Distribution Future Energy Scenarios 2022

Results and assumptions report

West Midlands licence area

Electricity Distribution

nationalgrid

Electricity Distribution

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.

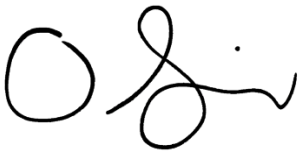
We have worked with Regen to help us understand what the changes that are forecast throughout the next decade and beyond might mean for our distribution network and the investment that may be needed to meet customers' changing needs. These forecasts are the foundation of our strategic investment process, 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 West Midlands 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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Electricity Distribution

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.

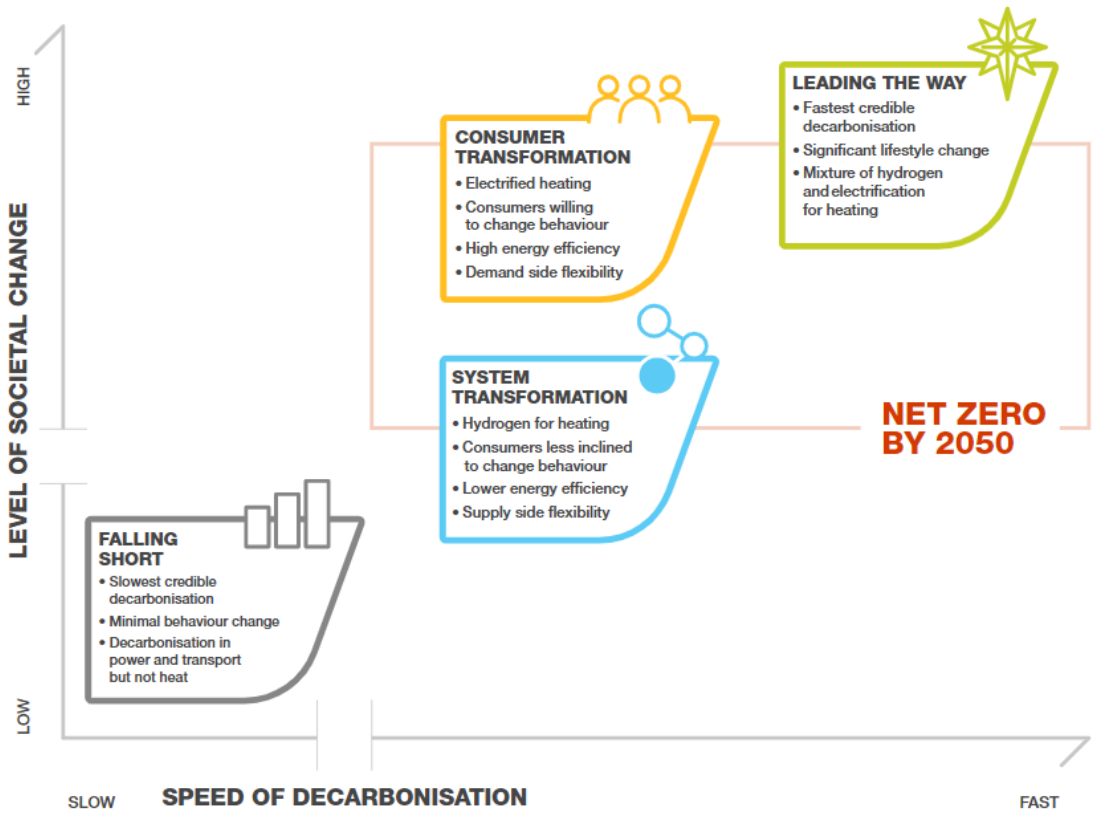
The DFES projections are directly informed by stakeholder engagement to reflect local and regional drivers, the ambitions of local authorities and national governments, and the views of other sector stakeholders, such as project developers, technology companies and community groups.

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



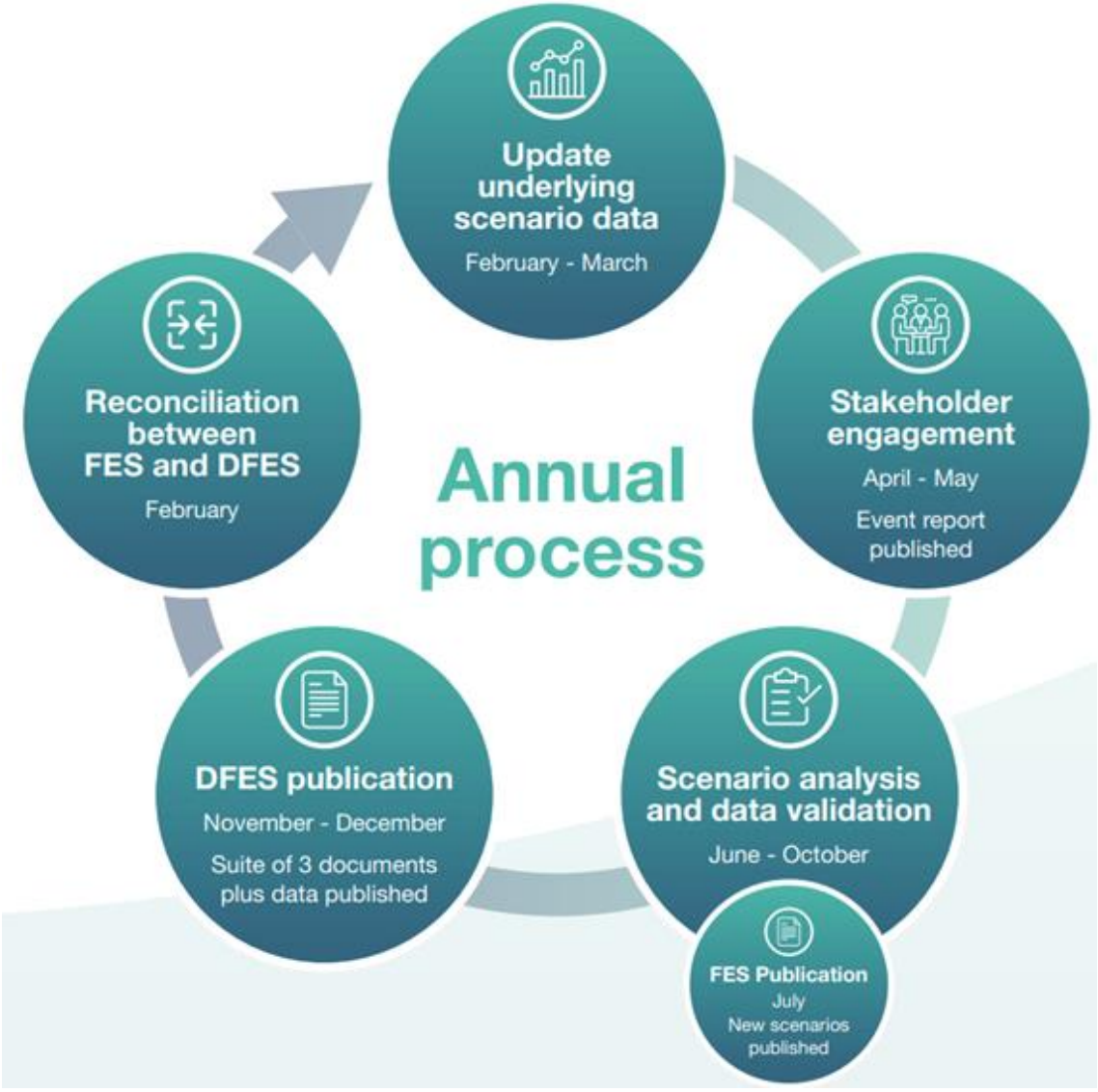
Scope

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 on an annual basis, 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 West Midlands licence area

The key features of the West Midlands licence area are detailed in the following table, and depicted in Figure 3 and Figure 4:

Aspect	Characterisation
Geography	The NGED West Midlands licence area runs from Stroud in the south to Stoke-on-Trent in the north, and ranges from highly urban areas, such as Birmingham, to many rural and protected areas. There are a number of towns and cities along the M5 and M6, which run south to north through the licence area. The large urban and industrial conurbation in the centre of the licence area includes Birmingham, the UK's second-most populous city, Wolverhampton and Solihull. However, the licence area also encompasses many rural areas, as well as national parks and AONBs such as the Cotswolds, the Wye Valley, the Peak District, Cannock Chase and the Shropshire Hills.
Distributed electricity generation	Distributed electricity generation has increased significantly over the last five-to-six years. Over 50% of capacity has only connected since 2015. Solar PV, fossil gas-fired power and waste processing sites make up the majority of distributed electricity generation capacity in the licence area. The largest generation site in the licence area is the 100 MW Fort Dunlop gas power plant.
Energy resources	Despite having lower solar irradiance than more southern areas of the UK, the West Midlands in proving attractive to developers. Other forms of renewables, such as onshore wind and hydro, have little resource potential in the licence area.
Distributed electricity demand	Currently, less than 2% of West Midlands households have an electric vehicle, and less than 0.5% have an electric heat pump.
Policy and government	The West Midlands licence area contains over 40 local authorities.

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

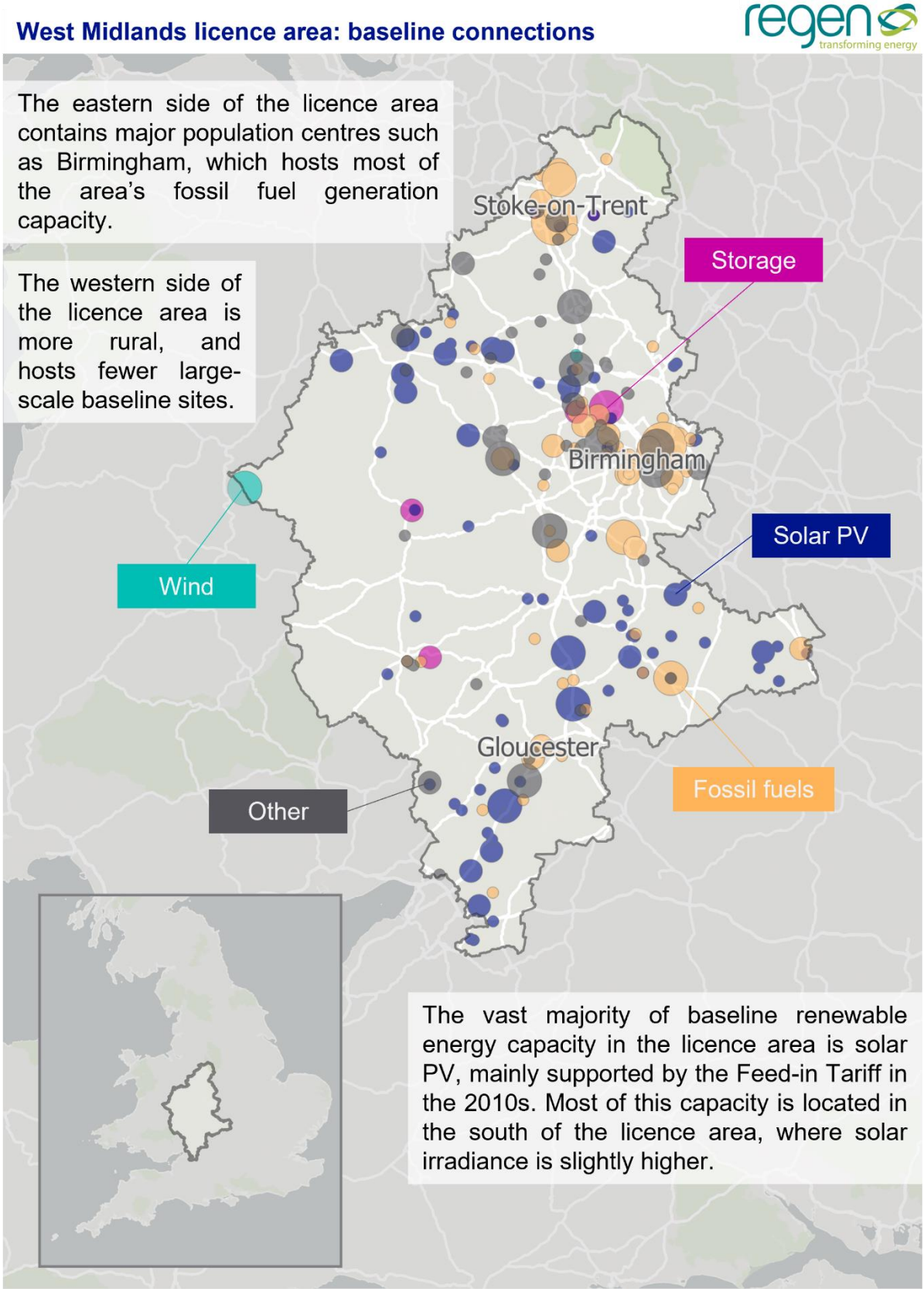
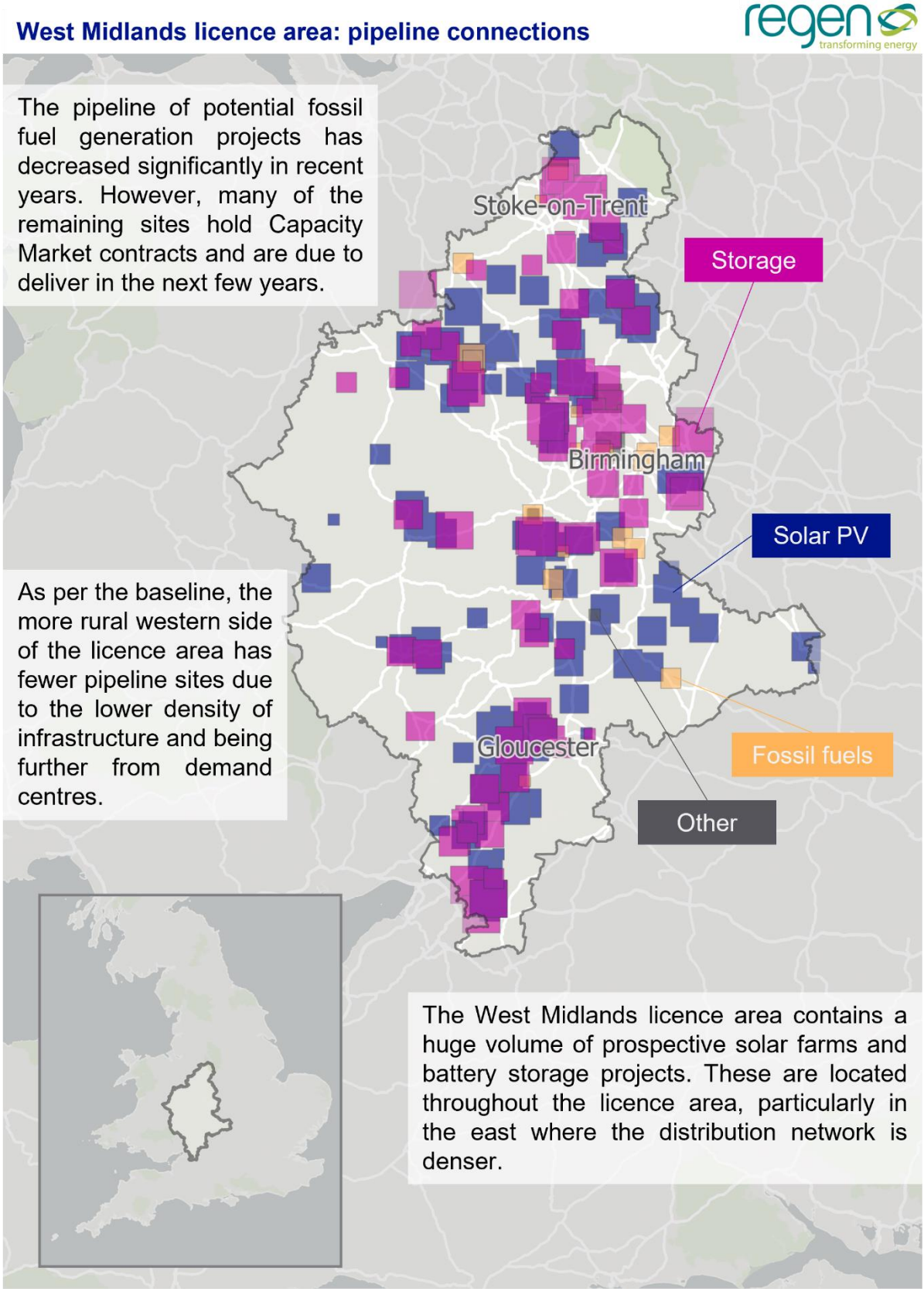


Figure 4 - The NGED West Midlands licence area, with the location of proposed 'pipeline' large-scale generation and storage sites



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 is 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), Energy Prices Bill and 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 impact of these energy policies and wider economic context is 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 West Midlands licence area

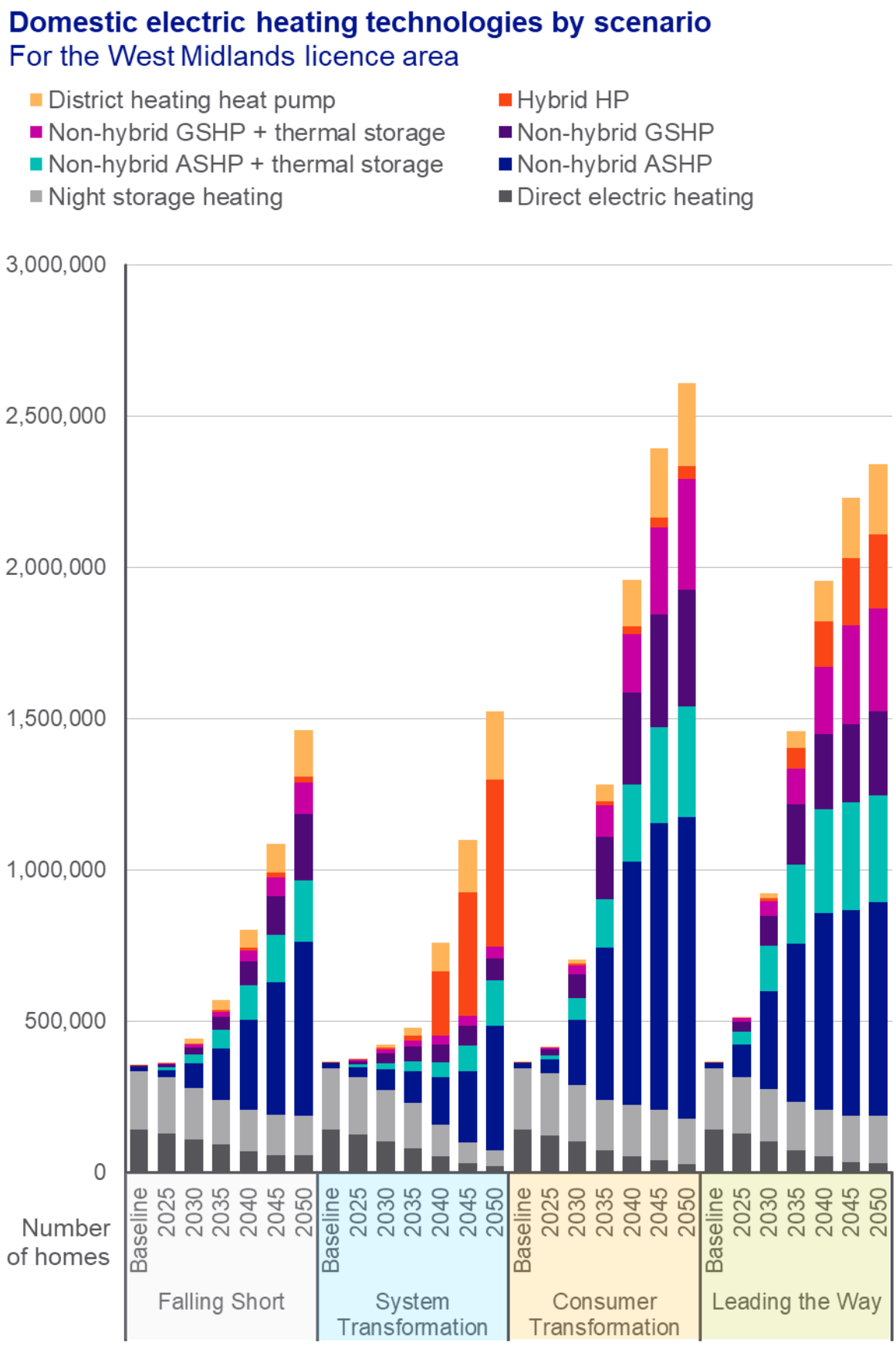
Domestic dwellings where electricity is the primary fuel for space heating and hot water, delivered through a heat pump or resistive electric heater.

