
# Distribution Future Energy Scenarios 2023

Results and assumptions report

**South Wales licence area**

Electricity Distribution

nationalgrid

# Foreword by National Grid DSO

April 2023 marked the start of the RIIO-ED2 price control period, throughout which planning and investment in the distribution network will be an important factor to enable our customers to reach their decarbonisation targets.

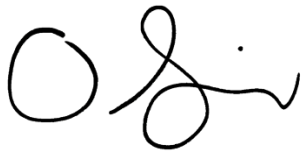
We have worked with Regen to help us understand what the changes that are forecast throughout the next decade and beyond might mean for our distribution network, and the investment that may be needed to meet customers' changing needs. These forecasts are the foundation of our strategic investment process, which is an ongoing analysis published biennially through the Network Development Plan (NDP). The NDP feeds into the Distribution Network Options Assessment process to determine the investment required to facilitate the UK's net zero ambitions while promoting a smart and flexible network. The next NDP will be published in May 2024 and will include the forecasts from DFES.

This report summarises the 2023 Distribution Future Energy Scenarios (DFES) study for the South Wales licence area. The network will see a large increase in distributed renewable generation and electricity storage connections. We predict high levels of low carbon technologies, such as electric vehicles and heat pumps and increasing household demand for electricity. The DFES study aims to understand where the growth of different technologies will be spatially distributed, which will materialise as load on our networks.

With our annual DFES cycle, we are able to incorporate and project new technologies in our analysis. In DFES 2023, we have added industrial heating to our projections and increased the granularity of our analysis down to Low Voltage (LV) level for several Low Carbon Technologies (LCT) to better inform reinforcement across our local networks. Additionally, we have continued to expand our engagement with Major Energy Users and industry representatives to better capture future changes in demand. As local authorities develop Local Area Energy Plans (LAEPs), we are continuing to proactively engage with them, ensuring that their ambitions are captured within our strategic investment process.

The scenario framework used in this study is heavily influenced by the UK and devolved government targets to reach net zero greenhouse gas emissions by 2050. Our projections provide a granular breakdown of the customers connected to the distribution network out to 2050, with three of the four scenarios being compliant with the UK 2050 net zero target.

This regional review is part of a wider suite of DFES documents hosted on our website alongside our interactive map. We welcome any feedback on the DFES process and outputs and will incorporate any suggestions into future forecasting activities.



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# Contents

# Glossary

| Short form | Definition | Short form | Definition |
|---|---|---|---|
| ACT | Advanced Conversion Technologies | GSP | Grid Supply Point |
| AD | Anaerobic Digestion | GW | Gigawatt |
| AONB | Area of Outstanding Natural Beauty | HGV | Heavy Goods Vehicle |
| ASHP | Air Source Heat Pump | HNDU | Heat Network Delivery Unit |
| CCGT | Combined-Cycle Gas Turbine | HNIP | Heat Network Investment Project |
| CCUS/CCS | Carbon Capture, (Utilisation) and Storage | HVO | Hydrotreated Vegetable Oil |
| CfD | Contract for Difference | IDNO | Independent Distribution Network Operator |
| CHP | Combined Heat and Power | kW | Kilowatts |
| DEFRA | Department for Environment, Food and Rural Affairs | LA | Local Authority |
| 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 |
| EfW | Energy from Waste | MCPD | Medium Combustion Plant Directive |
| EMR | Electricity Market Reform | MW (th, e) | Megawatts (thermal, electrical) |
| ENA | Energy Networks Association | NGED | National Grid Electricity Distribution |
| EPC | Energy Performance Certificate | OCGT | Open-Cycle Gas Turbine |
| ESA | Electricity Supply Area | ONS | Office for National Statistics |
| ESO | Electricity System Operator | OS | Ordnance Survey |
| EU | European Union | PHEV | Plug-in Hybrid Electric Vehicle |
| EV | Electric Vehicle | PV | (Solar) Photovoltaics |
| FES | National Grid ESO Future Energy Scenarios | REMA | Review of Electricity Market Arrangements |
| FiT | Feed-in Tariff | RHI | Renewable Heat Incentive |
| GB | Great Britain | SMR | Small Modular Reactor |
| GSHP | Ground Source Heat Pump | STOR | Short-Term Operating Reserve |

# Introduction to the National Grid Electricity Distribution DFES 2023

## Background

The National Grid Electricity Distribution (NGED) Distribution Future Energy Scenarios (DFES) provides granular scenario projections for:

- Distributed electricity generation, such as solar PV, wind, hydro, fossil-fuelled generation, waste 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.

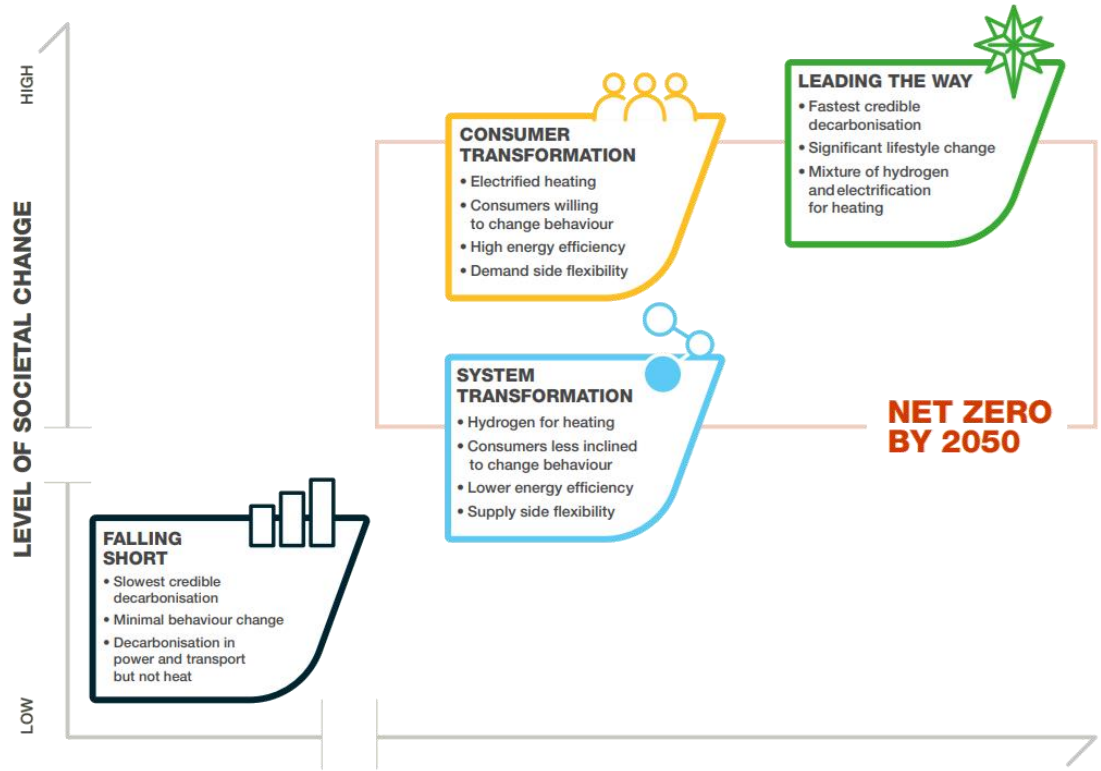
The DFES projections are directly informed by stakeholder engagement to reflect local and regional drivers, the ambitions of local authorities (including local area energy plans, where available) and national government targets and policies. The analysis is also influenced by the views of other sector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

For Distribution Network Operators (DNOs), 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.

## Scenarios

The NGED DFES uses the National Grid ESO Future Energy Scenarios (FES) 2023 as a framework, adopting the same national-level societal, technological, and economic assumptions as the FES: **Consumer Transformation**, **Falling Short**, **Leading the Way**, and **System Transformation**. However, the DFES is a bottom-up analysis of a changing energy system at a more granular level, reflecting specific regional and local factors. The DFES seeks to recognise and reflect that distributed energy, demand and storage will develop in different ways and at different paces across the country.

**Figure 1 – The National Grid ESO FES 2023 scenario framework**



## Scope

The NGED DFES 2023 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) Open Networks project.

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

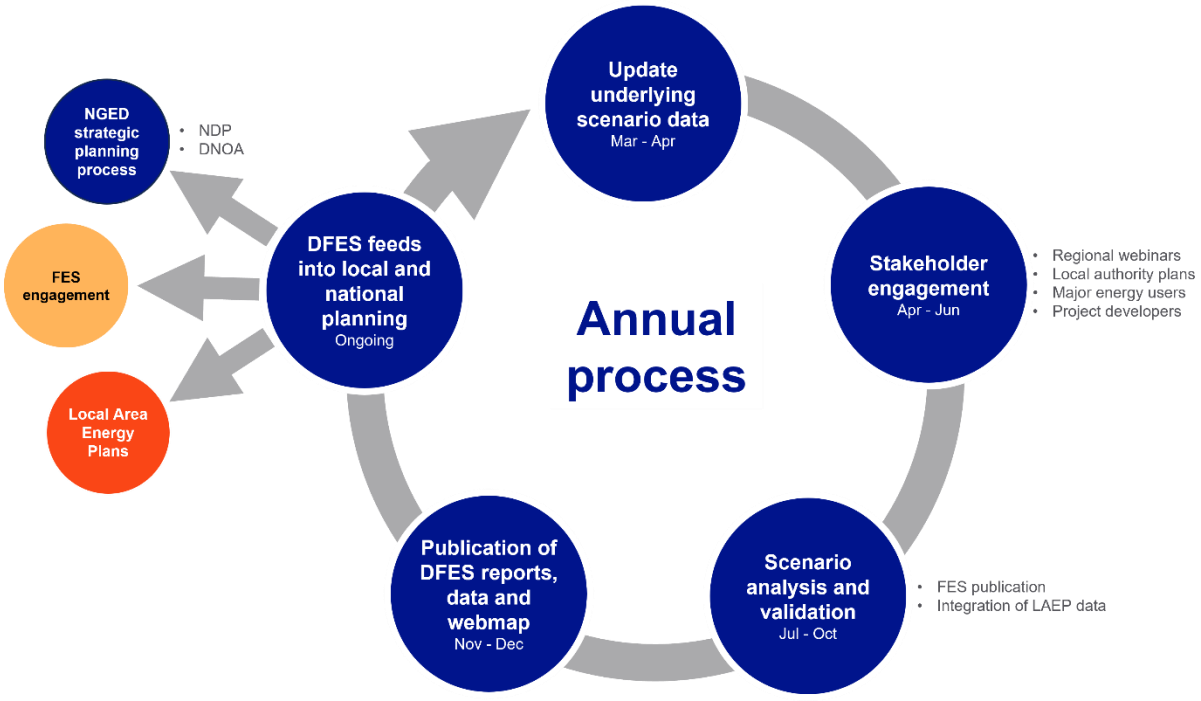
## Annual cycle

The NGED DFES is produced annually, allowing scenario projections to be regularly updated to reflect the most up-to-date information available. The DFES is published towards the end of the calendar year, a few months after the release of National Grid ESO FES. This allows the DFES 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 scenario and licence area. This annual cycle also allows for data sharing between the NGED DFES and the National Grid ESO FES teams, facilitating continuous improvement of the data quality, processes and scenario modelling.

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

The annual DFES outputs also feed into wider NGED strategic planning processes, such as Network Development Plans and Distribution Network Options Assessments for each of the four licence areas.

**Figure 2 – The NGED DFES annual process**



## Results

The NGED DFES 2023 analysis is produced to granular geographic areas known as Electricity Supply Areas (ESAs), of which there are four types:

- **Geographic ESA**: the geographic area as fed by a primary substation providing supplies at 11 kV or 6.6 kV.
- **Single customer ESA**: 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 connection agreement.
- **Low voltage ESA**: the geographic area as fed by a low voltage transformer, providing supplies at less than 11 kV. In the NGED DFES 2023, domestic-scale rooftop PV and batteries, electric heat and EV charger projections are produced at this highly granular level. The DFES 2023 is the first time this analysis has been carried out to low voltage granularity for the four NGED licence areas.

These ESAs are also split by local authority boundaries, allowing DFES data to be aggregated to local authority or primary substation level, allowing the data to 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 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. For previous DFES rounds, NGED has published the results of this process on their website.

## The South Wales licence area

The key features of the South Wales licence area are detailed in the following table and depicted in Figure 3 and Figure 4:

| Aspect | Characterisation |
|---|---|
| Geography | The NGED South Wales licence area is home to over 80% of the Welsh population, with around 1 million households and the urban areas in Cardiff, Newport, and Swansea. However, the majority of the land area itself is highly rural, across Mid Wales and the Brecon Beacons National Park. |
| Distributed electricity generation | Distributed electricity generation has changed a lot in recent years. Over 50% of capacity has connected since 2015. While over half of the total generating capacity is from onshore wind and solar PV, the largest power generation site in the licence area is the 40 MW Margam biomass energy plant near Port Talbot. |
| Energy resources | The South Wales licence area has significant solar PV and onshore wind resources, alongside potential for marine and floating offshore wind technologies. |
| Distributed electricity demand | Currently, less than 1% of South Wales households have an electric vehicle, and similarly less than 1% have an electric heat pump.<br>The licence area also hosts the South Wales Industrial Cluster, which is a major part of energy demand in the area. |
| Policy and government | The South Wales licence area is in Wales, and therefore impacted by Welsh government policy and UK government policy, depending on which matters are devolved. It also contains 18 local authorities, including the Forest of Dean and Herefordshire, which partially fall within the South Wales licence area despite being situated in England. |

**Figure 3 - The NGED South Wales licence area, with the location of existing 'baseline' large-scale generation and storage sites**

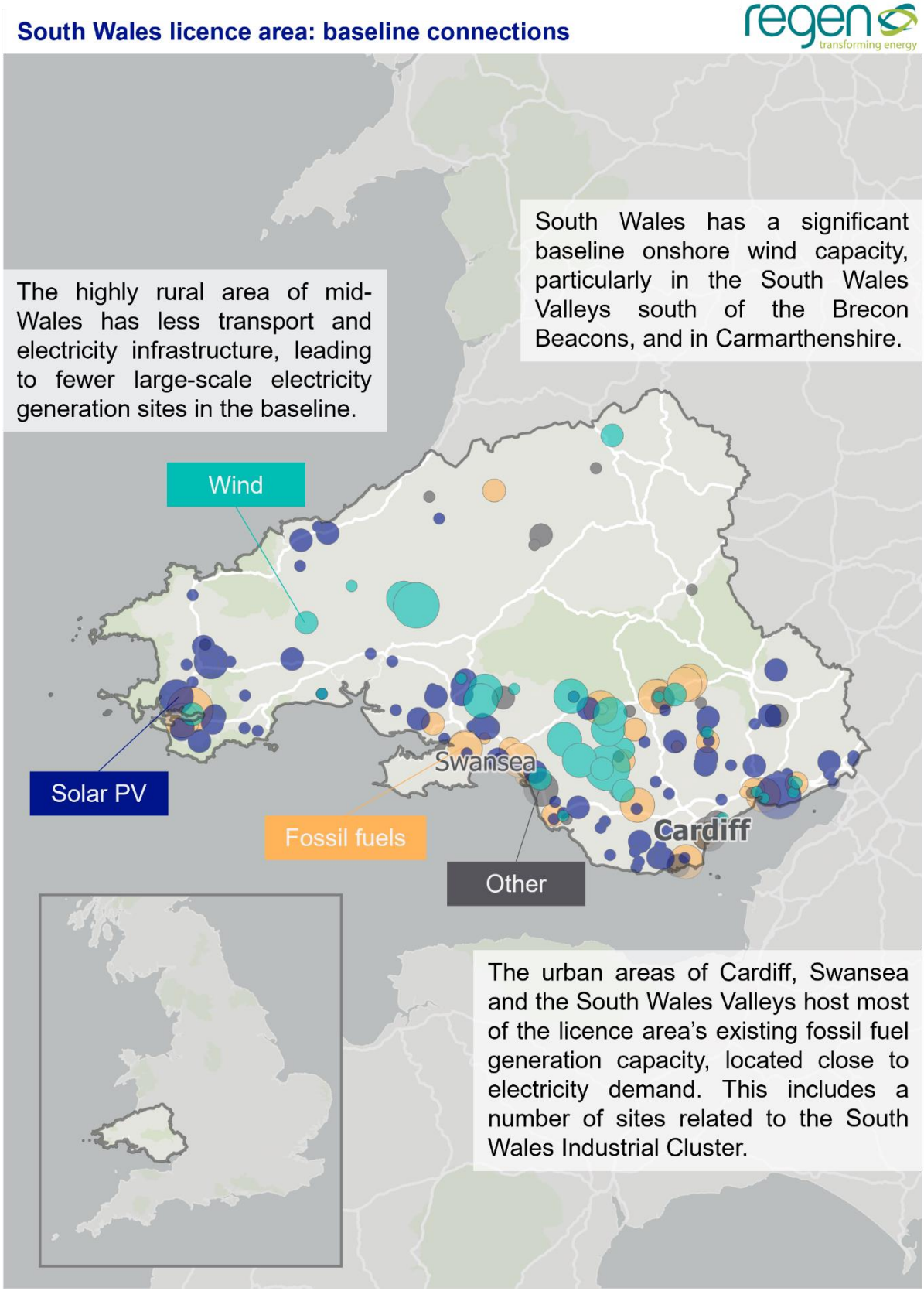
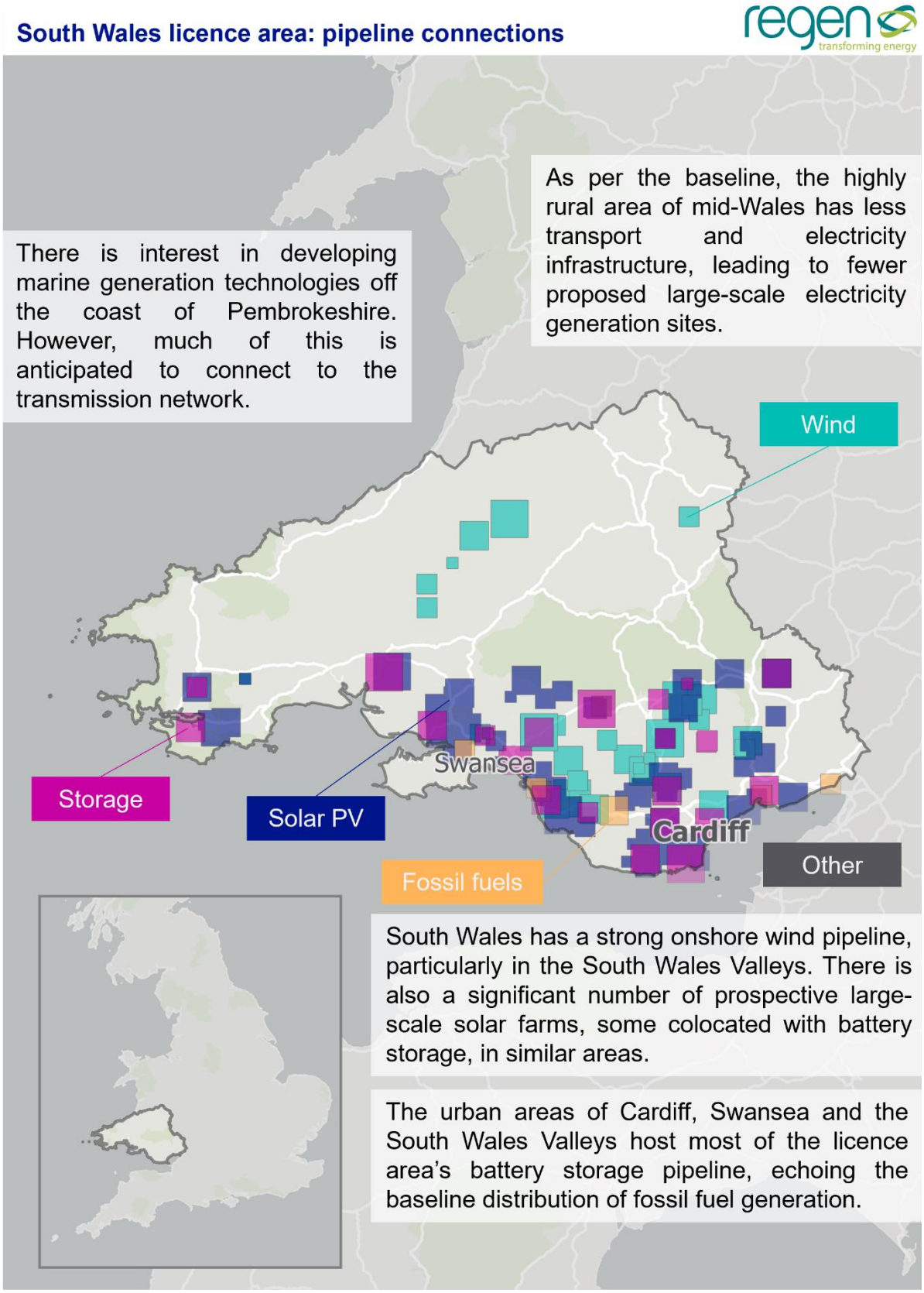


Figure 4 - The NGED South Wales licence area, with the location of proposed 'pipeline' large-scale generation and storage sites



# Methodology

This report details the analysis, assumptions and scenario outcomes for each individual technology in the 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 aspect | Characterisation |
|---|---|
| **Baseline analysis** | Existing generation, storage and demand connected to the distribution network are analysed to produce a baseline for the licence area. The 2023 baseline year represents the 2022/23 fiscal year, ending on 31 March 2023. This is based on NGED connection data, supplemented with project and energy subsidy programme registers, Department for Transport 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 planning approval, housing developments and proposed commercial development space in local authority planning documents. |
| **Scenario projections** | Key assumptions from the FES 2023 scenarios 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 engagement.

| 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 2023. These webinars aimed to allow a wide range of local stakeholders to communicate directly and 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 planning for new housing and commercial developments. In addition, where LAEP data was available, this was obtained and compared against the DFES scenarios to ensure the LAEP pathways are within the envelope of DFES scenario outcomes where applicable. |
| **Developer engagement** | Companies that are 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 electrolysis projects. |
| **Major energy user engagement** | A selection of large energy-consuming customers connected to NGED's network were contacted to seek views around decarbonisation plans, renewable energy deployment, flexibility technology uptake and electrification of heat and transport, if applicable. |

## Specific DFES aspects

While the scenario framework and high-level assumptions are driven by the FES 2023, a number of specific aspects of the current energy system have been considered in the DFES 2023 analysis:

| Aspect | Impact on DFES |
|---|---|
| **Reduced near-term projections under Falling Short** | Analysis of previous FES and DFES iterations suggests that projections for some small-scale technologies fall below the least-ambitious scenario, **Falling Short**. As a result, the near-term projections for these technologies have been reduced in order for the **Falling Short** scenario to provide NGED with a clearer low-case scenario to inform network planning. |
| **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.<br>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, 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 net zero emission targets.<br>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** | 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 **Falling Short** 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. |

## Energy policy

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, such as the Review of Electricity Market Arrangements (REMA) and the British Energy Security Strategy.

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, heat pump uptake and electric vehicle sales.

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. As a result, the potential impacts of these energy policies and wider economic context are assumed to be captured in this envelope of potential futures rather than being explicitly modelled in the DFES 2023.

This immediate impact, however, is considered to be reflected in the detailed analysis of the known pipeline of potential connections and the range of results under the four-scenario framework rather than being a distinct element of the modelling.

## Grid connections reform

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 given connection dates well into the 2030s.

As a result, grid connection processes are currently undergoing a number of reforms at both transmission and distribution levels. This could result in effective fast-tracking for projects that are 'shovel ready', requirements for holders of connection offers to demonstrate progression, and alternative forms of connection for assets such as battery storage, which would be generally expected to operate in a way that would alleviate constraints rather than add to them.

With regards to the DFES, the analysis is intentionally agnostic to constraints on the distribution network. This allows NGED to plan and upgrade the distribution network in areas where development is most suitable or targeted. However, the near-term projections are impacted by current network constraints, as these predominantly rely on the pipeline of accepted connections, which are naturally biased towards less constrained areas of the network where connection is more feasible in the near term.

Constraints on the transmission network, which are outside of NGED's control, are reflected under **Falling Short** only.

## Technologies not currently in scope

There are a small number of technologies that are not currently within the scope of DFES, but may be in the future. This includes:

- Maritime electrification – including vessels and associated chargers
- Aviation electrification – including planes and associated chargers
- Off-highway vehicle and plant electrification, such as agricultural vehicles and extractive industry vehicles, and associated chargers
- Electrification of industrial processes

While these technologies are currently out of scope of the DFES, they remain of interest and feature within the stakeholder engagement and research undertaken as part of the DFES process.


# Demand technologies

Results and assumptions

# Domestic electric heat in the South Wales licence area

**Domestic dwellings where electricity is the primary fuel for space heating and hot water, delivered through a heat pump or resistive electric heater.**

Data summary for domestic electric heat in the South Wales licence area:

| Number of homes (thousands) | | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|---|
| Non-hybrid heat pumps* (without thermal storage) | Falling Short | 7 | 23 | 77 | 331 |
| | System Transformation | | 29 | 60 | 197 |
| | Consumer Transformation | | 72 | 289 | 587 |
| | Leading the Way | | 84 | 306 | 426 |
| Non-hybrid heat pumps* with thermal storage | Falling Short | 0 | 12 | 39 | 189 |
| | System Transformation | | 14 | 31 | 94 |
| | Consumer Transformation | | 34 | 138 | 401 |
| | Leading the Way | | 44 | 165 | 350 |
| Hybrid heat pumps | Falling Short | 0 | 0 | 4 | 15 |
| | System Transformation | | 2 | 13 | 365 |
| | Consumer Transformation | | 2 | 9 | 32 |
| | Leading the Way | | 3 | 37 | 145 |
| Connections to heat pump-driven district heat networks | Falling Short | 0 | 3 | 10 | 47 |
| | System Transformation | | 2 | 9 | 65 |
| | Consumer Transformation | | 2 | 16 | 78 |
| | Leading the Way | | 2 | 16 | 66 |
| Resistive electric heating | Falling Short | 59 | 59 | 56 | 49 |
| | System Transformation | | 57 | 50 | 23 |
| | Consumer Transformation | | 57 | 52 | 41 |
| | Leading the Way | | 59 | 52 | 43 |

***** Note the heat pump figures shown are both Air Source Heat Pump (ASHP) and Ground Source Heat Pump (GSHP) projections combined. A full breakdown of heat technologies is included towards the end of the domestic heat chapter.

Summary:

- The South Wales licence area has a high proportion of on-gas homes, particularly around the dense urban areas of Cardiff, Swansea and Newport. These will require conversion to a form of low carbon heating by 2050 in order to meet both the UK and Welsh governments' carbon reduction targets.
- Under **Consumer Transformation** and **Leading the Way**, heat is primarily decarbonised via heat pumps in both the South Wales licence area and at a national level. Initial uptake is mostly modelled to occur in off-gas houses and well-insulated houses, before a wider-scale rollout of heat pumps across the majority of the housing stock is modelled out to 2050. For the South Wales licence area, this results in c. 1 million homes operating a form of heat pump by 2050 under **Consumer Transformation**.

