Distribution Future Energy Scenarios 2022

Results and assumptions report

East Midlands licence area

Electricity Distribution

nationalgrid

Foreword by National Grid DSO

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

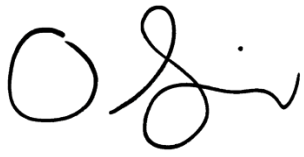
We have worked with Regen to help us understand what the changes that are forecast throughout the next decade and beyond might mean for our distribution network and the investment that may be needed to meet customers' changing needs. These forecasts are the foundation of our strategic investment process,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

This report summarises the 2022 Distribution Future Energy Scenarios (DFES) study for the East 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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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.

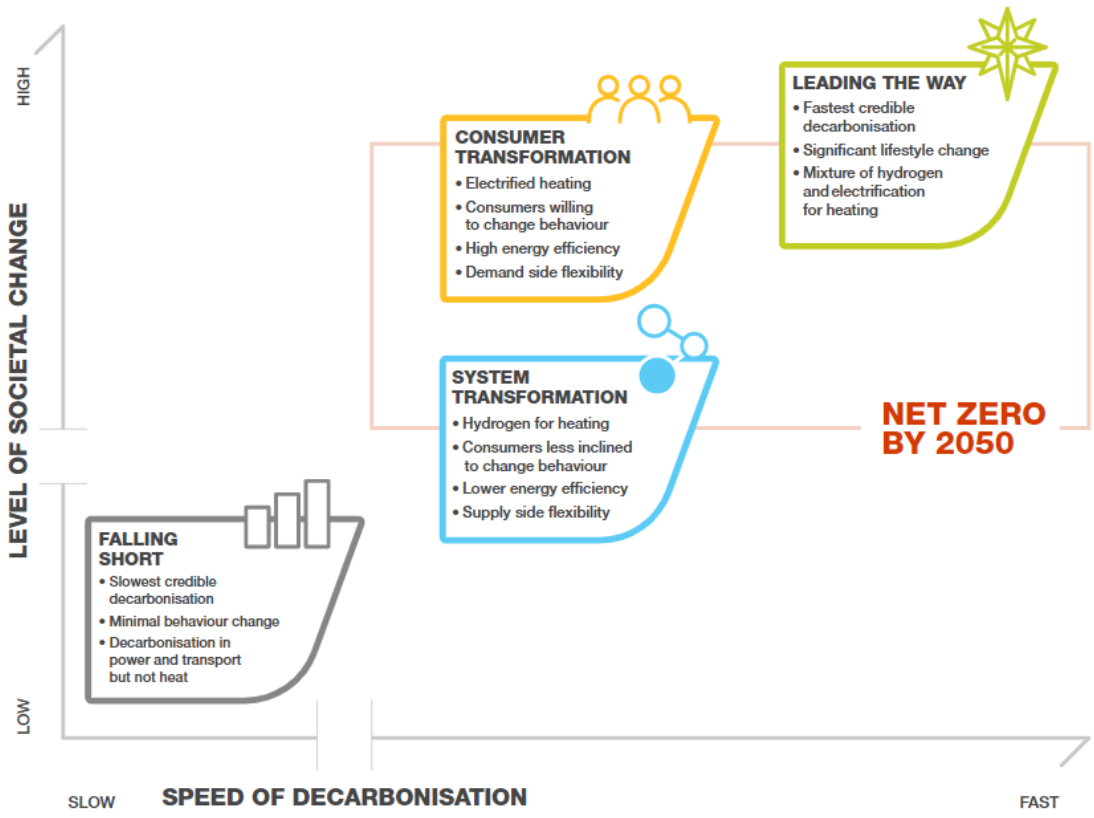
The DFES projections are directly informed by stakeholder engagement to reflect local and regional drivers, the ambitions of local authorities and national governments, and views of other sector stakeholders, such as project developers, technology companies and community groups.

For the DNOs, the DFES allows network planners to model and analyse different future load scenarios for their network. This data then informs integrated network planning and investment appraisal processes. The DFES also provides a key data resource and evidence base to enable NGED to appraise different investment options and develop the business case necessary to support future investment and regulated business plans.

Scenarios

The NGED DFES uses the National Grid ESO Future Energy Scenarios (FES) 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 East Midlands licence area

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

Aspect	Characterisation
Geography	The NGED East Midlands licence area can be broadly divided into the western high-population corridor along the M1, through Leicester, Milton Keynes, Derby and Nottingham, and the more rural eastern side, characterised by high-grade agricultural land and a strip of North Sea coastline.
Distributed electricity generation	Distributed electricity generation in the area has increased significantly over the last five-to-six years. Over 50% of capacity has connected since 2015. Fossil gas-fired power and solar PV make up over two-thirds of the distributed electricity generation capacity, owing largely to Corby Power Station in Northamptonshire, with a connection capacity of over 400 MW.
Energy resources	Despite having lower solar irradiance than more southern areas of the UK, the East Midlands has been attractive to solar developers. There are also a number of onshore wind farms in the east and south of the licence area.
Distributed electricity demand	Currently, less than 1% of East Midlands households have an electric vehicle, and less than 0.5% have an electric heat pump.
Policy and government	The East Midlands licence area contains over 60 local authorities, including city region councils like Nottingham City Council and Leicester City Council.

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

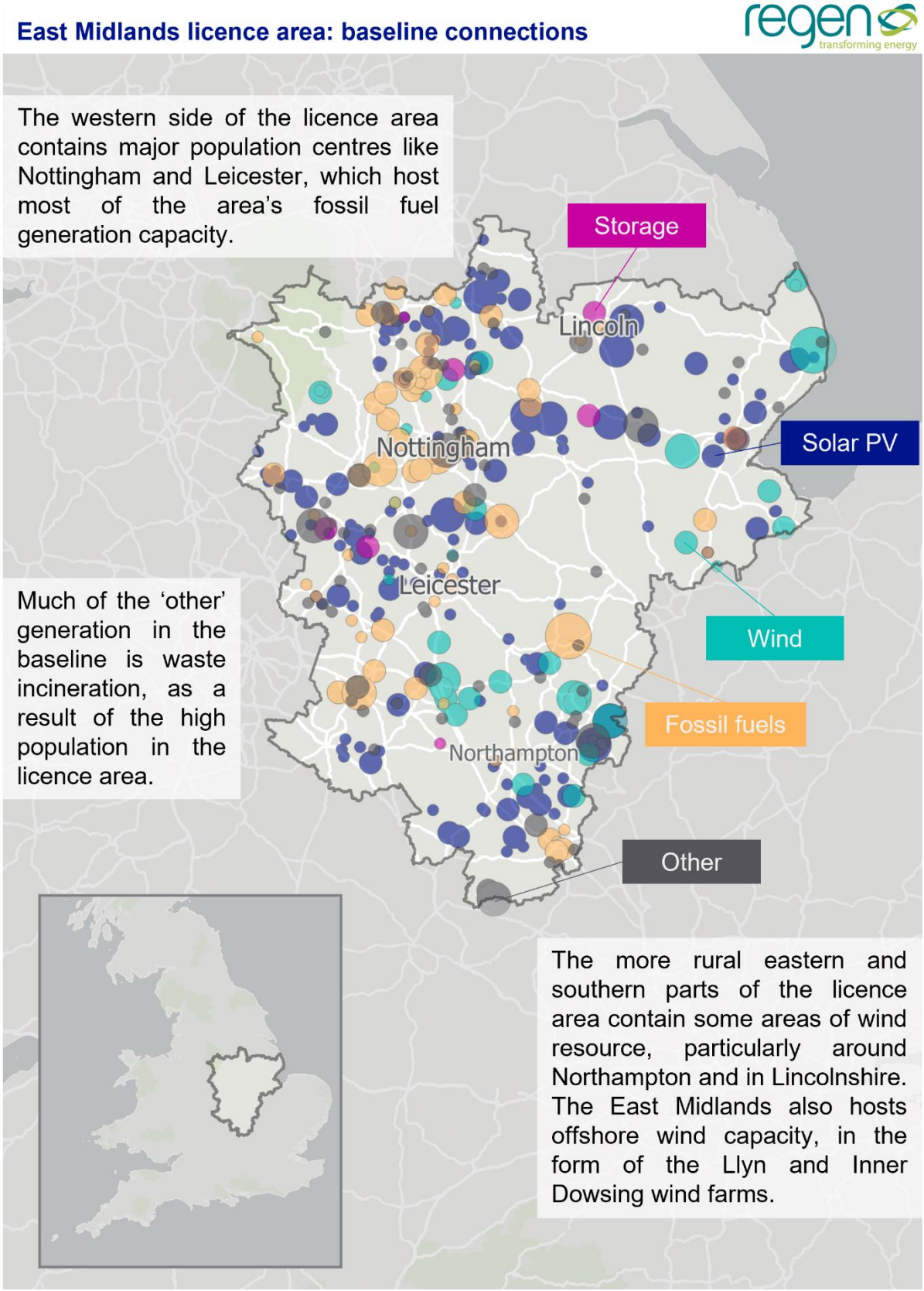
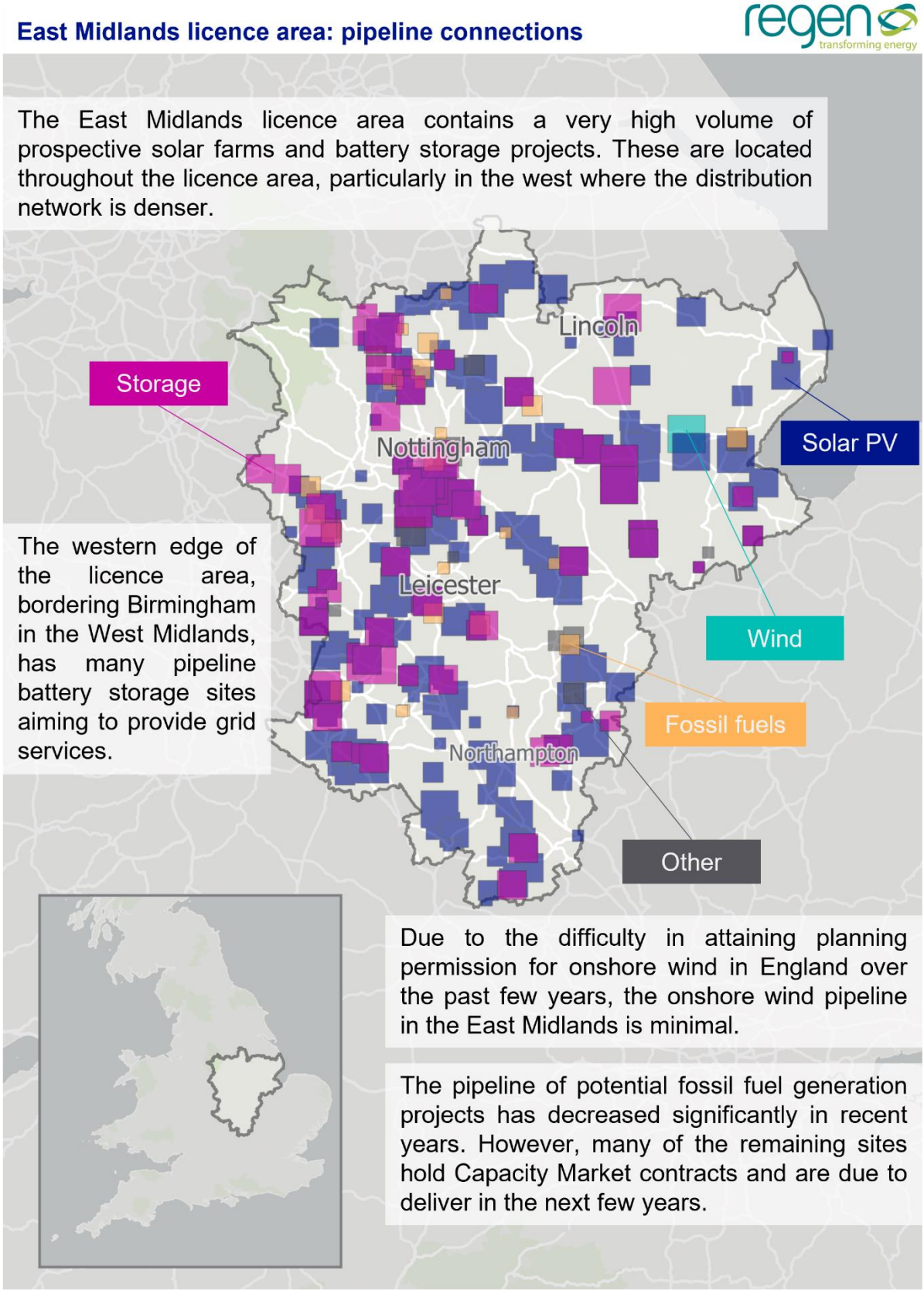


Figure 4 - The NGED East Midlands licence area, with the location of proposed 'pipeline' large-scale generation and storage sites



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 a 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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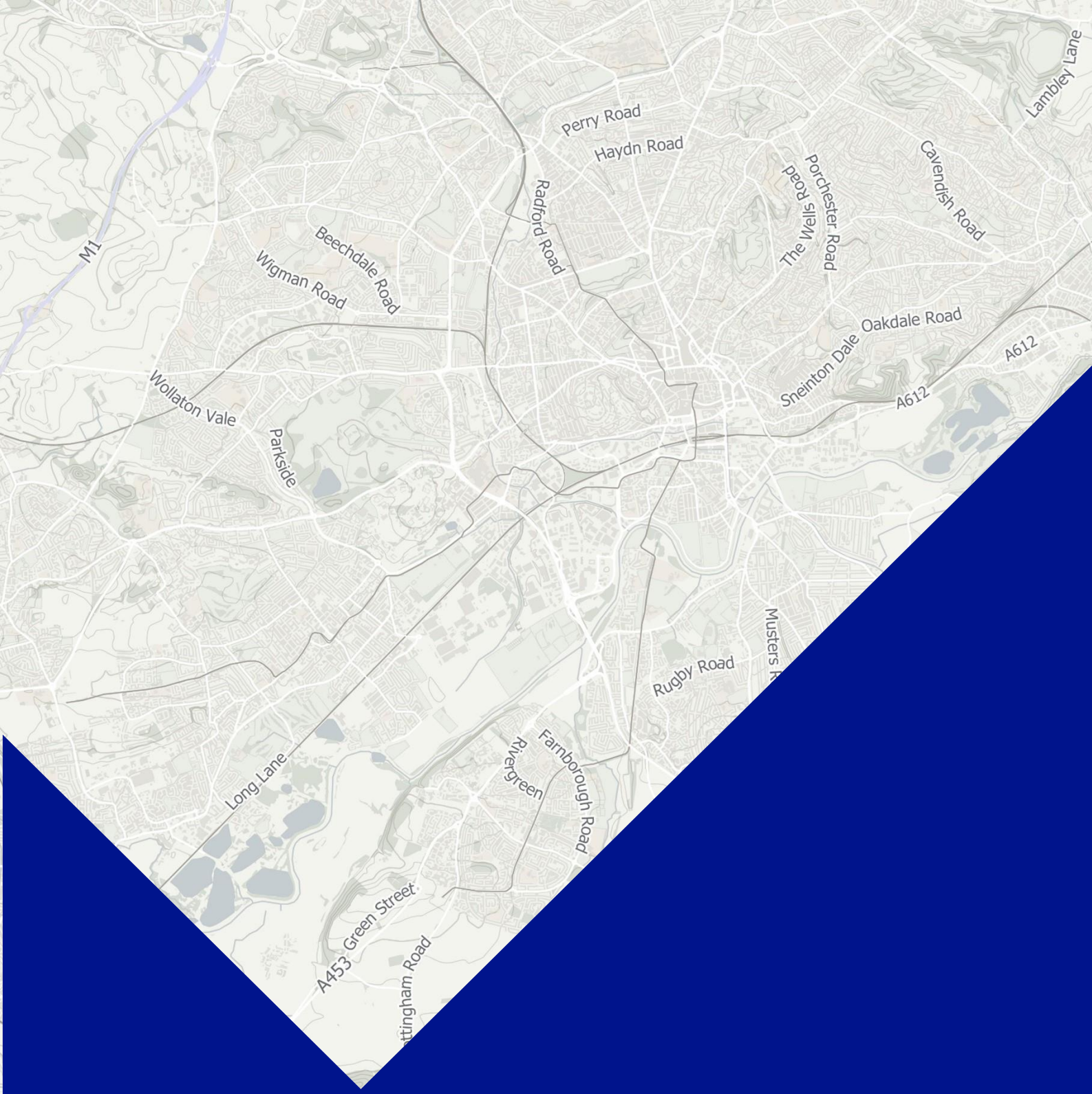
[i] National Grid ESO FES building block data



Demand technologies

Results and assumptions

Domestic electric heat in the East Midlands licence area

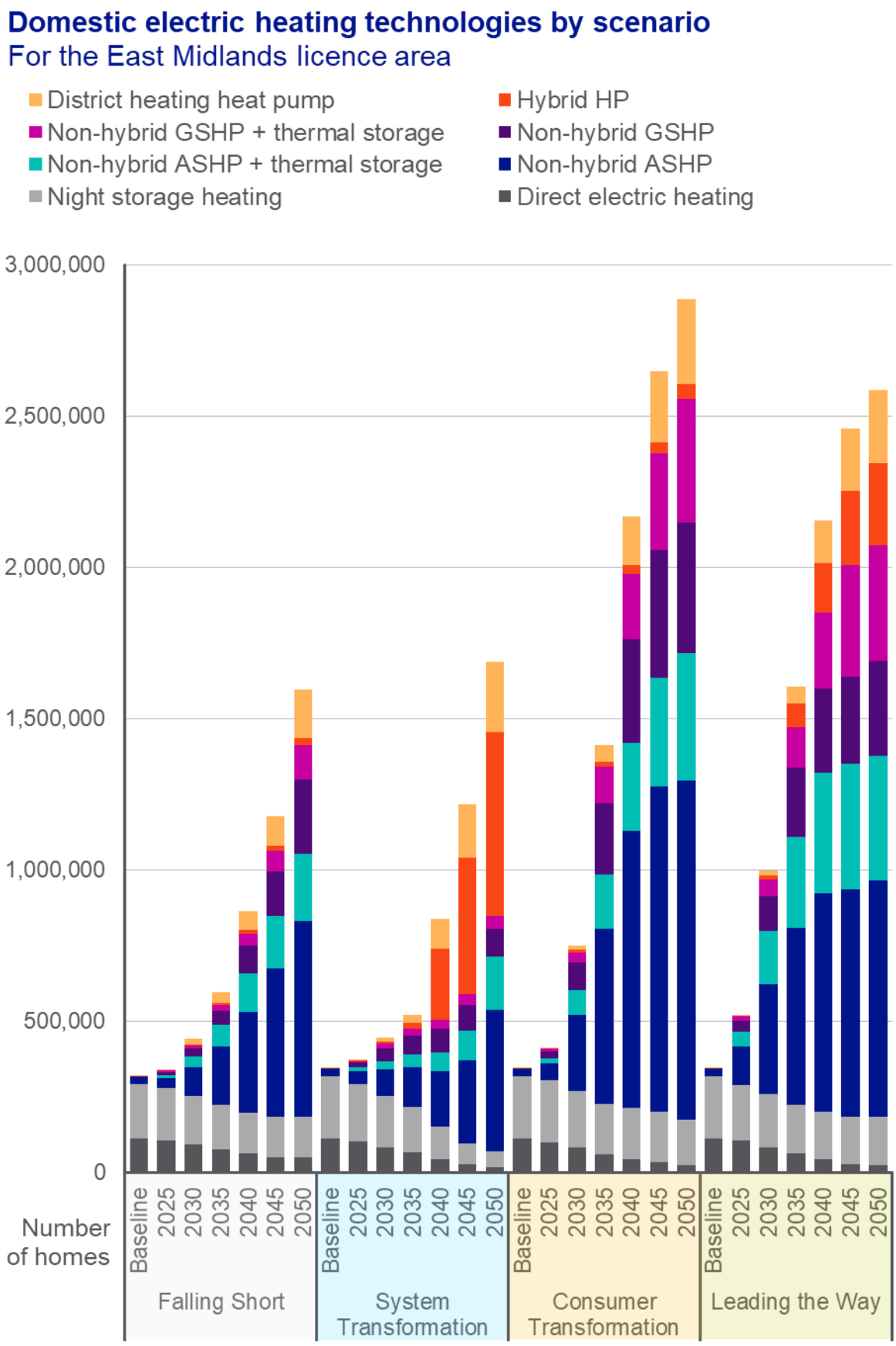
Domestic dwellings where electricity is the primary fuel for space heating and hot water, delivered through a heat pump or resistive electric heater.

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

Number of homes (thousands)		Baseline	2025	2030	2035	2040	2045	2050
Non-hybrid heat pumps* (without thermal storage)	Falling Short	28	45	122	239	425	638	893
	System Transformation		59	132	195	262	358	559
	Consumer Transformation		78	343	814	1,256	1,495	1,554
	Leading the Way		163	479	816	1,000	1,043	1,096
Non-hybrid heat pumps* with thermal storage	Falling Short	0	14	44	91	167	242	338
	System Transformation		17	41	64	94	136	221
	Consumer Transformation		24	114	298	509	681	827
	Leading the Way		63	232	436	650	780	792
Hybrid heat pumps	Falling Short	0	0	3	7	13	18	22
	System Transformation		2	6	19	233	449	607
	Consumer Transformation		1	8	18	27	37	49
	Leading the Way		2	12	75	165	246	273
Connections to heat pump-driven district heat networks	Falling Short	0.2	1	19	36	61	98	159
	System Transformation		1	10	26	98	178	232
	Consumer Transformation		1	14	57	160	235	282
	Leading the Way		1	16	58	138	206	240
Resistive electric heating	Falling Short	292	280	254	225	199	185	184
	System Transformation		274	243	212	153	107	84
	Consumer Transformation		286	257	221	209	199	178
	Leading the Way		273	249	217	199	185	187

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

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



Summary:

- The East Midlands licence area has a broad range of housing, from dense areas of on-gas houses and flats in built-up urban areas such as Leicester, Nottingham and Milton Keynes, to more rural, off-gas areas along the east coast. Overall, the building stock in the licence area is representative of 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 East 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 East Midlands licence area, this results in c. 2.4 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 East 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 702-bedroom student accommodation block in Nottingham, see build-out in the near term in all scenarios. Heat networks are modelled to increase across dense population centres 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 1.1% of existing homes with a heat pump in the licence area is very slightly ahead of the national average.