Data summary for domestic electric heat in the West Midlands licence area:

Number of homes (thousands)		Baseline	2025	2030	2035	2040	2045	2050
Non-hybrid heat pumps* (without thermal storage)	Falling Short	19	34	104	210	377	569	795
	System Transformation		42	100	152	215	301	485
	Consumer Transformation		63	295	709	1,109	1,323	1,384
	Leading the Way		142	420	723	898	937	987
Non-hybrid heat pumps* with thermal storage	Falling Short	0	13	40	81	147	216	304
	System Transformation		14	35	53	78	115	188
	Consumer Transformation		20	101	262	449	603	729
	Leading the Way		55	201	378	566	683	691
Hybrid heat pumps	Falling Short	0	0	2	7	12	16	20
	System Transformation		2	6	17	212	409	552
	Consumer Transformation		1	7	16	24	33	44
	Leading the Way		2	11	68	148	220	244
Connections to heat pump-driven district heat networks	Falling Short	0	0	18	35	59	94	154
	System Transformation		1	10	25	95	173	225
	Consumer Transformation		1	13	55	155	228	273
	Leading the Way		1	15	56	134	200	233
Resistive electric heating	Falling Short	336	316	279	240	208	191	190
	System Transformation		310	270	231	164	111	85
	Consumer Transformation		324	286	242	228	216	192
	Leading the Way		307	274	237	215	199	200

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

Figure 5 – Summary of domestic electric heating technologies by scenario, West Midlands licence area



Summary:

- The West Midlands licence area has a high proportion of homes located in Birmingham and the surrounding urban areas, but also features more rural, off-gas areas along the west of the licence area, bordering Wales. Overall, the building stock in the licence area is similar to the GB average, in terms of current heating technology use, housing types and tenure.
- Under **Consumer Transformation** and **Leading the Way**, heat is primarily decarbonised via heat pumps in both the West Midlands 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 West Midlands licence area, this results in c. 2.2 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, this results in the vast majority of homes in the West Midlands 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.
- A number of planned heat-pump-driven heat networks, including a 326-apartment development in Birmingham, see build-out in the near term in all scenarios. Heat networks are modelled to increase across more dense population centres such as Birmingham, Wolverhampton and Gloucester in the licence area under the three net zero scenarios.
- 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 0.8% of existing homes with a heat pump in the licence area is broadly in line with the national average.

Subtechnology	Number of homes	Proportion of homes
Non-hybrid ASHP	15,067	0.6%
Non-hybrid GSHP	3,840	0.2%
Hybrid heat pump	0	0.0%
Heat pump-driven district heat network	42	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 more common in the West Midlands compared to the national average, heating around 15% of homes compared to 11% nationally.

Much of these resistive electric heating homes are flats in Birmingham, as tower blocks in urban areas are more likely to be electrically heated.

Subtechnology	Number of homes	Proportion of homes
Night storage heaters	193,777	8.4%
Direct electric heaters	141,759	6.1%

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 decrease slowly 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 Belgrave Middleway development in Birmingham, are modelled to connect in the near term under every scenario.

Heat pumps

Scenario	Description	Proportion of homes with a heat pump in 2026	
		West Midlands	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. New build homes are also anticipated to be increasingly built with heat pumps under these scenarios. The high levels of housebuilding in the West Midlands therefore results in slightly above-average heat pump uptake in the near term. 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	
		West Midlands	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.	13%	8%
Consumer Transformation	A similar proportion of direct electric heated homes convert to night storage heaters in order to reduce heating costs.	13%	7%

	As the West Midlands has a higher baseline proportion of homes heated by resistive electric heating, this proportion is still above the GB average in 2026.		
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.	13%	8%
Falling Short		13%	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 a waste heat source, such as thermal or heavy industry.

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

New build homes are modelled to increasingly include low carbon heating appliances, mainly in the form of heat pumps or connections to a district heat network, under every scenario. A strong increase in heat pump uptake is modelled in new build homes from 2025, following a successful implementation of the Future Homes Standard[iii].

Heat pumps

Scenario	Description	Proportion of homes with a heat pump in 2035	
		West Midlands	GB (FES)
Leading the Way	In the medium term, the West Midlands remains broadly in line with the national trajectory for retrofitting heat pumps into homes, while a high level of housebuilding results in a higher uptake of heat pumps in the licence area, compared to the GB average. 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		39%	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	9%	7%

	heat pump uptake is limited to off-gas houses and new build homes.		
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**	
		West Midlands	**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.	9%	6%
Consumer Transformation		9%	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.	9%	6%
Falling Short		10%	6%

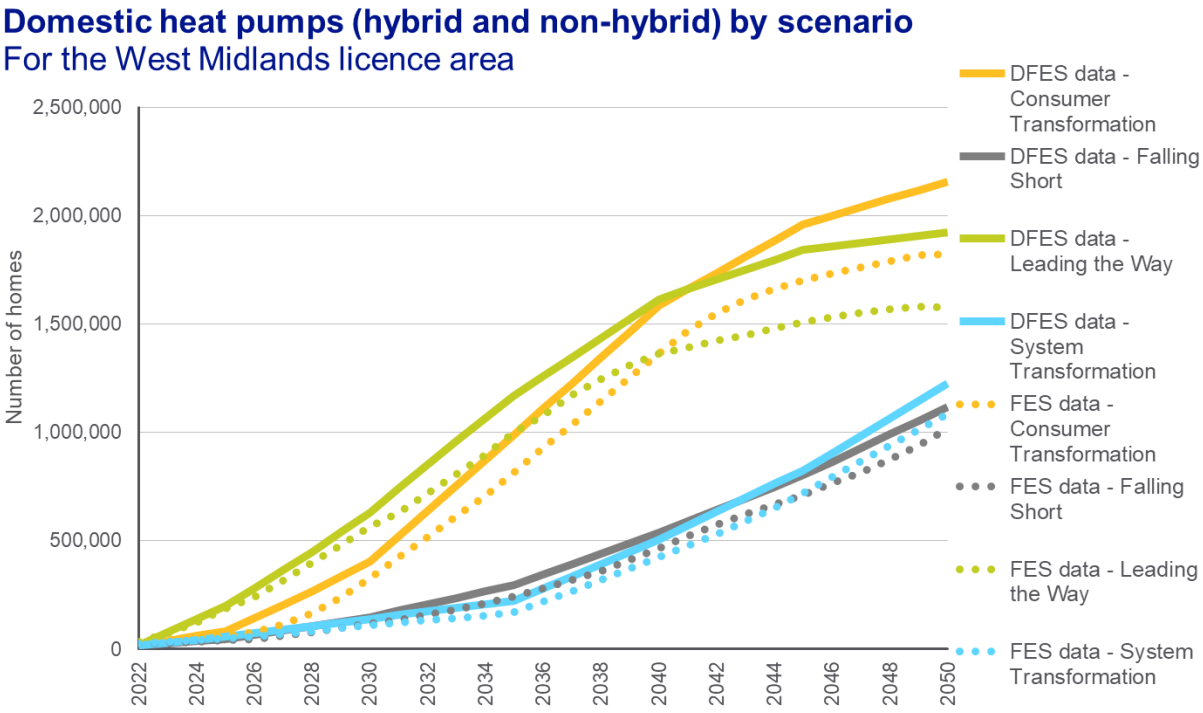
Long-term projections (April 2035 to March 2050)			
The heat decarbonisation trends established in the medium term continue out to 2050, especially under the net zero scenarios, as the country aims to meet its decarbonisation targets.			
Heat pumps			
Scenario	**Description**	**Proportion of homes with a heat pump, 2050**	
		West Midlands	**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 heating properties in 2050.	67%	64%
Consumer Transformation	By 2050, almost all properties are heated by standalone heat pumps, district heating or resistive electric heating by 2050.	77%	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.	44%	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.	41%	41%

Resistive electric heating			
Scenario	**Description**	**Proportion of homes with resistive heating, 2050**	
		West Midlands	**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 hydrogen boilers, depending on the scenario.	7%	5%
Consumer Transformation		7%	5%
System Transformation		3%	2%
Falling Short		7%	5%

Reconciliation with National Grid FES 2022

Figure 6 – Number of domestic heat pumps by scenario, West Midlands 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.
- The property archetype-based heat analysis in the DFES models heat pump uptake based on existing heating technologies, building types, building efficiency, tenure and district heating potential. In these aspects, the West Midlands is similar to the overall GB average.
- New build homes are modelled separately and are modelled to increasingly be built with heat pumps installed under each scenario. As the West Midlands has a strong pipeline of planned housing developments, and a projected continued population growth, this potentially accounts for the higher uptake of heat pumps in the long term under every DFES scenario.

- 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 are 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 West Midlands 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 West Midlands licence area:

Number of vehicles (thousands)		Baseline	2025	2030	2035	2040	2045	2050
Battery electric cars, LGVs and motorbikes	Falling Short	38	101	382	1,057	2,164	3,115	3,410
	System Transformation		115	511	1,597	2,918	3,332	3,157
	Consumer Transformation		235	1,062	2,496	3,274	3,313	3,144
	Leading the Way		186	1,035	2,649	3,266	3,095	2,531
Plug-in hybrid electric cars, LGVs and motorbikes	Falling Short	22	45	114	215	323	222	85
	System Transformation		43	103	178	134	58	0
	Consumer Transformation		39	77	112	78	32	0
	Leading the Way		46	100	94	49	0	0
Battery electric HGVs, buses and coaches	Falling Short	0	0	1	4	15	42	59
	System Transformation		0	3	12	30	40	37
	Consumer Transformation		0	3	16	46	66	68
	Leading the Way		0	4	17	44	66	63

Data summary for EV chargers in the West Midlands licence area:

Number of chargers (thousands)		Baseline	2025	2030	2035	2040	2045	2050
Domestic chargers	Falling Short	29	71	217	601	1,227	1,769	1,872
	System Transformation		83	318	950	1,676	1,788	1,813
	Consumer Transformation		169	604	1,398	1,855	1,911	1,911
	Leading the Way		136	664	1,630	1,889	1,926	1,937
Non-domestic chargers	Falling Short	2	3	8	21	47	72	85
	System Transformation		3	11	36	70	81	84
	Consumer Transformation		5	19	46	63	66	69
	Leading the Way		4	18	45	61	65	69

Summary:

- 2% of cars in the West Midlands licence area are currently battery electric or plug-in hybrid, slightly 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 higher 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 2 million EV chargers, predominantly off-street domestic chargers.

Modelling assumptions and results

Baseline

Electric vehicles

While the electric vehicle baseline represents around 2% of all vehicles registered in the West Midlands licence area, uptake of electric vehicles across the UK has been steadily accelerating. This has been due to a number of factors, including:

- Favourable tax benefits and grant support 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	33.1
Plug-in hybrid car	22.3
Pure electric LGV	4.6
Plug-in hybrid LGV	0.0
Other electric vehicles	0.5

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	29.4
	Non-domestic	1.6

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 notably by 2026, however, the extent to which this occurs depends heavily on the scenario, as detailed below.

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, almost 10% of cars are electrified under these scenarios, and over 3% of LGVs and buses.	232	141
Consumer Transformation		274	175
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.	158	86
Falling Short		147	74

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. 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	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. With such a rapid shift toward battery electric vehicles, plug-in hybrid vehicles see relatively little uptake, and begin to decline in the 2030s. EV uptake is facilitated by a widespread rollout of domestic and non-domestic charging.	2,759	1,675
Consumer Transformation		2,625	1,444

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.	1,787	987
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.	1,276	622

Long-term projections (April 2035 to March 2050)

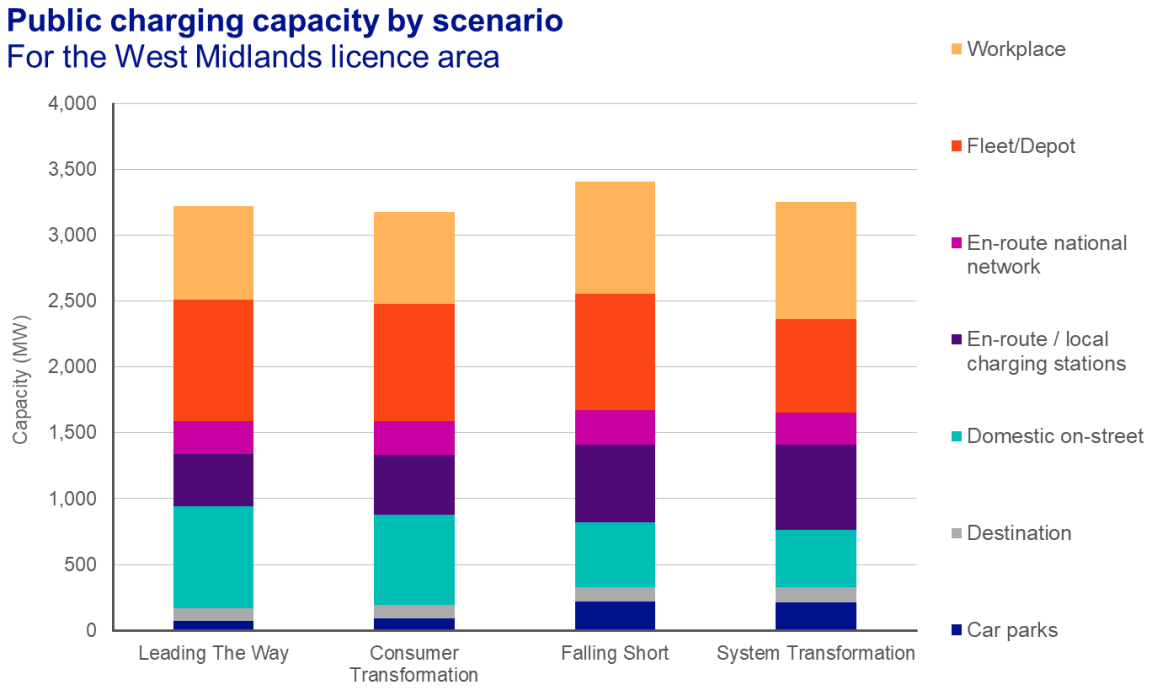
Under the three net zero scenarios, EV adoption approaches saturation and new EV uptake slows in most areas. Harder-to-electrify vehicles that saw lower uptake in the near term, such as HGVs, see a higher uptake out to 2050.

The uptake of EVs slows and then reduces in some scenarios in the long term, reflecting a lower level of car ownership and higher use of public transport. It is assumed that while EV numbers may reduce in the 2040s under some scenarios, installed EV chargers will remain in place, but see lower utilisation as the overall number of vehicles on the road decreases.

Scenario	Description	Total 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.	2,595	2,006
Consumer Transformation		3,212	1,980
System Transformation	Both EV adoption and associated 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.	3,194	1,897
Falling Short	EV adoption, and subsequent EV charger capacity, continues increasing out to 2050. By this point, almost all road vehicles are electrified.	3,555	1,957

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, West Midlands licence area

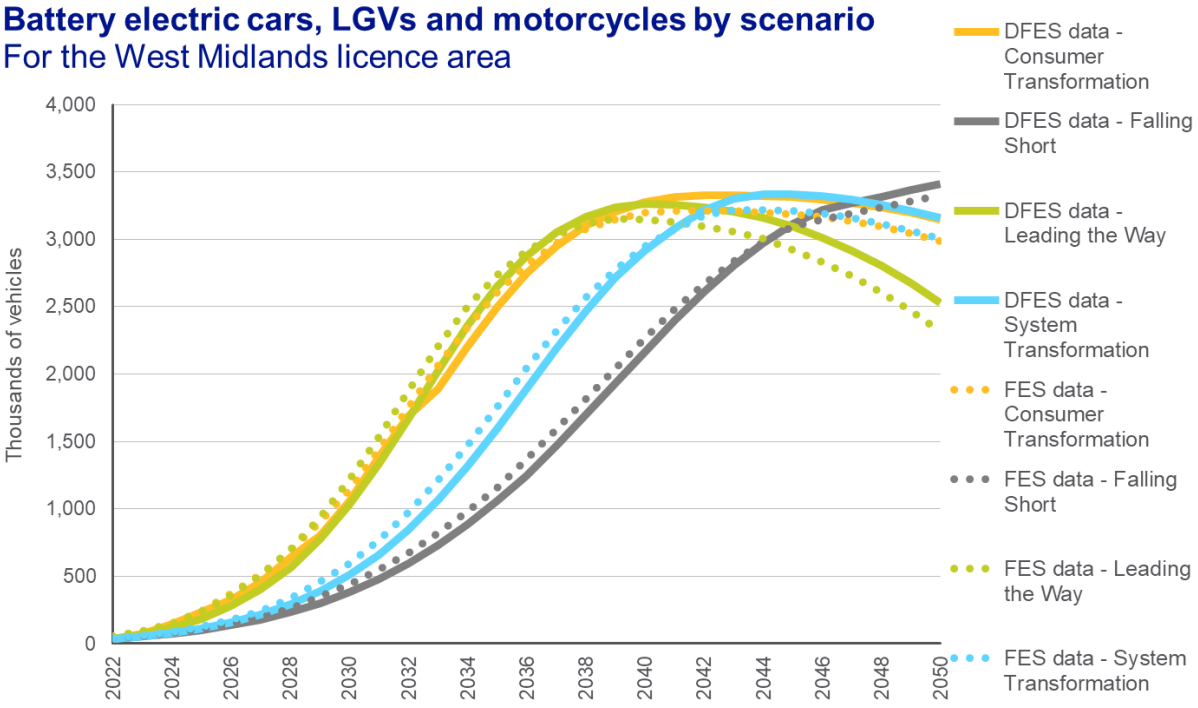


Figure 8 – Number of plug-in hybrid cars, LGVs and motorcycles by scenario, West Midlands licence area

