Distribution Future Energy Scenarios 2021

East Midlands licence area

Results and assumptions report

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WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

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Glossary

Acronym	Definition
ACT	Advanced Conversion Technologies
AD	Anaerobic Digestion
ASHP	Air Source Heat Pump
BECCS	Bioenergy with Carbon Capture and Storage
BEIS	Department for Business, Energy and Industrial Strategy
BEV	Battery Electric Vehicles
CCGT	Combined-Cycle Gas Turbine
CCUS	Carbon Capture and Storage
CHP	Combined Heat and Power
DFES	Distribution Future Energy Scenarios
DNO	Distribution Network Operator
EMR	Electricity Market Reform
ENA	Energy Networks Association
EPC	Energy Performance Certificate
ESA	Electricity Supply Area
ESO	Energy System Operator
EV	Electric Vehicle
FES	National Grid ESO Future Energy Scenarios
FHS	Future Homes Standard
GHG	Green House Gases
GIS	Geographic information system
GSHP	Ground Source Heat Pump
GSP	Grid Supply Point
GW	Gigawatt
HGV	Heavy Goods Vehicle
HNDU	Heat Network Delivery Unit
HNIP	Heat Network Investment Project
kW	Kilowatt
LA	Local Authority
LCT	Low Carbon Technology
LGV	Light Goods Vehicle
LPG	Liquefied petroleum gas
LV	Low Voltage
MW	Megawatt
OCGT	Open-Cycle Gas Turbine
PHEV	Plug-in Hybrid Electric Vehicle
PV	Solar Photovoltaics
REPD	Renewable Energy Planning Database
RHI	Renewable Heat Incentive
SCR	Significant Code Review
SMR	Steam Methane Reformation
UKCS	UK Continental Shelf

Introduction to the WPD DFES 2021

Background:

The DFES provides granular scenario projections for generation, demand and storage technologies that are or will be connected to the electricity distribution network. In the WPD DFES 2021, this also includes projections for new housing, commercial and industrial developments, which represent sources of new electricity demand. The projections are fundamentally informed by stakeholder engagement, to reflect local and regional drivers, the needs and plans of local authorities, and views of other stakeholders.

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 WPD to appraise different investment options and develop the business case necessary to support future investment, including regulated business plans.

Figure 1 – The WPD DFES annual process

The scope:

The WPD DFES 2021 scope encompasses all technologies that directly connect to or interact with the distribution network in the four WPD licence areas: South Wales, South West, East Midlands, and West Midlands. By definition, this excludes large-scale assets connecting directly to the National Grid transmission network, such as nuclear power, most offshore wind, and many gas-fired power stations.

The DFES analyses technology types which are of a similar scope to the National Grid FES 2021. These are standardised against “building blocks” as reported in the FES 2021, developed by the ENA Open Networks project.

The analysis considers both existing connections and the pipeline of future potential projects aiming to be deployed within WPD’s licence areas. This report focusses on those projects within the East Midlands licence area.

The scenarios used for projection purposes extend from 2021 to 2050 and are aligned to the four FES 2021 scenarios: **Consumer Transformation**, **Leading the Way**, **Steady Progression**, and **System Transformation**. In this year’s DFES analysis, several new technologies have been included for the first time. These include hydrogen electrolysis, hydrogen-fuelled power generation, and several types of electrified heating. The technology types and assumptions are under constant review and may change with future FES and DFES rounds in line with stakeholder feedback.

The results and assumptions:

The WPD DFES 2021 analysis is produced to granular geographic areas known as Electricity Supply Areas (ESAs), of which there are two types:

- Geographic ESA: the geographical area supplied by a Primary Substation (which contains WPD-owned distribution substations) providing supplies at a voltage below 33 kV
- Single customer ESA: a customer directly supplied at 132, 66 or 33 kV or by a dedicated Primary Substation’.

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

The DFES provides projections of capacity (MW) and numbers (i.e. number of EVs or heat pumps), but does not include analysis of network loads, load profiles or peak demand etc. This network load analysis is run by WPD network strategy and planning teams. WPD has published the results of this process on their website.

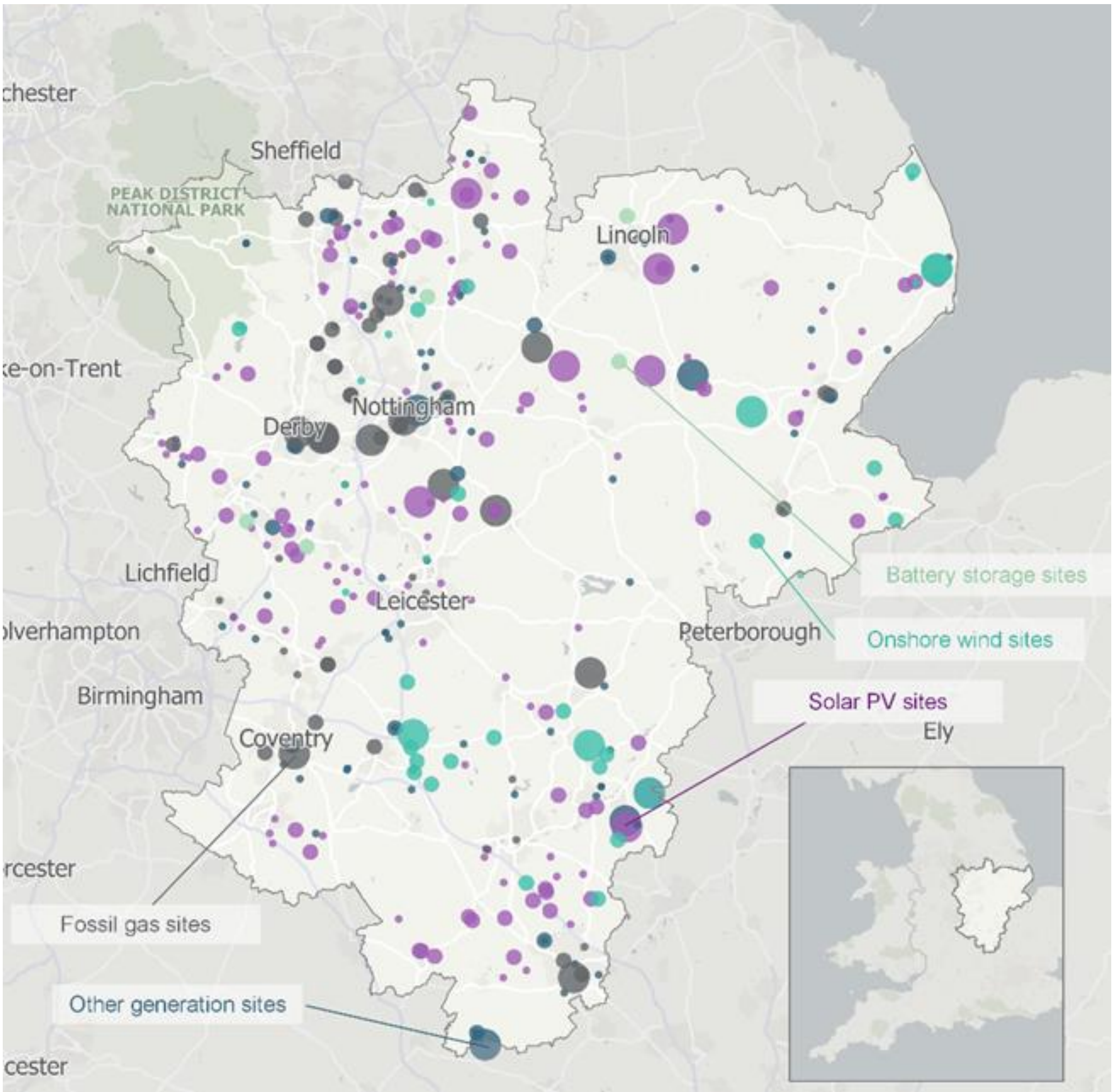
The East Midlands licence area

The 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 in the area has increased significantly over the last five-to-six years, with over 50% of capacity 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.

In terms of electricity demand, domestic demand has steadily fallen over the last ten years as a result of increasing energy efficiency. However, new low carbon technologies such as electric vehicles and heat pumps are anticipated to increase electricity demand from homes and businesses. Currently, less than 1% of East Midlands households have an electric vehicle, and less that 0.5% have an electric heat pump. However, this has potential to rapidly increase over the coming decades, significantly altering the demand on the electricity distribution network in the region.

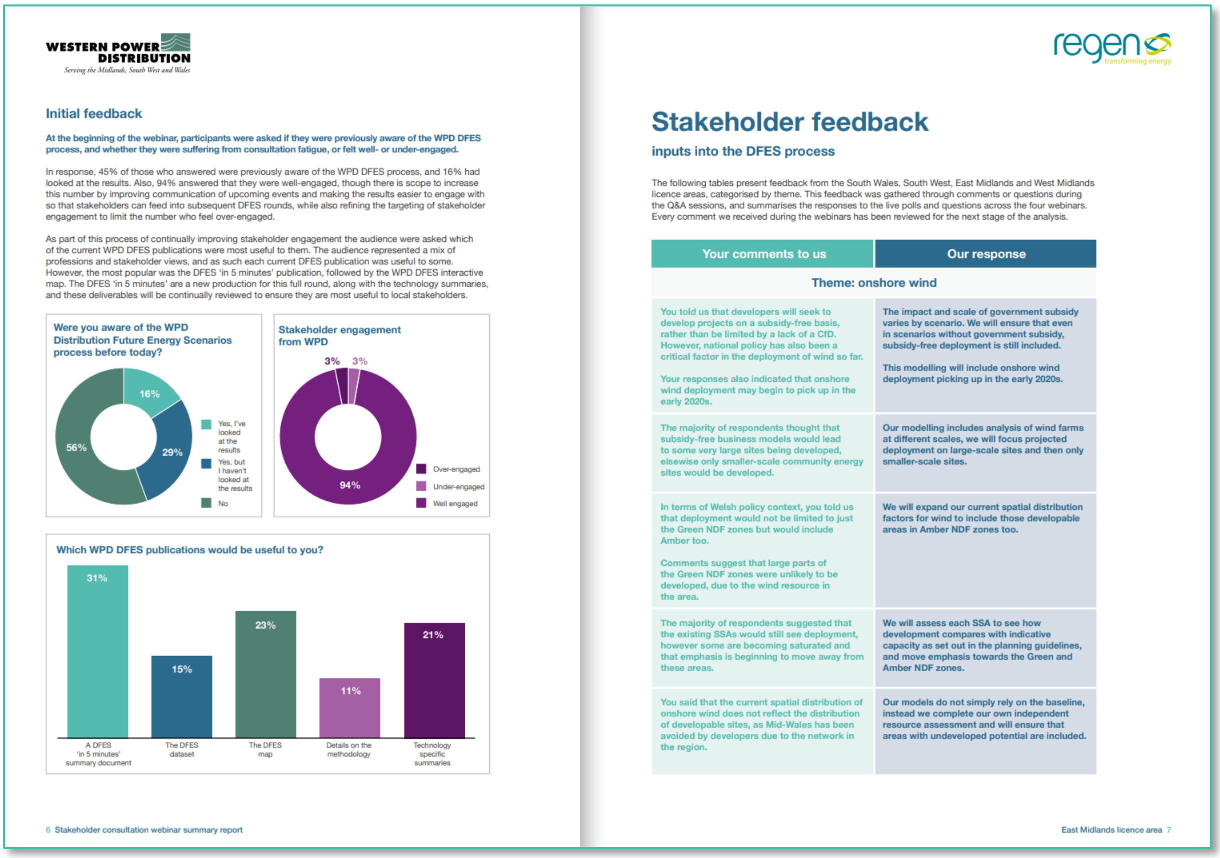
Figure 2 - The WPD East Midlands licence area, with the location of large-scale generation and storage sites



Local stakeholder influences

The development of the DFES has enabled WPD to take a more proactive approach to network planning. Stakeholders have been consulted via a series of consultation events, as well as direct engagement with local authority planners, climate emergency officers, project developers, energy technology companies, asset owner/operators and community energy representatives.

The four consultation events, one per licence area, were held online in June 2021. This allowed high levels of attendance and participation across a wide range of local stakeholders, to directly communicate and seek views on the analysis for the various technologies in-scope at a licence-area-specific level. To watch a recording of the stakeholder engagement events, or to read the reports summarising how the feedback has been incorporated into the DFES, visit the WPD DFES website.



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Initial feedback

At the beginning of the webinar, participants were asked if they were previously aware of the WPD DFES process, and whether they were suffering from consultation fatigue, or felt well- or under-engaged.

In response, 45% of those who answered were previously aware of the WPD DFES process, and 16% had looked at the results. Also, 94% answered that they were well-engaged, though there is scope to increase this number by improving communication of upcoming events and making the results easier to engage with so that stakeholders can feed into subsequent DFES rounds, while also refining the targeting of stakeholder engagement to limit the number who feel over-engaged.