Sub-technology	Number of homes	Proportion of homes
Non-hybrid ASHP	23,490	0.9%
Non-hybrid GSHP	4,490	0.2%
Hybrid heat pump	0	0.0%
Heat pump-driven district heat network	221	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 common in the East Midlands, in line with the GB average, heating around 12% of homes. The majority of these homes have night storage heaters rather than direct electric heating.

Sub-technology	Number of homes	Proportion of homes
Night storage heaters	177,989	7.1%
Direct electric heaters	114,218	4.6%

Near-term projections (April 2022 to March 2026)

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

Near-term connections to heat pump-driven heat networks are based on the existing pipeline of planned heat networks. Heat networks that are well advanced in planning, such as the Island Quarter Phase 2 student accommodation in Nottingham, are modelled to connect in the near term under every scenario.

Heat pumps

Scenario	Description	Proportion of homes with a heat pump in 2026	
		East 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 increasingly be built with heat pumps under these scenarios. The high levels of housebuilding in the East 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**.	4%	3%
Falling Short		3%	2%

Resistive electric heating

Scenario	Description	Proportion of homes with resistive heating in 2026	
		East 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.	10%	8%
Consumer Transformation	A similar proportion of direct electric heated homes convert to night storage heaters in order to reduce heating costs.	11%	7%

System Transformation	A very small proportion of resistive electric heated homes convert to a heat pump under these scenarios in the near term. However, a greater proportion moves onto the mains gas network in order to reduce heating costs. Similarly to the other two scenarios, a small proportion of direct electric heated homes convert to night storage heaters.	10%	8%
Falling Short		11%	8%

Medium-term projections (April 2026 to March 2035)

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

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

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

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

Heat pumps

Scenario	Description	Proportion of homes with a heat pump in 2035	
		East Midlands	GB (FES)
Leading the Way	In the medium term, the East 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 overall 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.	46%	42%
Consumer Transformation		40%	35%
System Transformation	Heat pump uptake in on-gas homes is minimal under this scenario, except for a small proportion of homes that install a hybrid hydrogen heat pump. This is a result of low carbon hydrogen being anticipated to replace the fossil gas network in the 2030s and 2040s under this scenario. Otherwise, the majority of heat pump uptake is limited to off-gas houses and new build homes.	10%	7%

Falling Short	Heat pump uptake in on-gas homes is minimal, as fossil gas heating remains the most common form of heating under this scenario. Otherwise, the majority of heat pump uptake is in off-gas houses.	12%	11%

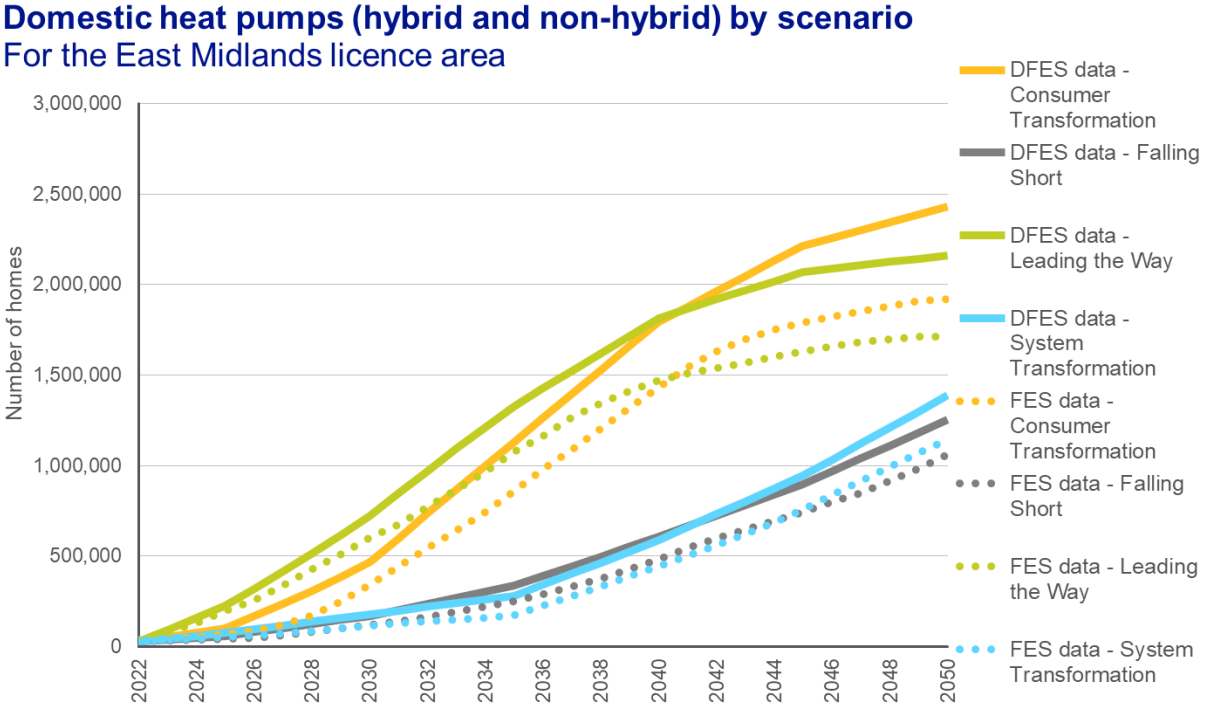
Resistive electric heating			
Scenario	**Description**	**Proportion of homes with resistive heating in 2035**	
		East Midlands	**GB (FES)**
Leading the Way	The overall number of resistive heated homes continues to decrease in the medium term, replaced by district heating in denser urban areas and flats, 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.	8%	6%
Consumer Transformation		8%	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.	7%	6%
Falling Short		8%	6%

Long-term projections (April 2035 to March 2050)			
The heat decarbonisation trends established in the medium term continue out to 2050, especially under the net zero scenarios, as the country aims to meet its decarbonisation targets.			
Heat pumps			
Scenario	**Description**	**Proportion of homes with a heat pump in 2050**	
		East 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 properties in 2050.	68%	64%
Consumer Transformation	By 2050, almost all properties are heated by standalone heat pumps, district heating or resistive electric heating by 2050.	78%	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.	45%	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 in 2050**	
		East 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.	6%	5%
Consumer Transformation		6%	5%
System Transformation		3%	2%
Falling Short		6%	5%

Reconciliation with National Grid FES 2022

Figure 6 – Number of domestic heat pumps by scenario, East 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 East Midlands is very 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 East 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 East 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 East Midlands licence area:

Number of vehicles (thousands)		Baseline	2025	2030	2035	2040	2045	2050
Battery electric cars, LGVs and motorbikes	Falling Short	58	130	453	1,237	2,534	3,650	4,001
	System Transformation		146	605	1,874	3,428	3,917	3,714
	Consumer Transformation		286	1,248	2,927	3,845	3,895	3,701
	Leading the Way		229	1,217	3,106	3,837	3,643	2,986
Plug-in hybrid electric cars, LGVs and motorbikes	Falling Short	35	60	136	251	377	259	99
	System Transformation		57	123	208	157	68	0
	Consumer Transformation		52	92	131	91	38	0
	Leading the Way		61	118	110	58	0	0
Battery electric HGVs, buses and coaches	Falling Short	0	0	1	5	21	61	86
	System Transformation		0	3	16	42	56	51
	Consumer Transformation		1	4	23	65	94	98
	Leading the Way		1	5	22	63	95	91

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

Number of chargers (thousands)		Baseline	2025	2030	2035	2040	2045	2050
Domestic chargers	Falling Short	43	90	252	699	1,439	2,079	2,135
	System Transformation		104	370	1,108	1,968	2,038	2,087
	Consumer Transformation		203	698	1,623	2,120	2,198	2,233
	Leading the Way		166	771	1,896	2,152	2,211	2,219
Non-domestic chargers	Falling Short	2	3	8	20	44	70	84
	System Transformation		3	11	34	67	78	82
	Consumer Transformation		5	19	45	63	67	71
	Leading the Way		4	17	44	60	65	69

Summary:

- 2.6% of cars in the East Midlands licence area are currently battery electric or plug-in hybrid, in line with 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 2.2 million EV chargers, which are predominantly off-street domestic chargers.

Modelling assumptions and results

Baseline

Electric vehicles

While the electric vehicle baseline represents less than 3% of all vehicles registered in the East Midlands licence area, uptake of electric vehicles across the UK has been steadily accelerating[vi]. This has been due to a number of factors, including:

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

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

Vehicle type	Thousands of vehicles
Pure electric car	50.6
Plug-in hybrid car	35.0
Pure electric LGV	6.4
Plug-in hybrid LGV	0.1
Other electric vehicles	0.6

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	43.2
	Non-domestic	1.8

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 EV drivers and increasing consumer confidence. By 2025, almost 10% of cars are electrified under these scenarios, and over 3% of LGVs and buses.	290	170
Consumer Transformation		338	208
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.	204	107
Falling Short		191	93

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.	3,238	1,940
Consumer Transformation		3,080	1,668

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.	2,099	1,142
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.	1,494	718

Long-term projections (April 2035 to March 2050)

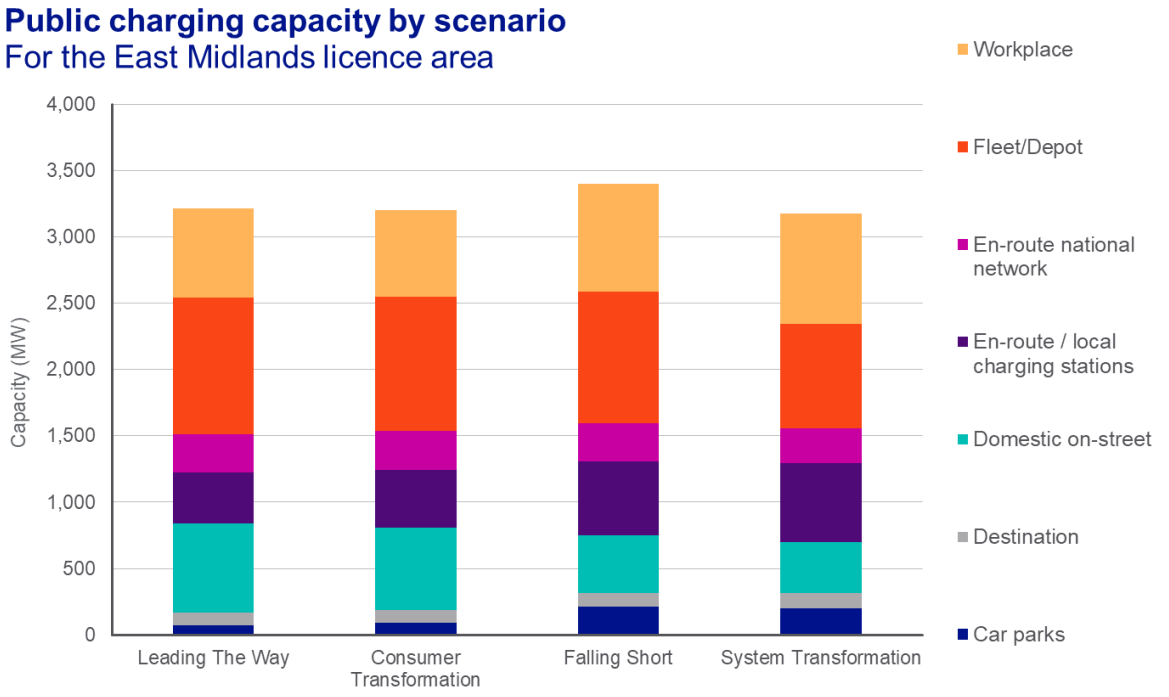
Under the three net zero scenarios, EV adoption approaches saturation and new EV uptake slows in most areas. Harder-to-electrify vehicles that saw lower uptake in the near term, such as HGVs, see a higher uptake out to 2050.

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.	3,077	2,288
Consumer Transformation		3,799	2,304
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.	3,765	2,169
Falling Short	EV adoption, and subsequent EV charger capacity, continues increasing out to 2050. By this point, almost all road vehicles are electrified. The reduction in the number of vehicles owned and on the road is less under this scenario.	4,186	2,219

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, East Midlands licence area

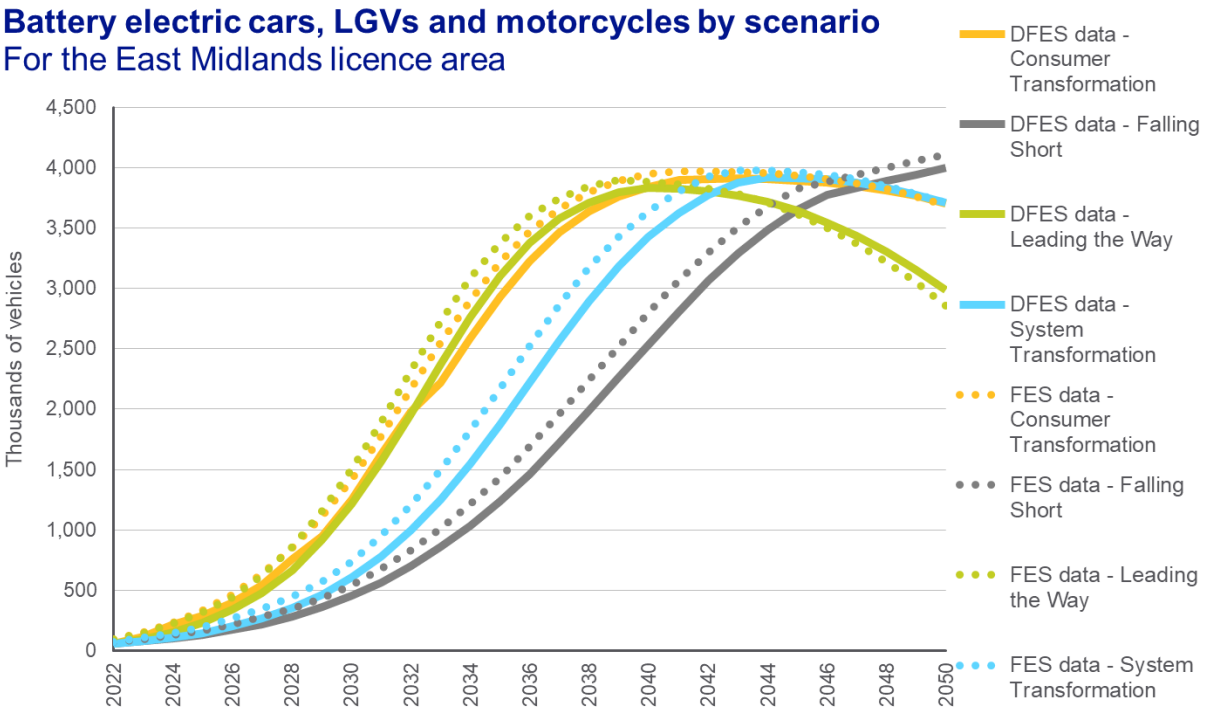


Figure 8 – Number of plug-in hybrid cars, LGVs and motorcycles by scenario, East Midlands licence area

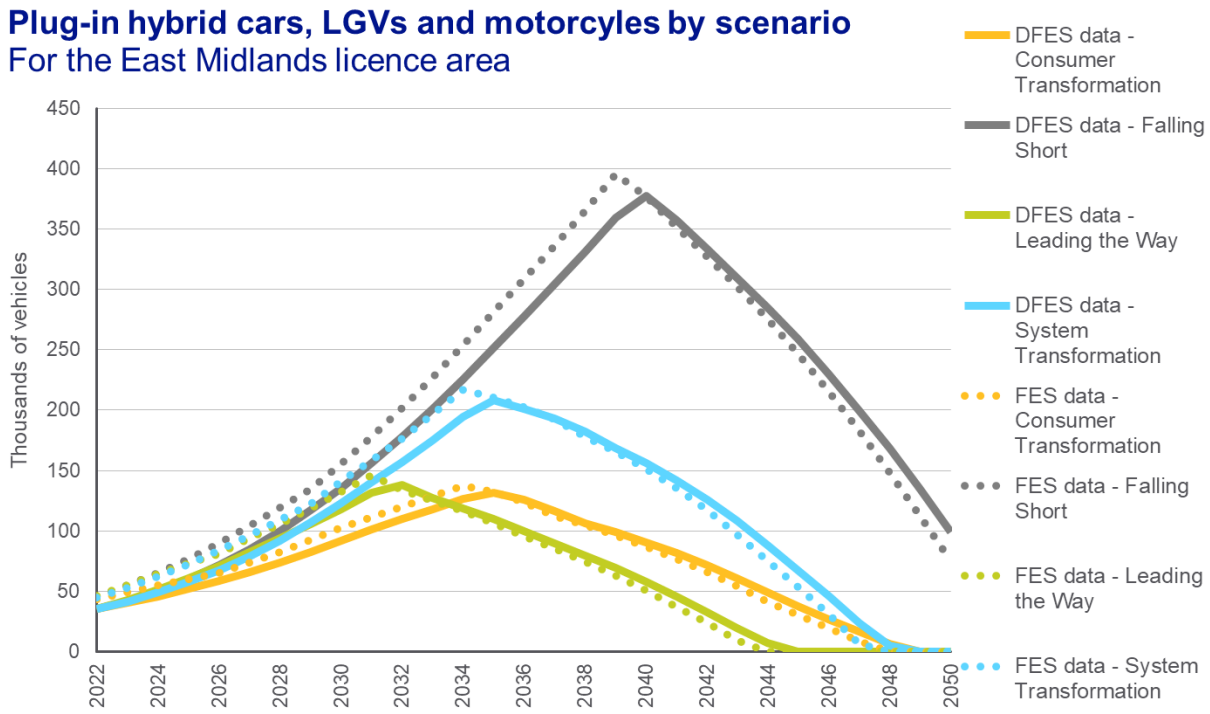
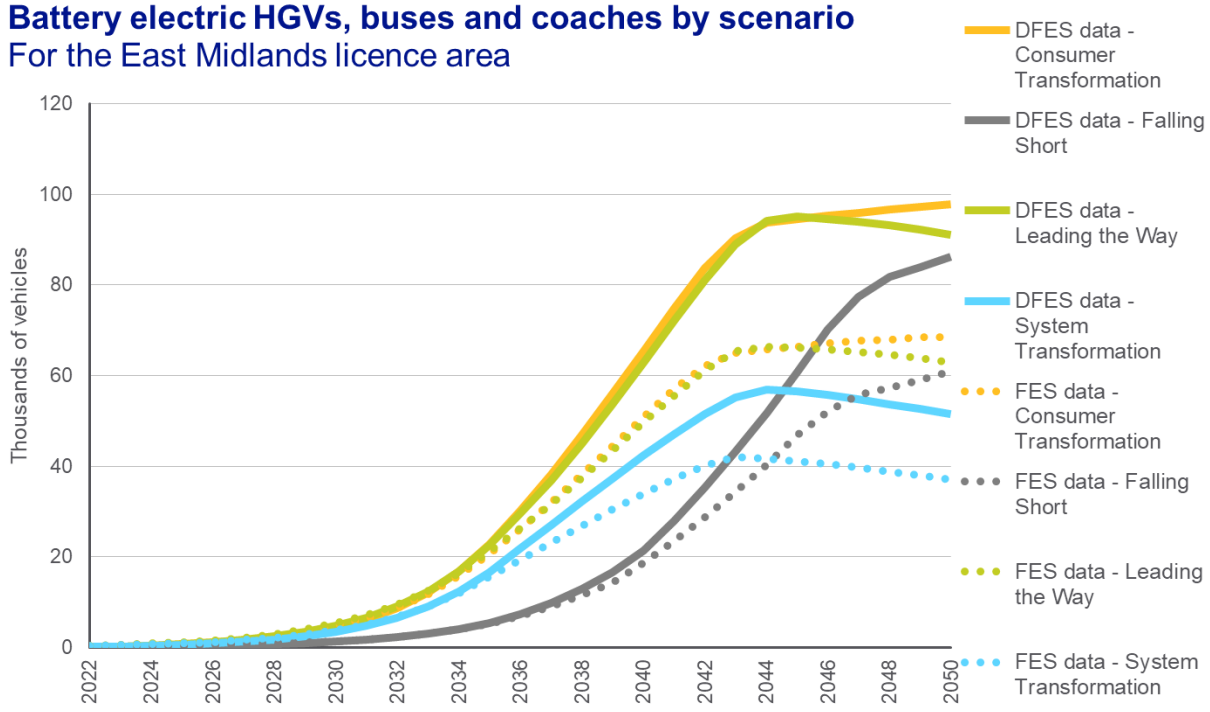


Figure 9 – Number of battery electric HGVs, buses and coaches by scenario, East Midlands licence area



- 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

very similar between the DFES and the FES projections.

- However, the 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 East 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 East Midlands licence area:

Capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	0	4	12	26	29	38	105
System Transformation		25	82	141	207	333	479
Consumer Transformation		7	15	52	104	157	231
Leading the Way		27	94	151	223	348	527

Summary:

- Hydrogen electrolysis is an emerging technology at the forefront of potential future low carbon hydrogen production. As an emerging sector, there is significant uncertainty around its wider role[vii] in net zero and, of specific concern to DFES analysis, the amount of capacity that could be connected to the distribution network is unclear.
- Through the British Energy Security Strategy[viii], the UK government has set an ambitious target of 10 GW of low carbon hydrogen production capacity by 2030, specifying at least 5 GW of this to come from hydrogen electrolysis. Only a handful of electrolysis projects are currently operational across the UK.
- There are no operational hydrogen electrolysis projects in the East Midlands licence area currently; however, there are a number of hydrogen projects in planning, including:
    - A new Motive Fuels hydrogen refuelling station in Derby[ix]
    - The installation of a hydrogen energy generation plant at Redfield Road in Nottingham, which has received both planning permission[x] and accepted a connection agreement with National Grid Electricity Distribution.
- 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 East Midlands is at the heart of the UK's transport sector, comprising road and rail networks, East Midlands Airport, the UK's biggest cargo airport, and vehicle manufacturers, including Toyota, Jaguar Land Rover, Rolls Royce and JCB. This could provide an opportunity for the East Midlands to become a hub for low carbon hydrogen transport, especially given East Midlands Airport's 'free port' status[xii] and decarbonisation targets.
- In addition to this, the licence area has significant unconstrained renewable energy resources and gas network infrastructure. These factors, combined with a strong transport hub, has driven a significant potential for hydrogen electrolysis capacity in both the medium and long-term.
- The largest resultant capacity of distribution-connected hydrogen electrolysis in 2050 is modelled under **Leading the Way** (527 MW) and **System Transformation** (479 MW). This reflects a 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 lowest capacity by 2050 is modelled under **Falling Short** (105 MW), reflecting limited government policy support for this technology and the assumption that this scenario does not reach net zero.