- Under **System Transformation**, decarbonisation of heat is driven primarily by low carbon hydrogen, either through standalone hydrogen boilers or hybrid heat pumps. With a high proportion of on-gas homes and a potential hydrogen hotspot in the South Wales Industrial Cluster, this results in the vast majority of homes in the South Wales licence area converting to hydrogen boilers or hydrogen hybrid heat pumps by 2050.
- Under **Falling Short**, progress towards heat decarbonisation is slow, and despite some uptake of heat pumps in the late 2030s and the 2040s, many homes remain heated by fossil gas boilers in 2050, as the UK fails to meet its carbon emissions reduction targets.
- Heat-pump-driven heat networks see high uptake across Cardiff and other dense population centres in the licence area under the three net zero scenarios as a low carbon form of heating well suited to urban areas or areas proximal to a waste heat source.
- The number of households on resistive electric heating decreases in all scenarios, replaced by 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.

Figure 5 – Summary of domestic electric heating technologies by scenario, South Wales licence area

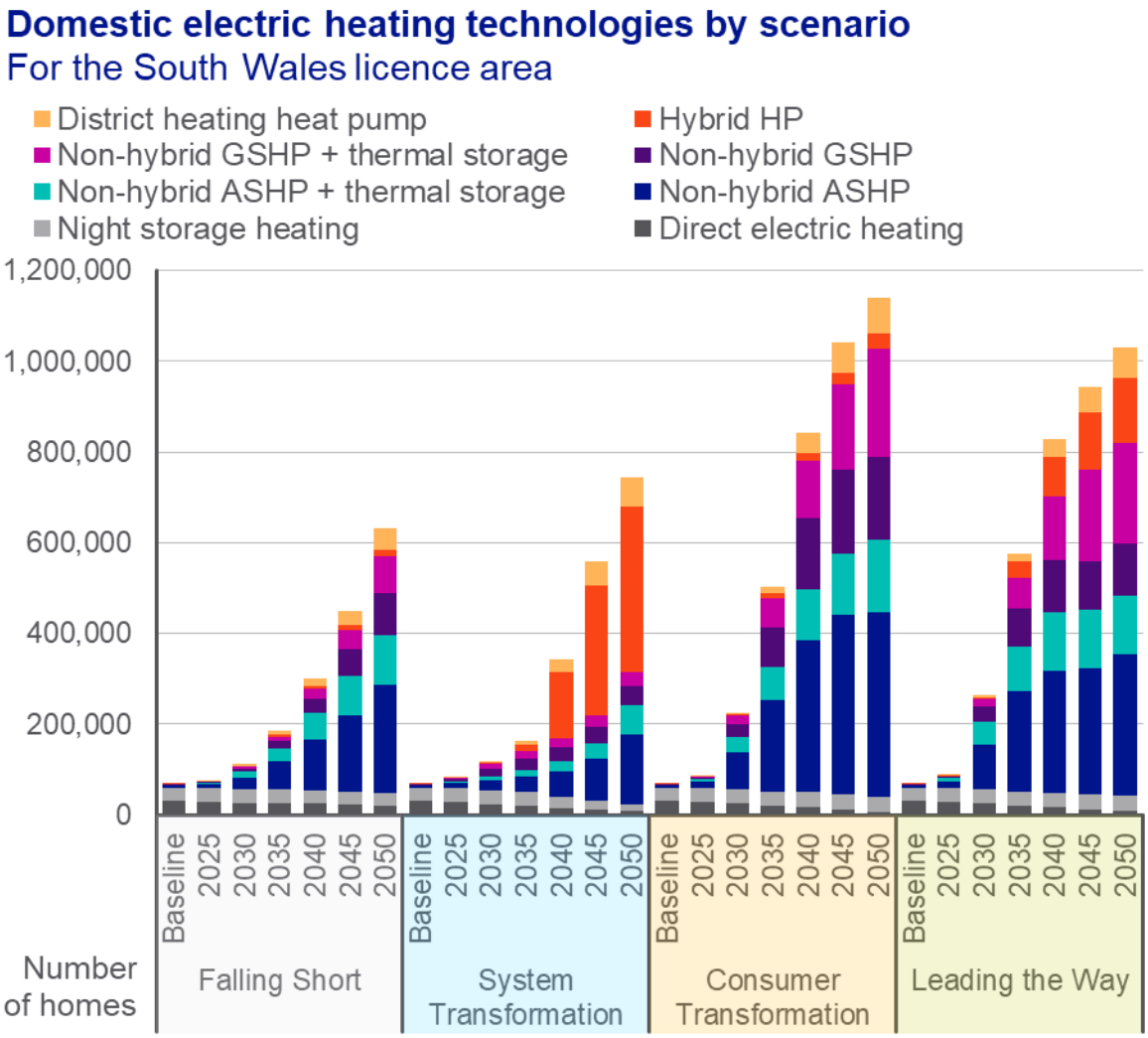
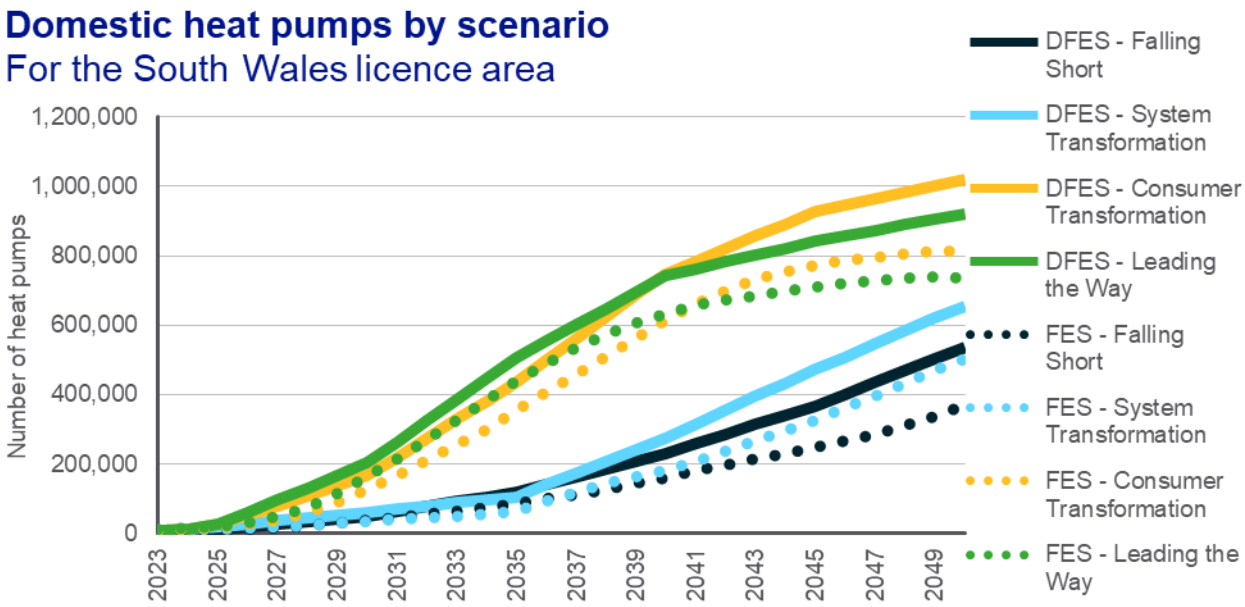


Figure 6 – Number of domestic heat pumps (hybrids and non-hybrid) by scenario, South Wales licence area




## Modelling assumptions and results

**Baseline**

Heat pumps

Most heat pumps in existing homes 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 0.7% of existing homes with a heat pump in the licence area is slightly below the national average. This is likely due to the higher proportion of on-gas houses, as much of the current heat pump uptake has been in off-gas homes.

| Sub-technology | Number of homes | Proportion of homes |
|---|---|---|
| Non-hybrid ASHP | 6,261 | 0.6% |
| Non-hybrid GSHP | 1,154 | 0.1% |
| Hybrid heat pump | 16 | 0.0% |
| Heat pump-driven district heat network | 0 | 0.0% |

Due to a lack of evidence, the modelling assumes no thermal storage (such as a hot water cylinder) as a 'worst case' for existing heat pumps.

Resistive electric heating

Resistive electric heating is less common in South Wales compared to the national average, heating around 6% of homes compared to 8% nationally.

This is due to a high level of on-gas homes in built-up areas, while off-gas homes in more rural areas of the licence area are more commonly heated by oil.

The resistive electric heating baseline has been revised down since DFES 2022 as a result of Census 2021 data being released.

| Sub-technology | Number of homes | Proportion of homes |
|---|---|---|
| Night storage heaters | 28,852 | 2.7% |
| Direct electric heaters | 30,294 | 2.8% |

**Near-term projections (April 2023 to March 2028)**

The estimated uptake of different types of electric heating is modelled based on a number of key factors assessed for the licence area, including housing types, current heating systems and sociodemographic factors. Across the net zero scenarios, the uptake of heat pumps is projected to increase significantly by 2026, particularly in off-gas homes heated by oil and LPG etc., while the number of homes heated by resistive electric heating is projected to slowly decrease under every scenario in the near term.

Near-term connections to heat pump-driven heat networks are based on the existing pipeline of planned heat networks. Heat networks that are well advanced in planning, such as the Swansea Waterfront development, are modelled to connect in the near term under every scenario.

Heat pumps

| Scenario | Description | % of homes with a heat pump, 2028 | |
|---|---|---|---|
| | | South Wales | GB (FES) |
| **Leading the Way** | The uptake of ASHP and GSHP heat pumps is highest in these scenarios, as GB progresses towards its 2028 goal of 600,000 installations per year.<br>Off-gas and well-insulated homes are modelled to have particularly high uptake; however, a small proportion of on-gas houses and flats also convert to a heat pump, supported by the Boiler Upgrade Scheme. As a result, the South Wales licence area sees a similar near-term uptake of heat pumps relative to GB overall.<br>Under **Leading the Way**, many of these heat pumps are equipped with thermal storage, either via a conventional hot water tank or a more modern heat battery. | 12% | 11% |
| **Consumer Transformation** | | 10% | 10% |
| **System Transformation** | Near-term decarbonisation of heat is low under these scenarios, with heat pump uptake restricted to off-gas housing, replacing oil, LPG and resistive electric heating, and well-insulated homes in which a heat pump installation is likely to be easiest. This is linked to a longer-term strategy to introduce low carbon hydrogen supply and hydrogen boilers under **System Transformation**. | 4% | 6% |
| **Falling Short** | | 3% | 6% |

Resistive electric heating

| Scenario | Description | % homes with resistive heating in 2028 | |
|---|---|---|---|
| | | South Wales | GB (FES) |
| **Leading the Way** | Under these two scenarios, around 5% of houses and flats heated by resistive electric heating convert to a heat pump by 2026.<br>A similar proportion of direct electric heated homes convert to night storage heaters in order to reduce heating costs. | 5% | 8% |
| **Consumer Transformation** | | 5% | 7% |

| | | | |
|---|---|---|---|
| System Transformation | A very small proportion of resistive electric heated homes convert to a heat pump under these scenarios in the near term. However, a greater proportion move onto the mains gas network in order to reduce heating costs.<br>Similarly to the other two scenarios, a small proportion of direct electric heated homes convert to night storage heaters. | 5% | 7% |
| **Falling Short** | | 5% | 7% |

**Medium and long-term projections (April 2028 to March 2050)**

Heat decarbonisation accelerates in the medium and long term across GB, especially under the three net zero scenarios, as the country aims to meet its decarbonisation targets.

Under two of the scenarios, **Consumer Transformation** and **Leading the Way**, heat pumps are the main means of decarbonising heating in on-gas and off-gas properties, alongside district heat networks, driven by heat pumps or waste heat in dense urban areas or areas near a waste heat source, such as thermal or heavy industry.

Under **System Transformation** and **Falling Short**, heat pump uptake is more limited. Under **System Transformation** specifically, this is due to hydrogen boilers becoming the preferred heating technology for on-gas homes. Under **Falling Short**, decarbonisation of heat is slower across the country, and heat pump uptake is mainly limited to off-gas homes in the medium term.

New build homes are modelled to increasingly include low carbon heating appliances, mainly in the form of heat pumps or connections to a district heat network, under every scenario. A strong increase in heat pump uptake is modelled in new build homes from 2025, following a successful implementation of the Welsh Building Regulations Part L.

Heat pumps

| Scenario | Description | % homes with a heat pump in 2050 | |
|---|---|---|---|
| | | South Wales | GB (FES) |
| **Leading the Way** | Under these scenarios, many on-gas homes have converted to a heat pump by 2035, driven by a national shift in heating technologies.<br>Under both scenarios, heat pumps with thermal storage increase in popularity in the late 2020s and 2030s, enabling shifting of domestic demand to lower cost periods of the day.<br>By 2050, almost all domestic properties are heated by heat pumps, district heating or resistive electric heating. A small number of homes are heated by hydrogen boilers or hydrogen hybrid heat pumps under **Leading the Way** only. | 81% | 80% |
| **Consumer Transformation** | | 91% | 92% |
| **System Transformation** | Heat pump uptake in on-gas homes is minimal in the medium term under this scenario, except for a small proportion of homes that install a hybrid hydrogen heat pump. This is a result of low carbon hydrogen being anticipated to replace the fossil gas network in the 2030s and 2040s under this scenario. Otherwise, the majority of heat pump uptake is limited to off-gas houses and new build homes.<br>Uptake of heat pumps increases substantially in the 2040s, particularly hydrogen hybrid heat pumps, | 60% | 60% |

| | | | |
|---|---|---|---|
| | which represent around one-third of all heat pumps in this scenario. The remainder of homes are heated by hydrogen boilers under this scenario. | | |
| **Falling Short** | Heat pump uptake in on-gas homes is minimal, as fossil gas heating remains the most common form of heating under this scenario. Otherwise, the majority of heat pump uptake is in off-gas houses in the medium term.<br>Long-term progress towards net zero is slow, and by 2050, many homes are still heated by fossil gas, despite a substantial heat pump uptake in the 2040s. | 49% | 53% |
| Resistive electric heating | | | |
| **Scenario** | **Description** | **% homes with resistive heating in 2050** | |
| | | **South Wales** | **GB (FES)** |
| **Leading the Way** | The overall number of resistive heated homes continues to decrease over time, replaced by district heating in denser urban areas and flats, and standalone heat pumps elsewhere. Direct electric heated homes that cannot convert to these technologies generally shift to night storage heating, enabling shifting of demand to lower cost periods of the day. | 4% | 5% |
| **Consumer Transformation** | | 3% | 5% |
| **System Transformation** | The overall number of resistive heated homes decreases over time, replaced by connections to the fossil gas or hydrogen network. Direct electric heated homes that cannot convert to these technologies generally shift to night storage heating, enabling shifting of demand to lower cost periods of the day. | 2% | 2% |
| **Falling Short** | | 4% | 5% |

### Reconciliation with National Grid FES 2023

- The DFES outcomes for total heat pumps under each scenario are broadly aligned with the FES 2023 data, albeit with slightly higher overall outcomes under every scenario by 2050. This could be due to differences in the total housing stock modelled in the FES and DFES.
- In the near term, uptake of heat pumps in South Wales is higher in the DFES in all scenarios. The property archetype-based heat analysis in the DFES models near-term heat pump uptake mostly in off-gas dwellings, new build homes, and owner-occupied homes, driven by direct stakeholder engagement in all four NGED licence areas. In some of these metrics, the South Wales licence area is above the overall GB average. The modelling of new-build housing developments and their associated heating technologies also has a major impact on near-term uptake.

### Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| Current heating technology, categorised into on-gas, resistive electric heating, and off-gas (predominantly heating oil) | EPC data, ONS Census |
| Building type, categorised into semi-detached and detached houses, terraced houses, and flats | EPC data, ONS Census |

| | |
|---|---|
| Tenure, categorised into owner-occupied, private rented and socially rented | EPC data, ONS Census |
| Construction age band, categorised into pre-1930 and post-1930 construction. This aligns with the NGED DEFENDER project. | EPC data |
| Areas with potential for district heat networks, or an existing heat network pipeline project | Heat network pipeline data[i] and Opportunity Areas for District Heat Networks in the UK[ii] - BEIS |

## Large-scale heat pumps for district heating

As discussed in this section, domestic properties connecting to heat-pump-driven district heat networks have been modelled under the four DFES scenarios. Similarly, floorspace of non-domestic properties connecting to a heat network has also been modelled.

Informed by analysis of heat network project and procurement pipelines[iii], National Grid ESO FES data and assumptions, and best practice guides from e.g. CIBSE[iv] and BSRIA[v], the electrical capacity of the large-scale heat pumps driving future district heat networks has been projected under the four DFES scenarios, based on the domestic and non-domestic connections in each scenario.

It should be noted that heat network design is complex and effectively unique to each heat network based on the geography and topology of each area, the anchor loads and secondary loads of the network and its subsections, and supplementary sources of heat, such as waste heat from industrial processes.

Several assumptions have been made in the calculation of large-scale heat pump capacity:

- In alignment with the National Grid ESO FES, future district heat networks are assumed to be predominately driven by a heat pump, coupled with thermal storage but supported by a secondary gas, biomethane or hydrogen-fuelled boiler to provide additional heat during periods of peak demand. As a result, this reduces the diversified demand on the heat pump element of the heat network to approximately 1 kW per domestic connection and just under 10 W per sqm of non-domestic floorspace.
- Heat network connections and the location of large-scale heat pumps to drive these networks have been located based on DESNZ's Opportunity Areas for District Heating Networks in the UK[ii]. This National Comprehensive Assessment accounts for the heating and cooling demand on prospective district heating networks, alongside sources of heat such as waste-to-energy plants, waste heat and air, ground and water-source heat pumps.
- The heat networks are assumed to be planned ahead of need in each scenario rather than directly matching demand in each year of the analysis. In the modelling, large-scale heat pumps are based on the demand three years ahead of the installation date and in stages of 50 kWe.

As a result of this modelling, capacity of large-scale heat pumps for district heating ranges in South Wales in 2050 ranges from 51 MW under **Falling Short** to 85 MW under **Consumer Transformation**.

# Non-domestic electric heat in the South Wales licence area

**Non-domestic premises where electricity is the primary fuel for space heating and hot water, delivered through a heat pump or resistive electric heater.**

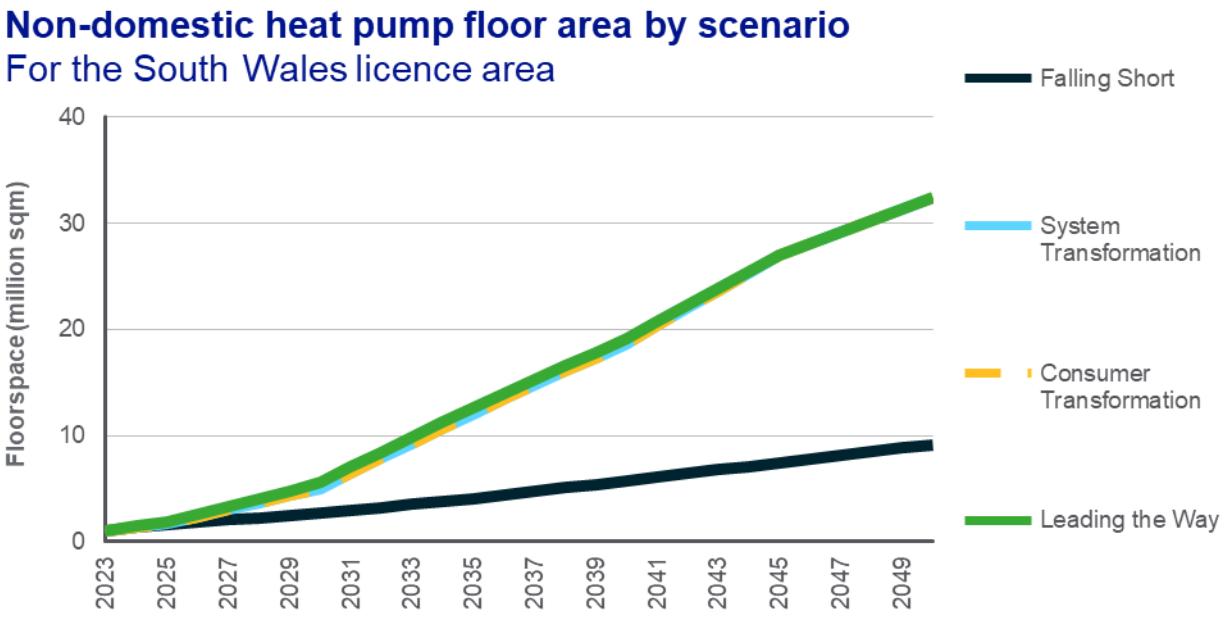
Data summary for non-domestic electric heat in the South Wales licence area:

| Total floorspace (million sqm) | | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|---|
| Heat pumps | Falling Short | 1 | 2 | 4 | 9 |
| | System Transformation | | 4 | 12 | 32 |
| | Consumer Transformation | | 4 | 12 | 32 |
| | Leading the Way | | 4 | 13 | 32 |
| Resistive electric heating | Falling Short | 5 | 5 | 5 | 5 |
| | System Transformation | | 5 | 4 | 2 |
| | Consumer Transformation | | 5 | 4 | 2 |
| | Leading the Way | | 4 | 3 | 2 |

Summary:

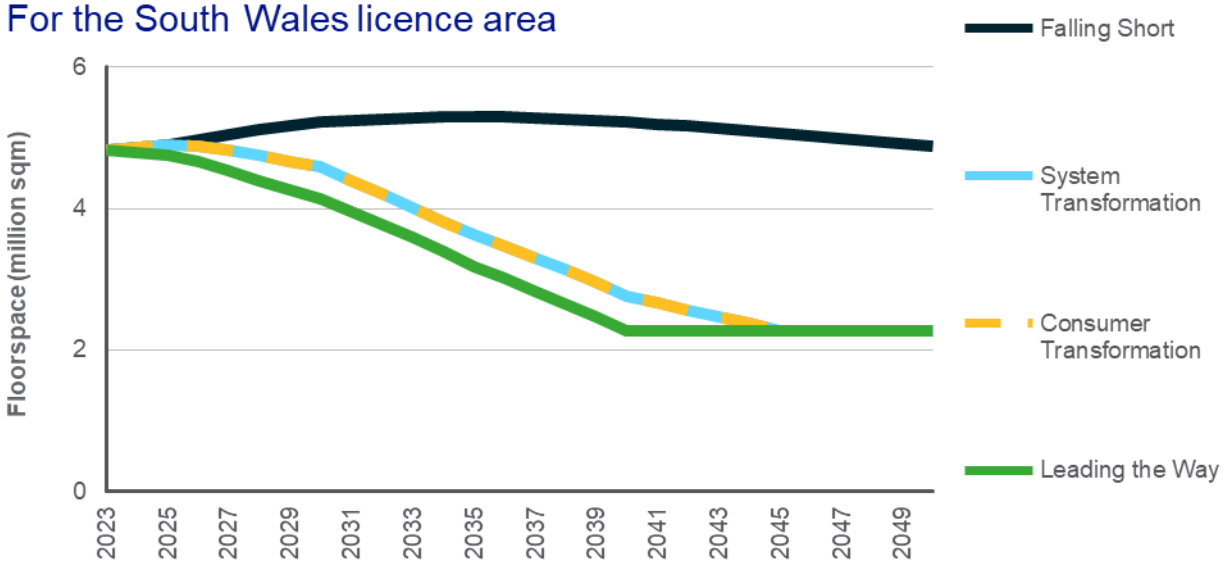
- Heating in non-domestic buildings is currently dominated by gas-fired central heating, resistive electric heating and air conditioning.
- A DESNZ evidence update of low carbon heating and cooling in non-domestic buildings[vi] found that non-domestic building decarbonisation pathways are strongly influenced by the existing heating system and HVAC environment.
- In the three net zero scenarios, this results in buildings currently heated by gas, oil or LPG moving to an air-source or ground-source heat pump or connecting to a district heat network, while most buildings with resistive electric heating moving to more efficient air-to-air heat pumps, operating similarly to air conditioners.
- Under **Falling Short**, similarly to domestic heat, progress towards decarbonisation of buildings is slow for all types of non-domestic buildings.

Figure 7 – Non-domestic floorspace heated by heat pumps by scenario



## Non-domestic resistive electric heating by scenario

For the South Wales licence area




### Modelling assumptions and results

| Baseline | | |
|---|---|---|
| Analysis of EPC and DEC data suggested that 5 million square meters of floorspace is heated by resistive electric heating. This does not include buildings with air conditioning that are recorded as predominantly providing cooling.<br>EPC and DEC data do not record whether a building is heated by a heat pump. As a result, the heat pump baseline is informed by MCS installation data. | **Technology** | **Total floorspace (million sqm) and proportion*** |
| | Heat pumps | 1<br>(2%) |
| | Resistive electric heating | 5<br>(10%) |

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

| Near-term projections (April 2023 to March 2028) | | | |
|---|---|---|---|
| **Scenario** | **Description** | **Total heated floorspace (million sqm) and proportion by 2028** | |
| | | **Heat pumps** | **Resistive electric** |
| **Leading the Way** | 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. By 2030, around 20% of these buildings are heated by a heat pump under the three net zero scenarios.<br>Towards the end of the 2020s, the pipeline of new heat networks is built out, and a number of non-domestic buildings begin to connect.<br>For new build non-domestic properties, electric | 4<br>(8%) | 4<br>(9%) |
| **Consumer Transformation** | | 4<br>(8%) | 5<br>(10%) |
| **System Transformation** | | 4<br>(8%) | 5<br>(10%) |

| | | | |
|---|---|---|---|
| | heating quickly becomes the dominant technology. This follows a trend which has seen new build electric heating in new build non-domestic properties growing from under 40% of floorspace in 2018 to 70% of floorspace in 2023. | | |
| **Falling Short** | Progress towards heat decarbonisation is slow, with small, incremental uptake of heat pumps in off-gas and direct electric heated buildings. | 2 (5%) | 5 (11%) |

| **Medium and long-term projections (April 2028 to March 2050)** | | | |
|---|---|---|---|
| **Scenario** | **Description** | **Total heated floorspace (million sqm) and proportion by 2050** | |
| | | **Heat pumps** | **Resistive electric** |
| **Leading the Way** | Non-domestic heat decarbonisation accelerates in the 2030s, with a high proportion of buildings shifting to electrified heat by 2040. | 32 (57%) | 2 (4%) |
| **Consumer Transformation** | In currently gas-heated premises, air-source and ground-source heat pumps are preferred where a district heating connection is not available. | 32 (57%) | 2 (4%) |
| **System Transformation** | In premises with direct electric heating, moving to an air-to-air heat pump is more suitable. | 32 (57%) | 2 (4%) |
| **Falling Short** | Progress towards heat decarbonisation remains slow, with many properties remaining heated by natural gas by 2050. Much of the heat pump uptake that is achieved is in the form of direct electric heating shifting to air-to-air heat pumps. | 9 (16%) | 5 (9%) |

### Reconciliation with National Grid FES 2023

- As the FES non-domestic heat outputs are reported in numbers of installations rather than heated floorspace. The modelling aims to mirror the high-level outcomes from non-domestic heating in each of the four FES scenarios.