As part of this process of continually improving stakeholder engagement the audience were asked which of the current WPD DFES publications were most useful to them. The audience represented a mix of professions and stakeholder views, and as such each current DFES publication was useful to some. However, the most popular was the DFES 'in 5 minutes' publication, followed by the WPD DFES interactive map. The DFES 'in 5 minutes' are a new production for this full round, along with the technology summaries, and these deliverables will be continually reviewed to ensure they are most useful to local stakeholders.

6 Stakeholder consultation webinar summary report

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Stakeholder feedback

inputs into the DFES process

The following tables present feedback from the South Wales, South West, East Midlands and West Midlands licence areas, categorised by theme. This feedback was gathered through comments or questions during the Q&A sessions, and summarises the responses to the live polls and questions across the four webinars. Every comment we received during the webinars has been reviewed for the next stage of the analysis.

Your comments to us	Our response
Theme: onshore wind	
You told us that developers will seek to develop projects on a subsidy-free basis, rather than be limited by a lack of a CfD. However, national policy has also been a critical factor in the deployment of wind so far. Your responses also indicated that onshore wind deployment may begin to pick up in the early 2020s.	The impact and scale of government subsidy varies by scenario. We will ensure that even in scenarios without government subsidy, subsidy-free deployment is still included. This modelling will include onshore wind deployment picking up in the early 2020s.
The majority of respondents thought that subsidy-free business models would lead to some very large sites being developed, elsewise only smaller-scale community energy sites would be developed.	Our modelling includes analysis of wind farms at different scales, we will focus projected deployment on large-scale sites and then only smaller-scale sites.
In terms of Welsh policy context, you told us that deployment would not be limited to just the Green NDF zones but would include Amber too. Comments suggest that large parts of the Green NDF zones were unlikely to be developed, due to the wind resource in the area.	We will expand our current spatial distribution factors for wind to include those developable areas in Amber NDF zones too.
The majority of respondents suggested that the existing SSAs would still see deployment, however some are becoming saturated and that emphasis is beginning to move away from these areas.	We will assess each SSA to see how development compares with indicative capacity as set out in the planning guidelines, and move emphasis towards the Green and Amber NDF zones.
You said that the current spatial distribution of onshore wind does not reflect the distribution of developable sites, as Mid-Wales has been avoided by developers due to the network in the region.	Our models do not simply rely on the baseline, instead we complete our own independent resource assessment and will ensure that areas with undeveloped potential are included.

East Midlands licence area 7

Methodology summary

The DFES methodology is summarised below. A more detailed methodology report is available on [the WPD DFES website.]

Baseline analysis

Existing generation and demand on the distribution network is analysed to produce a baseline for the future scenarios. The baseline year for this year's analysis is up to the end of March 2021. This is based on WPD connection data, supplemented with project and subsidy registers, Department for Transport data, planning data, EMR Delivery Body Capacity Market registers and other national datasets. This produces an accurate starting point for the future scenarios, alongside analysis of historical uptake and location for each technology.

Pipeline analysis

Once a baseline is established, projects that are currently in development are analysed, reflecting the likely changes to generation and demand in the near term. This includes sites that have accepted a connection offer from WPD but that have not yet connected, or sites that are otherwise active, such as applying for or securing planning permission. Where possible, a discussion is held with a developer or relevant organisation to inform the scenario projections for these projects.

Demand from new domestic and non-domestic property developments is also included in the analysis. Local authority planning departments are contacted to verify the information and to provide insight into the rate of development within their planning period (in most cases the next 10-15 years). This consultation with local authorities also identifies where there are plans or strategies for supporting renewable energy deployment, decarbonisation of heat and transport, net zero declarations and any other energy-related plans or ambitions. These local factors are then, where possible, reflected in the scenario analysis and spatial distribution.

Annual cycle

WPD DFES is published on an annual basis, allowing scenario projections to be regularly updated to reflect the most up-to-date information available. The DFES is produced over the summer and published in the autumn, a few months after the release of the National Grid ESO FES publication and data. This allows the DFES to integrate the high-level scenario framework and assumptions from the latest FES, undertake a technology-specific reconciliation at licence area level (where possible) and should allow the outcomes and findings of the DFES to feed into the following year's FES.

The WPD DFES uses the FES as a framework, adopting the same scenario naming convention, broad national societal, technological and economic assumptions. However the DFES is a bottom-up analysis of a changing energy system at a regional and sub-regional level that reflects specific regional and local factors. For most technologies, the national view presented by the FES is not directly reflected at a regional or local level. For example, an increase in onshore wind capacity at a national level will inevitably be reflected more in areas of significant onshore wind resource, such as South Wales, and less so in areas with limited resource, such as the West Midlands. The regular annual cycle allows for data sharing between the WPD DFES and the National Grid ESO FES teams, facilitating continuous improvement of the data quality and processes.

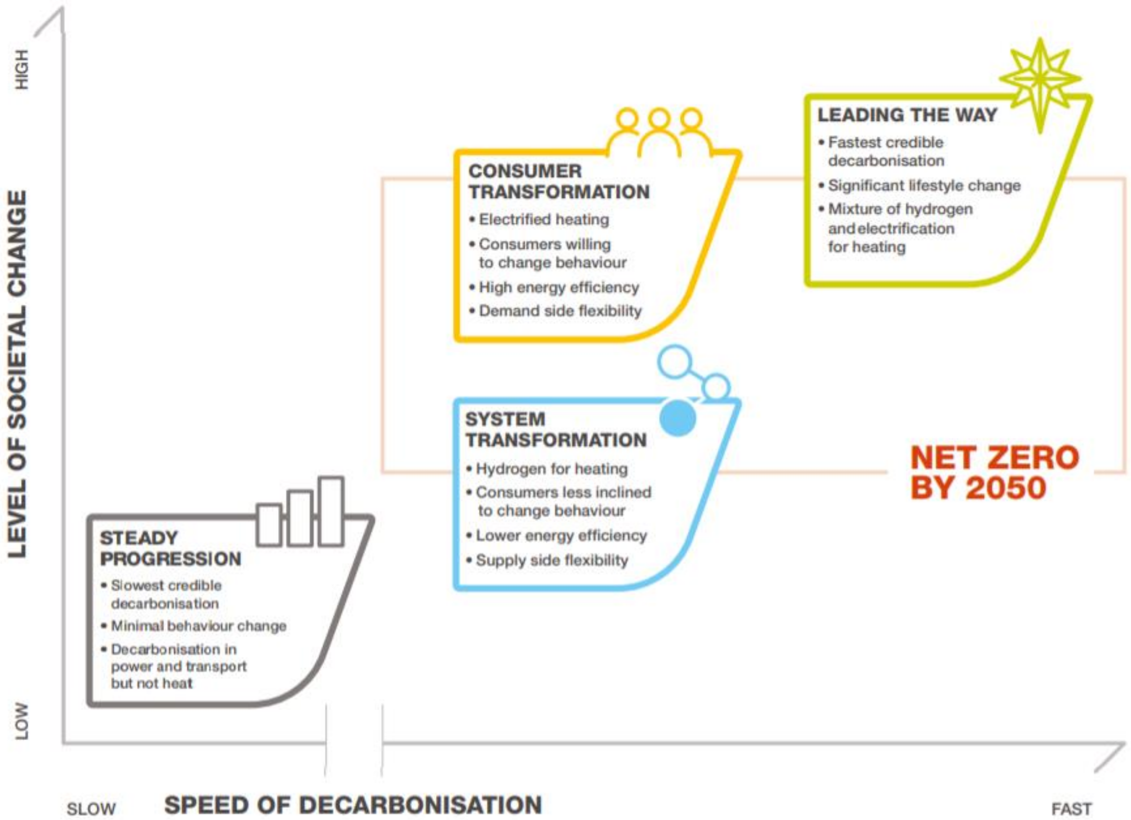
Scenario projections

The WPD DFES 2021 uses the same four future scenarios as the National Grid ESO FES 2021. These are the same scenarios as the 2020 iterations of the DFES and FES, but have been updated to reflect new information, data and policy drivers over the past year. The scenarios reflect various speeds of decarbonisation against levels of societal change, as illustrated in Figure 3.

Of these four scenarios, three (**Leading the Way**, **Consumer Transformation**, and **System Transformation**) meet the government target of net zero emissions by 2050. However they achieve these emissions reductions in different ways and at different rates. The remaining **Steady Progression** scenario represents a failure to meet net zero carbon emissions by 2050.

Key assumptions from the FES 2021 scenarios have been included in the DFES analysis and are detailed throughout this report. Further assumptions made to inform the DFES projections, including technology costs, spatial factors, the fate of sites in the pipeline etc. are detailed in the technology specific sections of this report.

Figure 3 – The National Grid ESO FES 2021 scenario framework



Access and Forward-looking Charges Significant Code Review

Ofgem announced in summer 2021 some minded to decisions related to the Access SCR[1], in particular the intention to reduce the connection boundary for distribution connections. This means projects could have a lower cost to connect to the distribution network from April 2023. The consultation about these and other changes closed in August 2021, and a final decision is expected before the end of Q1 2022.

At the Charging Futures Forum in September 2021, Ofgem stated that they retain their view that the benefits of these changes will outweigh the increased cost to consumers. Therefore, within this final decision, there is anticipated to be a 'shallow' boundary for demand connections, removing all contribution to network reinforcement. For generation, a 'shallower' boundary for connections is also anticipated, essentially meaning a reduction in the contribution to reinforcement. It will likely consist of limiting the contribution to the required reinforcement based on the voltage level the generation asset is connecting at, and removing any contributions for reinforcement in the voltage level above. This is positive news for project developers, as it is often the 'one above' reinforcement that involves the highest costs.

However, Ofgem have stated that they are developing some 'mitigations' to protect consumers against any particularly high costs that these changes may trigger, which could dampen the benefits for project developers. The details of these mitigations are yet to be clarified.

It is likely that the impact of the changes to demand charging will be most significant for high electricity users, with a lower impact on domestic households, due to the latter being less likely to trigger reinforcement work.

The largest impact would be expected for high electricity demand technologies such as EV chargers. 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 an equivalent short-term uptick after April 2023. The change will benefit existing industrial or business users looking to electrify demand, heat or processes. Hydrogen electrolysers would also likely benefit significantly from these changes, though significant deployment of electrolyser capacity is not anticipated until after these potential changes would be implemented.

From the generation side, the benefits are likely to be much more project specific, as it will depend on whether there are constraints and resultant reinforcement that will be triggered at the voltage level above that which the project is connecting at. Many generation projects will still be facing high costs for 'sole use assets' and reinforcement at their connection voltage. Given that costs rise with the voltage level, the potential changes would likely result in greater benefits for small LV generators and rooftop solar.

Battery storage connections, with both demand and generation capacity, could also be strongly influenced by the outcome of the SCR.

For the purposes of this DFES analysis, it has been assumed that the minded-to decision is implemented under **Consumer Transformation** and **Leading the Way**.

Retained capacity for decommissioning assets

Across the four DFES scenarios, some technologies will see a level of decommissioning between the baseline year and 2050. This largely consists of technologies that are incompatible with net zero carbon emissions, such as unabated fossil fuel power generation.

However, when an asset ceases conventional operation, the connection agreement held by the operator and the associated contracted export capacity secured with WPD is not automatically relinquished. It is likely that at least some sites will retain their connection capacity, with a view to participating in network ancillary services such as Short Term Operating Reserve, 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 2021 analysis has assumed that any connection capacity 'freed up' by the mothballing of a site, the removal of a generation asset or significantly reduced onsite operating hours, is either retained for ten years, or until a newly commissioned technology has been modelled to take its place, whichever comes sooner. This assumption is based on engagement with stakeholders, and internal network planning teams at WPD.