Baseline
There is no capacity currently connected to the distribution network in the East Midlands licence area. West Beacon Farm[xiii] in Nottingham housed a 34 kW electrolyser as part of the HARI project in the early 2000s. The electrolyser converted surplus on-site renewable generation into hydrogen, which was used to generate energy for the farm. This site has since decommissioned.

Near-term (April 2022 to March 2025)		
Pipeline project details	**Scenario**	**Modelled connection date**
In collaboration with Shell, ITM Motive is adding hydrogen refuelling to Shell's service station at Willington in Derbyshire. Motive Fuels was aiming for this station to be operational in summer 2022.	**Falling Short**	Sep 2025
	System Transformation	Sep 2023
	Consumer Transformation	Sep 2022
	Leading the Way	
Conrad Energy was granted planning permission in February 2022 for the installation of a hydrogen production facility (4 MW) adjacent to Conrad Energy's existing gas generating site on Redfield Road in Nottingham to optimise the existing gas supply and operating gas engines. This project has an accepted connection agreement with National Grid Electricity Distribution.	**Falling Short**	Jan 2025
	System Transformation	Jan 2024
	Consumer Transformation	July 2023
	Leading the Way	

There are a number of additional active hydrogen initiatives for the East Midlands licence area:

- The East Midlands Hydrogen Innovation Zone[xiv] was launched by the University of Nottingham and aims to take advantage of the East Midland's 'free port' status, as well as its position as a transport and freight hub. The possibility of repurposing decommissioned coal power stations across the Midlands for hydrogen production is also to be explored.
- H2GVMids[xv] demonstration programme recently received Innovate UK funding on behalf of the Department for Transport to deliver a fleet of hydrogen-fuelled lorries in the Midlands. The feasibility study into the use of hydrogen for 44-tonne lorries, using the Midlands as a trial area of focus, will involve the development of a hydrogen refuelling station.
- The East Midlands Airport has committed to achieving net zero status by 2038, with hydrogen expected to play a key role[xvi]. The Airport has formed a consortium to create a Hydrogen Hub, supplying green hydrogen to airport vehicles and 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 East 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 based on the visibility of currently active projects in the region.

By 2025, **Leading the Way** is modelled to have the most installed capacity (27 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 East Midlands licence area sees a significant development of hydrogen electrolysis capacity in the medium-term, as electrolyser units become commercially viable and localised demand for low carbon hydrogen increases. The use of electrolysis in industry, power generation, transport and as a source of flexibility increases and hydrogen clusters begin to form. Under **System Transformation** and **Leading the Way**, hydrogen is integrated with existing 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%	26 MW
System Transformation	35%	141 MW
Consumer Transformation	36%	52 MW
Leading the Way	24%	151 MW

Long-term (April 2035 to March 2050)

The M1 runs the length of the East Midlands licence area and is at the heart of the transport sector, comprising road and rail networks, East Midlands Airport, the UK's biggest cargo airport, and vehicle manufacturers, including Toyota, Jaguar Land Rover, Rolls Royce and JCB. This could provide an opportunity for the East Midlands to become a hydrogen hub for transport, especially given East Midlands Airport's 'free port' status and 2038 decarbonisation targets.

In the longer term, hydrogen electrolysers are expected to scale up their capacity by increasing the number of modules connecting to a compressor. The 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%	105 MW
System Transformation	17%	479 MW
Consumer Transformation	17%	231 MW
Leading the Way	20%	527 MW

Comparison to DFES 2021

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

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

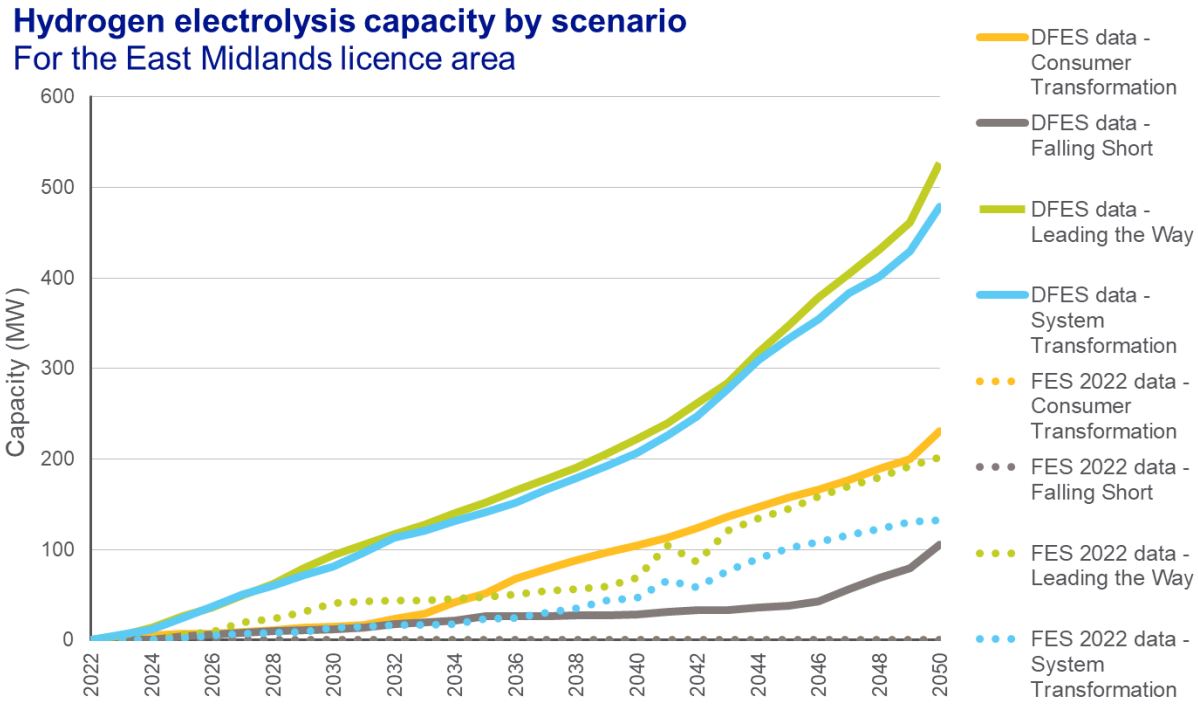
Key modelling assumptions for DFES 2022

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

Hydrogen distribution factors

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

Figure 10 – Installed capacity of hydrogen electrolysis by scenario, East 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 all scenarios, the DFES projections for the East Midlands licence area are significantly higher than the FES projections in the longer term.
- 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 East Midlands licence area finds **System Transformation** and **Leading the Way** to have very similar projection trajectories. This is due to the significant transport and logistics sector within the East Midlands licence area, 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.
- Along with major urban areas such as Derby, Nottingham, Leicester and Coventry, East Midlands is well positioned to become a future hub for hydrogen production and demand. From the feedback received, these transport-fuelling assets are more likely to be connected at the distribution network level.
- By 2050, **Leading the Way** has the most installed capacity in the East Midlands licence area (527 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, renewable resources, gas network infrastructure and existing hydrogen activity.

Factors that will affect deployment at a local level

Description	Source
Location of key development zones for hydrogen production and demand, such as ports, airports and potential hydrogen storage.	Regen analysis
Location of heavy industry energy users.	National Atmospheric Emissions Inventory, BEIS
Location of heavy transport and fuelling hubs, using road traffic counts for light commercial vehicles, heavy goods vehicles and buses and coaches.	Department for Transport
Location of larger-scale renewable energy generators, based on Regen's spatial distribution of ground-mounted solar PV and onshore wind resource, as potential sites for colocation.	Regen analysis

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

New developments in the East Midlands licence area

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

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

Houses (thousands)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	0	68	197	311	400	474	548
System Transformation		79	220	350	443	527	611
Consumer Transformation		79	220	350	443	527	611
Leading the Way		96	262	393	498	596	693

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

Floorspace (sqm, 100,000s)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	0	55	133	207	232	234	234
System Transformation		66	155	217	229	233	233
Consumer Transformation		66	155	217	229	233	233
Leading the Way		71	167	214	232	234	234

Summary:

- The development of new housing and non-domestic sites represents future hotspots of conventional electricity demand, as these new developments are constructed and occupied over the scenario timeframe.
- These new developments have been modelled based on direct engagement with local authorities planning departments and analysis of local planning documents. These detail ‘under construction’ and ‘planned’ developments, as well as land areas that are allocated for future developments.
- Longer-term new housing developments, beyond the timeframe of local planning documents, have also been modelled, based on an analysis of ONS household projections.
- By 2050, this modelling results in between 550,000 and 690,000 new homes in the East Midlands licence area across the scenarios, representing a 22%-28% increase in the number of domestic customers.
- An additional 26.1 million square meters of non-domestic floorspace is also modelled to be developed in the East Midlands licence area under each scenario, predominantly composed of office, 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**
1,589	133,732

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

Local authority	**Number of homes**	**Largest development site**
West Northamptonshire	34,308	Daventry North East Sustainable Urban Extension (3,535 homes)
North Northamptonshire	29,052	Hanwood Park (3,354 homes)
Milton Keynes	25,549	East of M1 Strategic Growth Area (5,000 homes)

Non-domestic

Subcategory	**Number of sites**	**Total non-domestic floorspace (sqm)**
Factory and warehouse	374	10,243,258
Office	296	7,752,573
School and college	102	1,207,402
Retail	68	122,944
Other (e.g. medical, hotel, sport & leisure)	142	4,252,897

In the East 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 219-hectare Northampton Gateway Rail Freight Interchange[xvii], the largest individual site in the collected data.

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

Modelled developments (April 2022 to March 2050)	
Domestic	
There are two forms of new housing that are not captured by developments currently in planning and have as such been modelled to ensure the DFES scenarios capture a range of housebuilding trends between 2022 and 2050. These are **residual developments** and **post-plan developments**, described in more detail below:	
Residual developments	These are small-scale developments of less than 20 homes, which are under the threshold of our data collection with local authorities. Analysis of previous new developments data suggests that these developments could account for approximately 5% of total new-build housing. As a result, a 5% uplift was applied to the planned projections throughout the scenario timeframe, to account for these residual developments.
Post-plan developments	This accounts for housing developments that could occur in the medium and long term, beyond the current timescales of local authority planning. As planned developments tail off in the 2020s and 2030s, post-plan developments are modelled to account for additional future housebuilding out to 2050. These post-plan development projections are tailored to each local authority, based on ONS household projections[xviii].
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, East Midlands licence area

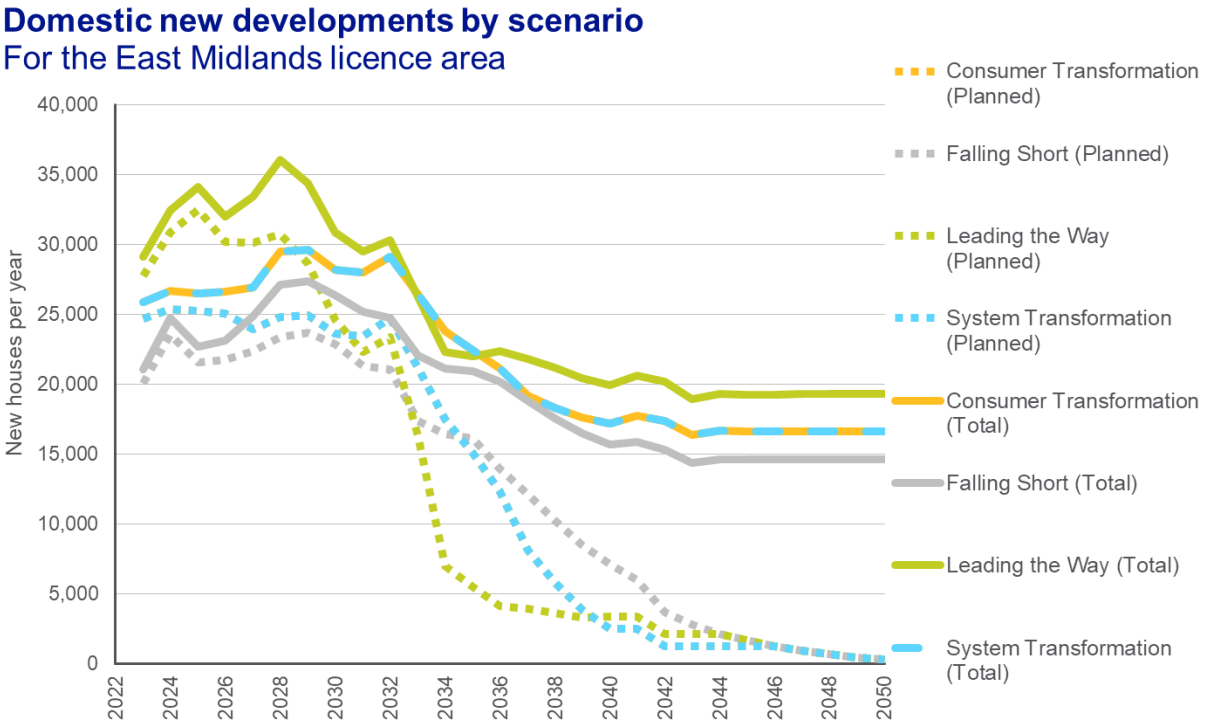
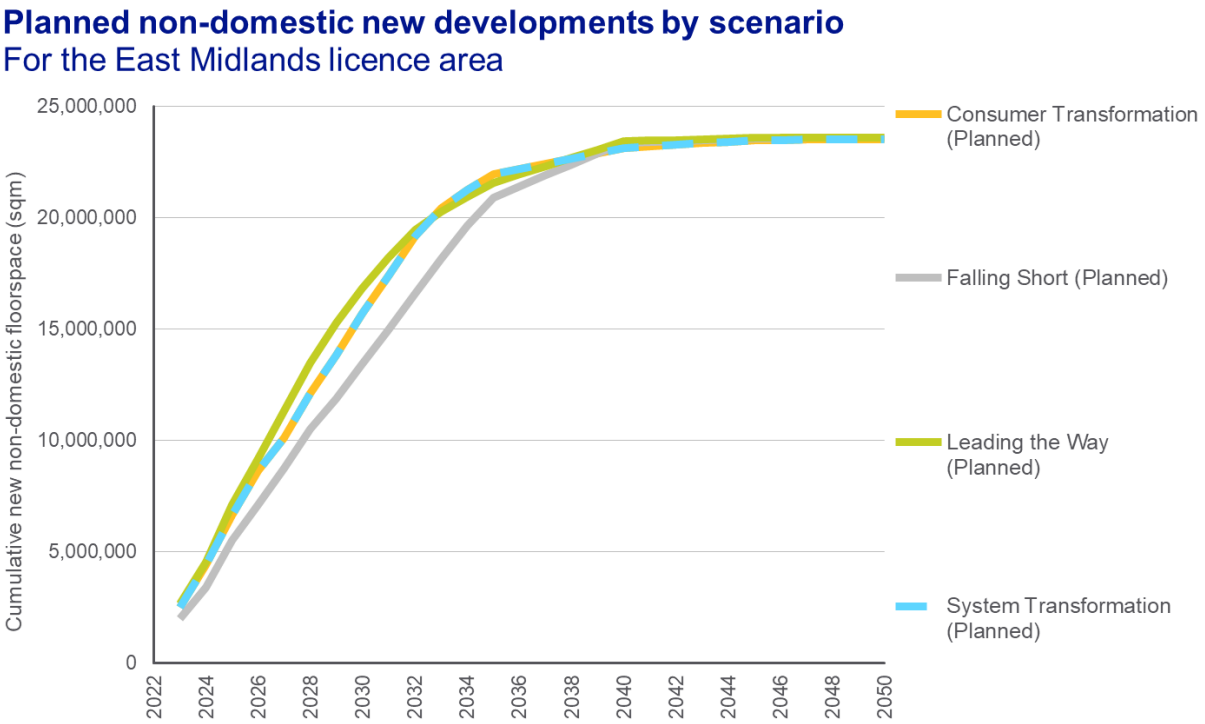


Figure 12 – Cumulative planned non-domestic developments by scenario, East Midlands licence area



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 East 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 East Midlands licence area:

Air conditioning units (thousands)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	25	38	77	172	359	748	1,514
System Transformation		36	65	117	231	434	796
Consumer Transformation		36	65	117	231	434	796
Leading the Way		25	25	25	25	25	25

Summary:

- Domestic air conditioning is not currently common in the UK, with only c.1% of UK homes currently containing an air conditioning unit.
- In the East Midlands licence area, modelling suggests around 1.0% of homes currently have an air conditioning unit.
- Increased summer temperatures, extended heat waves and reducing costs could result in an increased uptake of air conditioning units over the coming decades. In addition to these factors, the UK building stock is not optimised around passive cooling, which could drive increased levels of active cooling, such as air conditioners.
- Air conditioning uptake is likely to be focused in urban areas such as Nottingham, 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**
25,142	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. 36,000-38,000 units in homes by 2025 in these scenarios.
System Transformation	
Consumer Transformation	
Leading the Way	Uptake of domestic air conditioning is minimal, with households opting for passive cooling methods such as shading, ventilation and insulation. As a result, very few new air conditioning units are installed by 2025.

Medium-term and long-term (April 2025 to March 2050)		
Scenario	**Description**	**2050 homes with air conditioning**
Falling Short	Increasing frequency of heat waves and societal reluctance to engage in passive cooling methods leads to exponential uptake of domestic air conditioning, as the 'easiest' route to comfortable internal temperatures.	c. 1,514,000 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. 796,000 homes c. 30% 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. 25,000 homes c. 1% of total housing stock

Modelling assumptions

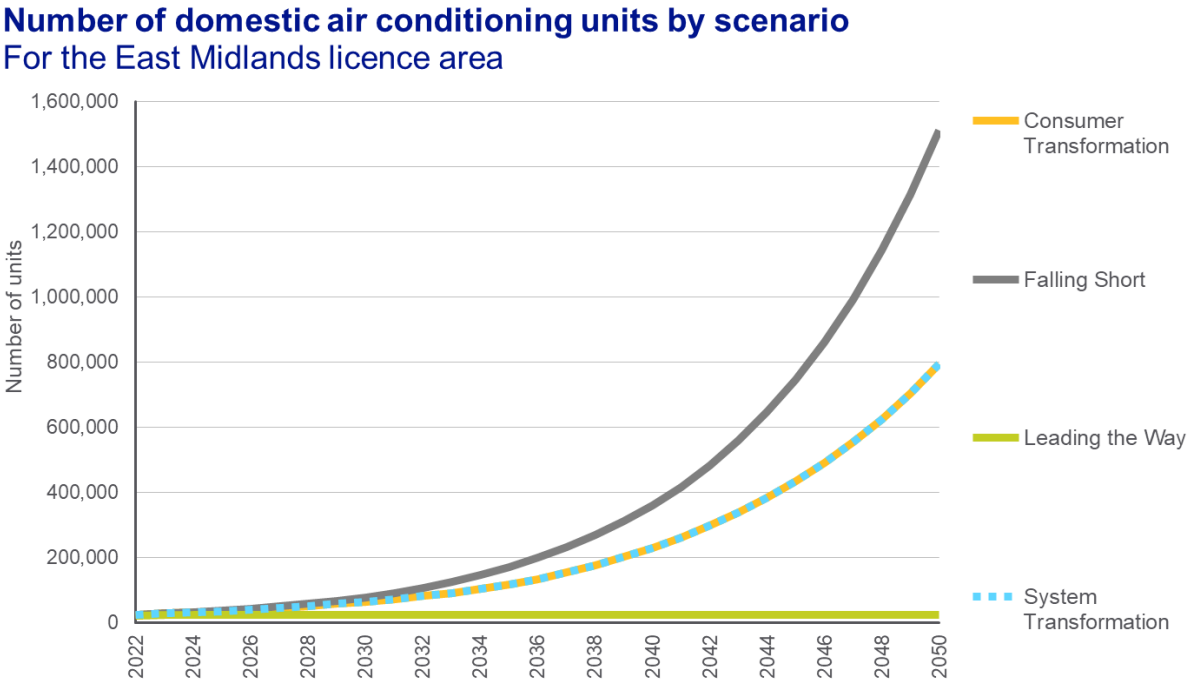
The uptake of domestic air conditioning in each scenario is modelled using:

- Cooling degree days at 18.5 °C, where the East 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 East Midlands 53% below the national average. This metric is used in every scenario.
- Proportion of households in fairly dense urban areas, with the East Midlands 18% 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 East Midlands 7% below 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.

