampton. The FES framework assumes that hydrogen transmission is limited under these scenarios. Under **Holistic Transition**, sites within 20 km of a cluster are able to convert to hydrogen from the early 2030s, expanding to over 150 km by the late 2040s. This results in over 300 MW of capacity connecting by 2050. Under **Electric Engagement**, the development of hydrogen-fuelled generation is more limited, starting in the mid-2030s and only occurring at sites within 50 km of an anticipated cluster. This results in just 7 MW of capacity connecting by 2050 due to the licence area's distance from industrial or hydrogen clusters.
Hydrogen Evolution	Existing and pipeline fossil gas-fired generation sites are modelled to convert to hydrogen once hydrogen is locally available and the gas-fired plant has been decommissioned. Hydrogen availability is modelled based on the distance to a planned hydrogen transmission network, namely Project Union, or an anticipated hydrogen or industrial cluster, such as the South Wales Industrial Cluster or Southampton. Sites within 20 km of a cluster are able to convert to hydrogen from the early 2030s, expanding to over 150 km by the late 2040s. In addition, due to the wider availability of hydrogen under this scenario and the benefits of hydrogen as a high-capacity, low-utilisation 'peaking' technology, current gas reciprocating engines are modelled to replant with an additional 50% capacity. This results in over 500 MW of capacity connecting by 2050.

Counterfactual	In alignment with the FES 2024 framework, there is no development of hydrogen-fuelled generation at any point under this scenario.

Uptake modelling factors

The below factors are used to inform the overall uptake of hydrogen-fuelled generation in the South West licence area.

Factor	Modelling impact	Source
Existing baseline and pipeline of gas-fired generation	Modelled conversion of gas-fired generation sites to hydrogen-fuelled generation forms the basis of the capacity, timing and location of hydrogen-fuelled generation.	NGED DFES 2024
Location of industrial clusters and planned hydrogen clusters	Timing of the modelled conversion of gas-fired generation sites is based on the distance from industrial clusters and planned hydrogen clusters in all three net zero scenarios.	Regen analysis, DESNZ Track-1 CCUS clusters
Location of planned hydrogen networks	Timing of the modelled conversion of gas-fired generation sites is based on the distance from planned hydrogen networks under the **Hydrogen Evolution** scenario.	Regen analysis, National Gas

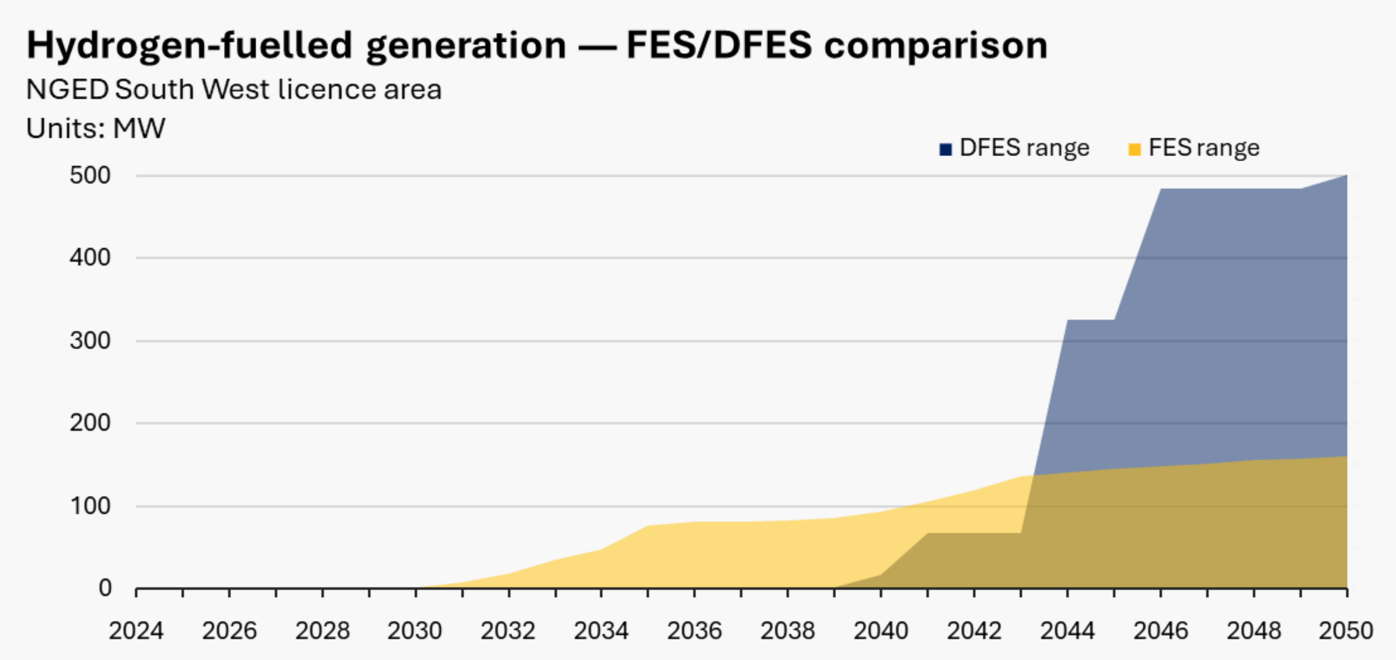
Spatial factors

The below factors are used to inform the spatial distribution of hydrogen-fuelled generation capacity across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Existing baseline and pipeline of gas-fired generation	The location of future hydrogen-fuelled generation sites is based solely on the location of baseline and pipeline gas-fired generation sites in the licence area.	NGED DFES 2024

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.



- The DFES outcomes in the South West licence area are not well aligned with the FES data at a licence area level. The DFES analysis and stakeholder engagement suggests that availability of hydrogen at scales large enough for power generation is unlikely to occur in the early 2030s, resulting in a later uptake in the DFES modelling under all scenarios. Once hydrogen is available, however, there is a sizeable baseline of existing thermal generation that could be converted to hydrogen-fuelled generation. As a result, the 2050 outcomes in the DFES exceed the FES under **Hydrogen Evolution** and **Holistic Transition**.