Example outcomes for decommissioning technologies include:

Decommissioned technology	Alternative technologies	Applied in which scenario
Diesel generation	Battery storage Hydrogen-fuelled generation Retained capacity	All scenarios
Fossil gas generation	Battery storage Hydrogen-fuelled generation Retained capacity	Leading the Way Consumer Transformation System Transformation

List of technology types analysed as part of the WPD DFES 2021:

DFES technology	DFES sub-technology	Equivalent Building block ID number
Biomass & Energy Crops (including CHP)	-	Gen_BB010
CCGTs (non CHP)	-	Gen_BB009
Geothermal	-	Gen_BB019
Hydro	-	Gen_BB018
Hydrogen-fuelled generation	-	Gen_BB023
Marine	Tidal stream	Gen_BB017
Marine	Wave energy	Gen_BB017
Non-renewable CHP	<1MW	Gen_BB001
Non-renewable CHP	>=1MW	Gen_BB002
Non-renewable Engines (non CHP)	Diesel	Gen_BB005
Non-renewable Engines (non CHP)	Gas	Gen_BB006
OCGTs (non CHP)	-	Gen_BB008
Other generation	-	-

Renewable Engines (Landfill Gas, Sewage Gas, Biogas)	-	Gen_BB004
Solar Generation	Commercial rooftop (10kW - 1MW)	Gen_BB012
Solar Generation	Domestic rooftop (<10kW)	Gen_BB013
Solar Generation	Ground mounted (>1MW)	Gen_BB012
Waste Incineration (including CHP)	-	Gen_BB011
Wind	Offshore Wind	Gen_BB014
Wind	Onshore Wind <1MW	Gen_BB016
Wind	Onshore Wind >=1MW	Gen_BB015
Storage	Co-location	Srg_BB001
Storage	Domestic Batteries (G98)	Srg_BB002
Storage	Grid services	Srg_BB001
Storage	High Energy User	Srg_BB001
Storage	Other	Srg_BB004
Domestic	-	Dem_BB001a
Non domestic	A1/A2	Dem_BB002b
Non domestic	A3/A4/A5	Dem_BB002b
Non domestic	B1	Dem_BB002b
Non domestic	B2	Dem_BB002b
Non domestic	B8	Dem_BB002b
Non domestic	C1	Dem_BB002b
Non domestic	C2	Dem_BB002b
Non domestic	D1	Dem_BB002b
Non domestic	D2	Dem_BB002b
Non domestic	Sui Generis	Dem_BB002b

Air conditioning	-	Lct_BB014
Demand	Block load	-
Electric vehicles	Hybrid car (non-autonomous)	Lct_BB002
Electric vehicles	Hybrid LGV	Lct_BB004
Electric vehicles	Pure electric bus and coach	Lct_BB003
Electric vehicles	Pure electric car (autonomous)	Lct_BB001
Electric vehicles	Pure electric car (non-autonomous)	Lct_BB001
Electric vehicles	Pure electric HGV	Lct_BB003
Electric vehicles	Pure electric LGV	Lct_BB003
Electric vehicles	Pure electric motorcycle	Lct_BB001
EV Charge Point	Car parks	Lct_BB012b, LCT_BB013b
EV Charge Point	Destination	Lct_BB012b, LCT_BB013b
EV Charge Point	Domestic 13A	Lct_BB010b
EV Charge Point	Domestic off-street	Lct_BB010b
EV Charge Point	Domestic on-street	Lct_BB010b
EV Charge Point	En-route / local charging stations	Lct_BB012b, LCT_BB013b
EV Charge Point	En-route national network	Lct_BB012b, LCT_BB013b
EV Charge Point	Fleet/Depot	Lct_BB011b
EV Charge Point	Workplace	Lct_BB011b
Heat pumps	District heating	Lct_BB009
Heat pumps	Domestic –Hybrid	Lct_BB006
Heat pumps	Domestic - Non-hybrid ASHP	Lct_BB005
Heat pumps	Domestic - Non-hybrid GSHP	Lct_BB005
Heat pumps	Domestic - Hybrid + thermal storage	Lct_BB006

Heat pumps	Domestic - Non-hybrid ASHP + thermal storage	Lct_BB005
Heat pumps	Domestic - Non-hybrid GSHP + thermal storage	Lct_BB005
Hydrogen electrolysis	-	Dem_BB009
Resistive electric heating	Direct electric heating	-
Resistive electric heating	Night storage heaters	-

[1] Ofgem Minded to Position on the Access and Forward-looking Charges Significant Code Review

Results and assumptions

Demand technologies

New demand in the East Midlands licence area

Summary of modelling assumptions and results.

Technology specification:

New property developments can have a significant impact on local electricity demand and therefore are included in DFES analysis. We categorise new developments as new domestic developments (houses) and non-domestic sites (e.g. factory/warehouse, offices, retail, sports & leisure etc.).

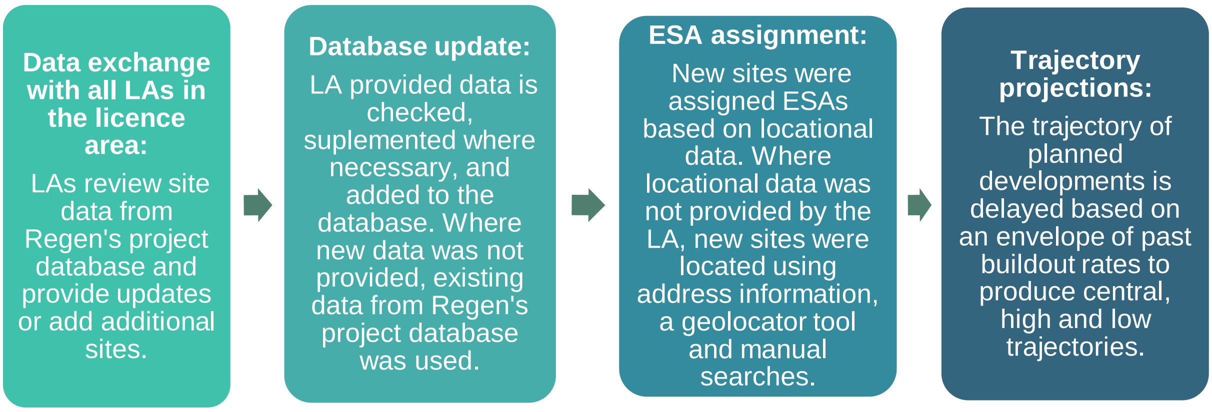
Data on planned domestic and non-domestic developments is gathered through engagement with all local authorities in the licence area. Alongside historic build rates, this is used to inform local-level projections for future housing numbers and non-domestic floorspace (sqm).

Process and assumptions:

Database update and ESA assignment

- Through engagement with the LAs, development plans are verified and used to update a database of new developments. These contain location, size, likely use (for non-domestic), development stage and planned buildout timescale.
- Every LA within the licence area was contacted, with the previously collected data presented for verification or modification. A SharePoint database allowed local authorities to view and update the data themselves. Over half of LAs provided new data through the SharePoint or directly to the project team. For the remaining local authorities, Regen's existing project database was used; this database was developed through previous DFES iterations.

Figure 4 - Summary of methodology for the assessment of new developments



- All sites are assigned an ESA:
  - Most could be carried over from Regen's existing project database.
  - For newly provided developments with locational data, ESAs were assigned using GIS mapping. Large sites near an ESA border were manually checked and split across the neighbouring ESA where appropriate.
  - The remaining sites are assigned ESAs using a geolocator tool and manual searches. The tool runs the names of the developments through the OpenStreetMap search tool and where the search fails, further individual investigation of the development is carried out to locate it.

- Some sites are provided by LAs without a buildout rate. For these sites, an estimate is modelled based on the development stage, type, and typical regional site development rates.
- For non-domestic analysis, LA provided site areas are converted into floorspace (sqm) using a conversion ratio specific to the type of development and derived from historic DFES data.
- The LAs were also asked about existing or draft decarbonisation strategies for energy, transport, waste, and heating in their local area. This data was used to inform analysis within the wider WPD DFES 2021.

Trajectory projections

Delay factors and historic build rates

- Planned developments peak in the medium term; it is likely that a proportion of these developments will be subject to delays. To reflect this, the model applies delay factors to planned buildout timescales. In this way, the location and scale of development is maintained, but the period over which the sites are built is extended.

Table 1: Domestic delay factors, the percentage of domestic developments which are completed as planned, with the remainder delayed.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030-2050
High	85%	75%	65%	60%	60%	60%	60%	75%	75%	75%
Central	75%	65%	55%	50%	50%	45%	55%	55%	55%	55%
Low	65%	55%	45%	40%	40%	40%	40%	40%	40%	35%

- Three historic domestic build rates are determined using the past ten years of build out data:
    - 'High' is an average of the three years with the highest build rates.
    - 'Central' is an average of the ten-year period.
    - 'Low' is an average of the three years with the lowest build rates.
- These delay factors and historic housebuilding rates are then used to define a central trajectory, a high growth trajectory and a low growth trajectory.
- There is limited historic build rate data available for non-domestic developments. The delay factors are similarly determined and applied to account for project delays for non-domestic sites.

Table 2: Non-domestic delay factors, the percentage of non-domestic developments which are completed as planned, with the remainder delayed.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030-2050
High	90%	90%	90%	90%	90%	70%	50%	55%	55%	55%
Central	80%	80%	80%	70%	70%	45%	35%	35%	35%	35%
Low	70%	70%	70%	60%	60%	35%	20%	20%	20%	20%

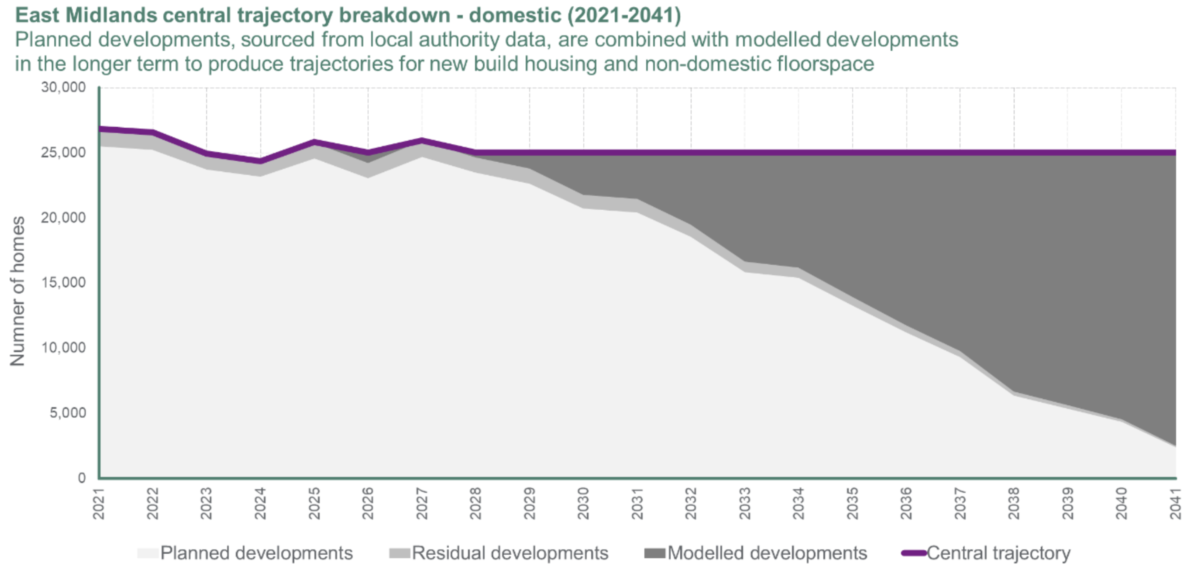
Residual sites and modelled development

- The domestic analysis seeks to capture all significant developments, defined as 20 homes or more. Analysis of previous new developments studies suggests this cut-off leaves about 5% of homes un-recorded, so these 'residual' small-scale sites are modelled and included in the final trajectory.
- There is a natural reduction in the data for planned developments after 2025 given the longer timeframe. Additional domestic developments are modelled post 2025, this 'modelled development' brings the long-term trajectory up to the levels of historic averages.
- There are no residual sites or 'modelled developments' for non-domestic developments.

Assigning trajectories to scenarios

- The 2021 FES shows no variation in new developments across the trajectories. However, for WPD's network planning the analysis applies the trajectories as follows:
    - **Leading the Way** uses the high trajectory.
    - **Consumer Transformation** and **System Transformation** use the central trajectory.
    - **Steady Progression** uses the low trajectory.

Figure 5



Results:

- For the East Midlands licence area, the domestic central trajectory varies around an historic build rate of 25,000 homes annually.
- The non-domestic central trajectory rises to 1.2million sqm of floorspace added annually in the near term and maintains this level through the 2020s.
- Of the planned non-domestic developments, 52% is factory and warehouse and 19% is office space.
- NEW BEACON ROAD GRANTHAM 33 11kV S STN has the highest number of domestic developments projected to build out: over 10,000 and driven by the 9000 home GR3-H1/4 allocations.
- WELLINGTON ST 33 11kV S STN has the greatest amount of non-domestic floorspace due to be developed: 1.85million sqm and driven by the 1.6million sqm Branston Locks mixed use development which has outline planning permission.
- These projections also inform the analysis of domestic technologies such as electric vehicles, heat pumps and rooftop solar PV. The spatial data from the local plans define where on the WPD network these technologies may be located.