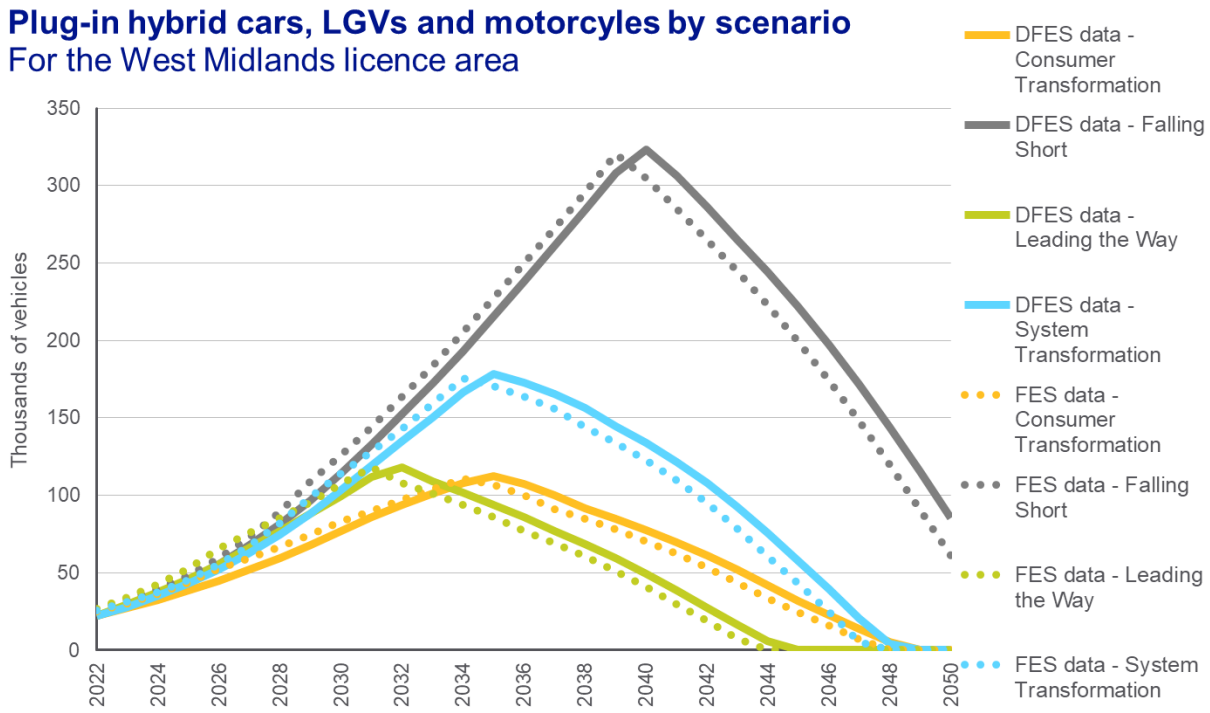
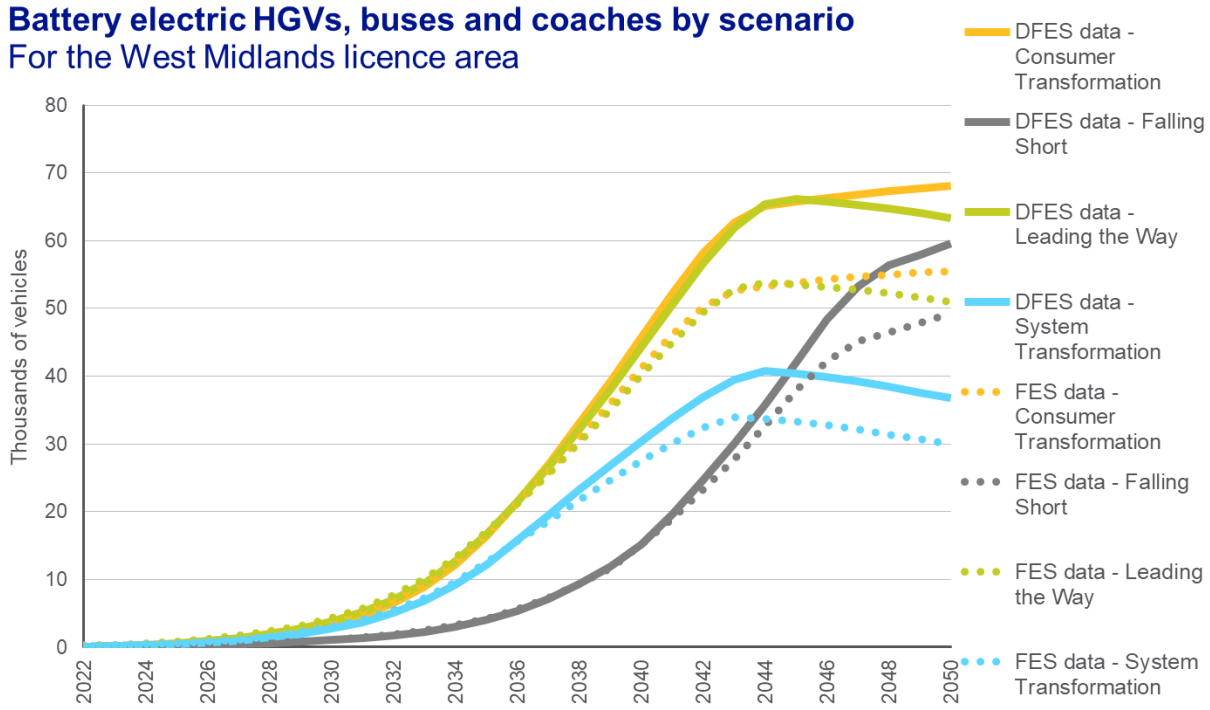


Figure 9 – Number of battery electric HGVs, buses and coaches by scenario, West Midlands licence area



- 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 2050 figures by scenario are similar between the DFES and the FES projections.

- However, uptake of battery electric HGVs, buses and coaches is much higher in the DFES. The reason for this variance is unclear, but is likely to be due to differences in the modelled baseline number of these vehicles. The DFES modelling uses DfT vehicle licencing data to inform the baseline of vehicles by body type in the licence area, which subsequently guides the uptake of electric vehicles, as these are assumed to typically replace existing petrol and diesel vehicles over time.
- The different EV charger archetypes are not broken down in the FES 2022 data at a GSP, licence area or national level. As such, a reconciliation is not possible. For vehicle efficiencies, mileage and vehicle numbers, FES projections and assumptions were used 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 West Midlands 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 West Midlands licence area:

Capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	4	4	13	25	25	30	86
System Transformation		28	104	171	239	343	464
Consumer Transformation		7	22	73	138	200	295
Leading the Way		33	106	166	235	347	501

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 role[vi] 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[vii], 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.
- There are a number of operational hydrogen projects in the West Midlands licence area, including:
    - The UK's largest hydrogen refuelling station at Tyseley Energy Park[viii], capable of refuelling c. 50 HGVs a day, alongside Birmingham's new fleet of hydrogen double-decker buses. This is supplied by a 3 MW electrolyser.
    - The HyDeploy[ix] project at Keele University is also located in the West Midlands and is demonstrating the use of hydrogen in homes for the first time in the UK. This includes an operational 500 kW electrolyser.
- There are a number of potential future hydrogen initiatives within the West Midlands licence area, including a hydrogen vehicle refuelling hub in Shropshire and a hydrogen electrolyser at Cotswold airport as part of the HyFlyer[x] project.
- From 2023, new hydrogen electrolysis projects are eligible for both capital and revenue funding support through the government's electrolytic allocation round[xi]. 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 Midlands is a transport hub, comprising many road and rail networks, which could provide a potential opportunity for the West Midlands to become a hydrogen hub to support the decarbonisation of heavy transport. The University of Birmingham developed the UK's first hydrogen-powered train (HydroFLEX[xii]), which was successfully tested on the UK's rail network in September 2020.
- The West Midlands licence area also has Triassic salt basins around Staffordshire and Worcester that could be used for hydrogen storage in the future.
- The largest capacity of distribution-connected hydrogen electrolysers in 2050 is modelled under **Leading the Way** (501 MW) and **System Transformation** (464 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** (86 MW), reflecting limited government policy support for this technology and the assumption that this scenario does not reach net zero.

Baseline

There is a 3 MW hydrogen refuelling station in the Tyseley Energy Park in Birmingham which is capable of refuelling c. 50 HGVs a day, alongside Birmingham's new fleet of hydrogen double-decker buses. ITM Motive, the operating company, is aiming to replicate this business model at other locations around the UK.

The HyDeploy project at Keele University has a 0.5 MW electrolyser installed and has sought to demonstrate the potential future use of hydrogen in homes.

Near-term (April 2022 to March 2025)

There are no known electrolysis projects with accepted connection offers in the West Midlands licence area.

However, there are a number of active hydrogen initiatives in the West Midlands licence area:

- The H2GVMids[xiii] demonstration programme has recently received Innovate UK funding on behalf of the Department of Transport to deliver a fleet of hydrogen-fuelled trucks in the Midlands. The feasibility study into the use of hydrogen for 44-tonne trucks, using the Midlands as a trial area of focus and will involve the development of a hydrogen refuelling station to enable the demonstrator.
- The HyDeploy project is also looking at expanding its hydrogen production capacity, subject to further government funding.
- Shropshire Council is exploring the construction and operation of a hydrogen refuelling facility at the Battlefield energy recovery facility in Shrewsbury. The hydrogen produced would fuel commercial vehicles such as lorries and buses. Shrewsbury has been identified as one of the region's top ten sites for hydrogen refuelling facilities due to its location next to the A5 international transport corridor.
- Octopus Hydrogen is supplying electrolytic hydrogen to zero-emission aviation company ZeroAvia as part of the HyFlyer II programme, which is seeking to develop a certifiable hydrogen-electric powertrain for aircraft.

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 West Midlands 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 (33 MW) and **Falling Short** the least installed capacity (4 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 transport hub, the West Midlands licence area sees a significant development of hydrogen electrolysis capacity in the medium-term, as electrolyser units become commercially viable and demand increases. In particular, the use of electrolysis in industry, power generation, flexibility and transport becomes widely supported, and hydrogen clusters begin to form. Under **System Transformation** and **Leading the Way**, hydrogen is blended into the gas networks and 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%	25 MW
System Transformation	35%	171 MW
Consumer Transformation	36%	73 MW
Leading the Way	24%	166 MW

Long-term (April 2035 to March 2050)

Alongside six major motorways running in the licence area, including the M5 and M6, and major urban areas such as Birmingham, Stoke-on-Trent, Wolverhampton and Gloucester, the West Midlands is likely to see significant hydrogen electrolyser capacity connected by 2050 to provide hydrogen fuelling locations. However, due to individual project size, a large proportion of this is likely to be on the transmission network rather than the distribution network.

The potential for hydrogen trains could increase electrolyser capacity significantly under some scenarios. In Network Rail's Traction Decarbonisation Network Strategy[xiv], the central-Wales train line has been earmarked as a potential route for hydrogen trains. This includes the line going through Shrewsbury; hence, the Shrewsbury train depot could be a prime location for a medium to large-scale electrolyser; however, the business models for hydrogen train refuelling are unclear, as well as the network to which any electrolysers would connect. The Department for Transport is aiming to remove all diesel-only trains from the network by 2040, suggesting that the conversion of parts of the rail network to hydrogen is more likely to happen in the longer term.

The West Midlands licence area also has Triassic salt basins around Staffordshire and Worcester that could be used for future hydrogen storage. If, upon exploration, these are found to be suitable, large-scale hydrogen production facilities could locate adjacent to these storage areas, as this would reduce transportation miles, enable a more efficient hydrogen supply chain and ultimately reduce the cost of hydrogen.

In the long term, hydrogen electrolysers are expected to scale up their capacity by increasing the number of modules connecting to a compressor. The total capacity of distribution network 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%	86 MW
System Transformation	17%	464 MW
Consumer Transformation	17%	295 MW
Leading the Way	20%	501 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 the 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 source 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 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**.

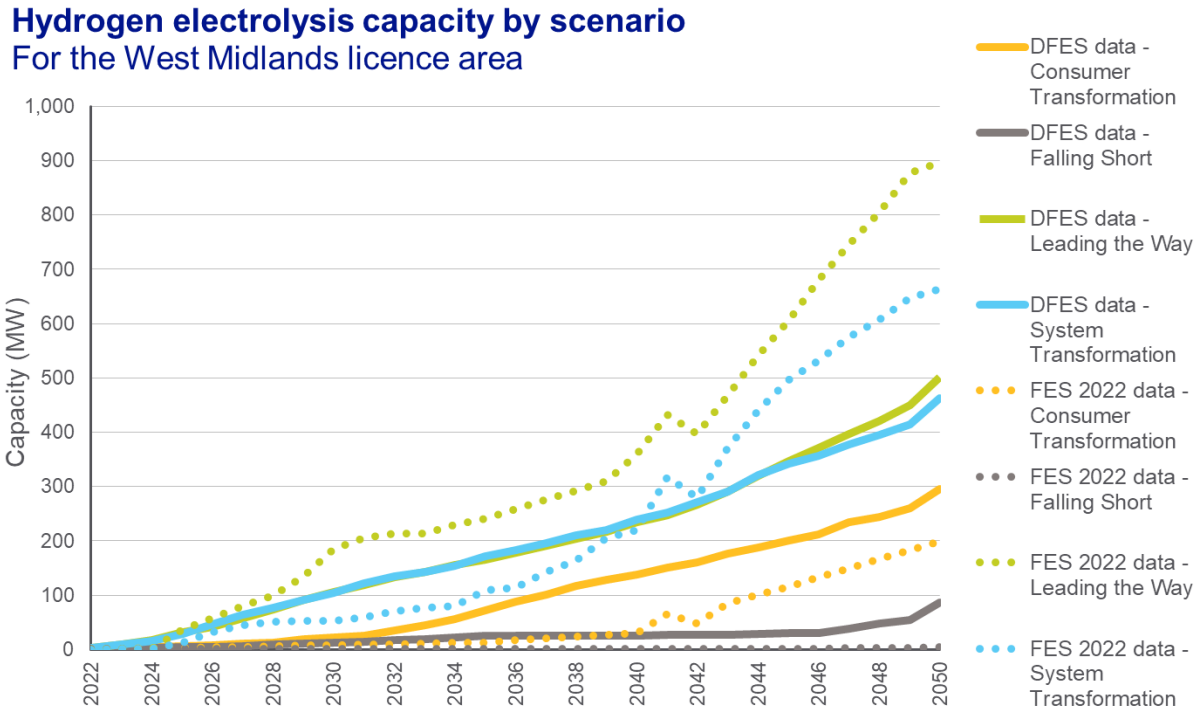
Key modelling assumptions for DFES 2022

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 the West Midlands
Industrial energy demand	Medium	Medium	Medium	High	Low
Heavy transport demand	Medium	Medium	Medium	Medium	High
Large-scale hydrogen storage	Low	Low	Low		High
Location of maritime activity	Low	Medium	Low		Low
Access to the gas network	Low		Low	Low	Medium
Renewable energy resource	Medium	Medium	Medium		Low
Hydrogen innovation projects	High	High	High	High	Medium
Rail network decarbonisation	Low	Low	Low		High
Existing grey hydrogen sites	Low	Low	Low	Low	Low

Reconciliation with National Grid FES 2022

Figure 10 – Installed capacity of hydrogen electrolysis by scenario, West Midlands 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 West Midlands licence area are significantly lower than the FES projections in the long term. In comparison, under **Consumer Transformation** and **Falling Short**, the DFES projections are higher than those in the FES projections.
- This is likely to be 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 West Midlands licence area finds **System Transformation** and **Leading the Way** to have very similar projection trajectories. This is due to the large transport and logistics industry in the West Midlands, which is an important source of hydrogen demand in **System Transformation** 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 West Midlands licence area (501 MW). This represents c.6% of all GB-distribution connected electrolysis capacity under this scenario, which is viable based on the region's size, transport infrastructure, storage resources 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 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 West Midlands licence area

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

Data summary for new domestic developments in the West Midlands licence area:

Houses (thousands)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	0	40	125	210	286	354	419
System Transformation		47	140	238	321	397	471
Consumer Transformation		47	140	238	321	397	471
Leading the Way		56	168	274	368	456	542

Data summary for new non-domestic developments in the West Midlands licence area:

Floorspace (sqm, 100,000s)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	0	24	71	116	128	129	129
System Transformation		29	85	122	128	129	129
Consumer Transformation		29	85	122	128	129	129
Leading the Way		31	91	119	128	129	129

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, the domestic modelling results in between 420,000 and 540,000 new homes in the West Midlands licence area, representing an 18%-23% increase in the number of domestic customers.
- An additional 13.3 million square meters of non-domestic floorspace is also modelled to be developed in the West Midlands 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**
1,422	205,326

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

Local authority	**Number of homes**	**Largest development site**
Birmingham	30,890	Langley Sustainable Urban Extension (2,860 homes)
Stroud	16,834	Sharpness new settlement (2,400 homes)
Stratford-on-Avon	15,545	Long Marston Airfield Garden Village (3,100 homes)

Non-domestic

Subcategory	**Number of sites**	**Total non-domestic floorspace (sqm)**
Factory and warehouse	404	5,769,338
Office	315	4,702,305
Retail	85	759,982
School and college	50	56,329
Other (e.g. medical, hotel, sport & leisure)	125	1,829,595

In the West Midlands 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 300-hectare, rail-served West Midlands Interchange[xv] logistics site in South Staffordshire, the largest site logistics development site in the UK.

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 scenarios capture a range of housebuilding trends between 2022 and 2050.	
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[xvi].
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, West Midlands licence area

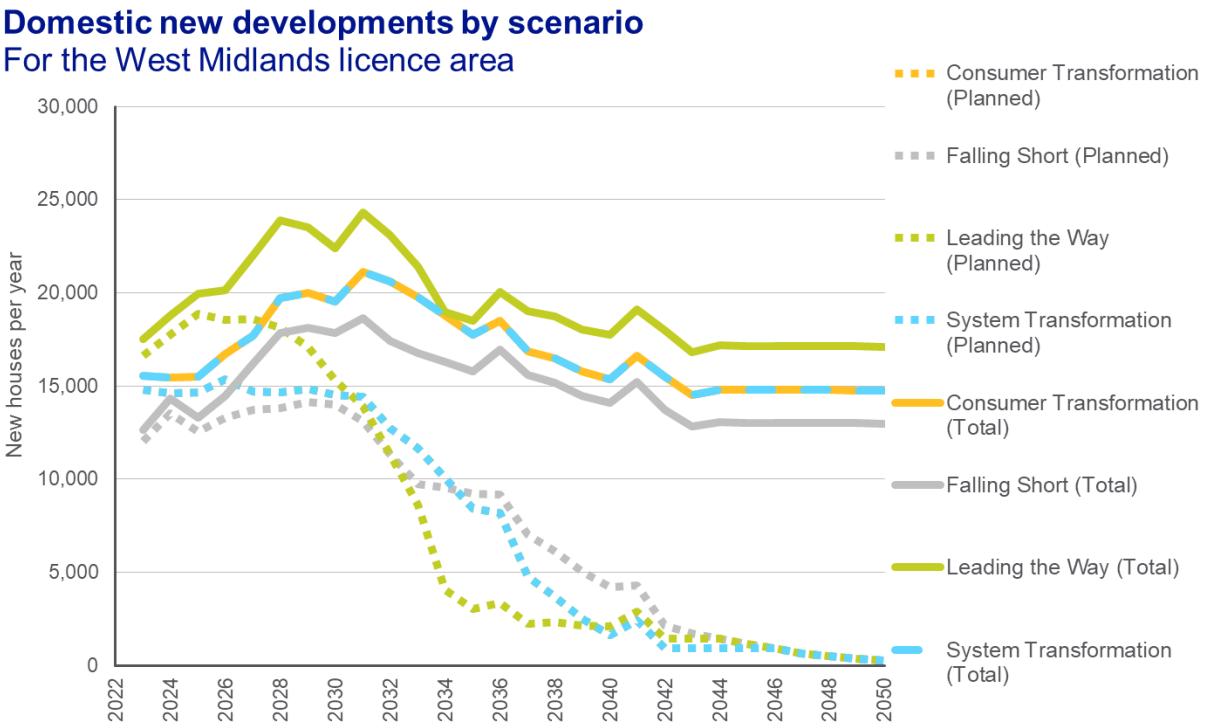
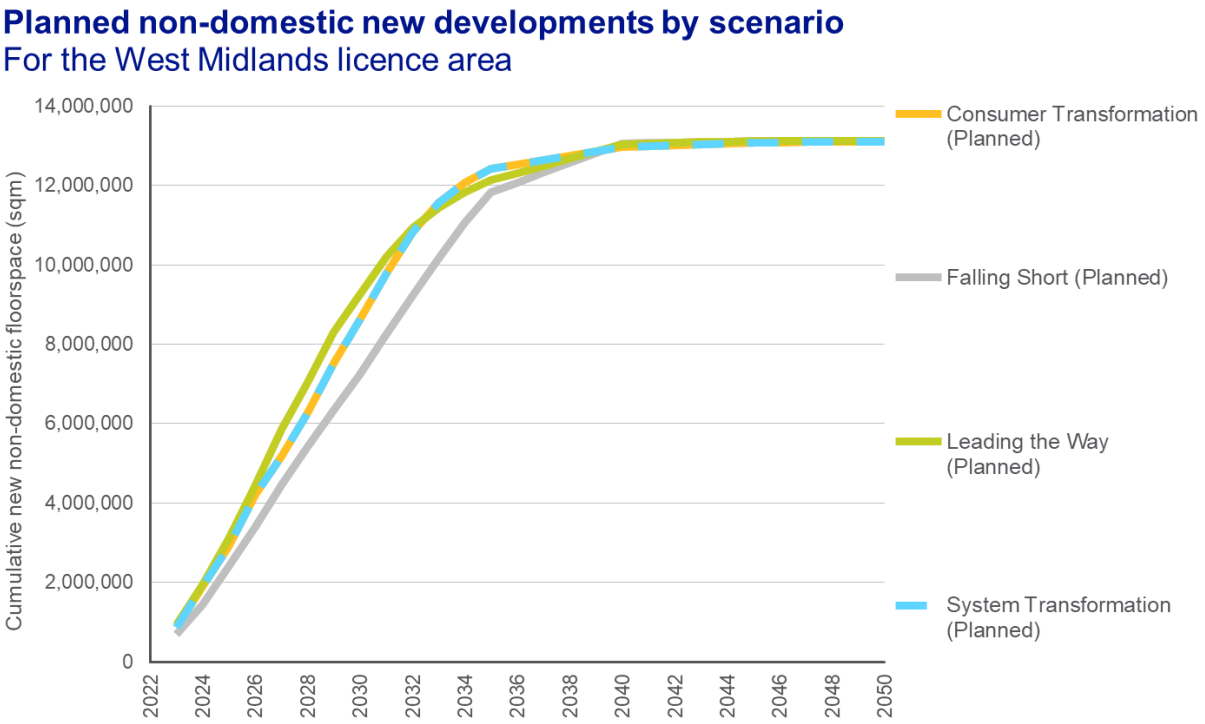


