Distribution Future Energy Scenarios 2022

Results and assumptions report

South Wales licence area

Electricity Distribution

nationalgrid

Foreword by National Grid DSO

Throughout the next RIIO-ED2 price control period, strategic planning and investment in the distribution network will be an important factor to enable our customers to reach their decarbonisation targets.

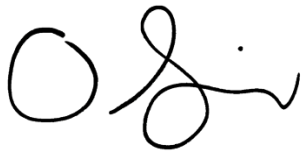
We have worked with Regen to help us understand what the changes that are forecast throughout the next decade and beyond might mean for our distribution network and the investment that may be needed to meet customers' changing needs. These forecasts are the foundation of our strategic investment process, which is an ongoing analysis published biennially through the Network Development Plan (NDP). The NDP then 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.

This report summarises the 2022 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.

Our annual DFES cycle allows incorporation of newly developed and projected technologies to the analysis. In DFES 2022, we have further developed the assumptions behind the storage pipeline and electrified heating technology demand profiles, as well as starting routine engagement with Major Energy Users to better capture future changes in demand. As local authorities develop Local Area Energy Plans (LAEPs), we are ensuring that these 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	GSHP	Ground Source Heat Pump
AD	Anaerobic Digestion	HGV	Heavy Goods Vehicle
AONB	Area of Outstanding Natural Beauty	GSP	Grid Supply Point
ASHP	Air Source Heat Pump	GW	Gigawatt
BECCS	Bioenergy with Carbon Capture, Utilisation and Storage	HNDU	Heat Network Delivery Unit
BEIS	Department for Business, Energy and Industrial Strategy	HNIP	Heat Network Investment Project
BEV	Battery Electric Vehicles	HVO	Hydrotreated Vegetable Oil
CCGT	Combined-Cycle Gas Turbine	kW	Kilowatt
CCUS	Carbon Capture, Utilisation and Storage	LA	Local Authority
CfD	Contract for Difference	LCT	Low Carbon Technology
CHP	Combined Heat and Power	LGV	Light Goods Vehicle
DFES	Distribution Future Energy Scenarios	LPG	Liquefied Petroleum Gas
DfT	Department for Transport	LV	Low Voltage
DNO	Distribution Network Operator	MCPD	Medium Combustion Plant Directive
EMR	Electricity Market Reform	MW	Megawatt
ENA	Energy Networks Association	NGED	National Grid Electricity Distribution
EPC	Energy Performance Certificate	OCGT	Open-Cycle Gas Turbine
ESA	Electricity Supply Area	PHEV	Plug-in Hybrid Electric Vehicle
ESO	Electricity System Operator	PV	(Solar) Photovoltaics
EV	Electric Vehicle	REMA	Review of Electricity Market Arrangements
FES	National Grid ESO Future Energy Scenarios	REPD	Renewable Energy Planning Database
FHS	Future Homes Standard	RHI	Renewable Heat Incentive
FiT	Feed-in Tariff	SCR	Significant Code Review
GB	Great Britain	SMR	Steam Methane Reformation
GHG	Greenhouse Gases	STOR	Short-Term Operating Reserve
GIS	Geographic Information System	UKCS	UK Continental Shelf

Introduction to the National Grid Electricity Distribution DFES 2022

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.

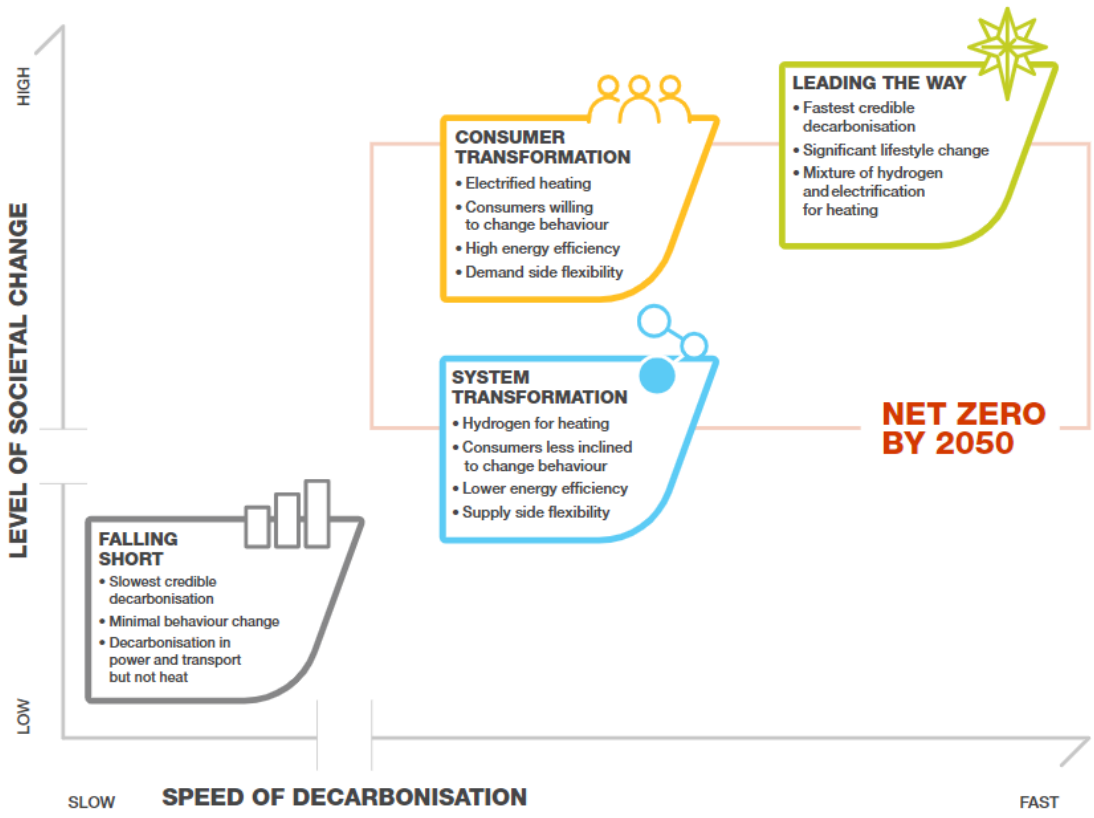
The DFES projections are directly informed by stakeholder engagement to reflect local and regional drivers, the ambitions of local authorities and national governments, and the views of other sector stakeholders, such as project developers, technology companies and community groups.

For the DNOs, the DFES allows network planners to model and analyse different future load scenarios for their networks. 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) as a framework, adopting the same national-level societal, technological, and economic assumptions as the FES 2022: **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. 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 2022 scenario framework



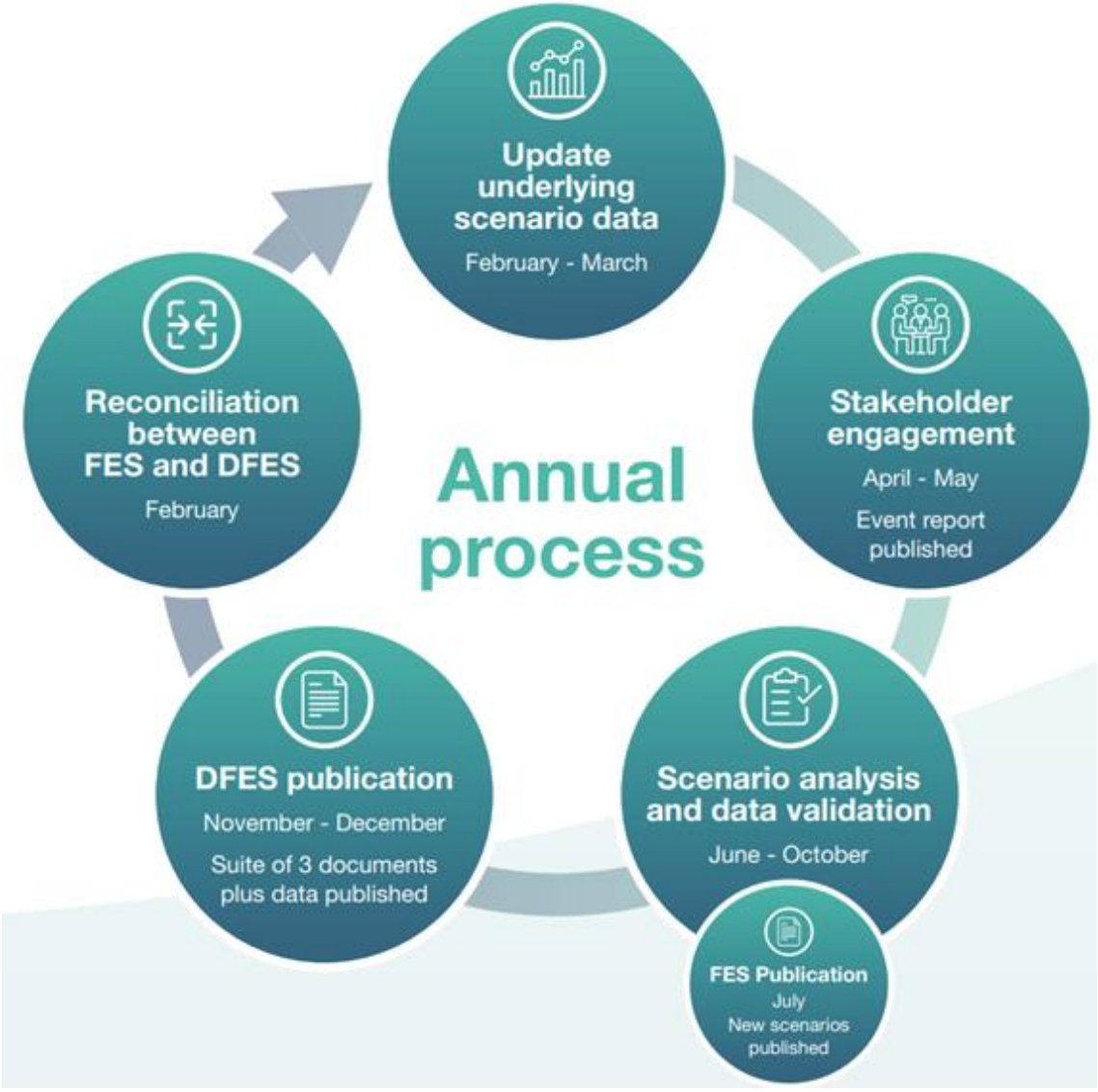
Scope

The NGED DFES 2022 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 'building blocks', developed by the ENA Open Networks project[i]. The scope does not include large-scale assets connecting directly to the National Grid transmission network, such as 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.

Figure 2 – The NGED DFES annual process



Results

The NGED DFES 2022 analysis is produced to granular geographic areas known as Electricity Supply Areas (ESAs), of which there are three 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.

These ESAs are also split by local authority boundaries, allowing DFES data to be aggregated to local authority or primary substation level.

Depending on the technology building block, the DFES provides projections of electrical power capacity (MW) and 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 network strategy and planning teams 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. Over half of the total generating capacity is from onshore wind and solar PV. However, 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 0.5% of South Wales households have an electric vehicle, and similarly less than 0.5% have an electric heat pump. 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

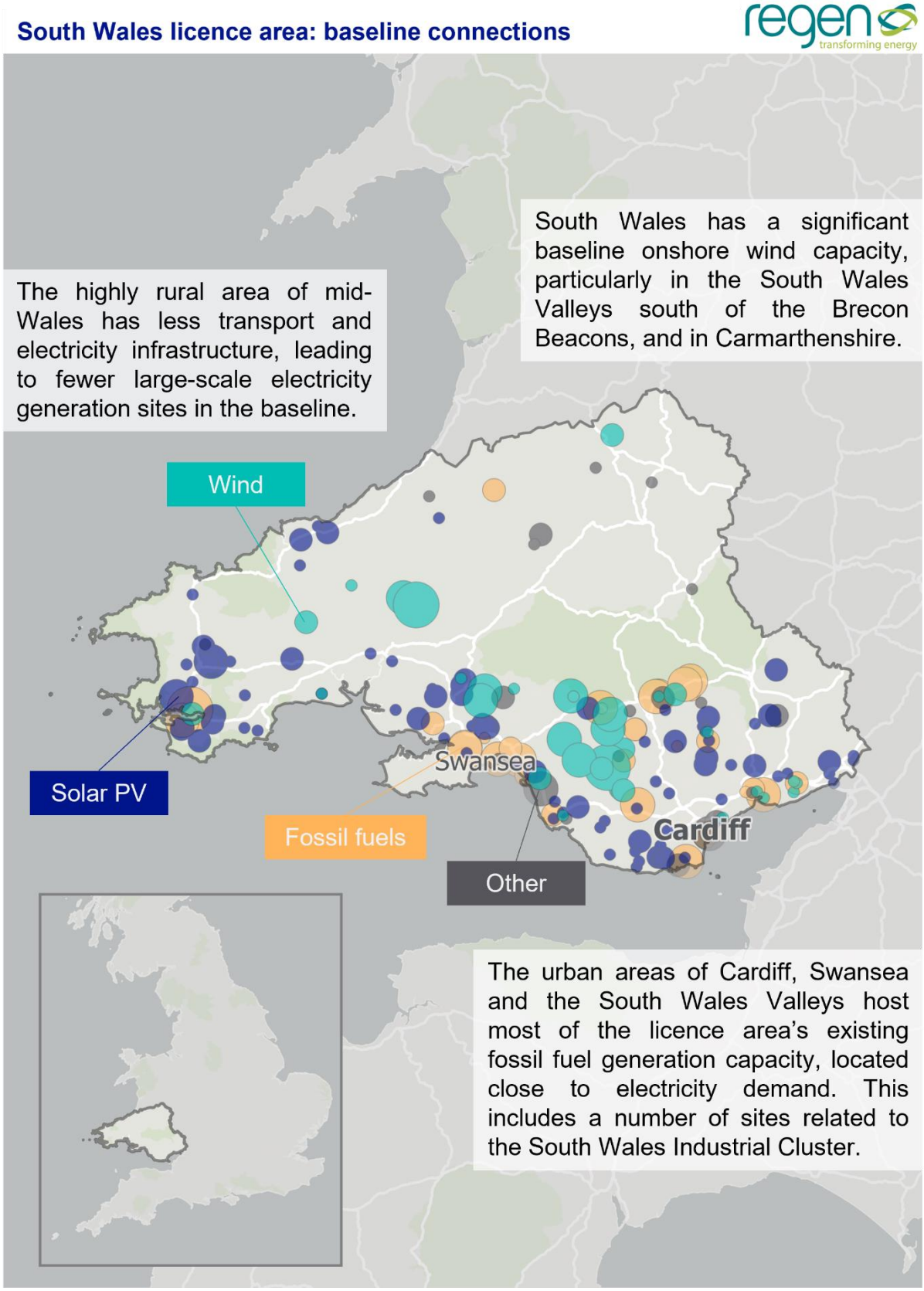
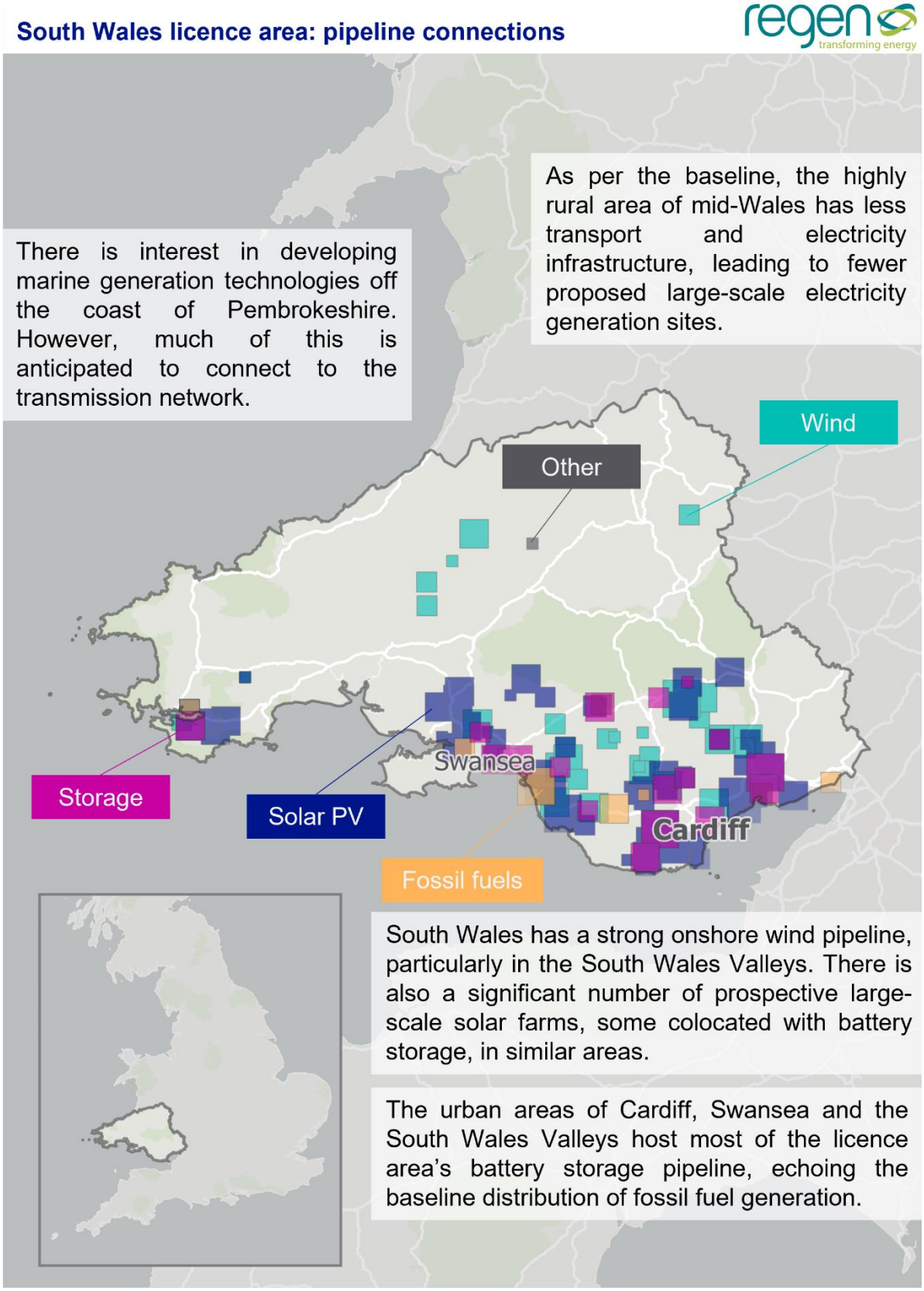


Figure 4 - The NGED South Wales licence area, with the location of proposed 'pipeline' large-scale generation and storage sites



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:

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 2022 baseline year represents the 2021/22 fiscal year, ending on 31 March 2022*. 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 2022 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.

* note that this baseline year differs from the FES 2022, which has a baseline year of 2021. As a result, some of the comparisons to FES are impacted by the DFES being published later in the year, with the benefit of several more months of data. The final baseline and pipeline data for DFES 2022 was updated on 1 September 2022.

Local stakeholder influences

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

Stakeholder engagement approach	Description of how feedback is fed into the DFES
Consultation webinars	Four consultation events, one per licence area, were held online in July 2022. 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 authority new developments	An online data exchange was shared with local authority planning departments, sharing and updating registers of future housing and business floorspace developments across NGED's licence areas.
Project and technology 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 2022, a number of specific aspects of the current energy system have been considered in the DFES 2022 analysis:

Aspect	Impact on DFES
Access and Forward-looking Charges Significant Code Review	In May 2022, Ofgem published their final Decision and Direction on the Access SCR, deciding to reduce the overall connection charge faced by those connecting to the distribution network. This means projects will have a lower cost to connect to the distribution network from April 2023. This is positive news for project developers, as it is intended to reduce the cost to connect to the distribution network. It is likely that the impact of the changes will be most significant for high electricity demand technologies, such as EV chargers, hydrogen electrolysers and industrial process electrification. This could lead to a potential pause in connections of high voltage charging hubs, and slower electrification of transport depots, before April 2023, followed by a short-term uptick after April 2023. Where appropriate, this has been implemented in the DFES projections. Whilst there is also some benefit to battery storage and distributed generation projects, the reduction in connection costs is less and therefore will have a less significant influence on the connection timelines for these technologies.
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, will be decommissioned by 2050. However, when an asset ceases operation, the connection agreement with NGED and the associated agreed export capacity held by the operator is not automatically relinquished. It is, therefore, likely that some sites will retain their connection capacity, with a view to participating in network ancillary services such as Short Term Operating Reserve (STOR), or for the potential future connection of an alternative generation or storage technology that is more compatible with net zero emission targets. To address this, the DFES 2022 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 network planning teams at NGED.
Reflecting upstream constraints on the transmission network	Upstream constraints on the transmission network can 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. 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 Statements of Works, 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 only. 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 and wider context

Similar to the network planning consideration, several areas of energy policy and wider energy sector context have been considered in the DFES analysis. The current global energy crisis has resulted in a number of energy policy shifts and announcements, such as the Review of Electricity Market Arrangements (REMA), the Energy Prices Bill 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 and an increase in electric vehicle sales, although this is showing early signs of slowing

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 2022.

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.

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[i] National Grid ESO FES building block data

Demand technologies

Results and assumptions

Domestic electric heat in the South Wales licence area

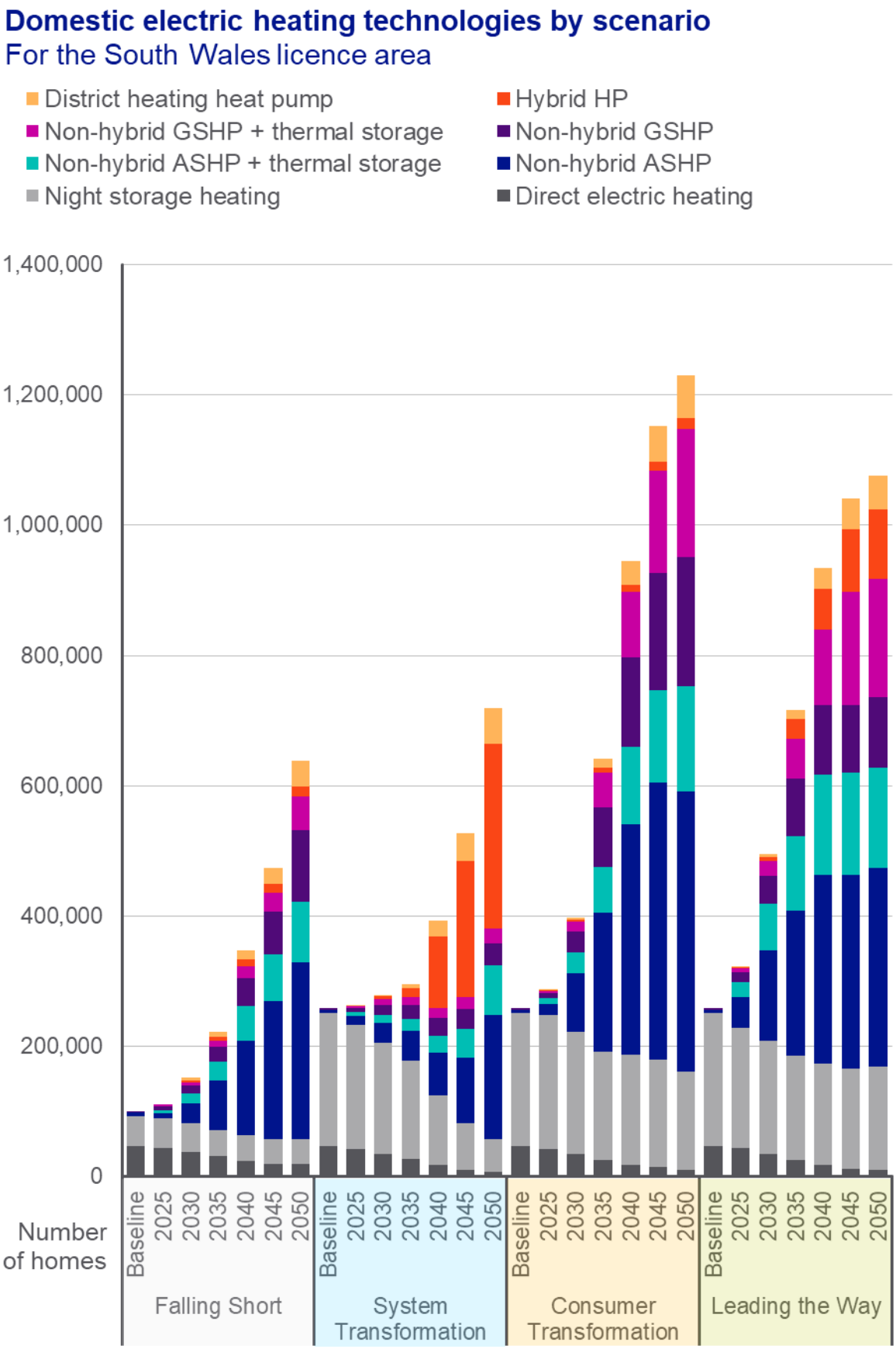
Domestic dwellings where electricity is the primary fuel for space heating and hot water, delivered through a heat pump or resistive electric heater.

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

Number of homes (thousands)		Baseline	2025	2030	2035	2040	2045	2050
Non-hybrid heat pumps* (without thermal storage)	Falling Short	7	14	44	98	189	276	382
	System Transformation		19	46	68	92	132	223
	Consumer Transformation		25	122	304	490	605	630
	Leading the Way		61	181	310	396	401	415
Non-hybrid heat pumps* with thermal storage	Falling Short	0	8	20	39	72	102	144
	System Transformation		9	20	30	42	63	101
	Consumer Transformation		12	47	124	220	300	358
	Leading the Way		30	95	176	271	330	334
Hybrid heat pumps	Falling Short	0	0	2	5	9	13	15
	System Transformation		1	5	13	111	209	283
	Consumer Transformation		1	4	7	10	13	16
	Leading the Way		2	7	30	63	97	106
Connections to heat pump-driven district heat networks	Falling Short	0	0	5	9	15	24	40
	System Transformation		0	2	7	25	43	55
	Consumer Transformation		0	3	14	37	55	66
	Leading the Way		0	4	14	31	46	53
Resistive electric heating	Falling Short	93	89	82	72	63	58	58
	System Transformation		87	78	68	50	35	28
	Consumer Transformation		91	82	71	67	64	57
	Leading the Way		87	80	70	64	60	60

***** 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 below.

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



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.

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[ii], 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	5,195	0.5%
Non-hybrid GSHP	1,814	0.2%
Hybrid heat pump	0	0.0%
Heat pump-driven district heat network	0	0.0%

Due to a lack of evidence, the modelling assumes no thermal storage for existing heat pumps.

Resistive electric heating

Resistive electric heating is less common in South Wales compared to the national average, heating around 9% of homes compared to 11% nationally.

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

Sub-technology	Number of homes	Proportion of homes
Night storage heaters	45,582	4.3%
Direct electric heaters	47,452	4.5%

Near-term projections (April 2022 to March 2026)

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 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	Proportion of homes with a heat pump in 2026	
		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. 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. Larger semi-detached and detached homes are assumed to convert more readily, based on previous FiT data. South Wales' uptake is slightly above the GB average. 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%	10%
Consumer Transformation		6%	4%
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**	3%	3%
Falling Short		3%	2%

Resistive electric heating

Scenario	Description	Proportion of homes with resistive heating in 2026	
		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. A similar proportion of direct electric heated homes convert to night storage heaters in order to reduce heating costs.	8%	8%
Consumer Transformation		8%	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 moves onto the mains gas network in order to reduce heating costs. Similarly to the other two scenarios, a small proportion of direct electric heated homes convert to night storage heaters.	8%	8%
Falling Short		8%	8%

Medium-term projections (April 2026 to March 2035)

Heat decarbonisation accelerates in the medium-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 both on-gas and off-gas properties, alongside district heat networks, driven by heat pumps or waste heat in dense urban areas or areas near to 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 heating 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 Building Regulations Part L[iii].