Figure 13 – Number of domestic air conditioning units by scenario, East Midlands licence area



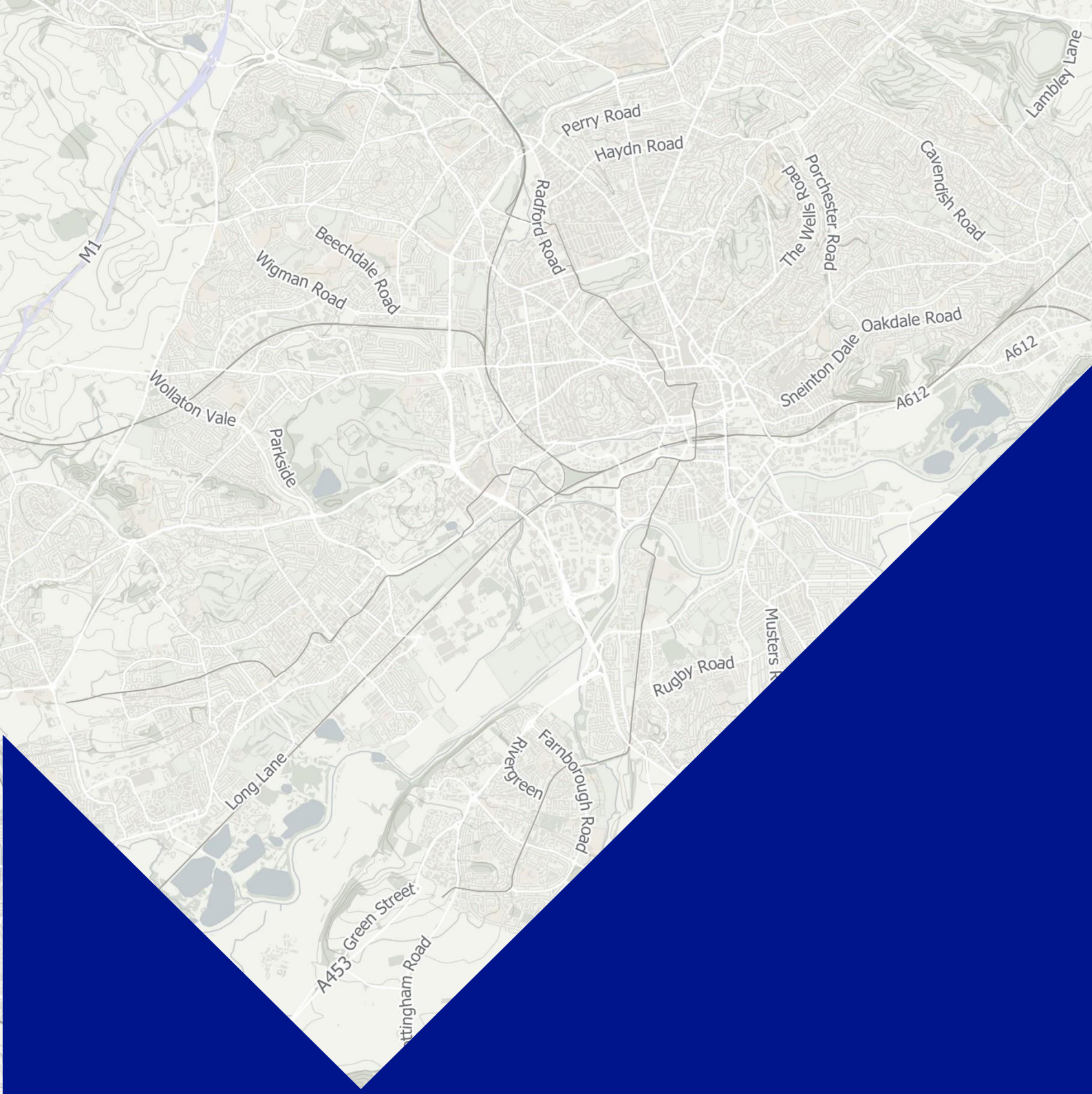
- The FES 2022 does not directly detail the number of domestic air conditioning units, making a direct comparison to the DFES not possible. However, FES 2022 does contain national-level data on annual domestic air conditioning demand by scenario, and an assumed consumption of 500 kWh/year for a typical domestic air conditioning unit. These factors allow for reconciliation at a high level.
- The East 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, in addition to a fairly high proportion of homes in denser urban areas.

Factors that will affect deployment at a local level

Factor	Source
Early uptake of domestic air conditioning is focused in denser urban areas such as Bristol and Plymouth. Later uptake expands to areas of lower housing density in scenarios where domestic air conditioning becomes more prevalent.	OS Addressbase
Affluence, based on net annual income after housing costs, impacts the near-term distribution of air conditioning, due to the relatively high upfront and running costs of domestic air conditioning units.	ONS Income Estimates for Small Areas

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

[ii] Boiler Upgrade Scheme
[iii] Future Homes Standard
[iv] Heat network pipelines
[v] Opportunity Areas for District Heat Networks in the UK, BEIS
[vi] DfT vehicle statistics
[vii] Building the hydrogen value chain, Regen, 2021
[viii] British Energy Security Strategy, HM Government, 2022
[ix] Motive Fuels
[x] "New "innovative" hydrogen power plant approved in Nottinghamshire will only emit water vapour and air", Nottingham Post, 2020
[xi] BEIS Electrolytic Allocation Round 2022
[xii] East Midlands Freeport
[xiii] West Beacon Farm
[xiv] East Midlands Hydrogen Innovation Zone
[xv] H2GVMids
[xvi] East Midlands Airport developing hydrogen fuel capabilities, Leicester & Leicestershire Enterprise Partnership, 2022
[xvii] Northampton Gateway Rail Freight Interchange
[xviii] 2018-based household projections by local authority



Generation technologies

Results and assumptions

Large-scale solar in the East Midlands licence area

Solar generation sites of installed capacity of 1 MW and above

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

Capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	1,144	1,590	2,610	3,194	3,328	3,518	3,708
System Transformation		2,629	3,326	4,201	4,656	5,103	5,584
Consumer Transformation		2,639	3,283	4,152	4,607	5,055	5,535
Leading the Way		3,369	4,017	5,164	5,753	6,176	6,244

Summary:

- The East Midlands licence area has historically shown a reasonable level of large-scale solar PV deployment, with over 1 GW of distribution connected capacity connected over the past decade.
- There is a significant 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 grown significantly from 116 (3,305 MW) to 211 (6,037 MW) since DFES 2021 – an 83% 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 East 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 73% of projects being successful in planning. The East Midlands has the lowest level of local ambition, evidenced by 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 limitation.
- Under the most ambitious scenario, **Leading the Way**, solar reaches c. 4.0 GW by 2030, and continues to c. 6.2 GW by 2050. Under **Consumer Transformation**, c. 3.3 GW is reached by 2030, and c. 5.5 GW by 2050.

Modelling assumptions and results

Baseline		
Number of sites	**Total capacity**	**Description**
165	1,144 MW	2021 was a positive year for new ground mount solar deployment[xix]. The recent uptick in solar projects follows a period of limited growth since 2017, indicating that the post-FIT lull in project development could be coming to an end. The vast majority of historic solar development was as a result of the FiT scheme, which supported solar projects of up to 5 MW with subsidy payments for all electricity generated. At the height of the FiT period, over 943 MW of capacity was deployed between 2012 and 2016 in the East Midlands. Installed capacity has reached 1,144 MW by 2022, bringing the average installed capacity of large-scale distributed solar to 7 MW in the region. The largest distribution-connected site is Inkersall Grange in South Somerset at 46 MW of installed capacity. This project was connected in 2020.

Pipeline (April 2022 to March 2028)	
Number of pipeline sites	**Total capacity**
211	6,037 MW

Installed solar capacity in the UK is forecast to grow by over 1 GW in 2022 and over 2 GW in 2023[xix]. In the East Midlands, the capacity of identified pipeline projects has shown a relative increase of c. 83%, compared to the number of sites looking to connect to the network in the past year and a half, from 116 (3,305 MW) by the end of Q1 2021 to 211 (6,037 MW) in Q3 2022. When asked how much of this pipeline of projects is likely to connect, stakeholders responded that lots would likely connect, but over time out to the mid-2030s. The average capacity of sites accepted to connect to the network is 29 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	Three new solar sites have been confirmed to be under construction: Gorse Lane (20 MW) and White Cross Lane (23 MW) in North Kesteven and Manor Farm (19 MW) in East Lindsey.	3	62 MW
Planning Permission Granted	1,098 MW of solar capacity from 39 sites has been approved in planning in the East Midlands, significantly up from 706 MW from 27 sites identified in DFES 2021. Four sites (totalling 184 MW) are located in Newark and Sherwood, and a further four (totalling 76 MW) are located in Buckinghamshire. The remaining 31 sites are spread across the licence area. The largest site with planning approval is the 70 MW Vicarage Drove Energy Centre development in Boston (which includes a 50 MW solar farm and a 20 MW co-located battery). Construction for this site is commencing in 2023. The highest capacity standalone solar site (not co-located with battery) is the 60 MW Brigstock PV in North Northamptonshire, which was awarded a CfD during the fourth allocation round in 2022.	39	1,098 MW
Planning Application Submitted	28 solar sites have submitted a planning application. Five sites are approximately 50 MW in size (three in Rushcliffe, one in Melton and one in South Derbyshire), one of which, Church Farm, is aiming for construction in 2024, pending planning approval. 23 of these sites have been modelled to connect in the 2020s under **Leading the Way**, and 14 were modelled to connect under **Consumer Transformation** and **System Transformation**. This reflects an analysis of local solar planning friendliness and local ambition.	28	784 MW
Pre-planning	32 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 11 consultation websites were identified, including one for the 204 MW Temple Oak Energy Park.	32	1,403 MW

No information	No development evidence could be found for 2,507 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.	100	2,507 MW
Rejected, Withdrawn or Abandoned	Five sites were found to be rejected in planning, two were expired, and one site was abandoned. Four of these eight unsuccessful sites were each c. 40 MW capacity.	8	180 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. In addition to this, some repowering occurs in the early-2030s under **Leading the Way**, slightly later in other scenarios, as legacy sites are retrofitted with new generation solar modules.

Scenario	Description	Capacity by 2035
Falling Short	Capacity growth 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. 3.2 GW by 2035, favouring areas with high historic planning friendliness and available resource. Early repowering of older sites is rare, leaving baseline sites at their original capacities.	3,194 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.	4,201 MW
Consumer Transformation	Local ambition plays a larger role than historic planning friendliness in determining where projections are located. As under **System Transformation**, 4.2 GW is deployed by 2035.	4,152 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 5.2 GW of capacity installed by 2035. Historic planning friendliness plays a relatively small role.	5,164 MW

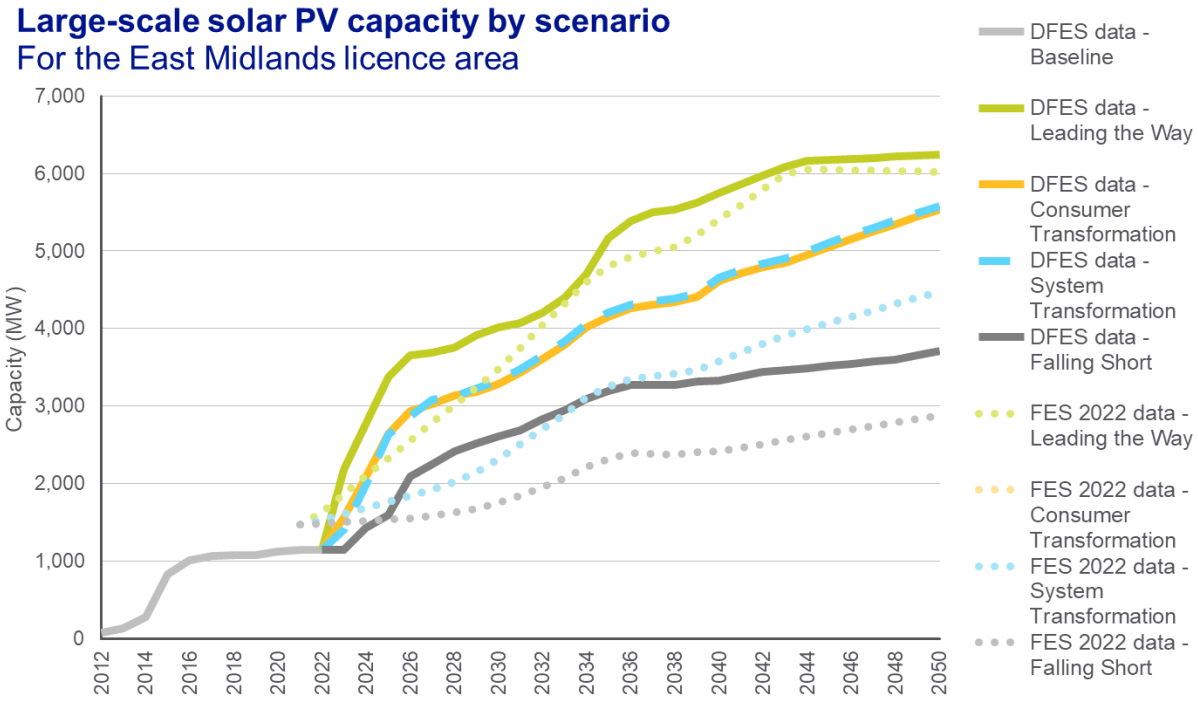
Long-term (April 2035 to March 2050)

Post-2035, long-term projections are determined by solar resource availability above all other factors. This is due to the assumption that factors like planning friendliness and local government ambition are less likely to reflect past trends, due to changes in local administration, public opinion and broader energy system policies. Deployment saturation is seen in areas with strong historic planning friendliness, which in turn pushes developers to seek connections in other high solar resource areas. Repowering legacy sites with new higher-yield solar PV modules takes place from the 2030s onwards, peaking in the late 2030s under **Consumer Transformation** and **System Transformation**. Standard modules in the 2010s were 250 W, with today's standard offering at 540 or above for ground-mounted solar farms[xx]. 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. 3.7 GW under **Falling Short** to c. 6.2 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 3.7 GW by 2050 – though still more than triple the baseline capacity.	3,708 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.	5,584 MW
Consumer Transformation		5,535 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.	6,244 MW

Reconciliation with National Grid FES 2022

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



- The FES 2022 baseline is c.400 MW higher than the DFES 2022 baseline for the East Midlands licence area. The reason for this variance is unclear; this was also present in DFES 2021.
- 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. There is a notable increase in the 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 largely follow the FES 2022 trends and rates of development. The DFES models troughs and peaks as sites move to repower from the 2030s onwards, but otherwise it reflects a similar rate of growth under each scenario beyond the pipeline period.

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[xxi]
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 East 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 East Midlands licence area:

Capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	520	602	711	850	995	1,142	1,295
System Transformation		663	995	1,388	1,790	2,195	2,604
Consumer Transformation		802	1,499	2,293	3,090	3,906	4,733
Leading the Way		809	1,530	2,362	3,199	4,056	4,927

Summary:

- During the 2010s, the East Midlands licence area saw small-scale solar deployment as a result of the Feed-in Tariff support scheme, at levels slightly above the GB average.
- Deployment of small-scale solar had stalled in recent years. However, recent increases in energy prices have resulted in 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 4.9 GW.

Modelling assumptions and results

Baseline			
Scale	**Number of sites**	**Total capacity**	**Notes**
Domestic (Under 10 kW)	96,095	337	Equivalent to 4% of homes
Commercial (10 kW–1 MW)	3,306	182	Average array size: 55 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 420 MW of capacity, 84% of the baseline, was deployed in the East 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 to energy bills.			

Pipeline (April 2022 to March 2024)

There are over 600 small-scale solar sites in the pipeline, representing over 45 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 East Midlands licence area has a notable number and capacity of commercial-scale pipeline sites, including many planned rooftop arrays on warehouses.

Scale	Number of pipeline sites	Total capacity
Domestic (Under 10 kW)	336	1.8 MW
Commercial (10 kW–1 MW)	270	42.9 MW

Pipeline assessment

Scale	Number of sites	Total capacity	Scenario outcomes
Below 50 kW	457 (75% of total)	5.3 MW (12% 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	134 (22% of total)	27.8 MW (62% 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	15 (2% of total)	11.6 MW (26% of total)	Two of these sites have attained planning permission and go ahead 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[xxii].

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

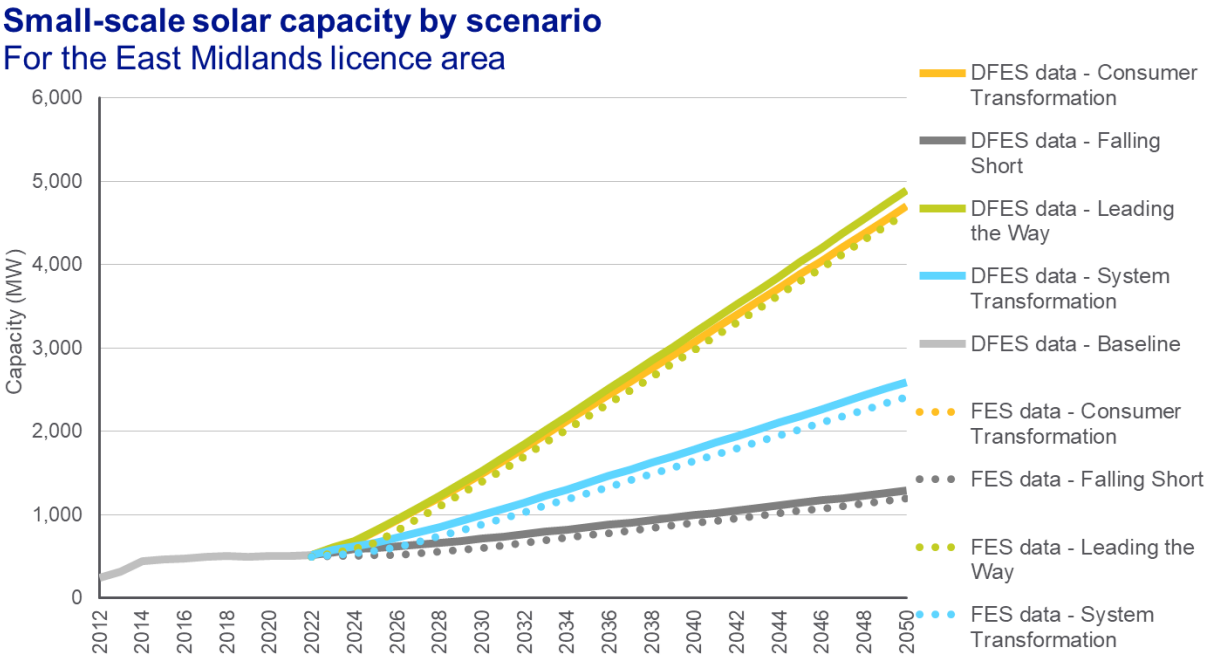
Under **Consumer Transformation** and **Leading the Way**, deployment of rooftop solar on new-build homes accelerates towards this figure over the 2020s and early 2030s. However, under **System Transformation** the changes to Building Regulations Part L have been modelled to have a lower impact, and 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 4.9 GW by 2050 under **Leading the Way**.	4,927 MW
Consumer Transformation		4,733 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.	2,604 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.	1,295 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.	Moderately above the GB average
Irradiance	Sunnier licence areas have been modelled to see greater uptake of rooftop PV, as higher levels of irradiance reduce the payback periods for rooftop PV installations.	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 below 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.	Well below the GB average

Figure 15 – Capacity of small-scale solar generation by scenario, East 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 East Midlands licence area

Onshore wind electricity generation

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

Capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	412	412	418	461	527	613	672
System Transformation		412	432	527	676	803	927
Consumer Transformation		469	611	949	1,438	1,904	1,985
Leading the Way		413	522	797	1,202	1,567	1,660

Summary:

- There is a significant baseline (412 MW) of distributed onshore wind in the East Midlands licence area, hosting some of the first commercial wind farms in the UK. Over two-thirds of the baseline capacity was connected between 2011 and 2017.
- There is potential for significant growth in additional wind capacity in the licence area due to available resource, land availability and high levels of local ambition. Unconstrained wind resource is highest very high in the East Midlands, making it a new prime area of interest for wind developers.
- Planning friendliness in the region is mixed, with around 47% of onshore wind projects that have been through the planning process securing approvals. Due to these factors, stronger growth in connected capacity is seen under **Consumer Transformation** and **Leading the Way**, while **Falling Short** sees a more limited uptake, due to lack of momentum for planners accepting the pipeline of new projects, failing to reach net zero goals.
- Onshore wind capacity grows 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 over 600 MW, reaching just below 2 GW by 2050 under the same scenario.

Modelling assumptions and results

Baseline			
Scale	**Number of sites**	**Total capacity**	**Description**
Total	368	412	The vast majority of sites (c. 89%) are made up of small turbines of below 1 MW. However, the majority of installed capacity (c. 89%) is made up of sites of over 1 MW. The East Midlands has a large amount of developable land and high wind speeds, which contributes to its attractiveness for wind development.
Above 1 MW	39	368	Nine of the large-scale sites are located in West Northamptonshire, totalling 78 MW, and 5 in North Northamptonshire, totalling 92MW. The rest are spread across the licence area with an average installed capacity of 9 MW. The largest wind site connected to the distribution network in the licence area is the 32 MW site at Chelveston Renewable Energy Park.

Below 1 MW	329	44	The majority of small-scale wind sites connected between 2012 and 2015, with development stagnating thereafter. Approximately 238 projects with an average capacity of 27 kW were supported by the FIT scheme.

Pipeline (April 2022 to March 2028)	
Number of pipeline sites	**Total capacity**
2	55 MW

There are only two pipeline onshore wind sites in the licence area, one of which is Heckington Fen with an accepted connection offer of 54 MW. Due to Ministry of Defence (MOD) objections which have caused setbacks for site development, the site is only modelled to connect under **Consumer Transformation**. Under **Leading the Way**, the modelling has reflected the potential for the developer to commission a 500 MW solar park instead so as to avoid MOD restrictions on radar concerns[xxv].

The second pipeline site is not modelled to connect under any scenario, since no supporting information was found online to assess the stage of its 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. This information has been derived from direct developer engagement as well as Renewable Energy Planning Database and local authority planning portal analysis, and has been used to inform the medium-term projection years modelled in the DFES.

Pipeline analysis			
Status	**Scenario outcomes**	**Sites**	**Capacity**
Planning Permission Granted	Heckington Fen (54 MW)	1	54 MW
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	One unidentified site in South Holland of 500 kW in capacity with unknown planning status.	1	500 kW

Planning logic and assumptions

The assumptions around the proportion of pipeline sites and capacity that make it through planning at each stage are derived from a statistical analysis of the Renewable Energy Planning Database.