Figure 6

East Midlands domestic trajectories (2021-2041)
Modelled through planned developments compared to high, central and low historic building rates

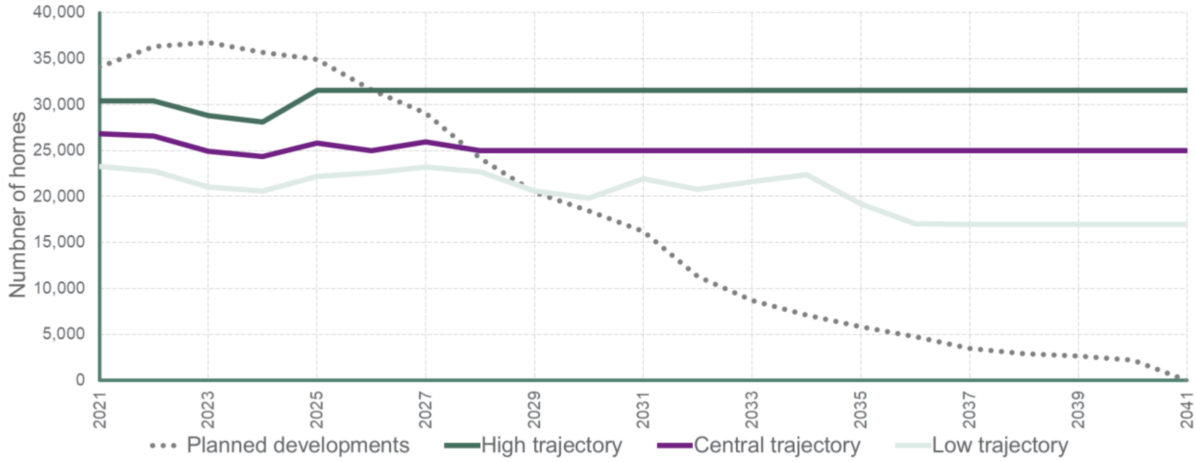
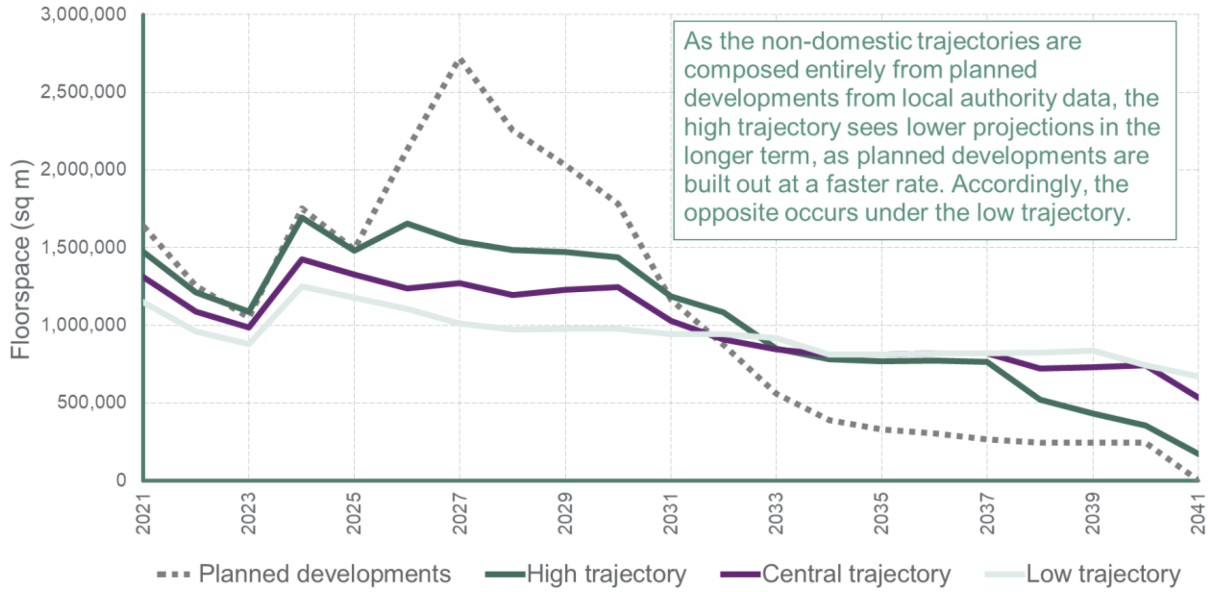


Figure 7

East Midlands non-domestic trajectories (2021-2041)
Trajectories produced through applying delay factors to planned developments



Stakeholder engagement:

- The initial stage of this process is reliant on engagement with LAs in the licence area. Over half of LAs provided new data, through the SharePoint or directly to the project team. For the remaining local authorities, Regen's existing project database was used.
- With many LAs engaging directly with the process, the projections are based on the most accurate and up to date information available.
- Some LAs were not able to provide information within the timeframe of the project, especially due to resourcing pressures as a result of the ongoing COVID-19 pandemic.
- Regen's project database ensured that all LAs were represented with recent high granularity development data.
- Alongside the new developments data exchange, the LAs were also asked about existing or draft decarbonisation strategies for energy, transport, waste, and heating in their local area. This data was used to inform analysis within the wider WPD DFES 2021.

Heat pumps in the East Midlands licence area

Summary of modelling assumptions and results

Technology specification:

Domestic dwellings where a heat pump is the primary source of space heating and hot water. This category is divided into a number of technologies and sub-technologies, based on the heating technology and configurations that represent different loads on the electricity distribution network:

- Non-hybrid heat pumps, powered purely by electricity - Building block Lct_BB005. This is subdivided into:
    - Air source heat pumps without thermal storage
    - Air source heat pumps with thermal storage (in the form of a hot water cylinder or a phase-change material thermal store)
    - Ground source heat pumps without thermal storage
    - Ground source heat pumps with thermal storage.
- Hybrid heat pumps, a combination of a heat pump and a secondary non-electric heat source that can be used at times of peak electricity demand or high electricity prices - Building block Lct_BB006.
    - For the purposes of the DFES, the fuel of the secondary heat source, such as biofuel, fossil gas or hydrogen, is not broken out in the projections.
- District heat network heat pumps, specifically houses connected to a network of hot water provided via a large-scale heat pump – Building block Lct_BB009.

Data summary for heat pumps in the East Midlands licence area:

Thousands of dwellings		Baseline	2025	2030	2035	2040	2045	2050
Non-hybrid air source heat pumps (of which have thermal storage)	**Steady Progression**	14 (0)	37 (11)	140 (32)	283 (63)	462 (99)	562 (123)	650 (142)
	System Transformation		49 (13)	109 (26)	210 (50)	324 (76)	426 (106)	495 (127)
	Consumer Transformation		92 (21)	340 (76)	750 (168)	1318 (302)	1685 (423)	1788 (482)
	Leading the Way		217 (55)	656 (175)	1074 (305)	1364 (494)	1411 (603)	1480 (650)
Non-hybrid ground source heat pumps (of which have thermal storage)	**Steady Progression**	4 (0)	15 (5)	40 (13)	83 (27)	132 (46)	188 (59)	232 (70)
	System Transformation		18 (6)	59 (20)	90 (31)	125 (44)	144 (52)	158 (61)
	Consumer Transformation		25 (7)	82 (23)	265 (97)	528 (224)	748 (347)	903 (459)
	Leading the Way		52 (19)	184 (73)	364 (168)	555 (303)	744 (466)	804 (488)

Hybrid heat pumps	**Steady Progression**	0	0	11	21	30	31	32
	System Transformation		4	11	62	262	469	666
	Consumer Transformation		6	16	60	119	166	183
	Leading the Way		9	56	139	260	310	337
District heat network heat pumps	**Steady Progression**	0	2	4	5	5	7	8
	System Transformation		2	7	20	39	54	61
	Consumer Transformation		3	9	30	64	93	105
	Leading the Way		3	8	28	61	88	109

Summary:

- In line with potential options for decarbonising heat at a national level, there is a dramatic shift to low carbon heating in the East Midlands licence area in all three of the net zero scenarios. Under **Consumer Transformation** and **Leading the Way**, this results in heat pumps becoming the predominant domestic heating technology in the East Midlands by 2050.
- Under **System Transformation**, decarbonisation of heat on a national level is driven by hydrogen, either through standalone boilers or hybrid heat pumps. With the vast majority of homes in the East Midlands connected to the fossil gas network, there is strong hybrid heat pump uptake in this scenario. Off-gas homes are still mainly decarbonised through a non-hybrid heat pump.
- Dense urban areas of the East Midlands, such as Leicester, Nottingham and Milton Keynes, see roll-out of a number of planned and potential future heat networks in the three net zero scenarios.

Modelling assumptions and results:

Baseline

- The East Midlands licence area has an estimated 18,000 dwellings heated via a heat pump, of which 14,000 are thought to be on air source heat pumps, with the remaining 4,000 on ground source heat pumps.
- This baseline has been derived through analysis of EPC records, RHI data and WPD data on heat pump installations.
- Due to lack of evidence, the modelling assumes no thermal storage for existing heat pumps.
- The modelling suggests that around 0.7% of homes in the East Midlands are heated by a heat pump. This is similar to the national average of 0.6% of homes, reflecting that the East Midlands has a similar housing stock to GB as a whole.
- The primary deployment driver for domestic heat pumps in existing homes in GB in recent years has been the domestic RHI.

Near-term (April 2021 to March 2025)

- All six forms of domestic heat pump heating have modelled holistically at a national and regional level, alongside resistive electric heating and non-electric heating. This has been achieved through applying scenario trajectories to 36 dwelling archetypes, based on current heating technology, building type, tenure and district heating potential.

Non-hybrid heat pumps

- In the near term, heat pump deployment ramps up in every net zero scenario, as the UK government looks to achieve 600,000 heat pump installations annually by 2028[2]. This ambition is achieved in the **Consumer Transformation** scenario, and exceeded under **Leading the Way**.
- As per the UK government's consultation on future support for low carbon heat[3], off-gas buildings are likely to be targeted in the near-term, supported through schemes such as the Clean Heat Grant[4].
- While the East Midlands has a similar proportion of off-gas home as the rest of the UK, it has higher levels of home ownership and semi-detached/detached houses. As a result, the uptake of heat pumps in the East Midlands licence area is slightly ahead of the national trajectory.
- Heat pumps are assumed to be combined with thermal storage in 30% of new installations in all scenarios unless the heat pump is combined with a resistive electric back-up element. This is based on the proportion of homes with a hot water cylinder, as per the English Housing Survey[5], and weighted towards larger houses due to the greater average floorspace.
- In the near-term, most new build homes are expected to continue installation of fossil gas and resistive electric heating systems in all scenarios. However, under **Consumer Transformation** and **Leading the Way**, heat pump installations in new builds increase ahead of the Future Homes Standard implementation in 2025.

Hybrid heat pumps

- Hybrid heat pumps see minimal uptake in the near-term. Fully electric solutions are preferred under **Consumer Transformation** and **Leading the Way**, while existing gas, oil and LPG heating systems remain installed under **System Transformation** and **Steady Progression**.

District heating heat pumps

- Near-term modelling of district heating heat pumps directly uses data from HNDU and HNIP[6], the Heat Networks Planning Database[7], and direct engagement with local authority planners.
- Several district heating pipeline projects were identified, including in Leicester, Bedford and Derbyshire.
- However, none of these projects were planning to be heated via a heat pump, instead of being heated by waste heat, Energy from Waste CHP or fossil gas CHP.

Medium-term (April 2025 to March 2035)

Non-hybrid heat pumps

- Non-hybrid heat pumps continue to be installed in off-gas homes throughout the 2020s. In larger or less well-insulated houses, both air source and ground source heat pumps are installed alongside thermal storage.
- In areas of denser population, such as terraced houses and flats, GSHP installations are likely to connect to shared ground loops. This reduces the installation cost on a per-home basis, compared to each dwelling having an individual borehole or slinky loop[8].
- The Future Homes Standard[9] is implemented from 2025 under two scenarios, preventing new-build homes from connecting to the fossil gas network.
    - Under **Consumer Transformation** and **Leading the Way** the FHS is implemented as anticipated, resulting in heat pumps becoming the heating technology of choice for the vast majority of new builds. This is spread roughly equally across ASHPs, GSHPs on communal loops, and district heating heat pumps.
    - Under **System Transformation**, the FHS is implemented but circumvented through new build homes installing hydrogen-ready boilers, in anticipation of conversion of the fossil gas network to low carbon hydrogen in this scenario. As a result, heat pump uptake in new builds remains low.
    - Under **Steady Progression**, the FHS is not implemented. As such, the majority of new builds continue to install fossil gas boilers, and heat pump uptake in new builds remains low.

Hybrid heat pumps

- Hybrid heat pump uptake accelerates in the 2030s under the three net zero scenarios, as heat decarbonisation is targeted across the entire building stock.
- Under **Consumer Transformation** and **Leading the Way**, hybrid heat pumps are predominantly installed in off-gas houses, combined with a biofuel backup heater, and on-gas houses combined with a fossil gas or hydrogen boiler. Uptake is projected to be minimal in flats, owing to lower heat demand and space constraints preventing uptake of two heating systems in a small home.
- Under **System Transformation**, hybrid heating systems are installed in some homes as mitigation against the higher price of distributed hydrogen compared to fossil gas.