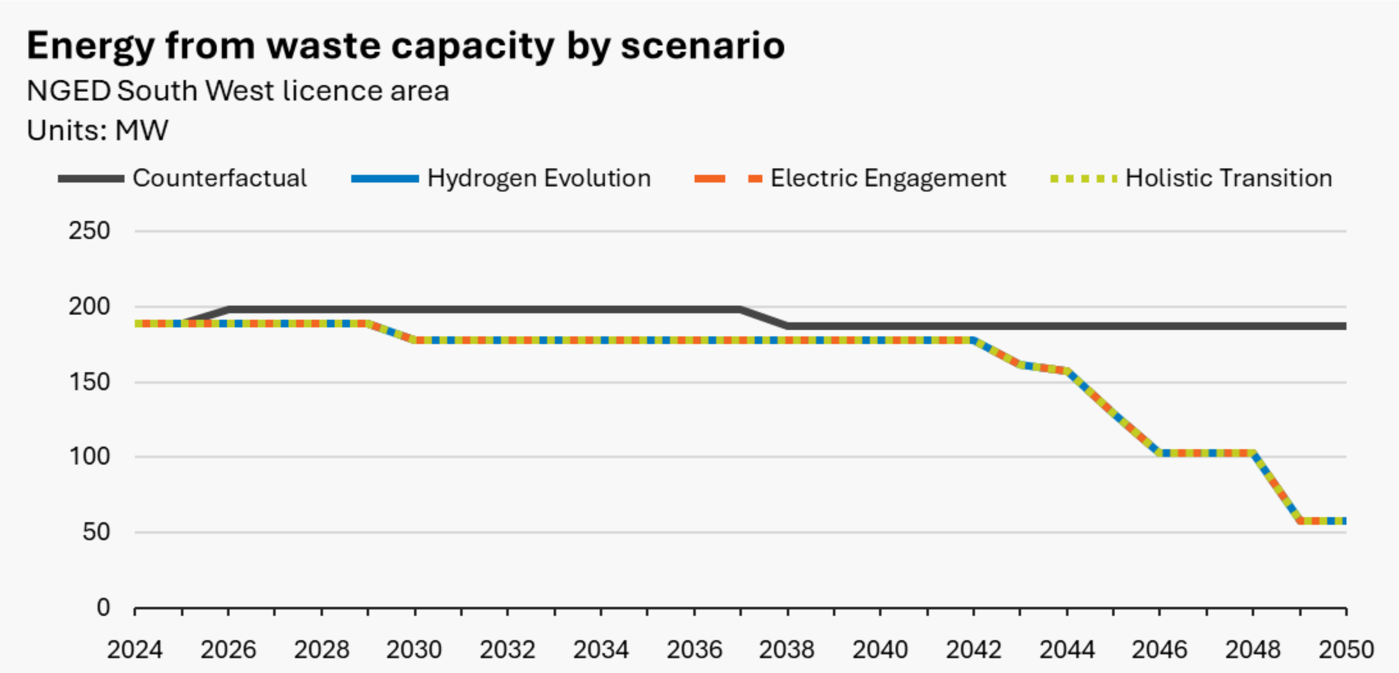
Comparison to DFES 2023

- The outcomes for **Hydrogen Evolution** and **Holistic Transition** have been inverted compared to DFES 2023, mirroring the same change in the FES 2024 framework.
- Sites are no longer limited by a maximum 'mothballing period' of ten years between gas-fired plant decommissioning and hydrogen-fuelled generation commissioning. This aims to represent existing sites as prospective site locations for thermal generation (including hydrogen-fuelled generation), regardless of whether the site is a conversion of an existing plant or a new build project.

Energy from waste

Summary

- Energy from waste, conventionally in the form of waste incineration, has historically been used alongside the landfill of waste that has not been reused or recycled. There is a substantial 189 MW baseline of new energy from waste projects currently operating in the South West licence area.
- There is only one pipeline site in development in the licence area. This site has limited evidence of recent development and is therefore only modelled to connect under the **Counterfactual** scenario.
- Waste incineration is highly carbon intensive and, therefore, sites are modelled to decommission under the three net zero scenarios out to 2050 as cleaner approaches to waste management become commonplace. More efficient energy from waste plants, such as Advanced Conversion Technology (ACT) gasification plants, operate beyond 2050 under all four scenarios.
- In contrast, only a single older waste incineration plant is modelled to decommission under the **Counterfactual**, with nearly 200 MW of energy from waste capacity still operating in 2050



Modelling assumptions and results

Baseline and pipeline

Source: NGED connections data

	Development status	Capacity (MW)	Description
Baseline	Operational	191	Operational energy from waste capacity in the South West ranges from sites built in the early 2000s, to newer sites commissioned in 2021. The largest site, the 48 MW Severnside Energy Recovery Centre, is an incineration site that qualifies as

			an Energy Recovery Facility due to its high-levels of energy efficiency.
Pipeline	Accepted to connect	10	The single pipeline site has a history of development, including being granted planning permission in 2012 and winning a CfD in AR2. However, there is no evidence of recent development. As such, the project is modelled to connect only under the **Counterfactual** scenario.

Projections

Scenario	Description
Holistic Transition	Under the net zero scenarios, conventional waste incineration sites are projected to decommission after 30 years of operational life[49], reflecting a reduced volume of waste in these scenarios and the drive to reduce carbon emissions.
Electric Engagement	More efficient sites, using ACT gasification or sites classified as 'Energy Recovery Facilities' (incineration sites that meet higher energy efficiency criteria), are not projected to come offline under any scenario out to 2050. This assumes that any remaining waste in the 2030s and 2040s is processed at less carbon-intensive, highly efficient ACT sites under these scenarios.
Hydrogen Evolution	Due to the Severnside Energy Recovery Centre and some other more recently deployed baseline sites remaining online, 58 MW of energy from waste capacity remains operational in the South West in 2050 under these scenarios.
Counterfactual	Lower levels of societal change and limited progress towards carbon emission reduction means that waste incineration sites continue to operate up to 40 years after their commissioning date. This results in the 187 MW remaining online in 2050, with only one older baseline site decommissioning.