Heat pumps

Scenario	Description	Proportion of homes with a heat pump in 2035	
		South Wales	GB (FES)
Leading the Way	In the medium term, South Wales remains broadly in line with the national trajectory for heat pump uptake. Under these scenarios, many on-gas homes have converted to a heat pump by 2035, driven by a national shift in heating technologies. 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.	45%	42%
Consumer Transformation		38%	35%
System Transformation	Heat pump uptake in on-gas homes is minimal 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.	10%	7%
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.	12%	11%

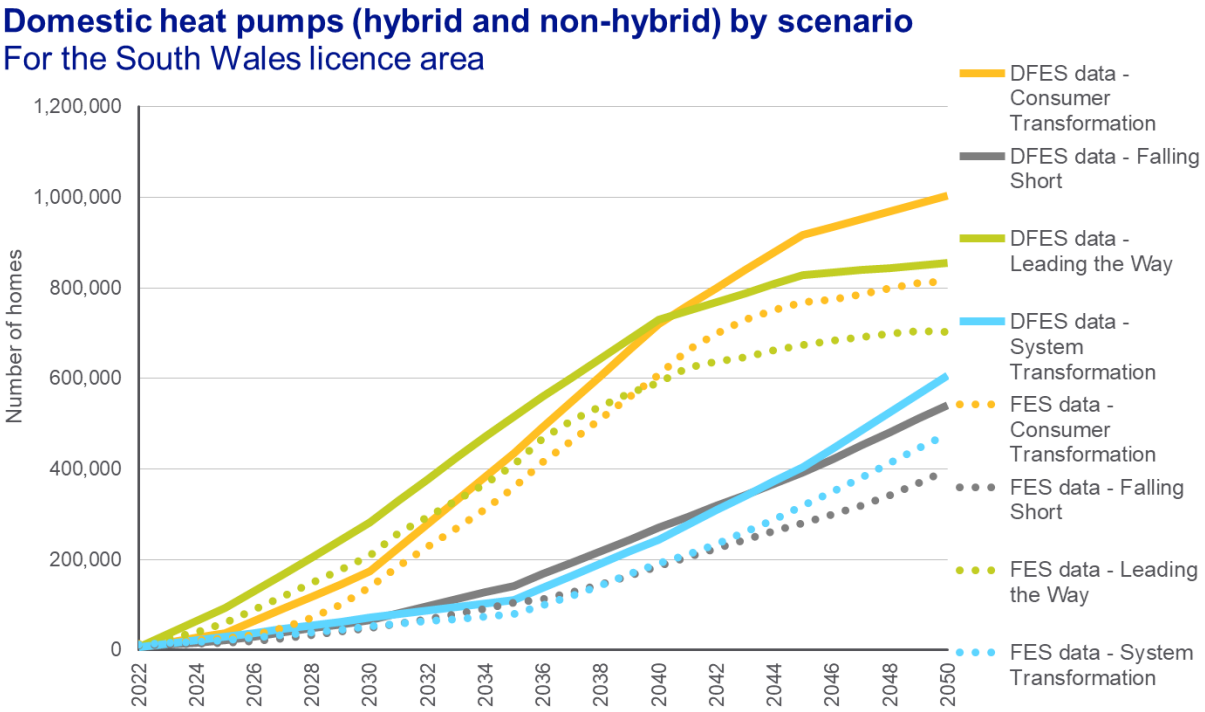
Resistive electric heating			
Scenario	**Description**	**Proportion of homes with resistive heating in 2035**	
		South Wales	**GB (FES)**
Leading the Way	The overall number of resistive heated homes continues to decrease in the medium term, replaced by district heating in denser urban areas and flats, 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.	6%	6%
Consumer Transformation		6%	7%
System Transformation	The overall number of resistive heated homes decreases in the medium term, 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.	6%	6%
Falling Short		6%	6%

Long-term projections (April 2035 to March 2050)			
The heat decarbonisation trends established in the medium term continue out to 2050, especially under the net zero scenarios, as the country aims to meet its decarbonisation targets.			
Heat pumps			
Scenario	**Description**	**Proportion of homes with a heat pump in 2050**	
		South Wales	**GB (FES)**
Leading the Way	By 2050, almost all domestic properties are heated by heat pumps, district heating or resistive electric heating by 2050. Hydrogen boilers become available in some population centres, modelled to be installed in less than 10% of domestic properties in 2050.	70%	64%
Consumer Transformation	By 2050, almost all properties are heated by standalone heat pumps, district heating or resistive electric heating. In South Wales, standalone heat pump uptake is ahead of the GB trend, due to the number of properties outside of built-up areas that are less likely to have access to a district heat network.	83%	73%
System Transformation	Uptake of heat pumps increases substantially in the 2040s, particularly hydrogen hybrid heat pumps, which represent around one-third of all heat pumps in this scenario. The remainder of homes are heated by hydrogen boilers under this scenario.	50%	44%
Falling Short	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.	45%	41%

Resistive electric heating			
Scenario	**Description**	**Proportion of homes with resistive heating in 2050**	
		South Wales	**GB (FES)**
Leading the Way	Under these scenarios, the proportion of homes heated by resistive electric heating continues to decrease, replaced by district heating, heat pumps and, where available, hydrogen boilers.	5%	5%
Consumer Transformation		5%	5%
System Transformation		2%	2%
Falling Short		5%	5%

Reconciliation with National Grid FES 2022

Figure 6 – Number of domestic heat pumps by scenario, South Wales licence area



- The DFES outcomes for total heat pumps under each scenario are broadly aligned with the FES 2022 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 and could be the reason for this variance.
- The Building Block data provided in the FES 2022 classifies an 'ASHP with a resistive heating element' as a hybrid heat pump, whereas the DFES analysis considers this to be a variation of a non-hybrid heat pump. Accordingly, the reconciliation has been undertaken using combined figures for both non-hybrid and hybrid heat pumps together. Building block data for resistive electric heating and heat pump-driven district heat networks is not specifically provided in the FES 2022 data, and as such, a direct reconciliation is not possible.

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
Current levels of energy efficiency, categorised into well-insulated homes (EPC B and above) and less well-insulated homes	EPC data
Areas with potential for district heat networks, or an existing heat network pipeline project	Heat network pipeline data[iv], and Opportunity Areas for District Heat Networks in the UK[v] - BEIS

For input, evidence and assumptions based on stakeholder engagement, a separate summary report can be found here

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	2025	2030	2035	2040	2045	2050
Battery electric cars, LGVs and motorbikes	Falling Short	8	35	156	441	904	1,302	1,426
	System Transformation		41	210	668	1,221	1,394	1,321
	Consumer Transformation		63	440	1,044	1,370	1,387	1,317
	Leading the Way		56	429	1,108	1,367	1,297	1,062
Plug-in hybrid electric cars, LGVs and motorbikes	Falling Short	5	15	46	90	135	92	36
	System Transformation		14	42	74	56	24	0
	Consumer Transformation		13	31	47	32	13	0
	Leading the Way		16	41	39	21	0	0
Battery electric HGVs, buses and coaches	Falling Short	0	0	0	1	5	14	20
	System Transformation		0	1	5	11	15	13
	Consumer Transformation		0	1	6	16	22	23
	Leading the Way		0	2	6	16	23	22

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

Number of chargers (thousands)		Baseline	2025	2030	2035	2040	2045	2050
Domestic chargers	Falling Short	8	26	90	249	504	722	787
	System Transformation		31	131	394	689	766	766
	Consumer Transformation		46	250	577	761	779	779
	Leading the Way		42	275	674	804	808	813
Non-domestic chargers	Falling Short	1	1	3	8	18	28	32
	System Transformation		1	5	14	27	32	33
	Consumer Transformation		1	8	18	24	25	27
	Leading the Way		2	7	18	24	25	27

Summary:

- 1% of cars in the South Wales licence area are currently battery electric or plug-in hybrid, well below the national average of 2.5%. This is anticipated to increase substantially under every scenario as the UK looks to decarbonise the transport sector.
- In all scenarios, petrol and diesel vehicles are replaced by low emissions vehicles between now and 2050.
    - Under **Consumer Transformation** and **Leading the Way**, passenger vehicles such as cars and LGVs are rapidly electrified, bolstered by a ban on sales of new petrol and diesel vehicles from 2030. 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.
    - Under **System Transformation**, the electrification of vehicles is slightly slower, with the ban on sales of new petrol and diesel cars being pushed back until 2032. Additionally, a high availability of low carbon hydrogen in this scenario results in a minority of passenger and non-passenger vehicles converting to 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, and there are still petrol and diesel vehicles on the road in 2050 under this scenario.
- In the latter years of the scenarios, some autonomous EVs are projected. This is strongly dependent on technological advances and societal change, and as such have been directly aligned with national projections. This results in a decline in the overall number of vehicles on the road, particularly under **Leading the Way** in the 2040s and less so under **Falling Short**.
- Regen's EV charger model determines the EV charger capacity required to charge the number of vehicles projected under each of the four DFES scenarios. This capacity is converted to a subsequent number of EV chargers, 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. This allocation is driven predominantly by the number of each vehicle type in the projections, and assumptions around how EVs may be charged under each of the FES scenarios. These charging behaviour assumptions are primarily driven by the National Grid ESO FES data.
- By 2050, all four of the future scenarios feature around 800,000 EV chargers, which are predominantly off-street domestic chargers.

Modelling assumptions and results

Baseline

Electric vehicles

While the electric vehicle baseline represents less than 1% of all vehicles registered in the South Wales licence area, uptake of electric vehicles across the UK has been steadily accelerating[vi].

This has been due to a number of factors, including:

- Favourable tax benefits and grant support for ultra-low emissions vehicles
- Increasing consumer confidence and awareness of electric vehicles
- Electrification of commercial vehicle fleets
- Financial benefits of high mileage vehicles compared to petrol or diesel vehicles.

While the vast majority of electric vehicle uptake has centred on cars, other vehicles, such as LGVs and buses, are also beginning to see uptake.

Vehicle type	Thousands of vehicles
Pure electric car	7.1
Plug-in hybrid car	4.9
Pure electric LGV	0.8
Plug-in hybrid LGV	0.0
Other electric vehicles	0.3

EV chargers		
As the number of electric vehicles has increased, the number of EV chargers has similarly grown steadily. In addition to most domestic EV owners having a home charging port, 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**	**Thousands of chargers**
	Domestic	8.0
	Non-domestic	0.6

Near-term projections (April 2022 to March 2025)

The acceleration in EV uptake over the past few years is anticipated to continue under every scenario. The number of EVs on the road is expected to increase dramatically by 2026, however, reflecting the baseline, South Wales uptake remains below the GB average.

Scenario	Description	Total electric vehicles by 2025 (000s)	Total EV chargers by 2025 (000s)
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. By 2025, over 8% of cars are electrified under these scenarios, and around 3% of LGVs and buses.	72	43
Consumer Transformation		75	47
System Transformation	Uptake of electric vehicles increases substantially, but less rapidly than the other two net zero scenarios due to lower consumer engagement. However, over 5% of cars are electrified by 2025 under both scenarios.	55	32
Falling Short		51	28

Medium-term projections (April 2025 to March 2035)

The uptake of electric vehicles and EV chargers is modelled to continue accelerating between 2025 and 2035 across all scenarios, with adoption in South Wales catching up with the rest of GB. Between 2030 and 2035, bans on the sale of petrol and diesel cars and vans result in electric vehicles representing the vast majority of new vehicles in this period.

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.

Scenario	Description	Total electric vehicles by 2035 (000s)	Total EV chargers by 2035 (000s)
Leading the Way	Battery 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. EV uptake is facilitated by a widespread rollout of domestic and non-domestic charging, including charging at workplaces, car parks and destinations, such as shopping centres.	1,153	692
Consumer Transformation		1,097	596

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. Plug-in hybrid vehicles see moderate uptake, but battery electric vehicles are the dominant EV technology across all vehicle classes. While domestic charging is most common, rapid en-route charging also sees high uptake under this scenario.	747	408
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. Plug-in hybrid vehicles see moderate uptake, but battery electric vehicles are the dominant EV technology across all vehicle classes.	533	258

Long-term projections (April 2035 to March 2050)

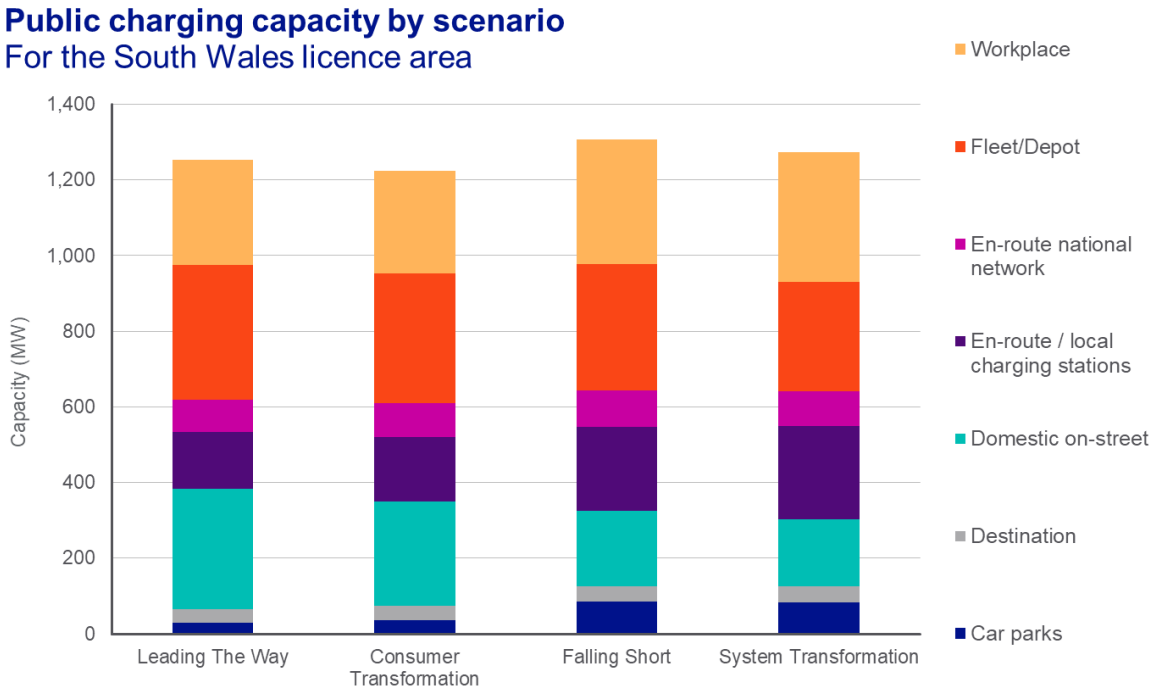
Under the three net zero scenarios, EV adoption approaches saturation and new EV uptake slows in most areas. Harder-to-electrify vehicles that saw lower uptake in the near term, such as HGVs, continue to see a higher uptake out to 2050.

The uptake of EVs slows and then reduces in some scenarios, reflecting a lower level of car ownership and higher use of public transport in the long term. 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 electric vehicles by 2050 (000s)	Total EV chargers by 2050 (000s)
Leading the Way	Both EV adoption and associated EV charger capacity peak in the early 2040s. By this point, almost all road transport is electrified. Across the 2040s, the overall number of vehicles on the road decreases considerably in these scenarios, driven by an increased uptake in autonomous vehicles and greater use of public transport and active travel.	1,084	840
Consumer Transformation		1,341	806
System Transformation	Both EV adoption and subsequent EV charger capacity peak in 2045. By this point, almost all passenger vehicles and buses and coaches are electrified. Around half of HGVs are also electrified under this scenario, with the remainder fuelled by low carbon hydrogen.	1,335	799
Falling Short	EV adoption, and subsequent EV charger capacity, continues increasing until 2050. By this point, almost all road vehicles are electrified.	1,482	820

Breakdown of public EV charger capacity in 2050 by scenario

While the DFES data presents numbers of EV chargers, the electrical capacity of these different charger types has a significant effect on their impact on the network. The electrical capacity of each public charger sub-technology in 2050 under each scenario is illustrated in the figure below:



Reconciliation with National Grid FES 2022

Figure 7 – Number of battery electric cars, LGVs and motorcycles by scenario, South Wales licence area

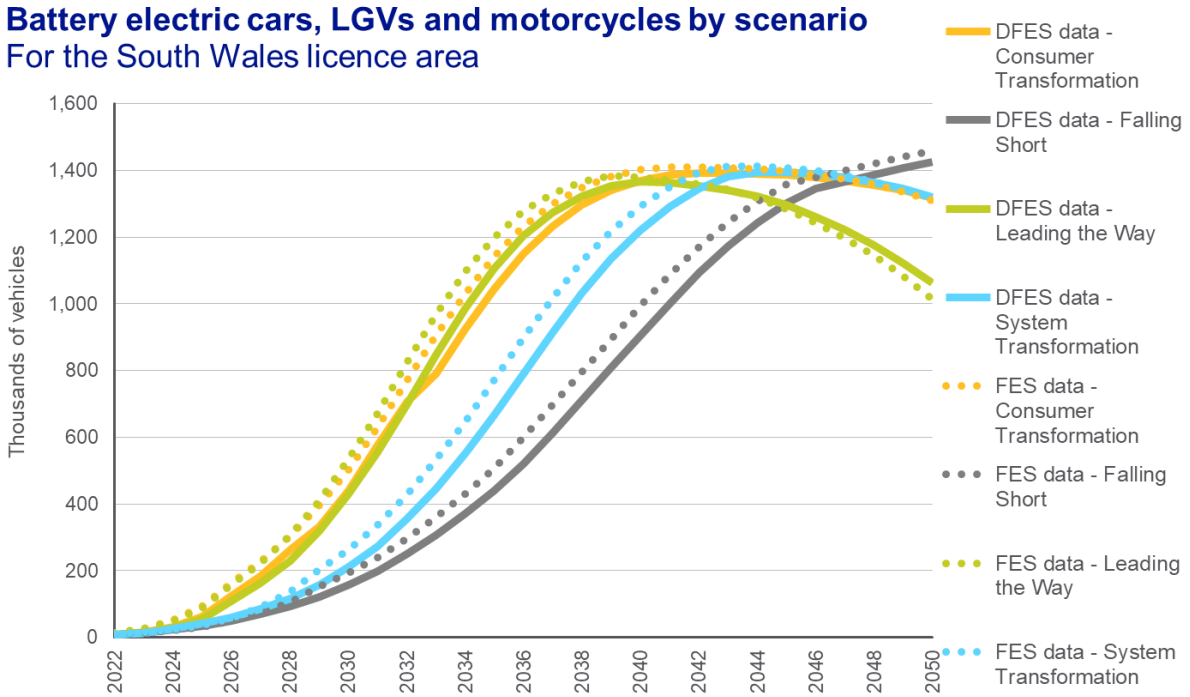


Figure 8 – Number of plug-in hybrid cars, LGVs and motorcycles by scenario, South Wales licence area

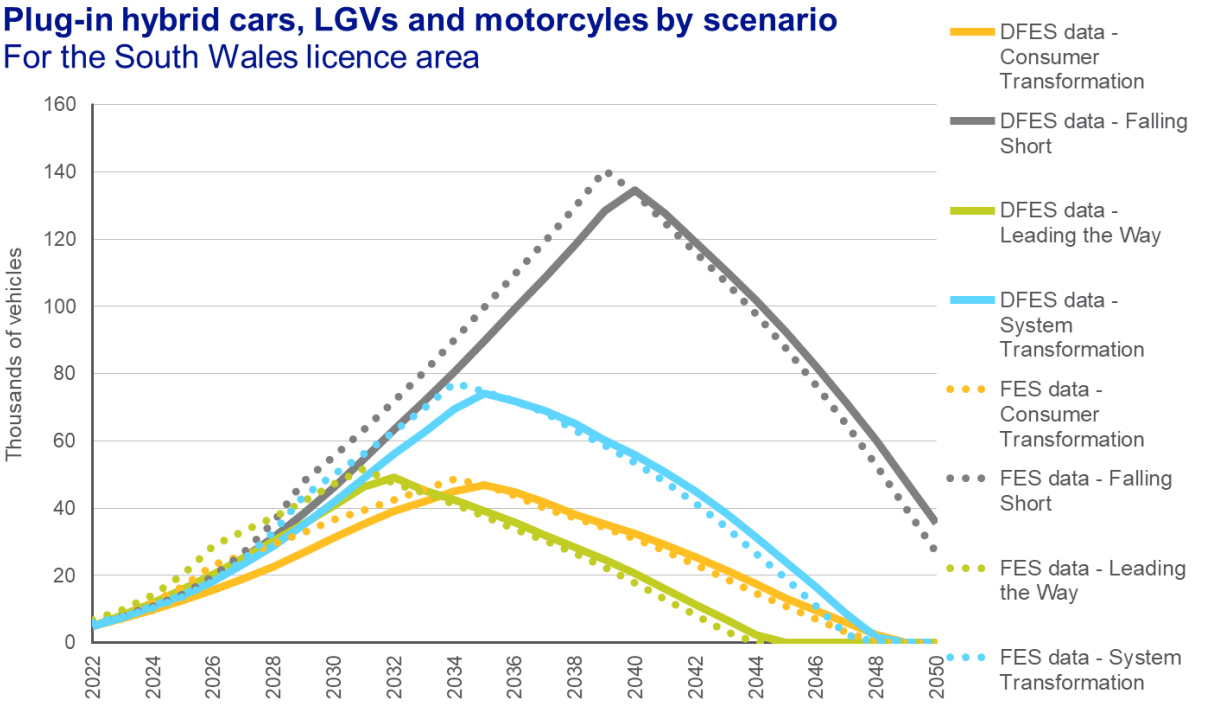
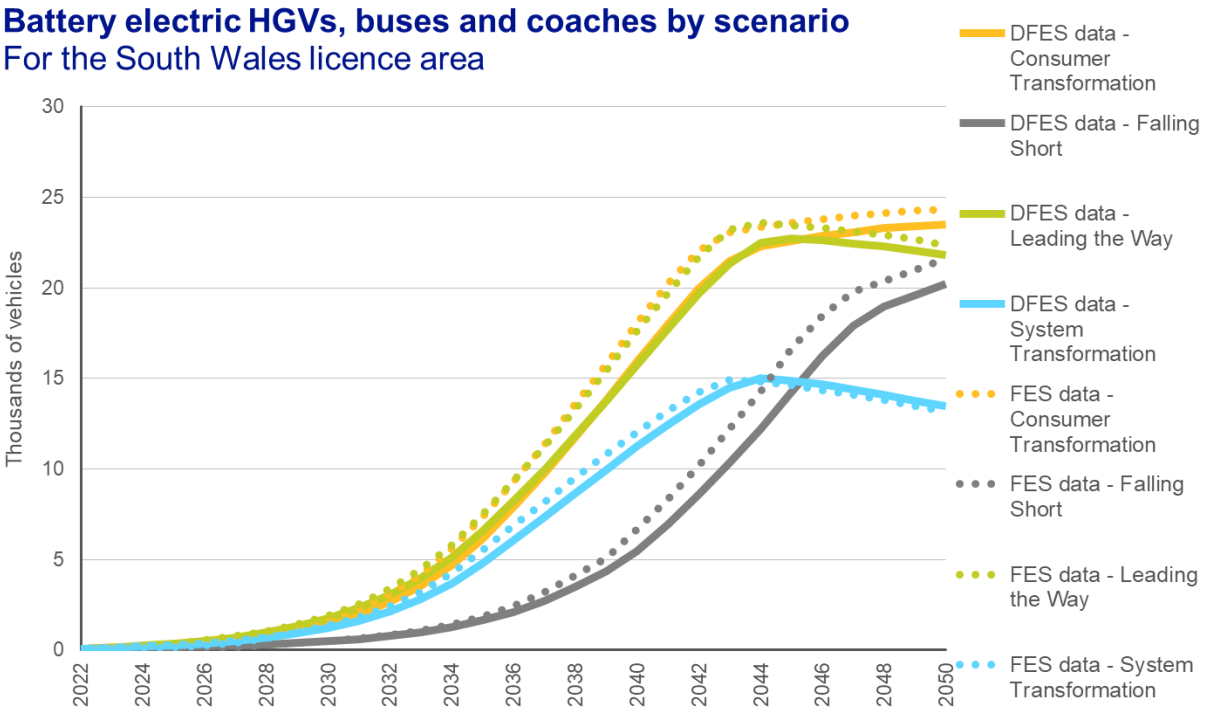


Figure 9 – Number of battery electric HGVs, buses and coaches by scenario, South Wales licence area



- 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.
- As illustrated in the figures above, the rate of EV uptake and the 2050 figures by scenario are very similar between the DFES and the FES projections.

- The EV charger building blocks are not included in the FES 2022 data at a GSP or national level. As such, a reconciliation is not possible. For vehicle efficiencies, mileage and vehicle numbers, FES projections and assumptions were used 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 of existing EV chargers is used as an indicator for the location of projected EV chargers	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

For input, evidence and assumptions based on stakeholder engagement, a separate summary report can be found here

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	2025	2030	2035	2040	2045	2050
Falling Short	1	2	29	64	68	80	174
System Transformation		19	70	130	203	332	475
Consumer Transformation		16	36	86	157	222	314
Leading the Way		38	130	202	286	421	590

Summary:

- Hydrogen electrolysis is an emerging technology at the forefront of potential future low carbon hydrogen production. As an emerging sector, there is significant uncertainty around its wider role[vii] in net zero, and, of specific concern to DFES analysis, the amount of capacity that could be connected to the distribution network is unclear.
- Through the British Energy Security Strategy[viii], the UK government has set an ambitious target of 10 GW of low carbon hydrogen production capacity by 2030, specifying at least 5 GW of this to come from hydrogen electrolysis. Only a handful of electrolysis projects are currently operational across the UK.
- The only operational hydrogen electrolyser in the South Wales licence area connected to the distribution network is a 46 kW electrolyser in Baglan Energy Park[ix].
- There is one hydrogen electrolysis project in the South Wales licence area with a connection offer from NGED at the Pengarnddu Industrial Estate in Merthyr Tydfil. This project, developed by Conrad Energy, has not yet applied for planning permission.
- There are a number of future hydrogen proposals within the South Wales licence area:
    - The South Wales Industrial Cluster[x], a partnership between Welsh industry, energy suppliers, infrastructure providers, academia, and public sector organisations, has been awarded £1.5 million of UKRI funding. The consortium project aims to establish a hydrogen economy in South Wales, focused on heavy industry in particular. This is likely to include the development of electrolysis capacity.
    - Marubeni and Bridgend County Borough Council signed an MoU in July 2022[xi] to work together to research and develop a 5 MW green hydrogen project in Bridgend. This project is in the early stages of planning.
    - 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 with hydrogen, as well as Pembrokeshire Council's fleet of HGVs and local buses[xii].
- From 2023, new hydrogen electrolysis projects are eligible for both capital and revenue funding support through the government's electrolytic allocation round[xiii]. This programme aims to achieve 1 GW of hydrogen electrolysers being in construction or operation by 2025, by supporting projects over 5 MW to completion. This support is initially provided through up front capital grants and ongoing revenue subsidy payments, then after two years switches to a cost-competitive auction process.
- The Welsh Government published a pathway for hydrogen in 2020, with the consultation response published in 2022, to support the implementation of hydrogen projects in the near term. This study covers both electrolytic hydrogen and CCUS-enabled hydrogen production, and has a number of recommendations and conclusions for the hydrogen sector in Wales, including deploying 200 fuel cell buses, establishing a 10 MW+ renewable hydrogen production facility by 2023/24 and supporting industrial decarbonisation[xiv].