Figure 12 – Cumulative planned non-domestic developments by scenario, West Midlands licence area



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 West Midlands licence area

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

Data summary for air conditioning uptake in the West Midlands licence area:

Air conditioning units (thousands)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	24	36	72	165	348	723	1,460
System Transformation		34	61	109	221	420	773
Consumer Transformation		34	61	109	221	420	773
Leading the Way		24	24	24	24	24	24

Summary:

- Domestic air conditioning is not currently common in the UK, with only c.1% of UK homes currently containing an air conditioning unit.
- The current position in the West Midlands aligns with the national average, with modelling suggesting that 1% of homes in the licence area 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 Birmingham, 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**
23,529	1.0%
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. 34,000-36,000 thousand 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. 1,460,000 homes c. 60% 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. 773,000 homes c. 31% 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. 24,000 homes c. 1% of total housing stock

Modelling assumptions

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

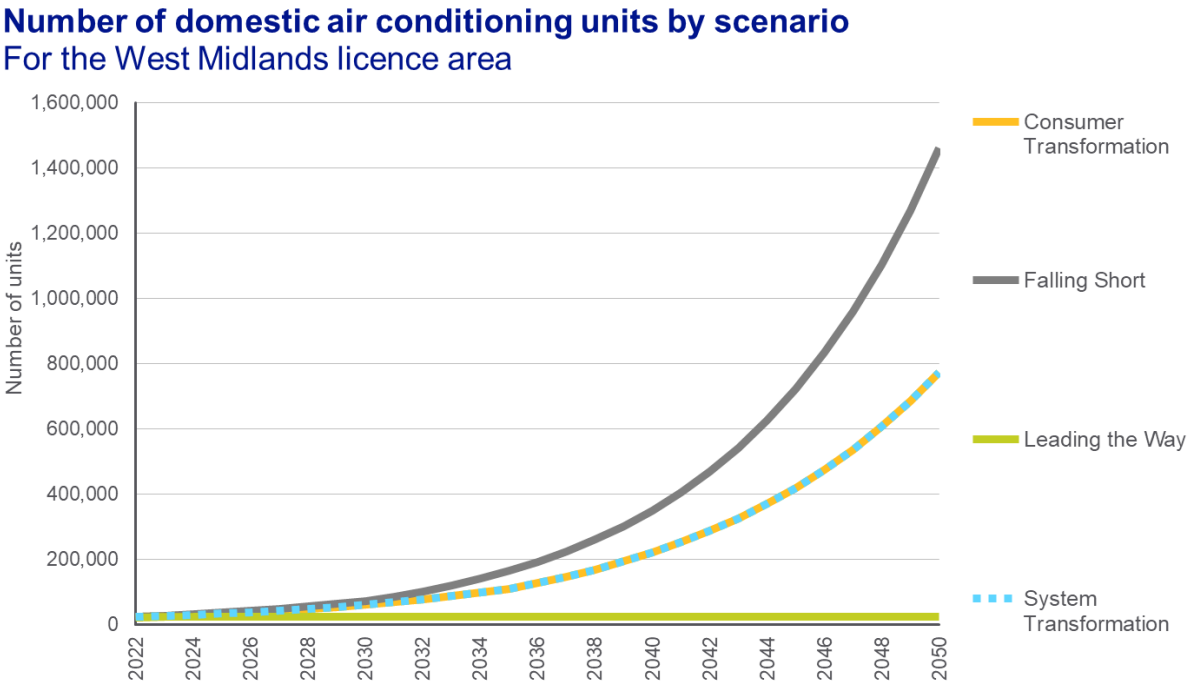
- Cooling degree days at 18.5 °C, where the West Midlands is above the national average due to its inland climate. This metric is used in every scenario.
- Proportion of households in very dense urban areas, with the West Midlands 51% below the national average. This metric is used in every scenario.
- Proportion of households in fairly dense urban areas, with the West Midlands 8% 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 West Midlands directly in line with the national average. This metric is used in **Falling Short**, as air conditioning becomes common even outside of 'heat island' areas.

Future Homes Standard

The draft Future Homes Standard 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, West Midlands 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 West Midlands licence area sees uptake of air conditioning slightly above the national level seen in FES 2022, due to the higher level of cooling degree days in the region compared to the national average. The region also has a fairly high proportion of homes in denser urban areas, albeit this is below the GB 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 Birmingham. 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] Future Homes Standard
[iv] Heat network pipelines
[v] Opportunity Areas for District Heat Networks in the UK, BEIS
[vi] Building the hydrogen value chain, Regen, 2021
[vii] British Energy Security Strategy, HM Government, 2022
[viii] Tyseley Refuelling Hub
[ix] HyDeploy
[x] HyFlyer
[xi] BEIS Electrolytic Allocation Round 2022
[xii] HydroFLEX
[xiii] H2GVMids
[xiv] Traction Decarbonisation Network Strategy, Network Rail, 2020
[xv] West Midlands Interchange
[xvi] 2018-based household projections by local authority

Generation technologies

Results and assumptions

Large-scale solar in the West Midlands licence area

Solar generation sites of installed capacity of 1 MW and above

Data summary for Large-scale solar power in the West Midlands licence area:

Capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	472	628	1,140	1,422	1,493	1,591	1,689
System Transformation		1,256	1,784	2,241	2,437	2,684	2,930
Consumer Transformation		1,166	1,784	2,242	2,438	2,685	2,931
Leading the Way		1,844	2,741	3,460	3,798	4,013	4,048

Summary:

- The West Midlands licence area has historically shown a low level of large-scale solar PV deployment, with less than 0.5 GW of distribution connected capacity connected over the past decade.
- There is a large pipeline of projects in the licence area, representing a vast increase in developer interest in the region compared to previous years. The number of sites with an accepted network connection offer has significantly increased from 62 (2,328 MW) to 125 (4,368 MW) since DFES 2021 – an 88% relative increase in total pipeline capacity since 2021.
- Solar remains one of the cheapest forms of renewable energy, with further cost reductions helping the technology to realise economies of scale. The West Midlands 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 75% of projects being successful in planning. The West Midlands has a moderate level of local ambition evidenced through renewables target setting and net zero policy compared to the other three 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. 2.7 GW by 2030, and continues to c. 4 GW by 2050. Under **Consumer Transformation**, c. 1.8 GW is reached by 2030, and c. 2.9 GW by 2050.

Modelling assumptions and results

Baseline		
Number of sites	**Total capacity**	**Description**
93	472 MW	2021 was a positive year for new ground mount solar deployment[xvii]. 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. At the height of the FiT period, over 429 MW of capacity was deployed between 2012 and 2016 in the West Midlands. Installed capacity has reached 472 MW by 2022, bringing the average installed capacity of large-scale distributed solar to 5.3 MW in the region. The largest distribution-connected site is the Hillhouse Farm Cambridge Solar Power site in Stroud at 30 MW of installed capacity. This project was connected in 2015.

Pipeline (April 2022 to March 2028)	
Number of pipeline sites	**Total capacity**
125	4,368 MW

Installed solar capacity in the UK is forecast to grow by over 1 GW in 2022 and over 2 GW in 2023[xvii]. In the West Midlands, the capacity of identified pipeline projects has shown a relative increase of c. 88%, compared to the number of sites looking to connect to the network in the past year and a half, from 62 (2,328 MW) by the end of Q1 2021 to 125 (4,368 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 were unsure if this would happen quickly or out to the mid-2030s. The average capacity of sites accepted to connect to the network is 35 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	One new solar site was identified to be under construction, commencing in November 2021 – the New Cross Hospital solar farm at 7 MW.	1	7 MW
Planning Permission Granted	490 MW of solar capacity from 15 sites has been approved in planning in the West Midlands, up from 127 MW from 5 sites identified in DFES 2021. Four sites (totalling 151 MW) are located in Wychavon. The remaining 11 sites are spread throughout the licence area. Four sites are around 50 MW in size, two of which are in Wychavon, one in Stroud and one in Lichfield. The Cawarden Solar Farm (50 MW) in Lichfield is due to commence construction in 2022.	15	490 MW
Planning Application Submitted	14 sites have submitted a planning application, all of which are modelled to connect under **Leading the Way**, due to high levels of planning friendliness and local ambition across the West Midlands licence area. 13 sites are modelled to connect under **Consumer Transformation** and **System Transformation**. The largest of these sites is a 53 MW solar farm in Tewkesbury.	14	544 MW
Pre-planning	27 sites were found to be in various stages of pre-planning, at least 16 of which were seeking an environmental pre-screening application or had already received a pre-screening opinion. At least four consultation websites have been identified, including the c. 40 MW Larport Solar Farm.	27	1,106 MW
No information	No development evidence could be found for c. 2,170 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 only in local authorities where planning applications have a very high success rate.	66	2,170 MW
Rejected, Withdrawn or Abandoned	Two sites (21 and 30 MW respectively) were found to be refused in planning, one rejected in planning in 2021 and the other in 2022. Both of these sites were located in Telford and Wrekin.	2	51 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 has sufficient irradiance levels, is in proximity to the existing distribution network, 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. 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 is moderate, with a slight decrease in momentum from 2026-2035 as some pipeline sites connect on delayed timelines. Past 2035, this moderate capacity growth continues, reaching c. 1.4 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.	1,422 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.	2,241 MW
Consumer Transformation	Local ambition plays a larger role than historic planning friendliness in determining where projections are located. As under **System Transformation**, 2.2 GW is deployed by 2035.	2,242 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 close to 2.5 GW of capacity installed by 2035. Historic planning friendliness plays a small role.	3,460 MW

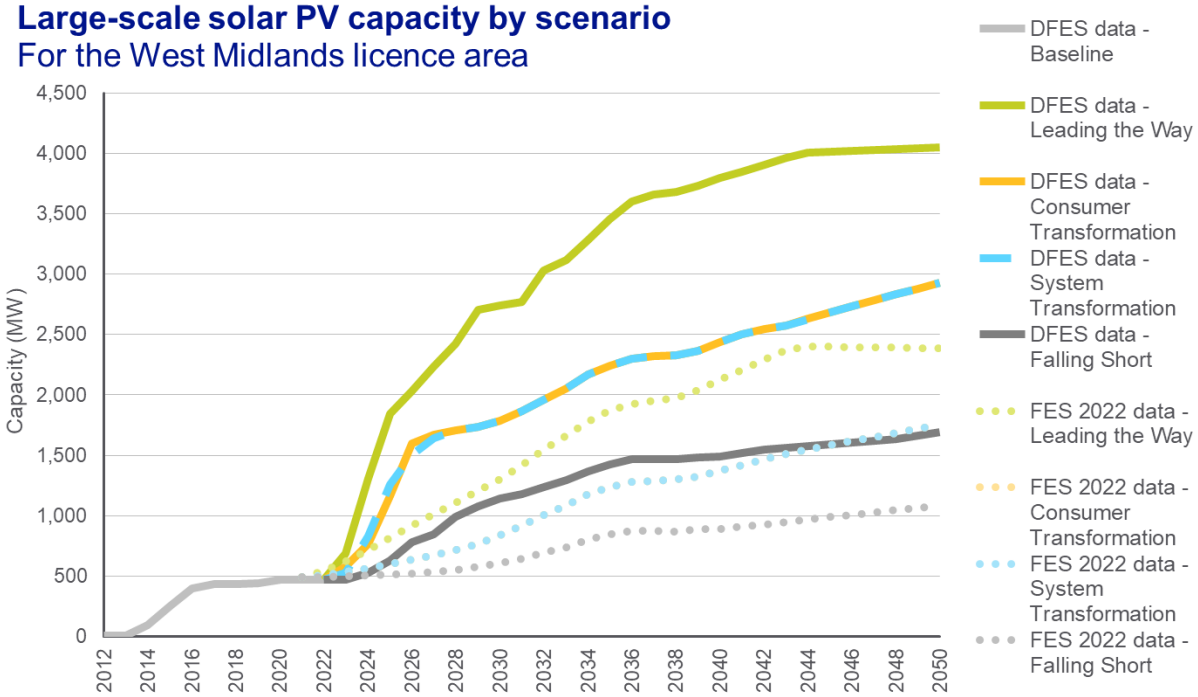
Long-term (April 2035 to March 2050)

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-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[xviii]. 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. 1.7 GW under **Falling Short** to c. 4 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 c. 1.7 GW by 2050.	1,689 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 solar sites are modelled to repower at +25% of their original capacity.	2,930 MW
Consumer Transformation		2,931 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. Older solar sites are modelled to repower at +50% of their original capacity.	4,048 MW

Reconciliation with National Grid FES 2022

Figure 14 – Electrical capacity of large-scale solar by scenario, West Midlands licence area



- The FES 2022 baseline closely matches the DFES 2022 baseline for the West Midlands licence area.
- DFES 2022 models a very strong near-term uptake of solar in the licence area under all three net zero scenarios, compared to a moderately 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 planning acceptance are modelled to connect to the network under varying timeframes. The increase in positive development evidence for the pipeline strongly supports this near-term increase. This is a notable increase in the total capacity of accepted connection offers corresponding to accepted planning applications this year, when compared to DFES 2021.
- From the mid-2020s onwards, DFES 2022 projections continue to project higher levels of development under all scenarios relative to FES 2022 trends and rates of development. The overall capacity buildout is notably higher due to a strong pipeline buildout in the 2020s, as well as a slight re-allocation of projections from the South West licence area to account for the available unconstrained resource in West Midlands, 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 England, OS Addressbase
Local ambition, reflecting the local authority policy landscape and proclivity to renewable energy and net zero goals.	Climate Score Cards[xix]
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 West Midlands 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 West Midlands licence area:

Capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	427	488	573	682	793	904	1,015
System Transformation		536	791	1,085	1,382	1,680	1,981
Consumer Transformation		651	1,196	1,795	2,399	3,021	3,649
Leading the Way		655	1,214	1,836	2,463	3,110	3,764

Summary:

- During the 2010s, the West Midlands licence area saw small-scale solar deployment as a result of the Feed-in Tariff support scheme, at levels directly in line with the GB average.
- Deployment of small-scale solar had stalled in recent years. However, recent increases in energy prices have resulted in a strong 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 over nine 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 3.8 GW.

Modelling assumptions and results

Baseline			
Scale	**Number of sites**	**Total capacity**	**Notes**
Domestic (Under 10 kW)	70,125	236	Equivalent to 3.0% of homes
Commercial (10 kW–1 MW)	2,932	191	Average array size: 65 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 330 MW of capacity, 81% of the baseline, was deployed in the West Midlands 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 nearly 500 small-scale solar sites in the pipeline, representing over 35 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. The West Midlands licence area has a notable number and capacity of commercial-scale sites, including many planned rooftop arrays on warehouses.		
Scale	**Number of pipeline sites**	**Total capacity**
Domestic (Under 10 kW)	270	1.4 MW
Commercial (10 kW–1 MW)	210	34.2 MW

Pipeline assessment			
Scale	**Number of sites**	**Total capacity**	**Scenario outcomes**
Below 50 kW	355 (74% of total)	3.9 MW (11% 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	111 (23% of total)	20.3 MW (57% 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	14 (3% of total)	11.4 MW (32% of total)	Four of these sites have attained planning permission and are modelled to connect in 2023 under every scenario. The remaining sites were not found in planning and are modelled to connect between 2023 and 2024 in the net zero scenarios, and between 2024 and 2025 under **Falling Short**.

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[xx].

This proportion of homes with rooftop solar is anticipated to increase, as changes to Building Regulations (Part L)[xxi] 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[xxii].

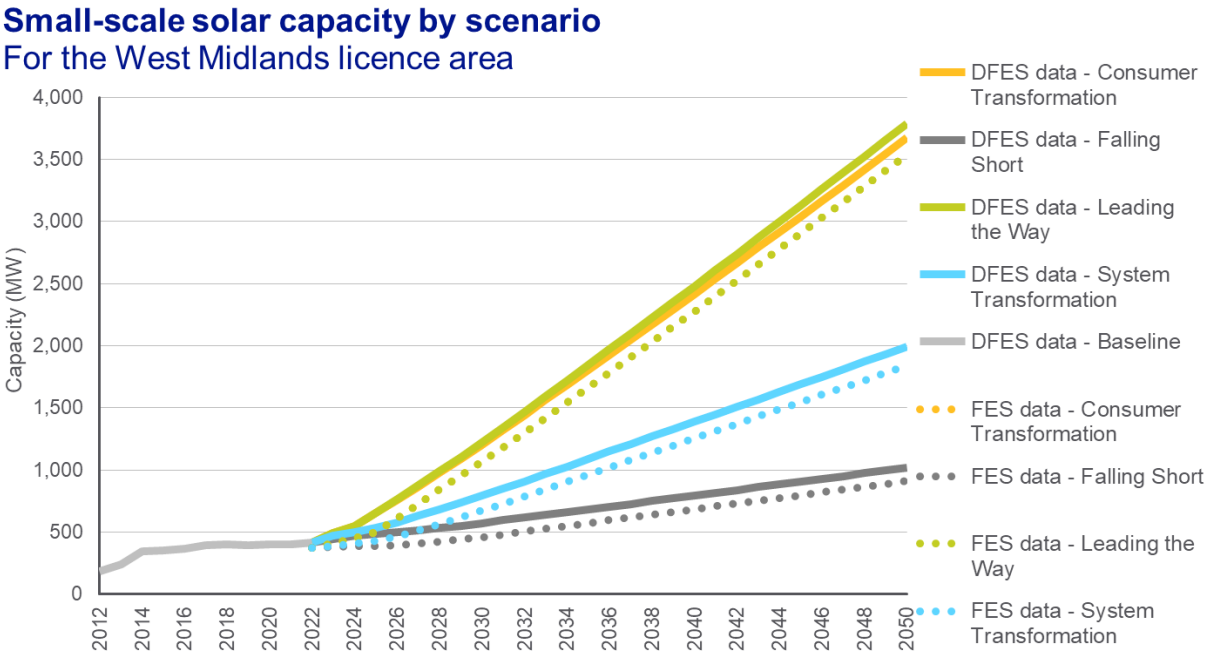
Under **Consumer Transformation** and **Leading the Way**, deployment of rooftop solar on new-build homes accelerates towards this figure over the 2020s and early 2030s. However, under **System Transformation** the changes to Building Regulations Part L have been modelled to have a lower impact, and 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 3.8 GW by 2050 under **Leading the Way**.	3,764 MW
Consumer Transformation		3,649 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.	1,981 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.	1,015 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.	In line with 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.	Moderately below 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.	Slightly 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.	Slightly above the GB average
Local authority	Local authority ambitions, in the form of climate emergency declarations or renewable generation targets, are modelled to 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.	Slightly above the GB average

Figure 15 – Capacity of small-scale solar generation by scenario, West Midlands 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, albeit with the DFES projections being slightly above the FES in every scenario. This is due to an uptick in deployment modelled under the DFES in the near term, reflecting the known pipeline of accepted connections for domestic and commercial rooftop solar PV.
- 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 West Midlands licence area

Onshore wind electricity generation

Data summary for onshore wind power in the West Midlands licence area:

Capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	52	52	53	57	61	66	79
System Transformation		52	54	62	78	100	115
Consumer Transformation		53	69	102	156	226	237
Leading the Way		53	64	90	133	191	203

Summary:

- There is a small (52 MW) baseline of distributed onshore wind in the West Midlands licence area, showing a lot lower deployment to date compared to neighbouring licence areas.
- Contrary to other licence areas, the West Midlands does not have large amounts of available and unconstrained wind resource areas, with the licence area hosting only c.1% of total unconstrained wind resource in Great Britain.
- Planning friendliness is also relatively low, with only around 35% of onshore wind projects that have been through the planning process securing approval, further limiting future growth potential in this licence area. Due to these factors, some growth in connected capacity is seen under **Consumer Transformation** and **Leading the Way**, while **Falling Short** sees very limited uptake, due to lack of momentum for planners accepting the pipeline of new projects, failing to reach net zero goals.
- A moderate amount of new onshore wind capacity is modelled to connect steadily in the licence area out into the 2030s and early 2040s, levelling out in the late 2040s as climate goals are largely met a few years ahead of target, especially under **Consumer Transformation** and **Leading the Way**.
- In all scenarios, baseline sites developed during the Feed-in Tariff years of 2012 to 2018 are assumed 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 69 MW, reaching nearly 250 MW by 2050 under the same scenario.