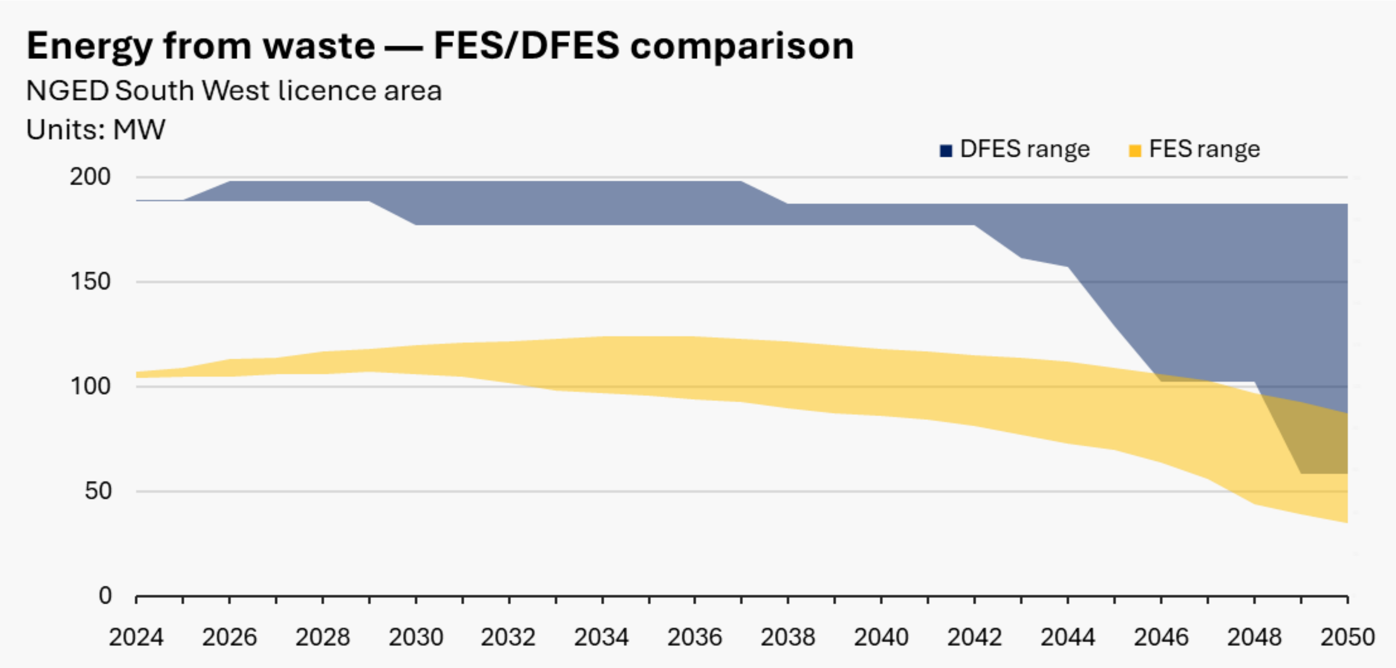
Uptake modelling and spatial distribution factors

The below factors are used to inform the spatial distribution of waste incineration capacity across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Decommissioning timescales	The potential operating lifespan of incineration energy from waste plants determines the projected decommissioning dates of individual sites under each scenario.	Desk research
Location of existing baseline and pipeline sites	All energy from waste spatial modelling is based on existing baseline and pipeline sites.	NGED connections data

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.



- The DFES baseline is substantially higher than the FES baseline. The reason for this is unclear. It is possible that this is due to a difference in technology classification, or assignment of sites on licence area borders to GSPs in the FES regional data.
- The overall scenario trends are broadly matched across the DFES and FES outcomes. However, the DFES modelling of discrete baseline and pipeline sites results in a more explicit reflection of scenario trends in the DFES outcomes.

Comparison to DFES 2023

- The outcomes and modelling methods for energy from waste are closely aligned between DFES 2023 and DFES 2024.

Other generation

Summary

- There are 23 connected sites in the licence area that have not been categorised as a particular technology, totalling 0.5 MW. These are likely to be small-scale fossil-fuel generation sites, but they could not be specifically identified as such in the NGED connections data.
- There are no additional other generation sites with accepted connection offers.
- There are no projections for other generation in the South West licence area, resulting in 0.5 MW under all scenarios by 2050.

Modelling assumptions and results

Baseline and pipeline

Source: NGED connections data

	Development status	Capacity (MW)	Description
Baseline	Operational	0.5	There are 23 connected sites in the South West licence area that could not be categorised as a particular technology. The largest of these sites is 125 kW, located in South Gloucestershire.
Pipeline	In development	-	There are no additional sites with accepted connection offers.

Uptake modelling and spatial distribution factors

The below factors are used to inform the overall uptake and spatial distribution of other generation in the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Location of connected and in-development sites	The DFES projections are wholly based on operational and in-development sites, as identified through NGED's connection data.	NGED connections data

Comparison to DFES 2023

- Compared to DFES 2023, the baseline is lower and there are no pipeline sites in the connections data this year, due to the successful reclassification of sites to a modelled technology.