### Factors that will affect deployment at a local level

| **Factor** | **Source** |
|---|---|
| Current heating technology of each non-domestic building | Non-domestic EPC and Display Energy Certificate data |
| Building environment of each non-domestic building, including heating demand, cooling demand and HVAC system. | Non-domestic EPC and Display Energy Certificate data |
| Existing baseline of non-domestic heat pump installations | MCS installation data |
| Areas with potential for district heat networks, or an existing heat network pipeline project | Heat network pipeline data[vii], and Opportunity Areas for District Heat Networks in the UK[viii] - BEIS |

# Electric vehicles and EV chargers in the South Wales licence area

**Pure electric and plug-in hybrid electric vehicles and associated domestic and non-domestic electric vehicle chargers required to charge them.**

Data summary for electric vehicles in the South Wales licence area:

| Number of vehicles (thousands) | | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|---|
| Battery electric cars, LGVs and motorbikes | Falling Short | 13 | 93 | 441 | 1,425 |
| | System Transformation | | 116 | 667 | 1,321 |
| | Consumer Transformation | | 235 | 1,043 | 1,316 |
| | Leading the Way | | 211 | 1,107 | 1,061 |
| Plug-in hybrid electric cars, LGVs and motorbikes | Falling Short | 7 | 32 | 90 | 35 |
| | System Transformation | | 30 | 74 | 4 |
| | Consumer Transformation | | 24 | 47 | 2 |
| | Leading the Way | | 31 | 40 | 3 |
| Battery electric HGVs, buses and coaches | Falling Short | 0 | 0 | 2 | 20 |
| | System Transformation | | 1 | 5 | 15 |
| | Consumer Transformation | | 1 | 6 | 24 |
| | Leading the Way | | 1 | 7 | 23 |

Data summary for EV chargers in the South Wales licence area:

| Capacity of chargers (MW) | | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|---|
| Domestic chargers | Falling Short | 85 | 406 | 1,529 | 3,709 |
| | System Transformation | | 495 | 2,171 | 3,597 |
| | Consumer Transformation | | 1,041 | 4,209 | 5,280 |
| | Leading the Way | | 946 | 4,516 | 5,874 |
| Non-domestic chargers | Falling Short | 40 | 120 | 304 | 994 |
| | System Transformation | | 147 | 523 | 977 |
| | Consumer Transformation | | 197 | 614 | 805 |
| | Leading the Way | | 194 | 660 | 838 |

Summary:

- Over 1% of vehicles in the South Wales 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.
- Under **Consumer Transformation** and **Leading the Way**, passenger vehicles such as cars and LGVs are rapidly electrified over the 2020s and 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 in these scenarios. In these scenarios, EVs become the default new car choice regardless of any ban on petrol and diesel vehicle sales in the 2030s.

- Under **System Transformation**, the electrification of vehicles is slightly slower. Additionally, a higher availability of low carbon hydrogen in this scenario results in a small number of passenger and non-passenger vehicles being fuelled by hydrogen.
- The electrification of transport is slowest under **Falling Short**. While by 2050 the vast majority of vehicles are still electrified, a high proportion of this electrification occurs in the 2040s.
- Regen's EV charger model determines the charger capacity required to charge the number of vehicles projected under each of the four DFES scenarios, split across a number of different domestic and non-domestic charger types, such as rapid en-route chargers and slow and fast chargers in public car parks. In addition, eHGV chargers have been modelled as their own category, with deployment centred on HGV service stations along the strategic road network.
- By 2050, total EV charger capacity in South Wales ranges between 5 GW and 7 GW.

Figure 8 – Number of plug-in (battery electric and hybrid) cars, LGVs and motorcycles by scenario, South Wales licence area

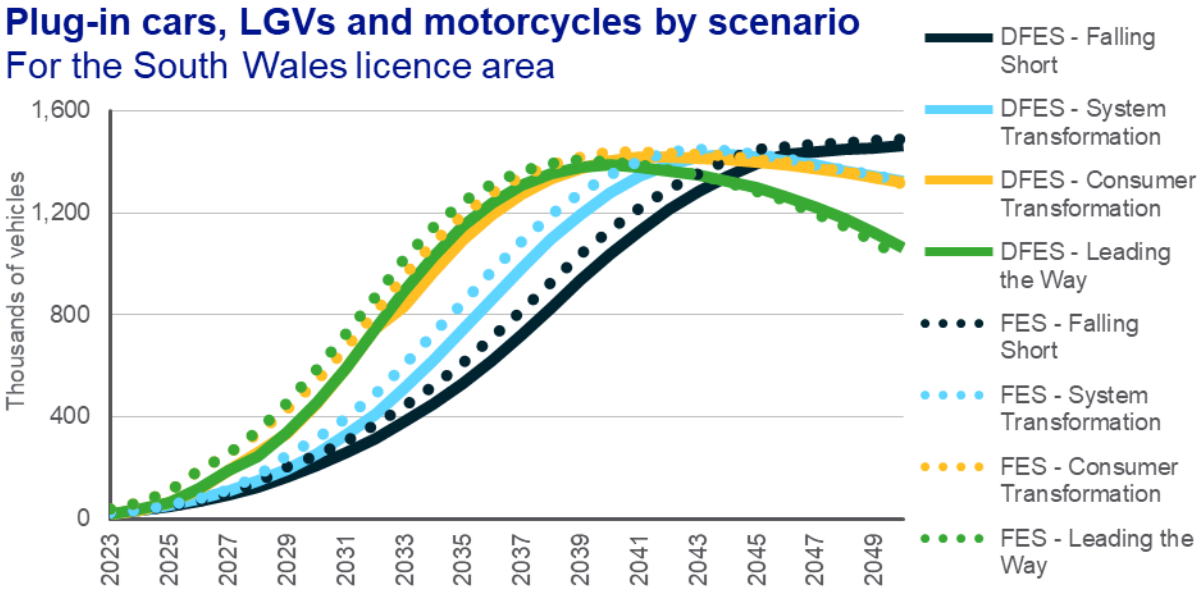
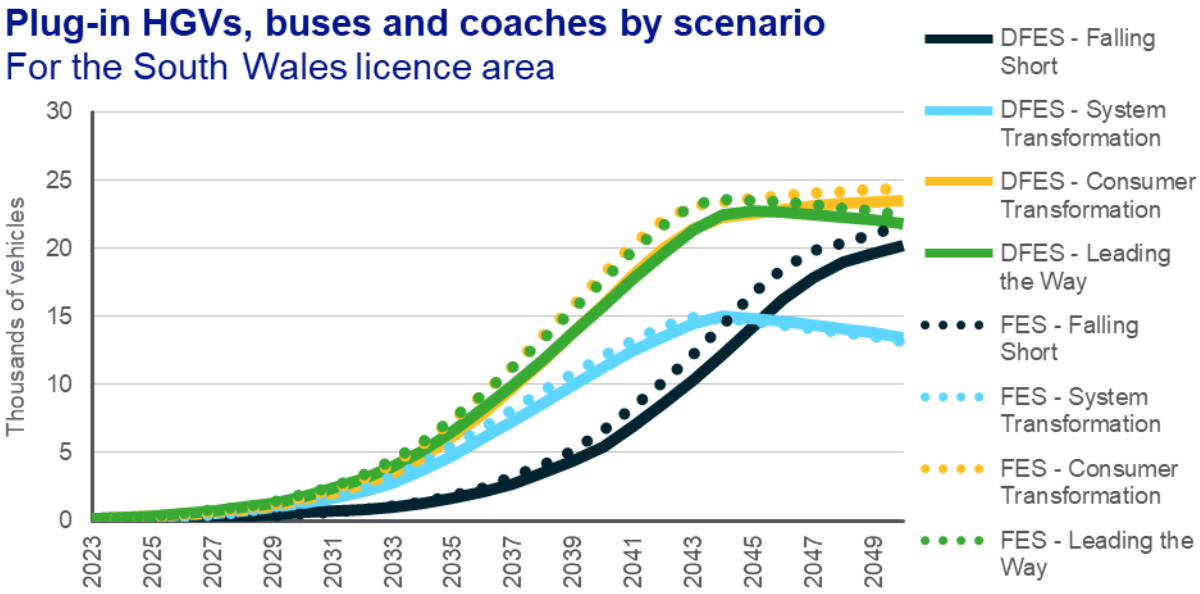



Figure 9 – Number of plug-in (battery electric and hybrid) HGVs, buses and coaches by scenario, South Wales licence area



**Baseline**

Electric vehicles

The electric vehicle baseline represents 1.3% of vehicles registered in the South Wales licence area. This is around half of the uptake in the neighbouring South West and East Midlands licence areas.

Uptake of electric vehicles across the UK has been steadily accelerating. This has been due to a number of factors, including favourable tax benefits and grant support, increasing consumer confidence and electrification of commercial vehicle fleets.

While the vast majority of electric vehicle uptake has centred on cars, other vehicles are also beginning to see uptake. In particular, sales of electric LGVs have significantly increased in the last two years.

| Vehicle type | Thousands of vehicles |
|---|---|
| Pure electric car | 11 |
| Plug-in hybrid car | 7 |
| Pure electric LGV | 1 |
| Other electric vehicles | 1 |

EV chargers

As the number of electric vehicles has increased, the number and capacity of EV chargers has similarly increased. In addition to most domestic EV owners having a home charger, non-domestic chargers in the form of car park chargers, workplace charging and rapid en-route chargers on forecourts have seen an increasing rollout in recent years.

| Charger type | Capacity (MW) |
|---|---|
| Domestic | 85 |
| Non-domestic | 40 |

**Near-term projections (April 2023 to March 2028)**

The acceleration in EV uptake seen over the past few years is anticipated to continue under every scenario, however the extent of this varies under the four future scenarios.

Charger uptake is tied to EV uptake, with domestic and non-domestic chargers continuing to be installed in order to meet demand. This is augmented by the known pipeline of accepted connection offers for major EV charger installations connecting to the NGED distribution network, predominantly in the form of en-route charging hubs at service stations on major M and A roads such as the M4.

| Scenario | Description | Total plug-in vehicles by 2028 (000s) | EV charger capacity by 2028 (MW) |
|---|---|---|---|
| **Leading the Way** | Uptake of electric vehicles and EV chargers rapidly increases under these scenarios, driven by favourable financial conditions for EVs and increasing consumer confidence. | 243 | 1,140 |
| **Consumer Transformation** | The majority of EV charger capacity is domestic chargers in this period. However, uptake of rapid en-route and on-street chargers increases substantially. | 260 | 1,238 |
| **System Transformation** | Uptake of electric vehicles increases substantially, but less rapidly than the other two scenarios due to lower levels of consumer engagement. However, over 5% of cars are electrified by 2025 under both scenarios. | 147 | 642 |
| **Falling Short** | The majority of EV charger capacity is domestic chargers in this period. However, uptake of rapid en-route and on-street chargers increases substantially. | 125 | 526 |

**Medium and long-term projections (April 2028 to March 2050)**

The uptake of electric vehicles and EV chargers is modelled to continue accelerating between 2025 and 2035 across all scenarios. Between 2030 and 2035, major reductions in the sale of petrol and diesel cars and vans result in electric vehicles representing the vast majority of new vehicles in this period. Recent policy uncertainty around the end of sales of petrol and diesel vehicles is reflected in the three net zero scenarios.

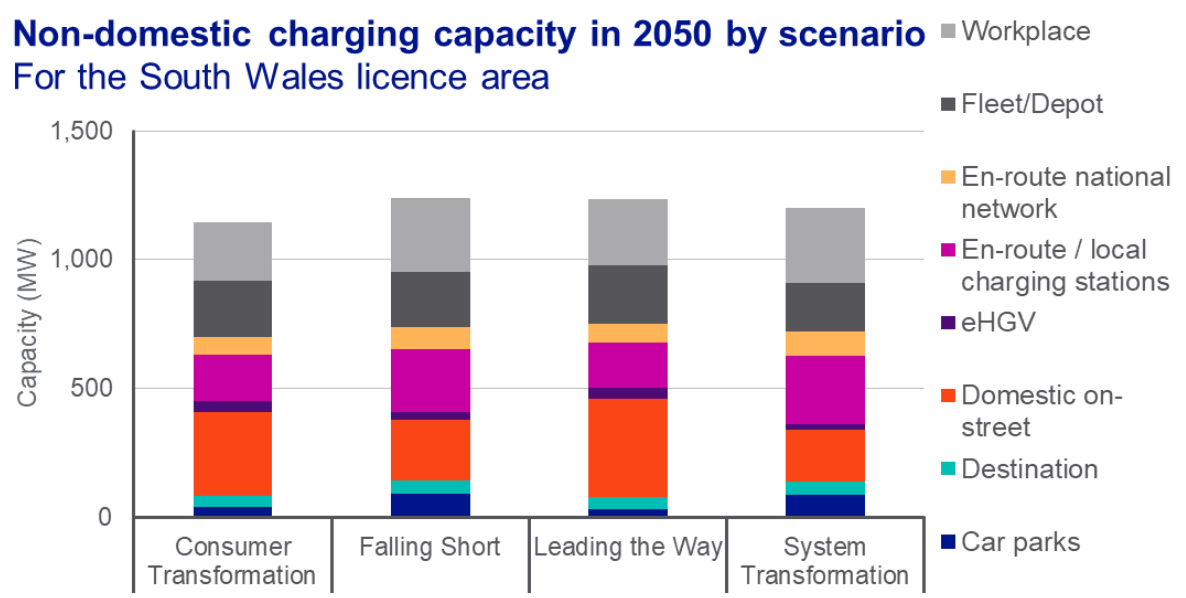
By 2035, the installation rate of EV chargers slows. Homes with multiple EVs are assumed not to purchase a second charger at the same rate as their first, and the demand for additional public charging reduces as the majority of vehicles are electrified under net zero scenarios by this point.

In the longer term, under the three net zero scenarios, EV adoption approaches saturation and new EV uptake slows in most areas. Harder-to-electrify vehicles that saw lower uptake in the near term, such as HGVs, 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. It is assumed that while EV numbers may reduce in the 2040s under some scenarios, installed EV chargers will remain in place but see lower utilisation as the overall number of vehicles on the road decreases.

| Scenario | Description | Total plug-in vehicles by 2050 (000s) | EV charger capacity by 2050 (MW) |
|---|---|---|---|
| **Leading the Way** | EVs dominate new car and LGV sales from the late 2020s under these scenarios, and from 2030 almost all new cars and LGVs are electric. Harder-to-electrify vehicles such as buses and HGVs also see accelerated uptake in the medium-term, with the majority of road vehicles electrified by 2035.<br><br>With such a rapid shift toward battery electric vehicles, plug-in hybrid vehicles see relatively little uptake, and begin to decline in the 2030s.<br><br>EV uptake is facilitated by a widespread rollout of domestic and non-domestic charging. This includes a specific eHGV charger category, with 350 kW and 1 MW chargers at major service stations.<br><br>Under **Leading the Way**, in addition to the above, overall vehicle ownership falls as car sharing via autonomous vehicles, active travel and greater use of public transport reduce the need for private vehicle ownership under this scenario. | 1,087 | 6,712 |
| **Consumer Transformation** | | 1,342 | 6,085 |
| **System Transformation** | 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 medium-term, but hydrogen-fuelled alternatives also begin to be adopted, limiting EV uptake for these vehicles.<br><br>Plug-in hybrid vehicles see moderate uptake, with battery electric vehicles being the dominant EV technology across all vehicle classes.<br><br>While domestic charging is most common, rapid en-route charging also sees high uptake under this scenario. | 1,340 | 4,574 |

| | | | |
|---|---|---|---|
| **Falling Short** | 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.<br>Plug-in hybrid vehicles see moderate uptake, but battery electric vehicles are the dominant EV technology across all vehicle classes. | 1,480 | 4,703 |

Breakdown of non-domestic EV charging capacity in 2050 by scenario




## Reconciliation with National Grid FES 2023

- As the EV market and provision of EV charging infrastructure are heavily driven by national factors, the DFES projections for EVs and EV chargers in the licence area strongly mirror the national FES outcomes.
- The different EV charger subtechnologies are not broken down in the FES 2023 data at a GSP, licence area or national level. As such, a reconciliation is not possible. For vehicle efficiencies, mileage and vehicle numbers, FES projections and assumptions were used to inform the DFES analysis, where available.

## Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| The baseline of existing electric vehicles and petrol/diesel vehicles strongly informs the uptake of future electric vehicles | DfT statistics |
| The baseline and pipeline of existing EV chargers is used as an indicator for the location of projected EV chargers | DfT data, NGED data, National Chargepoint Registry, Open Charge Map |
| Access to off-street and on-street parking, affluence and rurality are considered in the near-term uptake of electric vehicles and the associated off-street and on-street domestic EV chargers | ONS Census |
| The location of petrol/diesel fuelling stations is used to indicate the location for projected en-route EV chargers | OS Addressbase |
| The location of car parks, workplaces and fleets/depots are used to indicate the location of projected car park, workplace and fleet/depot EV chargers. | OS Addressbase |

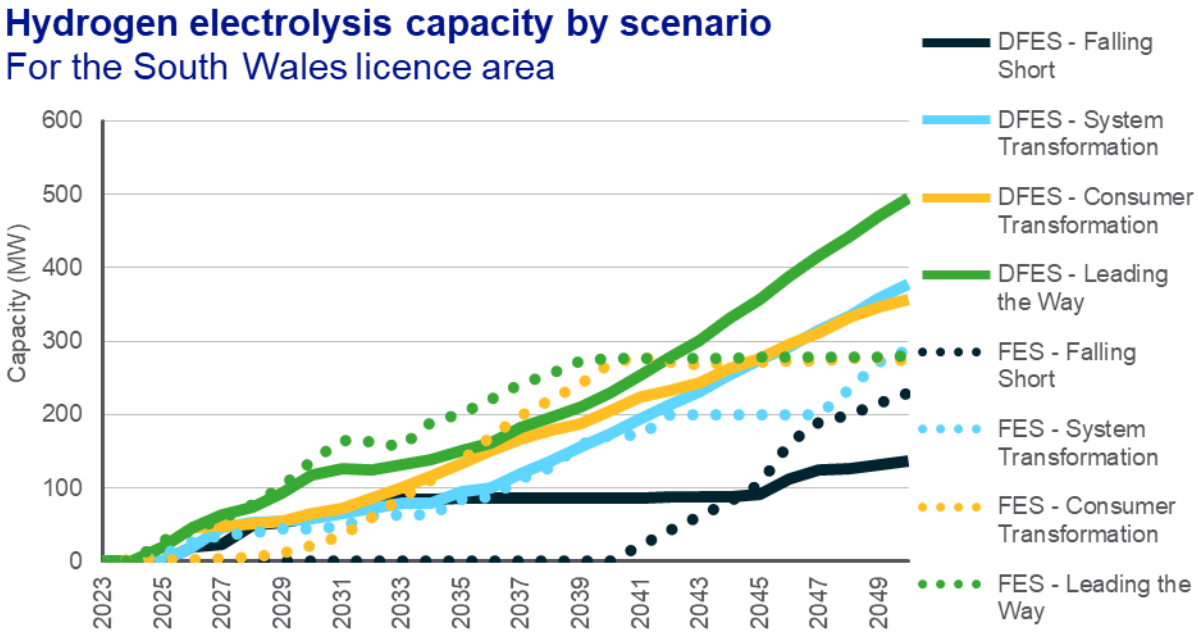
# Hydrogen electrolysis in the South Wales licence area

**Capacity of distribution network connected hydrogen electrolysers. This does not include CCUS-enabled hydrogen produced via the reformation of natural gas.**

Data summary for hydrogen electrolysis uptake in the South Wales licence area:

| Capacity (MW) | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|
| **Falling Short** | 0.1 | 49 | 86 | 137 |
| **System Transformation** | | 52 | 94 | 378 |
| **Consumer Transformation** | | 51 | 133 | 358 |
| **Leading the Way** | | 75 | 150 | 495 |

Figure 10 – Installed capacity of hydrogen electrolysis by scenario, South Wales licence area




Summary:

- Hydrogen is currently produced at scale via reformation of fossil gas with carbon dioxide released directly into the atmosphere. In the future, hydrogen will be produced either via electrolysis, where water is split into component molecules of hydrogen and oxygen using electricity, or via reformation of fossil gas with carbon capture and storage.
- Hydrogen electrolysis is not a new technology but is yet to be commercially deployed at scale. There is still significant uncertainty around hydrogen's role in decarbonising the economy. The deployment of hydrogen electrolysis is a potentially disruptive source of electricity demand on the electricity distribution network, with uncertainty around where and when electrolyser developers might connect to the distribution network in the future.
- The UK Government has set a target of 10 GW of low carbon hydrogen production capacity by 2030, with 5 GW to come from hydrogen electrolysis. Based on analysis of planning applications, Regen estimates there is currently less than 100 MW of electrolyser capacity connected across Great Britain.

- **Leading the Way** and **System Transformation** see significant deployment of hydrogen as an energy vector and gas networks are assumed to be developed to enable nationwide hydrogen distribution. In **Consumer Transformation** and **Falling Short**, hydrogen demand is significantly lower and hydrogen distribution networks are not developed.
- There is currently 0.1 MW of electrolyser capacity connected to the distribution network in the South Wales licence area and a strong pipeline of five projects with cumulative capacity of at least 53 MW with evidence of progress through the planning system in South Wales.
- In the medium and long term, projections for electrolyser capacity are modelled based on expected supply and demand drivers for electrolytic hydrogen in each licence area under each of the four future scenarios.
- South Wales is one of the regions with the highest existing demand for hydrogen, including two refineries located in Pembrokeshire, which drives projections for hydrogen capacity, particularly in **Falling Short** and **Consumer Transformation** scenarios.
- South Wales has very high levels of maritime activity, which is an important factor in the long-term demand for electrolysed hydrogen under the **System Transformation** and **Consumer Transformation** scenarios and to a lesser extent in **Leading the Way.**
- The combination of strong renewable generation potential (particularly wind), evidence of projects already locating in the region, proximity to National Gas' planned Project Union hydrogen transmission backbone, and significant existing industrial energy demand result in electrolysis capacity projections of nearly 500 MW in South Wales by 2050 under **Leading the Way**.

### Modelling assumptions and results

**Baseline**

There is currently one electrolyser with 0.1 MW capacity connected to the distribution network in the South Wales licence area. This project is located in Swansea.

**Near-term (April 2023 to March 2028)**

The projections for distribution network connected electrolyser capacity until 2025 are based on evidence of progress through the planning system.

There is a strong pipeline of electrolyser projects in the South Wales licence area with capacity totalling at least 53 MW. The pipeline consists of 5 projects, some of which are not proposing to connect to the distribution network:

- 7.4 MW project in Bridgend (non-networked)
- 20 MW project in Pembrokeshire
- 17.5 MW project in Monmouthshire
- 8 MW project in Merthyr Tydfil
- Project in Bridgend (capacity unknown)

There are also projects in development without accepted connection offers or planning system progress that do not influence the projections:

- The South Wales Industrial Cluster, a partnership between Welsh industry, energy suppliers, infrastructure providers, academia, and public sector organisations, has been awarded £1.5 million in UKRI funding. The project aims to establish a hydrogen economy in South Wales, focused on heavy industry.
- The Trecwn Green Energy Hub, a green hydrogen project in Pembrokeshire developed by Statkraft. The project is looking to supply trains running on the central Wales train line, as well as Pembrokeshire Council's fleet of HGVs and local buses.

After 2025, the projections are based on a combination of project evidence and long-term modelling as described in the **Medium and long-term** section below.

| Pipeline project details | Scenario | Connection date | |
|---|---|---|---|
| Sites with planning approval | **Falling Short** | 1.5 years | From approval |
| | **System Transformation** | 1.5 years | |
| | **Consumer Transformation** | 1 year | |
| | **Leading the Way** | 1 year | |
| Sites with planning submitted | **Falling Short** | 2 years | From submission |
| | **System Transformation** | 2 years | |
| | **Consumer Transformation** | 1.5 years | |
| | **Leading the Way** | 1.5 years | |
| Sites with some pre-planning evidence | **Falling Short** | 2027 | |
| | **System Transformation** | 2026 | |
| | **Consumer Transformation** | 2026 | |
| | **Leading the Way** | 2026 | |

**Medium and long-term (April 2028 to March 2050)**

The projections for distribution network connected electrolyser capacity from 2028 to 2050 are based on the national projections from FES 2023. The proportion of these national capacity projections that are located within the licence area is based on a regional analysis of hydrogen supply and demand factors, which are weighted based on the overall level of distributed hydrogen assumed under the four scenarios.

An assessment of hydrogen supply and demand factors for all GB licence areas was completed, enabling the presence of these factors in South Wales (compared to the rest of GB) to be determined. These factors were used to inform the level of electrolytic hydrogen production and thus the projected capacity of hydrogen electrolysis by scenario.

For example, one factor used was future hydrogen transmission network coverage. This was determined using the proportion of the length of proposed hydrogen transmission pipelines in each licence area, using National Gas's published plans under Project Union.

The weightings applied to these factors were derived from assumptions in the FES scenario framework and the volume of hydrogen demand projected in each sector in each scenario.