Modelling assumptions and results

Baseline			
Scale	**Number of sites**	**Total capacity**	**Description**
Total	161	52	The vast majority of sites (c. 98%) are made up of small turbines below 1 MW. However, the majority of installed capacity (c. 77%) is made up of sites over 1 MW.
Above 1 MW	4	40	Two large-scale sites are located in South Staffordshire, totalling 4 MW, and another 1.7 MW site in Newcastle-under-Lyme. The largest onshore wind site connected in the licence area is the 35 MW Garreg Lwyd Wind Farm located in Powys.
Below 1 MW	157	13	The majority of small-scale wind sites connected between 2013 and 2017, with development stagnating thereafter. Approximately 129 projects with an average capacity of 22 kW were supported by the FIT scheme.

Pipeline (April 2022 to March 2028)	
Number of pipeline sites	**Total capacity**
2	0.02 MW

There are only two micro-scale pipeline onshore wind sites in the licence area, both of which are modelled to connect under **Leading the Way** and **Consumer Transformation**. Despite not being able to identify planning documentation, at such small capacities it is assumed that both receive approval or are progressed under permitted development.

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. Pipeline 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.

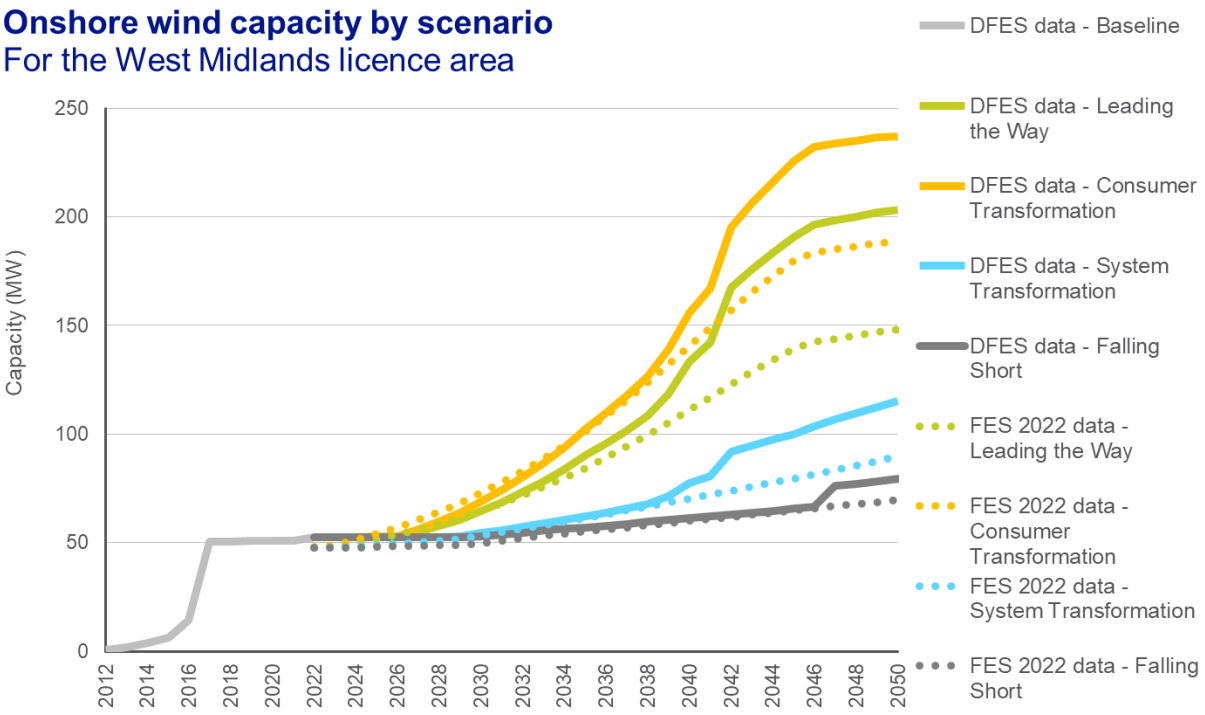
Pipeline analysis			
Status	**Scenario outcomes**	**Sites**	**Capacity**
Planning Permission Granted	No sites were found with granted planning permission	--	--
Under Construction	No sites were found to be under construction	--	--
Planning Application Submitted	No sites were found to have an undecided planning application in progress.	--	--
Pre-planning	No sites were found in pre-planning	--	--
No information	Two unidentified sites in Herefordshire and South Gloucestershire	2	0.02 MW

Medium-term (April 2028 to March 2035)		
Scenario	**Description**	**Capacity by 2035**
Falling Short	Wind capacity in the region remains stagnant out until 2030, with no pipeline sites coming online. Without many sites in planning, it takes over a decade to reignite developer interest in new wind projects under this scenario. This is due to the assumption that planning regimes remain inhibitory towards new wind farm developments under this scenario.	57 MW
System Transformation	In the medium term, wind farms see very limited development as a result of low levels of planning friendliness and wind resource availability. Some sites come online to take advantage of the resource that is available.	62 MW
Consumer Transformation	Limited interest in onshore wind development starts to pick up from 2027 onwards on top of repowering of some older sites. Distributed onshore wind (including at smaller distribution network scale) is seen as a key technology to reducing carbon emissions in the electricity sector, but growth is constrained by the limited amount of available and unconstrained wind resource in the licence area.	102 MW

Leading the Way	A small amount of onshore wind growth capacity connects to the distribution network out to 2035, although some of the added capacity connects to the transmission level network. This results in a slightly lower capacity connected to the distribution network than is seen under **Consumer Transformation**. Unconstrained wind resource is very low in the West Midlands, limiting wind power growth under all scenarios.	90 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. A small number of sites continue to connect at similar levels to historic rates. Sites larger than 5 MW experience a repowering of +25%.	79 MW
System Transformation	Long-term deployment of onshore wind sees very limited growth as more large-scale wind farms connect at transmission-level voltages in areas with unconstrained resource. Repowering rates remain modest, accounting for some of the steady growth into the 2030s and 2040s. Sites larger than 5 MW experience a repowering of +25%[xxiii]. All other sites repower at +50%.	115 MW
Consumer Transformation	Small-scale distributed wind capacity sees the highest growth in this licence area under this scenario, reaching 226 MW by 2045, levelling out to 237 MW by 2050. Sites larger than 5 MW repower at +50%. All other sites repower at +100%.	237 MW
Leading the Way	Limited resource availability caps growth under this scenario. Sites larger than 5 MW experience a repowering of +50%. All other sites repower at +100%. The flattening of projections from 2045 onwards in **Leading the Way** and **Consumer Transformation** reflects assumption in the FES 2022, and can be seen as a cannibalisation of onshore wind as land and resource becomes saturated in the licence area.	203 MW

Figure 16 – Electrical capacity of onshore wind by scenario, West Midlands licence area



- The FES 2022 baseline (48 MW) is closely aligned with the DFES 2022 baseline (52 MW) for the West Midlands licence area. The variance seen is less than in 2021, which saw a FES baseline of 15 MW compared to the DFES 2021 figure of 49 MW. This suggests that the FES baseline is more closely reflecting the same sites identified in the DFES baseline.
- Near-term pipeline projections are also closely aligned, seeing an uplift to 64 MW by 2028 under **Consumer Transformation** under the FES, compared to 60 MW under the DFES.
- There is a slight deviation from the FES 2022 in the long term, which relates to a potentially different approach to the repowering of existing turbines and wind farms in the DFES. 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 models.
- Another reason for higher long-term ambition in **Consumer Transformation** and **Leading the Way** in the DFES than reflected in the FES is due to the bias imposed on projections by the ban on new onshore wind capacity in England, instead favouring deployment in Wales and Scotland, due to more favourable planning environments. This approach is not fully reflective of the wind resource availability in other English licence areas. The DFES projections are evidenced by an in-house wind resource assessment that redistributes licence area projections in proportion to several factors, including available and unconstrained resource, as well as a regional analysis of planning friendliness.
- Compared to FES 2021, FES 2022 long-term projections by 2050 have increased drastically from c. 40 MW to c. 190 MW under **Consumer Transformation**. This suggests that the FES figures are approaching a level of ambition that is closer to that shown in the DFES analysis under this scenario. The FES analysis has therefore opted to reflect at least some development in the licence area.

Factors that will affect deployment at a local level

Factor	Source
Regen in-house resource assessment, taking into consideration wind resource land availability and planning constraints in the licence area.	NOABL wind speed data, Natural England, OS addressbase
Local ambition, reflecting the local authority policy landscape and proclivity to renewable energy and net zero goals.	Climate Score Cards[xxiv]
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

Hydro in the West Midlands licence area

Hydropower electricity generation

Data summary for hydropower in the West Midlands licence area:

Capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	1	1	1	1	1	1	1
System Transformation		1	1	1	1	1	1
Consumer Transformation		1	1	1	1	1	1
Leading the Way		1	1	1	1	1	1

Summary:

- The West Midlands has minimal hydropower resource, with a baseline totalling under 1 MW.
- Due to lack of suitable hydropower sites, combined with a lack of subsidy support and increased abstraction licencing costs, there is no further uptake of hydropower in the West Midlands under any scenario.

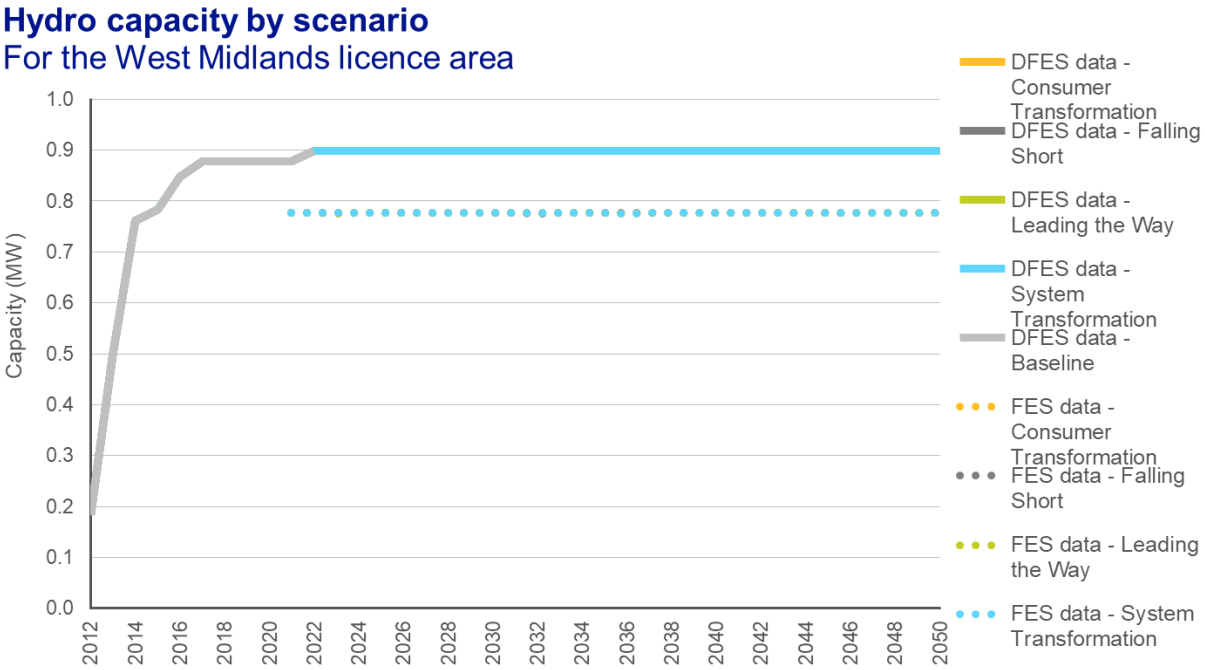
Modelling assumptions and results

Baseline			
Scale	**Number of sites**	**Total capacity**	**Description**
100-250 kW	3	0.5 MW	The three sites of 100 kW capacity or higher are located in Shropshire and Wychavon. These projects were deployed between 2012 and 2014, supported by the Feed-in Tariff scheme.
Below 100 kW	26	0.4 MW	Over 90% of this capacity was deployed between 2009 and 2016, supported via the Feed-in Tariff scheme

Pipeline (April 2022 to March 2025)
There are no pipeline hydropower sites in the West Midlands licence area. As such, there is no hydropower deployment in the near term under any scenario.

Medium and long-term projections (April 2025 to March 2050)		
Scenario	**Description**	**Capacity by 2050**
Leading the Way	Hydropower resource in the West Midlands is limited to very small and micro-scale hydropower. High abstraction licence costs in England[xxv] and lack of subsidy support results in no further deployment of hydropower in the West Midlands under any scenario.	0.9 MW
Consumer Transformation		
System Transformation		
Falling Short		

Figure 17 – Electrical capacity of hydropower by scenario, West Midlands licence area



- There is a very small difference of around 100 kW between the DFES and FES 2022 baselines for hydropower in the West Midlands licence area, likely due to visibility and treatment of micro-scale hydropower sites. The FES scenario assumptions for small-scale hydro are reflected in the DFES projections, with no deployment of any further hydropower in the licence area under any scenario.

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

Biomass in the West Midlands licence area

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

Data summary for biomass power in the West Midlands licence area:

Capacity (MWe)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	11	12	12	12	12	12	12
System Transformation		12	14	16	19	22	25
Consumer Transformation		12	12	13	14	15	16
Leading the Way		12	13	14	15	16	18

Summary:

- The biomass baseline in the West Midlands consists of small-scale sites, predominantly providing combined heat and power to business parks, airports, universities and other groups of commercial and public buildings.
- In other areas of the country, biomass capacity decreases in the three net zero scenarios as larger-scale standalone biomass power generation is progressively decommissioned. However, as the West Midlands mainly hosts smaller-scale CHP biomass generation, there is some growth in the capacity in all three net zero scenarios as a means of decarbonising heat, particularly under **System Transformation**.
- Under **Falling Short**, biomass capacity remains relatively static as alternative uses of bioenergy in harder-to-decarbonise sectors are not achieved under this scenario.

Modelling assumptions and results

Baseline

With the exception of a 2.7 MW site burning miscanthus and other energy crops in Eccleshall, Stafford, all remaining operational biomass sites in the West Midlands licence area appear to use biomass for CHP.

The sites heated and powered by this biomass generation include Birmingham International Airport, a number of business parks, university buildings and a garden centre. Over half of the baseline sites are located in Herefordshire.

Scale	Capacity	Number of sites
1-5 MW	8 MW	3
Below 1 MW	3 MW	18

Details of largest baseline sites

Site name	Location	Connection date	Capacity
Thorn Business Park	Hereford, Herefordshire	October 2006	4.2 MW
Eccleshall Biomass	Eccleshall, Stafford	August 2007	2.7 MW
Sigeric Business Park	Hereford, Herefordshire	January 2010	1.0 MW

Pipeline (April 2022 to March 2026)

Number of pipeline sites	Total capacity
3	0.5 MW

There is a small pipeline of three sites, ranging from 7-400 kW in size. These sites have been assigned connection years based on their development progress and scenario assumptions.

Pipeline analysis			
Status	**Scenario outcomes**	**Sites**	**Capacity**
Operational	This single site at Harper Adams University appears to already be commissioned. This connection is therefore assumed to go ahead in the first year of every scenario.	1	0.4 MW
Too small to evidence	Two projects of 7 kW and 70 kW capacity respectively are too small to evidence in planning, and have been assumed to progress in 2023 due to their very small scale.	2	0.1 MW

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

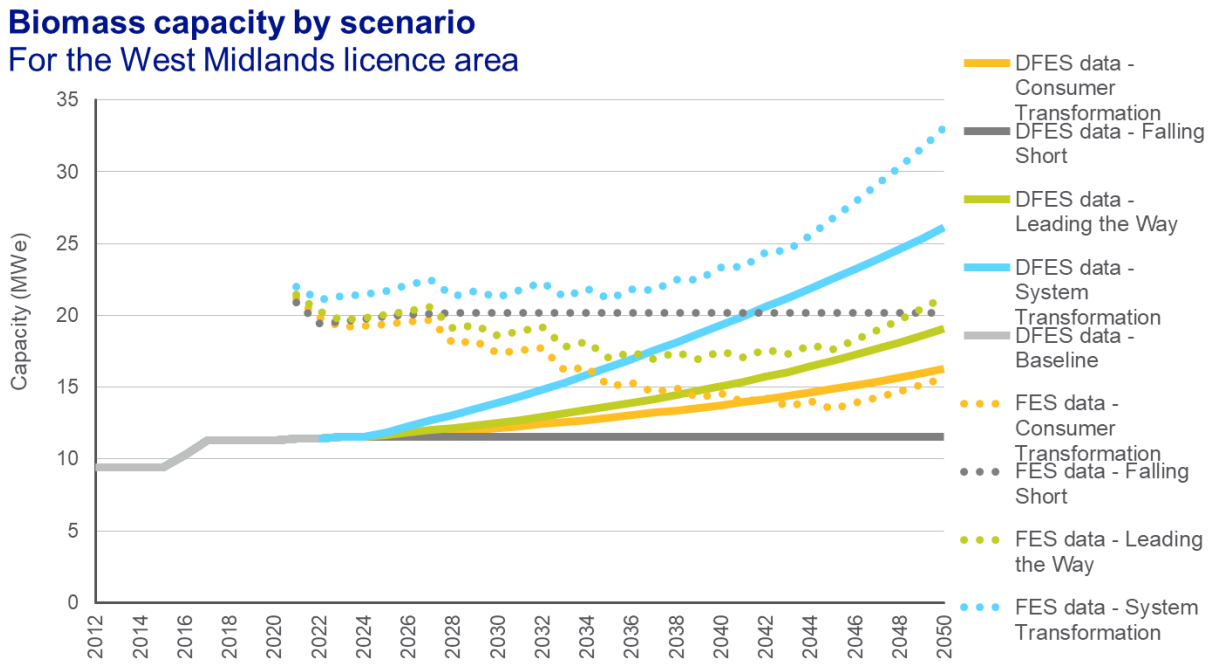
Due to its relatively small scale, the 2.7 MW standalone biomass generation baseline site is assumed to operate at the same capacity throughout the scenario timeframe in all four scenarios.