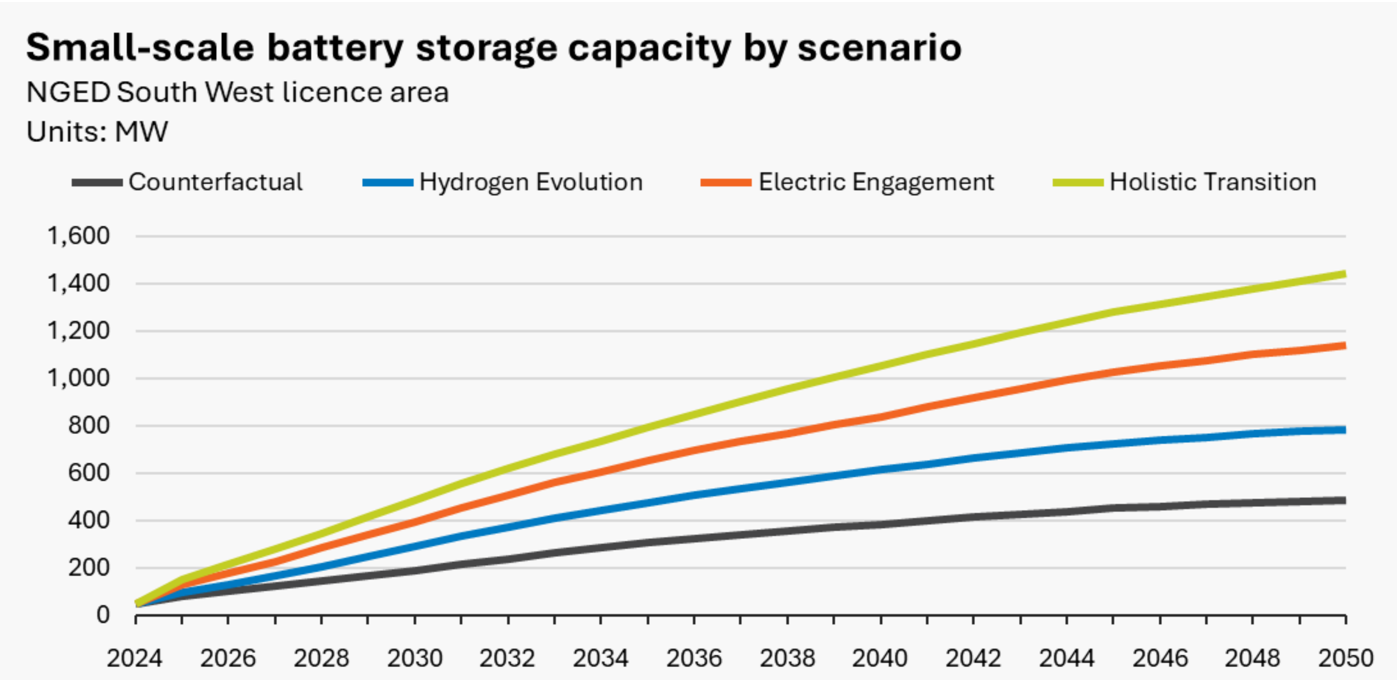
Storage technologies

Results and assumptions

Small-scale battery storage

Summary

- Small-scale battery storage, in the form of domestic batteries and batteries installed at commercial and industrial properties with high energy demand, has a relatively small baseline in the South West but a high potential to grow under every scenario.
- Domestic battery uptake is closely tied to the uptake of domestic rooftop solar PV. In the past two years, over half of domestic PV installations have been installed alongside a domestic battery. This trend is modelled to continue in the near term under all four scenarios. In the longer term, adoption of domestic batteries reduces, as other forms of demand flexibility are favoured.
- Installations of behind-the-meter batteries at 'high energy user sites', such as factories, hospitals and universities, are projected to increase under all four scenarios. This is a reflection of businesses seeking to maximise the self-consumption of onsite renewable generation, as well as using batteries for onsite energy management and participating in commercial balancing services.
- There is some uncertainty around how prevalent domestic and non-domestic batteries will be in the future, compared to alternative sources of flexibility such as smart charging, V2X and thermal storage. As a result, there are a range of outcomes modelled for small-scale battery storage in the licence area, from 0.5 GW under the **Counterfactual** to 1.4 GW under **Holistic Transition**.



Modelling assumptions and results

Baseline and pipeline

Source: NGED connections data and SolarPower Europe market outlook report

	Installation type	Capacity (MW)	Description
Baseline	Domestic	46	The lack of available data for domestic battery storage installations means that the true baseline capacity is not well understood. This is due to the majority of home batteries being installed alongside a solar PV installations and only one of the technology types typically being recorded. There is no complete national database for domestic battery installations. Engagement with domestic solar and battery installers suggests that over half of domestic solar PV installed in 2023 and 2024 were installed alongside a home battery. This aligns with a market outlook report by SolarPower Europe, which suggests a UK residential battery storage fleet of 1.1 GWh.[50] The domestic battery baseline has therefore been modelled based on a disaggregation of this market outlook to licence areas based on domestic solar PV uptake, since the two technologies are very often installed in tandem.
	High energy user	3	There are 24 'high energy user' battery storage sites in the baseline. These are defined as sites with an export capacity of 10 kW to 1 MW. While a large number of these sites have been installed in the last two years, the baseline of commercial and industrial battery storage assets in the licence area dates back as far as 2016.
Pipeline	Domestic (< 10 kW)	0.1	In part due to NGED's new 'connect and manage' scheme for domestic low-carbon installations, there is currently little pipeline data for domestic battery storage installations. The pipeline of small-scale battery storage consists almost entirely of high energy user installations, between 10 kW and 1 MW. This 18-site pipeline totalling 2 MW, is modelled to connect in 2025 under all four scenarios due to the small scale of the sites that can be deployed quickly under permitted development. Additional domestic-scale battery capacity, not represented by known connection applications data, is likely to be deployed in the very near term. This has been considered in the DFES modelling under all scenarios.
	Commercial (10 kW - 1 MW)	2	

Projections

- Domestic battery projections are directly tied to domestic rooftop solar PV projections in the DFES modelling.
- High energy user battery storage projections are driven by the scale of commercial and industrial premises in the licence area.

Scenario	Description
Holistic Transition	Under this scenario, the proportion of domestic solar installations being installed with an accompanying domestic battery starts at 55% in the near term, reflecting current market reports, and decrease to 25% by 2050 as uptake of EVs (potentially with V2X capability) and thermal storage reduces the case for standalone domestic storage. Overall uptake remains still highest of all the scenarios due to the number of highly engaged consumers. Deployment at high energy user sites increases significantly over the scenario timeframe as more businesses seek to manage their onsite energy use and costs through flexibility technologies. Small-scale battery capacity, therefore, reaches 1.4 GW by 2050 under this scenario.
Electric Engagement	Under this scenario, the proportion of domestic solar installations being installed with an accompanying domestic battery starts at 55% in the near term, reflecting current market reports, and decreases to 20% by 2050 as uptake of EVs (potentially with V2X capability) and thermal storage reduces the case for standalone domestic storage. Uptake still remains high due to the number of highly engaged consumers. Deployment at high energy user sites increases over the scenario timeframe as more businesses seek to manage their onsite energy use and costs through flexibility technologies. Small-scale battery capacity, therefore, reaches 1.1 GW by 2050 under this scenario.
Hydrogen Evolution	Under this scenario, the proportion of domestic solar installations being installed with an accompanying domestic battery starts at 55% in the near term, reflecting current market reports, and decreases to 12% by 2050 as uptake of EVs (potentially with V2X capability) and thermal storage reduces the case for standalone domestic storage and consumers are not strongly engaged in demand flexibility. Deployment at high energy user sites increases moderately over the scenario timeframe as a limited number of businesses seek to manage their onsite energy use and costs through flexibility technologies. Small-scale battery capacity, therefore, reaches 0.8 GW by 2050 under this scenario.
Counterfactual	Under this scenario, the proportion of domestic solar installations being installed with an accompanying domestic battery starts at 55% in the near term, reflecting current market reports, and decreases to 10% by 2050 as uptake of EVs (with V2X capability) and thermal storage reduces the case for standalone domestic storage and consumers are not engaged in demand flexibility. Deployment at high energy user sites increases slowly over the scenario timeframe as only a small number of businesses seek to manage their onsite energy use and costs through flexibility technologies. Small-scale battery capacity, therefore, reaches 0.5 GW by 2050 under this scenario.