- The South Wales licence area is home to Riversimple, a hydrogen fuel cell car company. Riversimple's first prototype Rasa was finished in 2016 and the company is pioneering a novel sale-of-service model. Riversimple cars are now compatible with Motive refuelling stations across the country.
- South Wales also hosts a significant number of industrial-scale gas and electricity consumers and heavy industry. These sectors and customers are potential sources of future low carbon hydrogen demand.
- The largest capacity of distribution-connected hydrogen electrolysers in 2050 is modelled under **Leading the Way** (590 MW) and **System Transformation** (475 MW). This reflects the large-scale rollout of hydrogen as a net zero option for transport, industry and heat, and the establishment of a national hydrogen network that is modelled in these scenarios.
- In contrast, the least capacity is modelled under **Falling Short** (174 MW), reflecting limited government policy support for this technology and the assumption that this scenario does not reach net zero.

Modelling assumptions and results

Baseline
The only operational hydrogen electrolyser in the South Wales licence area connected to the distribution network is a 46 kW electrolyser in Baglan Energy Park as part of the University of South Wales' Hydrogen Centre. A 10 kW electrolyser unit is also operational at Hanson's Port Talbot site; however, this is powered by on-site renewables and does not have a dedicated network connection.

Near-term (April 2022 to March 2025)		
Pipeline project details	**Scenario**	**Modelled connection date**
8 MW hydrogen electrolyser at the Pengarnddu Industrial Estate in Merthyr Tydfil. This project, developed by Conrad Energy, has not yet applied for planning permission but has been offered a connection agreement with NGED in August 2022. Conrad Energy has recently had planning permission granted for a hydrogen electrolyser in Plymouth.	**Falling Short**	August 2026
	System Transformation	August 2025
	Consumer Transformation	February 2025
	Leading the Way	
Marubeni and Bridgend County Borough Council signed an MoU in July 2022 to jointly work together to research and develop a 5 MW green hydrogen project in Bridgend. This project is in the early stages of planning.	**Falling Short**	Not modelled to connect due to uncertainty around planning and finances.
	System Transformation	2026
	Consumer Transformation	2025
	Leading the Way	2024

There are a number of additional active hydrogen initiatives for the South Wales licence area:

- 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 in particular.
- 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.
- Decarbonisation of existing high-carbon hydrogen production at refineries such as Valero in Pembrokeshire.

Due to the nascent stage of the hydrogen sector, these initiatives have been used to influence the DFES projections for the near term; however, there is still limited information on them, and hence they have not been modelled as pipeline sites.

The UK government has set a target of 1 GW of electrolytic hydrogen power capacity by 2025. Whilst the South Wales licence area could see some projects being developed under this support programme, it is unlikely that significant electrolysis capacity will seek to connect to the distribution network by 2025. Under this timescale, **Leading the Way** is modelled to have the most installed capacity (38 MW) and **Falling Short** the least installed capacity (2 MW). This is due to a supportive policy environment assumed under the **Leading the Way**, as well as an earlier rollout in the mid-2020s. Under **System Transformation**, these same projects are supported, but slightly later, with **Consumer Transformation** seeing deployment in the mid-2030s. **Falling Short** has less supportive government policy and projects are less likely to get developed in the near term.

Medium-term (April 2025 to March 2035)

The UK government has set a further target of 10 GW of low carbon hydrogen production capacity by 2030, with at least half coming from hydrogen electrolysis. From consultation with electrolyser manufacturers, 5-10 MW electrolyser units are anticipated to become commercially viable by 2030, and the demand for hydrogen from hydrogen-fuelled heavy vehicle fleets and public transport will increase across all scenarios in this timeframe.

As a key industrial cluster, the South Wales licence area has significant potential for the development of hydrogen electrolysis capacity in the medium-term, as electrolyser units become commercially viable and local demand increases. In particular, The use of electrolysis in industry, power generation, transport and as a source of flexibility increases and hydrogen clusters begin to form. Under **System Transformation** and **Leading the Way**, hydrogen is blended into the existing gas network, and hydrogen is able to be transported to areas of demand.

The DFES has referenced the FES 2022 GB projections and projections for the licence area to inform the medium and long-term capacity projections. This has been augmented by Regen's analysis of potential future sources of local hydrogen demand for each licence area.

Scenario	Percentage of GB capacity on the distribution network (FES 2022)	Total capacity by 2030
Falling Short	100%	64 MW
System Transformation	35%	130 MW
Consumer Transformation	36%	86 MW
Leading the Way	24%	202 MW

Long-term (April 2035 to March 2050)

There are major industrial areas in Newport, Port Talbot and Pembroke and ports along the southern coast of the South Wales licence area. As the region is likely to see significant development in hydrogen electrolysers in the future, it is likely that a significant amount of this capacity will be connected to the transmission network. This modelling assumption was supported by key developers engaged as part of the DFES 2022.

The potential for hydrogen-fuelled trains could increase electrolyser capacity significantly. In Network Rail's Traction Decarbonisation Network Strategy[xv], the central-Wales train line has been earmarked for hydrogen. This includes the line ending in Swansea; hence the Swansea train depot could be a prime location for a medium or large-scale electrolyser. This has been supported by Statkraft's intentions to develop the Trecwn Green Energy Hub, a green hydrogen project in Pembrokeshire to supply trains running on the central-Wales train line, as well as Pembrokeshire Council's fleet of HGVs and local buses.

In the longer term, hydrogen electrolysers are expected to scale their capacity by increasing the number of modules connecting to a compressor. The total capacity of distribution-connected electrolysers rapidly increases out to 2050, due to wider hydrogen sector developments, such as:

- The repurposing of large-scale storage facilities for hydrogen
- A decrease in upfront capital costs to deploy electrolysers
- Increased demand for low carbon gases such as electrolytic hydrogen
- The colocation of hydrogen electrolysers with renewable generation, to provide invaluable balancing services to a high-renewable net zero electricity system.

Scenario	Percentage of GB capacity on the distribution network (FES 2022)	Total capacity by 2050
Falling Short	85%	174 MW
System Transformation	17%	475 MW
Consumer Transformation	17%	314 MW
Leading the Way	20%	590 MW

Comparison to DFES 2021

There are a number of key differences between the scenario projections for hydrogen electrolysis capacity in DFES 2021 and DFES 2022. This is due to substantial modelling and data improvements, resulting in notably different projections in the near, medium and long term. The reasons for these variations include:

- The FES 2022, for the first time, has detailed specific data on the split of hydrogen electrolyser capacity that could be connected to the distribution and transmission networks separately. This has allowed for more accurate reference projections for capacity that will connect at distribution network voltages, which was a key area of uncertainty in the DFES 2021 modelling. This has resulted in an overall reduction in the projections of distribution-connected electrolysers, in particular for **Consumer Transformation**. In DFES 2021, it was assumed that c. 74% of total electrolyser capacity would be connected to the distribution network in **Consumer Transformation**; however, in the latest FES 2022 analysis, only 17% is modelled to be distribution-connected. Hence, following FES 2022 assumptions has resulted in a significant decrease in capacity projected under this scenario in DFES 2022.
- The UK government's increased ambition for hydrogen electrolysis capacity (1 GW by 2025 and at least 5 GW by 2030) has increased the potential uptake of electrolysis in the near term. Combined with the 2022 energy cost crisis, the FES 2022 analysis shows a larger focus on electrolytic hydrogen over CCUS-enabled hydrogen, particularly in **System Transformation**.

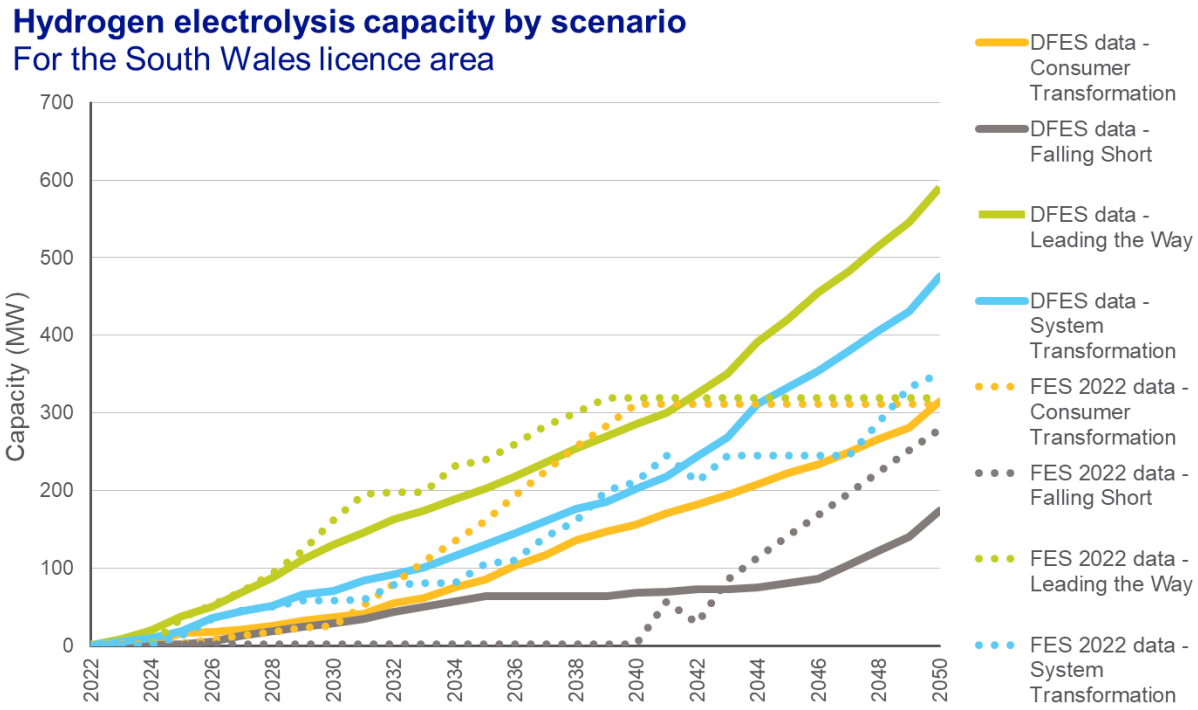
Key modelling assumptions for DFES 2022

From engaging with key stakeholders, electrolyser manufacturers and project developers, a number of factors that could influence the location and use-cases of distribution connected hydrogen electrolysers were identified. These factors were weighted based on the assumptions underpinning the FES scenarios and the resultant scenario projections (2023–2050) were based on Regen's analysis of the presence of these factors in the licence area.

Hydrogen distribution factors					
Factor	**Leading the Way**	**Consumer Transformation**	**System Transformation**	**Falling Short**	**Presence of this factor in South Wales**
Industrial energy demand	Medium	Medium	Medium	High	High
Heavy transport demand	Medium	Medium	Medium	Medium	Low
Large-scale hydrogen storage	Low	Low	Low		Low
Location of maritime activity	Low	Medium	Low		Medium
Access to the gas network	Low		Low	Low	Low
Renewable energy resource	Medium	Medium	Medium		Medium
Hydrogen innovation projects	High	High	High	High	Medium
Rail network decarbonisation	Low	Low	Low		High
Existing grey hydrogen sites	Low	Low	Low	Low	High

Reconciliation with National Grid FES 2022

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



- The FES 2022, for the first time, has regional projections for hydrogen electrolysis, allowing for a more accurate reconciliation between Regen's licence area projections and the FES 2022 GSP datasets.
- Under **System Transformation** and **Leading the Way**, the DFES projections for the South Wales licence area are significantly higher than the FES projections in the longer term. In comparison, under **Falling Short**, the DFES projections are lower than those in the FES projections.
- These variances are likely due to differences in modelling approaches around the scale and sources of demand for hydrogen present in the licence area and the prioritisation of some future demand customers being met by distribution-scale or transmission-scale electrolyser projects.
- DFES 2022 analysis for the South Wales licence area finds **Leading the Way** to have the highest capacity in the long term. This is because of the large industrial sector in South Wales, which is an important source of potential future hydrogen demand in **Leading the Way** and is assumed to result in significant capacity of hydrogen electrolysis on the distribution network.
- By 2050, **Leading the Way** has the most installed capacity in the South Wales licence area (590 MW). This represents c.7% of all GB-distribution connected electrolysis capacity, which is viable based on the region's size, transport infrastructure, storage resources, gas network infrastructure and existing hydrogen activity.

Factors that will affect deployment at a local level

Description	Source
Location of key development zones for hydrogen production and demand, such as ports, airports and potential hydrogen storage.	Regen analysis
Location of heavy industry energy users.	National Atmospheric Emissions Inventory, BEIS
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
Location of larger-scale renewable energy generators, based on Regen's spatial distribution of ground-mounted solar PV and onshore wind resource, as potential sites for colocation.	Regen analysis

For input, evidence and assumptions based on stakeholder engagement, a separate summary report can be found here

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	2025	2030	2035	2040	2045	2050
Falling Short	0	18	48	74	94	111	127
System Transformation		21	54	83	104	122	140
Consumer Transformation		21	54	83	104	122	140
Leading the Way		25	64	92	114	136	157

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

Floorspace (sqm, 100,000s)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	0	7	28	51	59	60	60
System Transformation		9	34	55	59	60	60
Consumer Transformation		9	34	55	59	60	60
Leading the Way		10	37	53	60	60	60

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.
- These new developments have been modelled based on direct engagement with local authorities planning departments and analysis of local planning documents. These detail ‘under construction’ and ‘planned’ developments, as well as land areas that are allocated for future developments.
- Longer-term new housing developments, beyond the timeframe of local planning documents, have also been modelled based on an analysis of ONS household projections.
- By 2050, this modelling results in between 130,000 and 160,000 new homes in the South Wales licence area, representing a 12%-15% increase in the number of domestic customers.
- An additional 6.3 million square meters of non-domestic floorspace is also modelled to be developed in the South Wales licence area under each scenario, predominantly composed of office and factory and warehouse developments.

Modelling assumptions

Baseline
As the scope of the new developments analysis in the DFES is focused on future additional/new developments of domestic and non-domestic buildings, no baseline is defined for this technology.

Planned developments (April 2022 to March 2042)	
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 (2021) DFES analysis. The local authorities then provide updates or 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, supplemented where necessary from other online data sources, and added to the database. Where new data was not provided, the data is gathered through publicly available planning documents such as 5-year housing land supplies and local plans, where necessary.
ESA assignment	Sites are assigned spatially mapped to NGED's network infrastructure based on locational data. 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 data on housebuilding and construction of new non-domestic premises.

Domestic

Number of development sites identified	**Total number of houses**
586	343,194

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

Local authority	**Number of homes**	**Largest development site**
Cardiff	23,904	North West Cardiff (3,934 homes)
Rhondda Cynon Taf	8,922	Llanilid Strategic Opportunity Area (1,500 homes)
Swansea	7,397	West of Llangyfelach Road (1,088 homes)

Non-domestic

Subcategory	**Number of sites**	**Total non-domestic floorspace (sqm)**
Factory and warehouse	142	2,226,793
Office	127	2,159,408
School and college	30	227,008
Retail	19	548,467
Other (e.g. medical, hotel, sport & leisure)	75	915,416

In the South Wales licence area, the vast majority of planned non-domestic development is employment land, in the form of offices and factory and warehouse floorspace. This includes the 170-hectare St Athan Aerospace Business Park[xvi] in the Vale of Glamorgan, located west of Cardiff Airport.

Where possible, the planned development floorspace for each site from the data collection has been used in the modelling. Where planned floorspace was not available, overall planned site areas have been converted into floorspace based on benchmarking figures for specific development types (school, retail, office etc.), based on the sites in the data that have both floorspace and site area detailed.

Modelled developments (April 2022 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 2022 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[xvii].
Non-domestic	
The non-domestic scenario projections are based on planned developments only.	

Results

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

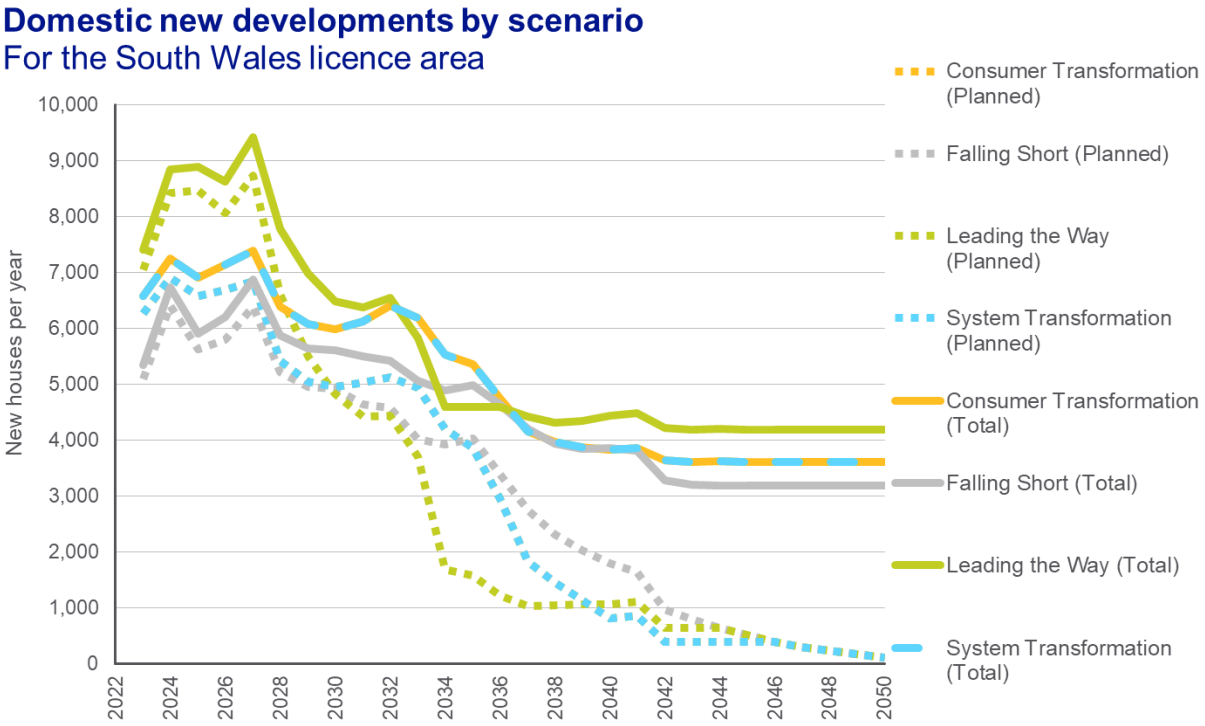
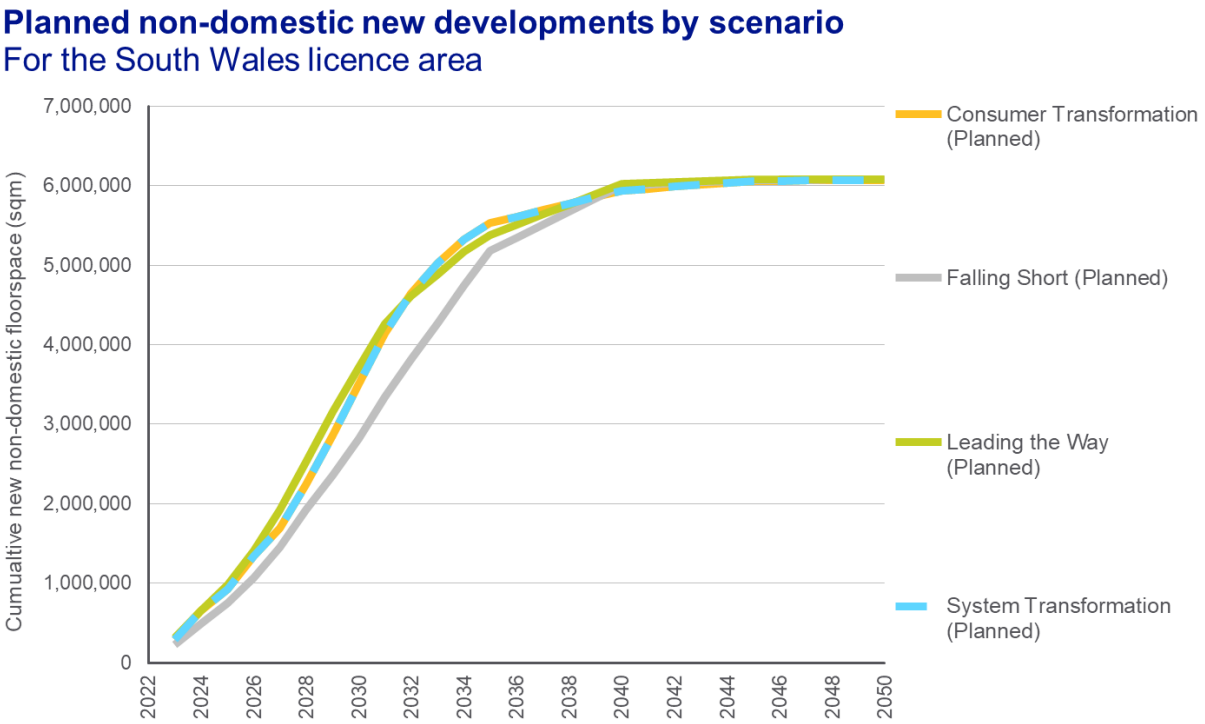


Figure 12 – Cumulative planned non-domestic developments by scenario, South Wales licence area



Reconciliation with National Grid FES 2022

- 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 that denser city centres or highly rural areas.	Census 2011, EPC records

For input, evidence and assumptions based on stakeholder engagement, a separate summary report can be found here

Air conditioning in the South Wales licence area

Domestic air conditioning units, based on a typical portable or window-mounted air conditioner

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

Air conditioning units (thousands)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	6	8	17	36	74	155	314
System Transformation		8	14	25	49	90	163
Consumer Transformation		8	14	25	49	90	163
Leading the Way		6	6	6	6	6	6

Summary:

- Domestic air conditioning is not currently common in the UK, with only c.1% of UK homes currently containing an air conditioning unit.
- In the South Wales licence area, modelling suggests around 0.5% of homes currently have an air conditioning unit.
- Increased summer temperatures, extended heat waves and reducing costs could result in an increased uptake of air conditioning units over the coming decades. In addition to these factors, the UK building stock is not optimised around passive cooling, which could drive increased levels of active cooling, such as air conditioners.
- Air conditioning uptake is likely to be focused in urban areas such as Cardiff, due to the 'heat island effect' causing increased temperatures in built-up areas, alongside the greater number of smaller dwellings, such as flats, that are more susceptible to high temperatures.
- Given the small baseline and uncertainty around future domestic cooling methods, there is a broad range of scenario outcomes, from minimal further uptake under **Leading the Way** to air conditioning becoming commonplace under **Falling Short**.

Modelling assumptions and results

Baseline	
Number of domestic units	Proportion of homes with an air con unit
5,555	0.5%
Modelling assumptions	
There is limited baseline data on domestic air conditioning levels in the UK. A 2016 report by Tyndall Manchester suggested that 1-3% of UK households reported some form of air conditioning. We have aligned with the National Grid FES 2022 data, which has a national baseline of around 330,000 domestic air conditioners, equivalent to around 1.1% of homes nationally. To estimate the licence area baseline, this national figure has been distributed based on regional temperate data and housing density.	

Near-term (April 2022 to March 2025)	
Scenario	**Description**
Falling Short	Uptake of domestic air conditioning increases due to more frequent summer heat waves. The majority of uptake is assumed to be in denser urban areas where active cooling demand is highest. This results in c. 8,000 units in homes by 2025 in these scenarios.
System Transformation	
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. As a result, very few new air conditioning units are installed by 2025.

Medium-term and long-term (April 2025 to March 2050)		
Scenario	**Description**	**2050 homes with air conditioning**
Falling Short	Increasing frequency of heat waves and societal reluctance to engage in passive cooling methods leads to exponential uptake of domestic air conditioning, as the 'easiest' route to comfortable internal temperatures.	c. 314,000 homes c. 29% of total housing stock
System Transformation	Over time, air conditioning becomes common in all types of dwelling. Uptake of domestic air conditioning accelerates in urban areas due to heat island effects and the prevalence of smaller dwellings such as flats.	c. 163,000 homes c. 15% of total housing stock
Consumer Transformation		
Leading the Way	However, aims to limit carbon emissions and electricity consumption temper uptake, with passive cooling measures also seeing uptake.	c. 6,000 homes c. 1% of total housing stock

Modelling assumptions

The uptake of domestic air conditioning in each scenario is modelled using:

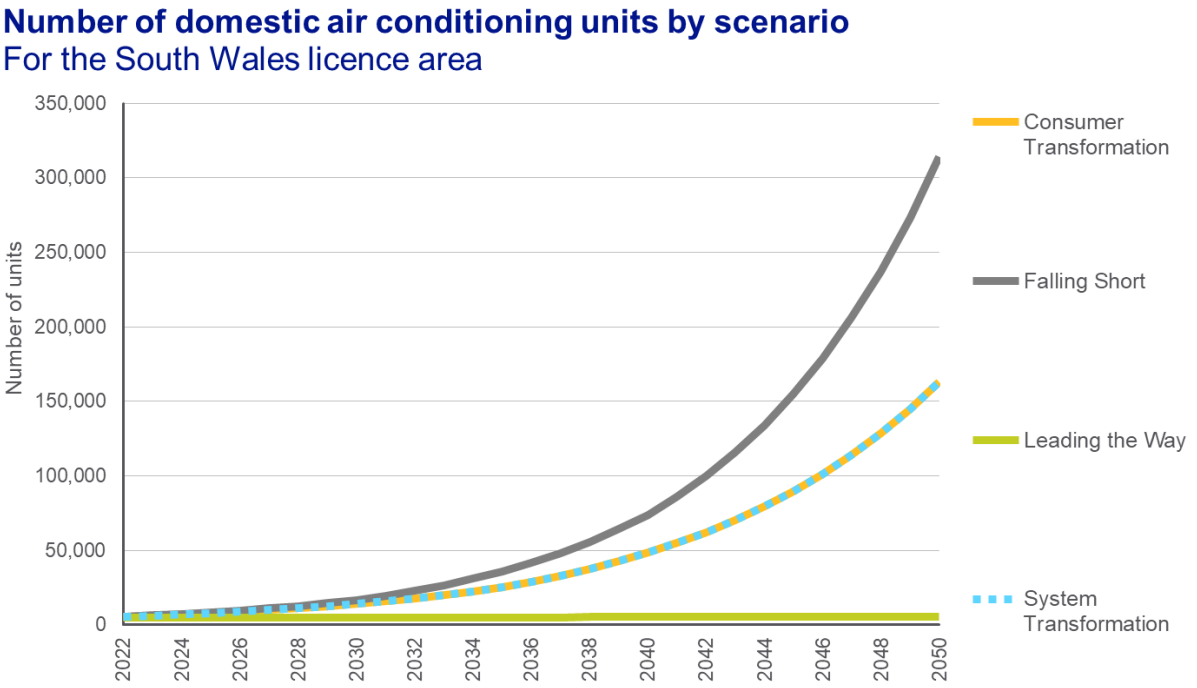
- Cooling degree days at 18.5 °C, where South Wales is significantly below the GB average due to the cooling Atlantic climate. This metric is used in every scenario.
- Proportion of households in very dense urban areas, with South Wales 52% below the national average. This metric is used in every scenario.
- Proportion of households in fairly dense urban areas, with South Wales 32% below the national average. This metric is used in every scenario except **Leading the Way**, which has minimal domestic air conditioning uptake.
- Proportion of households in any form of urban area, with the South Wales 18% below the national average. This metric is used in **Falling Short**, as air conditioning becomes common even outside of 'heat island' areas.