District heating heat pumps

- Medium-term modelling of district heating heat pumps follows national trends, based on BEIS' 'Opportunity areas for district heating networks in the UK'[10] combined with housing density. The BEIS study correlates hotspots of heat demand with potential heat sources, which could be upgraded via a large-scale heat pump.
- This results in uptake in urban areas where heat demand is particularly dense, such as Leicester, Bedford and Derby.

Long-term (April 2035 to March 2050)

Non-hybrid heat pumps

- Under **Consumer Transformation** and **Leading the Way**, heat pumps become the dominant form of domestic heating in the UK. This includes a wholesale shift from fossil gas boilers to heat pumps in the 2030s and 2040s.
  - In the East Midlands licence area, this results in around 2.7 million non-hybrid heat pumps by 2050 under **Consumer Transformation**, and 2.3 million under **Leading the Way**.
  - In both scenarios, ASHPs make up approximately 65% of non-hybrid heat pumps, with GSHPs making up the remaining 35%.
- Under **System Transformation** and **Steady Progression**, non-hybrid heat pump uptake is more limited.
  - Under **System Transformation**, this is due to the presence of hydrogen boilers and hybrid heat pumps as low carbon heating technologies, which replaces the majority of current fossil gas heating.
  - Under **Steady Progression**, progress towards heat decarbonisation is slow, as the UK fails to meet net zero by 2050.
- Thermal storage has potential to increase in all scenarios, especially as new phase-change thermal stores come to market and consumers become more engaged with energy consumption. By 2050, over half of retrofit non-hybrid heat pumps are alongside a form of thermal storage under **Consumer Transformation** and **Leading the Way**. This includes retrofitting of thermal storage onto heat pump installations that were previously installed without.
- For new build homes, the medium-term assumptions continue to 2050. In developments in more densely populated areas, district heating heat pumps are favoured over standalone non-hybrid heat pumps.

Hybrid heat pumps

- Hybrid heat pumps see rapid uptake under **System Transformation** as hydrogen becomes available as a heating fuel on a national level, replacing the fossil gas network.
  - In this scenario, the majority of hydrogen is produced through reformation of natural gas. As a result of losses during the conversion and delivery of blue hydrogen, it is anticipated to be substantially more expensive than fossil gas for the end consumer.
  - This results in high levels of hybrid heat pump uptake, as heating via a heat pump is anticipated to be more cost-effective outside of the winter heating season than a standalone hydrogen boiler in many cases.

District heating heat pumps

- As per the medium-term, district heating heat pumps are deployed in denser urban areas and new housing developments under the net zero scenarios.

Figure 8

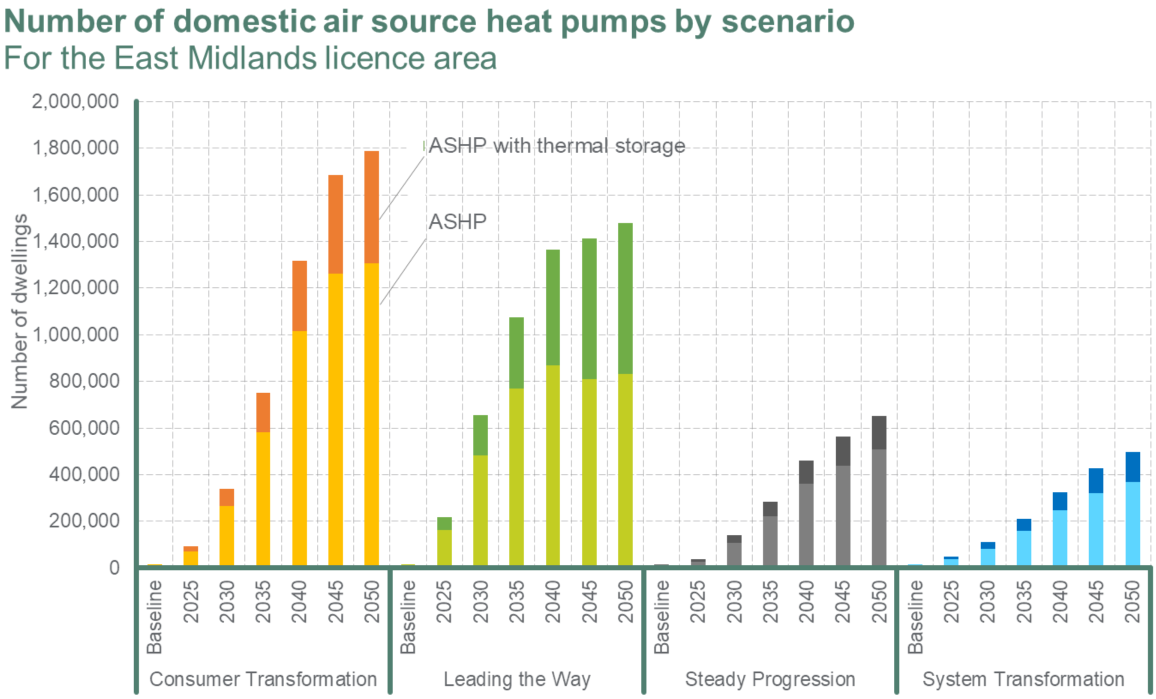


Figure 9

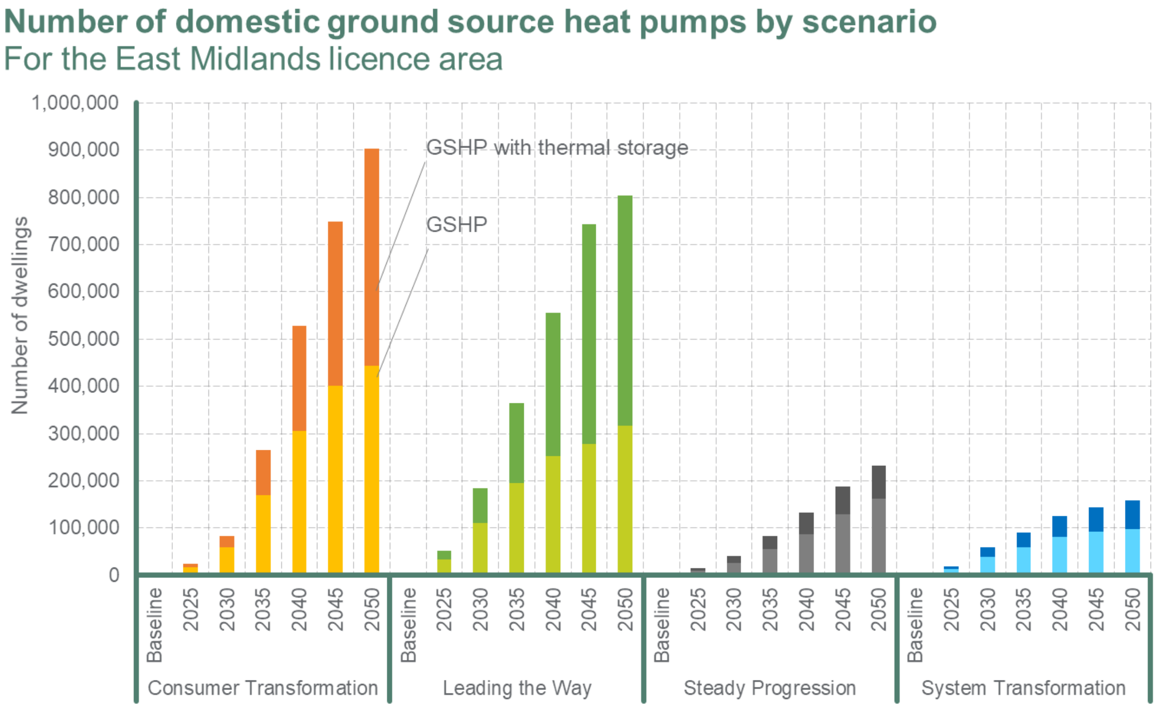


Figure 10

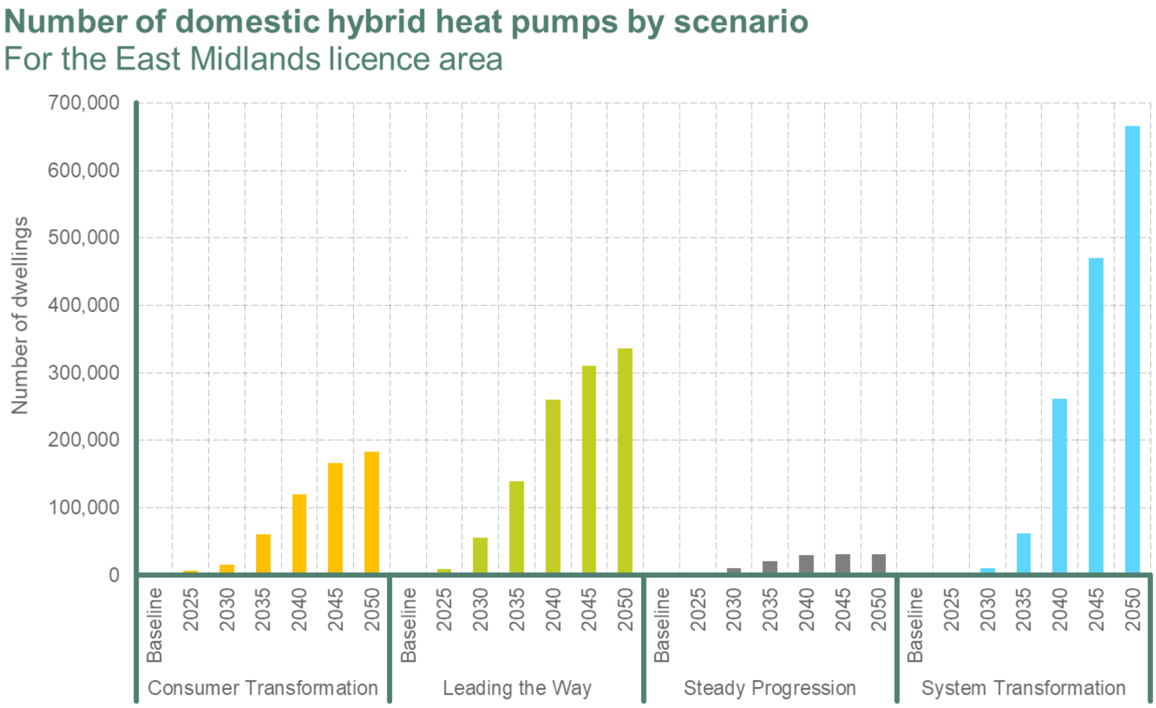
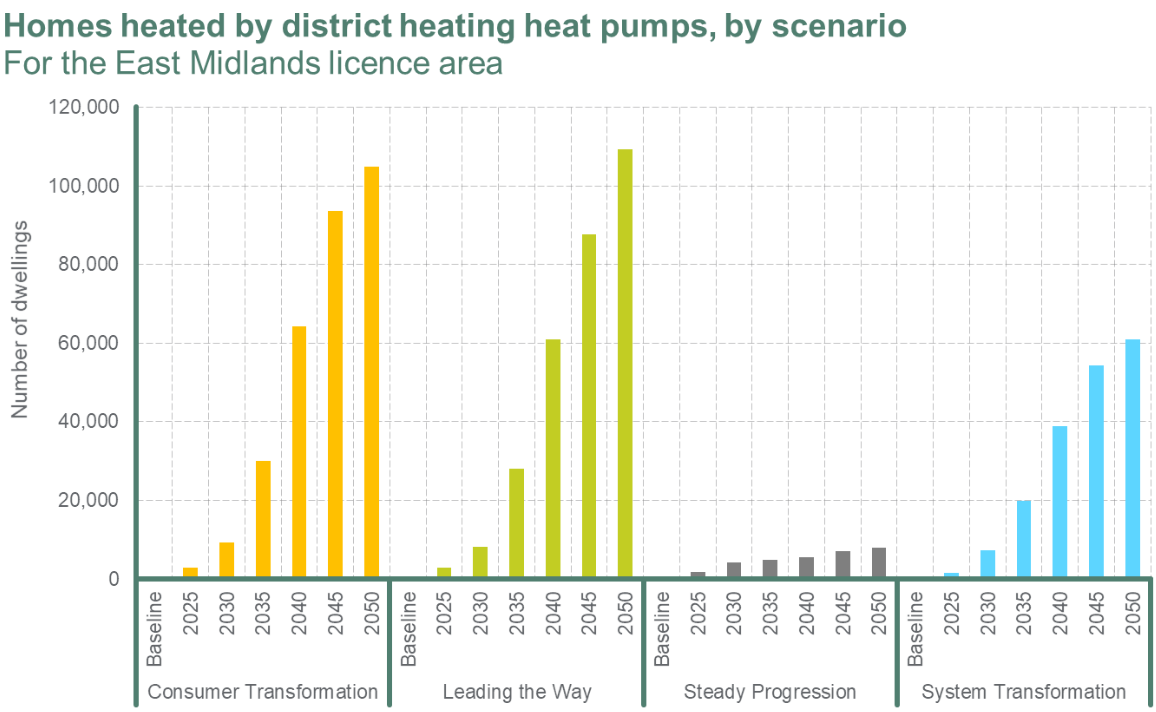
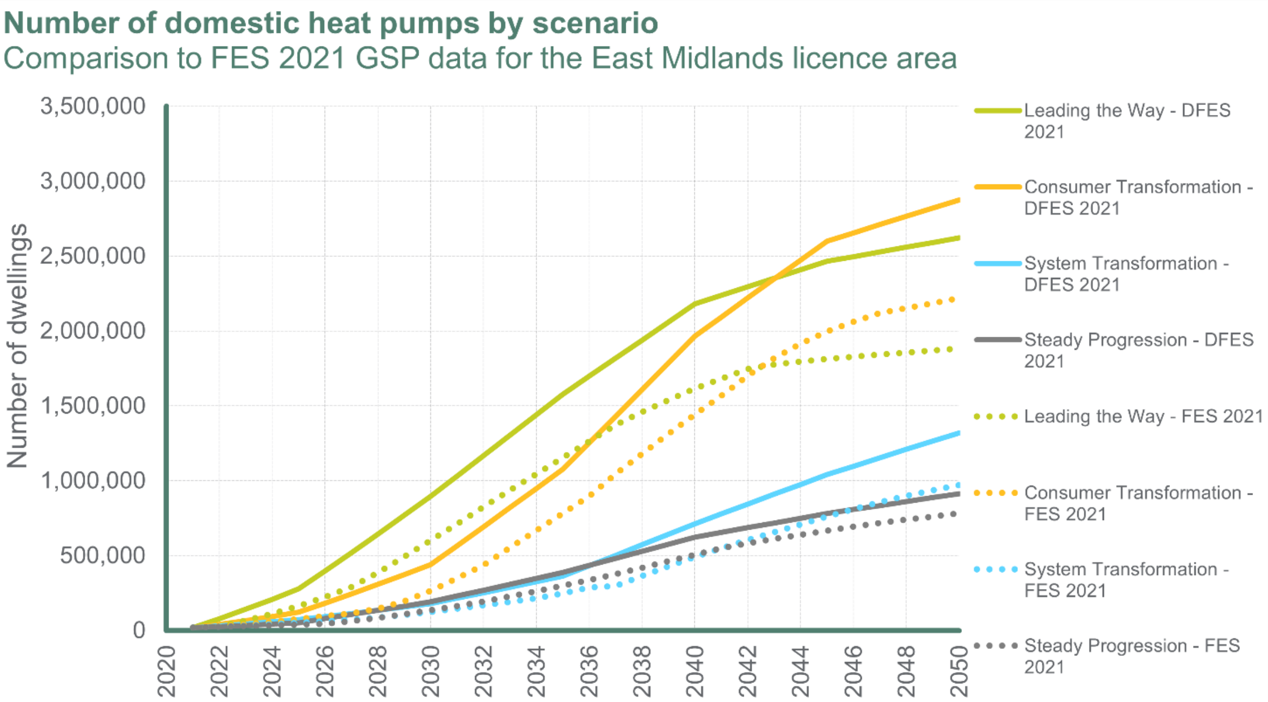