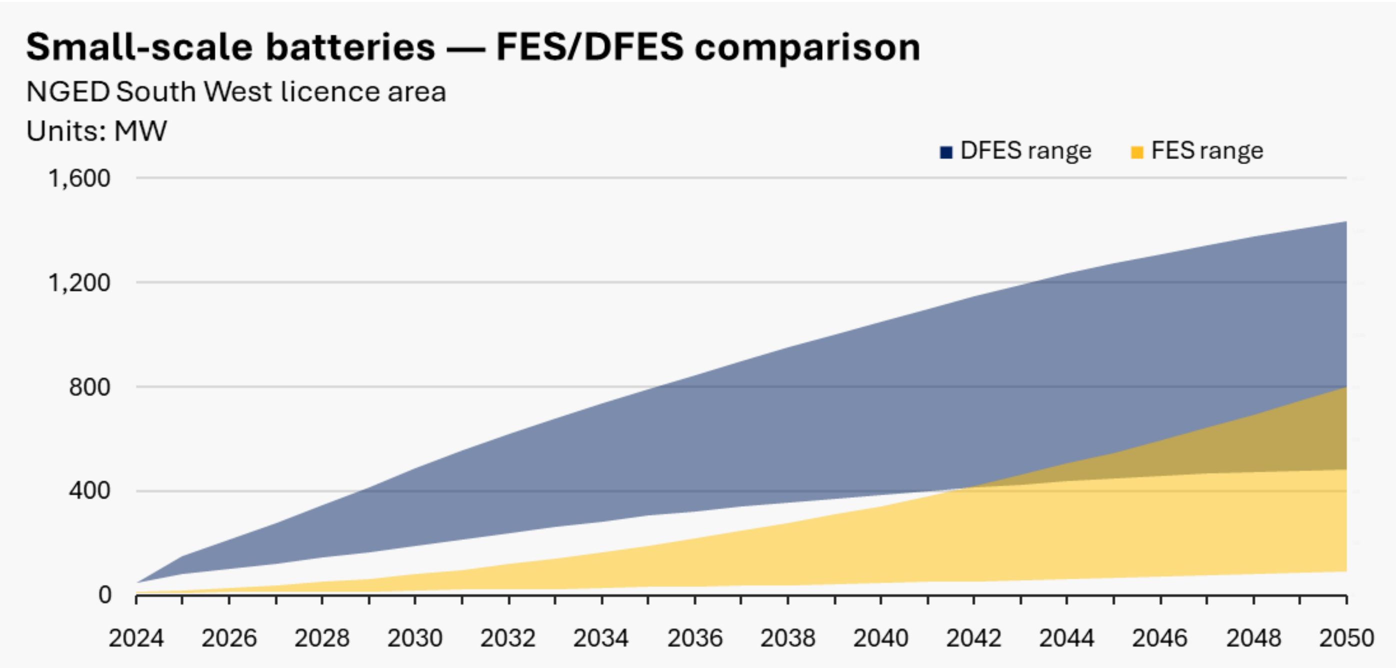
Uptake modelling and spatial distribution factors

The below factors are used to inform the overall uptake and the spatial distribution of small-scale batteries in the South West licence area, down to LV and 11 kV ESAs.

Factor	Modelling impact	Source
Domestic rooftop solar PV uptake	Domestic battery storage uptake and the location of installations are directly tied to the uptake of domestic solar PV uptake.	DFES modelling
Number and location of 'high energy user' commercial and industrial sites	High energy user battery storage uptake and distribution is based on the number and location of existing energy-intensive non-domestic properties, such as industrial estates, hospitals, universities and factories.	OS Addressbase

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.



- The DFES outcomes for small-scale batteries are significantly higher than the to FES 2024, driven by modelling differences regarding domestic batteries.
- Based on engagement with domestic solar and battery installers, combined with market report data and domestic solar PV projections, the DFES small-scale battery baseline is significantly above the FES. This reflects high-levels of domestic battery installations over the past two years.
- These currently occurring trends are projected to continue into the near term, reflecting real-world uptake of domestic battery storage systems over the past several years. They are then modelled to decline in the longer term as other domestic flexibility options, such as smart charging, V2X and thermal storage, become more prevalent. This is opposite to the FES trend, where domestic battery uptake continues to accelerate over the scenario timeframe out to 2050. The DFES analysis aims to reflect current trends in domestic battery uptake as informed by industry stakeholders.