As a result of this analysis, hydrogen electrolysis capacity reaches almost 0.5 GW by 2050 under **Leading the Way**.

| Scenario | Capacity by 2050 (MW) |
|---|---|
| **Falling Short** | 137 |
| **System Transformation** | 378 |
| **Consumer Transformation** | 358 |
| **Leading the Way** | 496 |

| Scenario | Regional supply considerations | Regional demand considerations |
|---|---|---|
| **Falling Short** | Hydrogen distribution networks are not developed under this scenario, so hydrogen production and demand are matched at a | In the medium and long term, hydrogen demand is primarily driven by the industrial sector, with road transport accounting for less than 10% of overall demand in the |

| | | |
|---|---|---|
| | local level.<br><br>Electrolyser projects are therefore limited overall in the medium and long term and located close to hydrogen demand. | licence area.<br><br>In the long term, power generation grows to provide approximately 20% of demand. |
| **System Transformation** | **Medium-term:** These scenarios see high levels of hydrogen blended into the existing methane supplied through the gas network. This means the coverage of the existing gas network infrastructure is an important regional supply consideration in this scenario.<br><br>**Long-term:** The development of a hydrogen distribution pipeline network is a defining characteristic of electrolysis development under these scenarios. This reduces the need for demand and production to be as locally tethered and allows hydrogen production sites to be developed in areas that are most appropriate. This results in a balance between the proximity to the hydrogen gas transmission system, renewable energy projects (including for co-location) and sources of low carbon hydrogen demand. | **Medium-term:** demand for hydrogen is driven mainly by blending into gas distribution networks for end-use in I&C, residential and power generation applications.<br><br>**Long-term:** residential heat becomes the greatest demand for hydrogen out to 2050. Hydrogen is used across all sectors (by order of demand share):<br><br>• Residential heating<br>• Industrial & commercial<br>• Shipping<br>• Road transport<br>• Power generation<br>• Aviation<br>• Rail |
| **Leading the Way** | | **Medium-term:** demand is driven mainly by blending into the gas distribution networks for end-use in I&C, residential and power generation applications.<br><br>**Long-term:** blending is replaced with direct use in the same three sectors. Shipping demand grows to become the largest demand sector. Demand for hydrogen for aviation grows but remains small. |
| **Consumer Transformation** | Hydrogen production and demand are matched at a regional level because hydrogen distribution networks are not developed. Electrolyser projects are therefore limited and located close to hydrogen demand. | **Medium-term:** shipping, power generation and industrial activity are all significant demand sectors.<br><br>**Long-term:** shipping demand grows to become the largest sector, and a small amount of demand comes from aviation in addition to power generation and industry. |

| Hydrogen distribution factors | | | | | |
|---|---|---|---|---|---|
| Factor | Scenario weighting | | | | Level in South Wales |
| | Leading the Way | Consumer Transformation | System Transformation | Falling Short | |
| Industrial energy demand | High | High | High | High | Medium |
| Heavy transport demand | Low | Medium | Medium | High | Low |
| H2 transmission network coverage | Medium | Low | Medium | Low | Medium |
| Location of maritime activity | Medium | High | High | Low | High |
| Gas distribution network coverage | High | Low | High | Low | Low |
| Gas-powered electricity generation | Medium | High | Medium | Medium | Medium |
| Hydrogen innovation projects | High | High | High | High | Medium |
| Location of aviation activity | Low | Low | Low | Low | Low |
| Existing grey hydrogen demand sites | Medium | Low | Low | High | High |
| Renewable electricity generation | Medium | Low | Low | Low | Medium |

### Reconciliation with National Grid FES 2023

- In the Net Zero compliant scenarios hydrogen electrolyser capacity in the DFES exceeds that projected in the FES 2023 across the projection timeline to 2050. In the very long term, in **Falling Short**, the FES projections exceed the DFES, though South Wales remains the leading NGED licence area for hydrogen electrolysis capacity.
- In scenarios where year-on-year capacity increases are high (such as **System Transformation** and **Leading the Way**) the DFES projections are likely to be significantly higher than the FES 2023. In the FES, if the year-on-year increase in capacity in a Grid Supply Point (GSP) exceeds 50 MW, then the capacity is allocated to the transmission network; if it is less than 50 MW, then it is allocated to the distribution network. In contrast, the DFES takes the total electrolyser capacity across Great Britain allocated to distribution networks in the FES and distributes this down to individual licence areas. Therefore, the DFES is much less likely to forecast 0 MW capacity increases in an individual licence area.

### Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| Location of key development zones for hydrogen production and demand, such as airports and potential hydrogen storage. | Regen analysis |
| Location of heavy industry energy users. | National Atmospheric Emissions Inventory |
| Location of heavy transport and fuelling hubs, using road traffic counts for light commercial vehicles, heavy goods vehicles and buses and coaches. | Department for Transport |

# New developments in the South Wales licence area

**New-build property developments, including new housing and new non-domestic sites.**

Data summary for new domestic developments in the South Wales licence area:

| Houses (thousands) | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|
| **Falling Short** | -* | 32 | 84 | 146 |
| **System Transformation** | | 40 | 96 | 155 |
| **Consumer Transformation** | | 40 | 96 | 155 |
| **Leading the Way** | | 53 | 106 | 166 |

* there are currently around 1.05 million domestic customers in the South Wales licence area.

Data summary for new non-domestic developments in the South Wales licence area:

| Floorspace (sqm, 100,000s) | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|
| **Falling Short** | -* | 15 | 40 | 53 |
| **System Transformation** | | 16 | 44 | 53 |
| **Consumer Transformation** | | 16 | 44 | 53 |
| **Leading the Way** | | 16 | 48 | 53 |

* there are currently around 95 thousand non-domestic customers in the South Wales licence area. Floorspace recorded in EPC and DEC data totals 46 million sqm.

Summary:

- The development of new housing and non-domestic sites represents future hotspots of conventional electricity demand, as these new developments are constructed and occupied over the scenario timeframe.
- The modelling of new developments is based on direct engagement with local authorities' planning departments and analysis of local planning documents submitted to Regen. These detail the planning stages of each new development, i.e., 'under construction', 'full planning permission', or allocated land space for future use.
- The local planning documents provide data out to 2042, so new long-term housing developments were modelled based on an analysis of ONS household projections.
- By 2050, this modelling results in between 146,000 and 166,000 new homes in the South Wales licence area across the scenarios, representing a 23-26% increase in the number of domestic houses between 2023 and 2050.
- An additional 5.3 million square meters of non-domestic floorspace is also modelled in the licence area under each DFES scenario.

Figure 11 – Cumulative planned and total new housing developments by scenario, South Wales licence area

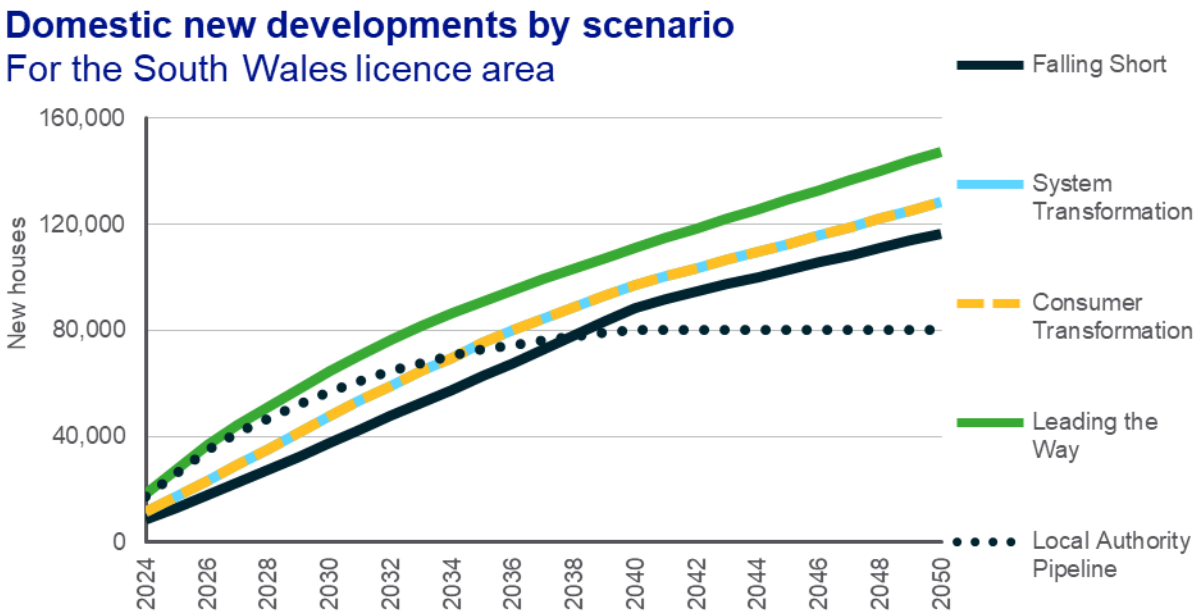
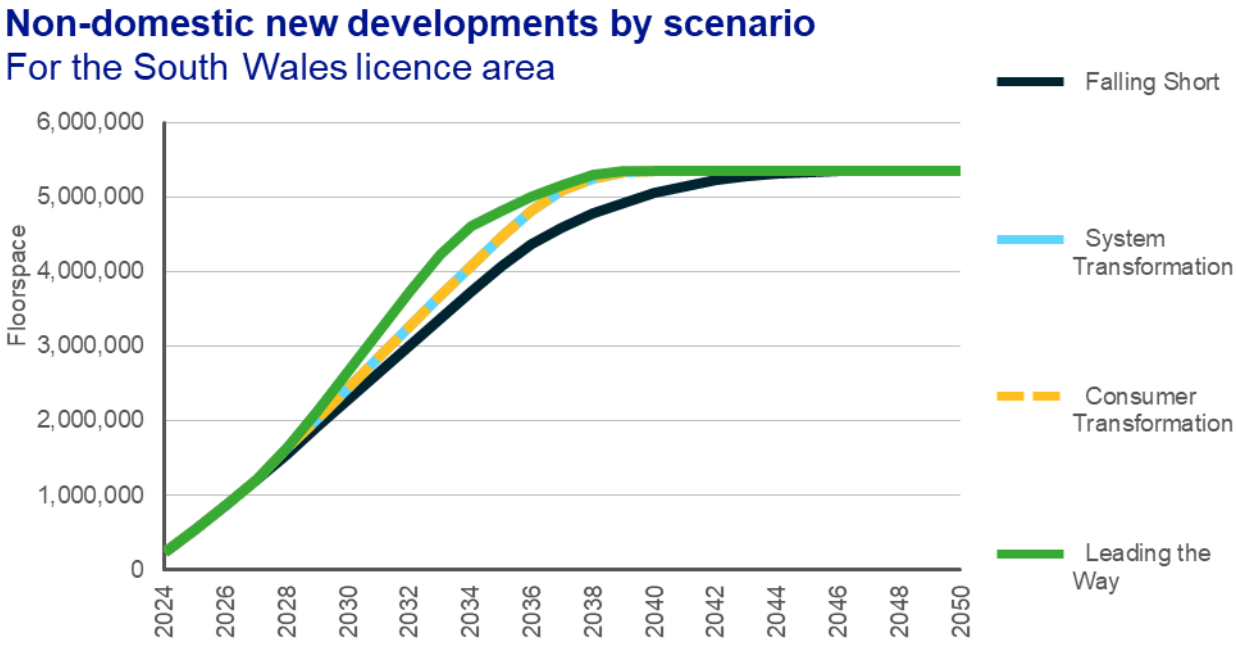



Figure 12 – Cumulative planned non-domestic developments by scenario, South Wales licence area



Modelling assumptions

| 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. |

| Planned developments (April 2023 to March 2050) | |
|---|---|
| Methodology | |
| **Data exchange with all LAs in the licence area** | Planning departments in all local authorities in the NGED licence areas are contacted to review a data register of existing new developments, sourced from the previous DFES analysis. The local authorities then provide updates to existing sites and add additional sites (where appropriate) to this register. This process aims to capture housing developments of 20 homes or more. |
| **Database update** | This LA-provided data is checked and supplemented where necessary from other online data sources. Where new data was not provided, data is gathered through publicly available planning documents such as 5-year housing land supplies and local plans, as necessary. |
| **ESA assignment** | Sites are spatially mapped to NGED's network infrastructure based on their location. Where locational data is not provided, new sites were located using address information, automated geolocation or manual searches. |
| **Scenario projections** | The build-out profile of the new developments is adjusted to produce a range of scenario projections, based on historic housebuilding data and construction of new non-domestic premises. |

Domestic

| Total number of planned homes | Number of development sites identified |
|---|---|
| 80,358 | 528 |

The local authorities with the highest number of planned homes are detailed below:

| Local Authority | Number of homes | Number of sites | Largest development site |
|---|---|---|---|
| Cardiff | 22,629 | 67 | North-West Cardiff (3,934 homes) |
| Rhondda Cynon Taf | 8,299 | 61 | Llanilid Strategic Site (1,550 homes |
| Newport | 6,921 | 30 | Glan Llyn Former Llanwern Steelworks (3,214 homes) |

**Commentary on specific development sites:**

**Cardiff** has 67 planned sites, averaging just under 240 homes per site. In addition to the North-West Cardiff site, two other sites are planning for at least 1,000 homes.

- The two sites, Land West of Dumballs (3216 homes) and West of Pontprennau (1500 homes), are modelled to build out in the 2020s and early 2030s.
- Twenty-six sites have planning permission, with an additional ten sites currently under construction.

Of the 62 housing sites planned in **Rhondda Cynon Taf**, the Llanilid Strategic Site is the only site larger than 1,000 homes. All of these sites have been allocated in the local plan, with 37 sites having full or outline planning permission.

Outside of the Glan Llyn and Llanwern Village sites in **Newport**, totalling over 4,000 homes between them, the majority of Newport's sites are less than 100 homes in size.

Outside of these three LAs, the South Wales licence area has six other planned sites greater than 1,000 homes, accounting for 10,167 new homes. These range from under construction to early development, resulting in a spread of modelled housebuilding between 2024 and the 2040s:

- This includes a 1,067-home site in **Carmarthenshire** and a 1,088-home site in **Swansea**, both set to begin construction in 2024.
- A 3,709-home site in **Neath Port Talbot** is set to begin construction in 2025.
- Three sites - two in **Bridgend** (1,100 and 2,003) and one in Torfaen (1,200) - are estimated to begin construction in 2026.

Non-domestic

| Regen category | Non-domestic sites | | Total non-domestic floorspace (sqm) | |
|---|---|---|---|---|
| | Number | Proportion | Total per category | Proportion of total |
| Factory and warehouse | 144 | 36.6% | 2,557,309 | 46.0% |
| Office | 125 | 31.8% | 2,048,788 | 36.8% |
| Retail | 19 | 4.8% | 130,568 | 2.3% |
| School and college | 31 | 7.9% | 85,684 | 1.5% |
| Other (e.g. medical, hotel, sport & leisure) | 74 | 18.8% | 741,258 | 13.3% |

The vast majority (83%) of South Wales' non-domestic planned floorspace is designated as 'employment land', split into factory and warehouse or office space.

**Pembrokeshire** is the local authority with the most planned floorspace at 1.2 million sqm across 93 sites. This includes four unique sites with 50,000 sqm of planned floorspace. Three of these sites have received planning approval.

The licence area has 20 individual developments with a floorspace of 50,000 sqm or greater. Notable large sites include the St Athan Aerospace Business Park (0.45 million sqm) in **Vale of Glamorgan** located west of Cardiff Airport, and the West Wales Airport (0.18 million sqm) development in **Ceredigion**.

Where possible, the planned development floorspace for each site cited in the local authority data has been used in the DFES modelling. Where planned floorspace was not available, overall planned site areas have been converted into floorspace based on benchmarking figures for specific development types (i.e. school, retail, office etc.).

**Modelled developments (April 2023 to March 2050)**

Domestic

There are two forms of new housing that are not captured by developments currently in planning and have as such been modelled to ensure the DFES scenarios capture a range of housebuilding trends between 2023 and 2050. These are **residual developments** and **post-plan developments**, described in more detail below:

| | |
|---|---|
| **Residual developments** | These are small-scale developments of less than 20 homes, which are under the threshold of our data collection with local authorities. Analysis of previous new developments data suggests that these developments could account for approximately 5% of total new-build housing. As a result, a 5% uplift was applied to the planned projections throughout the scenario timeframe, to account for these residual developments. |
| **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 2020s and 2030s, post-plan developments are |

| | |
|---|---|
| | modelled to account for additional future housebuilding out to 2050. These post-plan development projections are tailored to each local authority, based on ONS household projections[ix]. |
| **Non-domestic** | |
| The non-domestic scenario projections are based on planned developments only. | |

### Reconciliation with National Grid FES 2023

- The FES scenarios include the same proportional growth of domestic customers across all four scenarios and at every GSP. In the DFES, a range of scenario outcomes have been modelled to aid 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 data and is unable to be compared.
- As a result of these factors, the new developments outputs have not been reconciled against the National Grid FES data.

### Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| Planned sites are located based on their address or the description of their location, and directly assigned to the ESA that they fall in. | Local authority engagement |
| Modelled sites 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, EPC records |

# Air conditioning (A/C) in the South Wales licence area

**Domestic A/C units, based on a typical portable or window-mounted air conditioner**

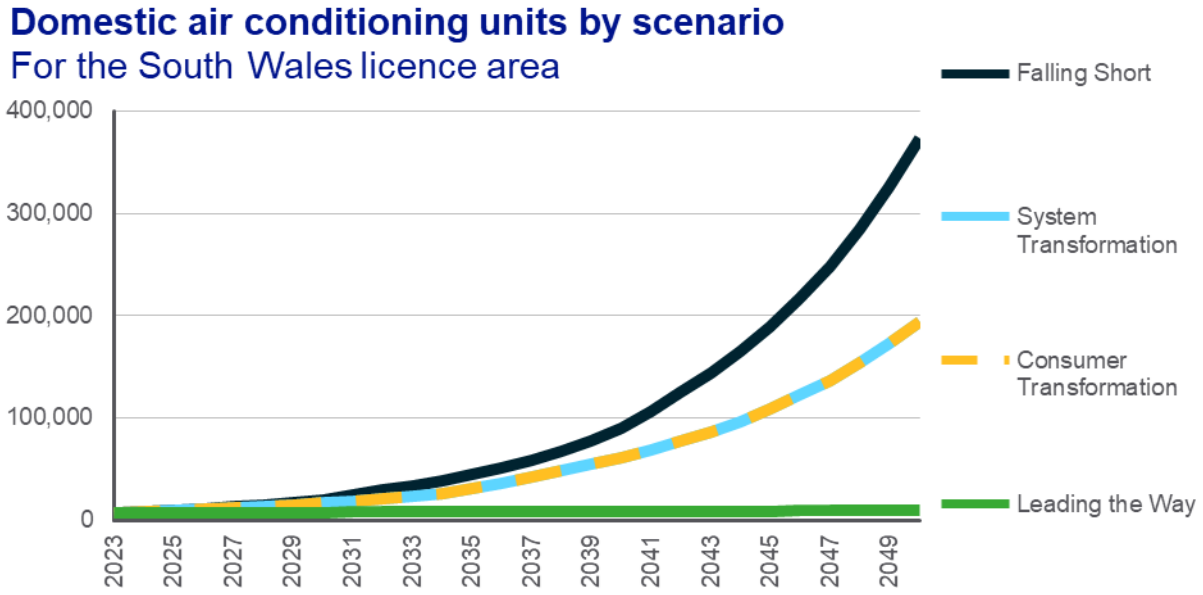
Data summary for air conditioning uptake in the South Wales licence area:

| A/C units (thousands) | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|
| **Falling Short** | 7 | 15 | 45 | 373 |
| **System Transformation** | | 13 | 31 | 194 |
| **Consumer Transformation** | | 13 | 31 | 194 |
| **Leading the Way** | | 7 | 8 | 9 |

Summary:

- Domestic air conditioning (A/C) is not currently common in the UK, with only c.1% of UK homes thought to have an A/C unit. However, this baseline is based on national estimates, as no register of domestic A/C uptake exists.
- In the South Wales licence area, modelling suggests around 0.7% of homes currently have an air conditioning unit.
- Increased summer temperatures and extended heat waves could result in an increased uptake of A/C units over the coming decades. The UK building stock is not optimised around passive cooling, which could see A/C uptake increase under some scenarios.
- A/C uptake is modelled to occur across all types of homes but is focused in urban areas due to the 'heat island effect' under which urban areas are notably warmer than surrounding rural areas, causing increased temperatures in built-up areas such as Cardiff.
- Given the small baseline and high level of uncertainty around whether domestic cooling will be active or passive in the future, there is a broad range of scenario outcomes, from minimal further uptake under **Leading the Way** to A/C becoming commonplace under **Falling Short**.

Figure 13 – Number of domestic air conditioning units by scenario, South Wales licence area



## Modelling assumptions and results

| Baseline | | |
|---|---|---|
| There is limited baseline data on domestic air conditioning levels in the UK. The DFES modelling has aligned with the National Grid FES 2023 data, which has a national baseline of around 330,000 domestic air conditioners (1.1% of GB homes).<br>To estimate the licence area baseline, this national figure has been distributed based on regional cooling demand and housing density. | Number of domestic units | Proportion of homes with an air con unit |
| | c. 7,000 | 0.7% |

| Projections (April 2023 to March 2050) | | |
|---|---|---|
| **Scenario** | **Description** | **2050 projection** |
| **Falling Short** | Increasing frequency of heat waves and low uptake of passive cooling methods leads to high uptake of air conditioning, as the 'easiest' route to comfortable internal temperatures. | c. 373,000 homes |
| **System Transformation** | Over time, air conditioning becomes common in all types of dwellings. Uptake of domestic air conditioning accelerates in urban areas due to heat island effects and the prevalence of smaller dwellings such as flats. | c. 194,000 homes |
| **Consumer Transformation** | | |
| **Leading the Way** | Uptake of domestic air conditioning is minimal, with households opting for passive cooling methods such as shading, ventilation and insulation. | c. 9,000 homes |
| New build homes | | |
| The Overheating: Approved Document O statutory guidance published by the Welsh Government in late 2021 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, uptake of air con in new-build homes is minimal under every scenario. | | |

## Reconciliation with National Grid FES 2023

- The FES 2023 does not directly detail the number of domestic air conditioning units by region, making a direct comparison to the DFES not possible.
- The South Wales licence area sees uptake of air conditioning below the national level seen in FES 2023, as the licence area is below the national average for both cooling demand and population density.

## Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| Early uptake of domestic air conditioning is focused in denser urban areas such as Cardiff and Swansea. In scenarios where domestic air conditioning becomes more prevalent, uptake expands to less dense areas. | Census 2021 |
| Affluence, based on net annual income after housing costs, impacts the near-term distribution of air conditioning, due to the relatively high upfront and running costs of domestic air conditioning units. | ONS Income Estimates for Small Areas |


# Generation technologies

Results and assumptions

# Large-scale solar in the South Wales licence area

**Solar generation sites of installed capacity of 1 MW and above**

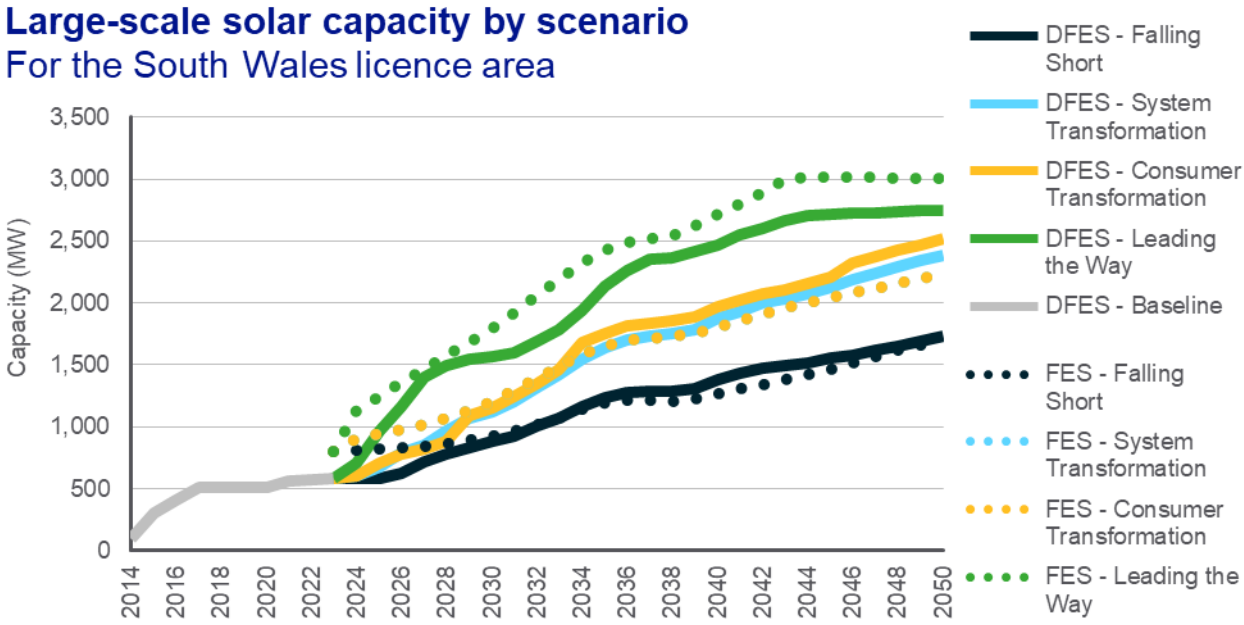
Data summary for large-scale solar power in the South Wales licence area:

| Capacity (MW) | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|
| **Falling Short** | 584 | 777 | 1,231 | 1,732 |
| **System Transformation** | | 962 | 1,641 | 2,388 |
| **Consumer Transformation** | | 879 | 1,757 | 2,519 |
| **Leading the Way** | | 1,495 | 2,140 | 2,750 |

Summary:

- The South Wales licence area has historically seen a moderate level of large-scale solar PV deployment, with 584 MW of capacity connected to the network.
- Deployment has slowed in recent years. However, a renewed developer interest in the region is reflected in the current volume of pipeline projects, with 69 sites totalling 1.7 GW in various stages of development.
- The capacity of large-scale solar in the licence area is expected to increase substantially in all scenarios out to 2050. In addition to the low cost of large-scale solar generation, South Wales has high historical planning success rates for solar projects. This combines with a significant amount of suitable land for solar farm development and areas of high solar irradiance.
- Scenario outcomes by 2050 range from 1.7 GW under **Falling Short**, three times the current baseline, to 2.8 GW under **Leading the Way**, nearly five times the baseline.

Figure 14 – Electrical capacity of large-scale solar by scenario, South Wales licence area



| Baseline | | |
|---|---|---|
| The majority of current installed large-scale solar PV capacity was deployed between 2012 and 2015, when Feed-in Tariff rates for solar PV were highest, with over 470 MW connecting during that time.<br>The South Wales baseline continues to grow with three sites connecting the 2020s, including a site of 54 MW in Newport, illustrating a move towards larger scale sites. | **Number of sites** | **Total capacity (MW)** |
| | 93 | 584 |

| Pipeline (April 2023 to March 2028) | | |
|---|---|---|
| The pipeline of projects with an accepted connection offer in the licence area now totals almost 1.8 GW, increasing by over 200 MW over the past year. This includes a 100 MW site in Carmarthenshire and a 50 MW site in Vale of Glamorgan.<br>The average capacity of pipeline sites in South Wales is 25 MW, substantially greater than the baseline average. | **Number of sites** | **Total capacity (MW)** |
| | 69 | 1,755 |

| Pipeline analysis | | | |
|---|---|---|---|
| **Status** | **Scenario outcomes** | **Number of sites** | **Total capacity (MW)** |
| **Planning Permission Granted** | Of the ten sites with granted permission, three are located in Carmarthenshire, totalling 85 MW of capacity. The largest site with planning permission (31 MW) is located in Newport. Three sites were granted permission this year: two in Rhondda Cynon Taf (7 MW and 7.5 MW) and a 1.1 MW site in Pembrokeshire.<br>Sites with planning granted are modelled to connect under all four scenarios with a delayed timeframe between 2024 and 2029, based on developer engagement and individual site research. | 10 | 158 |
| **Planning Application Submitted** | All sites with submitted planning applications are modelled to connect under **Leading the Way**. This was bespoken to this licence area as there were only a few sites compared to the other licence areas.<br>Under **Consumer Transformation**, four sites with installed capacity of less than 40 MW were modelled to connect.<br>Five submitted sites under **System Transformation** were modelled based on an analysis of the level of local ambition and historic planning permission success rates.<br>Under **Falling Short**, only sites with high levels of historic planning success for large-scale solar PV are modelled to connect. | 7 | 252 |

| | | | |
|---|---|---|---|
| **Pre-planning** | Pre-planning includes sites with evidence of development beyond an accepted connection offer, such as a screening opinion for the need for environmental impact assessments (EIA) or early-stage community engagement.<br><br>Sites in pre-planning stages were only modelled to connect under the three net zero scenarios. Under **System Transformation** and **Consumer Transformation**, 25% of sites were modelled to connect based on local ambition and historic planning permission success rates. Under **Leading the Way**, this was increased to 50%. | 18 | 293 |
| **No information** | Due to the size of the large-scale PV pipeline, sites with no evidence of development are only modelled to connect under the **Leading the Way** scenario. | 31 | 960 |
| **Rejected or Expired** | Sites that were rejected in planning, withdrew their application or have abandoned development were not modelled to connect under any scenario. | 3 | 92 |

**Medium and long-term (April 2028 to March 2050)**

Beyond the pipeline of projects currently in development, future projections are based predominantly on Regen's in-house solar resource assessment, which accounts for land availability, grid proximity, protected areas, solar irradiance and buildings.