Building Regulations Part L

The draft Wales Building Regulations Part L stipulates high energy efficiency for air conditioning and limits to oversizing cooling systems in new homes. As a result, the DFES 2022 modelling assumes that the vast majority of domestic air conditioning uptake is retrofitted in existing homes under every scenario.

Reconciliation with National Grid FES 2022

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



- The FES 2022 does not directly detail the number of domestic air conditioning units, making a direct comparison to the DFES not possible. However, FES 2022 does contain national-level data on annual domestic air conditioning demand by scenario, and an assumed consumption of 500 kWh/year for a typical domestic air conditioning unit. These factors allow for reconciliation at a high level.
- The South Wales licence area sees uptake of air conditioning below the national level seen in FES 2022, due to the analysis of cooling degree days and dense urban areas, in both of which the South Wales licence area is significantly below the national average.

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 Bristol and Plymouth. Later uptake expands to areas of lower housing density in scenarios where domestic air conditioning becomes more prevalent.	OS Addressbase
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

For input, evidence and assumptions based on stakeholder engagement, a separate summary report can be found here

[ii] Boiler Upgrade Scheme
[iii] Building Regulations Part L
[iv] Heat network pipelines
[v] Opportunity Areas for District Heat Networks in the UK, BEIS
[vi] DfT vehicle statistics
[vii] Building the hydrogen value chain, Regen, 2021
[viii] British Energy Security Strategy, HM Government, 2022
[ix] Hydrogen Centre
[x] South Wales Industrial Cluster
[xi] Council signs partnership agreement with Marubeni for new 5MW-class hydrogen energy project
[xii] Statkraft to develop its first UK-based green hydrogen project | Current News (current-news.co.uk)
[xiii] BEIS Electrolytic Allocation Round 2022
[xiv] Hydrogen in Wales consultation response (gov.wales)
[xv] See Traction Decarbonisation Network Strategy
[xvi] St Athan Aerospace Business Park
[xvii] StatsWales 2018-based household projections by local authority

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	2025	2030	2035	2040	2045	2050
Falling Short	572	611	971	1,248	1,317	1,415	1,513
System Transformation		843	1,123	1,573	1,796	2,037	2,283
Consumer Transformation		845	1,121	1,568	1,791	2,032	2,277
Leading the Way		1,080	1,679	2,248	2,573	2,789	2,824

Summary:

- South Wales has historically shown a moderate level of large-scale solar PV deployment, with over 0.5 GW of distribution-connected capacity connected over the past decade.
- There is a significant pipeline of projects in the licence area, representing a slight increase in developer interest in the region compared to previous years. The number of sites with an accepted network connection offer has slightly increased from 57 sites (1,530 MW) to 62 sites (1,542 MW) since DFES 2021.
- Solar remains one of the cheapest forms of renewable energy, with further cost reductions helping the technology to realise economies of scale. South Wales is expected to see a continued increase in projects due to the vast amounts of available resource, relatively high irradiance levels, and land availability.
- Planning friendliness is quite high in the region, with approximately 81% of projects being successful in planning. The licence area has a lower level of local ambition, evidenced through renewables target setting and net zero policy compared to the other licence areas.
- Current business models are based around larger-scale standalone solar farms, or co-location with battery storage. In the future, solar PV could also potentially be co-located with hydrogen electrolysis, in order to mitigate generation constraints or export limitations.
- Under the most ambitious scenario, **Leading the Way**, solar reaches c. 1.7 GW by 2030, and continues to c. 2.8 GW by 2050. Under **Consumer Transformation**, c. 1.1 GW is reached by 2030, and c. 2.3 GW by 2050.

Modelling assumptions and results

Baseline		
Number of sites	**Total capacity**	**Description**
90	572 MW	2021 was a positive year for new ground mount solar deployment[xviii]. The recent uptick in solar projects follows a period of limited growth since 2017, indicating that the post-FIT lull in project development could be coming to an end. The vast majority of historic solar development was as a result of the FiT scheme, which supported solar projects of up to 5 MW with subsidy payments for all electricity generated. At the height of the FiT period, over 470 MW of capacity was deployed between 2012 and 2015 in the South Wales licence area. Installed capacity reached 572 MW by 2022, bringing the average installed capacity of large-scale distributed solar to 6.4 MW. Two sites totalling 14 MW have connected in the 2020s in the licence area.

Pipeline (April 2022 to March 2028)	
Number of pipeline sites	**Total capacity**
62	1,542 MW

Installed solar capacity in the UK is forecast to grow by over 1 GW in 2022 and over 2 GW in 2023[xviii]. In South Wales, the number of identified pipeline projects shows a relative increase of c. 9%, compared to the number of sites looking to connect to the network in the past year and a half, from 57 (1,530 MW) by the end of Q1 2021 to 62 (1,542 MW) in Q3 2022. When asked how much of this pipeline of projects is likely to connect, stakeholders responded that lots would likely connect, but over time out to the mid-2030s. The average capacity of sites accepted to connect to the network is 25 MW. To gather specific project insight, Regen has engaged with project developers to determine project pipeline status and target delivery years.

Pipeline analysis

Status	Scenario outcomes	Sites	Capacity
Under Construction	Two new solar sites have been confirmed to be under construction: Carn Nicholas Farm (8 MW) in Swansea and Royal Mint (1 MW) in Rhondda Cynon Taf.	2	9 MW
Planning Permission Granted	141 MW of solar capacity from seven sites has been approved in planning in South Wales, up from 92 MW from 6 sites identified in DFES 2021. Three sites (totalling 97 MW) are located in Carmarthenshire, and other sites area located in Blaenau Gwent (31 MW), Rhondda Cynon Taf (8 MW), Neath Port Talbot (5 MW) and Bridgend (1 MW). The largest site is the 42 MW Hopkins Solar Farm in Carmarthenshire. A 30 MW Penderi solar Farm secured planning permission in July 2021, and has been modelled to connect at the earliest in 2025.	7	141 MW
Planning Application Submitted	Several large solar sites have submitted a planning application, all of which are modelled to connect under the three net zero scenarios due to high planning friendliness and local ambition in the South Wales licence area. Four of these sites have a prospective installed capacity of 50 MW: Rush Wall Solar Park in Newport, Oaklands Solar in the Vale of Glamorgan, Penpergwm Solar Farm in Monmouthshire and Parc Dyffryn in the Vale of Glamorgan.	7	254 MW
Pre-planning	Many sites were found to be in various stages of pre-planning, at least five of which were seeking an environmental pre-screening application or had already received a pre-screening opinion. At least three consultation websites were identified, including one for the 15 MW Penyrheol Solar Farm.	12	301 MW
No information	No development evidence could be found for c. 740 MW of pipeline capacity. Due to the sheer volume of pipeline sites, sites with no information are only modelled to connect under the most ambitious scenario, **Leading the Way**, and in only local authorities where planning applications have a very high success rate.	31	739 MW
Rejected, Withdrawn or Abandoned	Three sites were found to be refused in planning, two of which were in Newport (41 MW and 36 MW), and one in Pembrokeshire (22 MW).	3	99 MW

Planning logic and assumptions					
The assumptions around the proportion of pipeline sites and capacity that make it through planning at each stage, under each scenario, are derived from a statistical analysis of solar projects in the Renewable Energy Planning Database.					
Scenario	**Planning Granted or Under Construction**	**Planning Application Submitted**	**Pre-planning**	**No information**	**Years from Planning Submitted to completion**
Falling Short	100%	25%	10%	Removed from analysis	3-7 years
System Transformation	100%	75%	25%	Removed from analysis	2-7 years
Consumer Transformation	100%	75%	25%	Removed from analysis	2-7 years
Leading the Way	100%	90%	50%	30%	2-5 years

Medium-term (April 2028 to March 2035)		
There are key scenario-specific assumptions in the analysis that account for a mix of geographic factors that may influence solar PV uptake. The total modelled solar capacity by 2035 varies widely depending on the scenario. The main factor determining solar capacity growth is unconstrained solar resource – land that simultaneously has sufficient irradiance levels, is in proximity to the existing distribution network, is sited on medium-to-low agricultural grade land, outside of flood zones, and not located within protected areas, such as AONBs. A proportion of this solar resource is modelled to be exploited under the scenarios, reflecting the assumptions around the level of ambition for distributed renewables under each scenario. In addition to this, some repowering occurs in the early-2030s under **Leading the Way**, slightly later in other scenarios, as legacy sites are retrofitted with new generation solar modules.		
Scenario	**Description**	**Capacity by 2035**
Falling Short	Capacity growth remains limited, with a small resurgence from 2026-2030 as some pipeline sites connect on delayed timelines. Past 2030, there is limited projected capacity growth, reaching c. 1.2 GW by 2035, favouring areas with high historic planning friendliness and available resource. Early repowering of older sites is rare, leaving baseline sites at their original capacities.	1,248 MW
System Transformation	Historic planning friendliness plays a larger role than local ambition in determining where post-pipeline solar projections are located. There is steady but limited solar deployment out to 2035.	1,573 MW
Consumer Transformation	Local ambition plays a larger role than historic planning friendliness in determining where projections are located. As under **System Transformation**, 1.5 GW is deployed by 2035.	1,568 MW
Leading the Way	Pipeline projects with less development evidence continue to connect in the late 2020s and early 2030s, (in addition to those modelled to connect in the mid-2020s). This includes projects that have yet to apply for planning permission. At the same time, areas with high solar resource and local government ambition see additional growth, reaching over 2.2 GW of capacity installed by 2035. Historic planning friendliness plays a relatively small role.	2,248 MW

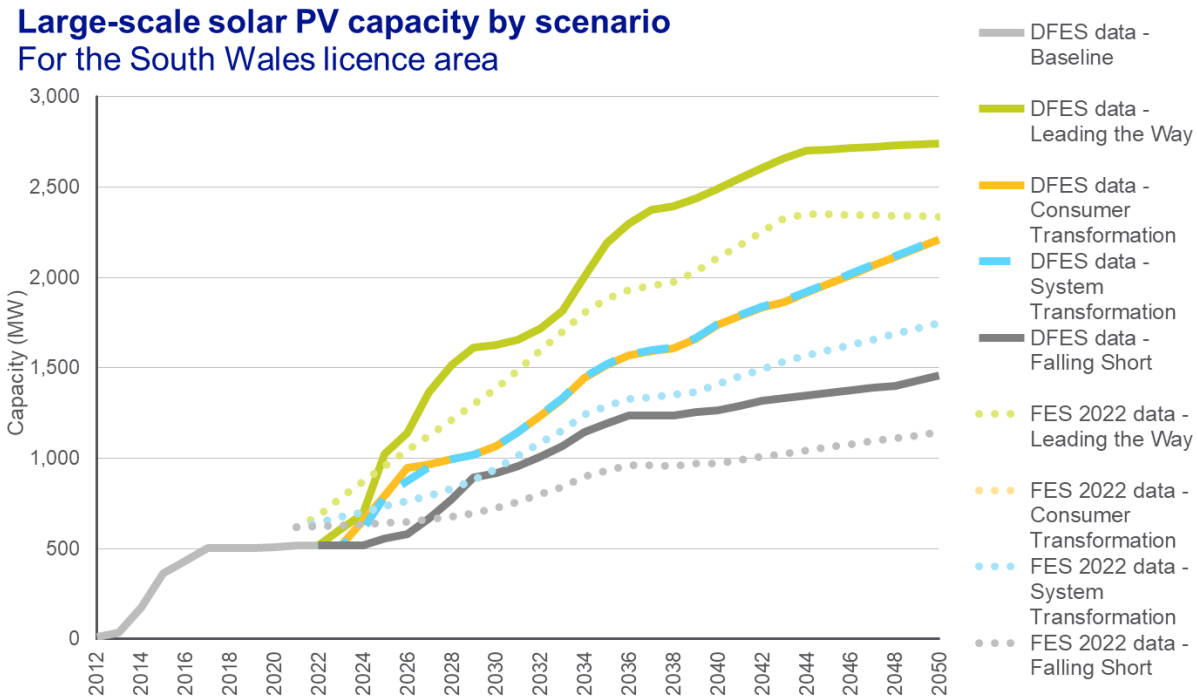
Long-term (April 2035 to March 2050)

Post-2035, long-term projections are determined by solar resource availability above all other factors. This is due to the assumption that factors like planning friendliness and local government ambition are less likely to reflect past trends, due to changes in local administration, public opinion and broader energy system policies. Deployment saturation is seen in areas with strong historic planning friendliness, which in turn pushes developers to seek connections in other high solar resource areas. Repowering legacy sites with new higher-yield solar PV modules takes place from the 2030s onwards, peaking in the late 2030s under **Consumer Transformation** and **System Transformation**. Standard modules in the 2010s were 250 W, with today's standard offering at 540 or above for ground-mounted solar farms[xix]. In the future, modules of over 600 W are likely to be deployed. As with the medium-term, the total installed solar PV capacity by 2050 ranges significantly by scenario, from c. 1.5 GW under **Falling Short** to c. 2.8 GW under **Leading the Way**.

Scenario	Description	Capacity by 2050
Falling Short	Repowering of sites is rare, leaving most baseline sites at their original capacities. Additional capacity growth begins to stagnate in the late-2030s, reaching just 1.5 GW by 2050 – though still triple the baseline capacity.	1,513 MW
System Transformation	Modelled deployment continues out to 2050 at a steady rate, with a focus on sites with high resource availability across the licence area. Older sites are modelled to repower at +25% of their original capacity.	2,283 MW
Consumer Transformation		2,277 MW
Leading the Way	Very high levels of solar development sees risk of self-cannibalisation, where low demand and high supply on sunny days leads to oversupply, constraints and low electricity prices. This contributes to a deceleration in newbuild ground-mount solar growth towards the end of the 2040s. The threat of self-cannibalisation is mitigated by co-location with battery storage and, in some cases, hydrogen electrolysis, as well as demand-side flexibility to meet peak generation. Sites are modelled to repower at +50% of their original capacity.	2,824 MW

Reconciliation with National Grid FES 2022

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



- The FES 2022 baseline is c.130 MW higher than the DFES 2022 baseline for the South Wales licence area. The reason for this variance is unclear and was also present in DFES 2021.
- DFES 2022 models a strong near-term uptake of solar in the licence area under all three net zero scenarios, compared to a strong near-term uptake solely under **Leading the Way** in the FES 2022. This is due to the rigorous pipeline status analysis undertaken by the DFES, where projects with accepted connection offers and high likelihood of acceptance are modelled to connect to the network under varying timeframes. The increase in positive development evidence in the pipeline strongly supports this near-term increase. There is a notable increase in the total capacity of accepted connection offers corresponding to accepted planning applications this year, compared to DFES 2021.
- From the mid-2020s onwards, DFES 2022 projections largely follow the FES 2022 trends and rates of development. The overall capacity buildout is higher due to strong pipeline evidence in the earlier years, followed by a slight re-allocation of potential future capacity projected in the South West licence area, to account for the available unconstrained resource in South Wales, as identified by Regen's in-house resource assessment. Whereas the FES modelling assumes that installed capacity will spread more evenly across the country as installed solar capacity increases, the DFES analysis allocates licence area level projections to areas with high levels of solar irradiance and land availability.

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.	NOABL wind speed 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[xx]
Proportion of solar sites that are successful with a planning application in the local planning authority.	Renewable Energy Planning Database

For input, evidence and assumptions based on stakeholder engagement, a separate summary report can be found here

Small-scale solar generation 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	2025	2030	2035	2040	2045	2050
Falling Short	188	210	250	302	354	406	459
System Transformation		233	356	496	638	780	923
Consumer Transformation		289	553	840	1,131	1,431	1,732
Leading the Way		291	560	858	1,158	1,468	1,781

Summary:

- During the 2010s, the South Wales licence area saw small-scale solar deployment as a result of the Feed-in Tariff support scheme, at levels slightly above the GB average.
- Deployment of small-scale solar had stalled in recent years. However, recent increases in energy prices have resulted in an uptick in deployment in 2022, and a pipeline of homes and businesses looking to install solar PV in the coming months and years.
- Beyond the near term, future deployment of small-scale solar varies strongly by scenario. Under **Consumer Transformation** and **Leading the Way**, high levels of electrified transport and heating drives small-scale solar uptake to reach almost ten times today's levels.
- Despite lower levels of electrification, **System Transformation** and **Falling Short** still see high levels of deployment, at five times and over two times today's levels respectively, as reducing costs and uptake of electric vehicles drives solar PV uptake under every scenario.
- By 2050, small-scale solar capacity is highest under **Leading the Way** at 1.8 GW.

Modelling assumptions and results

Baseline			
Scale	**Number of sites**	**Total capacity**	**Notes**
Domestic (Under 10 kW)	37,053	126	Equivalent to 3.5% of homes
Commercial (10 kW–1 MW)	1,245	62	Average array size: 50 kW
Feed-in Tariff deployment			
The vast majority of historic development occurred between 2010 and 2016, when Feed-in Tariff generation payments were highest. Over 150 MW of capacity, 84% of the baseline, was deployed in the South Wales licence area in these years.			
Recent deployment			
The Feed-in Tariff closed to new entrants in 2019, and Smart Export Guarantee rates have not proven lucrative enough alone to drive significant further deployment of small-scale solar PV. As such, deployment in the licence area had stalled, with only 10 MW deployed between 2019 and 2021. However, since April 2021, over 12 MW of capacity has been installed in the licence area in response to substantial increases in retail electricity and gas prices. This deployment is anticipated to continue into the near term as the cost-of-living crisis is causing further increases in energy bills.			

Pipeline (April 2022 to March 2024)

There are 150 small-scale solar sites in the pipeline, representing over 10 MW of potential additional capacity in the licence area. The vast majority of this capacity is commercial-scale sites, between 10 kW and 1 MW in size. However, this is partly due to domestic solar sites often commissioning quickly, and not holding a connection agreement for long before being installed.

Scale	Number of pipeline sites	Total capacity
Domestic (Under 10 kW)	64	0.3 MW
Commercial (10 kW–1 MW)	86	10.4 MW

Pipeline assessment

Scale	Number of sites	Total capacity	Scenario outcomes
Below 50 kW	112 (75% of total)	1.7 MW (16% of total)	This includes notified domestic rooftop arrays that are very unlikely to rescind their connection agreements. These sites are modelled to connect in 2023 under every scenario.
50-500 kW	33 (22% of total)	5.4 MW (50% of total)	These sites go ahead in 2023 under the three net zero scenarios. Under **Falling Short**, the most recent applications are not modelled to connect until 2024, while agreements that have been held for longer connect in 2023.
Above 500 kW	5 (3% of total)	3.7 MW (35% of total)	Four of these sites are under construction or have successfully attained planning permission and are modelled to connect in 2023 under every scenario. The remaining site was not found in planning and is modelled to connect in 2024 under every scenario.

Rooftop PV on new build homes (April 2022 to March 2050)

Rooftop PV on new build homes is modelled using the outputs of the DFES modelling of new housing developments. Currently, around 10% of recently built homes in England have been built with rooftop solar PV[xxi], and it has been assumed that the proportion in Wales is similar.

This proportion of homes with rooftop solar is anticipated to increase, as changes to Building Regulations (Part L)[xxii] to reduce carbon emissions for new-build homes have been introduced in June 2022, with further changes expected in 2025.

The impact of these regulations has been modelled to vary by scenario. In Scotland, more ambitious building regulations have already been in place for a number of years, resulting in an estimated 60-80% of new-build homes having rooftop solar[xxiii].

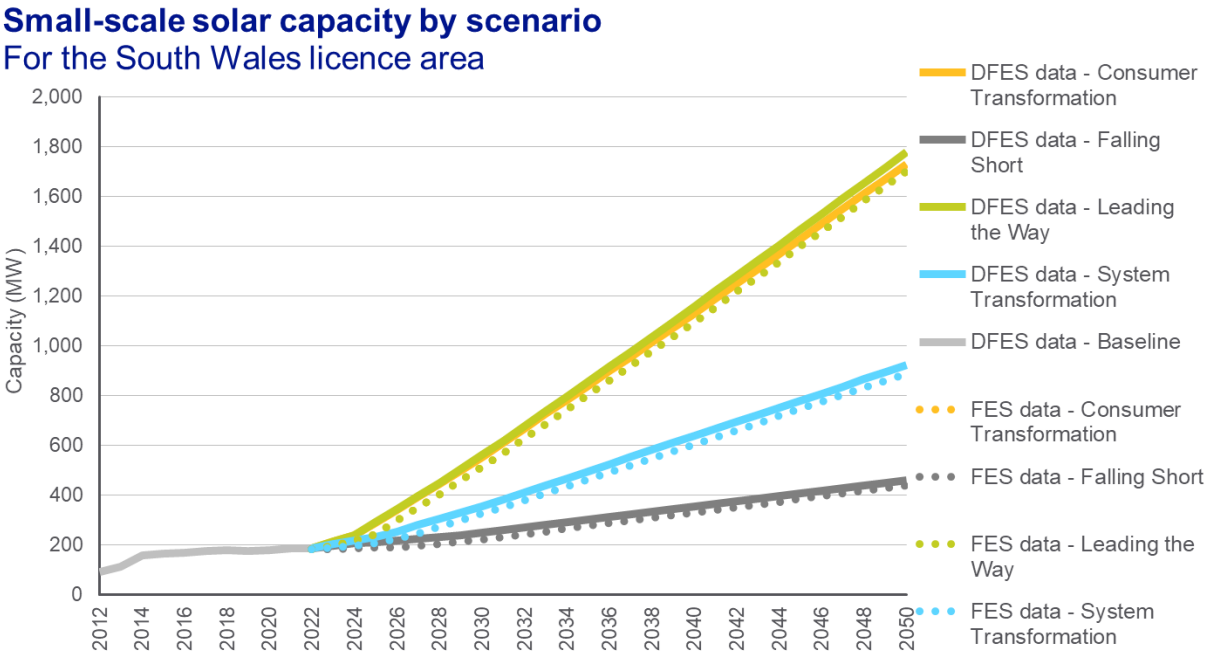
Under **Consumer Transformation** and **Leading the Way**, deployment of rooftop solar on new-build homes accelerates towards this figure over the 2020s and early 2030s. However, under **System Transformation** the changes to Building Regulations Part L have been modelled to have a lower impact, and under **Falling Short** deployment remains unchanged at 10% of new homes.

Scenario	Proportion of new-build homes with rooftop solar PV		
	2025	2030	2050
Falling Short	10%	10%	10%
System Transformation	15%	25%	40%
Consumer Transformation	20%	50%	70%
Leading the Way	20%	50%	70%

Medium and long-term projections (April 2024 to March 2050)		
In addition to modelled deployment on new-build homes, small-scale solar PV uptake accelerates from the mid-2020s in all scenarios. This is due to a combination of falling installation costs, and opportunities to increase self-consumption, such as through smart electric vehicle charging, domestic batteries and thermal storage.		
Scenario	**Description**	**Capacity by 2050**
Leading the Way	Under **Consumer Transformation** and **Leading the Way**, deployment is bolstered by high levels of consumers engaging with smart electricity usage, dynamic electricity tariffs and general green ambition. This results in a very high uptake of small-scale solar under these scenarios, peaking at just under 1.8 GW by 2050 under **Leading the Way**.	1,781 MW
Consumer Transformation		1,732 MW
System Transformation	Due to the need to decarbonise electricity demand quickly to meet carbon reduction ambitions, solar PV uptake is also high under **System Transformation**. However, greater use of larger-scale solutions and a reliance on low carbon hydrogen for space heating (rather than electrification) results in a lower uptake in small-scale solar than is seen in the other two net zero scenarios.	923 MW
Falling Short	**Falling Short** reflects a lower uptake of low carbon technologies, smart tariffs and less engaged consumers. This results in a much lower demand for small-scale solar on homes and businesses.	459 MW

Licence area building stock and demographic factors		
The licence area projections for small-scale solar PV are based on a number of building stock and demographic factors, based on engagement with local and regional stakeholders. These are detailed below:		
Factor	**Reason for inclusion**	**Licence area relative to GB**
Baseline	The proportion of homes and businesses with solar PV in the baseline is used as a key indicator of where solar is currently most active. The impact of this factor decreases in the 2030s and 2040s, as rooftop PV becomes more widespread.	Slightly above the GB average
Irradiance	Sunnier licence areas have been modelled to see greater uptake of rooftop PV, as higher levels of irradiance reduce the payback periods for rooftop PV installations.	In line with the GB average
Affluence	The average level of affluence in the licence area has a small impact on the deployment of domestic rooftop PV in the near term, due to the capital costs of solar PV installations. The impact of this factor decreases quickly as rooftop solar quickly becomes much more common under each scenario.	Moderately below the GB average
Building type	The number of semi-detached and detached homes in the licence area impacts the uptake of domestic PV. These buildings typically have more roof space and less shading.	Moderately above the GB average
Building tenure	Owner-occupied and socially rented homes are anticipated to see greater levels of domestic rooftop PV deployment now and in the future, compared to private rented homes.	Moderately below the GB average
Local authority and Welsh government	Local authority and Welsh government ambitions, in the form of climate emergency declarations or renewable targets, have a small impact on commercial rooftop PV uptake. Similarly, analysis of historic planning application success for solar projects has a small impact on the modelling.	Well above the GB average

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



- The FES and DFES outputs for small-scale solar PV in the licence area are closely aligned in the baseline year and throughout the projections.
- There is a small divergence between the DFES **Consumer Transformation** and **Leading the Way** scenarios, 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

For input, evidence and assumptions based on stakeholder engagement, a separate summary report can be found here

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	2025	2030	2035	2040	2045	2050
Falling Short	566	598	708	785	841	915	1,026
System Transformation		645	832	1,046	1,171	1,359	1,478
Consumer Transformation		701	1,100	1,564	2,000	2,580	2,655
Leading the Way		664	967	1,322	1,674	2,154	2,241

Summary:

- There is a significant baseline (566 MW) of distributed onshore wind in the South Wales licence area, much of which has been deployed in the past decade. High wind speeds and available land for wind development has led to the licence area becoming one of the main areas for onshore wind development in the UK, with significant transmission network connected capacity also coming online in the licence area.
- There is potential for significant growth in additional wind capacity in the licence area due to available wind resource, land availability and high levels of local ambition. Planning friendliness is highest compared to the other NGED licence areas, with around 59% of onshore wind projects that have been through the planning process securing approvals. Due to these factors, stronger growth in connected capacity is seen under **Consumer Transformation** and **Leading the Way**, while **Falling Short** sees a more limited uptake, due to lack of support from planners accepting the pipeline of new projects, failing to reach net zero goals.
- Onshore wind capacity in the licence area increases significantly out into the 2030s and early 2040s, levelling out in the late 2040s as decarbonisation targets are largely met a few years ahead of target, especially under **Consumer Transformation** and **Leading the Way**. Under these two scenarios, this accelerated onshore wind development in the licence area aligns with the Welsh Government's target of 70% of electricity generated in Wales to be met by renewable sources by 2030, including 1 GW of locally owned capacity.
- The 'Pre-Assessed Areas for Wind Energy', as identified in Future Wales: The National Plan 2040[xxiv], outline areas of South Wales where planning was presumed to be in favour of onshore wind development. Under this new policy approach, which supersedes the previous Strategic Search Areas (SSAs) methodology[xxv], areas outside of these designated areas are also encouraged for onshore wind development, so long as they avoid Areas of Outstanding Natural Beauty and qualify as Developments of National Significance[xxvi]. This policy change enables the potential for more wind energy (at various scales) in Wales, which will enable wind power to contribute a greater share of Welsh renewable energy targets compared to the previous Welsh Government SSA zoning policy.
- In all scenarios, baseline sites accredited under the Feed-in Tariff between 2012 and 2018 are modelled to repower at the end of their operational life of 25-30 years in the late 2030s and early 2040s.
- By 2030, connected capacity is highest under **Consumer Transformation** at just over 1 GW, reaching just over 2.5 GW by 2050 under the same scenario.