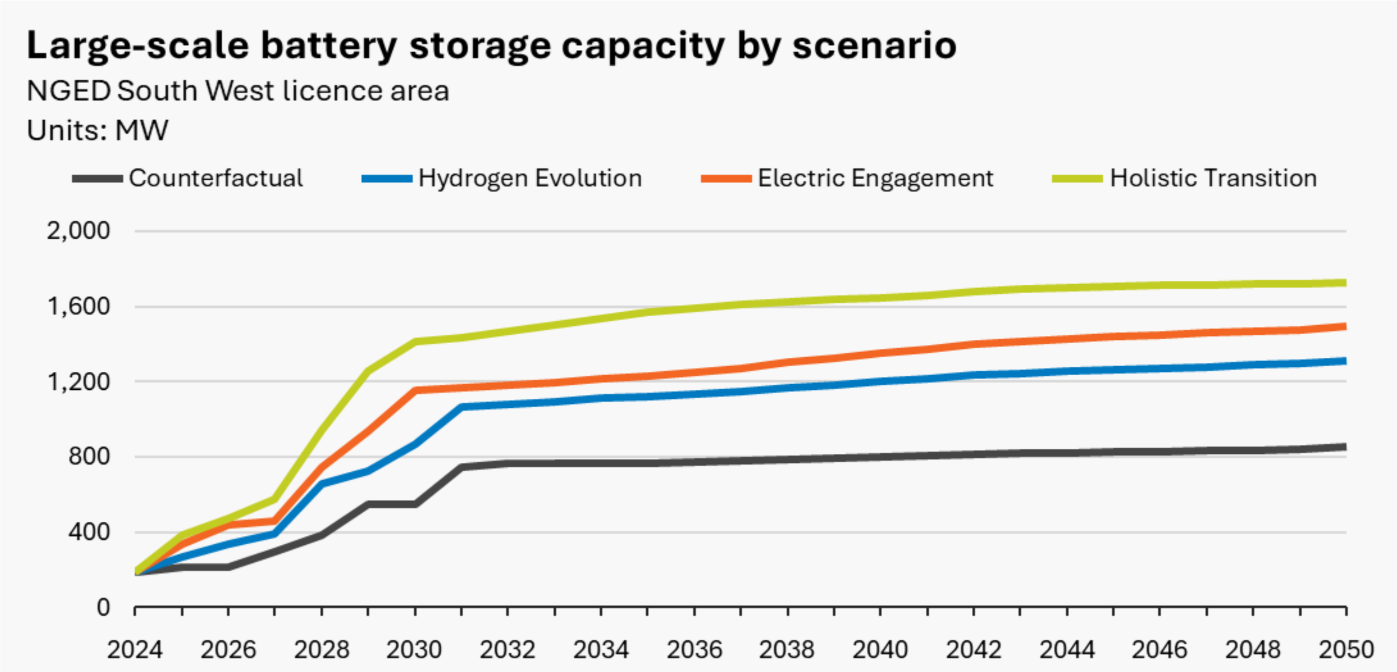
Comparison to DFES 2023

- The small-scale battery projections have changed significantly since DFES 2023, in both the baseline and the magnitude of projections over the scenario timeframe.
- Previous DFES small-scale battery projections were closely tied to the FES projections. As such, the changes detailed in the reconciliation to FES above also apply to this comparison.