Figure 11



Reconciliation with National Grid FES 2021:

Figure 12



Results in this section relate to the FES 2021 data for the relevant GSPs within the East Midlands licence area.

In the available GSP-level data, the National Grid FES 2021 does not split out district heating driven by heat pumps from other forms of district heating, such as biomass, gas CHP and waste heat. As a result, a direct reconciliation has not been undertaken.

The Building Block data provided in the FES 2021 classifies an 'ASHP with a resistive heating element' as a hybrid heat pump (Lct_BB006), whereas the DFES analysis considers this a variation of a non-hybrid heat pump (Lct_BB005). Accordingly, the reconciliation has been undertaken using combined figures for both non-hybrid and hybrid heat pumps.

- The rate of uptake of heat pumps, the type of heat pump, and the availability of alternative low carbon heating technologies are key, national-level assumptions that underpin much of the difference between the four scenarios.
- As a result, the DFES analysis has not looked to model these scenarios at a national level, but instead analysed how these scenarios may look on a regional and local level. Therefore, the analysis has strongly leant on the national FES outcomes for each heating technology as a starting point.
- Throughout the timescale of the analysis, the DFES results for the East Midlands are ahead of the National Grid FES GSP data in every scenario. The reason for this is not certain, but it could be due to the identified higher proportion of houses in the East Midlands compared to GB as a whole, and high levels of house building in the East Midlands throughout the scenarios timeframe.
- The breakdown of thermal storage is not directly detailed in the FES. However, it is stated that 60% of heat pumps have thermal storage by 2050 under **Leading the Way**, versus just 30% under **Steady Progression**. This range has been reflected in the modelling of non-hybrid heat pumps at 40% under **System Transformation** and 50% under **Consumer Transformation**.

Factors that will affect deployment at a local level:

- The spatial distribution of heating technologies has been modelled holistically based on the existing heat technology in the home, the building type, the tenure of the household in question and the district heating potential of each geographic ESA.
- Heat pump uptake increases throughout each scenario. In the nearer term, the distribution of heat pumps is weighted more heavily towards houses rather than flats, and owner-occupied and socially rented dwellings rather than privately rented dwellings. However, all dwelling archetypes see heat pump uptake in all scenarios.
- Analysis of dwelling archetypes have been used to model the spatial distribution of each heat pump sub-technology. For example:
  - Owner-occupied detached and semi-detached houses are considered more likely to have thermal storage alongside a heat pump, as this type of dwelling is most likely to already host a hot water cylinder or have space to install any form of thermal store.
  - Terraced houses and flats are considered more likely to host a ground-source heat pump, due to the potential to connect to a shared ambient ground-loop in more densely packed residential areas.
  - Private rented houses and flats are modelled to see slower uptake of heat pumps compared to owner-occupied and socially rented dwellings, which typically have a greater impetus to install building improvements.
- Additionally, homes located where existing district heat networks are sited or planned, or located within areas with potential for district heating, see focussed uptake of district heating heat pumps.
  - A near-term pipeline of district heat projects was identified through data from HNDU and HNIP, alongside the Heat Networks Planning Database.
  - The potential for district heating heat pumps in the longer term was derived from BEIS' 'Opportunity areas for district heating networks in the UK', combined with Output Area-level data on housing density.
- Regen's engagement with local authorities has been used to weight near-term and medium-term projections towards authority areas with clear heat decarbonisation strategies.
- New build housing is also a key influencer of local deployment. New housing developments are modelled specifically based on local planning data, using the exact location of each development.

Relevant assumptions from National Grid FES 2021:

Assumption number	3.1.3 – Heat pump adoption rates
Steady Progression	Low disposable income and low willingness to change lifestyle means consumers buy similar appliances to today
System Transformation	Medium disposable income, an increase in energy prices relative to today through carbon price but low willingness to change lifestyle and consumer preference is to minimise disruption to existing technologies
Consumer Transformation	Medium disposable income, high energy prices relative to today through carbon price incentives and a change in zeitgeist drive behavioural change to adopt new heating technologies
Leading the Way	High disposable income, high energy prices relative to today through carbon price incentives and a change in zeitgeist drive behavioural change to rapidly adopt and experiment with new heating technologies
Assumption number	**4.2.27 – Uptake of hybrid heating system units***
Steady Progression	Gas boilers still dominant and very low levels of hybridization
System Transformation	Hydrogen boilers dominant and very low levels of hybridization
Consumer Transformation	Moderate levels of heating hybridization. Even in a highly electrified heat landscape the availability of other fuels makes hybridization cost optimal in certain localities
Leading the Way	The drive to get to net zero early means taking the best from each fuel source and each technology to achieve optimum overall outcome for individual consumers and the system at large

* note that this assumption relates to the National Grid FES definition of hybrid heat pumps. This includes ASHPs with a resistive electric back-up heater, which are considered as non-hybrid heat pumps in the DFES.

Stakeholder feedback overview:

Heat pumps	
Your comments to us	Our response
Stakeholders said that off-gas fossil fuel-heated homes and new build homes would be most strongly targeted for heat pump deployment over the next decade, with on-gas homes and households in fuel poverty the least targeted. However, all options were considered likely to be targeted to some degree.	We have used these factors in the distribution of heat pumps between the baseline and 2028, considering current heating technologies, fuel access and demographic factors for each licence area.

Stakeholders noted that WPD may not have sight of all installed heat pumps.	We construct a baseline of low carbon technologies such as heat pumps from an array of sources, including WPD data, RHI data and Energy Performance Certificates. We believe this yields a reasonably accurate baseline.
Stakeholders noted that the condition of the building stock is likely to play a significant role in the uptake of heat pumps in the near term, with local authorities encouraged to tackle the worst-performing stock via whole-house retrofit.	We have modelled heat pump uptake across all types of housing, with an accelerated uptake in dwelling archetypes that see higher rates of fuel poverty and poor energy efficiency.
Stakeholders asked whether new build housing would be designed to avoid the need for significant space heating.	As it stands, the Future Homes Standard would not achieve levels of efficiency akin to the Passivhaus standard, where space heating demand is minimised. As a result, we have modelled new build housing as still requiring some form of space heating, typically via a heat pump.

References:

EPC data, Census 2011, RHI data, English Housing Survey, Regen consultation with local stakeholders.

Resistive electric heating in the East Midlands licence area

Summary of modelling assumptions and results

Technology specification:

A system using resistive electricity to provide primary space heat and hot water to domestic buildings, rather than driven by a heat pump. This has been subdivided into:

- Night storage heaters – dwellings heated by resistive electric heaters combined with a thermal store such as ceramic bricks, which are heated overnight on off-peak electricity and radiate stored heat during the daytime.
- Direct electric heaters – dwellings heated by electric heaters that directly radiate heat when required, also known as panel heaters.

There are no Open Networks Building Blocks for resistive electric heating.

Data summary for resistive electric heating in the East Midlands licence area:

Thousands of dwellings		Baseline	2025	2030	2035	2040	2045	2050
Night storage heaters	Steady Progression	153	150	140	130	123	120	121
	System Transformation		155	145	130	101	73	62
	Consumer Transformation		155	142	128	109	91	91
	Leading the Way		136	127	114	115	130	150
Direct electric heaters	Steady Progression	85	83	72	64	54	41	35
	System Transformation		85	71	58	41	25	15
	Consumer Transformation		87	69	53	36	15	9
	Leading the Way		81	69	49	36	24	23

Summary:

- Resistive electric heating, particularly direct electric heating, has historically been much more expensive to run than heating via gas, oil or an electric heat pump. Households on resistive electric heating are disproportionately likely to be in fuel poverty, as a result.
- The number of households on resistive electric heating decreases in all scenarios, with more affordable to run options such as heat pumps and district heating coming forward. Direct electric heating, as the least affordable heating method, is targeted more in the near term. There is a shift from direct electric heating to night storage heating in homes where a wet heating system, like a boiler or heat pump, is not feasible.
- There are homes remaining on resistive electric heating in 2050 in every scenario, despite its decreasing number. In dwellings where heat demand is low, such as well-insulated flats and small houses, it may not be economical to install more capital intensive wet heating system such as a heat pump. There may also be homes where resistive electric heating is the only electrified option, such as due to planning or structural constraints in select listed buildings and high-rise apartments.

Modelling assumptions and results:

Baseline

- The East Midlands licence area has an estimated 238,000 dwellings heated via resistive electric heating, of which 153,000 are thought to be on night storage heaters, with the remaining 85,000 on direct electric heating.
- This baseline has been derived through analysis of EPC records, Census 2011 data and WPD data on domestic customers connected to an Economy 7 meter.
- Resistive electric heating is slightly less common in the East Midlands compared to the national average, with around 9% of modelled homes heated primarily by resistive electric heating compared to 11% nationally.
- This is due to the majority of households in the East Midlands licence area living in towns and cities such as Nottingham, Leicester and Northampton, which are well served by fossil gas for domestic heating.
- Where resistive electric heating is present it is more common in flats, in line with the national picture.