Scenario	**Planning Granted or Under Construction**	**Planning Application Submitted**	**Pre-planning**	**No information**	**Years from Planning Submitted to completion**
Falling Short	100%	30%	25%	removed from analysis	6-10 years

System Transformation	100%	75%	40%	25%	5-9 years
Consumer Transformation	100%	80%	60%	50%	3-7 years
Leading the Way	100%	75%	40%	25%	5-9 years

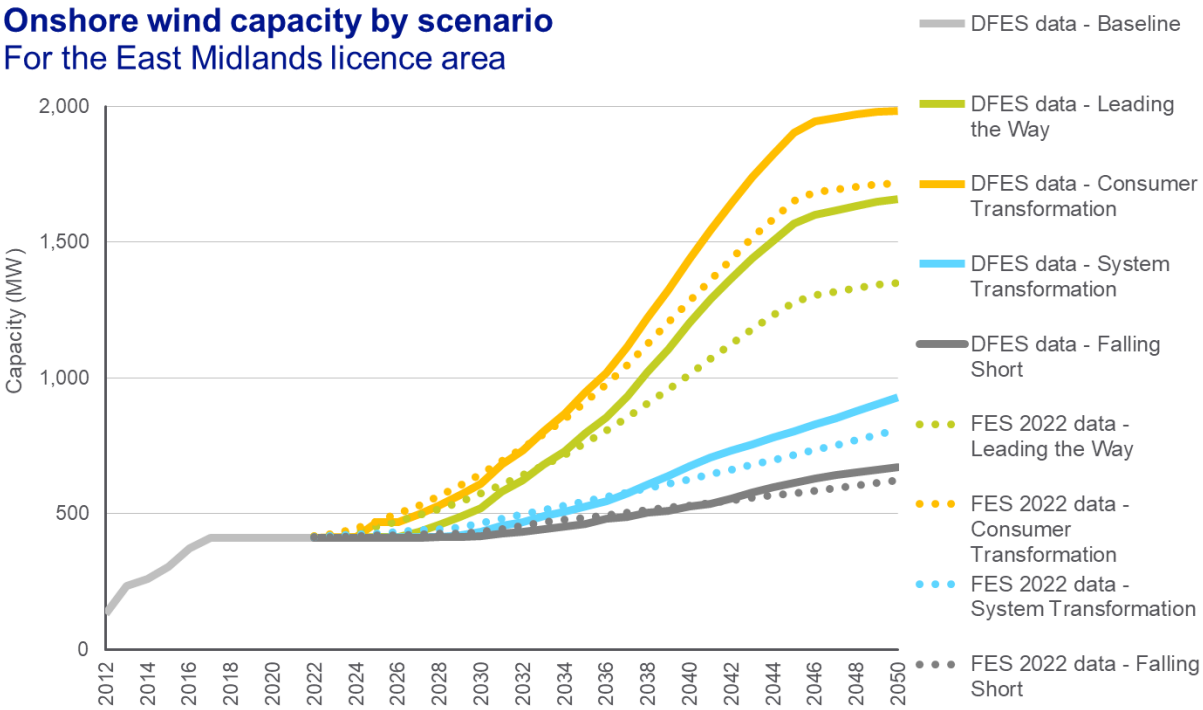
Medium-term (April 2028 to March 2035)		
Scenario	**Description**	**Capacity by 2035**
Falling Short	Wind capacity in the region remains stagnant out until 2030, with no pipeline sites coming online. Without many sites in planning, it takes over a decade to reignite developer interest in new wind projects under this scenario. This is due to an assumption that planning regimes remain inhibitory towards new wind farm developments in this scenario. A few legacy sites repower in the first half of the 2030s, increasing connected capacity.	461 MW
System Transformation	In the medium term, wind farms see limited development due to low levels of planning friendliness and a general preference for transmission-connected wind farms to achieve net zero goals.	527 MW
Consumer Transformation	New interest in onshore wind development picks up from 2027 onwards on top of repowering of some older sites. As much as 80% of sites with an application submitted in planning are successful in planning. Distributed onshore wind is seen as a key lever to reducing carbon emissions in the electricity system. Unconstrained wind resource is very high in the East Midlands, making it a prime area of interest for wind developers.	949 MW
Leading the Way	A significant amount of new onshore wind capacity connects to the distribution network out to 2035, although a notable amount of new wind capacity connects to the transmission network. This results in a slightly lower capacity connected to the distribution network than is seen under Consumer Transformation.	797 MW

Long-term (April 2035 to March 2050)		
Scenario	**Description**	**Capacity by 2050**
Falling Short	Distributed wind capacity in the region falls short of doubling the current baseline by 2050. Some new wind sites continue to connect at similar levels to historic rates. Sites larger than 5 MW experience a repowering of +25%.	672 MW
System Transformation	Long-term deployment of onshore wind sees steady yet limited growth as more large-scale wind farms connect at transmission-level voltages. Repowering rates remain modest, accounting for some of the new capacity connecting in the 2030s and 2040s. Sites larger than 5 MW experience a repowering of +25%[xxvi]. All other sites repower at +50% of their original capacity.	927 MW
Consumer Transformation	Small-scale distributed wind capacity sees the highest growth under this scenario, reaching 1.9 GW by 2045 and levelling out to nearly 2 GW by 2050. Sites larger than 5 MW experience a	1,985 MW

	repowering of +50%. All other sites repower at +100%.	
Leading the Way	Repowering and unconstrained wind resource continue to spur development out to 2050 under this scenario. Sites larger than 5 MW experience a repowering of +50%. All other sites repower at +100%. The flattening of new capacity from 2045 onwards in **Leading the Way** and **Consumer Transformation** reflects assumptions in the FES 2022, and can be seen as a cannibalisation of onshore wind as land and resource becomes saturated in the licence area.	1,660 MW

Reconciliation with National Grid FES 2022

Figure 2 – Electrical capacity of onshore wind by scenario, East Midlands licence area



- The FES 2022 baseline (416 MW) is closely aligned with the DFES 2022 baseline (412 MW) for the East Midlands licence area. Near-term pipeline projections are also largely aligned, seeing an uplift to 566 MW by 2028 under **Consumer Transformation** under the FES, compared to 530 under the DFES. This reflects limited new onshore wind sites with planning or positive development evidence.
- 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 existing blades with newer, higher-yield models.
- Another reason for an increased long-term ambition in **Consumer Transformation** and **Leading the Way** in the DFES, which exceeds the FES, is due to the bias imposed on projections by the ban on new onshore wind capacity in England. This bias is reflected in previous long-term projections in the FES that favour licence areas 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 from c. 1.5 GW to c. 1.7 GW under **Consumer Transformation**. This suggests that the FES figures are approaching a similar level of ambition to the DFES methodology.

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

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

Offshore wind in the East Midlands licence area

Offshore wind electricity generation, including fixed and floating foundations

Data summary for offshore wind in the East Midlands licence area:

Capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	194	194	194	194	194	194	194
System Transformation		194	194	194	194	194	194
Consumer Transformation		194	194	194	194	194	194
Leading the Way		194	194	194	194	194	194

Summary:

- Two offshore wind farms are currently connected to the distribution network in the East Midlands licence area.
- Fixed-foundation offshore wind on the east coast of GB has now scaled up to connect to the transmission network. Therefore, any future fixed offshore wind capacity in the East Midlands would almost certainly seek to connect to the transmission network.

Modelling assumptions and results

Baseline

The baseline consists of the adjacent Lynn and Inner Dowsing offshore wind sites of 97.2 MW capacity each, located off the coast of Skegness, Lincolnshire.

These sites, from the Crown Estate Offshore Wind Leasing Round 1, connected in 2008 before fully commissioning in 2009.

A further 20 MW of capacity was constructed within the wind farm boundary in 2013, but this capacity was connected to the nearby transmission network-connected Lincs Wind Farm.

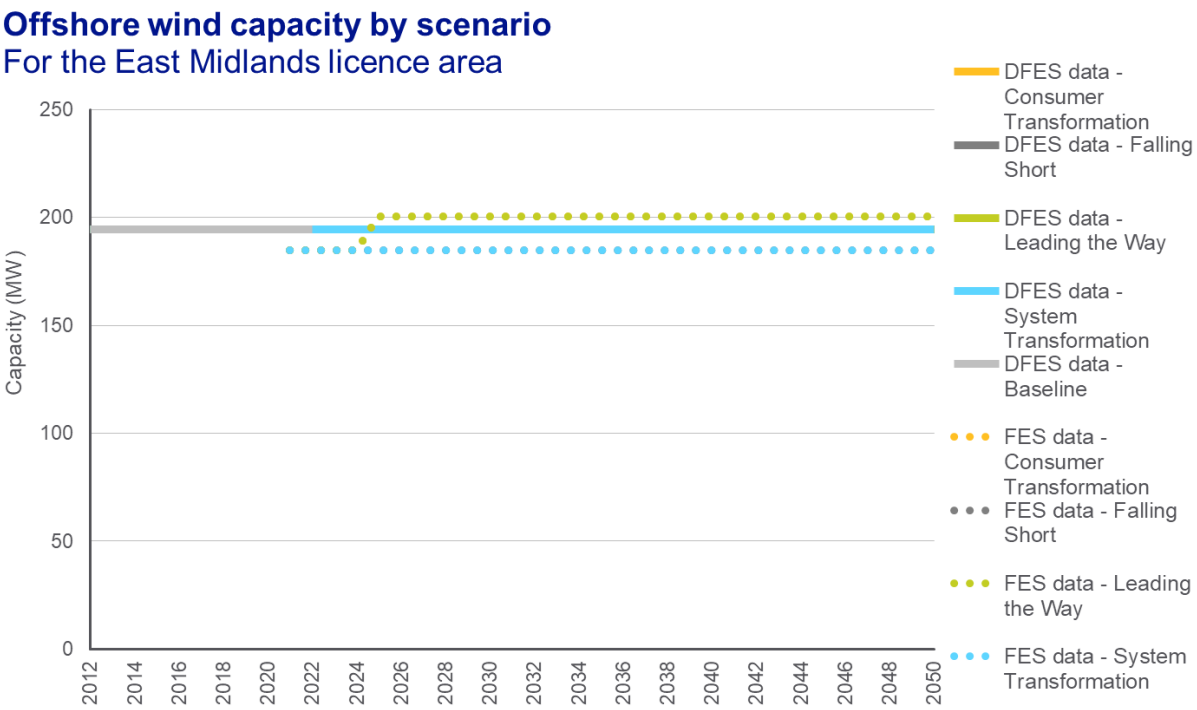
Projections (April 2022 to March 2050)

There are no prospective offshore wind sites in the licence area with an accepted network connection offer, in planning, or discovered through additional desk-based research.

Offshore wind projects are now being developed at much larger scales and ubiquitously connecting to the transmission network in England.

As such, no new offshore wind capacity is projected to connect at distribution level in any scenario.

Figure 16 –Capacity of offshore wind by scenario, East Midlands licence area



- The DFES 2022 projections for offshore wind in the East Midlands licence area are broadly aligned with the FES 2022 data, with a difference of 9 MW in the baseline.
- The FES 2022 data contains a 16 MW increase in capacity in the mid-2020s under **Consumer Transformation** and **Leading the Way**. This increase in capacity is not reflected in the DFES projections, as no evidence for further connection of offshore wind capacity to the East Midlands distribution network has been found.

Hydro in the East Midlands licence area

Hydropower electricity generation

Data summary for hydropower in the East Midlands licence area:

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

Summary:

- The East Midlands has minimal hydropower resource, with a baseline totalling under 2 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 East Midlands under any scenario.

Modelling assumptions and results

Baseline			
Scale	**Number of sites**	**Total capacity**	**Description**
100-250 kW	9	1.8 MW	The majority of this capacity, totalling 1.2 MW, is located in the Derbyshire Dales and Amber Valley local authorities, bordering the Peak District. There is also a 515 kW Environment Agency site in Colwick, Nottingham, the largest baseline site.
Below 100 kW	14	0.4 MW	The majority of this capacity was deployed between 2009 and 2016, supported via the Feed-in Tariff scheme, and located in the Derbyshire Dales.

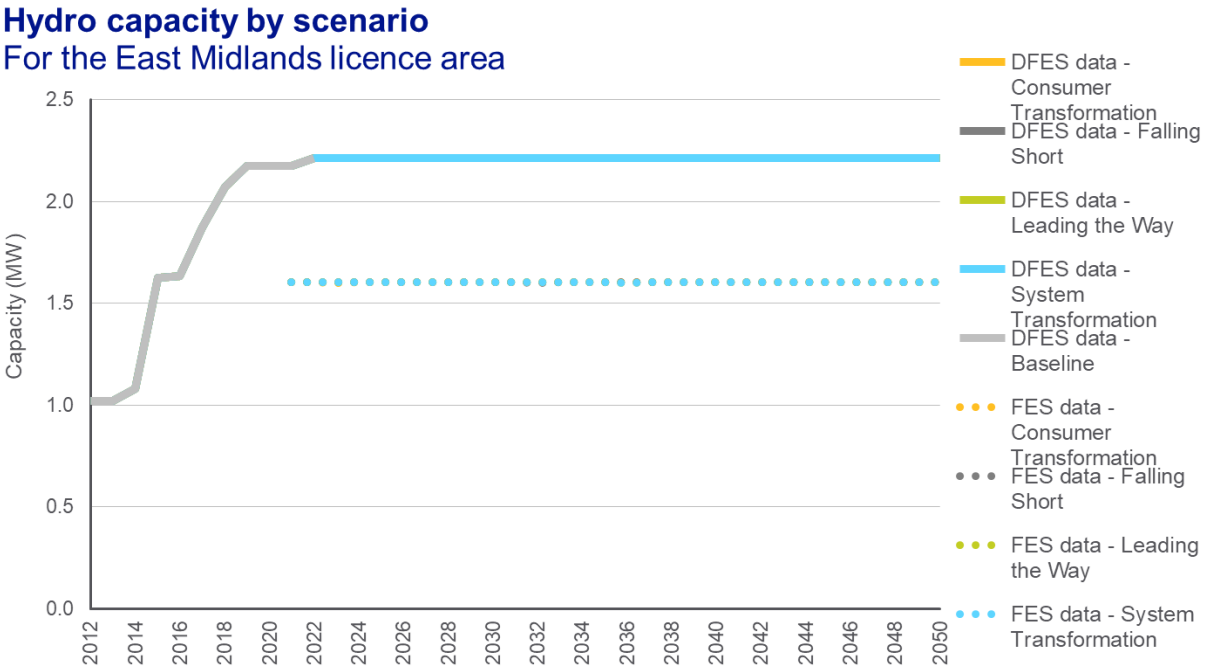
Pipeline (April 2022 to March 2025)
There are no pipeline hydropower sites in the East Midlands licence area. As such, there is no hydropower deployment in the near term under any scenario.

Medium and long-term projections (April 2025 to March 2050)		
Scenario	**Description**	**Capacity by 2050**
Leading the Way	Hydropower resource in the East Midlands is limited to very small and micro-scale hydropower. High abstraction licence costs in England[xxviii] and	2.2 MW
Consumer Transformation		

System Transformation Falling Short	lack of subsidy support results in no further deployment of hydropower in the East Midlands under any scenario.	

Reconciliation with National Grid FES 2022

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



- There is a difference of around 0.8 MW between the DFES and FES 2022 baselines for hydropower in the East 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 East Midlands licence area

Biomass-fuelled power generation, including standalone and CHP generation

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

Capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	92	96	105	105	105	105	105
System Transformation		97	107	88	90	47	30
Consumer Transformation		95	75	75	31	12	13
Leading the Way		95	75	76	32	13	15

Summary:

- The future of biomass power generation on the distribution network is impacted by competing demands for bioenergy to decarbonise sectors other than electricity, such as heat, transport, industry, aviation, and shipping. Despite being a dispatchable low carbon thermal generation technology, biomass sees a decrease over time under the three net zero scenarios as biomass for power is dominated by transmission-scale BECCS generation.
- Standalone biomass power generation is progressively decommissioned in the three net zero scenarios as bioenergy resources are used elsewhere. There is, however, some growth in the capacity of biomass CHP connecting to the distribution network in the licence area as a means of decarbonising heat, particularly under **System Transformation**.
- Under **Falling Short**, biomass power generation capacity remains relatively static as alternative uses of bioenergy in harder-to-decarbonise sectors are not deployed under this scenario. Installed capacity levels out at 105 MW by 2050 under this scenario.

Modelling assumptions and results

Baseline

Most of the baseline capacity is composed of four large-scale sites, which use biomass predominantly or entirely for electricity generation and grid export.

The smaller baseline sites, particularly those below 1 MW, are typically CHP plants using biomass to fuel on-site electricity generation and provide heat to buildings.

Scale	Capacity	Number of sites
Above 5 MW	85 MW	4
1-5 MW	5 MW	2
Below 1 MW	2 MW	9

Details of largest baseline sites

Site name	Location	Connection date	Capacity
Sleaford Renewable Energy Plant	Sleaford, Lincolnshire	May 2013	45 MW
Goosey Lodge	Rushden, Northamptonshire	June 2002	21 MW
Riverside Industrial Estate	Boston, Lincolnshire	November 2017	12 MW

Pipeline (April 2022 to March 2026)

Number of pipeline sites	Total capacity
5	13 MW

Three small-scale sites, and an operational 2.6 MW site, are modelled to connect in all scenarios. Two larger-scale sites, totalling 10.5 MW, connect in **Falling Short** and **System Transformation**

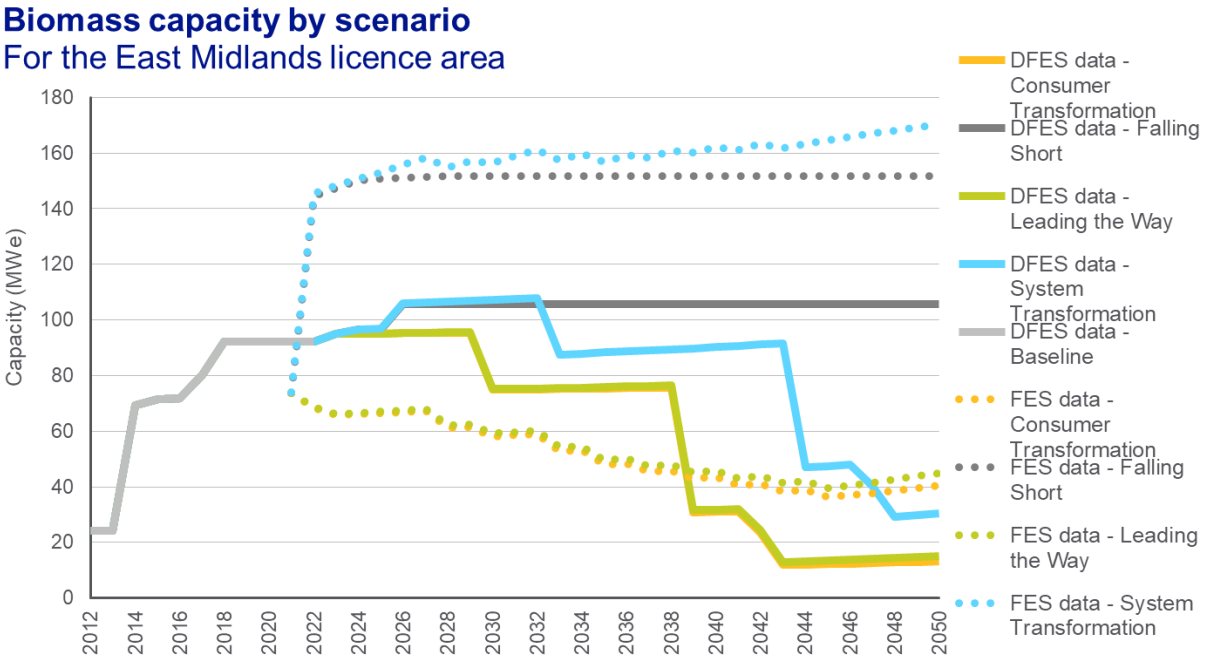
Pipeline analysis			
Status	**Scenario outcomes**	**Sites**	**Capacity**
Operational	A new 2.6 MW biomass generator in Atherstone appears to already be commissioned and is located alongside an existing baseline anaerobic digestion site. This site has been modelled to connect in 2023 in all scenarios.	1	2.6 MW
Planning permission granted	This site in South Holland, Lincolnshire has held granted planning permission since 2018, but there is no evidence of further progress to date, suggesting development may have stalled. As a result of this uncertainty, the site goes ahead in 2024 under **System Transformation** and **Falling Short** but does not progress under **Leading the Way** or **Consumer Transformation**.	1	1.5 MW
Pre-planning	A 9 MW site in Corby, North Northamptonshire has been announced, but has not yet applied for planning permission. Based on analysis of similar biomass development timescales, this project commissions in 2026 under **System Transformation** and **Falling Short** but does not progress under **Leading the Way** or **Consumer Transformation**.	1	9.0 MW
Too small to evidence	Two small projects of 5 kW and 75 kW capacity respectively are too small to require planning permission, and therefore have been assumed to progress in 2023 under all scenarios, due to their very small scale.	2	0.1 MW

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

Beyond the pipeline, the future of biomass generation on the distribution network is strongly dependent on competing demands for biomass from non-power sectors under each scenario, and whether the biomass is fuelling a standalone electricity generation site or a CHP plant.

Scenario	Standalone generation	CHP generation	Capacity by 2050
Leading the Way	Biomass is prioritised for transmission-scale BECCS and other hard-to-decarbonise sectors. As a result, standalone biomass is decommissioned 25 years after commissioning, around the end of its normal operational life.	Greater electrification of heat in these two scenarios results in less demand for biomass CHP. However, there is still some growth in biomass CHP capacity, particularly for use in fuelling heat networks, business parks and industrial sites.	15 MW
Consumer Transformation			13 MW
System Transformation	Standalone biomass is decommissioned 30 years after commissioning, as plants head towards the end of their operational life and biomass is prioritised for BECCS, hydrogen production and aviation.	While the provision of heat in this scenario is dominated by hydrogen, biomass CHP sees some uptake in the longer term in areas not connected to the hydrogen network.	30 MW
Falling Short	Standalone biomass generation remains online on the distribution network in this scenario, as other sectors' progress towards decarbonisation is slow.	Biomass CHP sees no growth in the long term under this scenario, as decarbonisation is slow and many sectors that may make use of low carbon CHPs do not fully decarbonise.	105 MW

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



- The FES GSP-level results for biomass power generation show an increase of 70 MW in the first year of the analysis. This significant uplift to 2023 is not seen in the NGED connections pipeline data, and as such is not reflected in the DFES outputs.
- In the longer term, the DFES aligns with the overall trend for distribution-connected biomass seen in the national FES 2022. Specifically where standalone biomass generation capacity reduces over time under the three net zero scenarios, as bioenergy resources are prioritised for other sectors than power generation and biomass CHP uptake is low. This outcome does not, however, appear to be reflected in the FES GSP-level results for the East Midlands.
- As a result, the DFES 2022 projections have been predominantly based on the potential decommissioning of individual projects, and aligning to the overall national FES assumptions.