Baseline			
Scale	**Number of sites**	**Total capacity**	**Description**
Total	390	566	The vast majority of sites (c. 90%) are made up of small turbines of below 1 MW. However, the majority of installed capacity (c. 91%) is made up of sites of over 1 MW. South Wales has a large amount of developable land and high wind speeds, which contributes to its attractiveness for wind development.
Above 1 MW	38	516	Eight of the large-scale distributed wind sites are located in Carmarthenshire, totalling 136 MW in capacity. This is followed by seven sites in Rhondda Cynon Taf (86 MW), six sites in Neath Port Talbot (88 MW), four sites in Bridgend (125 MW) and four sites in Newport (12MW). Project capacity varies widely across the licence area, and the average installed capacity of sites is 14 MW. The largest site connected to the distribution network in the licence area is the 75 MW Pant y Wal Wind Farm.
Below 1 MW	352	50	South Wales has a notable amount of operational small-scale wind capacity, with the majority of new sites connecting between 2014 and 2017. Approximately 265 projects with an average capacity of 43 kW were supported by the FIT scheme.

Pipeline (April 2022 to March 2028)	
Number of pipeline sites	**Total capacity**
42	884 MW

There is a significant pipeline of potential new onshore wind capacity in the licence area, 42 sites totalling 884 MW. The majority of this pipeline comes from seven sites, totalling 400 MW.

This significant pipeline leads to a substantial increase in installed capacity as these larger sites come online across the four scenarios. All known projects are modelled to connect pre-2033. In terms of planning status, three sites are under construction, five have granted planning permission, 14 are in pre-planning, and 16 have no information or specific considerations. 2 sites, totalling 21 MW, had been abandoned or withdrawn in planning. More information is shown in the table below.

In-depth analysis of new wind developments shows that sites can take a range of years to commission, depending on the capacity of the project. On average, larger sites take longer to commission, yet some of the smallest sites may also have longer construction timelines. This information has been derived from direct developer engagement as well as Renewable Energy Planning Database and local authority planning portal analysis, and has been used to inform the medium-term projection years modelled in the DFES.

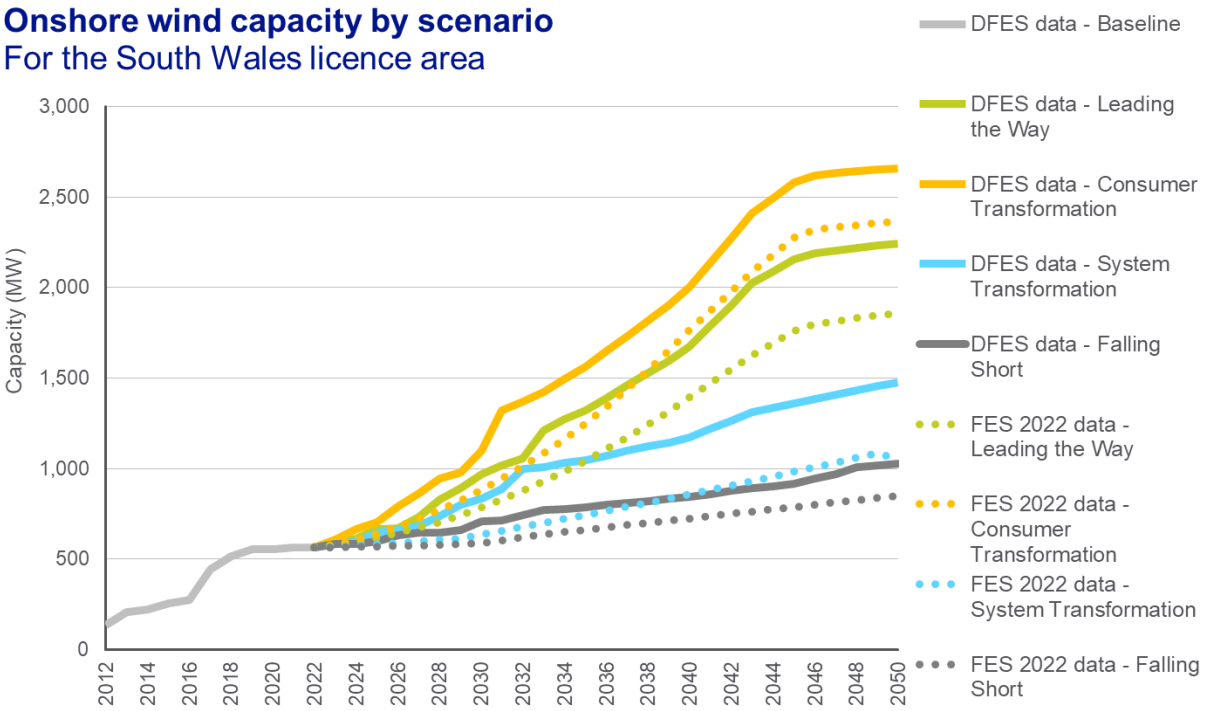
Pipeline analysis			
Status	**Scenario outcomes**	**Sites**	**Capacity**
Planning Permission Granted	The largest site is the 35 MW Foel Trawsnant Wind Farm, with full planning permission granted in 2014. The site is estimated to come online at the earliest by 2024 under **Consumer Transformation**. Another 15 MW project was originally approved in 2014, with several variations of planning conditions being applied. The remaining three sites are in Carmarthenshire (5 MW) and Rhondda Cynon Taf (10 and 2.5 MW).	5	67 MW
Under Construction	There are three sites under construction as of Q3 2022 in Blaenau Gwent (0.9 MW), Powys (13 MW) and Rhondda Cynon Taf (7 MW).	3	21 MW
Planning Application Submitted	Two sites have submitted applications and are pending a decision. The Upper Ogmore Find Farm in Cardiff is targeting 24 MW of capacity. In Pembrokeshire, an 18 MW site, Rhoscrowther Wind Farm, submitted an application in 2021 following public consultation.	2	42 MW
Pre-planning	Many sites have been identified to be in pre-planning, in that some evidence was provided by developers or consultation websites prior to submitting a full planning application. Of these sites, no more than 60% are modelled to be successful in the most ambitious scenario, **Consumer Transformation**. Where significant evidence in planning and developer ambition has been noted, such as with the Mynydd y Glyn wind farm, projects are modelled to come online over other projects with less substantial evidence, recent activity and high levels of local authority planning friendliness.	14	410 MW
No information	A total of 16 sites (232 MW) have no additional public information that is publicly available online. Resultantly, these sites are only modelled to connect under the net zero scenarios, outlined in the pipeline logic below.	16	323 MW
Abandoned or withdrawn in planning	Two sites have been abandoned or have a withdrawn planning application, and are assumed not to go ahead under any scenario.	2	21 MW

Planning logic and assumptions					
The assumptions around the proportion of pipeline sites and capacity that make it through planning at each stage are derived from a statistical analysis of the Renewable Energy Planning Database.					
Scenario	**Planning Granted or Under Construction**	**Planning Application Submitted**	**Pre-planning**	**No information**	**Years from Planning Submitted to completion**
Falling Short	100%	30%	25%	removed from analysis	6-10 years
System Transformation	100%	75%	40%	25%	5-9 years
Consumer Transformation	100%	80%	60%	50%	3-7 years
Leading the Way	100%	75%	40%	25%	5-9 years

Medium-term (April 2028 to March 2035)		
Scenario	**Description**	**Capacity by 2035**
Falling Short	Wind capacity continues to increase in the licence area. Development is dampened due to an assumption that planning regimes remain inhibitory towards new wind farm developments under this scenario. Sites continue to connect at similar levels to historic rates, making use of available land and resource.	785 MW
System Transformation	Onshore wind develops at a gradual and steady rate under this scenario, with several historic sites repowering in the early 2030s. A gradual increase in connected capacity is modelled as some distributed wind sites move through to connection. There is a general preference for transmission-connected wind farms to achieve net zero goals under this scenario, causing a limited capacity connecting at distribution network voltages.	1,046 MW
Consumer Transformation	A significant proportion of the pipeline continues to connect across the late 2020s and early 2030s, with 80% of sites with a live planning application successfully progressing through to development. Distributed onshore wind is seen as a key technology to reducing carbon emissions in the electricity system.	1,564 MW
Leading the Way	This scenario sees significant onshore wind capacity connecting in the licence area. Some of this new capacity connects to the transmission network, resulting in less overall capacity connected to the distribution network than under **Consumer Transformation**.	1,322 MW

Long-term (April 2035 to March 2050)		
Scenario	**Description**	**Capacity by 2050**
Falling Short	Distributed wind capacity in the region falls short of doubling the current baseline by 2050. Some new wind sites continue to connect at similar levels to historic rates. Sites larger than 5 MW experience a repowering of +25%.	1,026 MW
System Transformation	Long-term deployment of onshore wind sees steady, yet limited growth as more large-scale wind farms connect at transmission-level voltages. Repowering rates remain modest, accounting for some of the new capacity connecting in the 2030s and 2040s. Sites larger than 5 MW experience a repowering of +25%[xxvii]. All other sites repower at +50% of their original capacity.	1,478 MW
Consumer Transformation	Small-scale distributed wind generation capacity sees the highest growth under this scenario, reaching 2.58 GW by 2045 and levelling out to 2.65 GW by 2050. Sites larger than 5 MW experience a repowering of +50%. All other sites repower at +100%.	2,655 MW
Leading the Way	Repowering and unconstrained wind resource continue to spur development out to 2050. Sites larger than 5 MW experience a repowering of +50%. All other sites repower at +100%. The flattening of new capacity from 2045 onwards in **Leading the Way** and **Consumer Transformation** reflects the assumptions in the FES 2022, and can be seen as a cannibalisation of onshore wind as land and resource becomes saturated in the licence area.	2,241 MW

Figure 2 – Electrical capacity of onshore wind by scenario, South Wales licence area



- The FES 2022 and DFES 2022 baselines are aligned (566 MW) for the South Wales licence area. Near-term pipeline projections are also moderately aligned, seeing an uplift to 946 MW by 2028 in the DFES under **Consumer Transformation**, compared to 771 MW under the FES. This near-term variance is a reflection of the DFES pipeline analysis and evidence that reflects higher levels of planning ambition for the licence area under this scenario.
- There is some variance away from the FES in the long term, as DFES analysis takes a potentially different approach to the repowering of existing turbines and wind farms. This includes the repowering of existing sites at a higher capacity at the end of their operational life under the DFES, as well as the addition of extra turbines and retrofitting of existing blades with newer, higher-yield models. This has a specific impact on the projections in the South Wales licence area from 2030 onwards. Repowering then accelerates from 2040 onwards as baseline sites reach the end of their operational life, maintaining steady capacity growth out until 2045, notably above the FES in all scenarios.

Factors that will affect deployment at a local level

Factor	Source
Regen in-house resource assessment, incorporating 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 proclivity to renewable energy and net zero goals.	Climate Score Cards[xxviii]
Proportion of wind sites that are successful with a planning application in the local planning authority.	Renewable Energy Planning Database

For input, evidence and assumptions based on stakeholder engagement, a separate summary report can be found here

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 marinepower in the South Wales licence area:

Capacity (MW)		Baseline	2025	2030	2035	2040	2045	2050
Offshore wind	Falling Short	0	0	0	0	0	0	0
	System Transformation		0	8	8	8	8	8
	Consumer Transformation		0	20	20	20	20	20
	Leading the Way		0	20	20	20	20	20
Tidal stream	Falling Short	0	0	0	0	0	0	0
	System Transformation		0	0	6	12	12	12
	Consumer Transformation		0	6	18	24	30	30
	Leading the Way		0	6	18	24	30	30
Wave energy	Falling Short	0	0	0	0	0	0	0
	System Transformation		0	4	4	4	4	4
	Consumer Transformation		0	10	10	10	10	10
	Leading the Way		0	10	10	10	10	10

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 a pipeline of developing projects.
- The area around South Wales 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.
- Much of the offshore wind and marine energy development in South Wales is anticipated to connect at transmission level through the Pembrokeshire Demonstration Zone. As a result, while there is uptake of offshore wind and marine energy in all four scenarios, deployment on the distribution network is limited.

Modelling assumptions and results

Baseline
There are no operational baseline marine energy or offshore wind projects connected to the distribution network in South Wales.

Near-term projections (April 2022 to March 2030)

There are no offshore wind or marine sites with an accepted connection agreement. As a result, there is no deployment of offshore wind, tidal stream or wave energy in the licence area in the early 2020s.

Representatives of the marine and offshore wind sector in South Wales, including Marine Energy Wales and Celtic Sea Power, were engaged with to identify developing projects that could deploy in the near term.

The Bombora InSPIRE project[xxix], combing 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). The former has been modelled to connect in the three net zero scenarios, and the full commercial project is modelled to connect under **Consumer Transformation** and **Leading the Way** only, by 2028.

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, is coordinating with the Pembrokeshire Demonstration Zone and aiming to connect at transmission level.

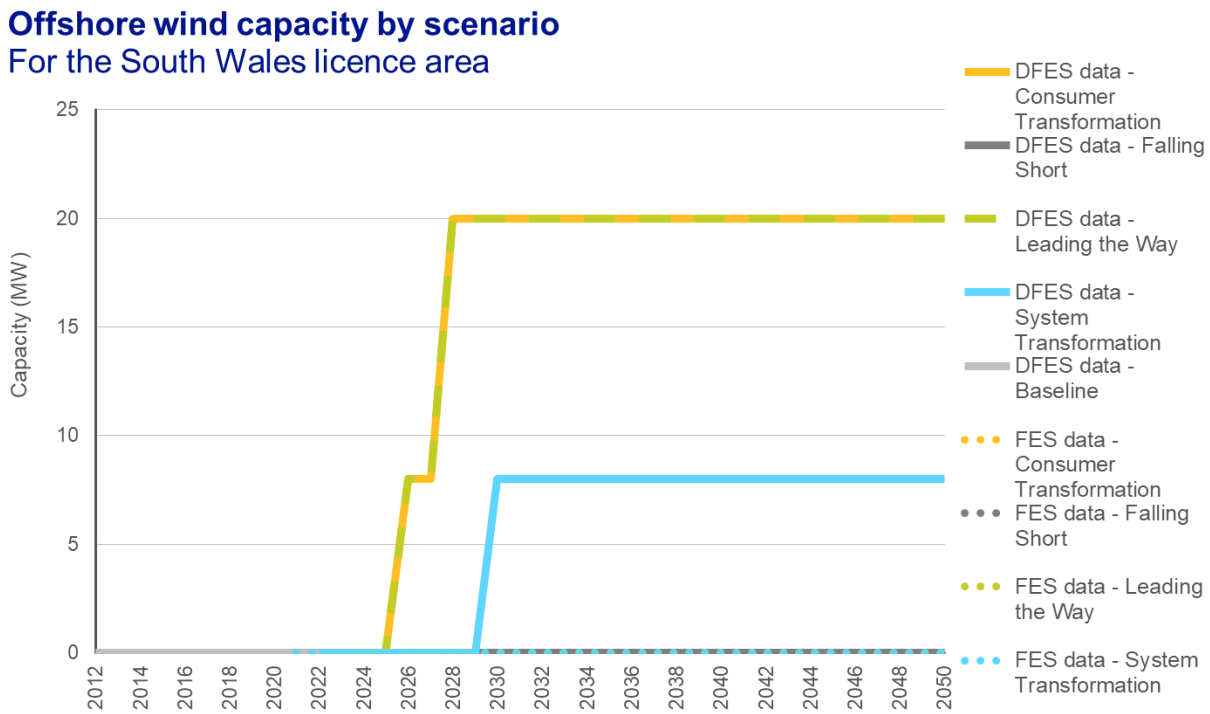
Medium and long-term projections (April 2030 to March 2050)

Engagement around the longer-term potential for offshore wind and marine energy generation in South Wales suggested that, beyond the near-term demonstration projects, any new or additional future sites would look to scale up to connect to the transmission network.

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 12 MW under **System Transformation**.

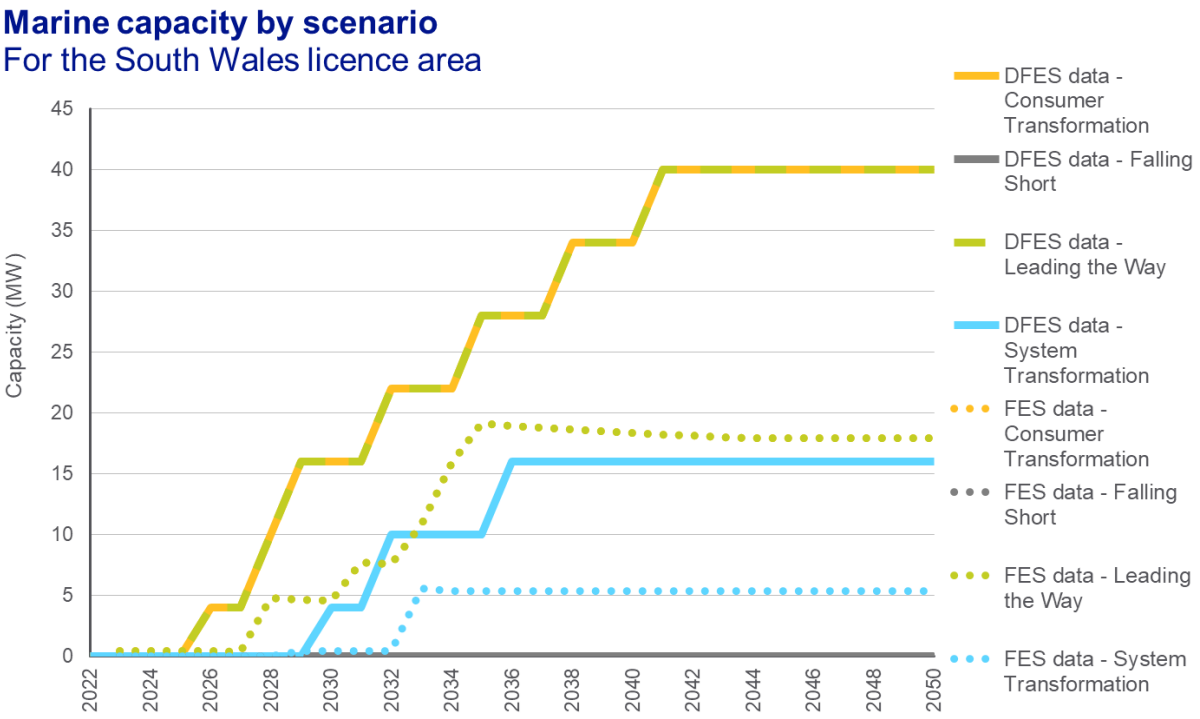
Reconciliation with National Grid FES 2022

Figure 16 – Capacity of offshore wind generation by scenario, South Wales licence area



- The National Grid FES 2022 projections for offshore wind in the South Wales licence area project no deployment under any scenario. This is broadly in line with the DFES, where the only deployment is up to 20 MW of capacity based on developing Bombora InSPIRE projects.

Figure 17 – Capacity of marine generation by scenario, South W**ales** licence area



- The DFES projections for marine generation are significantly higher than the FES projections in the three scenarios that see deployment. However, the peak variance is only 22 MW, under the **Consumer Transformation** and **Leading the Way** scenarios.
- This variance is mainly due to the modelling of a potential tidal stream array at Ramsey Sound, which was identified directly through engagement with project developers and marine energy sector representatives.

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

For input, evidence and assumptions based on stakeholder engagement, a separate summary report can be found here

Hydro in the South Wales licence area

Hydropower electricity generation

Data summary for hydropower in the South Wales licence area:

Capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	16	16	16	16	16	16	16
System Transformation		16	16	17	18	18	19
Consumer Transformation		16	18	20	22	24	26
Leading the Way		16	16	17	18	19	19

Summary:

- The South Wales licence area contains 16 MW of small and medium-scale hydropower sites, predominantly located in Mid Wales local authority areas of Powys and Ceredigion.
- With the closure of the Feed-in Tariff, deployment of smaller-scale hydropower has stalled. There are only two hydropower sites with accepted connection agreements in the licence area.
- Under the **Consumer Transformation** scenario, an additional 12 MW is modelled to come online by 2050. Significantly less capacity is modelled under the other scenarios, due to there being less focus on hydropower as a form of low carbon electricity generation.

Modelling assumptions and results

Baseline			
Scale	**Number of sites**	**Total capacity**	**Description**
Above 1,000 kW	4	12.7 MW	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. In total, these four sites represent over 80% of hydropower capacity in the South Wales licence area.
100-1,000 kW	7	1.1 MW	The sites in the 100-1,000 kW range were delivered through the Feed-in Tariff scheme in the 2010s. These smaller-scale sites are not limited to Mid Wales, with sites in Cardiff, Monmouthshire and Pembrokeshire.
Below 100 kW	84	1.7 MW	Very small-scale sites below 100 kW, averaging around 20 kW in size, were almost all supported via the Feed-in Tariff scheme.

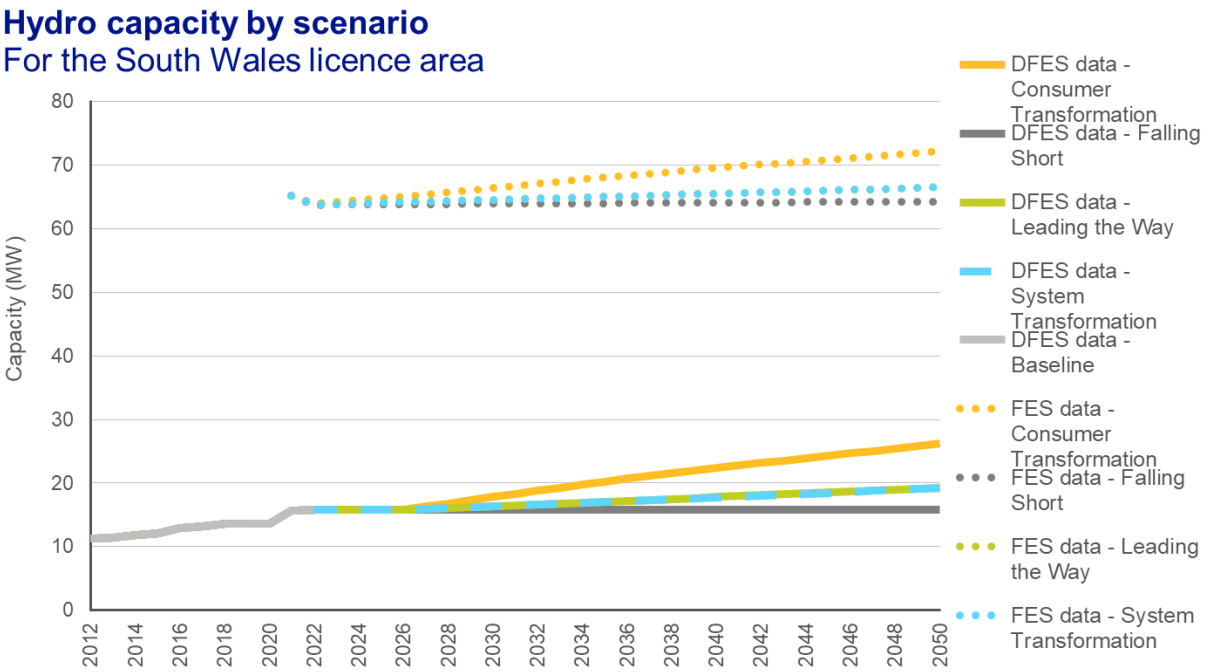
Pipeline (April 2022 to March 2025)		
Pipeline site location	**Capacity**	**Scenario outcome**
Elan Valley	1.5 MW	Located near to the existing 4.5 MW baseline site in the same location, this site attained planning permission in early 2019 but has seen no development since. This site goes ahead in the mid-2020s under the **Consumer Transformation** scenario, which sees higher demand for small-scale renewable generation and onsite electricity

		production. The site is not modelled to go ahead under any other scenario, due to the lack of development over the past few years.
Monmouthshire	0.05 MW	Limited evidence due to the very small scale. Goes ahead under **Consumer Transformation** and **Leading the Way**.

Medium and long-term projections (April 2025 to March 2050)		
Scenario	**Description**	**Capacity by 2050**
Consumer Transformation	With a focus on decarbonisation through consumer engagement, this project sees steady deployment of small-scale hydropower out to 2050. Hydropower deployment is mainly driven by demand for onsite electricity generation and community energy schemes.	26 MW
Leading the Way	Under these scenarios, small-scale hydropower deployment is limited as large-scale solutions are prioritised. However, hydropower is deployed at select sites to aid decarbonisation, particularly where sites above 1 MW capacity could be deployed.	19 MW
System Transformation		
Falling Short	Lack of subsidy support and slow decarbonisation results in no further hydropower deployment.	16 MW

Reconciliation with National Grid FES 2022

Figure 18 – Electrical capacity of hydropower energy by scenario, South Wales licence area



- There is a substantial difference of 48 MW between the baselines for hydropower in the South Wales licence area in the DFES and FES 2022 data – this discrepancy was present in the FES 2021 data. The reason for this discrepancy is not clear, but it is likely a result of the allocation of hydropower sites in highly rural Mid Wales 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 scenario assumptions for smaller-scale hydro are reflected in the DFES projections.

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

For input, evidence and assumptions based on stakeholder engagement, a separate summary report can be found here

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	2025	2030	2035	2040	2045	2050
Falling Short	72	72	72	72	72	72	72
System Transformation		72	72	73	54	55	6
Consumer Transformation		72	72	53	53	5	5
Leading the Way		72	72	53	54	5	5

Summary:

- The future of biomass power generation on the distribution network is impacted by competing demands for bioenergy to decarbonise sectors other than electricity, such as heat, transport, industry, aviation, and shipping. Despite being a dispatchable low carbon thermal generation technology, biomass sees a decrease over time under the three net zero scenarios as biomass for power is dominated by transmission-scale BECCS generation
- Standalone biomass power generation is progressively decommissioned in the three net zero scenarios as bioenergy resources are used elsewhere. There is, however, some growth in the capacity of biomass CHP connecting to the distribution network in the licence area as a means of decarbonising heat, particularly under **System Transformation**.
- Under **Falling Short**, biomass power generation capacity remains relatively static as alternative uses of bioenergy in harder-to-decarbonise sectors are not deployed under this scenario.

Modelling assumptions and results

Baseline

The South Wales biomass baseline consists of just five sites, detailed below. This includes two neighbouring large-scale sites in Port Talbot, totalling 72 MW capacity, and three smaller-scale sites.