Near-term (April 2021 to March 2026)

- All domestic heating technologies, such as resistive heating, heat pumps and non-electric boilers, are modelled holistically at a national and regional level. This has been achieved through applying scenario trajectories to 36 dwelling archetypes, based on current heating technology, building type, tenure and district heating potential.
- The number of dwellings on resistive electric heating decreases in the near term in all scenarios, as households look to or are supported to switch to more economic forms of domestic heating.
- There is some flux in resistive electric heating in the near term, such as homes converting to gas heating through the Fuel Poor Network Extension Scheme[11], homes upgrading to more modern night storage heaters through the Energy Company Obligation[12], and homes converting to more efficient electric heating such as heat pumps and district heating.
- Under **Consumer Transformation** and **Leading the Way**, higher heat pump and district heat deployment in the near term relates directly to a greater decrease in resistive electric heating.
- **Leading the Way** sees particularly strong uptake of heat pumps in the near term, with the UK meeting and exceeding its target of 600,000 heat pump installations per year by 2028. This predominantly targets off-gas and new-build housing. The modelling assumes up to 15% of night storage heated houses are converted to heat pumps in the near term under this scenario.
- Around 10% of new build properties currently install resistive electric heating, particularly new build flats and apartment blocks. This is projected to remain steady throughout the near term, regardless of the anticipated ban on gas connections in new build homes from 2025.

Medium-term (April 2026 to March 2035)

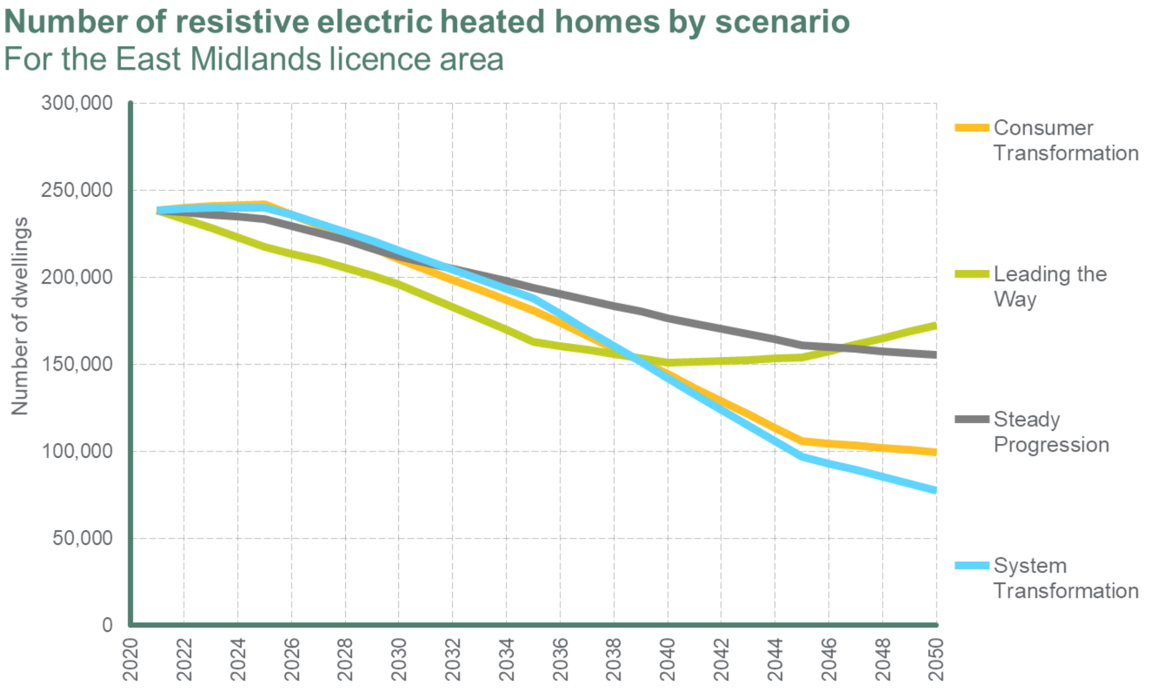
- Under **Consumer Transformation** and **Leading the Way**, accelerating heat pump and district heat deployment in the medium term results in further decreasing numbers of homes on resistive electric heating. This particularly impacts direct electric heating, as the most expensive from of electric heat.
- Under **Steady Progression** and **System Transformation**, more modest heat pump uptake is augmented by continued expansion of the fossil gas network and the rollout of a future hydrogen network respectively, similarly impacting resistive electric heating levels.
- By 2035, direct electric heating is reduced by between 25% under **Steady Progression** to 42% under **Leading the Way**.

- Under **Consumer Transformation** and **Leading the Way**, improvements to new ‘phase-change’ thermal storage results in up to 30% of direct electric heated homes converting to new, smart night storage heaters.
- By 2035, night storage heating is reduced by between 15% under **System Transformation** to 26% under **Leading the Way**. Almost half of baseline night storage heaters are removed by this point under **Leading the Way**. However, this is contrasted by new installations in new builds and conversions from direct electric heating.
- Direct electric heating is assumed to no longer be installed in new build homes beyond the near term in all scenarios, but night storage heating is still installed in a small majority of new developments. This decreases under the three net zero scenarios, as district heating and communal loop ground source heat pumps are preferred for denser new builds.

Long-term (April 2035 to March 2050)

- Direct electric heating continues to be marginal in all scenarios in the long term due to more affordable alternatives for low carbon heating. By 2050, direct electric heating levels are only 10% of the baseline under **Consumer Transformation**, compared to 40% of the baseline under **Steady Progression**.
- Under **Steady Progression**, the continued provision of the fossil gas network for heating results in a steady move away from resistive electric heating, despite the higher carbon emissions associated for fossil gas domestic heating.
- Under **System Transformation**, the prevalence of hydrogen for domestic heating accelerates the move away from resistive electric heating in the longer term. As a result, this scenario has the least resistive electric heating by 2050.
- Under **Consumer Transformation**, continued roll-out of heat pumps accelerates the move away from resistive heating. This includes district heating and communal loop ground source heat pumps in flats and urban areas, where resistive electric heating is more common.
- **Leading the Way** has the highest level of societal engagement, energy efficiency and technological advances in smart, phase-change storage heating. This results in next-generation storage heating becoming a more affordable form of domestic heating in the longer term, and a source of demand-side response flexibility through smart heaters and Time Of Use Tariffs. As a result, this scenario sees an uptick in night storage heating in the latter years of the scenario timeframe.

Figure 13



Reconciliation with National Grid FES 2021:

There are no resistive electric heating numbers presented at a GSP level in the FES 2021. Therefore, reconciliation has been undertaken in relation to national FES 2021 results for resistive electric heating.

The domestic heat modelling has been calibrated against the FES scenarios. As a result, differences on a regional level are directly related to the existing housing stock and new build development rates in the licence area.

In the case of the East Midlands licence area, direct electric heating and night storage heating reduce in line with the national trajectory.

Factors that will affect deployment at a local level:

- The spatial distribution of heating technologies has been modelled holistically based on the existing heat technology in the home, the building type, the tenure of the household in question and the district heating potential of each ESA.
- The distribution of homes replacing their resistive electric heating system is weighted more heavily towards houses rather than flats, and owner-occupied and socially rented dwellings rather than privately rented dwellings.
- New build housing is also a key influencer of local deployment of future smart storage heating. New housing developments are modelled specifically based on local planning data.

Relevant assumptions from National Grid FES 2021:

There are no assumptions in the FES 2021 that directly detail resistive electric heating. Assumptions around heat pump uptake, which strongly influences resistive electric heating, can be found in the Heat Pumps technology summary sheet.

Stakeholder feedback overview:

Resistive electric heating	
Your comments to us	Our response
Stakeholders said that resistive electric heating was most likely to remain in smaller houses and flats in the net zero future, rather than being replaced by heat pumps.	We have modelled resistive electric heating based on housing stock, existing heat technology and location, particularly accounting for the potential for district heating in urban rather than rural areas and the potential for resistive heat to remain in flats and smaller homes.
Stakeholders said that resistive electric heating would be replaced with heat pumps and district heating over time.	

References:

EPC data, Census 2011, English Housing Survey, Regen consultation with local stakeholders.

Electric vehicles in the East Midlands licence area

Summary of modelling assumptions and results.

Technology specification:

Electric vehicles (EVs) – including cars, buses and coaches, HGVs, LGVs and motorcycles, including Battery EVs and Plug-in Hybrid EVs.

Data summary for EVs in the East Midlands licence area:

Thousands of EVs		Baseline	2025	2030	2035	2040	2045	2050
Battery EVs	Steady Progression	28	148	521	1,385	2,711	3,689	3,963
	System Transformation		173	717	2,110	3,538	3,820	3,598
	Consumer Transformation		341	1,342	3,034	3,739	3,739	3,507
	Leading the Way		334	1,495	3,268	3,761	3,500	2,789
Plug-in Hybrid EVs	Steady Progression	21	62	136	240	317	207	63
	System Transformation		57	121	176	122	39	0
	Consumer Transformation		45	79	100	62	13	0
	Leading the Way		59	111	86	39	0	0

Summary:

- At present, EVs (including Battery EVs and Plug-in Hybrid EVs) represent approximately 1.2% of all vehicles in the East Midlands licence area. The GB average is 1.2%; therefore, the area has an average uptake of EVs. The area is projected to stay in line with the GB average as EVs become ubiquitous in the net zero scenarios by the late 2020s.
- Battery EV uptake has increased by 75% since the 2020 WPD DFES study. Meanwhile, Plug-in hybrid EV numbers have reduced by 16%. These changes are thought to primarily be the result of two factors – an increase in the sales rate of Battery EVs and adjustments in the Department for Transport's local vehicle registration data.
- The number of Plug-in Hybrid EVs in the licence area is 73% of the number of Battery EVs; this proportion is projected to reduce further in all scenarios, as Battery EVs become the dominant form of EV in the near term. The number of Plug-in Hybrid EVs peaks in the 2030s in all net zero scenarios followed by a decline to 2050.
- 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.

Modelling assumptions and results:

Baseline

- There are a total of 28,390 Battery EVs registered in the East Midlands licence area.
- There are a total of 20,590 Plug-in Hybrid EVs registered in the East Midlands licence area.

Near term (April 2021 – March 2025)

- The estimated uptake of EVs places the existing baseline at the bottom of a hockey stick curve of future uptake. Across all scenarios the uptake of EVs is expected to increase dramatically by 2025.
- It is projected that by 2025, there could be between around 148,000 Battery EVs in **Steady Progression** to 341,000 in **Consumer Transformation**.

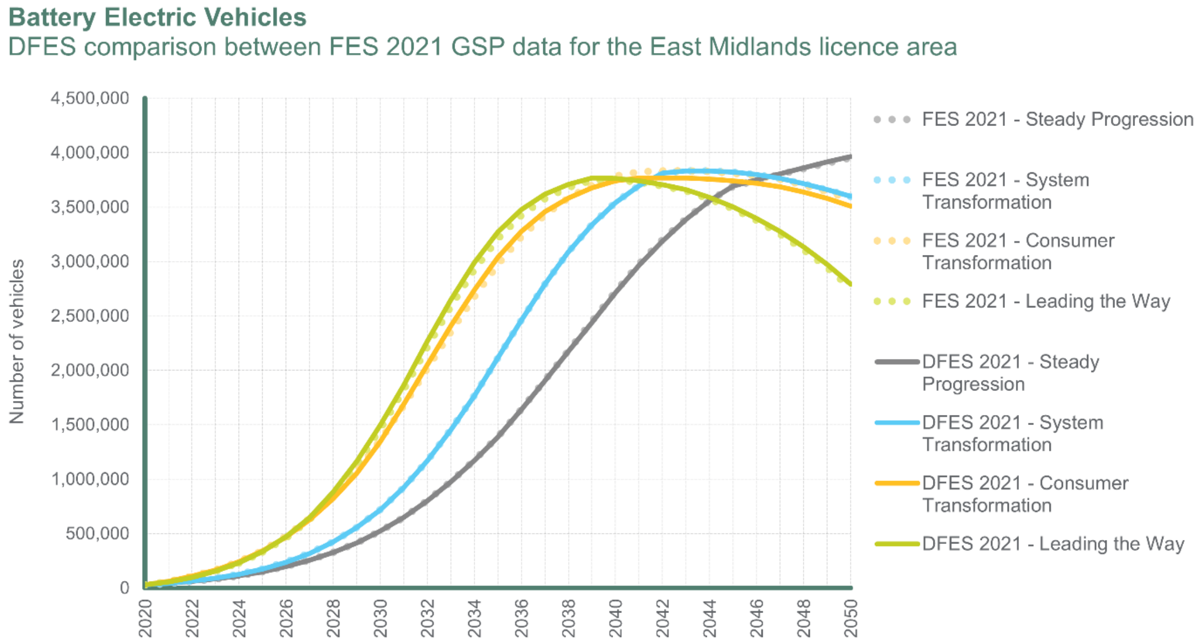
Medium term (April 2025 – March 2035)

- The uptake of EVs is expected to continue accelerating between 2025 and 2035 across all scenarios.
- By 2029, there are more than 1 million Battery EVs in the **Leading the Way** scenario, closely followed by **Consumer Transformation**.
- **Steady Progression** is the scenario with the fewest estimated Battery EVs by 2035, with around 1.1 million. **Leading the Way** remains the scenario with the most EVs, with over 3 million Battery EVs by 2035.
- EV uptake begins to slow in the mid-2030s as EV adoption approaches saturation, and only the hardest-to-electrify vehicle categories remain fossil-fuelled, such as HGVs. Furthermore, other factors contribute to uptake slowing, including the total number of vehicles on the road reducing, due to an increased use of public transport, vehicle sharing and active travel. These factors become more significant in the long term.