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 East Midlands licence area

Electricity generation from sewage gas, landfill gas and anaerobic digestion

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

Capacity (MWe)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	199	199	193	162	126	97	73
System Transformation		199	204	176	139	111	86
Consumer Transformation		201	225	202	166	139	115
Leading the Way		201	230	209	174	147	124

Summary:

- The 199 MW baseline of renewable engines in the East 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 3 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 201 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	55 MW	The majority of anaerobic digestion baseline capacity is individually of less than 2 MW capacity, located at numerous farms in rural areas. Over 50 MW of this capacity connected in the 2010s, supported by the Feed-in Tariff.

Sewage gas	21	23 MW	Sewage gas generation consists of small-scale sites of up to 3 MW, located at sewage treatment works in the licence area. These sites mainly provide CHP generation for onsite treatment processes.
Landfill gas	53	121 MW	The landfill gas baseline consists of medium-scale sites near urban areas, all connected between 1990 and 2012. All but one of these baseline sites are under 10 MW, the exception being the 18 MW Calvert Landfill site in Buckinghamshire.

Pipeline (April 2022 to March 2026)

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

Type of site	Number of sites	Capacity	Scenario outcomes
Anaerobic digestion	4	3.0 MW	All of these sites are in early stages of planning or have no public evidence of development. All four sites are modelled to connect only under **Consumer Transformation** and **Leading the Way**.
Landfill gas	1	0.5 MW	This site, located in Tamworth, previously achieved planning permission in 2009 but never went ahead. As a result, this re-exploration of the site is modelled to connect only under **Leading the Way**.

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

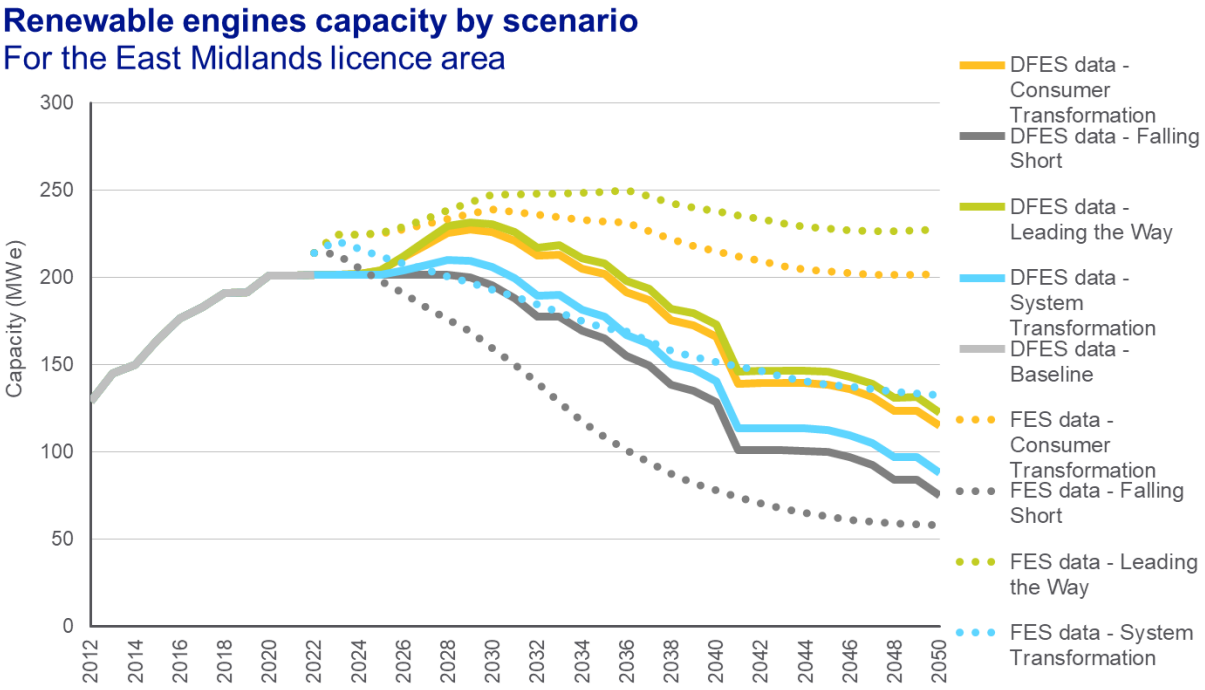
Type of site	Scenario outcomes
Anaerobic digestion	Future deployment of anaerobic digestion capacity has been informed by the existing baseline and pipeline in each licence area. Under **Consumer Transformation** and **Leading the Way**, deployment peaks in the late 2020s and early 2030s, as the electricity 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 baseline consisting mainly of landfill gas, 2050 capacity is lower than the baseline under every scenario.

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

Scenario	2050 capacity
Falling Short	73 MW
System Transformation	86 MW
Consumer Transformation	115 MW
Leading the Way	124 MW

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



- The DFES and FES baselines for renewable engines for the East Midlands licence area are broadly aligned.
- The near-term projections in the DFES diverge from the FES projections, as specific pipeline projects are modelled to connect under the net zero scenarios. The rapid near-term decrease in capacity 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. By 2050 however, the DFES does align more closely with the FES in this scenario, reflecting longer-term decommissioning timeframes.
- The 2050 outcome for the three DFES net zero scenarios is much lower than the FES. This is due to the modelling of specific baseline and pipeline site types, and the majority of capacity in the East Midlands being attributed to landfill gas sites with a limited operating life.

Factors that will affect deployment at a local level

Factor	Source
Sites already in the NGED connections baseline and pipeline	NGED
Regen's anaerobic digestion resource assessment, taking into account agricultural production, animal slurry and local authority food waste collection	Regen local authority engagement, Natural England, DEFRA

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

Diesel generation in the East 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 East Midlands licence area:

Capacity (MWe)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	94	97	62	15	0	0	0
System Transformation		62	15	0	0	0	0
Consumer Transformation		62	15	0	0	0	0
Leading the Way		61	0	0	0	0	0

Summary:

- The East Midlands licence area has a number of existing operational diesel engines, including 36.4 MW of larger standalone commercial diesel generation sites and 58 MW of behind-the-meter backup generators co-located with large energy user buildings. This is substantially higher than last year's DFES baseline due to a number of projects being successfully reclassified from 'other generation'.
- There is one new diesel site with an accepted connection agreement from NGED in the licence area; a 3.2 MW behind-the-meter backup generator in Bassetlaw. Due to its likely role as a standby generator, this site is modelled to connect in every scenario in the 2024 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 2028, 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 (36.4 MW)	25 sites (57 MW)
Largest baseline site:	25 MW Asfordby Coliery diesel generator, Melton

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 National Grid in the East Midlands licence area; a 3.2 MW behind-the-meter backup generator for Midlands Power Networks, an electrical engineering company in Bassetlaw. Due to its likely role as a backup generator, this site is modelled to connect in every scenario in the 2024 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.

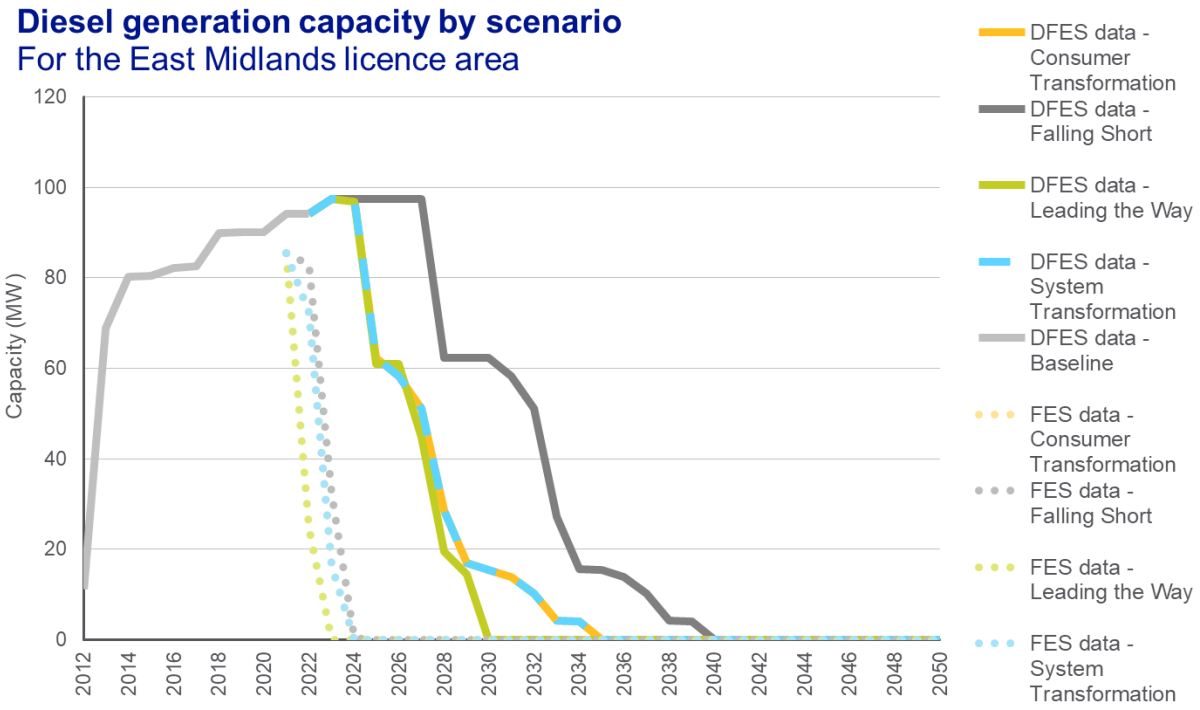
Scenario	Description	Earliest decommissioning year
Falling Short	No sites are modelled to disconnect in this timescale as it is assumed that the requirements under the MCPD do not fully encourage generator site operators to decommission or relinquish export capacity by March 2025.	2026 (standalone) 2031 (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 sites is a 25 MW generator in Asfordby, which was built in 2000.	2024 (standalone) 2026 (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 (91 MW) decommissioning by 1 January 2025. No backup generators decommission in this time period.	2024 (standalone) 2027 (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**.	2028 (standalone) 2040 (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 per year.	2025 (standalone) 2035 (backup)
Leading the Way	All standalone diesel generators are modelled to decommission by 2025, with a handful of backup generators (31 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, East Midlands licence area



- The current installed capacity of diesel generation in the East Midlands licence area is c.34 MW higher in the DFES data than in the FES 2022 data. This is thought to be due to DFES data also including behind-the-meter backup generators (28 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 29 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 East 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 East Midlands licence area:

Capacity (MWe)		Baseline	2025	2030	2035	2040	2045	2050
CCGT (non-CHP)	Falling Short	407	0	0	0	0	0	0
	System Transformation		0	0	0	0	0	0
	Consumer Transformation		0	0	0	0	0	0
	Leading the Way		0	0	0	0	0	0
OCGT (non-CHP)	Falling Short	36	356	356	356	356	356	356
	System Transformation		356	356	356	0	0	0
	Consumer Transformation		356	356	356	0	0	0
	Leading the Way		356	320	0	0	0	0
Reciprocating engines (non-CHP)	Falling Short	296	338	384	384	384	384	379
	System Transformation		328	325	298	55	0	0
	Consumer Transformation		328	325	298	55	0	0
	Leading the Way		304	293	0	0	0	0
Gas CHP	Falling Short	207	207	211	211	211	211	208
	System Transformation		176	168	125	0	0	0
	Consumer Transformation		176	168	125	0	0	0
	Leading the Way		168	125	0	0	0	0

Summary:

- There is a significant baseline (c. 1 GW) of existing operational fossil gas-fired generation connected to the distribution network in the East 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 31 additional sites with accepted connection offers with NGED in the East Midlands licence area, comprising three gas CHPs (6 MW) and 25 applications for reciprocating engines, totalling an additional 108 MW.
- The current primary role of distribution-scale fossil gas-fired generation is to provide flexibility and backup services. The operation of all types of fossil gas generation significantly reduces in the three net zero scenarios out to 2050, as the use of unabated fossil gas-fired electricity generation is at odds with the UK's net zero targets.

- The Smart Systems and Flexibility Plan[xxix], 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[xxx] 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 East Midlands licence area'.

Modelling assumptions and results

Baseline

There are 115 fossil-gas generation sites connected in the East Midlands licence area, totalling 946 MW. This is broken down into the following fossil gas technologies:

Sub-technology	Number of sites	Total capacity
CCGT (non-CHP)	1	407 MW
OCGT (non-CHP)	2	36 MW
Reciprocating engines (non-CHP)	53	296 MW
Gas CHP	62	207 MW

The largest site in the East Midlands licence area is Corby Power Station, a 407 MW CCGT which was commissioned in 1994 and is operated by ESB. Under the EU's Industrial Emissions Directive, plants not meeting pollution standards would have to perform upgrades or opt-out and retire by 2023. Corby Power Station has resultantly opted out and, therefore, will have to close in 2023. This has been reflected under all scenarios.

However, ESB is looking to replace the existing CCGT with a 320 MW OCGT, which would fall within the emissions limit. This site has prequalified in the T-4 Capacity Market for 2023 and has also received planning permission for the conversion of the site. Therefore, it is modelled to repower as an OCGT in 2024 under all scenarios, due to the current role of fossil gas as a flexibility asset.

Pipeline (April 2022 to March 2028)

Sub-technology	Number of pipeline sites	Total capacity
OCGT (non-CHP)	1	320 MW
Reciprocating engines (non-CHP)	23	102 MW
Gas CHP	7	15 MW

Pipeline analysis			
Status	**Scenario outcomes**	**Sites**	**Capacity**
Under construction	A 2 MW CHP at Tritax Symmetry Park is currently under construction and has therefore been modelled to connect in 2023 under all scenarios.	1	2 MW
Planning permission granted	There are three sites, totalling 19 MW, with an accepted connection offer from NGED that have also received planning permission. • Two of these sites (c. 13 MW) have been rejected in recent Capacity Market auctions, and so are only modelled to connect under **Falling Short**. • The remaining site (6.3 MW) is modelled to connect under all scenarios except **Leading the Way**, due to the focus on low carbon flexibility assets in the near term under this scenario. Additionally, the redevelopment of Corby Power Station as a 320 MW OCGT has prequalified in the T-4 Capacity Market for 2023 and has also received planning permission for the conversion of the site. Therefore, it is modelled to repower as an OCGT in 2024 under all scenarios, due to the current role of fossil gas as a flexibility asset.	4	339 MW
Planning application submitted	Two sites are awaiting planning decisions; one of them has secured a Capacity Market agreement for the 2025/26 delivery year and is, therefore, modelled to connect under all scenarios except **Leading the Way**. The other site has no further publicly available information and thus has only been modelled to connect under **Falling Short**.	2	9 MW
Pre-planning	The other 22 sites with connection offers from NGED are pre-planning; however: • Four of these sites (27 MW) have secured a Capacity Agreement off the back of recent Capacity Market auctions. These have been modelled to connect in time to meet their Capacity Market delivery years under all scenarios. • Two of these sites (14 MW) successfully prequalified for Capacity Market auctions, and so have been modelled to connect under all scenarios except **Leading the Way**, due to the focus on low carbon flexibility assets. • The other 16 sites do not have any further information and have been modelled to connect under **Falling Short** only.	22	84 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[xxxi] which proposed specific carbon intensity thresholds for entry into capacity auctions.

Whilst this limit does not immediately restrict fossil gas generators with low annual load factors, future developments or reductions to this threshold (off the back of deep policy reviews such as REMA) could prevent unabated fossil gas from participating in some markets. The scenario assumptions and outcomes for fossil-gas generation technologies reflect a range of views for this type of policy.

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

The operation of all types of unabated fossil gas generation significantly reduces in the three net zero scenarios out to 2050, as the use of fossil gas for electricity generation is at odds with the UK's net zero targets.

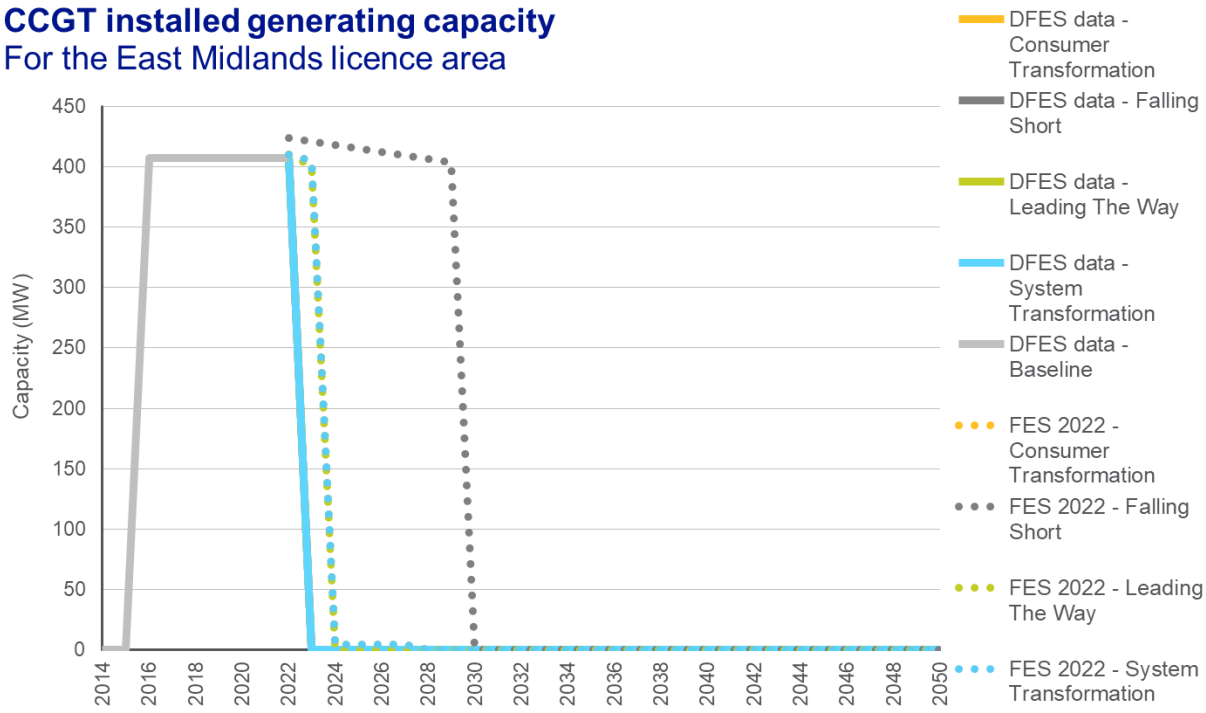
Sub-technology	Scenario	Description	Decommissioning timescale
CCGT (non-CHP)	Leading the Way	Corby Power Station (407 MW) is modelled to decommission under all scenarios in 2023, as it no longer meets the emissions limits specified under the EU's Industrial Emissions Directive. Under Falling Short, Corby Power Station repowers as an OCGT in 2024.	2023
	Consumer Transformation		
	System Transformation		
	Falling Short		
OCGT (non-CHP)	Leading the Way	In addition to the existing 36 MW capacity, a new 320 MW OCGT is modelled to come online at Corby Power Station, connecting in 2024. All OCGT capacity is modelled to decommission in the three net zero scenarios.	2032
	Consumer Transformation		2038
	System Transformation		2038
	Falling Short	In addition to the existing 36 MW capacity, a new 320 MW OCGT is modelled to come online at Corby Power Station, connecting in 2024. All OCGT capacity is modelled to remain operational across the period to 2050. This reflects gas turbine technology providing system flexibility alongside more responsive gas engine technologies and overall less action on decarbonisation.	Post-2050
Reciprocating engines (non-CHP)	Leading the Way	Gas reciprocating engine capacity is modelled to steadily reduce across the medium term. This reflects a rapid switch to alternative low carbon sources of flexibility such as electricity storage, bioenergy and hydrogen.	2023 – 2035
	Consumer Transformation	A moderate amount of reciprocating engine capacity continues to connect to the distribution network in the early 2030s, reflecting a slightly slower transition to lower carbon flexibility. Capacity then steadily decommissions so that no	2023 – 2043
	System Transformation		2023 - 2043

		capacity is operating on the network by 2050.	
	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 368 MW in 2028, some capacity is modelled to decommission, reflecting some transition away from fossil-fuel-driven flexibility. However, 362 MW remains in operation in 2050.	2023 – 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 209 MW still operational by this period.	2049 – post-2050

Reconciliation with National Grid FES 2022

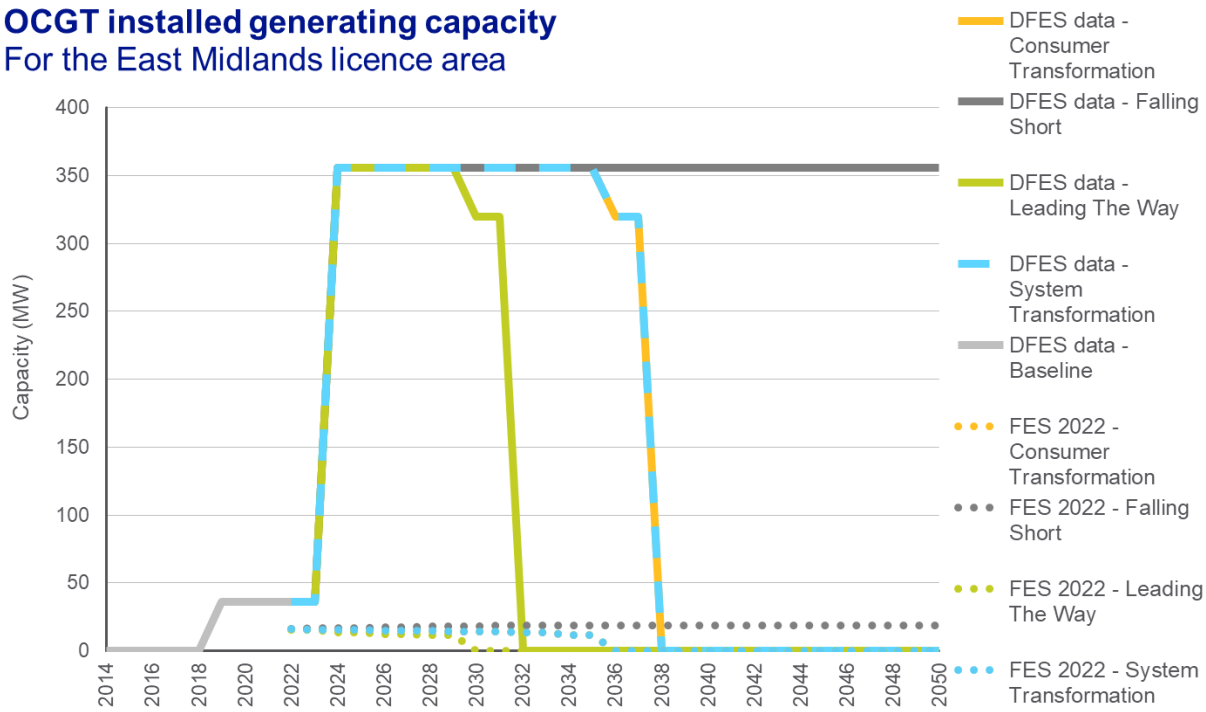
- For all of the fossil gas sub-technologies included, the DFES has sought to classify each of the baseline and pipeline sites based on connection data held by National Grid and through site-by-site reconciliation with Capacity Market registers published by the EMR Delivery Body.
- Each pipeline site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



- The DFES and FES baselines are well aligned and follow similar decommissioning trajectories; however, DFES models Corby Power Station to decommission in 2024 under all scenarios, due to ESB seeking to convert Corby's CCGT asset to a 320 MW OCGT, in order to reduce the emissions of the site. Under the EU's Industrial Emissions Directive, the CCGT at Corby will have to cease operation in 2023.