The fate of biomass CHP generation on the distribution network is strongly dependent on the demand for biomass from non-power sectors under each scenario, as detailed below.

Scenario	CHP generation	Capacity by 2050
Leading the Way	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.	18 MW
Consumer Transformation		16 MW
System Transformation	While heat is dominated by hydrogen, biomass CHP sees uptake in the longer term in areas not connected to the hydrogen network.	25 MW
Falling Short	Biomass CHP sees no further growth under this scenario, as decarbonisation is slow and many sectors do not fully decarbonise.	12 MW

Reconciliation with National Grid FES 2022

Figure 18 – Electrical capacity of biomass by scenario, West Midlands licence area



- The FES GSP-level baseline for the West Midlands licence area is approximately twice the DFES baseline. The reasons for this are unclear.
- In the longer term, the DFES aligns with the overall distribution-connected biomass trend in the national FES, in which CHP biomass generation on the distribution network increases under all three net zero scenarios as a means to decarbonise heat and industry.
- The FES GSP-level projections for the West Midlands show a decrease in capacity under the **Leading the Way** and **Consumer Transformation** scenarios, which is consistent with the FES assumptions for standalone biomass power generation. As over three-quarters of the West Midlands DFES baseline consists of biomass CHP, this trend is not seen in the DFES projections under these scenarios.

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 West Midlands licence area

Electricity generation from sewage gas, landfill gas and anaerobic digestion

Data summary for renewable engines in the West Midlands licence area:

Capacity (MWe)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	126	127	126	122	82	70	65
System Transformation		127	148	146	106	94	90
Consumer Transformation		130	181	188	150	140	136
Leading the Way		130	188	198	161	152	149

Summary:

- The 137 MW baseline of renewable engines in the West Midlands 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 minimal, totalling 8 MW.
- 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 the UK 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 an 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 137 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	52	47 MW	The majority of anaerobic digestion baseline capacity are small-scale sites located at farms in rural areas. The baseline also includes a 14 MW food waste site in Shropshire that provides 40% of the energy needs of a local aluminium plant[xxvi].

Sewage gas	13	18 MW	Sewage gas generation consists of small-scale sites of up to 5 MW, located at sewage treatment works in the licence area. These sites mainly provide onsite CHP generation.
Landfill gas	33	61 MW	The landfill gas baseline consists of small-scale sites of up to 5 MW near urban areas. All but one of these sites were connected between 1994 and 2016.

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 deployment during the 2010s.

Type of site	Number of sites	Capacity	Scenario outcomes
Anaerobic digestion	4	7.1 MW	A 3 MW site in Wychavon appears to currently be a gas-to-grid injection site and has been modelled to switch to electricity generation in the three net zero scenarios. Of the remaining sites, one is less than 100 kW and modelled to connect under every scenario. The other two sites, both 2 MW in size, are in early stages of planning or have no public evidence of development and are modelled to connect only under **Consumer Transformation** and **Leading the Way**.
Landfill gas	1	0.6 MW	This site, located in Kidderminster, has a recent connection agreement with no evidence of further development. As a result, this site is modelled to connect only under **Consumer Transformation** and **Leading the Way**.

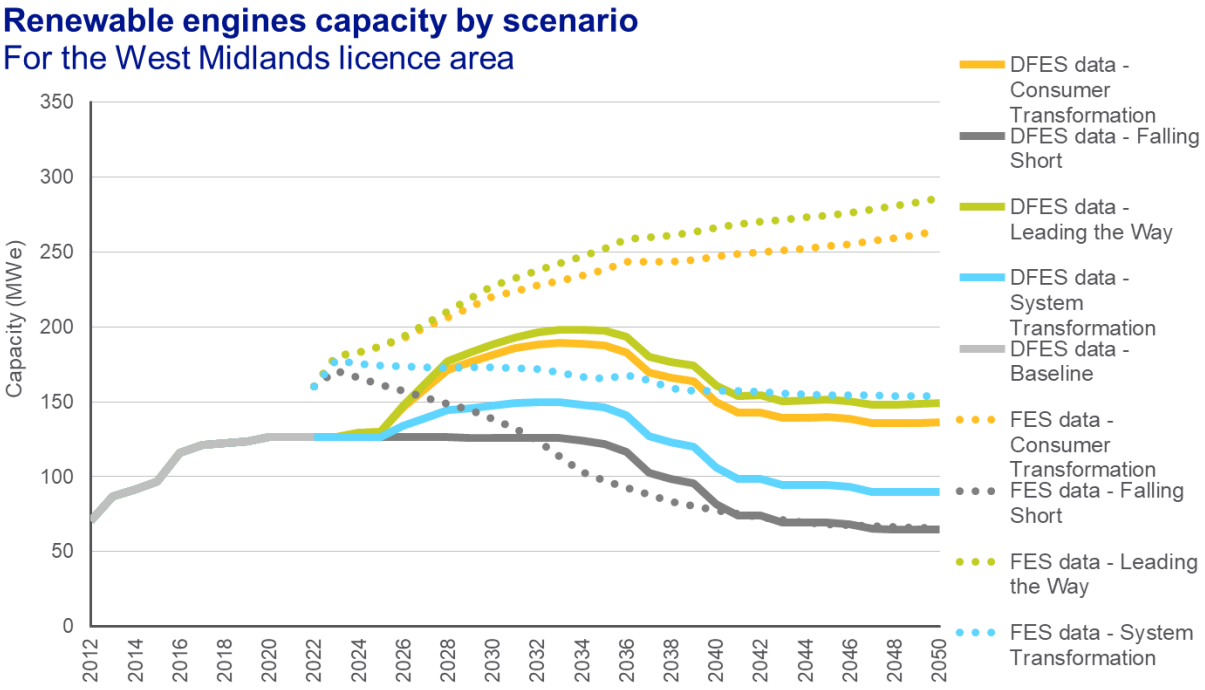
Medium and long-term projections (April 2026 to March 2050)

Type of site	Scenario outcomes
Anaerobic digestion	Future deployment of anaerobic digestion capacity has been informed by the existing baseline and pipeline in each licence area. 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 future outcomes of the three renewable energy technologies, total connected capacity by 2050 is higher than the current baseline under **Consumer Transformation** and **Leading the Way**. This is due to the deployment of anaerobic digestion under these scenarios. 2050 capacity is lower than the baseline under **System Transformation** and **Falling Short**, due to lower levels of renewable engine deployment.

Scenario	2050 capacity
Falling Short	65 MW
System Transformation	90 MW
Consumer Transformation	136 MW
Leading the Way	149 MW

Figure 19 – Electrical capacity of renewable engines by scenario, West Midlands licence area



- The FES baseline for renewable engines in the West Midlands licence area is c. 40 MW higher than the DFES. The reason for this small difference is not known. The FES 2021 was more closely aligned with the DFES baseline.
- 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 decrease in capacity in the 2020s in the FES projections under **Falling Short** is not reflected in the DFES, as no evidence has been found regarding decommissioning of baseline sites in the near term.
- The DFES projections under the three net zero scenarios are below the FES scenario projections in the medium and long term. This is due to the modelling of specific baseline and pipeline site types, and the significant capacity of landfill gas sites with a limited operating life in the licence area under these scenarios. The long-term projections under **Falling Short** are well aligned between the DFES and FES.

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 England, DEFRA

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

Diesel generation in the West Midlands 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 West Midlands licence area:

Capacity (MWe)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	140	141	99	50	0	0	0
System Transformation		136	50	0	0	0	0
Consumer Transformation		136	50	0	0	0	0
Leading the Way		80	0	0	0	0	0

Summary:

- The West Midlands licence area has a number of existing operational diesel engines, including 61 MW of larger standalone commercial diesel generation sites and 80 MW of behind-the-meter backup generators co-located with large energy user buildings.
- There is one site with an accepted connection agreement from NGED in the licence area; a 1 MW behind-the-meter backup generator in Haresfield, which applied for planning permission in 2021. Due to its likely role as a standby generator, this site is modelled to connect in every scenario in the 2023 financial year.
- 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**
7 sites (61 MW)	31 sites (80 MW)
Largest baseline site:	36.7 MW diesel generator on Northwick Estate, Cotswold

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 is one site with an accepted connection agreement from NGED in the West Midlands licence area; a 1 MW behind-the-meter backup generator in Haresfield, which applied for planning permission in 2021. Due to its role as a backup generator, this site is modelled to connect in every scenario in the 2023 financial year.

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.

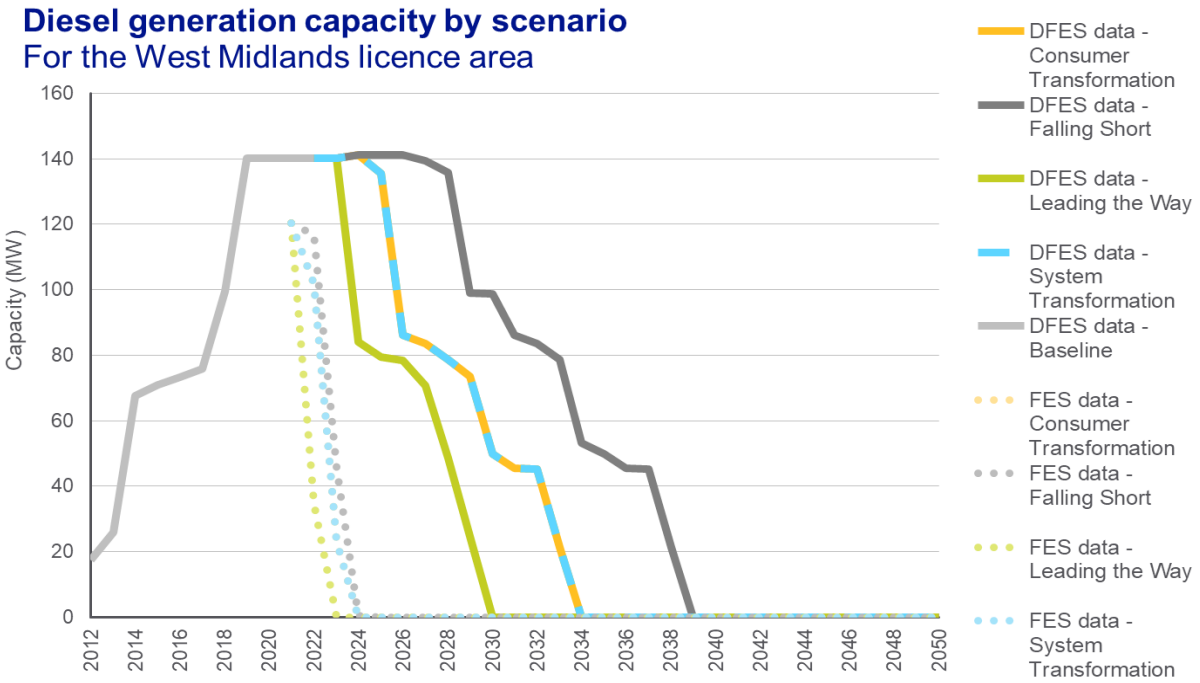
Scenario	Description	Earliest decommissioning year
Falling Short	No sites are modelled to disconnect in this timescale as it is assumed that the requirements under the MCPD do not fully encourage generator sites to decommission or relinquish export capacity by March 2025.	2026 (standalone) 2027 (backup)
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. The largest of these is a 37 MW generator in the Cotswold, which was built in 2013.	2024 (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 (97 MW) decommissioning by 1 January 2025. A handful of 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 2040 under **Falling Short**.	2033 (standalone) 2039 (backup)
System Transformation **Consumer 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 a year.	2030 (standalone) 2034 (backup)
Leading the Way	All standalone diesel generators are modelled to decommission by 2025, with a handful of backup generators (48 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 20 – Installed capacity of diesel generation by scenario, West Midlands licence area



- The current installed capacity of diesel generation in the West Midlands licence area is c.25 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 (49 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 33 existing and scoped 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 West Midlands 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 West Midlands licence area:

Capacity (MWe)		Baseline	2025	2030	2035	2040	2045	2050
OCGT (non-CHP)	Falling Short	100	100	100	100	100	100	100
	System Transformation		100	100	100	0	0	0
	Consumer Transformation		100	100	100	0	0	0
	Leading the Way		100	0	0	0	0	0
Reciprocating engines (non-CHP)	Falling Short	168	205	313	313	313	313	311
	System Transformation		203	142	123	37	0	0
	Consumer Transformation		203	142	123	37	0	0
	Leading the Way		135	121	0	0	0	0
Gas CHP	Falling Short	193	204	205	196	196	196	193
	System Transformation		112	102	59	5	0	0
	Consumer Transformation		112	102	59	5	0	0
	Leading the Way		101	58	0	0	0	0

Summary:

- There is a moderate baseline (c. 461 MW) of existing operational fossil gas-fired generation connected to the distribution network in the West Midlands 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 21 sites with accepted connection offers with NGED in the West Midlands licence area, comprising five gas CHPs (13 MW) and 16 applications for reciprocating engines, which total an additional 169 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[xxvii], 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[xxviii] also advised government to "produce a comprehensive long-term plan for weaning Great Britain off unabated gas power by 2035".
- Under **Falling Short** the installed capacity of gas reciprocating engines and gas CHPs increases in the near term as gas generators play an increasingly important role as flexible generation in the absence of strong growth in low carbon forms of flexibility.

- Leading the Way sees the most rapid decommissioning of existing fossil gas-fired generation, as this scenario models the quickest route to decarbonisation. This scenario also reflects a shift to lower carbon forms of flexibility.
- The need to accelerate a reduced dependence on fossil fuels in the UK, including to fuel flexible/dispatchable sources of generation, has come into sharp focus with the Russian invasion of Ukraine, necessitating the move away from Russian fossil fuels.
- Whilst the installed capacity of fossil gas generation may remain stable in some scenarios, the annual operating hours and energy output are assumed to decrease significantly by 2050 in all scenarios as the electricity system is decarbonised.
- At a national level, after 2030, hydrogen-fuelled generation becomes a potentially economical source of supply-side flexibility in some scenarios. This results in some existing fossil gas generation site locations 'repowering' with hydrogen-fuelled electricity generation assets between 2030 and 2050. The hydrogen-fuelled generation scenario analysis and results are outlined separately in 'Hydrogen-fuelled generation in the West Midlands licence area'.

Modelling assumptions and results

Baseline		
There are 103 fossil-gas generation sites connected in the West Midlands licence area, totalling 461 MW. This is broken down into the following fossil gas technologies:		
Sub-technology	**Number of sites**	**Total capacity**
OCGT (non-CHP)	1	100 MW
Reciprocating engines (non-CHP)	44	168 MW
Gas CHP	58	193 MW
Pipeline (April 2022 to March 2028)		
Sub-technology	**Number of pipeline sites**	**Total capacity**
Reciprocating engines (non-CHP)	**16**	**169 MW**
Gas CHP	**5**	**13 MW**

Pipeline analysis			
Status	**Scenario outcomes**	**Sites**	**Capacity**
Planning permission granted	There are six sites totalling 36 MW with an accepted connection offer from NGED, that have also received planning permission. All of these sites have either not bid into any Capacity Market auctions or have unsuccessfully prequalified. Therefore, they are modelled to connect under all scenarios except **Leading the Way**, due to the focus on low carbon flexibility assets.	6	36 MW
Planning application submitted	One 7.5 MW site is awaiting a planning decision, hence, it has been modelled to connect under **Falling Short** only.	1	7.5 MW

Planning application submitted	The other 14 sites with connection offers from NGED are pre-planning: • Six of these sites (34 MW) have secured a Capacity from a recent Capacity Market auction. These have been modelled to connect in time to meet their Capacity Market delivery years under all scenarios. • One site (6.9 MW) prequalified in a Capacity Market auction and is modelled to connect in all scenarios except **Leading the Way**. • Sites without any information in planning or the Capacity Market have been modelled to connect under **Falling Short** only.	14	138 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[xxix] , 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.

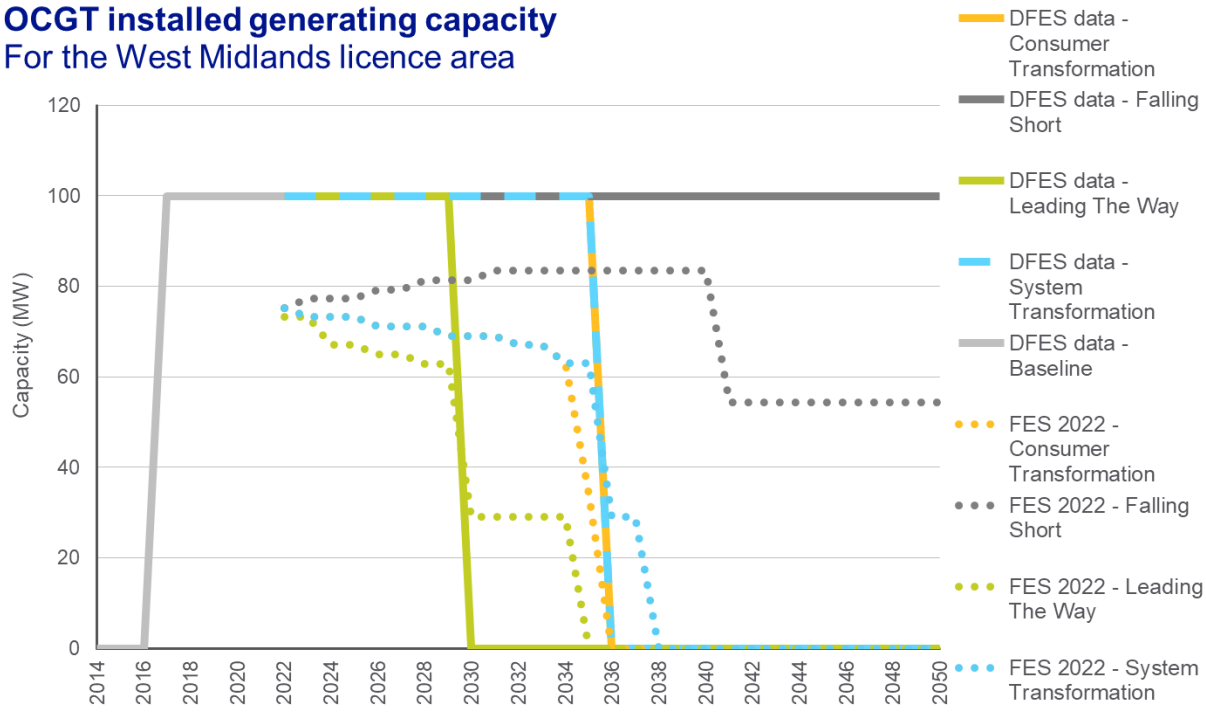
Sub-technology	Scenario	Description	Decommissioning timescale
OCGT (non-CHP)	**Leading the Way**	All OCGT capacity is modelled to decommission in the three net zero scenarios.	2030
	Consumer Transformation		2036
	System Transformation		2036
	Falling Short	The existing 100 MW capacity is modelled to remain 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	2024 - 2035

		flexibility such as electricity storage, bioenergy and hydrogen.	
	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 - 2042
	System Transformation		2024 - 2042
	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 329 MW in 2029, some capacity is modelled to decommission, reflecting some transition away from fossil-fuel-driven flexibility. However, 327 MW remains in operation in 2050.	2047 – 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 buildings such as factories, universities, hospitals or industrial sites. Under the three net zero scenarios, no additional increase in gas CHP capacity is modelled beyond the mid-2020s, and all gas CHP capacity is modelled to decommission by 2050 at the latest.	2024 – 2035
	Consumer Transformation		2024 - 2042
	System Transformation		2024 - 2042
	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 193 MW still operational by this period.	2035 – post-2050