In addition to new sites connecting, the repowering of baseline sites will also contribute to an increase in overall installed capacity in the region. As solar panel technology continues to improve, sites installed in the FiT era will be able to replace their current modules, typically rated around 250 W, with modules with a power density at least twice as high at the end of their operational life.

| Scenario | Description | Capacity by 2050 (MW) |
|---|---|---|
| **Falling Short** | Whilst the least ambitious of the four scenarios for renewable energy development, the DFES still models a capacity increase of nearly triple the baseline by 2050. Pipeline sites connecting with delayed timelines drive medium-term growth before the late 2030s when growth levels off, reaching 1.7 GW by 2050.<br><br>Repowering is assumed to have minimal impact under this scenario, with most site owners choosing to extend the life of their existing panels rather than increase capacity. | 1,732 |
| **System Transformation** | Solar PV deployment increases steadily under this scenario, reaching 2.4 GW by 2050. Repowering of baseline sites at the end of their operational life is modelled to increase capacity by 25%. | 2,388 |
| **Consumer Transformation** | Solar PV deployment increases steadily under this scenario, driven by high levels of local ambition, reaching 2.5 GW by 2050. Repowering of baseline sites at the end of their operational life is modelled to increase capacity by 25%. | 2,519 |
| **Leading the Way** | Solar PV deployment increases substantially, driven by a high proportion of the known pipeline being modelled to connect, including some sites with only limited evidence of development evidence. Repowering of baseline sites at the end of their operational life is modelled to increase capacity by 50%. Solar capacity resultantly reaches 2.7 GW by 2050 in the licence area. | 2,750 |

### Reconciliation with National Grid FES 2023

- The FES 2023 baseline is around 200 MW higher than the DFES 2023 baseline for the South Wales licence area. This could be due to the method that the FES uses to assign solar farms to GSPs on the edge of the licence area.
- The DFES 2023 near-term uptake reflects the very large pipeline of projects at various stages of development, augmented by direct engagement with developers on target connection years. This results in a similar level of near-term capacity growth between the FES and DFES scenarios.
- In the medium and longer term, the FES and DFES projections are closely aligned.

### Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| Regen in-house resource assessment, taking into consideration solar resource land availability and planning constraints in the licence area. | Solar irradiance data, Natural Resources Wales, OS Addressbase |
| Local ambition reflecting the local authority policy landscape and proclivity to renewable energy and net zero goals. | Climate Score Cards[x] |
| Proportion of solar sites that are successful with a planning application in the local planning authority. | Renewable Energy Planning Database |

# Small-scale solar in the South Wales licence area

**Solar PV generation sites with installed capacity of less than 1 MW. This includes domestic-scale rooftop PV of under 10 kW, and small-scale commercial PV of 10 kW–1 MW capacity.**

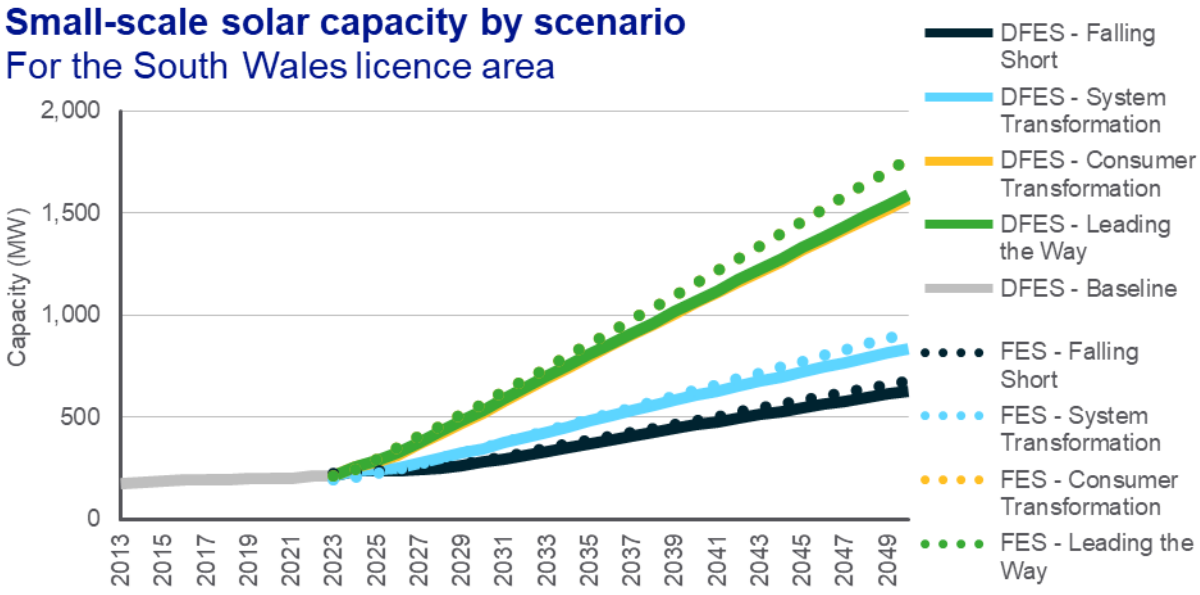
Data summary for small-scale solar generation in the South Wales licence area:

| Capacity (MW) | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|
| **Falling Short** | 218 | 256 | 372 | 621 |
| **System Transformation** | | 298 | 474 | 820 |
| **Consumer Transformation** | | 417 | 784 | 1,541 |
| **Leading the Way** | | 428 | 795 | 1,561 |

Summary:

- The recent increase in energy prices has resulted in an increase in solar PV deployment, with 25 MW of small-scale solar installed within the last year. The South Wales baseline now totals 218 MW, with 150 MW of this installed on domestic rooftops.
- Growth in the deployment of rooftop solar capacity in the UK has reached its highest level since the early the Feed-in-Tariff era (2010s). Across GB, installations in the first quarter of 2023 doubled compared to the previous year[xi].
- High electrification of transportation and heating drives the uptake of small-scale solar in homes and businesses under both **Consumer Transformation** and **Leading the Way**. Both of these scenarios see eight times the current level of installed capacity, each reaching c. 1.6 GW by 2050.
- **System Transformation** and **Falling Short** reflect lower levels of electrification, but both scenarios still show significant growth in small-scale solar, with over four times and three times the current capacity by 2050, respectively.

Figure 15 – Capacity of small-scale solar generation by scenario, South Wales licence area



Modelling assumptions and results

| Baseline | | | |
|---|---|---|---|
| The majority of small-scale solar was deployed in the Feed-in-Tariff era in the 2010s, with over 150 MW connecting during that period. South Wales is currently seeing a resurgence of small-scale solar deployment, with 25 MW growth to the baseline compared to DFES 2022. This growth is driven by a number of factors, including high electricity and gas prices. | | | |
| **Scale** | **Number of sites** | **Total capacity (MW)** | **Notes** |
| Domestic (<10 kW) | 39,009 | 154 | Equivalent to 3.5% of homes |
| Commercial (10 kW-1 MW) | 1,282 | 64 | Average array size: 50 kW |

| Pipeline (April 2023 to March 2024) | | |
|---|---|---|
| There are 123 small-scale solar sites in the pipeline, representing over 21 MW of potential additional capacity in the licence area. The majority of sites are categorized as commercial scale between 10 kW and 1 MW. This isn't reflective of the baseline due to domestic solar sites often commissioning quickly and not holding an accepted connection offer for long before being installed. This could mean that additional domestic-scale solar capacity could be deployed in the very near term, but this isn't represented by known connection applications data. | | |
| **Scale** | **Number of sites** | **Total capacity (MW)** |
| Domestic (<10 kW) | 28 | 0.1 |
| Commercial (10 kW-1 MW) | 95 | 21.3 |
| Pipeline analysis | | |
| All pipeline sites are modelled to connect in 2024 under all scenarios, with the exception of three sites with connection offers prior to 2020; these have been removed from modelling as they appear to have been abandoned. | | |

| Medium and long-term projections (April 2024 to March 2050) | | |
|---|---|---|
| The impacts of government policy have been considered in the modelling for every scenario to a varying degree. An example is changes to Building Regulations (Part L)[xii] that relate to the reduction in carbon emissions for new-build homes. On existing domestic and commercial rooftops, small-scale solar uptake accelerates due to the falling installation costs of both solar modules and domestic batteries and the increased use of solar to power electrified heat and transport.<br><br>By 2050 a significant range is seen across the scenarios for small-scale solar in the licence area, ranging from .63 GW under **Falling Short** to 1.6 GW under **Leading the Way**. | | |
| **Scenario** | **Description** | **Capacity by 2050 (MW)** |
| **Falling Short** | Reflecting a lower uptake of low carbon technologies, smart tariffs and less engaged customers, this scenario results in lower demand for small-scale solar. The rate of new builds with solar module installation remains at its current level of c. 10% until 2050. | 621 |

| | | |
|---|---|---|
| **System Transformation** | With the need to decarbonise electricity demand quickly to meet carbon reduction targets, solar PV uptake is also high under this scenario, reaching over 800 MW by 2050.<br>The rate of new builds with solar module installation is modelled to increase to 25% by 2030 and 40% by 2050. | 820 |
| **Consumer Transformation** | High levels of consumers engaging with smart electricity usage, dynamic electricity tariffs and high green ambition help boost small-scale deployment under these scenarios.<br>In addition, the rate of new builds with solar module installation is modelled to increase to 50% by 2030 and 70% by 2050.<br>This results in 1.6 GW of small-scale solar by 2050. | 1,541 |
| **Leading the Way** | | 1,561 |

### Reconciliation with National Grid FES 2023

- The FES and DFES outputs for small-scale solar PV in the licence area are closely aligned in the baseline, near-term and throughout the projection timeline to 2050.
- There is a small divergence between the DFES **Consumer Transformation** and **Leading the Way** scenarios in the late 2020s and early 2030s, which is not seen in the FES projections. This is due to the DFES new-build housing assumptions moderately differentiating between these two scenarios, whereas the FES modelling exhibits a single housebuilding projection for all four scenarios.

### Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| The factors detailed in the modelling assumptions above, such as building type, tenure and affluence, are used to model deployment at a local level. | OS Addressbase, ONS Census |
| New-build housing is modelled to include rooftop solar PV. As such, the outputs of the DFES new housing projections directly influence the location of small-scale solar PV in the projections. | DFES new developments projections |

# Onshore wind in the South Wales licence area

**Onshore wind electricity generation**

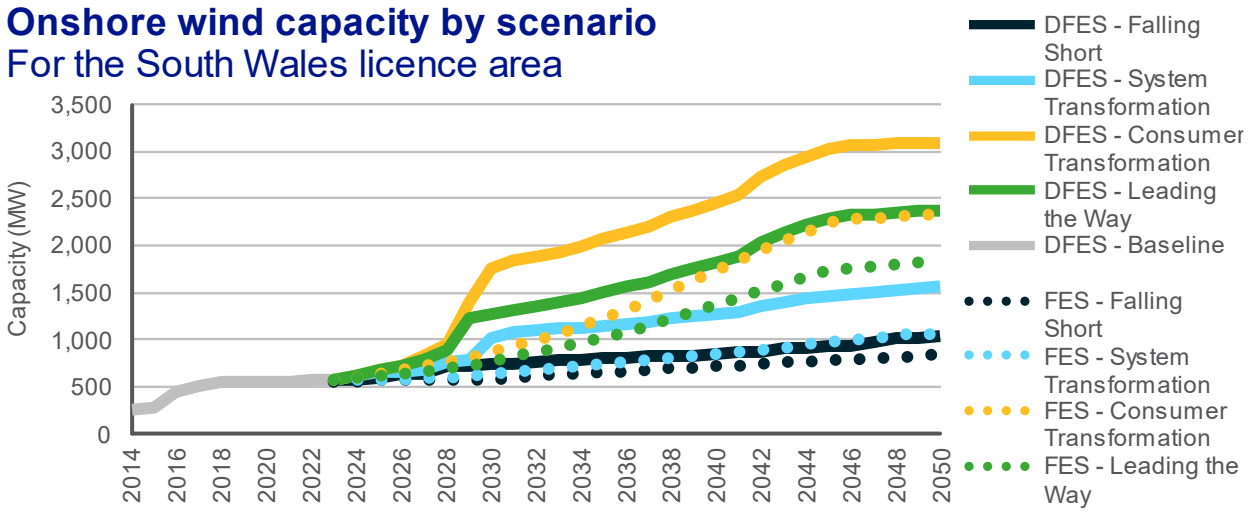
Data summary for onshore wind power in the South Wales licence area:

| Capacity (MW) | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|
| **Falling Short** | 561 | 714 | 796 | 1,034 |
| **System Transformation** | | 758 | 1,152 | 1,570 |
| **Consumer Transformation** | | 943 | 2,066 | 3,099 |
| **Leading the Way** | | 881 | 1,502 | 2,370 |

Summary:

- The South Wales licence area currently has a baseline of 561 MW of distributed onshore wind capacity, deployed mostly in the last decade.
- There is strong interest in further onshore wind development in South Wales in the near term, with 660 MW of onshore wind capacity securing connection offers since September 2022, growing the pipeline to nearly 1.8 GW. This is reflective of the available wind resource and policy landscape in South Wales.
- The Contract for Difference Allocation Round 5 was favourable for onshore wind, allocating nearly 1.5 GW on capacity across 24 sites. Foel Trawsnant, a 34 MW site, was awarded a CfD this year with a delivery year of 2028 and was modelled in all scenarios,
- Future Wales: The National Plan 2040[xiii] contains 'Pre-Assessed Areas for Wind Energy', which define areas where spatial planning is presumed to be in favour of onshore wind developments. This policy aims to enable wind power to contribute a large share of the Welsh government's renewable energy targets.
- Under **Consumer Transformation** and **Leading the Way**, Welsh Government targets are realised, with distributed onshore wind capacity in South Wales doubling between 2023 and 2030. This scale of deployment continues in the 2030s and 2040s, augmented by existing windfarms repowering at increased capacities at the end of their operational life. As a result, capacity reaches 2.4-3.1 GW by 2050 under these scenarios.
- There is comparatively less deployment of distributed onshore wind under **System Transformation** and **Falling Short**, as there is a greater focus on large-scale, transmission-connected power generation in these scenarios. Resultantly, capacity reaches between 1.0-1.6 GW by 2050 in the licence area under these scenarios.

Figure 16 – Electrical capacity of onshore wind by scenario, South Wales licence area



Modelling assumptions and results

| Baseline | | | |
|---|---|---|---|
| Over 90% of the connected capacity in South Wales comes from the 37 sites that are 1 MW or greater. The majority of this capacity is located around the South Wales Valleys, particularly in the TAN8 [xiv]areas that were previously defined by the Welsh Government for onshore wind deployment.<br>Two new distributed onshore wind sites have come online since September 2022, located in Rhondda Cynon Taf (2.5 MWand Caerphilly (0.75 MW). | **Scale** | **Number of sites** | **Total capacity (MW)** |
| | Small-scale (<1 MW) | 372 | 48 |
| | Large-scale (>=1 MW) | 37 | 513 |

| Pipeline (April 2023 to March 2028) | | |
|---|---|---|
| An additional 545 MW of capacity has entered the pipeline since September 2022, with the majority coming from two potential energy parks that will include BESS in Ceredigion (175 MW) and Powys (165 MW). This has resulted in the pipeline expanding to over 1.4 GW across 56 prospective sites. These have been modelled under each scenario based on an analysis of each site's current development status. | **Number of sites** | **Total capacity (MW)** |
| | 56 | 1,760 |

| Pipeline analysis | | | |
|---|---|---|---|
| **Status** | **Scenario outcomes** | **Number of sites** | **Total capacity (MW)** |
| **Under Construction** | A 13 MW site in the Powys is currently under construction and so connects under all scenarios. | 1 | 13 |
| **Planning Permission Granted** | Five of the nine sites with planning permission are under 5 MW and are modelled to connect in the next 1-3 years.<br>Foel Trawsnant is the largest onshore wind site with planning permission, at 35 MW, and is projected to connect in the late-2020s all scenarios. The Foel Trawsnant site received a Contract for Difference in the Allocation Round 5, with delivery year 2028. This allocation is reflected in the modelling. The other three granted sites are anticipated to connect before 2030 under all four scenarios. | 9 | 96 |
| **Planning Application Submitted** | The majority of sites with planning applications submitted are modelled to connect in **Consumer Transformation** and **Leading the Way**, while only around half are modelled to connect under **System Transformation** and **Falling Short**. Sites are modelled to progress based on the historic planning permission success rates of onshore wind in each local authority. | 6 | 119 |
| **Pre-planning** | Some additional sites have been considered to be in pre-planning, based on having live consultation websites, EIA scoping reports or evidence provided directly by developers. Around half of these sites are modelled to go ahead under the three net zero scenarios, focusing on sites within pre-assessed areas for wind energy or in local authority areas with higher levels of planning friendliness. None of these pre-planning sites go ahead under **Falling Short**. | 15 | 756 |

| | | | |
|---|---|---|---|
| **No information** | These sites have no publicly available information online, and as a result only sites in more favourable areas for onshore wind were modelled to connect under **Consumer Transformation** only. | 23 | 755 |
| **Rejected, Withdrawn or Abandoned** | These two sites were not modelled to connect under any scenario. | 2 | 21 |

| **Medium and long-term (April 2028 to March 2050)** | | |
|---|---|---|
| **Scenario** | **Description** | **Capacity by 2050 (MW)** |
| **Falling Short** | This scenario sees limited but steady onshore wind development, resulting in a near doubling of baseline capacity between 2023 and 2050. This mirrors the average rate of onshore wind deployment in the licence area over the past decade. Baseline sites with a capacity higher than 5 MW are modelled to repower with +25% capacity[xv]. | 1,034 |
| **System Transformation** | This scenario sees more focus on transmission network connected generation to achieve net zero targets, resulting in limited onshore wind deployment on the distribution network beyond the deployment of large-scale pipeline sites in the late 2020s with strong development evidence. Repowering of baseline sites with +25% results in an increased rate of capacity growth in the 2030s and 2040s. | 1,570 |
| **Consumer Transformation** | This scenario sees the largest growth in distributed onshore wind, reaching almost 3 GW by 2050 – more than five times the current baseline. As distributed onshore wind is key to reducing carbon emissions in this scenario, the modelling assumes continued deployment of new onshore wind sites in the licence area throughout the 2030s and early 2040s. In addition, baseline sites larger than 5 MW are modelled to repower with an additional 50% capacity due to an assumed availability of higher yield, more efficient turbines. | 3,099 |
| **Leading the Way** | This scenario is similar to **Consumer Transformation**, albeit with marginally lower levels of deployment due to the wider energy system being less heavily electrified under **Leading the Way**. Distributed wind capacity still reaches 2.4 GW by 2050 in the licence area under this scenario. | 2,370 |

### Reconciliation with National Grid FES 2023

- The FES 2023 and DFES 2023 baselines are very well aligned.
- In the near term, the DFES projections are much higher under every scenario. This reflects the concentration of onshore wind development in South Wales. The DFES pipeline analysis and desk research reflects higher levels of devolved government and local planning ambition, and the potential addition of onshore wind sites connecting to an IDNO in Mid Wales.
- Beyond the variance in near-term deployment in the 2020s, the DFES and FES projection trends for onshore wind are similar in the 2030s and 2040s under every scenario.

Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| Regen in-house resource assessment, taking into consideration wind resource land availability and planning constraints in the licence area. | NOABL wind speed data, Natural Resources Wales, OS addressbase |
| Local ambition, reflecting the local authority policy landscape and commitment to renewable energy and net zero goals. | Climate Score Cards[xvi] |
| Proportion of wind sites that are successful with a planning application in the local planning authority. | Renewable Energy Planning Database |

# Offshore wind and marine in the South Wales licence area

**Tidal energy, wave energy and offshore wind (fixed and floating) electricity generation**

Data summary for offshore wind and marine in the South Wales licence area:

| Capacity (MW) | | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|---|
| Offshore wind | Falling Short | 0 | 0 | 0 | 0 |
| | System Transformation | | 0 | 0 | 0 |
| | Consumer Transformation | | 8 | 20 | 20 |
| | Leading the Way | | 0 | 0 | 0 |
| Marine | Falling Short | 0 | 0 | 0 | 0 |
| | System Transformation | | 1 | 7 | 7 |
| | Consumer Transformation | | 5 | 29 | 41 |
| | Leading the Way | | 1 | 19 | 31 |

Summary:

- While there are no operational grid-connected offshore wind or marine energy generation projects in the South Wales licence area to date, there is activity in the form of development zones and early-stage projects.
- The area around Pembrokeshire has been identified by the Welsh Government and regional bodies, such as Marine Energy Wales, as a key strategic area for the development of offshore energy resources at both distribution and transmission scales.
- Floating offshore wind projects are already looking to scale up to transmission level capacities of 1 GW or more, and developing test and demonstration projects off South Wales are also looking to connect at transmission level. As a result, there is minimal deployment of offshore wind on the South Wales distribution network in all four scenarios out to 2050.

Figure 17 – Capacity of offshore wind generation by scenario, South Wales licence area

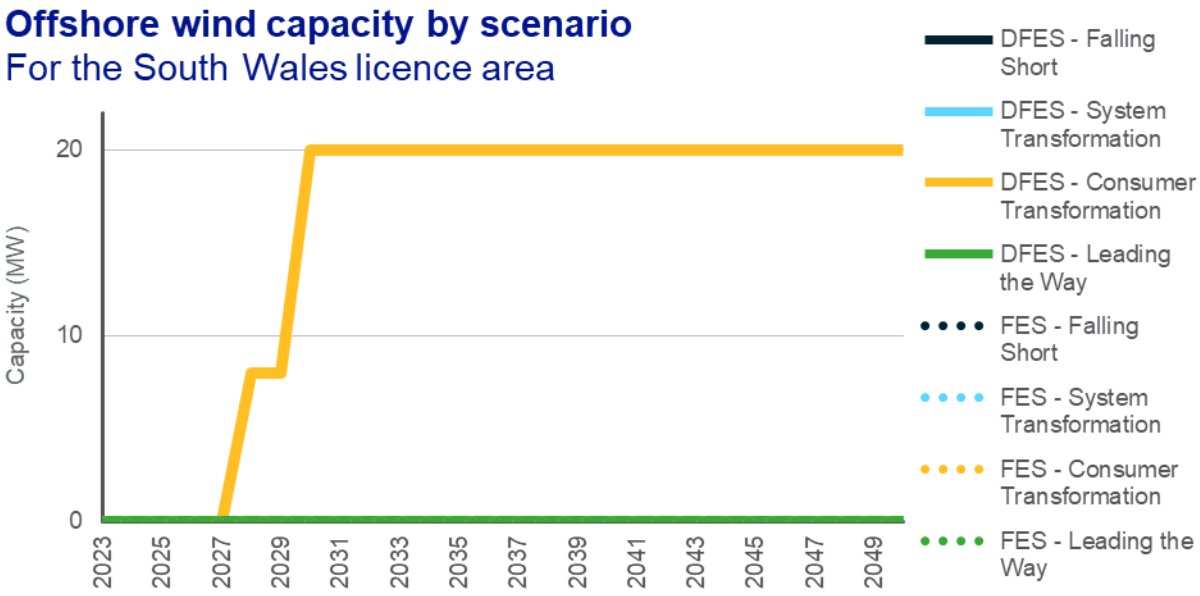
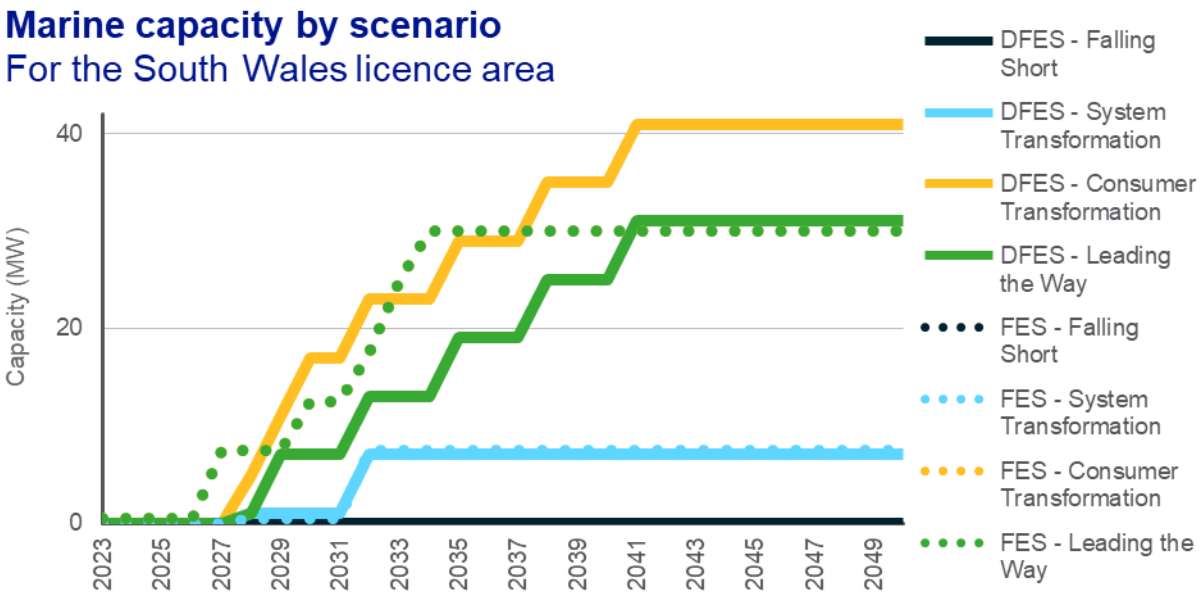


Figure 18 – Capacity of marine generation by scenario, South Wales licence area




## Modelling assumptions and results

### Baseline

There are no operational baseline marine energy or offshore wind projects connected to the distribution network in the South Wales licence area. Previous deployment of trial and demonstration projects have typically not been connected to export to the distribution network.

### Pipeline (April 2023 to March 2028)

There are no pipeline offshore wind or marine sites in South Wales.

### Medium and long-term projections (April 2028 to March 2050)

Representatives of the marine and offshore wind sector in South Wales, including Marine Energy Wales and Celtic Sea Power, were engaged to identify developing projects that could deploy in the longer term. This includes several sites that are currently in development but do not currently hold accepted connection offers with NGED.

#### Floating offshore wind

Much of the offshore wind and marine development in South Wales, including 300 MW of floating offshore wind capacity in the form of the Erebus, Llŷr 1 and Llŷr 2 projects, has previously been part of the Pembrokeshire Demonstration Zone (PDZ) and aiming to connect at transmission level.