Details of baseline sites

Site name	Location	Connection date	Capacity
Western Wood Biomass	Margam, Port Talbot	July 2008	49 MW
Western Wood Biomass 2	Margam, Port Talbot	January 2019	19 MW
Volac Factory	Lampeter, Ceredigion	April 2016	3.5 MW
Vale Bio Energy	Llancarfan, Barry	June 2012	0.5 MW
No information	Vale of Glamorgan	May 2018	0.1 MW

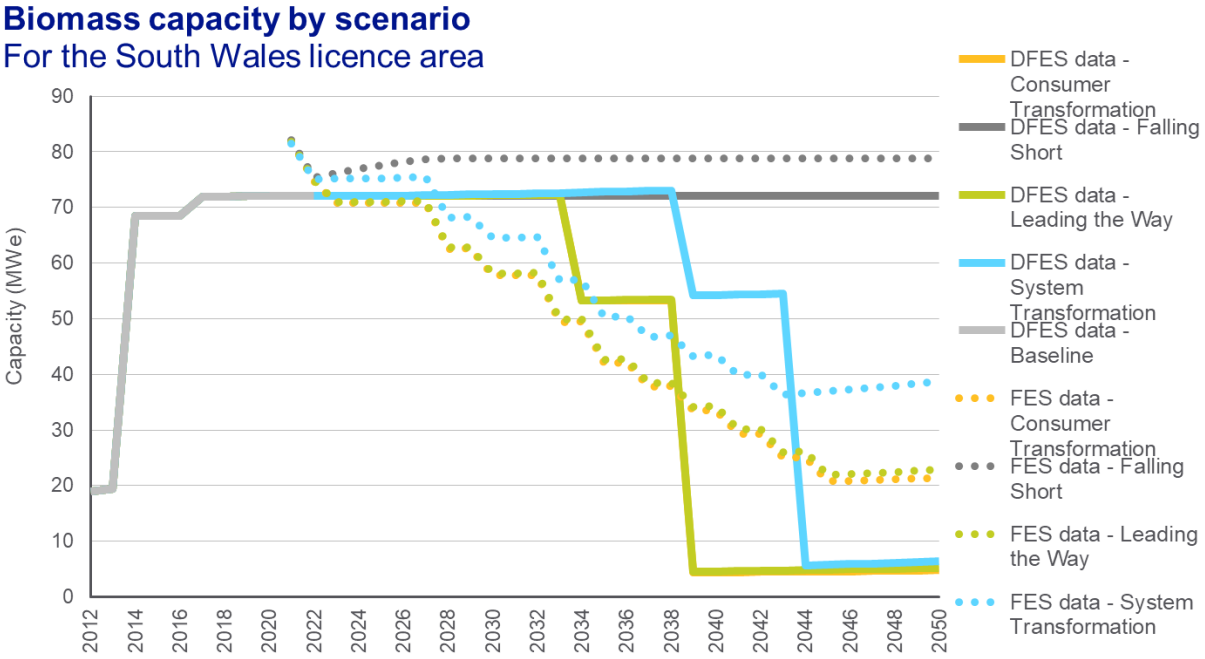
Pipeline (April 2022 to March 2026)

There are no biomass pipeline sites in the South Wales licence area.

Medium-term and long-term projections (April 2026 to March 2050)			
Beyond the pipeline, the fate of biomass generation on the distribution network is 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**
Leading the Way	Biomass is prioritised for transmission-scale BECCS and other hard-to-decarbonise sectors. As a result, standalone biomass is decommissioned 25 years after commissioning, as plants head towards the end of their operational life.	Greater electrification of heat in these two scenarios results in less demand for biomass CHP. However, there is still some growth in biomass CHP capacity, particularly for heating in heat networks, business parks and industrial sites.	5 MW
Consumer Transformation			5 MW
System Transformation	Standalone biomass is decommissioned 30 years after commissioning, around the end of its operational life and biomass is prioritised for BECCS, hydrogen production and aviation.	While heat in this scenario is dominated by hydrogen, biomass CHP sees uptake in the longer term in areas not connected to the hydrogen network.	6 MW
Falling Short	Standalone biomass generation remains on the distribution network in this scenario, as other sectors' progress towards decarbonisation is slow.	Biomass CHP sees no further growth under this scenario, as decarbonisation is slow and many sectors do not fully decarbonise.	72 MW

Reconciliation with National Grid FES 2022

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



- The FES GSP-level baseline is slightly higher than the DFES baseline. The reason for this is unclear.

- In the longer term, the DFES aligns with the overall distribution-connected biomass trend in the national FES, in which non-CHP biomass generation capacity reduces over time under the three net zero scenarios as bioenergy resources are prioritised for other sectors than power generation and biomass CHP uptake is low.
- With only four baseline sites, the bottom-up DFES projections are predominantly constructed based on the decommissioning of individual sites. As a result, the DFES net zero scenario projections see more stepped results compared to the more continuous FES GSP-level outputs, and result in lower 2050 outcomes as the two major biomass sites in South Wales are decommissioned.

Factors that will affect deployment at a local level

Factor	Source
Sites already in the NGED connections baseline and pipeline, categorised into standalone power generation and CHP sites.	NGED

For input, evidence and assumptions based on stakeholder engagement for this licence area, a separate summary report can be found here

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 (MWe)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	49	49	48	41	21	21	20
System Transformation		49	51	44	25	24	24
Consumer Transformation		50	57	52	32	32	32
Leading the Way		50	58	53	34	34	34

Summary:

- The 49 MW baseline of renewable engines in the South Wales licence area consists mainly of landfill gas, with smaller proportions of anaerobic digestion and sewage gas capacity. The pipeline of projects with accepted connection agreements is relatively small, consisting of four projects totalling 22 MW. However, 20 MW of this capacity is not anticipated to connect.
- Sewage gas, landfill gas and anaerobic digestion capacity projections are modelled separately, as these technologies see different outcomes in each of the four scenarios.
- Landfill gas is modelled to decommission over time in every scenario, as Wales moves towards more sustainable waste treatment and an overall reduction in waste production.
- Sewage gas 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.
- Anaerobic digestion of other feedstocks sees an 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.
- Overall, **Consumer Transformation** and **Leading the Way** see a small increase in capacity across the 2020s and early 2030s, as a result of anaerobic digestion deployment, before capacity reduces over the longer term as a result of landfill gas site decommissioning.
- **System Transformation** and **Falling Short** see a reduction in the capacity of renewable engine technologies over the scenario timeframe, as the reduction in capacity from landfill gas decommissioning is not countered by anaerobic digestion uptake in these scenarios.

Modelling assumptions and results

Baseline

The renewable engines baseline has been categorised into anaerobic digestion, sewage gas and landfill gas. The baseline totals 49 MW in the licence area.

While these sub-technologies fall under the renewable engines umbrella, the potential future outcome for each of these types of sites are markedly different under the DFES scenarios.

Type of site	Number of sites	Capacity	Details
Anaerobic digestion	6	4 MW	The anaerobic digestion baseline sites, ranging from 0.2 MW to 1.5 MW in size, are located in rural, agricultural areas including Ceredigion and Monmouthshire.

Sewage gas	2	10 MW	Both sewage gas sites, located in Neath Port Talbot and Cardiff, are owned and operated by Dwr Cymru Welsh Water.
Landfill gas	12	36 MW	The landfill gas baseline consists of medium-scale sites near built-up areas such as Cardiff, Swansea, Newport and Rhondda Cynon Taf. All but one of these sites were connected between 1998 and 2007.

Pipeline (April 2022 to March 2026)

The pipeline of projects with accepted connection agreements is very small compared to the baseline, indicating minimal near-term growth for these technologies. This is partly due to decreasing government support for renewable heat and electricity generation, such as the Renewable Heat Incentive and Feed-in Tariff which supported notable renewable engine project deployment during the 2010s.

Type of site	Number of sites	Capacity	Scenario outcomes
Anaerobic digestion	3	2 MW	One site that is under construction, and a second small-scale site with no planning information, are modelled to connect under **Consumer Transformation** and **Leading the Way**. The remaining site has withdrawn its planning application, and as such is not modelled to go ahead in any scenario.
Other	1	20 MW	This biodiesel-fuelled peaking plant at a Newport steelworks has no evidence of progression since 2016, and as such is not modelled to connect under any scenario.

Medium and long-term projections (April 2026 to March 2050)

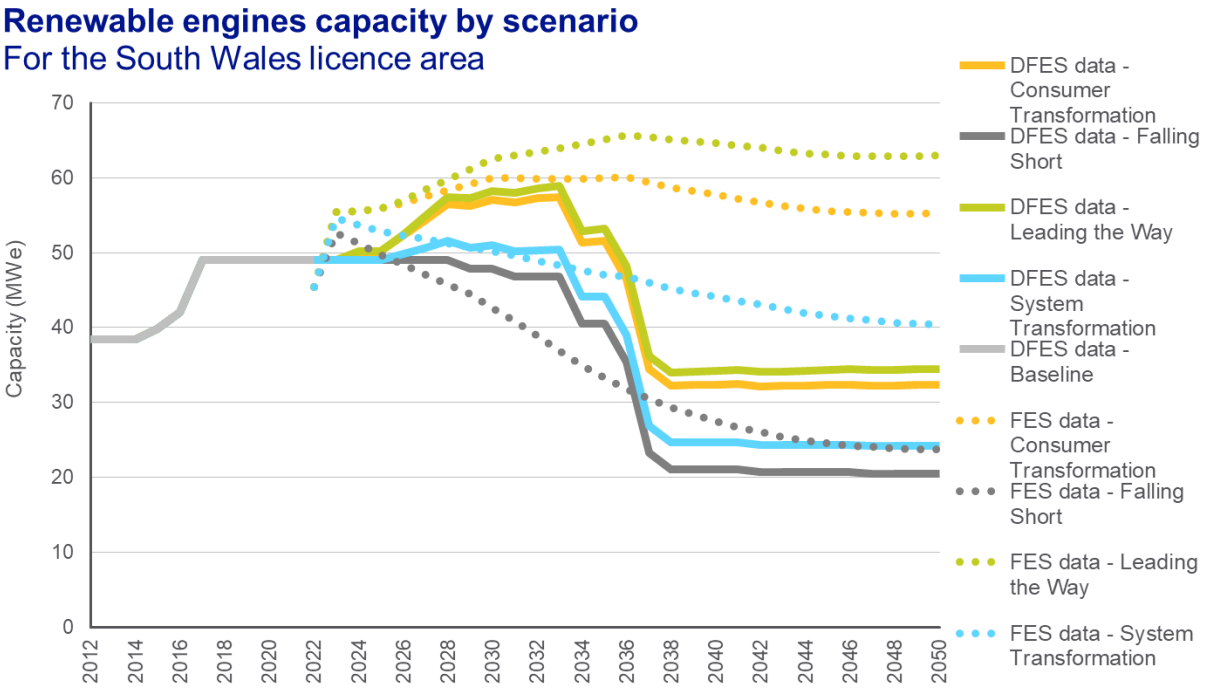
Type of site	Scenario outcomes
Anaerobic digestion	Future deployment of anaerobic digestion capacity has been informed by the existing baseline in each licence area, which is particularly low in South Wales. Under **Consumer Transformation** and **Leading the Way**, deployment peaks in the late 2020s and early 2030s, as the electricity system is rapidly decarbonised and small-scale, established renewables such as anaerobic digestion play a larger role.
Sewage gas	Sewage gas baseline and pipeline sites are modelled to remain connected at a consistent capacity out to 2050 under every scenario.
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.

As a result of the baseline consisting mainly of landfill gas, 2050 capacity is lower than the baseline under every scenario.

Under **Consumer Transformation** and **Leading the Way**, this is slightly mitigated by some future deployment of anaerobic digestion in agricultural areas.

Scenario	2050 capacity
Falling Short	20 MW
System Transformation	24 MW
Consumer Transformation	32 MW
Leading the Way	34 MW

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



- The DFES and FES baselines for renewable engines for the South Wales licence area are broadly aligned.
- The near-term projections in the DFES diverge from the FES projections, as specific pipeline projects are modelled to connect under the net zero scenarios. The sharp near-term increase in capacity in the FES projections under every scenario is not reflected in the DFES, as no evidence has been found regarding pipeline capacity of this scale in the NGED connections data.
- The South Wales projections under the three net zero scenarios are below the FES scenario projections in the medium and long term, and the 2050 outcome for all four DFES scenarios is lower than the FES scenarios. This is due to the modelling of specific baseline and pipeline site types, and the majority of capacity in South Wales being attributed to landfill gas sites with a limited operating life.

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 production, animal slurry and local authority food waste collection	Regen local authority engagement, Natural Resources Wales, DEFRA

For input, evidence and assumptions based on stakeholder engagement, a separate summary report can be found here

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	2025	2030	2035	2040	2045	2050
Falling Short	226	226	152	85	0	0	0
System Transformation		162	85	0	0	0	0
Consumer Transformation		162	85	0	0	0	0
Leading the Way		141	0	0	0	0	0

Summary:

- The South Wales licence area has a number of existing operational diesel engines, including 74 MW of larger standalone commercial diesel generation sites and 151 MW of behind-the-meter backup generators co-located with large energy user buildings. This is substantially higher than last year's DFES baseline due to a number of projects being successfully reclassified from 'other generation'.
- There are no projects with an accepted connection offer in the licence area.
- The operation of unabated diesel generation is at odds with net zero emissions targets and is restricted through the enaction of the Medium Combustive Plant Directive (MCPD) into UK law. This requires diesel (and other combustion engine) generation plants to adhere to stringent air quality limits through environmental permitting unless they only operate for a few hours per year.
- As a result, all standalone diesel generation operating commercially is modelled to disconnect in all scenarios by 2033, with **Leading the Way** seeing the most rapid disconnection of commercial diesel capacity.
- Behind-the-meter backup generators are expected to stay connected to the network for longer under all scenarios, as they provide crucial services to many high energy users, including hospitals, industry and supermarkets, and only operate for a few hours a year. This assumption was supported by some major energy users in the National Grid Electricity Distribution licence areas that were engaged as part of the DFES 2022 process, who noted that there are limited plans in place to replace diesel backup generators in the near term, with some organisations looking into alternative fuels such as HVO in the medium-to-longer term.

Modelling assumptions and results

Baseline	
Number and capacity (MW) of standalone commercial diesel generators	**Number and capacity (MW) of behind-the-meter backup generators**
5 sites (74 MW)	18 sites (151 MW)
Largest baseline site:	23.6 MW Tir John STOR generator, Swansea

Modelling assumptions

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 electricity network reserve services (such as Short Term Operating Reserve (STOR) or the Capacity Market), while smaller backup generators tend to be located onsite at a number of large energy consumer buildings, such as water industry sites, supermarkets, data centres, national rail sites and hospitals.

Medium Combustive Plant Directive

In 2019, a piece of EU legislation known as the Medium Combustion Plant Directive (MCPD) was passed into UK law. This requires plants to adhere to stringent air quality limits through environmental permitting unless they only 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. This type of companion technology is unlikely to be financially viable, at least in the near term. The price of diesel has also significantly increased in recent years, further impacting the business case for future diesel generation.

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, for example for backup power generation on islands when the power supply is interrupted.

The DFES modelling has sought to directly reflect the requirements set out under this regulation for diesel generation.

Near-term (April 2022 to March 2025)

There are no projects with an accepted connection offer in the South Wales licence area.

As a fossil fuel, the operation of unabated diesel-fuelled electricity generation contributes carbon emissions that are at odds with UK net zero targets. In addition to this, the requirements under UK environmental permitting laws have driven a rapid decommissioning of unabated commercial diesel generators under the **Leading the Way**, **Consumer Transformation** and **System Transformation** scenarios.

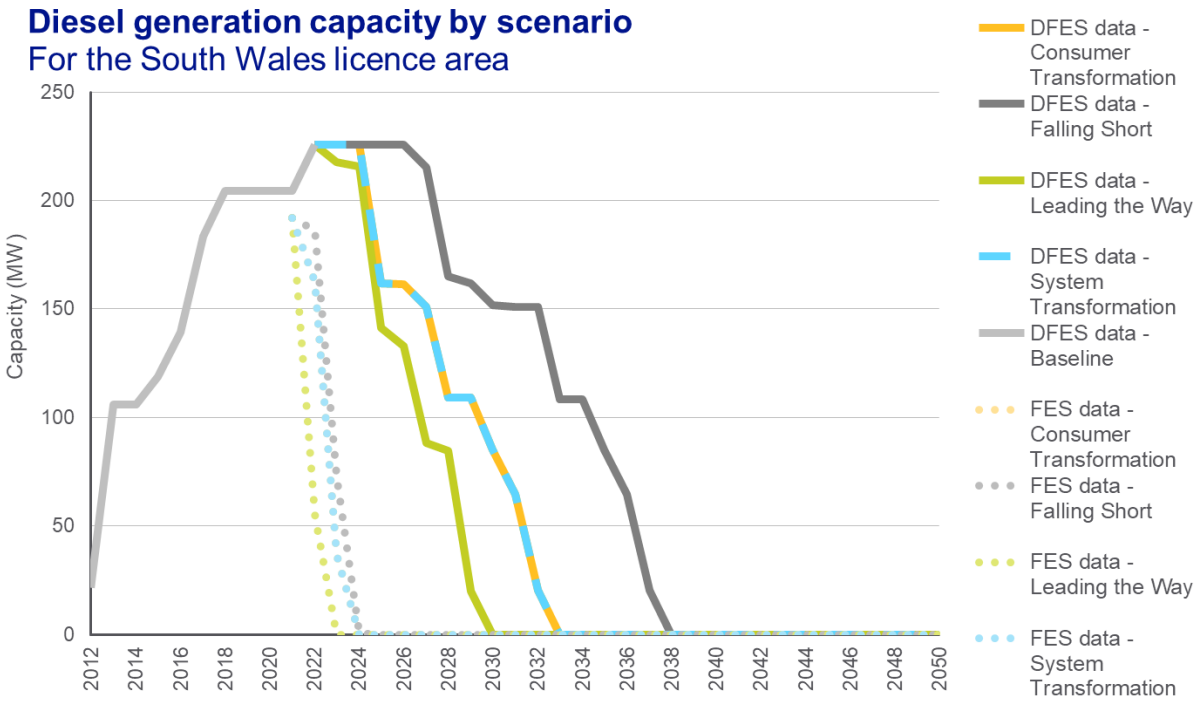
Scenario	Description	Earliest decommissioning year
Falling Short	No sites are modelled to disconnect in this timescale as it is assumed that the requirements under the MCPD do not fully encourage generator site operators to decommission or relinquish export capacity by March 2025.	2028 (standalone) 2027 (backup)
System Transformation	A few large standalone diesel plants are modelled to decommission in this timescale, due to the impact of the requirements under the MCPD. These include three 21 MW STOR generators in Swansea, Hirwaun and Briton Ferry.	2025 (standalone) 2025 (backup)
Consumer Transformation		

Leading the Way	Due to rapid decommissioning timescales seen in the FES 2022 diesel projections, echoing the likely decommissioning of commercial diesel sites due to the MCPD, **Leading the Way** has all standalone diesel generators (180 MW) decommissioning by 1 January 2025. A number of old backup diesel generators also decommission in this period.	2024 (standalone) 2023 (backup)

Medium-term and long-term (April 2025 to March 2050)		
Scenario	**Description**	**Latest decommissioning year**
Falling Short	Low carbon diesel or biodiesel could still play a role for backup generators, hence, the operation of existing plants has been modelled to extend out to 2038 under **Falling Short**.	2033 (standalone) 2038 (backup)
System Transformation	Standalone sources of flexibility are assumed to move to lower carbon alternatives, such as electricity storage, demand side response and cleaner 'dispatchable' generation technologies, such as anaerobic digestion. Some backup diesel generators continue to operate out to 2035, but only in mains failure situations, for a handful of hours per year.	2030 (standalone) 2033 (backup)
Consumer Transformation		
Leading the Way	All standalone diesel generators are modelled to decommission by 2025, with a handful of backup generators (24 MW) continuing to operate into the late-2020s. At this point, it is assumed under this scenario that even more stringent measures are in place and all forms of diesel-fuelled electricity generation are either fully abated or replaced with low carbon alternatives.	2025 (standalone) 2030 (backup)

Reconciliation with National Grid FES 2022

Figure 21 – Installed capacity of diesel generation by scenario, South Wales licence area



- The current installed capacity of diesel generation in the South Wales licence area is c.34 MW higher in the DFES data than in the FES 2022 data. This is thought to be due to DFES data also including behind-the-meter backup generators (46 MW).
- This is also reflected in the steep decommissioning timelines seen in the FES 2022 data, as it is unlikely that backup generators will adhere to the same stringent environmental permitting requirements as standalone plants.
- The DFES also has later decommissioning years for diesel generation than those assumed in the FES 2022. This delayed decommissioning timescale was considered to be more realistic, particularly for behind-the-meter backup generators.

Factors that will affect deployment at a local level

Factor	Source
Location of 20 existing diesel generation sites already in the National Grid connections data.	National Grid

For input, evidence and assumptions based on stakeholder engagement, a separate summary report can be found here

Fossil gas-fired power 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	2025	2030	2035	2040	2045	2050
CCGT (non-CHP)	Falling Short	0	117	117	117	117	117	117
	System Transformation		117	117	117	0	0	0
	Consumer Transformation		117	117	117	0	0	0
	Leading the Way		117	117	0	0	0	0
OCGT (non-CHP)	Falling Short	83	83	83	83	83	83	83
	System Transformation		83	83	21	0	0	0
	Consumer Transformation		83	83	21	0	0	0
	Leading the Way		83	0	0	0	0	0
Reciprocating engines (non-CHP)	Falling Short	283	343	375	375	375	347	325
	System Transformation		293	295	275	20	0	0
	Consumer Transformation		293	295	275	20	0	0
	Leading the Way		247	215	0	0	0	0
Gas CHP	Falling Short	112	114	114	114	114	114	114
	System Transformation		114	114	113	50	0	0
	Consumer Transformation		114	114	113	50	0	0
	Leading the Way		114	113	0	0	0	0

Summary:

- There is a moderate baseline (c. 480 MW) of existing operational fossil gas-fired generation connected to the distribution network in the South Wales licence area. This ranges from 20+ year-old gas power stations to small-scale gas CHPs connected behind-the-meter at commercial buildings less than 12 months ago.
- There are six sites with accepted connection offers with NGED in the South Wales licence area, comprising one CCGT (117 MW), one gas CHP (2 MW) and four applications for reciprocating engines, which total an additional 91.5 MW.

- The primary role of distribution-scale fossil gas-fired generation is to provide flexibility and back-up 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[xxx], 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[xxxi] 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 fossil gas generation capacity 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 'Hydrogen-fuelled generation in the South Wales licence area'.

Modelling assumptions and results

Baseline		
There are 50 fossil-gas generation sites connected in the South Wales licence area, totalling 480 MW. This is broken down into the following fossil gas technologies:		
Sub-technology	**Number of sites**	**Total capacity**
OCGT (non-CHP)	2	83 MW
Reciprocating engines (non-CHP)	23	283 MW
Gas CHP	24	112 MW

Pipeline (April 2022 to March 2028)		
Sub-technology	**Number of pipeline sites**	**Total capacity**
CCGT (non-CHP)	1	117 MW
Reciprocating engines (non-CHP)	4	92 MW
Gas CHP	1	2 MW

Pipeline analysis			
Status	**Scenario outcomes**	**Sites**	**Capacity**
Under construction	The 2 MW CHP at Llantrisant Business Park is currently under construction and is modelled to connect in 2023 under all scenarios.	1	2 MW
Planning permission granted	Two further sites have received planning permission: • A 40 MW gas reciprocating engine in Pencoed, which received planning permission in May 2019. This is modelled to connect under all scenarios except **Leading the Way**, due to the focus on low carbon flexibility assets in this scenario. • A 117 MW CCGT site at Port Talbot Steelworks, which has also secured a Capacity Market agreement for 2022/23. This is modelled to connect in time to meet its Capacity Market delivery year under all scenarios.	2	157 MW
Pre-planning	The other three sites with connection offers from NGED are pre-planning; however: • One of these sites (20 MW) has secured an agreement as part of the Capacity Market. These have been modelled to connect in time to meet their Capacity Market delivery years under all scenarios. • One site (20 MW) prequalified for the 2025/26 Capacity Market auction and is modelled to connect under all scenarios except **Leading the Way.** • One site (12 MW) has no further information and, therefore, has only been modelled to connect under **Falling Short**.	3	52 MW

Fossil fuel generation policy considerations

The Industrial Emissions Directive, in place since 2016, places emissions requirements on large and medium-scale power plants, with limitations on the annual operating hours. This affects some projects in the licence area, with operational hours assumed to reduce across the projection period.

In addition, in 2020 BEIS published guidance around carbon emission limits in the UK Capacity Market[xxxii] which proposed specific carbon intensity thresholds for entry into capacity auctions. Whilst this limit does not immediately restrict fossil gas generators with low annual load factors, future developments or reductions to this threshold (off the back of deep policy reviews such as REMA) could prevent unabated fossil gas from participating in some markets. The scenario assumptions and outcomes for fossil-gas generation technologies reflect a range of views for this type of policy.

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.

Sub-technology	Scenario	Description	Decommissioning timescale
CCGT (non-CHP)	**Leading the Way**	The new 117 MW CCGT plant at Port Talbot connects under all scenarios	2031

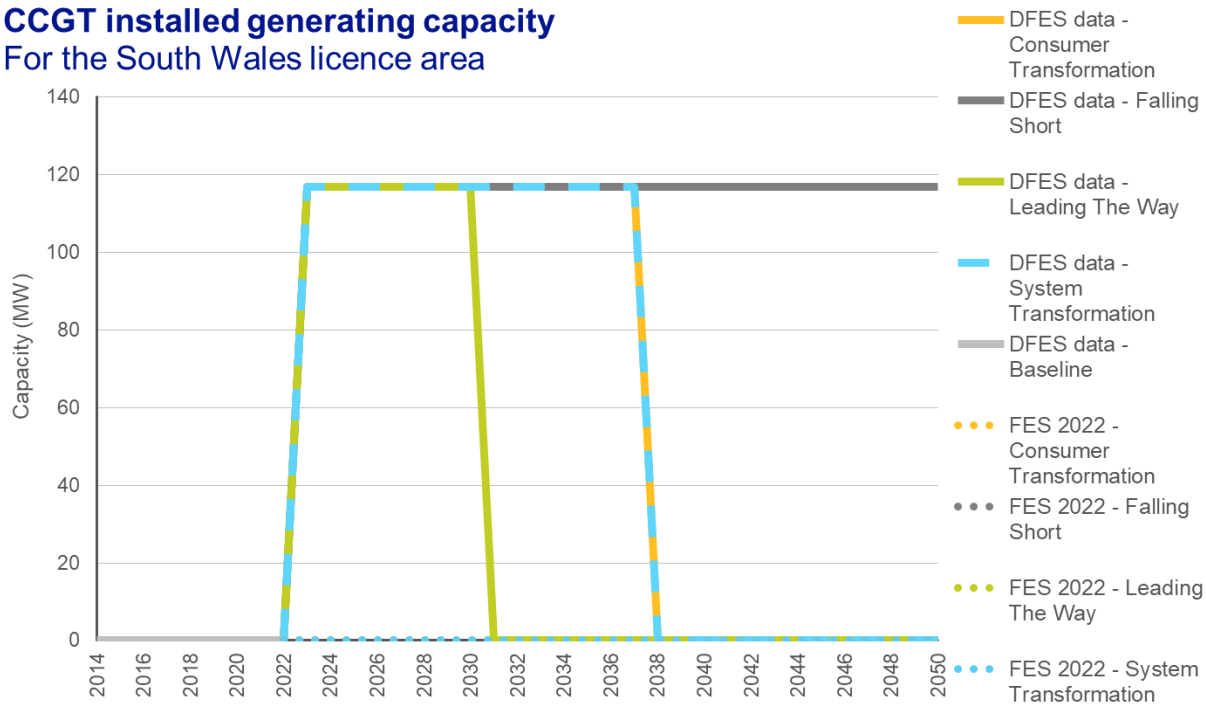
	Consumer Transformation	and then decommissions under the three net zero scenarios. Specifically, after an operational lifetime of eight years under Leading the Way and 15 years under Consumer Transformation and System Transformation.	2038
	System Transformation		2038
	Falling Short	The 117 MW Port Talbot site remains operational out to 2050 under Falling Short.	Post-2050
OCGT (non-CHP)	Leading the Way	All OCGT capacity is modelled to decommission in the three net zero scenarios.	2029 – 2030
	Consumer Transformation		2034 – 2036
	System Transformation		2034 - 2036
	Falling Short	The existing 83 MW capacity is modelled to remain operational across the period to 2050. This reflects gas turbine technology providing system flexibility alongside more responsive gas engine technologies and overall less action on decarbonisation.	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.	2024 - 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. Capacity then steadily decommissions so that no capacity is operating on the network by 2050.	2024 - 2043
	System Transformation		2024 - 2043
	Falling Short	Notable additional reciprocating 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. Following a peak of 375 MW in 2027, some capacity is modelled to decommission, reflecting some transition away from fossil-fuel-driven flexibility. However, 325 MW remains in operation in 2050.	2043 – post-2050
Gas CHP	Leading the Way	The majority of gas CHP sites in the licence area are small-to-medium engines located onsite at commercial	2027 – 2035

	Consumer Transformation	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, specifically after an operational lifetime of eight years under **Leading the Way** and 15 years under **Consumer Transformation** and **System Transformation**.	2032 - 2041
	System Transformation		2032 - 2041
	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 116 MW still operational by this period.	Post-2050

Reconciliation with National Grid FES 2022

- 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 resultantly caused some potential variances between the FES and the DFES in the 2022 baseline and in the near-to-medium term projections.