Reconciliation with National Grid FES 2022

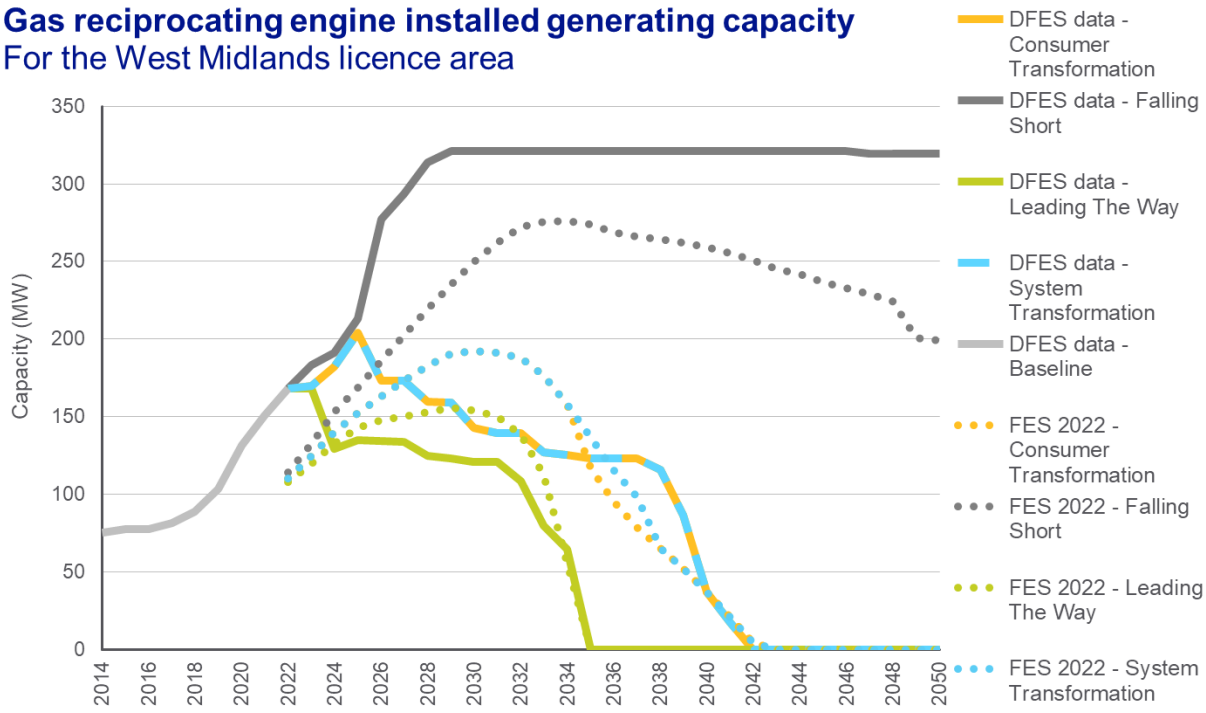
- For all of the fossil gas sub-technologies included, the DFES has sought to classify each of the baseline and pipeline sites based on connection data held by National Grid and through site-by-site reconciliation with Capacity Market registers published by the EMR Delivery Body.
- Each pipeline site 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 21 – Electrical capacity of OCGTs generation by scenario, West Midlands licence area



- The DFES baseline is slightly higher than that of the FES. The reason for this is unclear, but could be related to differences in sub-technology classification.
- As there is only a single 100 MW operational OCGT site in the DFES baseline, it is modelled to fully decommission in 2030. Whereas, the FES projections has modelled a more phased reduction in capacity.

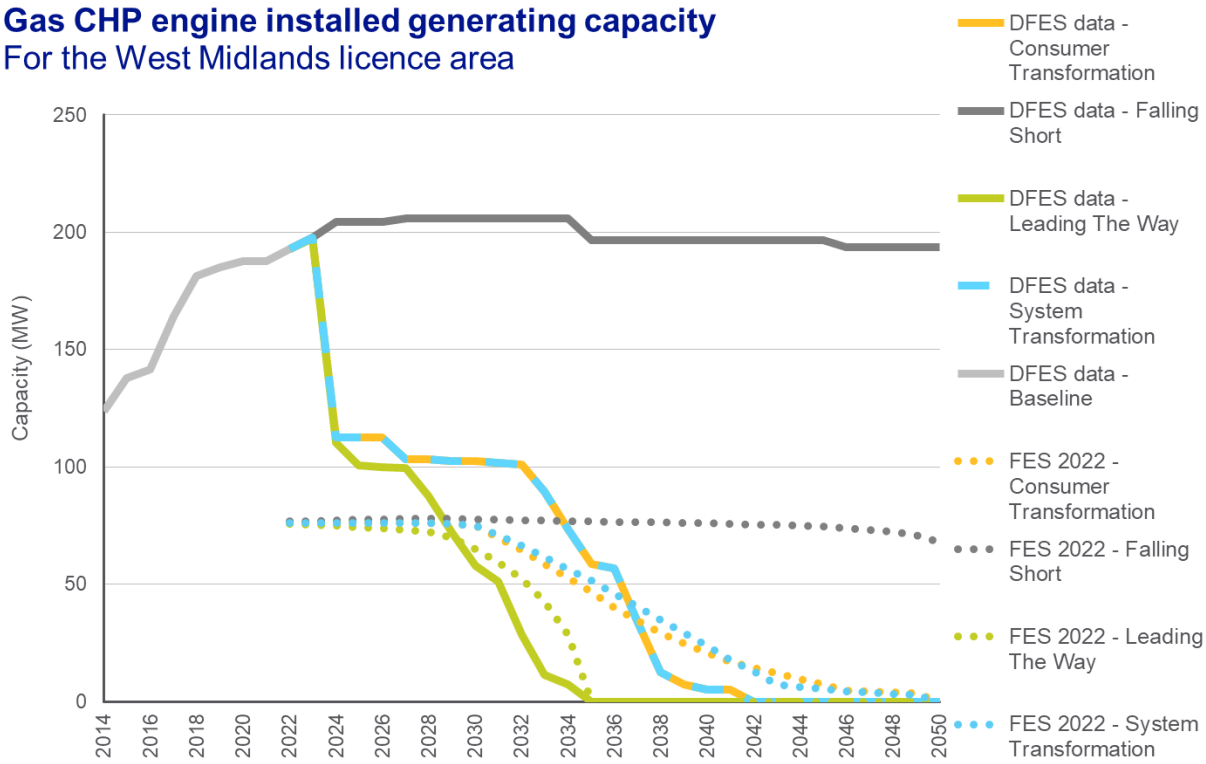
Figure 22 – Electrical capacity of fossil gas reciprocating engines by scenario, West Midlands licence area



- The DFES baseline is notably higher than that of the FES 2022. The reason for this is unclear.

- However, the near-term growth is aligned with the FES projections, when adjusted for the baseline variance. This increase in capacity is due to a large pipeline of reciprocating engines that could connect in the next few years due to having accepted connection agreements and positive activity in Capacity Market auctions.
- By 2050, the DFES 2022 projections have a higher capacity of gas reciprocating engines under **Falling Short** than the FES 2022. This is more aligned with the national FES projections, which assume that under **Falling Short**, gas plays an increasingly important role as flexible generation in the absence of strong growth in low carbon forms of flexibility.
- The decommissioning of reciprocating engine capacity in the DFES is less smooth than modelled in the FES, but is representative of individual sites relinquishing their connection agreements over time.

Figure 23 – Electrical capacity of fossil gas CHPs by scenario, West Midlands licence area



- The DFES baseline is notably higher than the FES 2022 baseline; the reason for this is unclear, but could be related to sub-technology classification.
- The near-term decommissioning in the DFES modelling results in the projections aligning closely to the FES in the 2030s under the three net zero scenarios.
- Under **Falling Short**, the decommissioning trend aligns with the FES; however, more capacity remains operational by 2050 in the DFES due to the higher baseline.

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 West Midlands 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 West Midlands licence area:

Capacity (MWe)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	0	0	0	0	0	0	0
System Transformation		0	3	54	117	288	363
Consumer Transformation		0	0	24	67	78	121
Leading the Way		0	20	182	214	428	568

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'[xxx] 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 suggested that 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 that have been identified as potential hydrogen supply zones, based on analysis undertaken for hydrogen electrolysis capacity in the West Midlands 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 the West Midlands, this is centred on Birmingham, as well as the areas around the M5, which runs the length of the licence area. The areas around Staffordshire and Worcester are also included, due to the presence of potential large-scale hydrogen storage in the salt field basins.
- 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 more overall 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 West Midlands has a moderate amount of existing gas and diesel generating capacity (c. 607 MW) along with a further pipeline of 182 MW. Therefore, in high hydrogen scenarios, the West Midlands licence area could 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 likely to be an expensive fuel and production at scale unlikely to be developed until the late 2020s or later.

- However, there is strong support for the role low carbon hydrogen can play in providing flexible power generation, which is covered in the UK Hydrogen Strategy[xxxi]. In July 2021, the UK government published a call for evidence on 'decarbonisation readiness'[xxxii] for new power generation. It is expected that from 2030, plants would be capable of accepting 100% hydrogen. This is also supported by the development of hydrogen turbine technology from leading manufacturers[xxxiii].

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 West Midlands licence area, or nationally.

However, there is currently 461 MW of gas-fired power generation and 146 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.

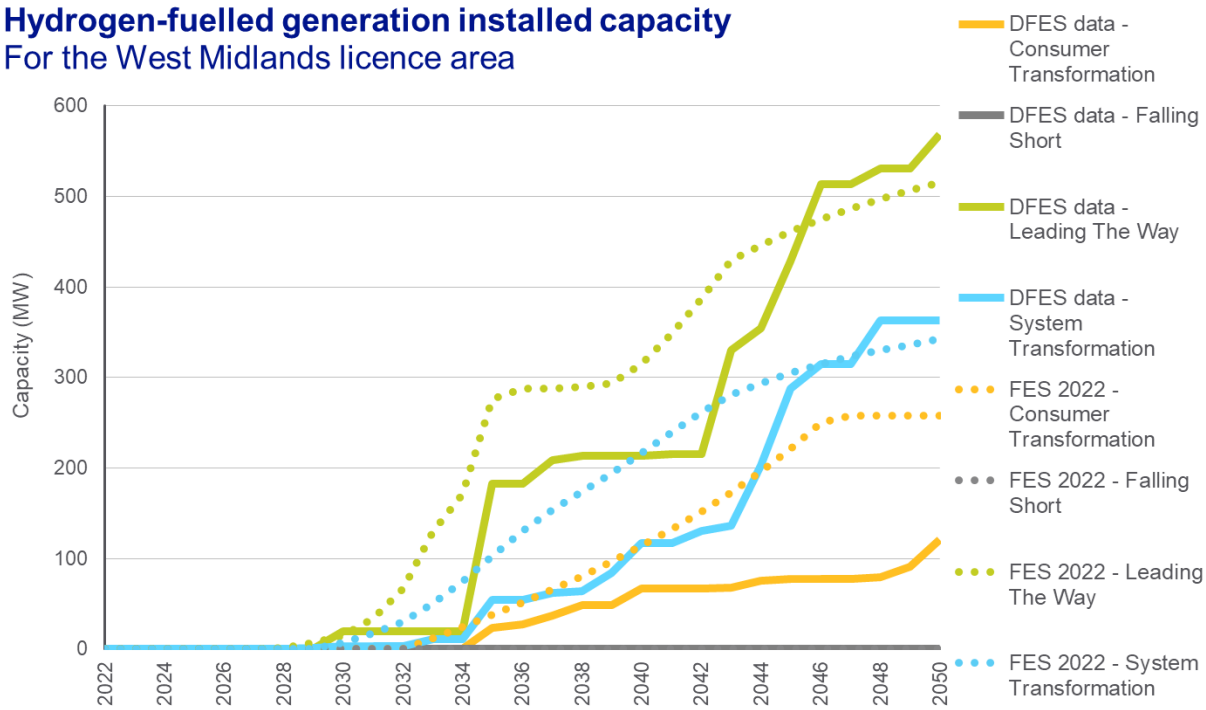
There are key sites in the West Midlands which may be early adopters of hydrogen, including the industrial regions of Birmingham and the areas around the Staffordshire and Worcester salt field basins, which could be used as large-scale hydrogen storage.

Projections have therefore centred around an analysis of existing (c. 600 MW) and pipeline (c. 180 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. 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.	214 MW	568 MW

	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 (723 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**.	67 MW	121 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.	117 MW	363 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 24 – Electrical capacity of hydrogen-fuelled generation by scenario, West Midlands licence area



- The DFES 2022 projections echo the uptake of hydrogen-fuelled generation at a national level as modelled in the FES 2022. In the West Midlands licence area, the DFES and FES projections are fairly well aligned, although **Consumer Transformation** is significantly lower under DFES 2022 than FES 2022 by 2050.
- 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 2030s, followed by a more rapid uptake from 2040 onwards.

Factors that will affect deployment at a local level

Factor	Source
Location of existing and known commercial gas and diesel sites in the West Midlands 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 West Midlands licence area

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

Data summary for waste incineration in the West Midlands licence area:

Capacity (MWe)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	319	369	421	421	370	345	345
System Transformation		369	421	345	345	232	200
Consumer Transformation		369	371	295	295	182	150
Leading the Way		369	371	295	295	182	150

Summary:

- Energy recovery from waste is considered the fourth level of the waste management hierarchy behind waste prevention, preparation for reuse and recycling[xxxiv]; however, electricity generation from unabated waste incineration is at odds with net zero targets, due to the level of associated carbon emissions.
- In the West Midlands licence area, there is 319 MW of existing operational waste incineration capacity (313 MW incineration, 54 MW ACT), as well as two incineration sites (52 MW) and one ACT site (50 MW) with accepted connection agreements.
- 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 (69 MW) are modelled to continue operating past 2050.

Modelling assumptions and results

Baseline	
Number and capacity of incineration sites	**Number and capacity of ACT sites**
14 sites (265 MW)	4 sites (54 MW)
Largest baseline site:	37.6 MW Hampton Loade Water Treatment Works incinerator

Pipeline (April 2022 to March 2030)	
Number and capacity (MW) of incineration sites	**Number and capacity (MW) of ACT sites**
2 sites (52.1 MW)	1 site (50 MW)

Pipeline analysis			
Status	**Scenario outcomes**	**Sites**	**Capacity**
Under construction	Kelvin waste-to-energy facility in Sandwell (49.9 MW) was granted planning permission in September 2019 and began construction in November 2021. Therefore, it is modelled to connect under all scenarios in 2024.	1	49.9 MW
Planning permission granted	Liberty Aluminium's 2.2 MW project received planning permission in September 2021 and is modelled to connect between 2025 and 2026, depending on the scenario. A 50 MW ACT site in Walsall received planning permission in September 2013. Due to the time since planning permission was granted, without any indication of construction, this site has only been modelled to connect under **System Transformation** and **Falling Short** in 2025.	2	52.2 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.

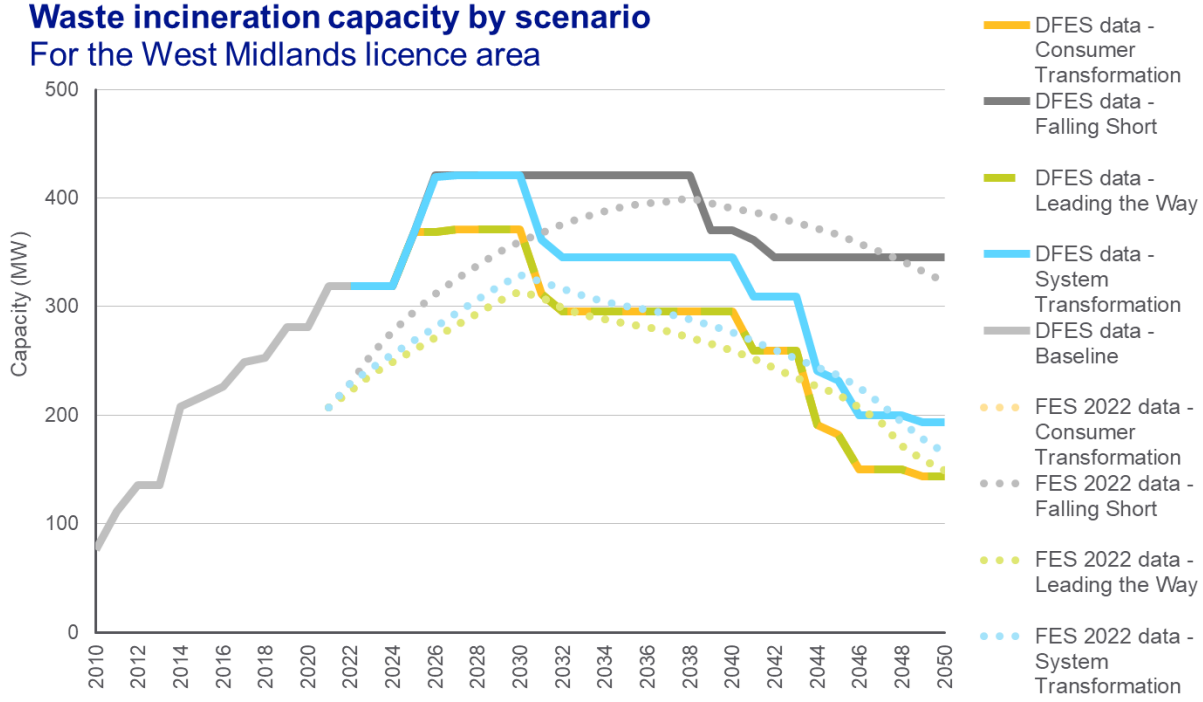
- IEA Bioenergy, in its 'Waste Incineration for the Future' paper[xxxv], concluded that, in order to remain relevant and continue to create value in a circular economy, the waste sector will have to innovate in energy technologies, system design and integration and business models.
- Additionally, a 2021 Deloitte study[xxxvi] 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[xxxvii], 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.	6	150 MW
Consumer Transformation	A number of large incineration sites are modelled to stay connected to the distribution network, under the assumption that these larger sites will have adopted abatement technologies or other innovative carbon reduction technologies, so they can continue to operate on a net zero electricity system.	6	150 MW
System Transformation	ACT gasification plants have lower associated carbon emissions, and any residual emissions can be abated, hence all ACT sites (69 - 119 MW, depending on the scenario) are modelled to continue operating past 2050. **System Transformation** has one more site (50 MW) remaining operational than **Leading the Way** and **Consumer Transformation**, due to the modelled connection of a new ACT site with planning permission.	7	200 MW
Falling Short	No significant changes in how society manages waste are assumed under this scenario, leaving waste available as a resource for unabated electricity generation. As a result, the majority (408 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.	18	345 MW

Reconciliation with National Grid FES 2022

Figure 25 – Electrical capacity of waste incineration by scenario, West Midlands licence area



- DFES 2022 analysis has 174 MW more operational waste incineration capacity in the West Midlands licence area than the FES 2022 data. The reasons for this are unclear but could relate to technology classification or spatial distribution of operational sites.
- The DFES 2022 assumptions align with FES 2022; however, the capacity projections differ due to the DFES's project-based approach, which identifies and models operational and scoped projects with connection agreements.
- For example, FES 2022, under **Falling Short**, models the connection of new waste incineration capacity until 2038, whereas DFES modelling models new capacity to connect until 2026, based on known sites with planning permission. Due to lengthy planning and construction timelines, it is assumed to be unlikely for additional sites not already with a connection agreement to be built in the 2030s. Some older sites are also modelled to decommission in the late 2030s and 2040s in the DFES 2022.