Engagement with the offshore wind sector, including Marine Energy Wales and Celtic Seas Power, suggested that the Llŷr projects, totalling 200 MW, could end up connecting at distribution level rather than via the PDZ. However, direct engagement with these developers suggested that this is not currently being considered. As a result, the Llŷr projects are modelled to connect at transmission level rather than distribution level under every scenario.

#### Combined wind and wave

The Bombora InSPIRE project, combining floating offshore wind and wave energy on a shared platform, is aiming to develop and deploy a pre-commercial project (8 MW wind and 4 MW wave capacity) and a commercial project (12 MW wind and 6 MW wave capacity).

However, it is possible that this project may be deployed in established marine testing sites at

BiMEP in northern Spain or EMEC in Orkney. As a result, these sites are only modelled to connect in South Wales under the **Consumer Transformation** scenario, commissioning in the late 2020s.

Tidal stream

The potential for tidal stream deployment around Ramsey Sound, off the coast of Pembrokeshire, was identified through engagement with sector representatives. Based on previous interest in the area, 30 MW of tidal stream capacity is modelled to connect under the **Consumer Transformation** and **Leading the Way** scenarios and 6 MW under **System Transformation**.

In addition, a 1 MW repowering of a previous tidal generation demonstration site in the Ramsey Sound by Cambrian Offshore is modelled to go ahead in the late 2020s under the three net zero scenarios. No distributed marine generation is projected to connect under **Falling Short**.

### Reconciliation with National Grid FES 2023

- For offshore wind, the National Grid FES 2023 projects no deployment in the South Wales licence area under any scenario. The DFES projections are based on projects with clear evidence of development and potential to connect to the distribution network.
- For marine energy, the FES and DFES projections are closely aligned. The DFEs projections for **Consumer Transformation** and **Leading the Way** do diverge compared to the FES. This is due to engagement with the marine energy sector highlighting the level of uncertainty around future tidal and wave energy deployment in South Wales, resulting in four credible future outcomes rather than just three.

### Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| Locations of potential future sites have been identified through desk research and developer engagement. | Desk research, developer engagement, engagement with sector representatives |

# Hydro in the South Wales licence area

**Hydropower electricity generation**

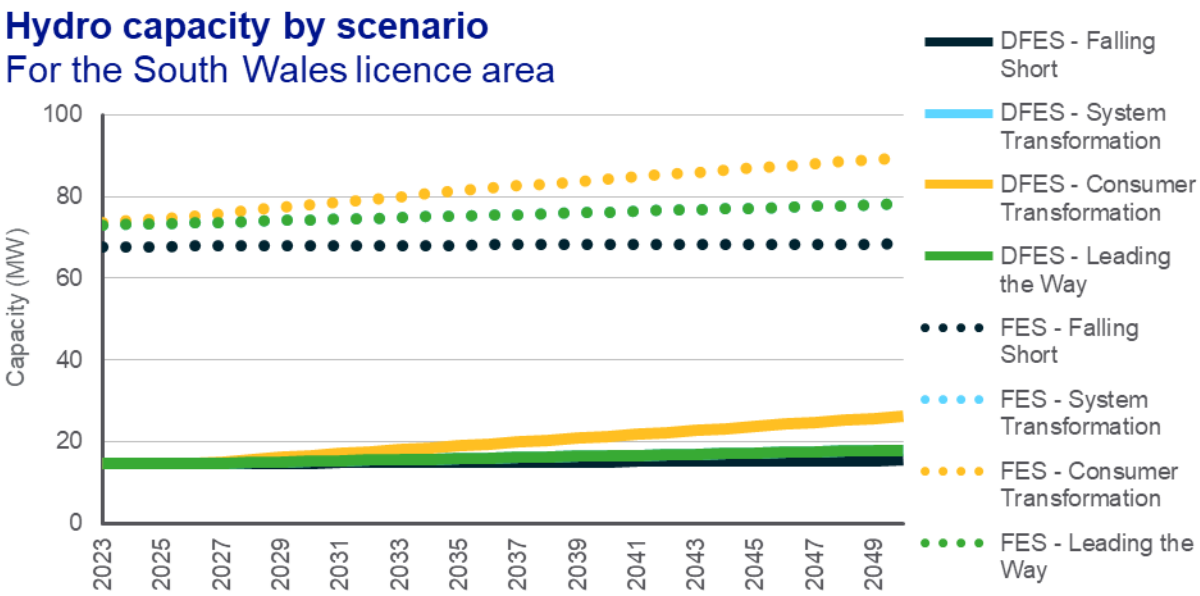
Data summary for hydropower in the South Wales licence area:

| Capacity (MW) | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|
| **Falling Short** | 15 | 15 | 15 | 15 |
| **System Transformation** | | 15 | 16 | 18 |
| **Consumer Transformation** | | 16 | 19 | 26 |
| **Leading the Way** | | 15 | 16 | 18 |

Summary:

- The South Wales licence area contains 15 MW of small and medium-scale hydropower sites, predominantly located in the Mid Wales local authority areas of Powys and Ceredigion.
- Following the closure of the Feed-in Tariff in 2019, deployment of small-scale hydropower has stalled. There are currently no pipeline hydropower sites in the South Wales licence area.
- Due to a lack of subsidy support and increased abstraction licencing costs[xvii], all scenarios see limited hydropower deployment in the licence area out to 2050. The scenario with the highest deployment, **Consumer Transformation**, sees an additional 11 MW of hydropower modelled to connect to the South Wales distribution network by 2050.

Figure 19 – Electrical capacity of hydropower by scenario, South Wales licence area



## Modelling assumptions and results

| Baseline | | | |
|---|---|---|---|
| Four sites that are between 1.3 and 5.5 MW capacity represent over 80% of the existing installed hydropower capacity in the South Wales licence area. Three of these sites, including a 5.5 MW site at Llyn Brianne, Ceredigion and a 4 MW site at Elan Valley, Powys, are operated by Dwr Cymru Welsh Water.<br>The remaining capacity was almost entirely developed off the back of the Feed-in Tariff incentive scheme in the 2010s. These small-scale sites are located across Mid Wales, Monmouthshire, Cardiff and Pembrokeshire. | **Scale** | **Number of sites** | **Total capacity (MW)** |
| | Small-scale (<1 MW) | 39 | 1.9 |
| | Large-scale (>=1 MW) | 4 | 12.7 |

| Pipeline (April 2023 to March 2028) |
|---|
| There are no hydropower pipeline sites with an accepted connection offer in the South Wales licence area. As a result, near-term deployment of hydropower is projected to be minimal under every scenario. |

| Medium and long-term projections (April 2028 to March 2050) | | |
|---|---|---|
| With hydropower deployment completely stalled in South Wales, projections beyond the pipeline period are strongly dependent on scenario assumptions and are resultantly limited to 2050. | | |
| **Scenario** | **Description** | **Capacity by 2050 (MW)** |
| **Consumer Transformation** | With a focus on decarbonisation through consumer engagement, this scenario sees limited but steady deployment of small-scale hydropower out to 2050. Hydropower deployment is driven by onsite electricity generation and community energy schemes. | 26 |
| **Leading the Way** | Under these scenarios, small-scale hydropower deployment is even more limited, as large-scale solutions are prioritised. However, hydropower is deployed at some select locations to aid decarbonisation, particularly where sites above 1 MW capacity could be deployed. | 18 |
| **System Transformation** | | |
| **Falling Short** | Lack of subsidy support and slow decarbonisation under this scenario results in no further hydropower deployment. | 15 |

## Reconciliation with National Grid FES 2023

- There is a substantial difference of over 50 MW between the DFES and FES baselines for hydropower in the South Wales licence area. The reason for this discrepancy is not clear, but it is likely the outcome of the method that the FES applies to regionally allocate hydropower capacity in highly rural Mid Wales, with capacity allocations to GSPs in the South Wales licence area and adjacent SP Manweb licence area to the north.
- Beyond the baseline discrepancy and the near-term pipeline, the FES and DFES trajectories for hydropower under each scenario are well aligned.

## Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| Future hydropower sites are modelled to be in similar geographical areas to existing hydropower, representing watercourses with an appropriate head difference for hydropower deployment. | NGED, Feed-in Tariff register |

# Biomass in the South Wales licence area

**Biomass-fuelled power generation, including standalone and CHP generation**

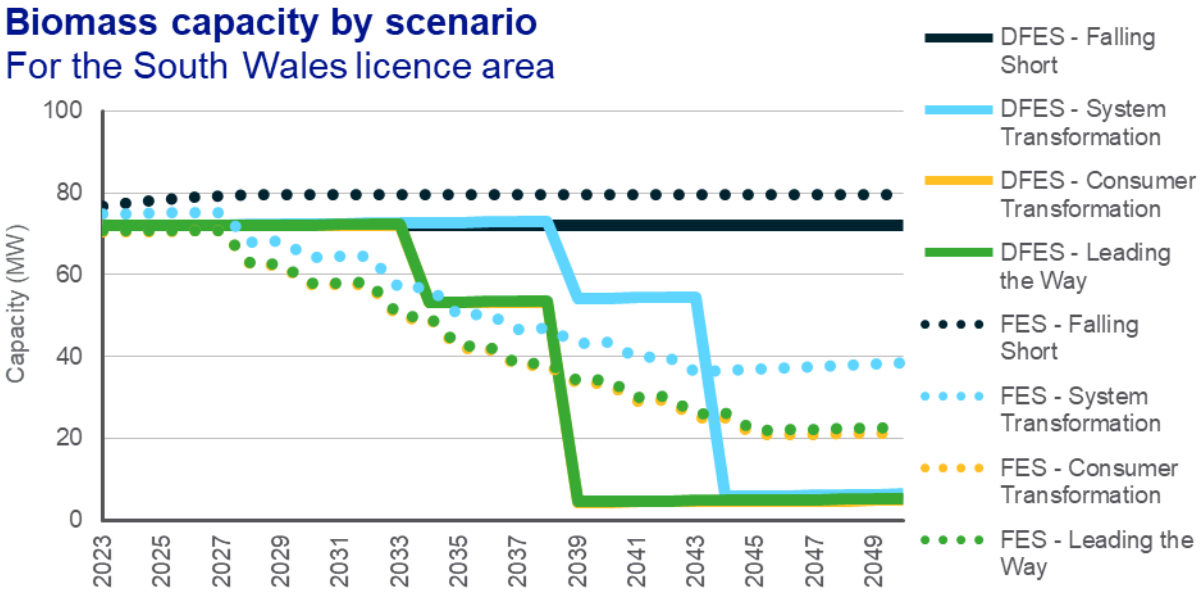
Data summary for biomass power in the South Wales licence area:

| Capacity (MWe) | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|
| **Falling Short** | 72 | 72 | 72 | 72 |
| **System Transformation** | | 72 | 73 | 6 |
| **Consumer Transformation** | | 72 | 53 | 5 |
| **Leading the Way** | | 72 | 53 | 5 |

Summary:

- The future of biomass power generation on the distribution network is impacted by competing demands for bioenergy in sectors such as heat, industry, aviation, and shipping. Despite being a low carbon, flexible generation technology, biomass sees a decrease over time under the three net zero scenarios as the use of biomass for power is prioritised for transmission-scale BECCS generation.
- Standalone biomass power generation is progressively decommissioned in the three net zero scenarios as bioenergy resources are used elsewhere, resulting in the vast majority of biomass capacity in South Wales decommissioning in the 2030s and 2040s.
- There is, however, some growth in the capacity of small-scale biomass CHP in the licence area as a means of decarbonising heat, particularly under **System Transformation**.
- Under **Falling Short**, biomass capacity remains stable as alternative uses of bioenergy in harder-to-decarbonise sectors are not progressed under this scenario.

Figure 20 – Electrical capacity of biomass by scenario, South Wales licence area



## Modelling assumptions and results

| Baseline | | | |
|---|---|---|---|
| The South Wales baseline almost entirely comprises two large-scale biomass power generation sites. The most recent of these sites, the 49 MW Margam Green Energy Plant, began operation in 2019 and is fuelled by waste wood.<br>Three smaller-scale sites, appearing to use biomass for CHP, were commissioned between 2012 and 2018. | **Scale** | **Number of sites** | **Total capacity (MW)** |
| | Under 5 MW | 3 | 4 |
| | Over 5 MW | 2 | 68 |

| Pipeline (April 2023 to March 2028) |
|---|
| There are no active biomass pipeline sites with accepted connections in the South Wales licence area. |

| Medium and long-term projections (April 2028 to March 2050) | | | |
|---|---|---|---|
| Beyond the pipeline, the prospects for biomass generation on the distribution network are strongly dependent on the demand for biomass from non-power sectors under each scenario and whether the biomass is fuelling standalone electricity generation or combined heat and power. | | | |
| **Scenario** | **Standalone generation** | **CHP generation** | **Capacity by 2050 (MWe)** |
| **Leading the Way** | Biomass is prioritised for transmission-scale BECCS and other hard-to-decarbonise sectors. As a result, standalone biomass is decommissioned after 25 years of operational life. | Greater electrification of heat results in less demand for biomass CHP. There is minor growth in CHP capacity for heating business parks and industrial sites. | 5 |
| **Consumer Transformation** | | | 5 |
| **System Transformation** | Biomass is prioritised for hydrogen production and BECCS. As a result, standalone biomass is decommissioned after 25 years of operational life. | While heat in this scenario is dominated by hydrogen, biomass CHP sees uptake in areas not connected to the hydrogen network. | 6 |
| **Falling Short** | Standalone biomass generation remains connected in 2050, as other sectors' decarbonisation progress is slow. | Biomass CHP sees no further growth under this scenario, as decarbonisation progress is slow. | 72 |

## Reconciliation with National Grid FES 2023

- The DFES and FES baselines are closely aligned. The FES baseline varies slightly in the 2023 year due to the FES analysis having a baseline year of 2022. This does not materially impact the reconciliation.
- The reduction in biomass capacity in South Wales follows similar trends in the FES and DFES scenarios. Due to this being driven by the decommissioning of two large-scale sites in the DFES, the projections are less incremental than in the FES.

## Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| Sites already in the NGED connections baseline and pipeline | NGED |

# Renewable engines in the South Wales licence area

**Electricity generation from sewage gas, landfill gas and anaerobic digestion**

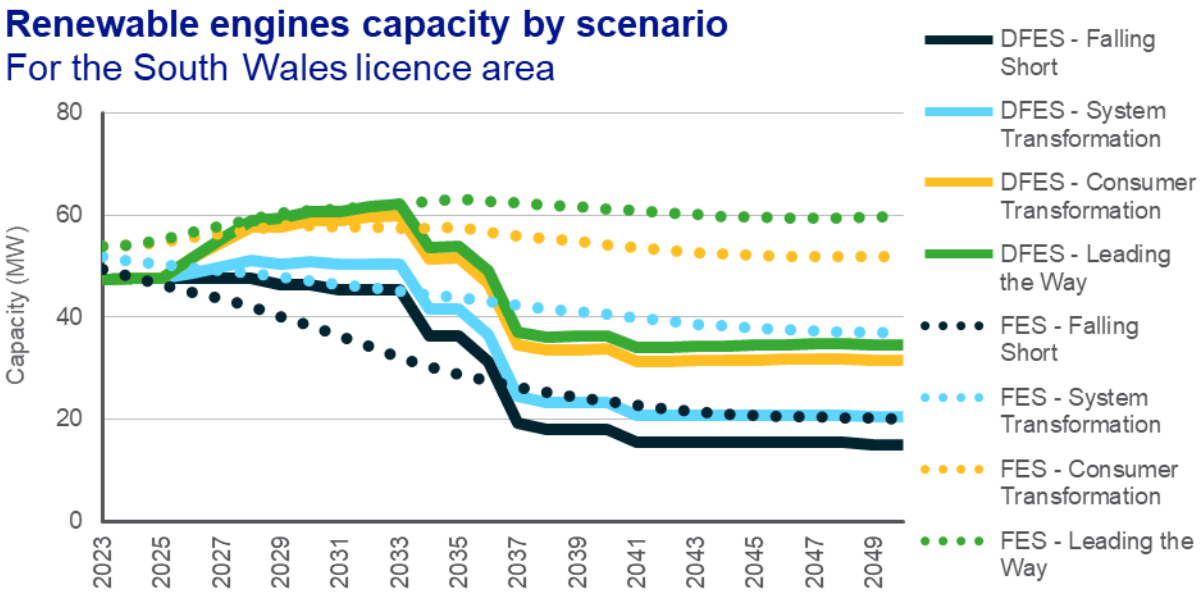
Data summary for renewable engines in the South Wales licence area:

| Capacity (MW) | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|
| **Falling Short** | 48 | 48 | 37 | 15 |
| **System Transformation** | | 51 | 42 | 21 |
| **Consumer Transformation** | | 58 | 52 | 32 |
| **Leading the Way** | | 59 | 54 | 35 |

Summary:

- Renewable engines are divided into three types of sites: landfill gas, anaerobic digestion at farms and food waste collection centres, and sewage gas at sewage treatment plants.
- Landfill gas, which makes up two-thirds of the baseline in South Wales, is modelled to decommission over time in every scenario, as Wales and the rest of the UK move towards more sustainable waste treatment and an overall reduction in waste production.
- Anaerobic digestion, accounting for around one-tenth of the renewable engines baseline capacity, is projected to increase in capacity under the three net zero scenarios, particularly under **Consumer Transformation** and **Leading the Way**. However, in all net zero scenarios, bioenergy resource is prioritised where possible for harder-to-decarbonise sectors such as industry, thereby limiting its role in electricity generation.
- Sewage gas, which makes up around one-fifth of the baseline, 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.

Figure 21 – Electrical capacity of renewable engines by scenario, South Wales licence area



## Baseline

Renewable engines are divided into three types of sites: landfill gas, anaerobic digestion at farms and food waste collection centres, and sewage gas at sewage treatment plants.

All of the anaerobic digestion baseline capacity in South Wales is at sites of less than 1.5 MW capacity, mainly in rural areas. Only 0.09 MW of capacity has been deployed since 2016.

The landfill gas baseline consists of sites near urban areas such as Cardiff and Newport. These sites are typically 1-5 MW in scale, and all connected from 1998 to 2010, with the exception of three smaller-scale sites of under 0.4 MW that connected between 2018 and 2023.

The sewage gas baseline consists of just two sites, both operated by Dwr Cymru Welsh Water.

| Type | Number of sites | Total capacity (MW) |
|---|---|---|
| Anaerobic digestion | 12 | 5 |
| Sewage gas | 2 | 10 |
| Landfill gas | 13 | 33 |

## Pipeline (April 2023 to March 2028)

There are just two projects in the pipeline, totalling 2.0 MW.

The largest of these sites, a 0.9 MW anaerobic digestor in Pembrokeshire, achieved planning permission and was under construction as of 2017. However, it is not clear what stage this project is at since that point. As a result, it is modelled to go ahead only under **Consumer Transformation** and **Leading the Way**.

The second pipeline project, a 0.25 MW project in Ceredigion, is modelled to go ahead in the near term under all four scenarios due to its small scale.

## Medium and long-term projections (April 2028 to March 2050)

| Type of site | Scenario outcomes |
|---|---|
| Anaerobic digestion | South Wales has lower potential for anaerobic digestion deployment than the neighbouring South West and West Midlands licence areas, partially due to the type of farming undertaken in the licence area. Previous stakeholder engagement noted that the lower levels of pork, beef and dairy farming compared to sheep holdings in Wales led to lower potential for anaerobic digestion. This is evidenced in the baseline.<br><br>The capacity of anaerobic digestion that is deployed under **Consumer Transformation** and **Leading the Way**, the deployment peaks in the late 2020s and early 2030s, as the electricity system is rapidly decarbonised and small-scale, established renewables such as anaerobic digestion plays a larger role.<br><br>In the longer term, deployment of anaerobic digestion for electricity generation slows as biogas is prioritised for hard-to-decarbonise sectors such as industry, aviation and shipping. |
| Sewage gas | Sewage gas baseline and pipeline sites are modelled to remain connected at a consistent capacity out to 2050 under every scenario. The lack of projects being developed indicates there is low potential for growth of sewage gas capacity. |
| Landfill gas | Landfill gas baseline and pipeline sites are modelled to have a lifespan of 30 years under every scenario, after which point the connection is decommissioned. The lack of projects being developed indicates there is low potential for growth of landfill gas capacity. |

### Reconciliation with National Grid FES 2023

- The FES and DFES baselines in South Wales are closely aligned, as are the near-term projections.
- The DFES projections decrease ahead of the FES in all four scenarios. This is driven by the projected decommissioning of three landfill gas sites in the mid-2030s, after 30 years of operational life. This is driven by typical production timescales of landfill gas sites.
- Beyond the three landfill gas sites mentioned above, the FES and DFES trends are closely aligned for the remainder of the projection timeframe.

### Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| Sites already in the NGED connections baseline and pipeline | NGED |
| Regen's anaerobic digestion resource assessment, taking into account agricultural land, animal slurry and local authority food waste collection. | Regen local authority engagement, Natural Resources Wales |

# Diesel generation in the South Wales licence area

**Diesel-fuelled electricity generation, including standalone commercial diesel plants and behind-the-meter diesel backup generators.**

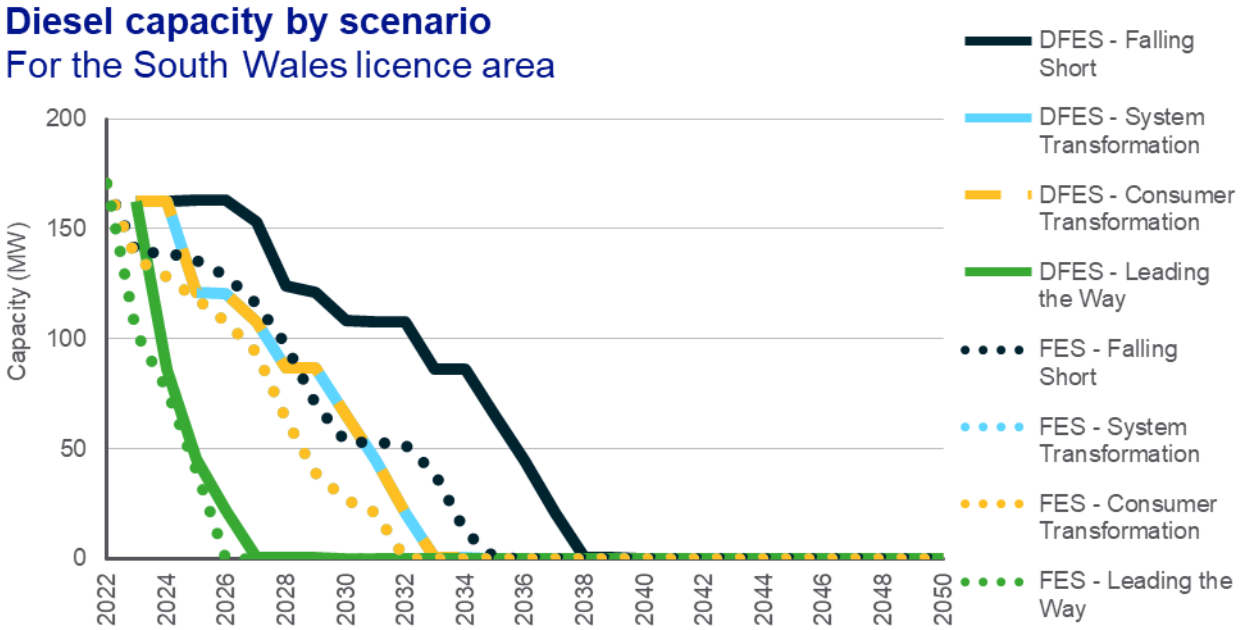
Data summary for diesel generation uptake in the South Wales licence area:

| Capacity (MWe) | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|
| **Falling Short** | 162 | 124 | 65 | 0 |
| **System Transformation** | | 87 | 0 | 0 |
| **Consumer Transformation** | | 87 | 0 | 0 |
| **Leading the Way** | | 1 | 0 | 0 |

Summary:

- Diesel electricity generation is being phased out as generators respond to policies designed to minimise air pollution in the short term and meet carbon targets in the longer term.
- There is already evidence of this response in the South Wales licence area, with just one new diesel generator looking to connect. Across the wider NGED distribution network, a number of diesel generators have disconnected since last year's DFES, showing very short lifetimes of around ten years.
- The operation of unabated diesel generation is at odds with net zero emissions targets and is restricted by the UK 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 through environmental permitting unless they only operate for 500 hours per year. This results in diesel capacity rapidly disconnecting from the network across all scenarios before 2050.
- Backup diesel generators are expected to remain connected to the network for longer under all scenarios, as they are operating for standby purposes only under the MCPD. Engagement with major energy users revealed that some organisations with backup diesel plants plan to switch to biofuels as an interim solution to reduce reportable carbon emissions.

Figure 22 – Installed capacity of diesel generation by scenario, South Wales licence area



**Baseline**

The 162 MW of existing operational sites in the licence area have been classified as either standalone commercial diesel generators or behind-the-meter backup generators. Larger diesel plants have historically targeted commercial network reserve services (such as Short-Term Operating Reserve (STOR) or the Capacity Market). One 20 MW site was re-classified from diesel to gas following this year's DFES asset owner/operator engagement process.

| Type | Number of sites | Total capacity (MW) |
|---|---|---|
| Backup | 14 | 107 |
| Commercial | 5 | 56 |

**Medium Combustive Plant Directive**

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 less than 500 hours per year.

Unabated commercial diesel generation falls within this regulation and, therefore, will no longer be able to operate from 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.

Backup diesel generators are exempt from similar environmental permit requirements, due to their limited operational hours. Additionally, backup generators are also allowed to extend their annual operating hours to 1,000 hours if needed in an emergency.

**Biofuels**

It is possible to substitute fossil diesel oil with biofuels that have similar properties for combustion in diesel generators. Vegetable oils can be esterified to produce **Biodiesel** or hydrotreated to produce **Hydrotreated Vegetable Oil** (HVO, sometimes referred to as green diesel).

Two organisations that operate backup generators responded to a survey sent to Major Energy Users to say that their decarbonisation strategy for backup power involved using HVO in the short term.

In some circumstances, substituting diesel with biofuels for power generation can reduce CO2 emissions but to achieve net zero the use of biofuels will have to be prioritised for other applications such as transport modes that require energy-dense liquid fuels (such as aviation and maritime) and power generation with CCS (carbon capture and storage). Therefore, it is assumed that the use of biofuels extends diesel generator lifetimes only in the Falling Short scenario.