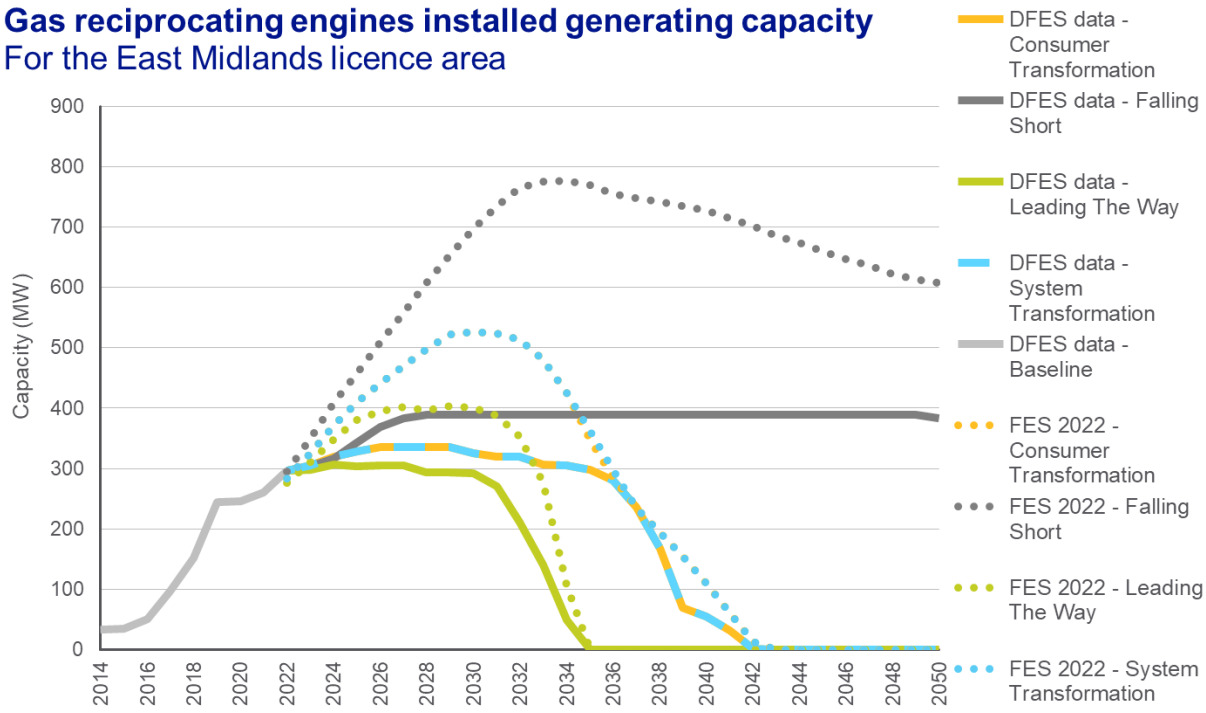
Figure 22 – Electrical capacity of OCGTs generation by scenario, East Midlands licence area



- The DFES baseline is moderately higher than the FES baseline.

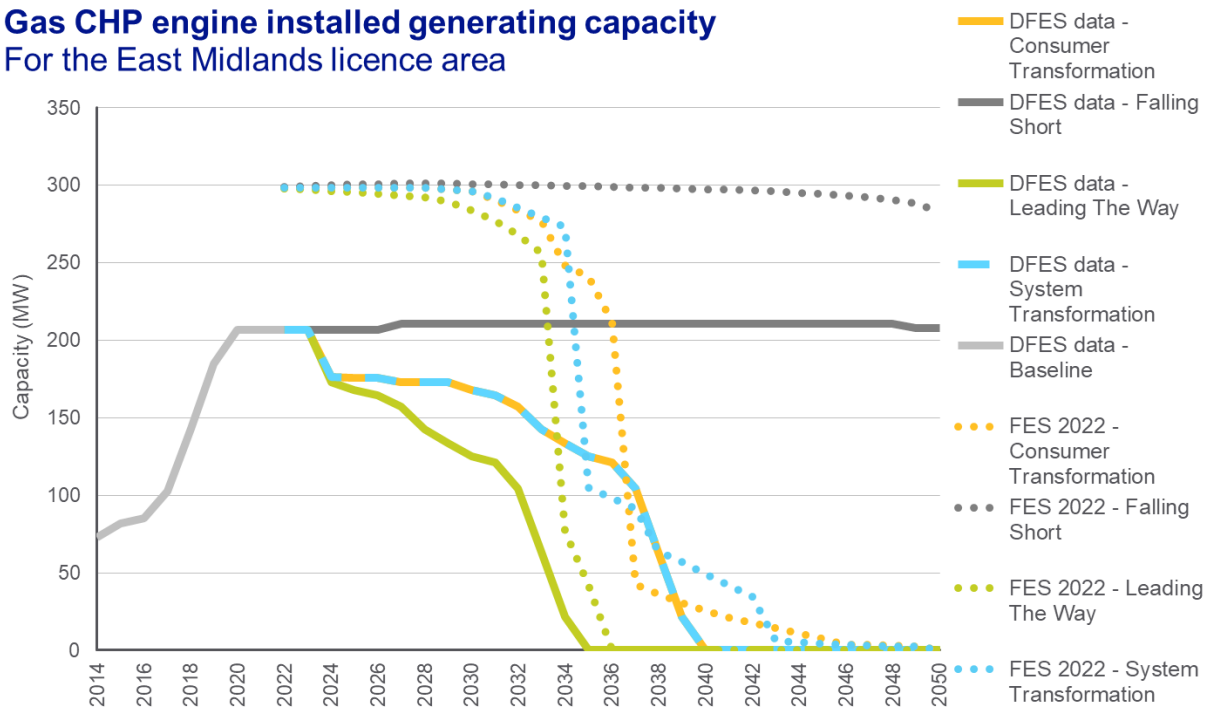
- FES 2022 does not model the repowering of Corby Power Station as an OCGT; however, this has been included in the DFES projections due to planning and Capacity Market information. It is not considered that Corby Power Station would decommission under **Falling Short** due to its continued role as a flexible asset; however, increasingly stringent emission directives and the increased availability of hydrogen as a low carbon fuel result in the decommissioning of Corby Power Station and the conversion of its assets to hydrogen-fuelled generation in the three net zero scenarios.

Figure 23 – Electrical capacity of fossil gas reciprocating engines by scenario, East Midlands licence area



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

Figure 24 – Electrical capacity of fossil gas CHPs by scenario, East Midlands licence area



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

Factors that will affect deployment at a local level

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

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

Hydrogen-fuelled generation in the East 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 East Midlands licence area:

Capacity (MWe)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	0	0	0	0	0	0	0
System Transformation		0	20	321	674	1,098	1,150
Consumer Transformation		0	22	276	296	617	693
Leading the Way		0	30	687	737	1,292	1,451

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'[xxxii] 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. With the analysis specifically suggesting 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 East 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 East Midlands, these include Nottingham and Derby, as well as the areas around the M1, which runs the length of the licence area.
- 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 East Midlands licence area has a significant amount of existing gas and diesel generating capacity (c. 1,042 MW) along with a further pipeline of 122 MW. Therefore, in high hydrogen scenarios, the East Midlands licence area is likely to be a key region for hydrogen-fuelled generation in the future under some scenarios.
- As a general consideration, the business case for hydrogen-fuelled electricity generation is likely to be challenging, with hydrogen 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 of low carbon hydrogen in providing flexible power generation, as stated in the UK Hydrogen Strategy[xxxiii]. In July 2021, the UK government published a call for evidence on 'decarbonisation readiness'[xxxiv] 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[xxxv].

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 East Midlands licence area, or nationally.

However, there is currently 923 MW of gas-fired power generation and 119 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.

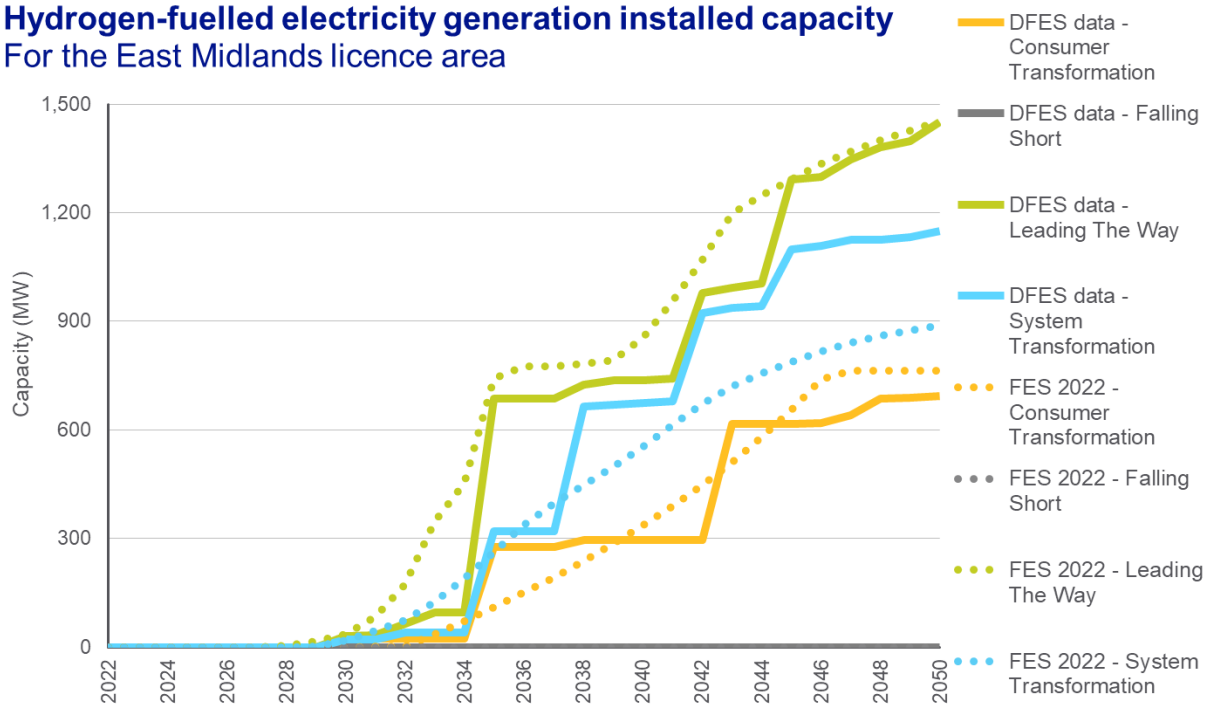
There are key sites in the East Midlands, highlighted in the East Midlands Hydrogen Innovation Zone proposal[xxxvi], which may be early adopters of hydrogen. These areas include the Ratcliffe-on-Soar transmission-connected coal power station site in Nottinghamshire, the East Midlands Intermodal Park in south Derbyshire and East Midlands Airport.

Projections have therefore centred around an analysis of existing (c. 1 GW) and pipeline (c. 120 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.	737 MW	1,451 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 (1,458 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**.	296 MW	693 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.	674 MW	1,150 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 25 – Electrical capacity of hydrogen-fuelled generation by scenario, East Midlands licence area



- The DFES 2022 projections echo the uptake of hydrogen-fuelled generation at a national level modelled in the FES 2022. In the East Midlands licence area, by 2050, the DFES has projected less capacity overall under **Leading the Way** and **Consumer Transformation**, and more capacity under **System Transformation** than FES 2022. This is a reflection of the DFES methodology of siting hydrogen generation at existing and pipeline fossil gas and diesel generation sites.
- Corby Power Station (320 MW) and Derwent Power Station (236 MW) are modelled to convert to hydrogen in 2035, resulting in a spike under **Leading the Way**. Due to early decommissioning timescales for existing and pipeline fossil fuel sites under these scenarios, plants are modelled to convert to hydrogen more quickly and do so in order to reduce the amount of time they are not operational.
- FES 2022 has modelled a smoother, more gradual increase in connected capacity between 2030 and 2050 under **Consumer Transformation** and **System Transformation**. Whereas DFES 2022 analysis has modelled discrete sites converting within potential hydrogen supply areas, resulting in a more stepped increase in capacity across the 2030s and 2040s.
- While existing plants may be capable of accepting 100% hydrogen by 2030, the DFES analysis also takes into account the long decommissioning and repowering timelines of existing fossil fuel plants and, therefore, models a slower uptake in the early-2030s, followed by a more rapid uptake from 2035 onwards.

Factors that will affect deployment at a local level

Factor	Source
Location of existing and known commercial gas and diesel sites in the East Midlands licence area.	National Grid
Spatial analysis of potential hydrogen supply areas, factoring in locations of existing hydrogen trials, large industrial clusters, the gas network, 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 East Midlands licence area

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

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

Capacity (MWe)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	191	237	348	368	336	312	311
System Transformation		237	348	292	291	278	229
Consumer Transformation		237	328	272	271	258	209
Leading the Way		237	328	272	271	258	209

Summary:

- Energy recovery from waste is considered the fourth level of the waste management hierarchy behind waste prevention, preparation for reuse and recycling[xxxvii]; however, electricity generation from unabated waste incineration is at odds with net zero targets, due to the level of associated carbon emissions.
- In the East Midlands licence area, there is 143 MW of existing operational waste incineration capacity (99.35 MW incineration, 43.25 MW ACT), as well as five incineration sites (121 MW) and four ACT sites (66 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 (109 MW) are modelled to continue operating past 2050.

Modelling assumptions and results

Baseline	
Number and capacity (MW) of incineration sites	**Number and capacity (MW) of ACT sites**
12 sites (142.6 MW)	1 site (48.6 MW)
Largest baseline site:	29.7 MW London Road Heat Station incinerator in Nottingham

Pipeline (April 2022 to March 2030)	
Number and capacity (MW) of incineration sites	**Number and capacity (MW) of ACT sites**
5 sites (121 MW)	4 sites (66 MW)

Pipeline analysis			
Status	**Scenario outcomes**	**Sites**	**Capacity**
Under construction	Newhurst Energy Recovery Facility (46 MW) in Leicestershire began construction in June 2020 and, according to the developers, is expected to be completed in 2023. This is reflected in all scenarios.	1	46 MW
Planning permission granted	The five waste incineration sites with planning permission are modelled to connect in all scenarios. However, these sites all received planning permission in 2016/17 with no apparent updates since. As a result, the development timeline has been modelled to be between eight and nine years from when planning permission was received. Four of these sites are ACT sites, showing a shift towards more environmentally friendly methods of waste management.	5	91 MW
Planning permission submitted	The Boston 2 Biomass Power Station site applied for planning permission for a 102 MW Energy from Waste plant in March 2021, with a connection agreement for 20 MW. This has been modelled to connect under **Falling Short** and **System Transformation** due to the lack of planning permission at this stage.	1	20 MW
Pre-panning	Due to a lack of planning information, this site is modelled to only connect under **Falling Short**, approximately eleven years from signing a connection agreement with NGED.	1	20 MW
Abandoned/refused	One site in Burton Latimer has not been modelled to connect under any scenario, due to having planning permission refused or being logged as abandoned in the Renewable Energy Planning Database.	1	10 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.

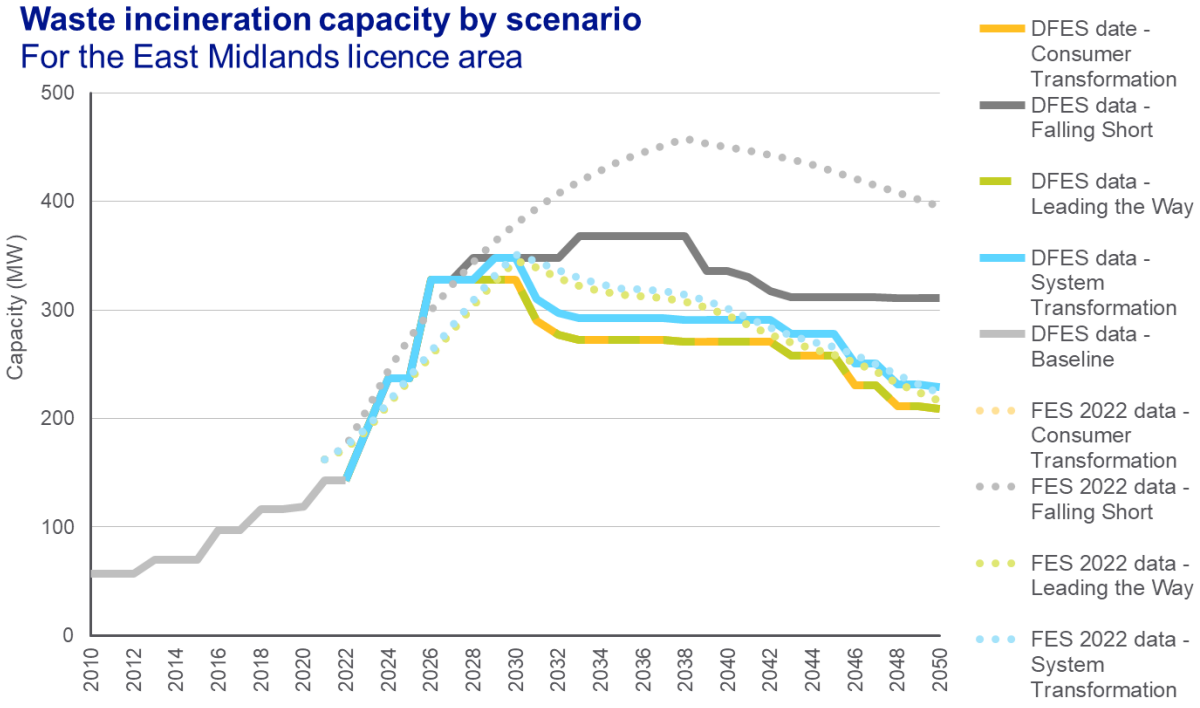
- IEA Bioenergy, in its 'Waste Incineration for the Future' paper[xxxviii], concluded that, in order to remain relevant and continue to create value in a circular economy, the waste sector will have to innovate in energy technologies, system design and integration and business models.
- Additionally, a 2021 Deloitte study[xxxix] 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[xl]; 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.	8	209 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.	8	209 MW
System Transformation	ACT gasification plants have lower associated carbon emissions, and any residual emissions can be abated, hence all ACT sites (109 MW) are modelled to continue operating past 2050. **System Transformation** has one more site (20 MW) remaining operational than **Leading the Way** and **Consumer Transformation**, due to the modelled connection of the Boston 2 Biomass Power Station in the near term.	9	229 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 (280 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.	13	311 MW

Reconciliation with National Grid FES 2022

Figure 26 – Electrical capacity of waste incineration by scenario, East Midlands licence area



- DFES 2022 and FES 2022 have similar baselines of operational waste incineration capacity in the East Midlands licence area.
- 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 238 MW of new waste incineration capacity out to 2038 in the licence area. The DFES 2022 data only has 177 MW of additional sites connecting, 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 East Midlands licence area