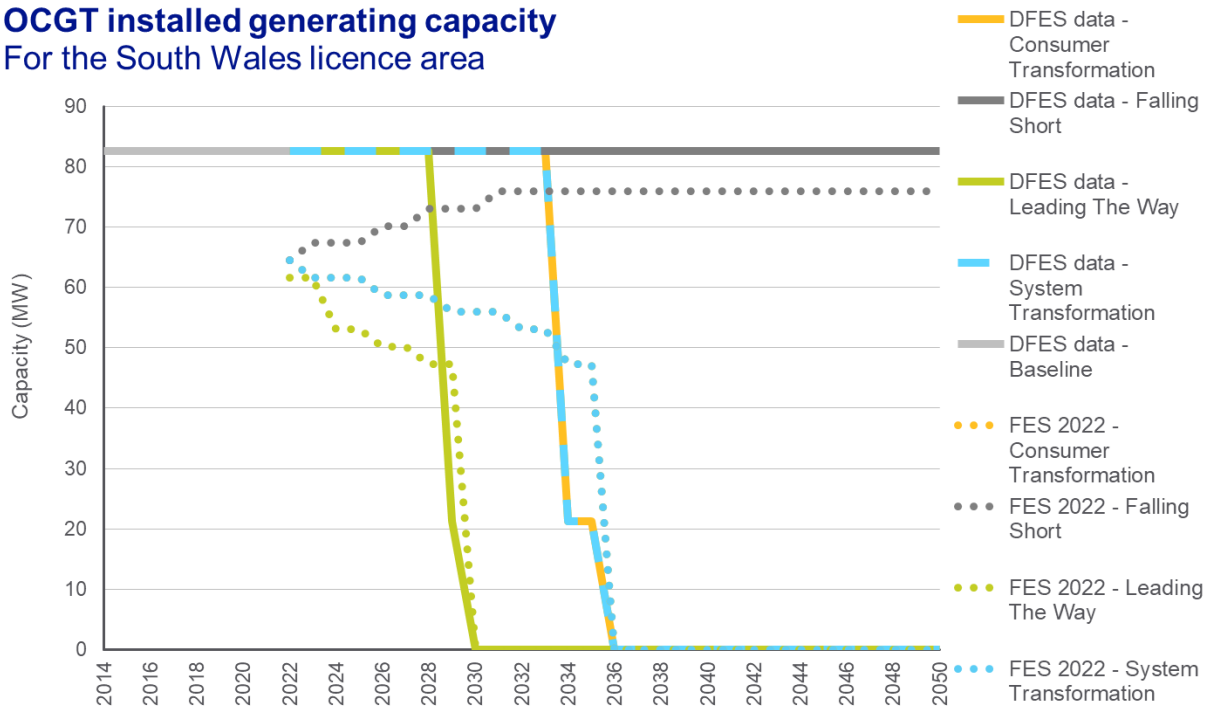
Figure 22 – Electrical capacity of CCGTs by scenario, South Wales licence area



- Both the DFES and FES projections have no operational CCGTs in the South Wales licence area.

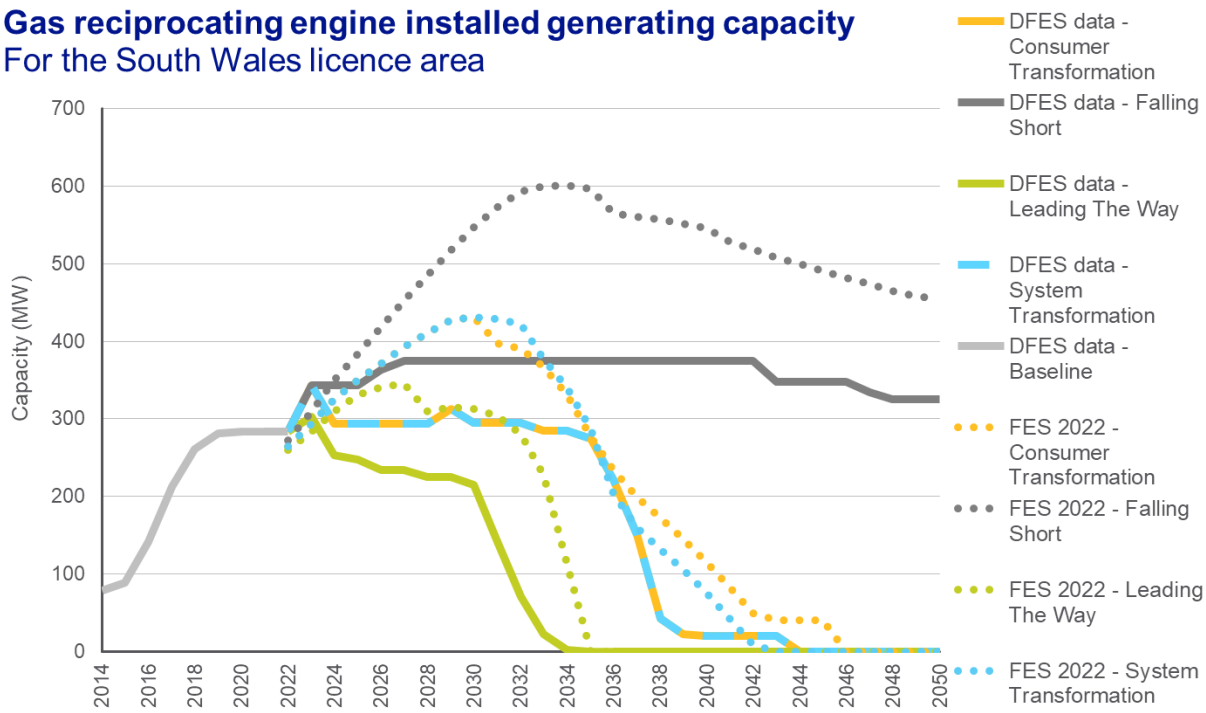
- However, the FES 2022 analysis does not include the 117 MW CCGT pipeline site at Port Talbot, which has received planning permission and won a Capacity Market agreement. This results in significantly different projections. The DFES has modelled this site to operate for eight years under **Leading the Way** and 15 years under **Consumer Transformation** and **System Transformation**.

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



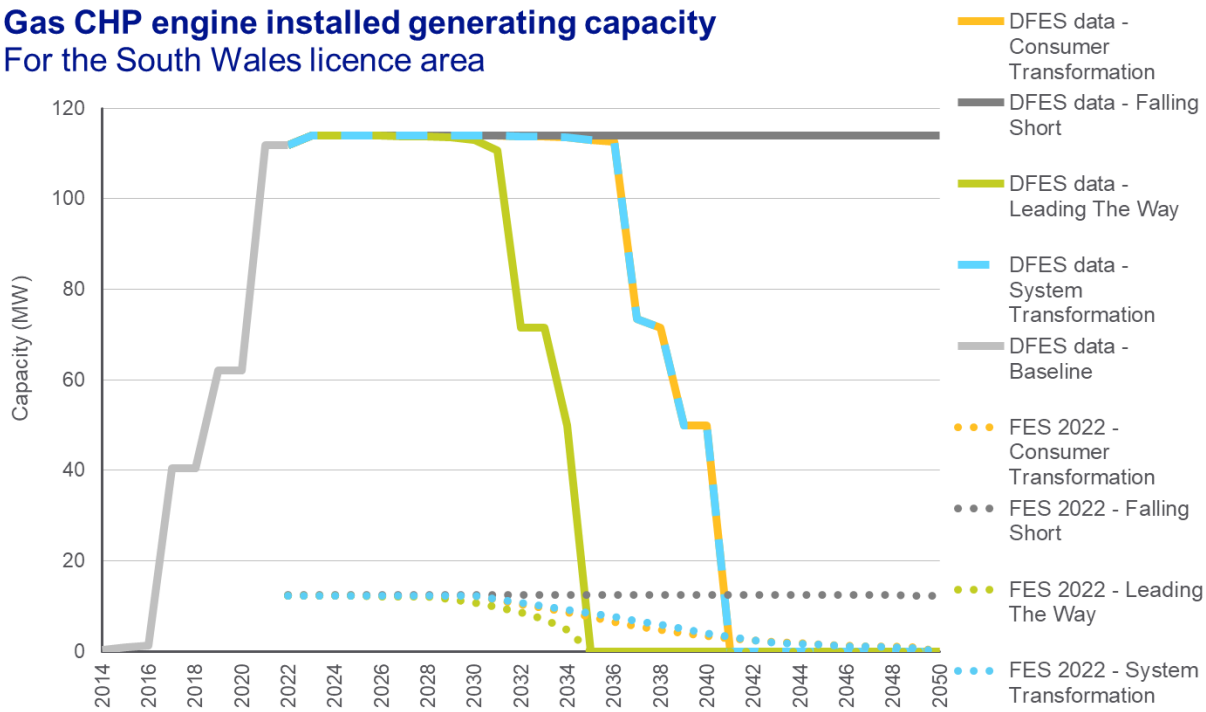
- The DFES baseline is slightly higher than that of the FES. This could relate to differences in gas sub-technology classification.
- As there are only two OCGT sites in the DFES baseline, the decommissioning of OCGTs in the South Wales licence area is very sharp. In comparison, the FES projections see stepped decommissioning, particularly in the 2020s. This implies the FES models more individual sites to be connected in the South Wales licence area, or a slow decrease in capacity at one site. The DFES projections are more realistic of the portfolio of projects that are connected to NGED's network in the South Wales licence area, and the relinquishing of their connection agreements.

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



- The DFES baseline is well aligned with the FES 2022; however, there is less projected near-term growth than in the FES projections. This is due to the capacity of reciprocating engines with a known connection agreement totalling less than the FES increase. With the current international gas market landscape and a focus on switching to low carbon forms of flexible generation in the medium term, it has been assumed that there will be a limited number of new fossil-gas sites looking to connect beyond those already with a connection agreement.
- The DFES decommissioning of reciprocating engine capacity is less smooth than modelled in the FES, but is representative of individual sites relinquishing their connection agreements over time.

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



- The DFES baseline is significantly higher (c. 100MW) than the FES 2022 baseline. The reasons for this are unclear. The FES 2021 baseline was nearer to 105 MW.
- The decommissioning logic used as part of the DFES analysis results in a more stepped decommissioning than the FES; however, this is more representative of sites relinquishing their connection agreements or removing individual engines over time.

Factors that will affect deployment at a local level

Factor	Source
The location of the known pipeline sites	National Grid
Proximity to electricity network and gas network infrastructure	Regen analysis

For input, evidence and assumptions based on stakeholder engagement, a separate summary report can be found here

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	2025	2030	2035	2040	2045	2050
Falling Short	0	0	0	0	0	0	0
System Transformation		0	0	264	541	666	685
Consumer Transformation		0	21	159	159	398	517
Leading the Way		0	92	516	662	798	880

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 some existing and pipeline commercial gas and diesel generation sites to convert to run hydrogen generation instead of fossil gas/diesel.
- Regen's 'A day in the life 2035'[xxxiii] 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 to be operational.
- Conversion to hydrogen generation in the DFES has been modelled to occur in regions within the licence area that have been identified as potential hydrogen supply zones, based on the analysis undertaken for hydrogen electrolysis capacity in the South Wales licence area.
- Hydrogen supply zones were identified where there is potential for hydrogen gas network conversion or are potential future hot spots for hydrogen development, such as heavy transport fuelling hubs and industrial clusters. In South Wales, these include Pembrokeshire, due to its significant industrial activity, as well as the areas around the M4, which runs along the southern coast of Wales.
- These supply zones were identified to convert in phases, representing the likely timescales of hydrogen supply for each zone. Under **Leading the Way** and **System Transformation**, a national hydrogen network is assumed to be developed in the medium term, which enables more of the licence area to have access to hydrogen and, overall, more opportunities for hydrogen generation sites to be developed.
- All FES scenarios see hydrogen fuelled generation connecting to the transmission network. However, under **Leading the Way**, more capacity is modelled to connect at the distribution network than the transmission network, which is the inverse of the other scenarios. This results in **Leading the Way** having the most capacity projected under the DFES analysis.
- Under **Falling Short,** no hydrogen generation capacity is modelled, due to an ongoing role of fossil-gas generation and a lack of hydrogen supply availability under this scenario.
- The South Wales licence area has a significant amount of existing gas and diesel generating capacity (c. 706 MW) along with a substantial pipeline (211 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, with hydrogen unlikely to be an expensive fuel, and production at scale is unlikely to be developed until the late 2020s.

- However, there is strong support for the role of low carbon hydrogen in providing flexible power generation, including specifically in South Wales:
    - Welsh Government's 'Hydrogen in Wales' consultation[xxxiv] highlighted the opportunity to undertake a "trial of a hydrogen-fuelled gas engine providing responsive, dispatchable power generation".
    - In July 2021, the UK government published a call for evidence on 'decarbonisation readiness'[xxxv] for new power generation. It is expected that from 2030, plants would be capable of accepting 100% hydrogen.
    - Hydrogen turbine technology is already being developed by leading manufacturers[xxxvi].

Modelling assumptions and results

Baseline

As a technology, hydrogen-fuelled generation is a future consideration, which is not yet being trialled due to a lack of hydrogen supply across the UK. Thus, there is currently no hydrogen-fuelled generation connected to the distribution network in the South Wales licence area, or nationally.

However, there is currently 480 MW of gas-fired power generation and 226 MW of diesel generation connected to the distribution network in this licence area. These sites, under some scenarios, have the potential to host future low carbon hydrogen generation sites.

Pipeline (April 2022 to March 2030)

There is unlikely to be any development in grid-connected hydrogen-fuelled generation in the near term. This is due to gas-fired electricity generation still providing energy and flexibility to the system. In addition to this, the hydrogen supply chain is unlikely to be developed enough to allow hydrogen-fuelled generation to be viable in the near term.

The UK Hydrogen Strategy expects the 2020s to be focused on deploying electrolysers and scaling up long-duration hydrogen storage. This aims to enable the integration of hydrogen across the wider energy system by 2030, the availability of hydrogen as a fuel and manufacturers developing hydrogen-ready end-usage equipment, such as hydrogen turbines and generators

Medium and long-term projections (April 2030 to March 2050)

From 2030, hydrogen-fuelled generation sites may begin to connect in regions where hydrogen is likely to be produced at scale. At a national level, these are likely to be centred around existing hydrogen trial areas and future hydrogen hubs, such as Teesside and Grangemouth.

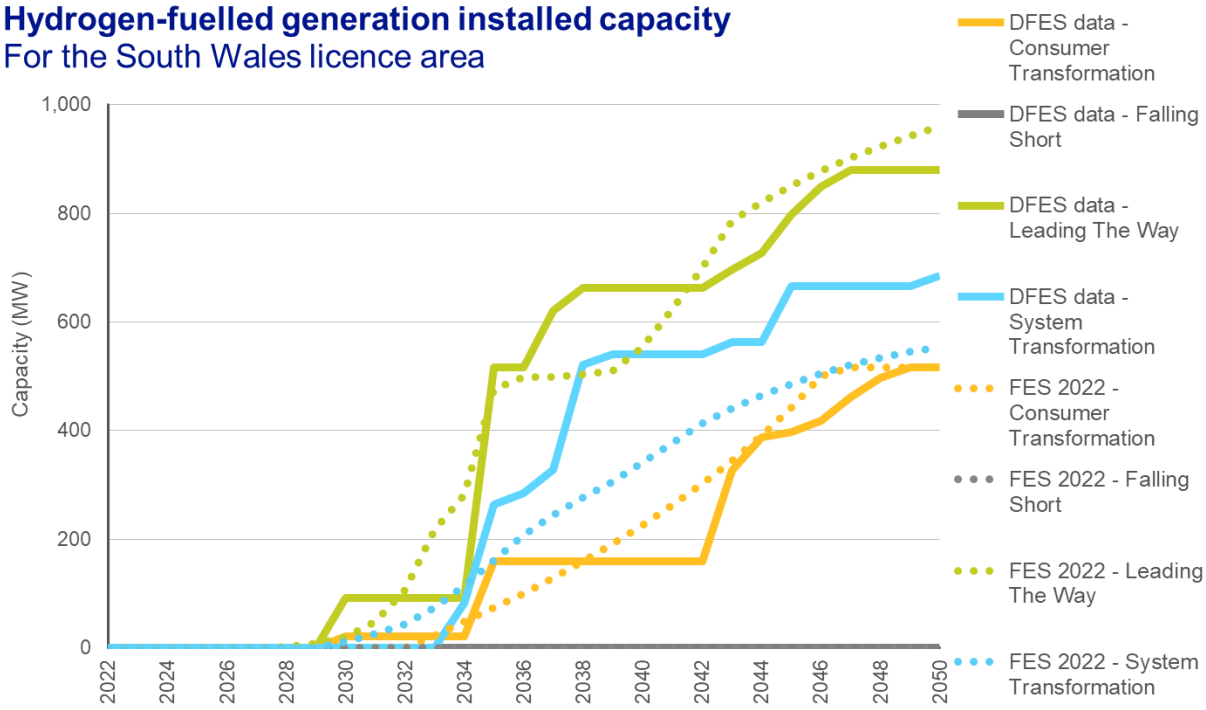
There are key sites in the South Wales licence area, highlighted in HyCymru's South Wales Industrial Cluster[xxxvii] plan, which may be early adopters of hydrogen, including Pembrokeshire, Port Talbot and Bridgend.

Projections have therefore centred around an analysis of existing (c. 700 MW) and pipeline (211 MW) sites located in potential future hydrogen development zones and the potential under each DFES scenario:

Scenario	Description	Capacity by 2040	Capacity by 2050
Leading the Way	Medium-scale sites (< 50 MW) in potential hydrogen zones are modelled to repower as hydrogen generators with 50% more capacity in the medium term, representing the most ambitious scenario for hydrogen-fuelled generation on the distribution network.	662 MW	880 MW

	Existing and pipeline fossil fuel sites outside of identified hydrogen zones are modelled to convert to hydrogen, due to the widespread availability of hydrogen transported through a national hydrogen network. Two-thirds of all hydrogen-fuelled generation in this scenario is modelled to be on the distribution network. This results in **Leading the Way** having the most capacity connected across the projection period (916 MW by 2050), reflecting the highest need for distributed low carbon flexibility.		
Consumer Transformation	The lack of a national hydrogen network under **Consumer Transformation** results in hydrogen only being produced near to demand. Therefore, existing and pipeline fossil fuel sites in identified hydrogen zones are modelled to convert to hydrogen, albeit later than **Leading the Way** and **System Transformation**, representing a slower development of the overall hydrogen sector. No sites outside of these zones are modelled to convert under **Consumer Transformation**.	159 MW	517 MW
System Transformation	Under **System Transformation**, it is assumed that fossil fuel sites currently connected to the distribution network in hydrogen development zones, repower hydrogen-fuelled generation sites at the same capacity. Existing and pipeline fossil fuel sites outside of identified hydrogen zones are also modelled to convert to hydrogen, due to the widespread availability of hydrogen transported through a national hydrogen network. Under **System Transformation**, significant capacity of hydrogen-fuelled generation is expected on the transmission network.	541 MW	685 MW
Falling Short	There is no hydrogen-fuelled generation capacity projected to connect under **Falling Short**, due to limited uptake of low carbon hydrogen, while fossil gas-fired flexible generation continues to operate out to 2050.	-	-

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



- The DFES 2022 projections echo the uptake of hydrogen-fuelled generation at a national level modelled in the FES 2022. In the South Wales licence area, the DFES and FES projections are well aligned, although **System Transformation** is moderately higher under DFES 2022 than FES 2022 by 2050.
- The 117 MW CCGT proposal at Port Talbot Steelworks is modelled to convert to hydrogen in 2035, resulting in a spike under **Leading the Way**. Due to early decommissioning timescales for existing and pipeline fossil fuel sites under **Leading the Way**, plants are modelled to convert to hydrogen more quickly and do so in order to reduce the amount of time they are not operational.
- FES 2022 has modelled a smoother, more gradual increase in connected capacity between 2030 and 2050 under **Consumer Transformation** and **System Transformation**. Whereas DFES 2022 analysis has modelled discrete sites converting within potential hydrogen supply areas, resulting in a more stepped increase in capacity across the 2030s and 2040s.
- While existing plants may be capable of accepting 100% hydrogen by 2030, the DFES analysis also takes into account the long decommissioning and repowering timelines of existing fossil fuel plants and, therefore, models a slow uptake in the early-2030s, followed by a more rapid uptake from 2035 onwards.

Factors that will affect deployment at a local level

Factor	Source
Location of existing and known commercial gas and diesel sites in the South Wales licence area.	National Grid
Spatial analysis of potential hydrogen supply areas, factoring in locations of existing hydrogen trials, large industrial clusters, proximity to the gas network, proximity to major roads and motorways and potential hydrogen storage facilities.	National Atmospheric Emissions Inventory, DfT, Regen analysis.

For input, evidence and assumptions based on stakeholder engagement, a separate summary report can be found here

Waste incineration in the South Wales licence area

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

Data summary for waste incineration in the South Wales licence area:

Capacity (MWe)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	62	81	81	81	81	76	76
System Transformation		81	81	76	76	70	58
Consumer Transformation		81	81	76	76	70	58
Leading the Way		81	81	76	76	70	58

Summary:

- Energy recovery from waste is considered the fourth level of the waste management hierarchy behind waste prevention, preparation for reuse and recycling[xxxviii]; however, electricity generation from unabated waste incineration is at odds with net zero targets, due to the level of associated carbon emissions.
- There is significantly less operational waste incineration capacity in the South Wales licence area than in the other NGED licence areas, with only 62 MW of existing projects made up of three incineration sites (50.7 MW) and one ACT site (11.7 MW).
- There is one site with a connection agreement with NGED, the 18.75 MW Enviroparks ACT in Hirwuan, which received planning permission in 2010 and began construction in 2016. This is believed to already be operational, hence has been modelled as connecting at the earliest pipeline date. It is assumed that this is not affected by the moratorium, as it was granted planning permission before this was enforced.
- In **Falling Short**, no significant changes in how society manages waste are assumed, leaving waste available as a resource for unabated electricity generation. As a result, the majority of all baseline and pipeline capacity is modelled to continue operating past 2050, except for those that have reached the end of their operational lifetime.
- Under **Leading the Way**, **Consumer Transformation** and **System Transformation**, a shift to a more sustainable society results in less waste produced and a reduced need for waste incineration; however, even in low carbon and highly circular economies, waste incineration will likely still be needed.
- As a result, a number of large incineration sites are modelled to stay connected to the distribution network in these scenarios, under the assumption that these larger sites will have adopted abatement technologies or other innovative carbon reduction technologies.
- ACT gasification plants have lower associated carbon emissions, and any residual emissions can be abated, hence all ACT sites (30 MW) are modelled to continue operating past 2050.

Modelling assumptions and results

Baseline	
Number and capacity (MW) of incineration sites	**Number and capacity (MW) of ACT sites**
3 (50.7 MW)	1 (11.7 MW)
Largest baseline site:	39.7 MW Viridor Trident Park energy from waste, Cardiff

Welsh government's moratorium on large-scale waste energy
In 2021, Welsh government declared a moratorium on new large-scale energy from waste in a drive to become a zero-waste, carbon net zero nation by 2050 and encourage a more circular economy. The moratorium covers new energy from waste plants with a capacity of 10 MW or more. Additionally, small-scale energy from waste plants of less than 10 MW will only be allowable if the applicant can demonstrate the need for such a facility for the non-recyclable wastes produced in the region and will not be allowed if waste is to be imported from outside of the proposed region in order to avoid locking in transport emission and associated pollution. As a result, no new energy from waste plants are modelled to connect in the licence area, excluding those that are already under construction or operational.

Pipeline (April 2022 to March 2030)

There is only one site in the South Wales pipeline for this technology.

Pipeline analysis

Status	Scenario outcomes	Sites	Capacity
Under construction	Enviroparks ACT (18.75 MW) in Hirwuan received planning permission in 2010 and began construction in 2016. This is believed to already be operational, hence the capacity has been modelled to connect at the earliest pipeline date. It is assumed that this is not affected by the moratorium, as it was granted planning permission before this was enforced.	1	18.75 MW

Long-term projections (April 2030 to March 2050)

Energy recovery from waste is considered as the fourth level of the waste management hierarchy behind waste prevention, preparation for reuse and recycling; however, electricity generation from unabated waste incineration is at odds with net zero targets, due to the level of associated carbon emissions.

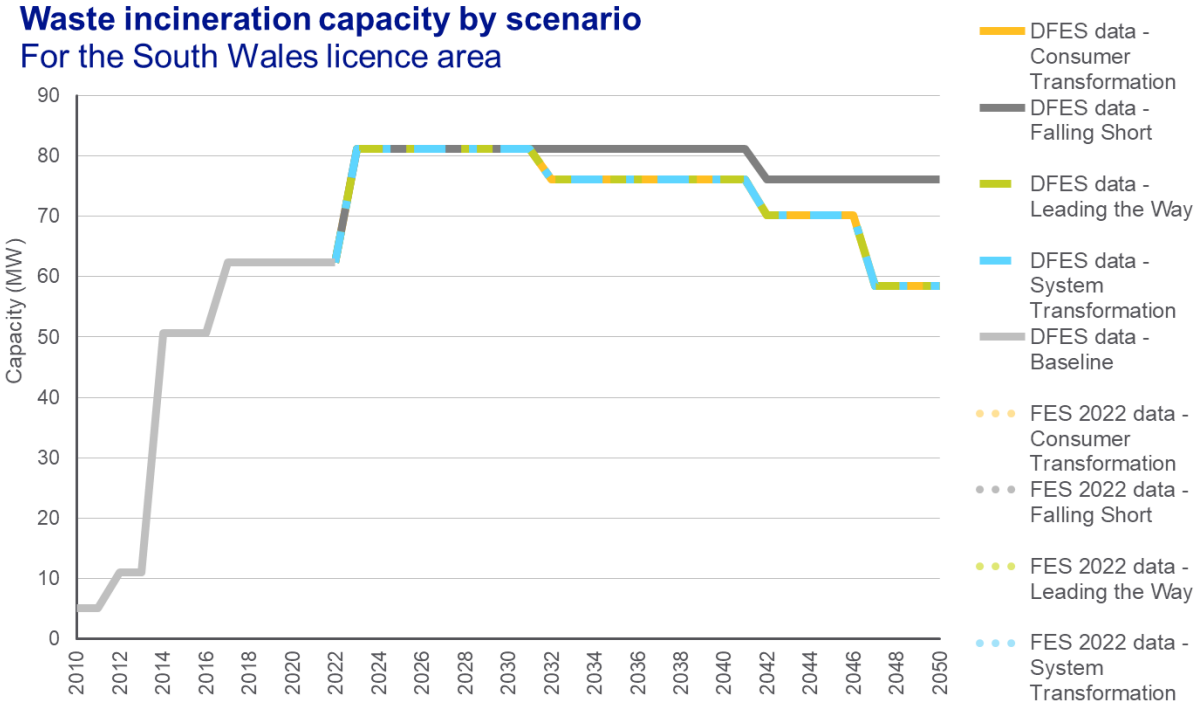
- IEA Bioenergy, in its 'Waste Incineration for the Future' paper[xxxix], concluded that, in order to remain relevant and continue to create value in a circular economy, the waste sector will have to innovate in energy technologies, system design and integration and business models.
- Additionally, a 2021 Deloitte study[xl] into how consumers are embracing sustainability found that, while there has been a sharp increase in the number of people adopting a more sustainable lifestyle (between March 2020 and March 2021), 51% of consumers still cite a lack of interest in the issue of sustainability.