**Projections (April 2023 to March 2050)**

| Scenario | Description | Backstop year for decommissioning |
|---|---|---|
| **Falling Short** | Biofuels could still play a role for backup generators, so diesel plants are modelled to run until the end of their operational life (up to 2035 for commercial generation and 2040 for backup generation). | Backup: 2040<br>Commercial: 2035 |
| **System Transformation** | Commercial sources of flexible generation are assumed to move to lower carbon alternatives, such as electricity storage. Some backup diesel generators continue to operate out to 2035, but only in mains failure situations, for a handful of hours per year. | Backup: 2035<br>Commercial: 2030 |
| **Consumer Transformation** | | |
| **Leading the Way** | Commercial diesel generators over 2 MWe are modelled to decommission by 2025, with a handful of backup | Backup: 2030 |

| | | |
|---|---|---|
| | generators and small commercial plant (43 MW) continuing to operate until 2030. | Commercial under 2 MWe: 2030<br>Commercial over 2 MWe: 2025 |

### Reconciliation with National Grid FES 2023

- DFES 2023 and FES 2023 projections are closely aligned for the South Wales licence area.
- In the DFES, small commercial and backup generators are assumed to decommission later than large commercial plant than in FES, reaching 0 MW capacity later in all scenarios.

### Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| Location of baseline and pipeline diesel generation sites | National Grid |

# Fossil gas-fired generation in the South Wales licence area

Fossil gas-fired power generation exporting to the distribution network, covering close cycle gas turbines (CCGT), open cycle gas turbines (OCGT), gas reciprocating engines and gas combined heat and power (gas CHP) plants.

Data summary for fossil gas-fired power generation in the South Wales licence area:

| Capacity (MWe) | | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|---|
| OCGT (non-CHP) | Falling Short | 83 | 83 | 83 | 83 |
| | System Transformation | | 83 | 21 | 0 |
| | Consumer Transformation | | 83 | 21 | 0 |
| | Leading the Way | | 83 | 0 | 0 |
| Reciprocating engines (non-CHP) | Falling Short | 301 | 401 | 401 | 351 |
| | System Transformation | | 291 | 253 | 0 |
| | Consumer Transformation | | 291 | 253 | 0 |
| | Leading the Way | | 243 | 0 | 0 |
| Gas CHP | Falling Short | 117 | 136 | 136 | 136 |
| | System Transformation | | 136 | 135 | 0 |
| | Consumer Transformation | | 136 | 135 | 0 |
| | Leading the Way | | 135 | 0 | 0 |

Summary:

- There is a moderate baseline (c. 500 MW) of existing operational fossil gas-fired generation connected to the distribution network in the South Wales licence area. This ranges from large gas turbine stations to small-scale gas CHPs and reciprocating engines.
- There are six sites with accepted connection offers with NGED in the licence area, comprising four applications for reciprocating engines and 2 CHPs, totalling 121 MW.
- The current primary role of distribution-scale fossil gas-fired generation is to provide flexibility and backup services. The operation of all types of fossil gas generation significantly reduces in the three net zero scenarios out to 2050, as the use of unabated fossil gas-fired electricity generation is at odds with the UK's net zero targets.
- The Smart Systems and Flexibility Plan, updated in July 2021, outlines projections for 30 GW of low carbon flexible assets by 2030 and 60 GW by 2050.
- The Climate Change Committee's Sixth Carbon Budget also advised government to "produce a comprehensive long-term plan for weaning Great Britain off unabated gas power by 2035".
- Under **Falling Short**, the installed capacity of gas reciprocating engines and gas CHPs increases in the near term as gas generators play an increasingly important role as flexible generation in the absence of strong growth in low carbon forms of flexibility.
- **Leading the Way** sees the most rapid decommissioning of existing fossil gas-fired generation, as this scenario models the quickest route to decarbonisation. This scenario also reflects a shift to lower carbon forms of flexibility.

- The need to accelerate a reduced dependence on fossil fuels in the UK, including to fuel flexible/dispatchable sources of generation, has come into sharp focus with the Russian invasion of Ukraine, necessitating the move away from Russian fossil fuels.
- Whilst the installed capacity of fossil gas generation may remain stable in some scenarios, the annual operating hours and energy output are assumed to decrease significantly by 2050 in all scenarios as the electricity system is decarbonised.
- At a national level, after 2030, hydrogen-fuelled generation becomes a potentially economical source of supply-side flexibility in some scenarios. This results in some existing fossil gas generation site locations 'repowering' with hydrogen-fuelled electricity generation assets between 2030 and 2050. The hydrogen-fuelled generation scenario analysis and results are outlined separately in the next section'.

Figure 23 – Electrical capacity of OCGTs by scenario, South Wales licence area

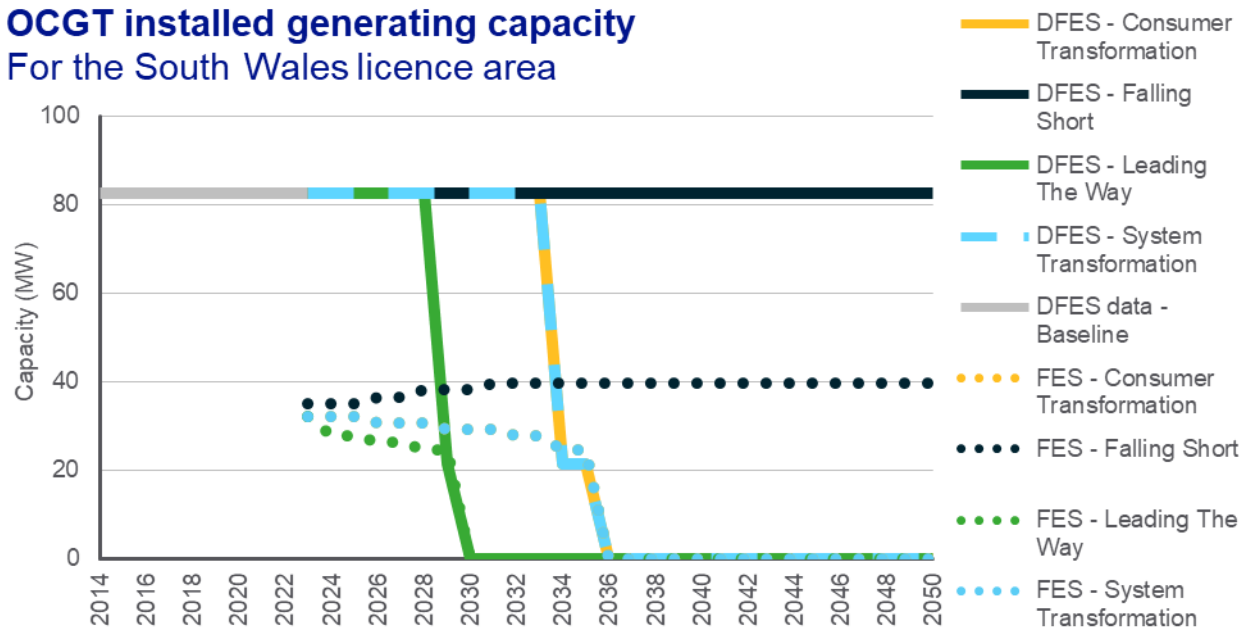



Figure 24 – Electrical capacity of fossil gas reciprocating engines by scenario, South Wales licence area

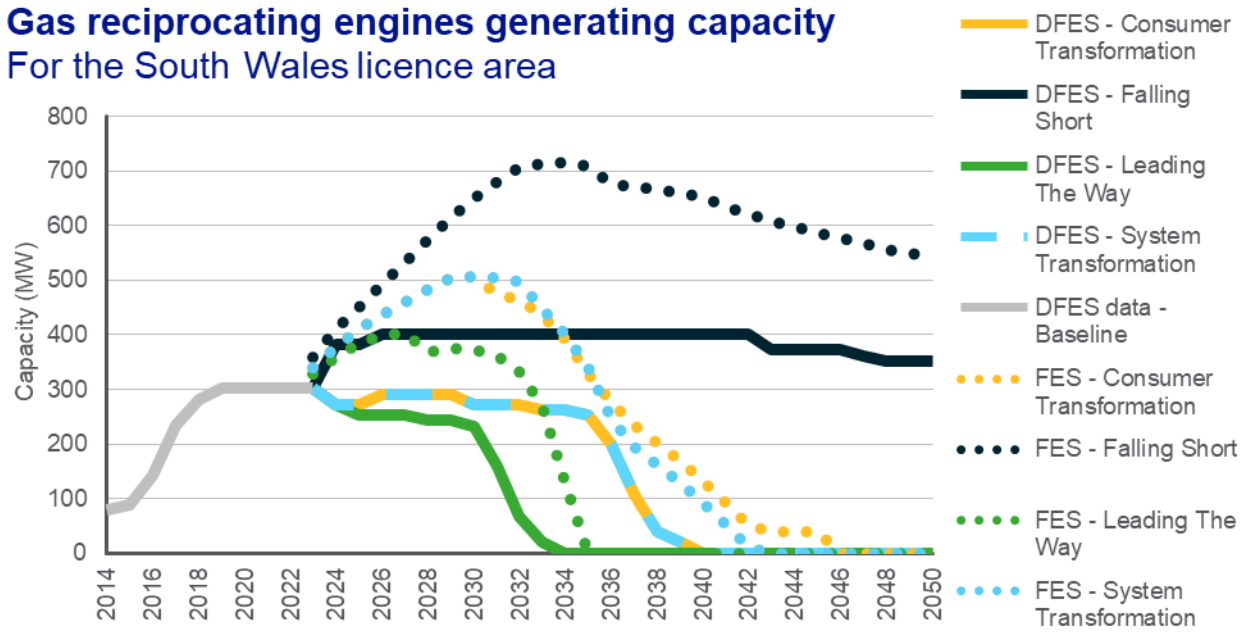
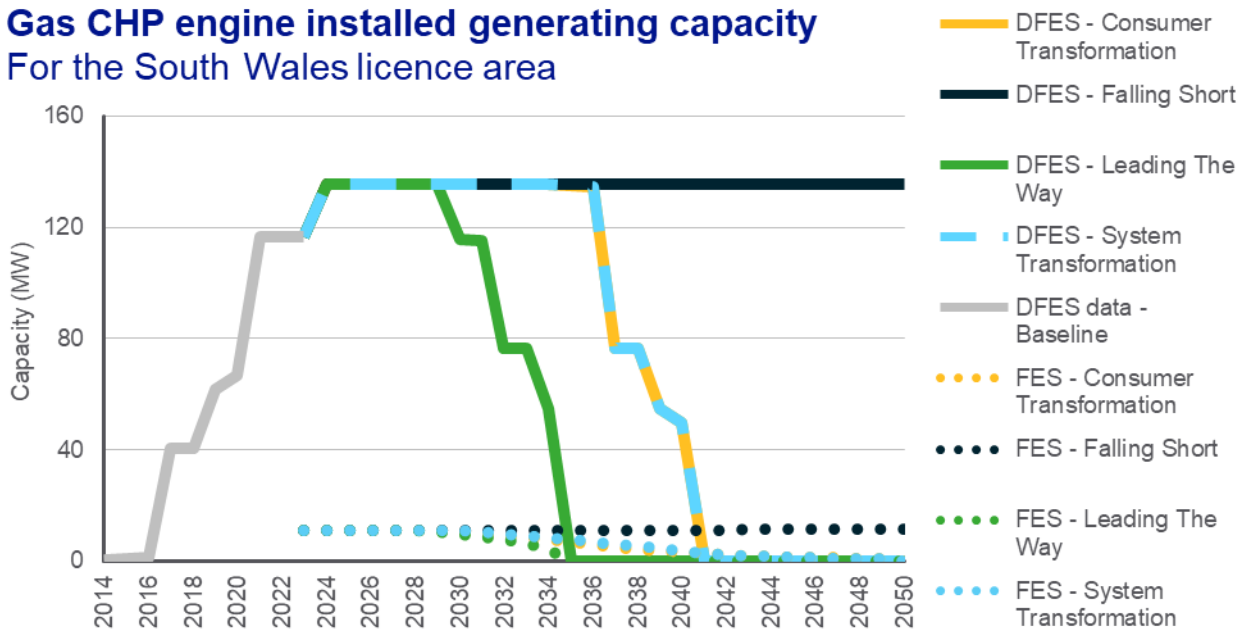


Figure 25 – Electrical capacity of fossil gas CHPs by scenario, South Wales licence area




## Modelling assumptions and results

| Baseline | | | |
|---|---|---|---|
| There are 51 fossil-gas generation sites connected in the South Wales licence area, totalling 513 MW. The largest site is a 61 MW OCGT in Pembrokeshire. The baseline is broken down into the following fossil gas technologies: | **Type** | **Number of sites** | **Total capacity (MW)** |
| | OCGT | 2 | 83 |
| | Reciprocating engines | 23 | 301 |
| | Gas CHP | 24 | 117 |

| Pipeline (April 2023 to March 2028) | | | |
|---|---|---|---|
| There are six fossil-gas generation sites with an accepted connection offer in the South Wales licence area, totalling 102 MW. The largest site in the pipeline is a 40 MW gas reciprocating engine in Rhondda Cynon Taf. The pipeline is broken down into the following fossil gas technologies: | **Type** | **Number of sites** | **Total capacity (MW)** |
| | Reciprocating engines | 4 | 100 |
| | Gas CHP | 2 | 21 |

| Pipeline analysis | | | |
|---|---|---|---|
| **Status** | **Scenario outcomes** | **Number of sites** | **Total capacity (MW)** |
| **Planning Permission Granted** | There are three sites, totalling 41 MW, with an accepted connection offer from NGED that have also received planning permission. These sites include:<br>• A 20 MW reciprocating engine in Newport<br>• A 19 MW CHP at Port Talbot and a smaller 2 MW CHP in Rhondda Cynon Taf | 3 | 41 |
| **Planning Application Submitted** | There is one site (a 40 MW reciprocating engine in Rhondda Cynon Taf) with an accepted connection offer from NGED that has also received planning permission. | 1 | 40 |
| **Pre-planning** | There are two sites with an accepted connection offer from NGED that have no evidence of progress through the planning system. These are both 20 MW reciprocating engines, one in Monmouthshire and the other in Rhondda Cynon Taf. | 2 | 40 |

| **Medium and long-term projections (April 2028 to March 2050)** | | | |
|---|---|---|---|
| The operation of all types of unabated fossil gas generation significantly reduces in the three net zero scenarios out to 2050, as the use of fossil gas for electricity generation is at odds with the UK's net zero targets. | | | |
| **Subtechnology** | **Scenario** | **Description** | **Decommissioning timescale** |
| **OCGT (non-CHP)** | **Leading the Way** | With only two OCGTs operating, capacity drops dramatically as these sites reach end of life in the net zero compliant scenarios. In Falling Short, capacity remains beyond 2050. | 2023 – 2030 |
| | **Consumer Transformation** | | 2023 – 2036 |
| | **System Transformation** | | 2023 – 2036 |
| | **Falling Short** | | Post-2050 |
| **Reciprocating engines (non-CHP)** | **Leading the Way** | Gas reciprocating engine capacity is modelled to steadily reduce across the medium term. This reflects a rapid switch to alternative low carbon sources of flexibility such as electricity storage, bioenergy and hydrogen. | 2023 – 2035 |
| | **Consumer Transformation** | A moderate amount of reciprocating engine capacity continues to connect to the distribution network in the early 2030s, reflecting a slightly slower transition to lower carbon flexibility. Sites then steadily decommission so that no capacity is operating on the network by 2050. | 2023 – 2043 |
| | **System Transformation** | | 2023 - 2043 |
| | **Falling Short** | Notable additional reciprocating | 2023 – post-2050 |

| | | | |
|---|---|---|---|
| | | engine capacity continues to connect to the distribution network in the medium term, reflecting this rapid-response technology continuing to win flexibility and reserve ancillary service contracts. After peaking, some capacity is modelled to decommission, reflecting the transition away from fossil-fuel-driven flexibility. | |
| Gas CHP | **Leading the Way** | The majority of gas CHP sites in the licence area are small-to-medium engines located onsite at commercial buildings such as factories, universities, hospitals or industrial sites. Under the three net zero scenarios, no additional increase in gas CHP capacity is modelled beyond the mid-2020s, and all gas CHP capacity is modelled to decommission by 2050 at the latest. | 2024 - 2035 |
| | **Consumer Transformation** | | 2024 – 2045 |
| | **System Transformation** | | 2024 - 2045 |
| | **Falling Short** | Under Falling Short, the gas CHP baseline continues to operate in the medium term, and only a small number of these CHPs decommission by 2050, with 209 MW still operational by this period. | 2049 – post-2050 |

### Reconciliation with National Grid FES 2023

- For all of the fossil gas sub-technologies included, the DFES has sought to classify each of the baseline and pipeline sites based on connection data held by National Grid and through site-by-site reconciliation with Capacity Market registers published by the EMR Delivery Body.
- Each pipeline site with an accepted connection offer was also individually assessed for evidence of development by reviewing online planning portals for planning activity and Capacity Market registers for capacity auction activity.
- These analyses have caused some variances between the FES and the DFES in the 2023 baseline and in the near-to-medium-term projections.
    - OCGT: The DFES baseline is significantly higher than the FES for OCGT installed capacity. The decommissioning timelines are well aligned.
    - Reciprocating engines: The DFES and FES baselines are well aligned. There is significantly more near-term growth in all scenarios in the FES compared to the DFES. The rate of growth projected in the FES would require projects in addition to the existing pipeline that hold accepted connection offers.
    - Gas CHP: The DFES baseline is significantly higher than the FES baseline. Decommissioning timescales are similar between projections, though the DFES sees sharper capacity decreases due to the higher baseline of installed capacity.

### Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| The location of the known pipeline sites | National Grid |

# Hydrogen-fuelled generation in the South Wales licence area

**Hydrogen-fuelled electricity generation, which has been modelled to connect to the distribution network in areas where there is the potential for hydrogen supply.**

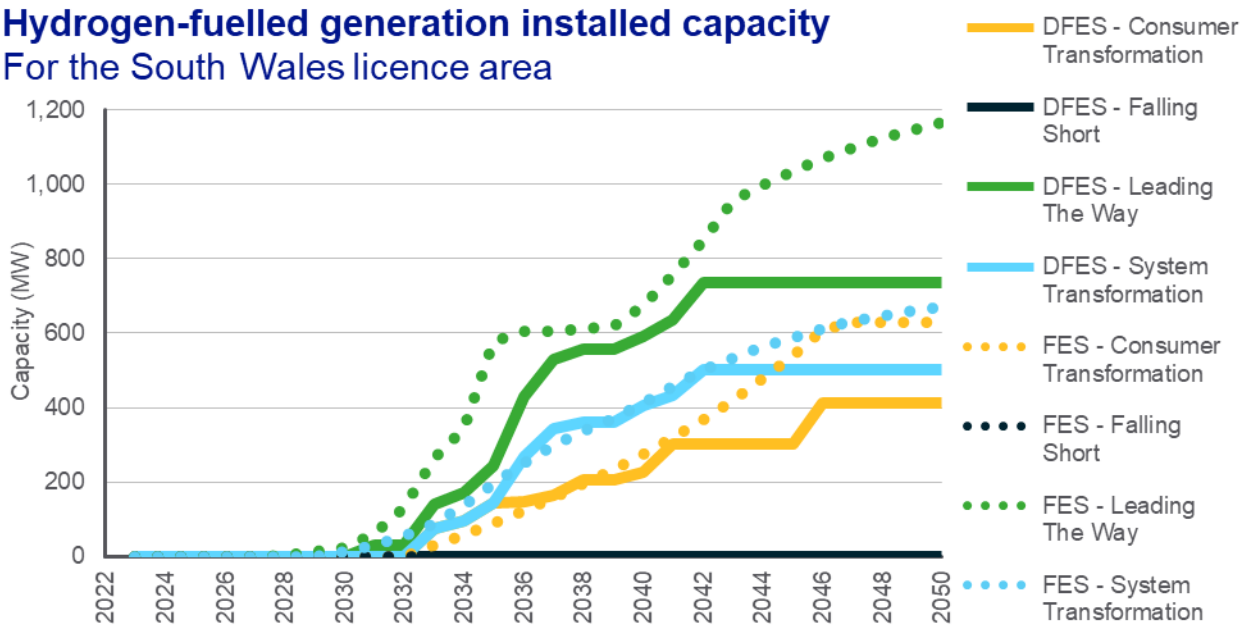
Data summary for hydrogen-fuelled generation in the South Wales licence area:

| Capacity (MWe) | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|
| **Falling Short** | 0 | 0 | 0 | 0 |
| **System Transformation** | | 0 | 144 | 500 |
| **Consumer Transformation** | | 0 | 144 | 414 |
| **Leading the Way** | | 0 | 244 | 735 |

Summary:

- Engagement with National Grid ESO highlighted that they expect most of the UK's dedicated hydrogen generation to be new-build (albeit located at existing sites) and optimised for peak running. The DFES has, therefore, modelled the potential for existing and pipeline commercial gas generation sites to convert to run hydrogen generation instead of fossil gas.
- Regen's 'A day in the life 2035' analysis with National Grid ESO has highlighted the potential role of hydrogen-fuelled generation in a net zero electricity system as a form of low carbon dispatchable generation. The analysis suggests a cold, calm and cloudy winter day might require between 10-15 GW of hydrogen-fuelled generation.
- Under **Leading the Way** and **System Transformation**, conversion to hydrogen generation in the DFES has been modelled to occur initially at sites in proximity to industrial clusters and the core hydrogen network proposed by National Gas.
- South Wales hosts a significant length of the gas National Transmission System, which under National Gas' Project Union plan would be converted to transport 100% hydrogen. 22 sites, with a combined capacity of over 320 MW, are operating within 10 km of the planned route.
- The South Wales industrial cluster, with hubs at Port Talbot and Pembroke Dock, are also enablers of hydrogen-fuelled generation in the medium term. 4 sites, with over 35 MW capacity combined, are operating within 10 km of either of the two hubs.
- In the long term, under **Leading the Way** and **System Transformation**, a national hydrogen network is assumed to be developed which enables more of the licence area to have access to hydrogen and more opportunity for hydrogen generation sites to be developed.
- The South Wales licence area has a significant amount of existing gas generating capacity (c. 513 MW) along with a further pipeline of 121 MW. Therefore, in high hydrogen scenarios, the South Wales licence area is likely to be a key region for hydrogen-fuelled generation in the future under some scenarios.
- As a general consideration, the business case for hydrogen-fuelled electricity generation is likely to be challenging and may require new markets to incentivise uptake. Hydrogen is likely to be an expensive fuel, with production at scale unlikely to be developed until the 2030s at the earliest.
- However, there is strong support for the role of low carbon hydrogen in providing flexible power generation, as stated in the UK Hydrogen Strategy. In October 2023, the UK government published its response to the consultation on The Hydrogen Production Business Model (HPBM), which intends to incentivise the production and use of low carbon hydrogen.

Figure 26 – Electrical capacity of hydrogen-fuelled generation by scenario, South Wales licence area




## Modelling assumptions and results

### Baseline

Hydrogen-fuelled generation is not yet being trialled due largely to a lack of hydrogen supply across the UK. There is currently no hydrogen-fuelled generation connected to the distribution network in the South Wales licence area or nationally.

### Pipeline (April 2023 to March 2028)

There is unlikely to be any development in grid-connected hydrogen-fuelled generation in the near term as fossil gas powered generation is still providing energy and flexibility to the system.

Developers contacted as part of the project research suggested that they were actively evaluating future plans but were unwilling to make final decisions before the government announces new policy in this space. A government consultation on market interventions required to incentivise the shift away from unabated gas towards hydrogen-fuelled generation is expected soon.

### Medium and long-term projections (April 2028 to March 2050)

With hydrogen-powered turbine and engine technology coming to market already, the critical enabler of hydrogen-fuelled generation will be access to hydrogen supply. Hydrogen is likely to be available first at industrial cluster sites as early as 2030 and then in proximity to hydrogen pipeline networks as they develop from 2035.

The South Wales licence area is well-placed to enable fossil gas-powered sites to convert to hydrogen with both industrial clusters and significant lengths of hydrogen network planned in the region:

- The industrial clusters at Port Talbot and Pembroke Dock are likely to enable hydrogen-fuelled generation from 2030. 4 sites, with over 35 MW capacity combined, are operating within 10 km of either of the two hubs.
- The core hydrogen network proposed by National Gas runs across the region from the LNG terminals in the west, past the industrial area of Port Talbot and east to the Midlands. 22 sites, with a combined capacity of over 320 MW, are operating within 10 km of the planned route.

| | | |
|---|---|---|
| However, the National Infrastructure Commission recently warned in its National Infrastructure Assessment that "If the steel industry does not require hydrogen then the case for a hydrogen pipeline to the area is weakened."<br><br>The medium and long-term projections are modelled according to the framework described below. | | |
| **Scenario** | **Description** | **Capacity by 2050 (MW)** |
| **Falling Short** | No hydrogen-fuelled generation capacity is projected as hydrogen networks are undeveloped and fossil gas-fuelled generation continues to provide flexibility in the absence of alternatives, such as battery storage and demand side response, until 2050. | 0 |
| **System Transformation** | This scenario sees high levels of policy support for hydrogen and a national hydrogen transportation network is developed. Sites are assumed to convert to hydrogen in the following order:<br>• Existing and pipeline fossil gas sites in proximity to industrial cluster zones are modelled to convert to hydrogen from 2030<br>• Sites in proximity to the hydrogen core network (as proposed by National Gas) are modelled to convert from 2035<br>• Remaining sites are assumed to convert from 2040, by which point hydrogen is assumed to be widely available through a national hydrogen network | 500 |
| **Consumer Transformation** | Hydrogen networks are assumed to be less developed in this scenario, and hydrogen is produced near to demand in industrial clusters. Sites in proximity to industrial clusters are repowered after 2030 and sites in proximity to a core hydrogen network (as proposed by National Gas) are repowered after 2045. | 414 |
| **Leading the Way** | This scenario sees moderate to high levels of policy support for hydrogen and a national hydrogen transportation network is developed. Hydrogen-fuelled generation is assumed to dominate the low running hours segment of the flexibility market; to reflect the lower capacity factors, sites are assumed to convert to hydrogen at 50% greater capacity in the following order:<br>• Existing and pipeline fossil gas sites in proximity to industrial cluster zones are modelled to convert to hydrogen from 2030<br>• Sites in proximity to the hydrogen core network (as proposed by National Gas) are modelled to convert from 2035<br>• Remaining sites are assumed to convert from 2040, by which point hydrogen is assumed to be widely available through a national hydrogen network | 735 |

### Reconciliation with National Grid FES 2023

- Neither FES nor DFES project any conversion to hydrogen in **Falling Short**.
- In both **Leading the Way** and **System Transformation** conversion begins from 2030 in the DFES at sites near the South Wales industrial cluster hubs. Hydrogen-fuelled generation capacity increases from 2035 as gas-powered sites in proximity to the hydrogen core network begin to convert. In the long-term, in these scenarios, the DFES projections are lower than the FES but at a similar level to existing gas-fired generation capacity today.

- In the DFES, uptake in **Consumer Transformation** slightly lags the other net zero scenarios, with hydrogen conversion occurring only at sites near the industrial cluster hubs from 2030 until 2045, when a core hydrogen is assumed to be developed.

### Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| Location of existing and known commercial gas sites in the South Wales licence area. | National Grid |
| Spatial analysis of industrial cluster locations and National Gas plans for a core hydrogen network. | Regen analysis |

# Energy from waste in the South Wales licence area

**Energy from Waste (EfW) sites, including incineration and Advanced Conversion Technologies (ACT).**

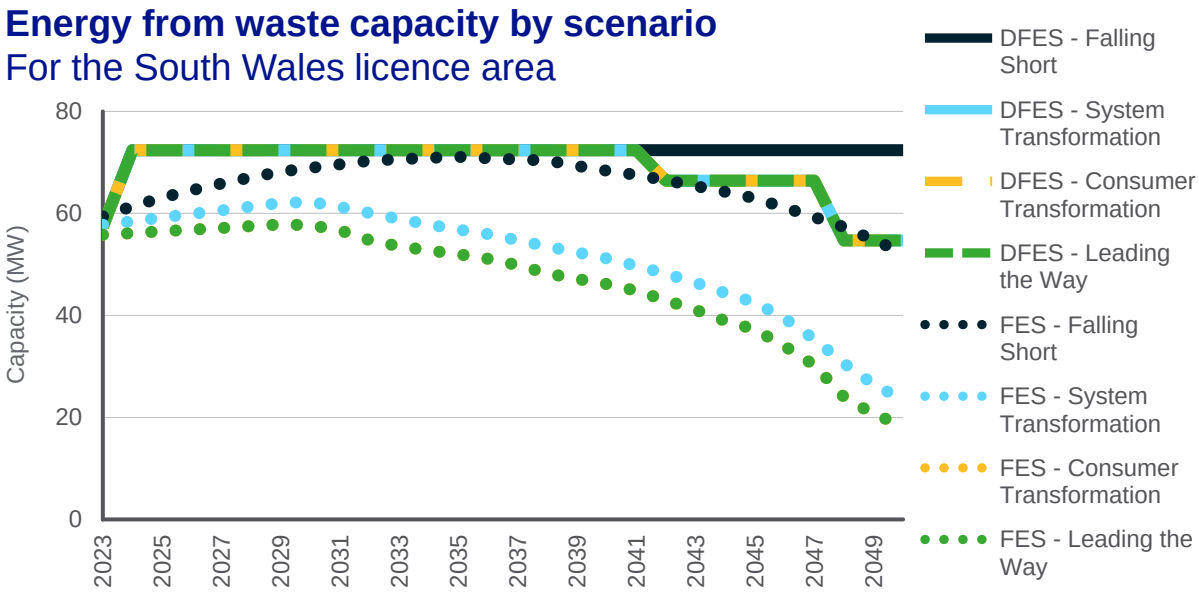
Data summary for energy from waste in the South Wales licence area:

| Capacity (MWe) | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|
| **Falling Short** | 57 | 72 | 72 | 72 |
| **System Transformation** | | 72 | 72 | 55 |
| **Consumer Transformation** | | 72 | 72 | 55 |
| **Leading the Way** | | 72 | 72 | 55 |

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 small 57 MW baseline of projects currently operating in South Wales. A Welsh Government moratorium on new large-scale energy from waste came into effect in 2021, limiting any further uptake in South Wales. As a result, there is only one 15 MW project with an accepted connection offer in the licence area.
- Waste incineration is highly carbon intensive and therefore sees reduced capacity under the three net zero scenarios out to 2050, as more environmentally friendly approaches to waste management become commonplace.
- More efficient energy from waste plants, such as ACT gasification plants, operate beyond 2050 under all four scenarios.
- Only a handful of very old waste incineration plants are modelled to decommission under **Falling Short**, which almost the same level of capacity operating by 2050 as the baseline.

Figure 27 – Energy from waste capacity by scenario, South Wales licence area



## Modelling assumptions and results

| Baseline | | | |
|---|---|---|---|
| The baseline of energy from waste capacity in South Wales was built between 2002 and 2017. The largest site, Trident Park, is a 40 MW incinerator built in Cardiff in 2014. A 2021 Welsh Government moratorium on large-scale energy from waste has effectively stopped energy from waste deployment in Wales[xviii]. | **Type** | **Number of sites** | **Total capacity (MW)** |
| | Incineration | 2 | 18 |
| | ACT | 1 | 40 |

| Pipeline (April 2023 to March 2028) | | |
|---|---|---|
| The only pipeline site in South Wales is a 15 MW site in Rhondda Cynon Taf. This site is listed as already operational in the Renewable Energy Planning Database. As a result, it is modelled to connect to the NGED network by the end of 2023 under all four scenarios. | **Number of sites** | **Total capacity (MW)** |
| | 1 | 15 |

| Medium and long-term projections (April 2028 to March 2050) | | |
|---|---|---|
| Other than this one 15 MW site, energy from waste projections in the licence area are wholly based on anticipated decommissioning dates of operational sites. These dates are based on the expected operational life of energy from waste sites, which vary under each scenario. | | |
| **Scenario** | **Description** | **Capacity in 2050 (MW)** |
| **Leading the Way** | Under the net zero scenarios, conventional waste incineration sites are projected to decommission after thirty years of operational life, reflecting a reduced volume of waste in these scenarios and the drive to reduce carbon emissions.<br>More efficient sites using ACT technology or classified as Energy Recovery Facilities are not projected to come offline under any scenario. This assumes that any remaining waste in the 2030s and 2040s is processed at less carbon intensive, highly efficient ACT sites under these scenarios. | 55 |
| **Consumer Transformation** | | 55 |
| **System Transformation** | | 55 |
| **Falling Short** | Under **Falling Short**, lower levels of societal change and limited progress towards carbon emission reduction mean that waste incineration sites continue to operate up to forty years after their commissioning date. Similarly to the net zero scenarios, more efficient ACT and ERF sites are assumed to continue operating beyond 2050. As a result, overall energy from waste capacity in this scenario is marginally higher in 2050 than today's operational baseline, | 72 |

## Reconciliation with National Grid FES 2023

- The DFES and FES baselines closely align, but the 15 MW site under construction in Rhondda Cynon Taf causes the near-term DFES projections to rise above the FES.
- In the longer term, the DFES projections do not fall as far as the FES, especially under the net zero scenarios. This is due to the Energy Recovery Facility at Trident Park, representing nearly two-thirds of the baseline, being assumed to remain online under every scenario.

## Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| Location of waste to energy baseline and pipeline sites. | National Grid |

# Other generation and nuclear SMR in the South Wales licence area

**Sites in NGED connections data where the technology could not be identified, and how nuclear Small Modular Reactors (SMR) are treated in the analysis.**

Data summary for other generation in the South Wales licence area:

| Capacity (MW) | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|
| All scenarios | 0 | 4 | 4 | 4 |

Summary:

- There are three connected sites in the licence area that have not been categorised as a particular technology, totalling 0.4 MW. These are likely to be small-scale fossil-fuelled sites, but they could not be specifically identified as such in the NGED connections data.
- There are 14 additional other generation sites with an accepted connection offer, totalling 3.8 MW. As with the baseline sites, these small-scale sites could not be positively identified as a specific technology. These pipeline sites have, therefore, been modelled to connect in 2023 under every scenario.
- There are no projections for other generation beyond this pipeline of accepted connections.

## Nuclear Small Modular Reactors

Nuclear SMR has been included in the scope of this year's DFES analysis. The UK government is targeting 24 GW of nuclear power capacity by 2050, delivered through a mixture of conventional nuclear power stations and SMR solutions.

Through desktop analysis, it has been assumed in the DFES that individual nuclear SMR sites will be large-scale and therefore exclusively connect to the transmission network.; This assumption is echoed in the National Grid ESO FES. The most advanced SMR technology currently in development in the UK is the Rolls-Royce SMR, which has a design capacity of 470 MW. This would require a transmission-level grid connection. This is the only SMR design which has progressed to Step 2 of the Generic Design Assessment process[xix].

The Holtec-160 SMR, a 160 MW design, was set to enter the Generic Design Assessment process as of late 2022[xx]. At this scale, a connection to NGED's distribution network (likely at the 132 kV level) could be feasibly possible. However, the three potential sites identified by Holtec — Trawsfynydd in North Wales, Heysham in Lancashire and Oldbury in South Gloucestershire — are all located at existing nuclear power stations with transmission network connections.

As a result, there is no projected nuclear SMR capacity in the licence area under any of the four scenarios out to 2050.

While there are not yet any indications that distribution network connected SMR is likely, the technology will remain in the scope of the DFES analysis and research.


# Storage technologies

Results and assumptions

# Battery storage in the South Wales licence area

**Battery storage, comprising four business models:**

- **Standalone network services** – typically multiple megawatt-scale projects that provide balancing, flexibility and support services to the electricity network
- **Generation co-location** – typically multiple megawatt-scale projects, sited alongside renewable energy (or occasionally fossil fuel) generation projects.
- **Behind-the-meter high-energy user** – typically single megawatt or smaller scale projects, sited at large energy-user operational sites to support on-site energy management or to avoid high electricity cost periods.

  These three business models combine to form 'large-scale' battery storage, which aligns with the FES building blocks.
- **Domestic-scale batteries** – typically 5-20 kW scale batteries that households buy to operate alongside rooftop PV or to provide backup services to the home. Includes domestic-scale batteries installed by small businesses.

Data summary for battery storage in the South Wales licence area:

| Capacity (MW) | | Baseline | 2028 | 2035 | 2050 |
|---|---|---|---|---|---|
| Standalone network services | Falling Short | 0 | 0 | 247 | 247 |
| | System Transformation | | 80 | 247 | 247 |
| | Consumer Transformation | | 247 | 297 | 297 |
| | Leading the Way | | 320 | 320 | 320 |
| | Storage Planning | | 320 | 763 | 763 |
| Generation co-location | Falling Short | 47 | 47 | 53 | 67 |
| | System Transformation | | 47 | 64 | 89 |
| | Consumer Transformation | | 47 | 112 | 112 |
| | Leading the Way | | 47 | 129 | 146 |
| | Storage Planning | | 47 | 179 | 179 |
| Behind-the-meter high-energy user | Falling Short | 1 | 7 | 14 | 28 |
| | System Transformation | | 7 | 21 | 65 |
| | Consumer Transformation | | 7 | 35 | 93 |
| | Leading the Way | | 10 | 35 | 93 |
| | Storage Planning | | 7 | 7 | 7 |
| Domestic-scale batteries | Falling Short | 2 | 6 | 10 | 67 |
| | System Transformation | | 13 | 27 | 108 |
| | Consumer Transformation | | 28 | 96 | 343 |
| | Leading the Way | | 34 | 124 | 435 |

Summary:

- Low-carbon dispatchable power is required in a net zero electricity system 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. Regen's analysis,[1] in partnership with ESO, suggested that across GB 80-100 GW of flexibility capacity will be needed by 2035, with 20-25 GW provided by electricity storage.
- The battery storage sector has grown rapidly since the first commercial-scale projects were launched in 2016, as production costs have dropped.
- The South Wales licence area currently has 29 operational large-scale battery storage sites totalling 48 MW and a pipeline of 1.2 GW.
- The battery storage pipeline across the four NGED licence areas is now 19 GW, up from 13.5 GW in 2022 and just 2 GW in 2021. In context, NGED currently manages connections of c. 11 GW of operational generation assets.
- Based on Regen's analysis of projects in this licence area, almost 270 MW of the storage pipeline has either received or submitted planning permission. A further 10 MW of projects have some pre-planning application evidence such as environmental impacting assessment screening.
- Upstream constraints on the transmission network can impact the deployment timescale of projects in the pipeline connecting at distribution level. These constraints have been directly reflected under the **Falling Short** scenario, but not in the three net zero scenarios. This allows the scenarios to represent a realistic range of potential future connections.
- Due to the unprecedented pipeline of large-scale battery storage projects across National Grid's licence areas, the DFES 2023 includes an additional scenario, **Storage Planning**, which is based solely on the significant pipeline of projects with connection offers with National Grid Electricity Distribution. This is outside of the envelope of the four National Grid ESO FES scenarios, which aim to represent a balanced energy system at a national level and to which the four main DFES scenarios broadly align, due to the scale of the battery storage pipeline.
- The South Wales licence area has a potential for long-term growth in connected storage capacity, though this is limited compared to other NGED licence areas. Factors that affect deployment of storage in South Wales include:
    - Notable 33 kV and 132 kV network infrastructure across the licence area – though this infrastructure is unevenly spread across the region
    - Moderate potential for solar deployment and higher potential for wind deployment which may be co-located with storage
    - Relatively few non-domestic properties with the potential for behind-the-meter batteries (South Wales has the lowest number of domestic properties out of NGED's four licence areas)
    - A significant potential for domestic rooftop solar which is now commonly installed alongside a domestic battery.

[1] Bridging the gap to Net Zero – a Day in the Life 2035 report, carried out by Regen and ESO

Figure 28 – Electrical capacity of large-scale battery storage by scenario (including the Storage Planning scenario), South Wales licence area

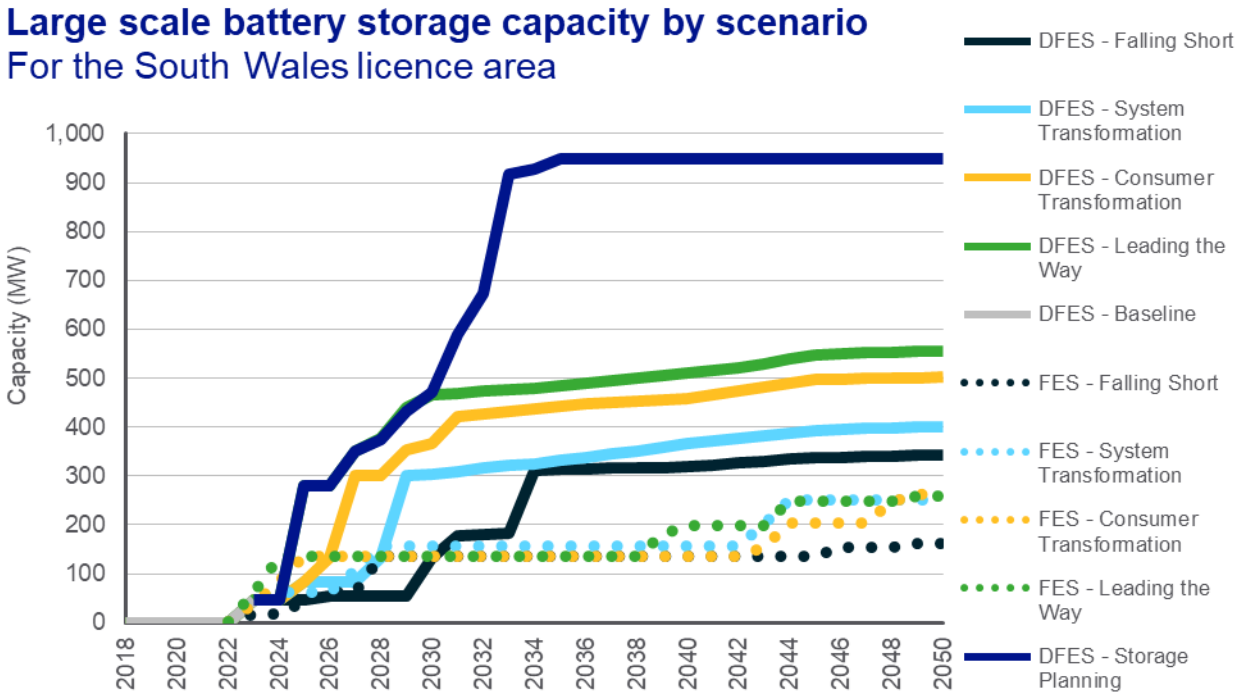
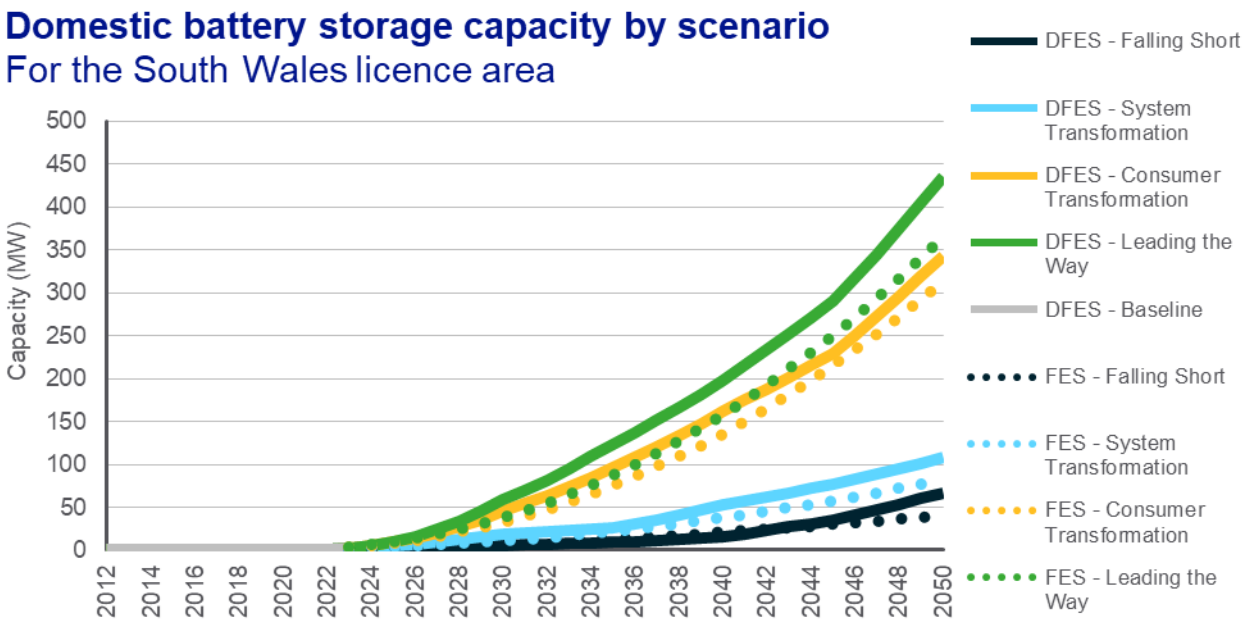



Figure 29 – Electrical capacity of domestic battery storage by scenario, South Wales licence area



**Baseline**

There are 20 large-scale battery storage projects totalling 47 MW. This is entirely made up of batteries co-located with renewable generation projects.

There are around 400 domestic batteries in the South Wales licence area, totalling 2.2 MW. Installation of domestic batteries and rooftop solar generation has increased rapidly over the past two years as consumers have sought to protect themselves from very high electricity prices. Unit prices for residential consumers reached around £0.32/kWh under the Energy Price Guarantee implemented by the UK Government at the peak of the energy price crisis, creating a strong financial incentive for installing domestic PV and battery storage.

| Type | Number of sites | Total capacity (MW) |
|---|---|---|
| Standalone network services | 1 | 0 |
| Generation co-location | 2 | 47 |
| Behind-the-meter high-energy user | 26 | 1 |
| Domestic-scale batteries | c. 400* | 2 |

* based on an average domestic-scale battery capacity of 5 kW

**Pipeline (April 2023 to March 2028)**

The pipeline of storage projects has surged across the country in the last couple of years. The South Wales licence area has a pipeline of 47 large-scale projects totalling 1.24 GW.

As a key technology that can provide flexibility services to the network, battery storage is active in the National Grid ESO's ancillary service markets. In recent years, the ESO has evolved their suite of response and reserve services, including the new trio of frequency response markets: Dynamic Containment, Dynamic Regulation and Dynamic Moderation. In addition, the ESO has launched a new Slow Reserve service and continues to deliver its network options assessment pathfinders for stability, voltage and reactive power services. Under the Government's Review of Energy Market Arrangements (REMA), opportunities for flexibility services are likely to continue to evolve.

The battery storage pipeline across the four NGED licence areas is 19 GW in 2023, up from 13.5 GW in 2022 and just 2 GW in 2021. This interest in development is also reflected at a national level, with over 150 GW of battery storage projects seeking a transmission network connection.

The length of the queue to secure a grid connection is a key challenge for the sector. There is over 400 GW of capacity waiting to connect to the transmission system, increasing by around 25 GW per month.

ESO and the ENA have announced short-term changes to accelerate connections, particularly affecting flexible battery storage projects, and ESO is working on longer-term connections reform. Regen has been supporting the developer industry and working closely with ESO to accelerate connection timelines.

| Type | Number of sites | Total capacity (MW) |
|---|---|---|
| Standalone network services | 22 | 763 |
| Generation co-location | 17 | 472 |
| Behind-the-meter high-energy user | 8 | 6 |

| Pipeline analysis | | | |
|---|---|---|---|
| **Status** | **Scenario outcomes** | **Number of sites** | **Total capacity (MW)** |
| Planning Permission Granted | In the South Wales licence area, five projects in the pipeline have been granted planning permission, totalling 217 MW of capacity. One of these projects, a 22 MW battery in Rhondda Cynon Taf, has pre-qualified in the Capacity Market (CM).<br>Sites with planning permission are modelled to connect to the network in all scenarios. Where projects hold a CM contract, they are modelled to connect in the relevant delivery year. | 5 | 217 |
| Planning Application Submitted | In the South Wales licence area, one project has submitted a planning application and is waiting for approval with 50 MW capacity.<br>Sites with a planning application are modelled to connect to the network in **Leading the Way** and **Consumer Transformation**, but only in **System Transformation** if they prequalified or won a CM contract and in **Falling Short** if they have been awarded a CM contract. | 1 | 50 |
| Pre-planning | Two projects have evidence of pre-planning progress, such as Environmental Impact Assessment screening, totalling 10 MW of capacity.<br>Sites with pre-planning evidence are modelled to connect to the network in **Leading the Way** and **Consumer Transformation**, but only in **System Transformation** if they prequalified or won a CM contract and in **Falling Short** if they have been awarded a CM contract. | 2 | 10 |
| No information | Most sites in the pipeline do not have evidence of project development beyond an accepted grid connection offer. In the South Wales licence area, almost 1 GW of capacity has no Capacity Market contracts or planning information.<br>In the three net zero compliant scenarios, projects that have no planning evidence are not modelled to connect unless they have if they prequalified or won a CM contract. In **Falling Short**, they are only modelled to connect if they have been awarded a CM contract. | 44 | 963 |

| **Medium and long-term (April 2028 to March 2050)** | | | | |
|---|---|---|---|---|
| **Business model** | **Projection methodology** | **Scenario** | **Capacity by 2035 (MW)** | **Capacity by 2050 (MW)** |
| Standalone network | Standalone storage continues to dominate the project pipeline and sees increased deployment across all | **Falling Short** | 247 | 247 |
| | | **System** | 247 | 247 |

| | | | | |
|---|---|---|---|---|
| services | scenarios by 2035.<br>The growth in capacity stalls beyond the late 2030s out to 2050, reflecting market saturation following a rapid roll-out in the 2020s. | **System Transformation** | | |
| | | **Consumer Transformation** | 297 | 297 |
| | | **Leading the Way** | 320 | 320 |
| | | **Storage Planning** | 763 | 763 |
| Generation co-location | Generation co-location capacity sees a moderate uptake in the South Wales licence area. This is in part due to moderately lower combined ground-mounted solar PV and onshore wind capacity projections by 2035, when compared to other licence areas across all scenarios.<br>Beyond 2035, the growth in new co-location capacity lessens as network capacity and flexibility markets saturate, and grid-scale battery projects co-locating with new solar and wind generation develop at a more moderate pace out to 2050. | **Falling Short** | 53 | 67 |
| | | **System Transformation** | 64 | 89 |
| | | **Consumer Transformation** | 112 | 112 |
| | | **Leading the Way** | 129 | 146 |
| | | **Storage Planning** | 179 | 179 |
| Behind-the-meter high-energy user | The South Wales licence area also has a lower number of non-domestic properties with the potential for a battery compared to other NGED licence areas. However, the uptake of behind-the-meter storage projects in the licence area does moderately increase in all scenarios by 2035. This reflects stakeholder feedback that high-energy users, such as industrial customers, could drive electricity storage deployment in the medium term.<br>Annual capacity deployment under this business model begins to increase further in the longer term out to 2050 under **Consumer Transformation** and **Leading the Way**, as more businesses seek to manage their onsite energy use and costs through flexibility technologies. | **Falling Short** | 14 | 28 |
| | | **System Transformation** | 21 | 65 |
| | | **Consumer Transformation** | 35 | 93 |
| | | **Leading the Way** | 35 | 93 |
| | | **Storage Planning** | 7 | 7 |
| Domestic-scale batteries | South Wales has moderate potential for domestic battery deployment in the medium and long term, based on domestic-scale rooftop PV deployment projections. The projections for domestic batteries are directly tied to domestic solar PV uptake in all four scenarios. | **Falling Short** | 10 | 67 |
| | | **System Transformation** | 27 | 108 |
| | | **Consumer Transformation** | 96 | 343 |
| | | **Leading the Way** | 124 | 435 |

### Reconciliation with National Grid FES 2023

- Large-scale battery storage:
    - The DFES and FES 2023 are well aligned on the baseline of existing battery capacity in the licence area. There was no large-scale storage at all until 2023.
    - Reflecting the very large near-term pipeline, the DFES 2023 projections significantly exceed the FES 2023 near-term projections. This is based on a detailed assessment of planning status, Capacity Market auction activity and direct engagement with battery project developers.
- Domestic-scale batteries: the DFES 2023 projections for domestic batteries align well with FES 2023 across the analysis period and in all scenarios. The DFES projection for the **Leading the Way** scenario is notably higher than the FES in the long term. This is because the proportion of small-scale solar capacity with battery storage is assumed to increase more in the DFES than the FES as battery costs fall over time.

### Factors that will affect deployment at a local level

| Factor | Source |
|---|---|
| Location of existing and known pipeline sites in the South Wales licence area. | National Grid |
| **Standalone network services:** Developable land proximate to the 33 kV and 132 kV electricity network. For 2023, this has been determined by the location of the significant number of sites with accepted connection offers across the licence area. | Regen analysis |
| **Generation co-location:** Proximity to existing and future ground-mounted solar PV and onshore wind projects within the licence area. | Regen analysis |
| **Behind-the-meter high-energy user:** Proximity to industrial estates and commercial buildings that could be suitable for battery storage installations. | Addressbase, local authority development data |
| **Domestic-scale batteries:** Domestic dwellings with rooftop PV. | Regen analysis |

# Endnotes

[i] Heat network pipelines
[ii] Opportunity Areas for District Heat Networks in the UK, BEIS
[iii] Heat networks pipelines
[iv] Integrating heat pumps in heat networks, CIBSE
[v] Rules of thumb; Guidelines for building services, BSRIA
[vi] Evidence update of low carbon heating and cooling in non-domestic buildings
[vii] Heat network pipelines
[viii] Opportunity Areas for District Heat Networks in the UK, BEIS
[ix] 2018-based household projections by local authority
[x] Council Climate Plan Scorecards 2022
[xi] Power Technology- Number of UK homes, 2023
[xii] Building Regulation (Part L)
[xiii] Future Wales: The National Plan 2040
[xiv] Technical Advice Note: 8 Planning for Renewable Energy, 2005
[xv] RWE completes German wind farm repowering, 2022
[xvi] RWE completes German wind farm repowering, 2022
[xvii] British Hydropower Association - Environment Agency charges press release, 2022
[xviii] Welsh Government moratorium on large-scale waste energy
[xix] Rolls-Royce SMR design moves to next stage of regulatory assessment, 2023
[xx] Holtec Britain applies to join UK government process for Generic Design Assessment, 2022

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