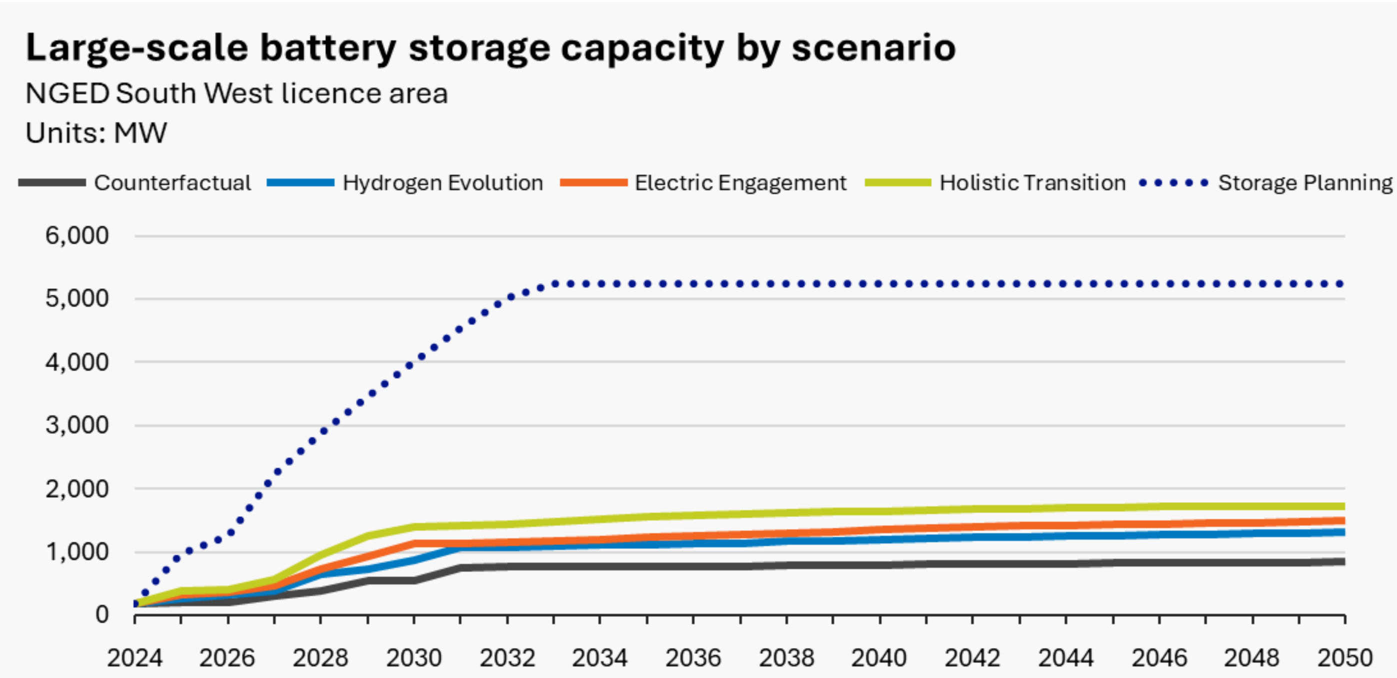
Large-scale battery storage

Summary

- Grid-scale battery storage has become one of the most active development sectors in the UK, with numerous developers and four listed capital investment funds seeking to develop battery storage projects at various scales across the country.
- In the context of the wider GB energy system, low-carbon dispatchable power and flexibility are required to manage variable generation, meet peak demand, ensure security of supply, manage network constraints and maximise the economic value of abundant renewable energy when it is available. As GB looks to achieve Clean Power by 2030 and a net zero power system by 2035, the rapid deployment of new large-scale (almost entirely Lithium-Ion based) battery storage is projected under every scenario as a key component to achieving these goals.
- There is a huge pipeline of prospective battery storage projects across the UK, and NGED's licence areas are no exception. In the South West licence area alone, the pipeline of battery storage sites that hold accepted connection offers currently totals over 5.5 GW.
- However, with significant reforms to network connection policy and battery storage asset revenues becoming challenging for new entrants, it is likely that only a limited proportion of this pipeline will progress through to development, even in the longer term. This is partially evidenced by only 1.1 GW being found to have obtained planning approval to date.
- As a result of these factors, the modelled deployment of the more advanced battery storage pipeline projects results in a range of scenario outcomes by 2030. **Holistic Transition** is the scenario that supports the highest uptake of decentralised battery storage, reaching 1.4 GW by 2030, while the **Counterfactual** reaches less than 0.5 GW in the same timeframe.
- Sites with submitted planning applications, pre-planning activity or no evidence planning activity have only been modelled to progress under the **Storage Planning** scenario. This scenario does not aim to represent a credible projection of storage development in the licence area, but instead models the connection of all batteries, with reasonable connection timelines assessed on a per-project basis, to provide NGED with added insight into the scale of the current battery storage pipeline.
- Beyond 2035, deployment of large-scale battery storage is projected to slow as the market becomes further saturated and alternative sources of flexibility such as small-scale battery storage, thermal storage and V2G see increased uptake. In addition, the development of a new market mechanism for long-duration electricity storage (LDES) creates the potential for other storage technologies to begin to build out in the longer term, though many of these may end up connecting to the transmission network, due to their scale (e.g. new strategic pumped hydropower sites).
- In all scenarios, deployment of new large-scale battery storage beyond the known pipeline is mostly limited to battery assets co-located with large-scale solar PV and onshore wind projects.
- As a result, the total amount of large-scale battery storage connected to the distribution network in the South West licence area in 2050 ranges from 0.9 GW under the **Counterfactual** to 1.7 GW under **Holistic Transition**.



Sites with submitted planning applications, pre-planning activity or no evidence planning activity have only been modelled to progress under the **Storage Planning** scenario. This scenario does not aim to represent a credible projection of storage development in the licence area, but instead models the connection of all batteries, with reasonable connection timelines assessed on a per-project basis, to provide NGED with added insight into the scale of the current battery storage pipeline. The cumulative impact of this scenario at a licence area level is illustrated in the graph below.



Modelling assumptions and results

Baseline and pipeline

Source: NGED connections data

	Development status	Capacity (MW)	Description
Baseline	Operational	184	Almost all of the operational large-scale battery storage capacity is comprised of standalone batteries providing grid services. The remaining proportion are battery assets co-located alongside electricity generation sites. Four battery projects have been commissioned since the beginning of 2023, totalling 82 MW. These sites are located in built-up areas of the licence area such as Bristol and Plymouth.
Pipeline	Granted planning permission	1,138	32 pipeline sites, 1.1 GW, have been granted planning permission and are all modelled to connect under the **Holistic Transition** and **Storage Planning** scenarios. Some of these sites are over 100 MW in size. The majority of these sites are also modelled connect in the remaining three scenarios, with the exception of five sites that either failed to prequalify or were rejected in Capacity Market auctions. Where a site has won a Capacity Market contract, it is modelled to connect in the contract delivery year in every scenario. Where a site has only prequalified in the Capacity Market, it is still projected to connect, buy delayed by a couple of years. Projects without Capacity Market information, which make up the majority of the sites with planning approval, are projected to connect between five and seven years from the date they obtained planning permission.
	Submitted planning application	490	Due to the size of the battery storage pipeline, only a small proportion of sites are likely to progress to installation and commissioning. Based on the FES 2024 outcomes at a GB level, and early information around NESO's Clean Power 2030 advice to the UK government, sites with granted planning permission are likely to represent enough capacity to meet 2030 and 2035 targets for large-scale battery storage capacity in NGED's licence areas. As a result, sites with submitted planning applications, pre-planning activity or no information have only been modelled to progress under the **Storage Planning** scenario. This scenario does not aim to be representative or credible at a licence area level, but instead models the connection of all batteries, with reasonable connection timelines, assessed on a per-project basis, to provide NGED with added insight into the scale of the current battery storage pipeline. In the four main DFES scenarios, only the very small proportion of sites that have positive Capacity Market activity but have not
	Pre-planning	817	
	No information	2,616	

		yet obtained planning permission are modelled to progress to build out, all within the late 2020s.
Rejected or withdrawn in planning, or abandoned	507	Sites that have been rejected in planning, withdrawn their application or been abandoned, do not progress under any scenario, including **Storage Planning**.

Projections

Scenario	Description
Holistic Transition **Electric Engagement** **Hydrogen Evolution** **Counterfactual**	In the four main DFES scenarios, the individual pipeline project evidence drives the vast majority of large-scale battery storage capacity deployment in the licence area. Additional deployment beyond the pipeline, starting in the early 2030s under the three net zero scenarios and the mid-2030s under the **Counterfactual**, is modelled mostly as battery storage co-located with the deployment of large-scale solar PV and onshore wind generation in the licence area across the 2030s and 2040s. Overall, post-pipeline development of large-scale battery storage is limited, owing to the high-levels of deployment in the 2020s and early 2030s as GB aims to achieve Clean Power by 2030 and a net zero power system by 2035. However, the deployment of battery storage continues in the licence area, through the uptake of small-scale battery installations in homes and businesses, as detailed in the small-scale battery storage section of this report. By 2050, in the South West licence area, installed large-scale battery storage capacity reaches 1.7 GW under **Holistic Transition**, 1.5 GW under **Electric Engagement**, 1.3 GW under **Hydrogen Evolution** and c. 0.9 GW under the **Counterfactual**.
Storage Planning	This scenario reflects an estimated connection year for the full pipeline of prospective projects only and does not project further capacity beyond this.

Uptake modelling factors

The below factors are used to inform the overall uptake of large-scale battery storage in the South West licence area.