Other generation in the West Midlands licence area

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

Data summary for other generation in the West Midlands licence area:

Capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	2	5	5	5	5	5	5
System Transformation		5	5	5	5	5	5
Consumer Transformation		5	5	5	5	5	5
Leading the Way		5	5	5	5	5	5

Summary:

- There are eleven other generation sites that have not been categorised as a particular technology, connected to the distribution network in the West Midlands licence area, totalling 2 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 35 additional other generation sites in the West Midlands with an accepted connection agreement, totalling 3 MW. As with the baseline sites, these small-scale sites could not be positively identified as a specific technology. These pipeline sites have, therefore, been modelled to connect in 2023 under every scenario.
- There are no projections for other generation beyond the pipeline of accepted connections.

[xvii] UK installed 730MW of solar PV in 2021
[xviii] The UK's solar landscape to 2030
[xix] Council Climate Plan Scorecards 2022
[xx] Future homes are solar homes – Solar Energy UK
[xxi] Building Regulations (Part L)
[xxii] Response to Scottish Building Regulations - Solar Energy UK
[xxiii] RWE completes German wind farm repowering, 2022
[xxiv] Council Climate Plan Scorecards 2022
[xxv] Environment Agency's outrageous fee hike 'pours cold water' on future small hydro schemes in England
[xxvi] Bridgenorth Aluminium Limited
[xxvii] Transitioning to a net zero energy system: Smarts Systems and Flexibility Plan 2021, BEIS
[xxviii] Sixth Carbon Budget, Climate Change Committee, 2020
[xxix] BEIS Carbon emissions limits in the Capacity Market, Sept 2020
[xxx] A day in the life of 2035
[xxxi] BEIS UK Hydrogen Strategy, Aug 2021
[xxxii] Call for evidence on the expansion of the 2009 Carbon Capture Readiness requirements
[xxxiii] GE hydrogen fuelled gas turbines
[xxxiv] The future of waste incineration in a modern circular economy, NABU, 2020
[xxxv] Waste incineration for the future, IEA Bioenergy, 2019
[xxxvi] How consumers are embracing sustainability, Deloitte, 2021
[xxxvii] Energy from waste, A guide to the debate, DEFRA, 2014

Storage technologies

Results and assumptions

Battery storage in the West Midlands 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 West Midlands licence area:

Capacity (MW)		Baseline	2025	2030	2035	2040	2045	2050
Standalone network services	Falling Short	87	132	366	369	373	376	380
	System Transformation		132	366	373	376	390	393
	Consumer Transformation		132	1,084	1,116	1,138	1,159	1,180
	Leading the Way		316	1,084	1,116	1,138	1,159	1,180
	Storage Planning		709	2,265	3,519	4,366	4,755	4,755
Generation co-location	Falling Short	4	4	104	108	109	114	115
	System Transformation		105	109	117	127	130	132
	Consumer Transformation		105	144	153	171	174	177
	Leading the Way		105	154	169	198	215	216
	Storage Planning		367	510	621	821	821	821
Behind-the-meter high-energy user	Falling Short	0	0	13	31	37	64	73
	System Transformation		0	13	47	93	150	170
	Consumer Transformation		1	24	82	115	217	247
	Leading the Way		1	41	79	140	214	244
	Storage Planning		1	5	18	28	31	31
Domestic batteries	Falling Short	0.1	2	4	10	19	44	85
	System Transformation		4	31	47	99	155	224
	Consumer Transformation		10	83	183	320	469	716
	Leading the Way		15	107	240	402	608	931

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[xxxviii].
- 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[xxxix].
- The West Midlands licence area currently has 46 operational battery storage sites, totalling 91 MW. 1.3 MW of this has connected since the DFES 2021 analysis was completed, which stems from 31, mainly domestic, sites.
- The West Midlands licence area also has the largest pipeline of battery storage projects with accepted connection offers across National Grid's network: 160 projects totalling c. 6 GW.
- Based on Regen analysis, over 1 GW of the storage pipeline has either received or submitted planning permission or entered into the Capacity Market. Additionally, over 3.3 GW 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 timescale of projects in the pipeline to connect at distribution level and have been reflected in 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 West Midlands licence area has a strong potential for long-term growth in connected storage capacity across National Grid's network. This is due to:
    - Significant 33kV and 132kV network infrastructure across the licence area for standalone battery storage projects to provide system services
    - Good potential for distributed renewable energy deployment, enabling co-location
    - The highest number of non-domestic properties with the potential for behind-the-meter batteries across National Grid's network
    - A significant potential capacity for domestic rooftop solar by 2050, enabling a notable capacity of domestic batteries to be co-located in homes.
- Overall battery storage capacity in 2050 in the West Midlands licence area ranges from 653 MW in **Falling Short** to 2.6 GW in **Leading the Way**.
- Under the **Storage Planning** scenario, which only applies to large-scale storage, 5.6 GW is modelled to connect by 2050.

Baseline

There are 46 battery storage projects totalling 91 MW currently connected to the distribution network in the West Midlands licence area, all of which have come online since 2017. 1.3 MW of this has connected since April 2021, when the DFES 2021 analysis was carried out. This comprises 31, mainly domestic, sites.

The largest operational site is the 41 MW storage asset at Bloxwich Industrial Estate which connected in 2018.

Business model	Number of sites	Total capacity (MW)
Standalone network services	4	87 MW
Generation co-location	16	4.3 MW
Behind-the-meter high-energy user	0	0
Domestic batteries	26	0.1 MW

Pipeline (April 2022 to March 2029)

Business model	Number of pipeline sites	Total capacity
Standalone network services	91	5,051 MW
Generation co-location	25	866 MW
Behind-the-meter high-energy user	8	35 MW
Domestic batteries	36	0.2 MW

The West Midlands licence area also has the largest pipeline of battery storage projects with accepted connection offers across NGED's network, with 160 projects totalling c. 6 GW. In comparison, the pipeline of projects with accepted connection offers from DFES 2021 was 560 MW, showing a significant increase in developer appetite for storage projects in the last 12 months.

Based on Regen's analysis, over 1 GW of the storage pipeline has either received or submitted planning permission or entered into the Capacity Market. Additionally, over 3.3 GW 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.

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[xl]: Dynamic Containment, Dynamic Regulation and Dynamic Moderation. In addition to this, the ESO has launched a new Slow Reserve service[xli] and continues to deliver its network options assessment pathfinders[xlii] 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 National Grid'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. 1MW) in the known pipeline and these sites are included in the modelling of the four DFES scenarios.

Pipeline analysis			
Status	**Scenario outcomes**	**Sites**	**Capacity**
Planning permission granted	• Two sites (45 MW) have secured a Capacity Market agreement and have been modelled to meet their contracted delivery year under all scenarios. • A 100 MW battery site in South Gloucestershire was granted planning permission in January 2021 and successfully prequalified for the 2022/23 Capacity Market auction. This site has been modelled to connect in: ○ **Falling Short: 2027** ○ **System Transformation: 2025** ○ **Consumer Transformation: 2024** ○ **Leading the Way: 2024** ○ **Storage Planning: 2024** • The other six sites (234 MW) have been modelled to connect between three and seven years from receiving planning permission, depending on the scenario.	8	379 MW
Planning application submitted	• There are 13 sites (763 MW) in the West Midlands licence area that have submitted a planning application but have not been found in the Capacity Market. These have not been modelled to connect under **System Transformation** or **Falling Short** due to lower flexibility requirements in these scenarios. • This includes a 280 MW project in Staffordshire Moorlands which submitted a planning application in August 2022.	13	763 MW
No information	• Modelling projects with positive planning information to connect already exceeds the FES 2050 projections under all scenarios; therefore, the remaining 88 sites (accounting for 4.5 GW) without any Capacity Market or planning information have only been modelled to connect under the **Storage Planning** scenario across the 2030s and 2040s.	88	4,526 MW
Too small for planning	• 47 sites, totalling 0.8 MW, have connection agreements with NGED but are too small to need to apply for planning. This includes all domestic installations. These sites are modelled to connect in 2024 under all scenarios.	47	0.8 MW

Medium and long-term projections (April 2029 to March 2050)

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 co-located 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 2.6 GW by 2050. This reflects a strong potential deployment landscape of batteries across all four business models.

Falling Short sees the lowest overall storage deployment in the licence area, reaching 653 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 is reflected in the longer term out to 2050, across all storage business models.

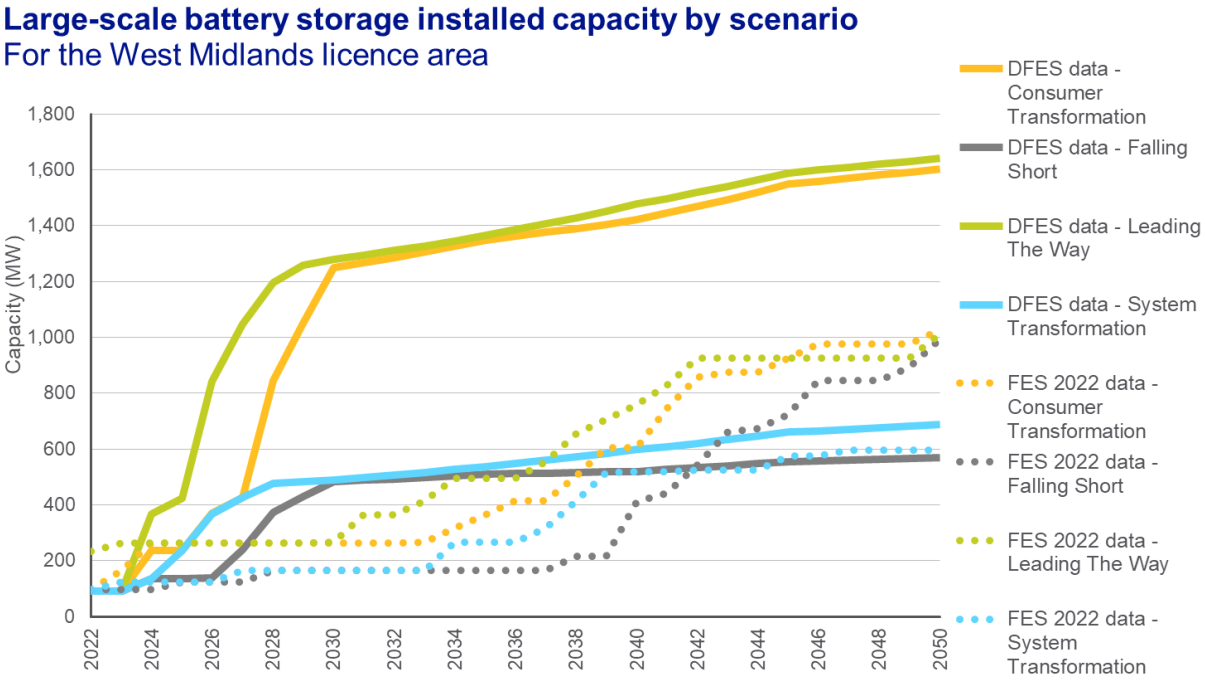
The **Storage Planning** scenario is a bespoke view of the very large pipeline of battery storage projects with an accepted connection offer from NGED. This scenario projection considers all sites, except those that have been rejected in planning, will go through to connection across the scenario timeframe, resulting in 5.6 GW of connected battery storage by 2050. This scenario mirrors the breakdown of the current pipeline by business model, hence 4.7 GW of this is standalone projects targeting grid services.

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. The growth in capacity reduces beyond the late 2030s out to 2050, reflecting a saturation of distribution network capacity and flexibility markets, reducing the number of large-scale standalone projects seeking to connect in the longer term.	**Falling Short**	369	380
		System Transformation	373	393
		Consumer Transformation	1,116	1,180
		Leading the Way	1,116	1,180
		Storage Planning	3,519	4,755
Generation co-location	Generation co-location capacity sees a moderate uptake in the West Midlands licence area, reflecting a lower combined ground-mounted solar PV and onshore wind development by 2035, when compared to other licence areas across all scenarios.	**Falling Short**	108	115
		System Transformation	117	132
		Consumer Transformation	153	177
		Leading the Way	169	216
		Storage Planning	621	821
Behind-the-meter high-energy user	The West Midlands licence area has the highest number of non-domestic properties with the potential for a battery across NGED's network. Thus, the uptake of behind-the-meter storage projects in the licence area is also significant across all scenarios by 2035.	**Falling Short**	31	73
		System Transformation	47	170

	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.	**Consumer Transformation**	82	247
		Leading the Way	79	244
		Storage Planning	18	31
Domestic batteries	The licence area has significant potential for domestic battery deployment in the medium term, due to the number of homes overall and significant domestic-scale rooftop PV deployment projections. Significant uptake of domestic storage is delayed until the longer term, with projections reflecting stakeholder feedback that domestic storage will be the business model with the lowest uptake in the near-to-medium term.	**Falling Short**	10	85
		System Transformation	47	224
		Consumer Transformation	183	716
		Leading the Way	240	931

Reconciliation with National Grid FES 2022

Figure 26 – Electrical capacity of large-scale battery storage by scenario, West Midlands licence area

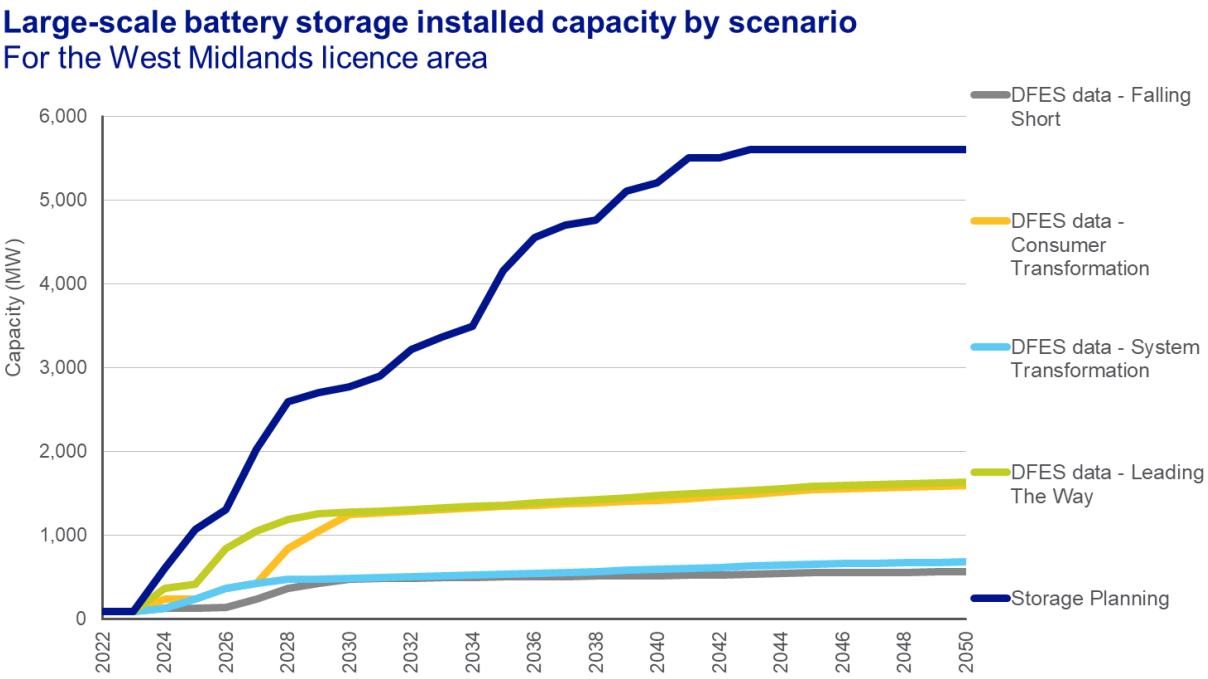


- The FES 2022 data is well aligned with the DFES baseline for the West Midlands licence area.
- Reflecting the very near-term pipeline, the DFES 2022 projections significantly exceed the FES 2022 near-term projections in all scenarios, reaching c.1.3 GW by 2028 under **Leading**

the Way, nearly 1 GW more than FES. This is based on a detailed assessment of planning status, Capacity Market auction activity and direct engagement with battery project developers.

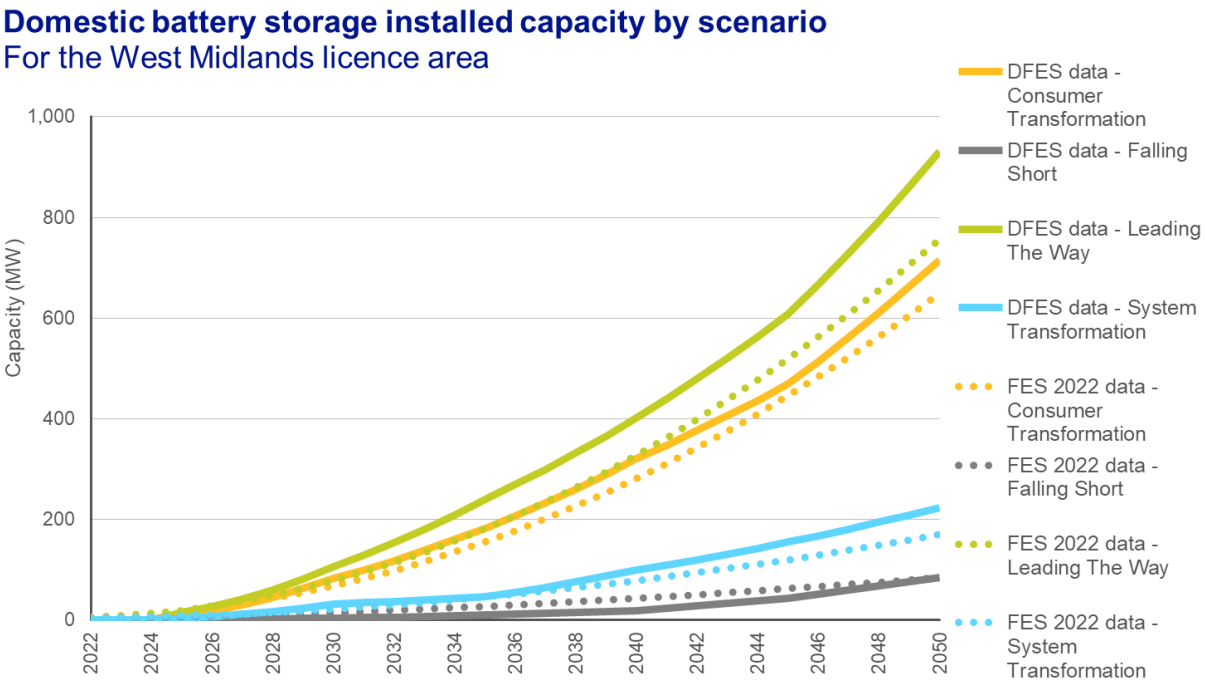
- The DFES 2022 has a wider spread of outcomes by 2050 for large-scale battery storage, reflecting the large near-term pipeline and the assumptions applied under different scenarios.
- In all scenarios, except for **Falling Short**, the DFES results in higher overall projections by 2050 than the FES. The DFES projections have aligned more closely with national FES trends than those at a licence area level.

Figure 27 – Electrical capacity of large-scale battery storage by scenario (including the Storage Planning scenario), West Midlands 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 battery projects with connection agreements with NGED.
- For context, the **Storage Planning** scenario is c. 4 GW higher than **Leading the Way** and **Consumer Transformation**, and c. 5 GW higher than **Falling Short** and **System Transformation** by 2050. 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 West Midlands licence area, which is not accounted for in the envelope of the four FES scenarios.

Figure 28 – Electrical capacity of **domestic** battery storage by scenario, West Midlands licence area



- The DFES 2022 projections for domestic batteries align well with FES 2022 across the analysis period and in all scenarios, with slightly more capacity projected under the DFES analysis due to the West Midlands licence area having a higher number of houses than the other NGED licence areas.

Factors that will affect deployment at a local level

Factor	Source
Location of existing and known pipeline sites in the West Midlands 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

[xxxviii] Transmission Entry Capacity (TEC) register
[xxxix] Large-scale battery storage in the UK: Analysing the 16GW of projects in development
[xl] National Grid ESO frequency response services
[xli] National Grid ESO Slow Reserve service
[xlii] National Grid ESO NOA Pathfinders

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