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

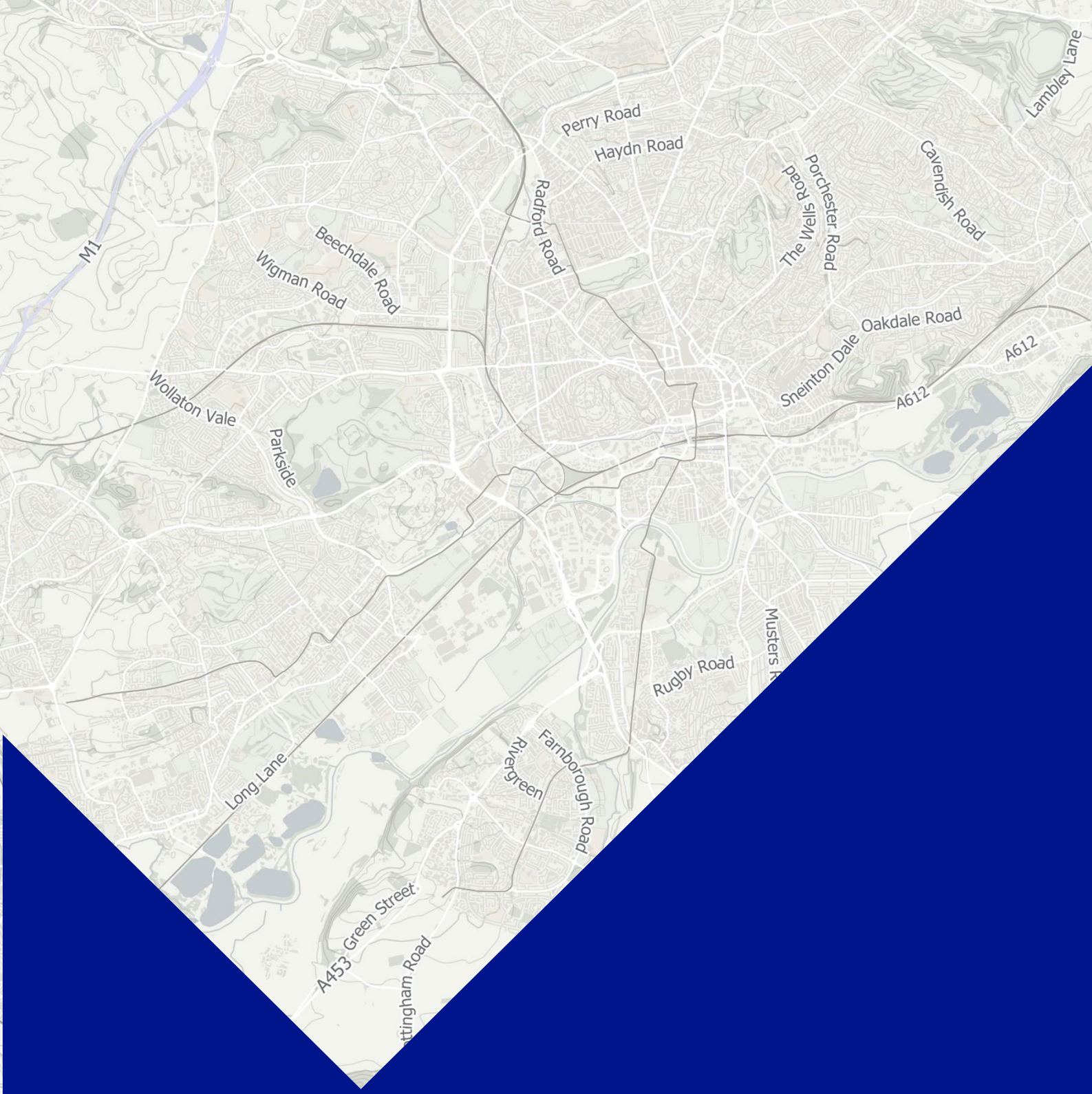
Data summary for other generation in the East Midlands licence area:

Capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	2	4	4	4	4	4	4
System Transformation		4	4	4	4	4	4
Consumer Transformation		4	4	4	4	4	4
Leading the Way		4	4	4	4	4	4

Summary:

- There are six other generation sites that have not been categorised as a particular technology, connected to the distribution network in the East 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 49 additional other generation sites in the East Midlands with an accepted connection agreement, totalling 2 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.

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



Storage technologies

Results and assumptions

Battery storage in the East 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 East Midlands licence area:

Capacity (MW)		Baseline	2025	2030	2035	2040	2045	2050
Standalone network services	Falling Short	56	345	789	796	804	811	819
	System Transformation		345	789	804	811	818	826
	Consumer Transformation		345	1,242	1,270	1,289	1,308	1,326
	Leading the Way		633	1,251	1,280	1,299	1,318	1,337
	Storage Planning		886	2,121	2,389	2,698	2,900	2,900
Generation co-location	Falling Short	4	9	9	19	21	34	35
	System Transformation		10	19	35	57	62	67
	Consumer Transformation		10	60	78	121	132	138
	Leading the Way		10	207	234	288	322	325
	Storage Planning		68	529	1,193	1,416	1,426	1,426
Behind-the-meter high-energy user	Falling Short	1	5	9	20	24	42	48
	System Transformation		6	9	30	61	98	112
	Consumer Transformation		6	29	52	74	141	161
	Leading the Way		6	28	50	91	140	160
	Storage Planning		6	28	28	28	28	28
Domestic batteries	Falling Short	0.2	2	5	14	26	61	117
	System Transformation		5	43	64	136	213	309
	Consumer Transformation		13	111	244	429	628	960
	Leading the Way		20	142	323	543	822	1,260

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[xli].
- 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[xlii].
- The East Midlands licence area currently has 63 operational battery storage sites, totalling 62 MW. 11.6 MW of this has connected since the DFES 2021 analysis was completed.
- The East Midlands licence area also has the second largest pipeline of battery storage projects with accepted connection offers across NGED's network; 207 projects totalling c. 4.3 GW.
- Based on Regen analysis, over 1.3 GW of the storage pipeline has either received or submitted planning permission or entered into the Capacity Market. Additionally, over 2.4 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 deployment timescale of projects in the pipeline connecting at distribution level. These constraints have been directly reflected under the **Falling Short** scenario, but not in the three net zero scenarios. This allows the scenarios to represent a realistic range of potential future connections to the distribution network.
- As a key technology providing flexibility services to the electricity system, battery storage projects are actively engaging with flexibility markets and ancillary services being procured by National Grid ESO. With the development of new frequency response services, new reserve services and system stability services, the revenue opportunities for battery operators to 'stack' is developing all the time.
- This year, due to the unprecedented pipeline of large-scale battery storage projects across NGED's licence areas, the DFES has included an additional scenario, **Storage Planning**, which is based solely on the significant pipeline of projects with connection agreements with National Grid Electricity Distribution.
- The East 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
    - Significant potential for distributed solar and wind deployment, enabling co-location.
    - A notable number of non-domestic properties with the potential for behind-the-meter batteries.
    - A significant potential capacity of 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 East Midlands licence area ranges from 1 GW in **Falling Short** to 3.1 GW in **Leading the Way**.
- Under the **Storage Planning** scenario, which only applies to large-scale storage, 4.4 GW is modelled to connect by 2050.

Baseline

There are 63 battery storage projects totalling 62 MW currently connected to the distribution network in the East Midlands licence area, all of which have come online since 2016. 11.6 MW of this has connected since April 2021, when the DFES 2021 analysis was carried out.

The largest operational site in the East Midlands licence area is an 11 MW battery energy storage system in Boston, which connected in May 2021.

Business model	Number of sites	Total capacity (MW)
Standalone network services	6	55.8 MW
Generation co-location	14	4.4 MW
Behind-the-meter high-energy user	5	1.5 MW
Domestic batteries	38	0.2 MW

Pipeline (April 2022 to March 2029)

Business model	Number of pipeline sites	Total capacity
Standalone network services	52	2,844 MW
Generation co-location	57	1,421 MW
Behind-the-meter high-energy user	5	26 MW
Domestic batteries	93	0.5 MW

The East Midlands licence area has the second largest pipeline of battery storage projects with accepted connection offers across NGED's network; 207 projects totalling c. 4.3 GW. In comparison, the pipeline of projects with accepted connection offers from DFES 2021 was 690 MW, showing a significant increase in developer appetite for storage projects in the last 12 months.

Based on Regen's analysis, over 1.3 GW of this pipeline has either received or submitted planning permission or entered into the Capacity Market. Additionally, over 2.4 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 these projects will not progress through to development in the future.

As a key technology that can provide rapid response flexibility services to the network, battery storage is active in a number of National Grid ESO's ancillary service market tenders and auctions. In recent years the ESO has evolved their suite of response and reserve services, notably with the evolution of the new 'trio of frequency response markets[xliii]: Dynamic Containment, Dynamic Regulation and Dynamic Moderation. In addition to this, the ESO has launched a new Slow Reserve service[xliv] and continues to deliver its network options assessment pathfinders[xlv] 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.1 MW) in the known pipeline, and these sites are included in the modelling of the four DFES scenarios.

Pipeline analysis			
Status	**Scenario outcomes**	**Sites**	**Capacity**
Under construction	• A battery storage facility at Chelveston Renewable Energy Park was granted planning permission in 2017 and is currently under construction. This project has a 4 MW grid connection offer with NGED and is modelled to connect in 2024 in all scenarios. • A 5 MW development at Manor Farm in East Lindsey was granted planning permission in November 2017 and was noted as being under construction in the Renewable Energy Planning Database. This project is modelled to connect in 2023 in all scenarios.	2	9 MW
Planning permission granted	• Six sites (286 MW) have secured a Capacity Market agreement and have been modelled to connect to meet their Capacity Market delivery year under all scenarios. • A 90 MW battery project was granted planning permission in February 2021 and is targeting a 2025 commissioning year. This has been modelled to connect in: ○ **Falling Short: 2029** ○ **System Transformation: 2027** ○ **Consumer Transformation: 2027** ○ **Leading the Way: 2025** ○ **Storage Planning: 2025** • The other four sites (247 MW) have been modelled to connect between three and seven years from receiving planning permission, depending on the scenario.	11	623 MW
Planning application submitted	• There are 11 sites (736 MW) in the East 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 204 MW project in South Kesteven which has submitted an application to National Infrastructure Planning in August 2022.	11	736 MW
No information	• Three additional sites (110 MW) have secured Capacity Market agreements for 2024/25 delivery years. These are modelled to meet their delivery year under all scenarios. • Modelling projects with positive planning information to connect already exceeds the FES 2050 projections under all scenarios; therefore, the remaining 68 sites (2.9 GW) without any Capacity Market or planning information have only been modelled to connect under the **Storage Planning** scenario across the 2030s and 2040s.	68	2,923 MW
Too small for planning	• 114 sites, totalling 0.7 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.	114	0.7 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 3.1 GW by 2050. This reflects a strong potential deployment of batteries across all four business models.

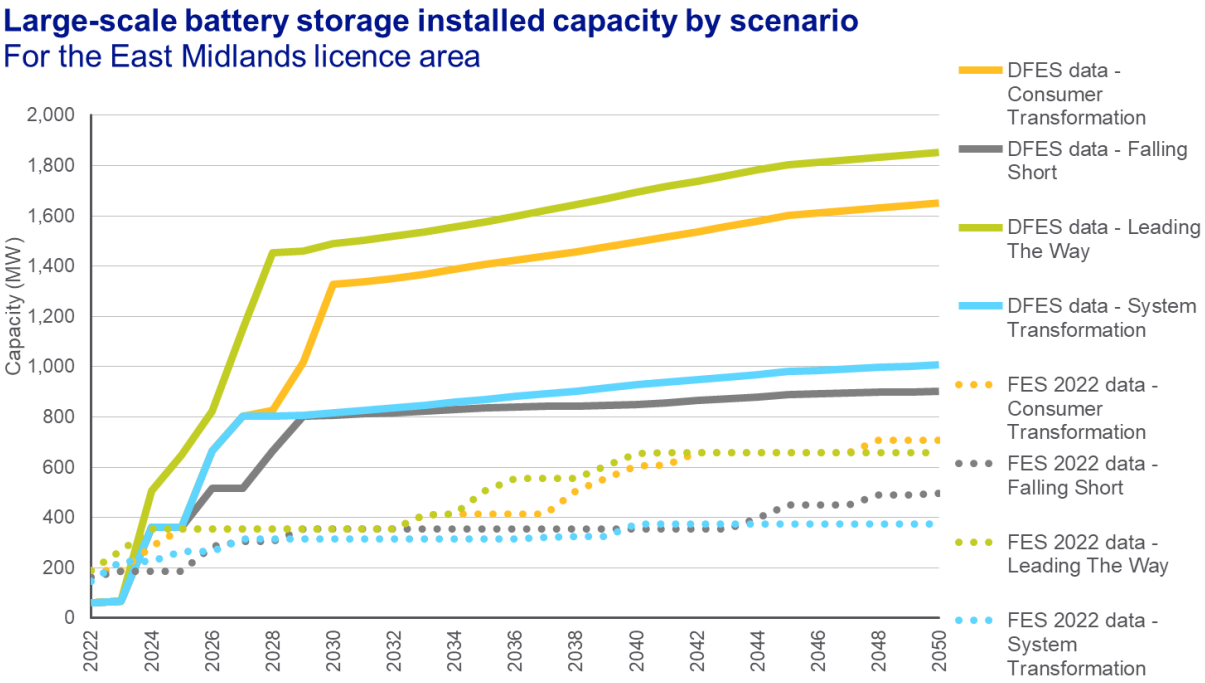
Falling Short sees the lowest overall storage deployment in the licence area, reaching 1 GW by 2050. This reflects a lesser need for electricity system flexibility, a lower renewable energy adoption and ongoing use of fossil fuel generation as a source of flex. This reduced development landscape is reflected in the longer term out to 2050, across all storage business models.

The **Storage Planning** scenario takes a bespoke view of the very large pipeline of battery storage projects with an accepted connection offer from NGED. This scenario projection considers all sites, except those that have been rejected in planning, will go through to connection across the scenario timeframe, resulting in 4.4 GW of connected battery storage by 2050. This scenario mirrors the breakdown of the current pipeline by business model. Hence 2.6 GW of this is standalone projects targeting grid services, and another 1.7 GW is collocated with renewable energy generation, and comparatively few behind-the-meter projects are resultantly modelled under this separate planning scenario.

Business model	Projection methodology	Scenario	Total capacity by 2035 (MW)	Total capacity by 2050 (MW)
Standalone network services	Standalone storage accounts for a significant proportion of the existing and known near-term storage pipeline capacity, and this business model continues to see 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**	796	819
		System Transformation	804	826
		Consumer Transformation	1,270	1,326
		Leading the Way	1,280	1,337
		Storage Planning	2,389	2,900
Generation co-location	Generation co-location capacity also sees a strong uptake in the East Midlands licence area. This is in part due to a notable number of co-location sites with accepted connection offers and the licence area having the highest combined ground-mounted solar PV and	**Falling Short**	19	35
		System Transformation	35	67

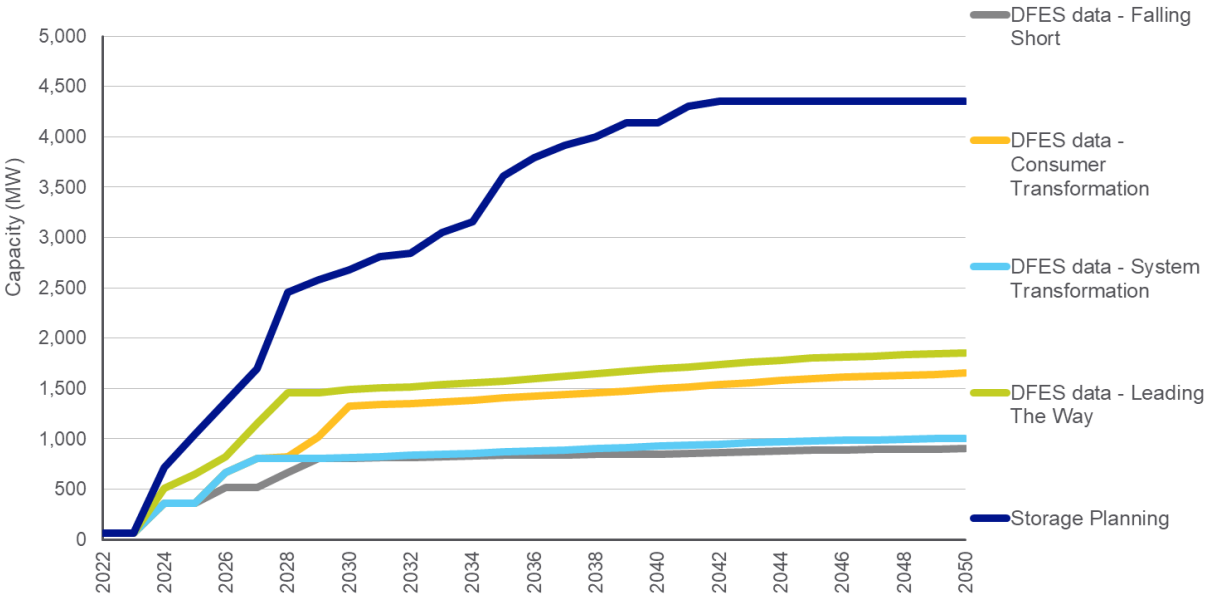
	onshore wind capacity projections by 2035 across NGED's network. Beyond this, the significant annual growth in new co-location capacity lessens, as network capacity and flexibility markets saturate, and grid-scale battery projects co-locating with new solar and wind generation develop at a more moderate pace out to 2050.	**Consumer Transformation**	78	138
		Leading the Way	234	325
		Storage Planning	1,193	1,426
Behind-the-meter high-energy user	The East Midlands licence area has the second 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 relatively strong across all scenarios by 2035. This reflects feedback from stakeholders that high-energy users, such as industrial customers, could drive electricity storage deployment in the medium term. Annual capacity deployment under this business model begins to increase further in the longer term out to 2050 under **Consumer Transformation** and **Leading the Way**, as more businesses seek to manage their onsite energy use and costs through flexibility technologies. The **Storage Planning** scenario does not see a strong uptake past the near term, due to the limited pipeline of behind-the-meter projects.	**Falling Short**	20	48
		System Transformation	30	112
		Consumer Transformation	52	161
		Leading the Way	50	160
		Storage Planning	28	28
Domestic batteries	The East Midlands licence area has significant potential for domestic battery deployment in the medium term, due to the overall number of homes and significant domestic-scale rooftop PV deployment projections. Significant uptake of domestic storage is delayed until the longer term, with projections under **Consumer Transformation** and **Leading the Way** reflecting stakeholder feedback that domestic storage will be the business model with the lowest uptake in the near-to-medium term.	**Falling Short**	14	117
		System Transformation	64	309
		Consumer Transformation	244	960
		Leading the Way	323	1,260

Figure 27 – Electrical capacity of large-scale battery storage by scenario, East Midlands licence area



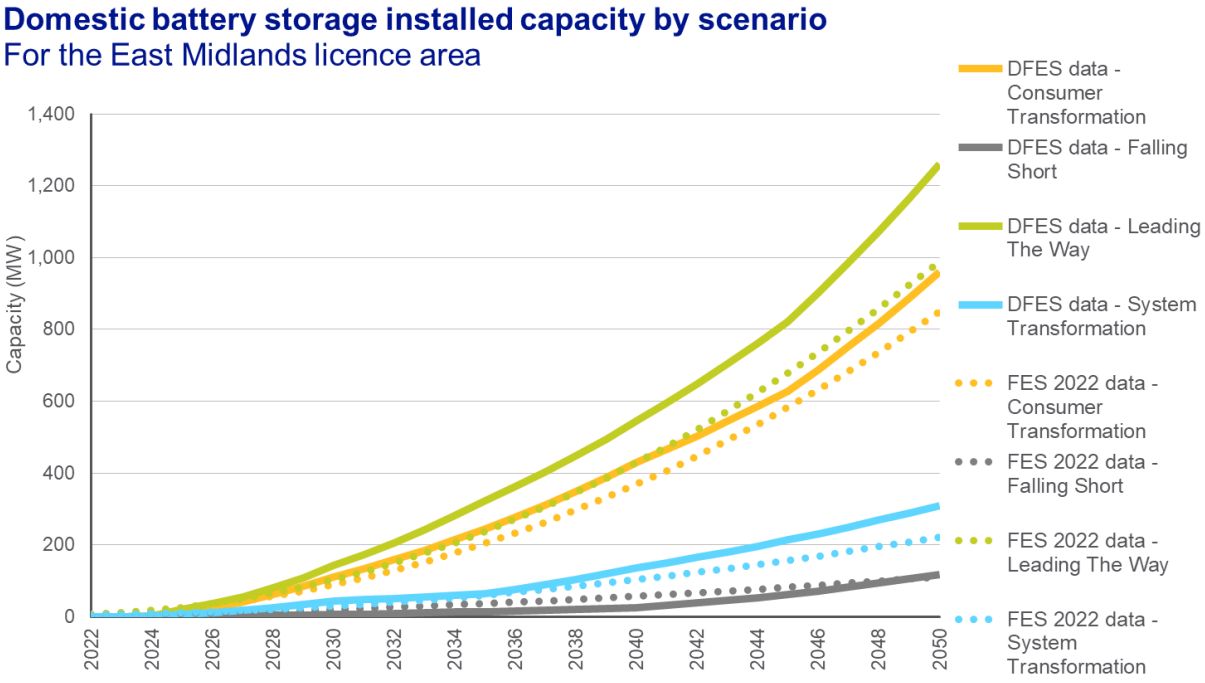
- The FES 2022 data is slightly above the DFES baseline for the East Midlands licence area.
- Reflecting the very large near-term pipeline, the DFES 2022 projections significantly exceed the FES 2022 near-term projections, reaching c.1.5 GW by 2028 under **Leading the Way**, over 1 GW more than FES. 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 assumptions applied under different scenarios.

Figure 28 – Electrical capacity of large-scale battery storage by scenario (including the Storage Planning scenario), East 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 nearly 3 GW higher than **Leading the Way** and c. 3.5 GW higher than **Falling Short** 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 East Midlands licence area, which is not accounted for in the envelope of the four FES scenarios.

Figure 29 – Electrical capacity of domestic battery storage by scenario, East 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 East 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 East 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 influenced 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

[xli] https://data.nationalgrideso.com/connection-registers/transmission-entry-capacity-tec-register
[xlii] https://www.energy-storage.news/large-scale-battery-storage-in-the-uk-analysing-the-16gw-of-projects-in-development/
[xliii] See National Grid ESO frequency response services: https://www.nationalgrideso.com/industry-information/balancing-services/frequency-response-services
[xliv] See National Grid ESO Slow Reserve service: https://www.nationalgrideso.com/industry-information/balancing-services/reserve-services/slow-reserve
[xlv] See National Grid ESO NOA Pathfinders: https://www.nationalgrideso.com/future-energy/projects/pathfinders

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