Factor	Modelling impact	Source
Progress in planning	The planning status and date of planning activity are used as key factors to determine whether battery storage pipeline sites progress through to connection, and in what year, under each scenario.	Local planning portals NSIP database
Capacity Market activity	Activity of individual battery storage projects in T-4 and T-1 Capacity Market auctions is used as an indicator of	EMR Capacity Market Registers

	when projects are likely to be ready to connect rather than the likelihood of them being deployed. This is in response to stakeholder engagement that suggests that the Capacity Market is no longer a key component of the revenue stack for battery storage business models.	
Technical limits offers	Where a project has accepted a technical limit offer with NGED, this anticipated energisation date is used as the minimum year of connection for that project under any scenario.	NGED connections data
Statement of Works transmission reinforcement timelines	Where a project is impacted by a transmission-level Statement of Works, the anticipated completion year this is used as the minimum year of connection for that project under the **Counterfactual**.	NGED connections data
Pipeline of co-located generation	Where battery sites are co-located with generation sites, typically wind and solar, the year of connection for the generation component has been used to guide the year of connection for the battery component.	NGED DFES 2024 large-scale solar PV and onshore wind modelling
Future projections of co-located generation	Beyond the pipeline, further deployment of battery storage capacity in the late 2030s and 2040s is linked to the development of in large-scale solar PV and onshore wind generation.	NGED DFES 2024 large-scale solar PV and onshore wind modelling

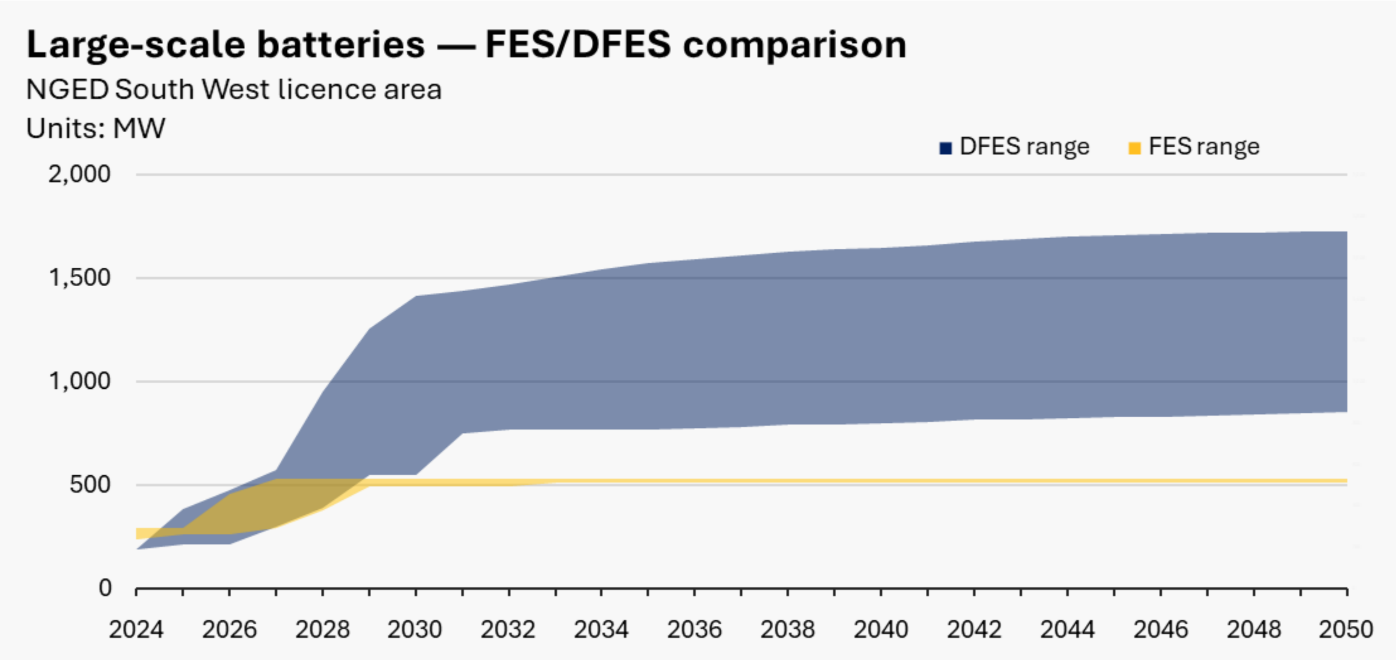
Spatial factors

The below factors are used to inform the spatial distribution of large-scale battery storage capacity across the South West licence area, down to 11 kV ESAs.

Factor	Modelling impact	Source
Location of existing baseline and pipeline sites	The vast majority of projected large-scale storage capacity is based on existing baseline and pipeline sites.	NGED connections data
Distribution of large-scale solar PV and onshore wind	Beyond the pipeline, the location of additional battery storage capacity in the late 2030s and 2040s is aligned to the distribution of large-scale solar PV and onshore wind capacity.	NGED DFES 2024 large-scale solar PV and onshore wind modelling

Reconciliation to FES 2024

The outcomes of the DFES modelling have been compared to the FES 2024 outcomes for the same licence area.



- The baseline and very near-term uptake of large-scale battery storage are both very well aligned between FES and DFES.
- From 2027 onwards, the DFES is significantly higher than the FES projections for the licence area. While there is substantial uncertainty around the proportion of the battery storage project pipeline that is likely to connect over the coming decade, the DFES analysis has only modelled sites to connect that have high-levels of positive development evidence, such as fully consented planning permission or Capacity Market contracts. This subset of the pipeline represents over 1 GW of potential future capacity. Therefore, the DFES scenarios, even though substantially higher than the FES, reflect a credible range of outcomes for these projects, based on site-by-site research and build-out timeframes, flexed by scenario.
- A relatively small amount of large-scale battery storage growth is projected in the DFES scenarios beyond the pipeline across the 2030s and 2040s. This is primarily based on battery storage co-located with large-scale solar PV and onshore wind sites. This is not reflected in the FES under any scenario, with large-scale battery storage capacity flatlining from the late 2020s in all scenarios, out to 2050.

Comparison to DFES 2023

- The modelling methods, business model assumptions and outcomes for large-scale battery storage are similar between DFES 2024 and DFES 2023.
- The assessment and assumptions around the future deployment of the pipeline have been more aggressive in DFES 2024, limiting uptake in all four scenarios to only sites with granted planning permission or positive Capacity Market activity. This results in slightly narrower range of 2050 scenario outcomes in the licence area, ranging from 0.9-1.7 GW in DFES 2024 compared to 0.8-1.8 GW in DFES 2023. This aims to reflect greater certainty around the role of battery storage in the energy system and an acknowledgement of the proposed reforms to connection policyand regional technology allocations proposed by NESO.

Endnotes

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