Additionally, while the operational life of an incineration facility is typically between 20 and 30 years[xli]; the connection agreement may not be relinquished immediately. Therefore, incineration facilities have been modelled to disconnect after 30 years in **Leading the Way**, **Consumer Transformation** and **System Transformation** and 40 years in **Falling Short**, in order to model the operational life range and the potential delay between decommissioning and relinquishing a connection agreement.

Scenario	Description	Number of sites	Capacity in 2050
Leading the Way	A shift to a more sustainable society results in less waste produced and a reduced need for waste incineration. However, even in highly circular economies, waste incineration will likely be needed.	2	58 MW
Consumer Transformation	All incineration sites are modelled to disconnect from the network, as they meet the end of their operational lifetime and more environmentally friendly ACTs are used for waste management in the licence area.	2	58 MW
System Transformation	ACT gasification plants have lower associated carbon emissions, and any residual emissions can be abated, hence all ACT sites (30 MW) are modelled to continue operating past 2050.	2	58 MW
Falling Short	No significant changes in how society manages waste are assumed under this scenario, leaving waste available as a source for unabated generation. As a result, the majority (76 MW) of all baseline and pipeline capacity is modelled to continue operating past 2050, except for those that have reached the end of their operational lifetime.	4	76 MW

Reconciliation with National Grid FES 2022

Figure 27 – Electrical capacity of waste incineration by scenario, South Wales licence area



- FES 2022 data does not have any waste incineration projections for the South Wales licence area, although it did model c.50 MW in FES 2021.
- While the moratorium on new energy from waste plants in Wales is recognised and is likely to hamper future development of this technology, this does not explain why FES 2022 has no operational waste incineration in the licence area.
- In contrast, the DFES 2022 models 62 MW of operational capacity, alongside 18.75 MW of additional capacity through the Enviroparks project.

Other generation in the South Wales licence area

Sites in NGED connections data where the technology could not be identified.

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

Capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	0.1	0.3	0.3	0.3	0.3	0.3	0.3
System Transformation		0.3	0.3	0.3	0.3	0.3	0.3
Consumer Transformation		0.3	0.3	0.3	0.3	0.3	0.3
Leading the Way		0.3	0.3	0.3	0.3	0.3	0.3

Summary:

- There are two other generation sites, which have not been categorised as a particular technology, connected to the distribution network in the South Wales licence area, totalling 0.1 MW. Based on location addresses and generating unit information, these are likely to be small-scale fossil-fuelled CHPs but could not be positively identified as such in the NGED connections data.
- There are eight additional other generation sites in South Wales with an accepted connection agreement, totalling 0.3 MW. As with the baseline sites, these small-scale sites could not be positively identified as a specific technology. These pipeline sites, therefore, have been modelled to connect in 2023 under every scenario.
- There are no projections for other generation beyond the pipeline of accepted connections.

[xviii] UK installed 730MW of solar PV in 2021
[xix] The UK's solar landscape to 2030
[xx] Council Climate Plan Scorecards 2022
[xxi] Future homes are solar homes – Solar Energy UK
[xxii] Building Regulations (Part L)
[xxiii] Response to Scottish Building Regulations - Solar Energy UK
[xxiv] Future Wales – The National Plan 2040
[xxv] Technical Advice Notes 8: Planning for Renewable Energy
[xxvi] Significant policy support for renewable energy and grid projects announced in Wales
[xxvii] RWE completes German wind farm repowering, 2022
[xxviii] Council Climate Plan Scorecards 2022
[xxix] Bombora InSPIRE project
[xxx] Transitioning to a net zero energy system: Smarts Systems and Flexibility Plan 2021, BEIS
[xxxi] Sixth Carbon Budget, Climate Change Committee, 2020
[xxxii] BEIS Carbon emissions limits in the Capacity Market, Sept 2020
[xxxiii] A day in the life of 2035
[xxxiv] Developing the hydrogen energy sector in Wales
[xxxv] Call for evidence on the expansion of the 2009 Carbon Capture Readiness requirements
[xxxvi] GE hydrogen fuelled gas turbines
[xxxvii] SWIC Cluster Plan
[xxxviii] The future of waste incineration in a modern circular economy, NABU, 2020
[xxxix] Waste incineration for the future, IEA Bioenergy, 2019
[xl] How consumers are embracing sustainability, Deloitte, 2021
[xli] Energy from waste, A guide to the debate, DEFRA, 2014

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 batteries** – typically 5-20 kW scale batteries that households buy to operate alongside rooftop PV or to provide backup services to the home.

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

Capacity (MW)		Baseline	2025	2030	2035	2040	2045	2050
Standalone network services	Falling Short	0	31	144	146	151	151	155
	System Transformation		31	144	155	155	158	158
	Consumer Transformation		31	144	187	194	194	194
	Leading the Way		31	161	218	226	226	226
	Storage Planning		47	177	183	183	183	183
Generation co-location	Falling Short	0.4	1	1	6	7	14	15
	System Transformation		1	5	14	26	30	33
	Consumer Transformation		1	6	17	44	53	57
	Leading the Way		1	13	28	61	85	87
	Storage Planning		64	114	275	357	357	357
Behind-the-meter high-energy user	Falling Short	0.4	1	6	14	17	26	28
	System Transformation		1	6	21	41	61	65
	Consumer Transformation		1	9	34	50	88	93
	Leading the Way		1	18	34	62	88	93
	Storage Planning		1	16	16	16	16	16
Domestic batteries	Falling Short	0	1	2	5	9	21	40
	System Transformation		2	15	22	47	73	105
	Consumer Transformation		5	40	87	151	220	335
	Leading the Way		7	51	113	189	285	434

Summary:

- As a sector that saw its first commercial-scale projects in 2016, battery storage has rapidly developed into an active and significant development sector.
- Battery storage has the largest pipeline of projects with an accepted connection offer of all technologies included in the DFES analysis, totalling 13.5 GW across the four NGED licence areas. Putting this into context, NGED currently manages connections of c. 10 GW of operational fossil fuel and renewable generation assets.
- This interest in development is also reflected at a national level, with over 47 GW of battery storage projects in 'scoping' seeking a transmission network connection[xlii].
- Many organisations have raised concern over the scale of the pipeline, how they are contributing to connection queues and potential grid constraints and the number of potentially speculative applications[xliii].
- The South Wales licence area only has a small baseline of 7 operational battery storage sites, totalling 0.8 MW. This is largely due to a Statement of Works notice that was in place for the licence area, preventing the connection of new thermal distributed generation and battery storage until 2027, which has subsequently been unlocked.
- The South Wales licence area has a notable pipeline of battery storage projects with accepted connection offers across NGED's network: 47 projects totalling 600 MW. In comparison, the pipeline of projects with accepted connection offers from NGED in DFES 2021 was only 220 MW, showing a significant increase in developer appetite for storage projects in the last 12 months. However, when compared with the other areas across NGED's network, the impact of the Statement of Works is still prominent.
- Based on Regen analysis, c. 140 MW of the South Wales storage pipeline has either received or submitted planning permission or entered into the Capacity Market. Additionally, nearly 140 MW has been offered a connection agreement with NGED in 2022 alone. These sites are unlikely to have already applied for planning or the Capacity Market, and many could be speculative; however, that does not mean that none of these projects will get developed in the future.
- 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 to the distribution network.
- As a key technology providing flexibility services to the electricity system, battery storage projects are actively engaging with flexibility markets and ancillary services being procured by National Grid ESO. With the development of new frequency response services, new reserve services and system stability services, the revenue opportunities for battery operators to 'stack' is developing all the time.
- This year, due to the unprecedented pipeline of large-scale battery storage projects across NGED's licence areas, the DFES has included an additional scenario, **Storage Planning**, which is based solely on the significant pipeline of projects with connection agreements with National Grid Electricity Distribution.
- The licence area has the potential for growth in connected storage capacity, though potentially fairly limited compared to other licence areas in NGED's network. This is due to:
    - Notable 33kV and 132kV network infrastructure across the licence area for standalone battery storage projects to provide system services
    - Moderate potential for renewable energy deployment, to enable co-location
    - South Wales has the lowest number of non-domestic properties with the potential for behind-the-meter batteries across National Grid's network
    - South Wales has the lowest number of domestic homes and thus potential for domestic rooftop solar by 2050 across National Grid's network. This impacts the potential for domestic batteries to be co-located in homes in the licence area.

- Overall battery storage capacity in 2050 in the South Wales licence area ranges from 238 MW in **Falling Short** to 840 MW in **Leading the Way**.
- Under the **Storage Planning** scenario, which only applies to large-scale storage, 556 MW is modelled to connect by 2050.

Modelling assumptions and results

Baseline

The South Wales licence area only has a small baseline of 7 operational battery storage sites connected to the distribution network, totalling 0.8 MW. This is largely due to a Statement of Works notice that was in place for the licence area, preventing the connection of new thermal distributed generation and battery storage until 2027, which has subsequently been alleviated ahead of time, due to the decommissioning of Aberthaw Power Station and Barry Power Station, releasing additional generation capacity on the transmission network in the area. The development of distributed battery storage capacity has therefore stalled to date but may increase in the 2020s. The largest operational site is a 390 kW battery in Newport, which connected in August 2020.

Business model	Number of sites	Total capacity (MW)
Standalone network services	0	0
Generation co-location	5	0.4 MW
Behind-the-meter high-energy user	2	0.4 MW
Domestic batteries	0	0

Pipeline (April 2022 to March 2029)

Business model	Number of pipeline sites	Total capacity
Standalone network services	12	228 MW
Generation co-location	13	356 MW
Behind-the-meter high-energy user	6	16 MW
Domestic batteries	16	0.1 MW

The South Wales licence area has a notable pipeline of battery storage projects with accepted connection offers across NGED's network, at 47 projects totalling 600 MW. In comparison, the pipeline of projects with accepted connection offers from NGED in DFES 2021 was only 220 MW, showing a significant increase in developer appetite for storage projects in the last 12 months. However, when compared with the other areas across National Grid's network, the impact of the Statement of Works is still prominent. This may change moving forward, as battery developers begin to seek areas of the network with capacity headroom.

Based on Regen's analysis, c. 140 MW of this pipeline has either received or submitted planning permission or entered into the Capacity Market. Additionally, nearly 140 MW has been offered a connection agreement with NGED in 2022, alone. These sites are unlikely to have already applied for planning or the Capacity Market, and many could be speculative; however, that does not mean that these projects will not progress through to development in the future.

As a key technology that can provide rapid response flexibility services to the network, battery storage is active in a number of National Grid ESO's ancillary service market tenders and auctions. In recent years the ESO has evolved their suite of response and reserve services, notably with the evolution of the new 'trio of frequency response markets[xliv]: Dynamic Containment, Dynamic Regulation and Dynamic Moderation. In addition to this, the ESO has launched a new Slow

Reserve service[xlv] and continues to deliver its network options assessment pathfinders[xlvi] for stability, voltage and reactive power services. Battery projects are ideally placed to bid into and secure contracts under a number of these services. Under the Government's Review of Energy Market Arrangements (REMA), these ancillary services and wider flexibility market structures could continue to evolve. The breadth of outcomes shown in the DFES reflects a range of accessible markets for battery storage assets.

This year, due to the unprecedented pipeline of battery storage projects in all of NGED's licence areas, the DFES has included an additional scenario, **Storage Planning**, which is based solely on the pipeline of large-scale battery projects with connection agreements with NGED. This scenario does not model domestic-scale battery projects, as there are very few (c.1 MW) in the known pipeline, and these sites are included in the modelling of the four DFES scenarios.

Pipeline analysis

Status	Scenario outcomes	Sites	Capacity
Under construction	Four battery projects totalling 8.5 MW are currently under construction and have therefore been modelled to connect in 2024 under all scenarios. These include: • 0.8 MW project at Llantrisant Business Park • 0.2 MW project colocated with solar PV at Rassau Industrial Estate's Energy Centre[xlvii] • Two projects (7.5 MW) at Rassau Industrial Estate which were granted planning permission in July 2021	4	8.5 MW
Planning permission granted	Four sites (115 MW) successfully pre-qualified in recent Capacity Market auctions but have not yet won Capacity Agreements. These have been modelled to connect in: ○ **Falling Short: 2027 - 2030** ○ **System Transformation: 2025 - 2028** ○ **Consumer Transformation: 2024 - 2026** ○ **Leading the Way: 2024 - 2026** ○ **Storage Planning: 2024 - 2026** This includes a 50 MW battery energy storage system in Cardiff, which was granted planning permission in December 2021, and a 21 MW battery project at Baglan Energy Park, which has secured a contract from the Capacity Market T-4 auction for 2025 delivery year.	4	115 MW
No information	Modelling projects with positive planning information to connect already matches the FES 2050 projections under all scenarios; therefore, the remaining 15 sites without any Capacity Market or planning information have only been modelled to connect under the **Storage Planning** scenario across the 2030s and 2040s.	16	476 MW
Too small for planning	23 sites, totalling 0.3 MW, have connection agreements with NGED but are too small to need to apply for planning. This includes all known domestic installations. These sites are modelled to connect in 2024 under all scenarios.	23	0.3 MW

Medium and long-term projections (April 2029 to March 2035)

The four business models for battery storage are modelled separately, and potential deployment in the licence area under these business models is driven by different factors.

While the known pipeline mainly consists of colocated battery storage projects or standalone batteries providing balancing services to the network, the significant year-on-year increase in development we are currently seeing under these business models may lessen over time as the grid and balancing markets are saturated with flexibility assets. However, there will likely continue to be interest to develop battery projects at all scales into the medium-long term, and it is assumed that the business case for behind-the-meter batteries collocated at high-energy user sites may increase, under some scenarios, as businesses look to manage their onsite energy consumption, reduce energy costs and move from being consumers to prosumers. This has been endorsed by DFES engagement with some key major energy users on NGED's network, with some suggesting aims to retrofit battery storage onsite at Universities, military premises, ports and water industry sites. In addition to this, there is the potential for an increased uptake of home batteries under some scenarios, with more homeowners deploying and rooftop PV seeking to increase self-consumption, as well a proliferation of domestic-level flexibility, time-of-use-tariffs and demand response.

In the long term, the biggest increase in projected battery storage capacity in the licence area is seen in **Leading the Way**, totalling 840 MW by 2050. This reflects a strong potential deployment of batteries across all four business models.

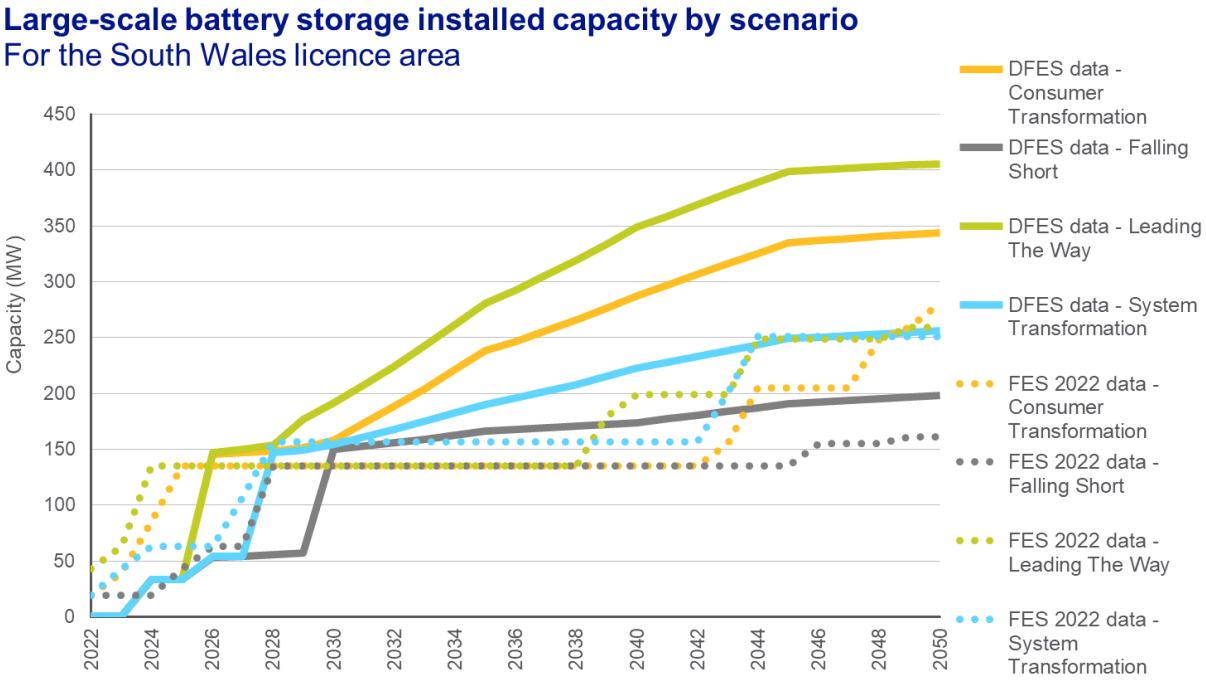
Falling Short sees the lowest overall storage deployment in the licence area, reaching 238 MW by 2050. This reflects a lesser need for electricity system flexibility, a lower renewable energy adoption and ongoing use of fossil fuel generation as a source of flex. This reduced development landscape has been reflected in the longer term, out to 2050, across all storage business models.

The **Storage Planning** scenario takes a bespoke view of the very large pipeline of battery storage projects with an accepted connection offer from NGED. This scenario projection considers all sites, except those that have been rejected in planning, will go through to connection across the scenario timeframe, resulting in 556 MW of connected large-scale battery storage by 2050. This scenario mirrors the breakdown of the current pipeline by business model, hence c. 357 MW of this is standalone projects targeting grid services, and comparatively few behind-the-meter projects are modelled under this separate planning scenario.

Business model	Projection methodology	Scenario	Total capacity by 2035 (MW)	Total capacity by 2050 (MW)
Standalone network services	Standalone storage accounts for a significant proportion of the existing and known near-term storage pipeline capacity and this business model continues to see an increased deployment across all scenarios by 2035. This projection continues out to 2050, flattening slightly in the 2040s, reflecting a potential saturation of network capacity and balancing markets.	**Falling Short**	146	155
		System Transformation	155	158
		Consumer Transformation	187	194
		Leading the Way	218	226
		Storage Planning	183	183
Generation co-location	Generation co-location capacity sees a moderate uptake in the South Wales licence area. This is in part due to a moderately lower combined ground-mounted solar PV and onshore wind capacity projections by 2035, when compared to other licence areas across	**Falling Short**	6	15
		System Transformation	14	33
		Consumer Transformation	17	57

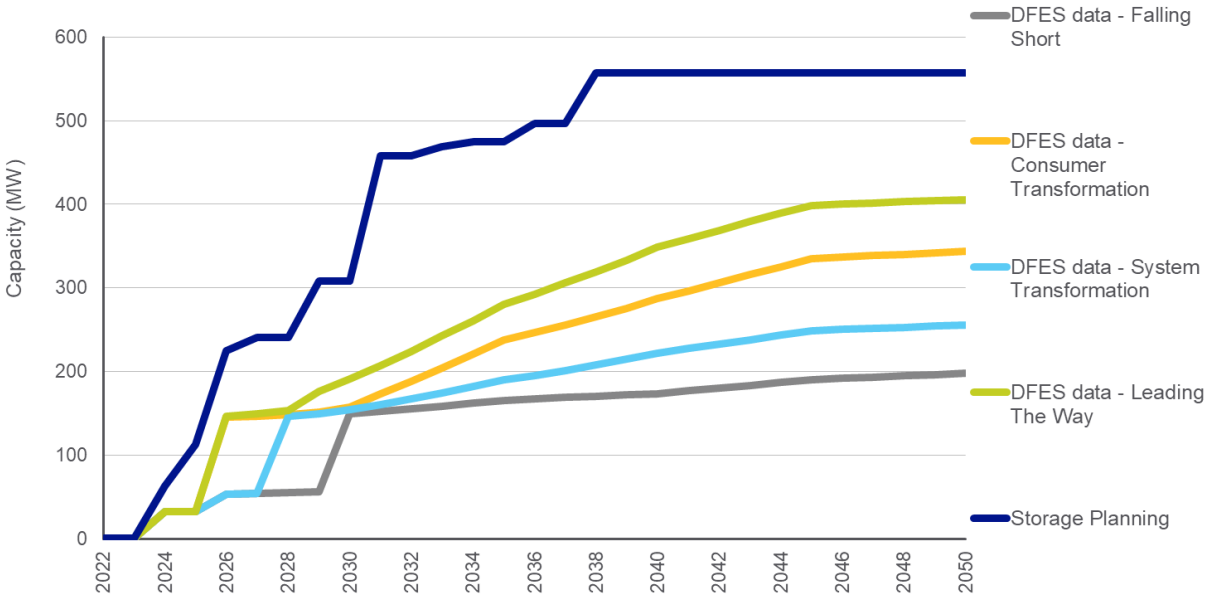
	all scenarios.	**Leading the Way**	28	87
		Storage Planning	275	357
Behind-the-meter high-energy user	The South Wales licence area also has a lower number of non-domestic properties with the potential for a battery, compared to other NGED licence areas. However, the uptake of behind-the-meter storage projects in the licence area does moderately increase in all scenarios by 2035. This reflects feedback from stakeholders that high-energy users, such as industrial customers, could drive electricity storage deployment in the medium term. 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. The **Storage Planning** scenario does not see a strong uptake past the near term, due to the limited pipeline of behind-the-meter projects.	**Falling Short**	14	28
		System Transformation	21	65
		Consumer Transformation	34	93
		Leading the Way	34	93
		Storage Planning	16	16
Domestic batteries	The licence area also has lower potential for domestic battery deployment in the medium term, with a lower number of homes compared to the other NGED licence areas. In general, the uptake of domestic storage is also delayed until the longer term, with projections under **Consumer Transformation** and **Leading the Way** reflecting stakeholder feedback that domestic storage will be the business model with the lowest uptake in the near-to-medium term.	**Falling Short**	5	40
		System Transformation	22	105
		Consumer Transformation	87	335
		Leading the Way	113	434

Figure 28 – Electrical capacity of large-scale battery storage by scenario, South Wales licence area



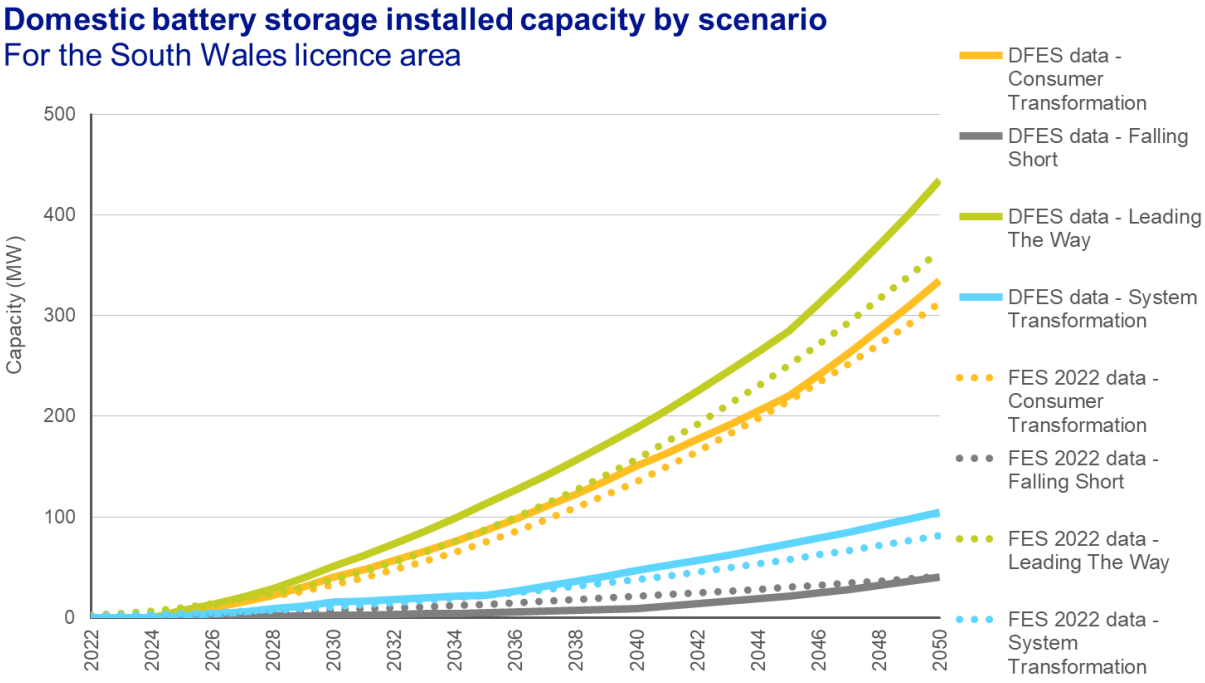
- The FES 2022 data is slightly below the DFES baseline for the South Wales licence area.
- The DFES 2022 projections do not align with FES 2022 projections until 2030. This is a reflection of a smaller-scale accepted connection pipeline and development evidence therein.
- By 2050, the DFES projections are moderately higher than the FES projections, with only **System Transformation** having less capacity in the DFES than the FES. This is a reflection of longer-term potential for battery capacity coming from co-location with solar and wind, as well as an interest in standalone battery assets looking to connect to the (now unlocked) distribution network in the licence area.

Figure 29 – Electrical capacity of large-scale battery storage by scenario (including the Storage Planning scenario), South Wales licence area



- This year, due to the unprecedented pipeline of battery storage projects in all of NGED's licence areas, the DFES has included an additional scenario, **Storage Planning**, which is based solely on the pipeline of large-scale projects with connection agreements with NGED.
- For context, the **Storage Planning** scenario is c.150 MW higher than the **Leading the Way** by 2050, and c.350 MW higher than **Falling Short**. This reflects a scenario where all projects currently with a connection agreement proceed to construction and operation across the scenario timeframe out to 2050, except sites that have been rejected in planning or the Capacity Market, which have been discounted.
- While it is likely that a proportion of projects in the pipeline will fall away and not proceed to operation, the **Storage Planning** scenario reflects the potential scale of storage development appetite seeking to connect to the distribution network in the South Wales licence area, which is not accounted for in the envelope of the four FES

Figure 30 – Electrical capacity of domestic battery storage by scenario, South Wales licence area



- The DFES 2022 projections for domestic batteries align well with FES 2022 across the analysis period and in all scenarios.

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 2022, 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 batteries: Domestic dwellings with rooftop PV.	Regen analysis

For input, evidence and assumptions based on stakeholder engagement, a separate summary report can be found here

[xlii] Transmission Entry Capacity (TEC) register
[xliii] Large-scale battery storage in the UK: Analysing the 16GW of projects in development
[xliv] National Grid ESO frequency response services
[xlv] National Grid ESO Slow Reserve service
[xlvi] National Grid ESO NOA Pathfinders
[xlvii] Infinite launches Wales' first multi technology Energy Centre to supply power directly to the community

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