Long term (April 2035 – March 2050)

- The uptake of EVs continues to increase in **Steady Progression** up until 2050 when Battery EVs total nearly 3.9 million.
- In the other scenarios, the number of Battery EVs peaks at around 3.8 million in the 2040s. This is followed in all scenarios by a reduction in the total number of vehicles. This reduced total varies from 3.6 million in **Consumer Transformation** to 2.8 million in **Leading the Way**.
- In **Leading the Way** and **Consumer Transformation**, the numbers of EVs reduces from the late 2030s and mid 2040s respectively. High levels of societal change in these scenarios, including an increased use of shared private vehicles and widespread switching to public and active travel, results in many homes opting to have one car, or no car at all.

Figure 14



Reconciliation with National Grid FES 2021:

- The WPD DFES 2021 projections are in line with the FES 2021 projections in this licence area, as reported for the Building Block ID numbers Lct_BB001, Lct_BB002, Lct_BB003, Lct_BB004'.

Factors that will affect deployment at a local level:

- The spatial distribution of EVs in the near term is based on affluence, rurality, existing vehicle baselines and the distribution of on and off-street parking. However, in the late 2020s under all net zero scenarios uptake is assumed to be ubiquitous, and almost all consumers are assumed to have the same likelihood of adopting an electric vehicle, though the distribution will necessarily be weighted towards those customers who have yet to purchase an EV.

Relevant assumptions from National Grid FES 2021:

Assumption number	3.3.5 - Uptake of battery electric vehicles 4.1.25 - The rate of uptake of plug-in hybrid electric vehicles
Steady Progression	Battery EV adoption is slow and does not meet policy ambitions. Sales ban of petrol & diesel cars is pushed back to 2035, and vans to 2040, to protect UK car industry sales. Low uptake of BEVs in the Bus and HGV sectors out to 2050. Availability from manufacturers to meet EU emissions standards is met from demand by fleets looking to gradually reduce emissions (through PHEVs) and drivers who are unwilling to shift to BEVs. New PHEV sales banned in 2040.
System Transformation	The right conditions are not fully achieved to create the consumer confidence needed for the market to achieve the government's 2030 ban on petrol & diesel cars and vans. The bans for cars and vans are pushed back to 2032 and 2035 respectively. Uptake in (BEV) HGV and Bus sector is limited by strong Hydrogen Fuel Cell Vehicle uptake. Higher demand for Plug-in Hybrid EVs as a transitional vehicle due to a higher proportion of consumers reluctant to transition to BEVs. New Plug-in Hybrid EV sales banned in 2035
Consumer Transformation	The government target to ban sales of petrol & diesel cars and vans by 2030 is met. There is significant uptake in the bus sector and across suitable HGVs. Subsidy environment, falling battery costs and increased consumer willingness to accept BEVs limits PHEV growth. New (PHEV) sales banned in 2035.
Leading the Way	The government target to ban sales of petrol & diesel cars and vans by 2030 is met. Uptake in the HGV sector is limited by strong Hydrogen Fuel Cell Vehicle uptake. There is significant uptake in the bus sector. Subsidy environment, falling battery costs and increased consumer willingness to accept BEVs limits PHEV growth. New (PHEV) sales banned in 2035.

References:

Department for Transport data, Climate Emergency declaration data, Regen consultation with local stakeholders, Census 2011.

Electric vehicle chargers in the East Midlands licence area

Summary of modelling assumptions and results

Technology specification:

Electric vehicle (EV) chargers – including eight charger archetypes of off-street domestic, on-street residential, car parks, destination, workplace, fleet/depot, en-route local and en-route national.

This relates to building blocks Lct_BB010a to Lct_BB013b.

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

EV chargers		Baseline	2025	2030	2035	2040	2045	2050
Domestic off-street EV chargers (Thousands of chargers)	**Steady Progression**	16	57	247	728	1,392	1,820	1,915
	System Transformation		73	426	1,338	2,127	2,252	2,252
	Consumer Transformation		128	599	1,476	1,797	1,801	1,801
	Leading the Way		137	824	1,864	2,035	2,035	2,035
Domestic on-street EV chargers (Thousands of chargers)	**Steady Progression**	0.5	3	11	29	56	75	79
	System Transformation		2	7	23	43	49	49
	Consumer Transformation		6	30	70	90	97	103
	Leading the Way		5	22	60	84	102	125
Non-domestic EV chargers (Thousands of chargers)	**Steady Progression**	2	2	6	20	45	68	81
	System Transformation		3	10	34	66	83	90
	Consumer Transformation		6	19	46	60	71	79
	Leading the Way		5	19	46	59	69	78

Summary:

- At present, the licence area has a slightly above average level of non-domestic charging availability per electric vehicle. As EVs become more widespread, in the 2020s and 2030s, the installation rate of charging points accelerates nationwide, though some regional differences in the type and level of charging that is available are projected to be maintained.
- These projections aim to represent the envelope of the possible spread and rate of deployment of EV chargers. In many modelling areas, there is a lack of behavioural evidence and so interim assumptions have been made.

Modelling assumptions and results:

Baseline

- There is an estimated total of c. 2,000 non-domestic EV chargers in the East Midlands licence area.
- It is estimated that there are over 16,000 domestic EV chargers in the East Midlands licence area, the vast majority of which are off-street chargers.
- The baseline is based on based on public EV charger registers combined with WPD data, and DfT vehicle registration data to model domestic chargers . Changes to EV registration data from DfT since WPD DFES 2020 has led to a lower baseline in some areas.

Near term (April 2021 – March 2025)

- The estimated uptake of EV chargers places the existing baseline at the bottom of a hockey stick curve of future uptake. Across all scenarios, the uptake of EV changers is expected to increase dramatically in the near term.
- It is projected that by 2025, there could be between around 56,000 domestic off-street chargers under **Steady Progression** to 135,000 under **Leading the Way**, alongside several thousand domestic on-street chargers in each scenario.
- The highest scenario for non-domestic chargers, **Consumer Transformation**, sees 5,700 non-domestic chargers by 2025, totalling 244 MW of capacity. This encompasses public chargers, as well as private chargers for workplaces or vehicle fleets.
- As part of the **Leading the Way** scenario, Ofgem's 'minded to' decision on network charging[13] has a short-term effect of public charger installations. It is assumed that a proportion of EV chargers that are projected to be developed in 2022 will wait until the network charging rules change in 2023.

Medium term (April 2025 – March 2035)

- Charger installation rates are expected to continue accelerating between 2025 and 2035 across all scenarios.
- **Steady Progression** is the scenario with the lowest estimated EV charger capacity in 2035, with around 0.7 million domestic EV chargers and 20,000 non-domestic chargers. **Leading the Way** becomes the scenario with the highest number of domestic EV chargers, totalling over 1.9 million, while **Consumer Transformation** has the most non-domestic chargers, totalling c. 46,000 with a capacity of 1.8 GW.
- EV uptake begins to slow in the mid-2030s as EV adoption approaches saturation and only the hardest-to-electrify vehicles remain fossil-fuelled, such as HGVs. As a result, the installation rate of EV chargers also slows. Homes with multiple EVs are assumed not to purchase a second charger at the same rate as the first, and the demand for additional public charging reduces as most vehicles are now electrified in the net zero scenarios.

Long term (April 2035 – March 2050)

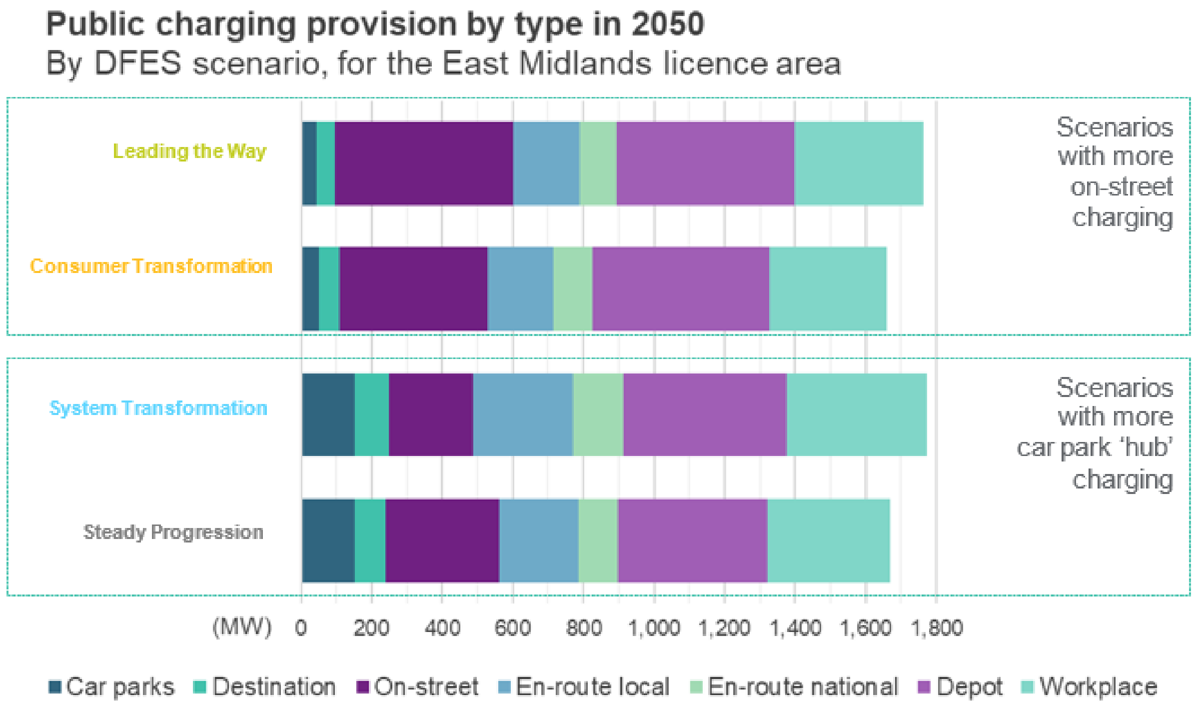
- While the uptake of EVs slows and then reduces in some scenarios in the long term, it is assumed that the number of off-street EV chargers will not reduce in line with EVs. An assumption is made that EV charger capacity will remain at the peak achieved in the years around 2040-2045, depending on scenario, rather than chargers decommissioning.
- The uptake of EVs and EV chargers continues to increase in **Steady Progression**, right up until 2050 when there are 1.9 million domestic EV chargers.
- In **Leading the Way** and **Consumer Transformation**, from the late 2030s and mid-2040s respectively as EVs approach market saturation and their numbers flat line, the capacity of domestic EV chargers similarly flat lines.
- In all scenarios, the modelled energy demand of EVs continues to increase through the 2040s, despite a reduction in EV numbers. This is predominantly due to increasing total mileage of vehicles. Therefore, non-domestic EV charging capacity also continues to increase.

Reconciliation with National Grid FES 2021:

- The EV charger building blocks are not included in the FES 2021 data at a GSP or national level. The bespoke EV charger projections in the DFES analysis are made using Regen's Net Zero Transport model that make use of FES EV projections and other assumptions where possible.
- Assumptions have been made as to the behaviour of EV and use of EV chargers based on stakeholder engagement that Regen has conducted with industry for several years. As more behavioural data and other evidence becomes available, these assumptions will be further refined in the future. These assumptions include:
    - Where each EV category will charge (at which EV charger archetype).
    - The predominant business models and EV charger utilisation at each charger archetype. For vehicle efficiencies, mileage and vehicle numbers, FES projections and assumptions were used.

Figure 15

Non-domestic and on-street EV charger capacity results, by scenario



Factors that will affect deployment at a local level:

- Domestic off-street charger distribution is based on the uptake of domestic electric vehicles. As a result, the distribution of vehicles associated with on and off-street parking was evaluated, with the anticipated result that a feeder is more likely to see domestic off-street EV charging in more rural and more affluent areas where off-street parking exists.
- The spatial distribution of non-domestic chargers was analysed in a different manner for each archetype. En-route local and national charging locations were evaluated based on the density of local housing, the volume of local traffic, the distribution of existing petrol stations and the road classification the site is located on. Car parks, workplace and fleet depot locations were analysed from Ordnance Survey AddressBase data.
- The distribution analysis uses affluence as one of the key factors driving the uptake of EV chargers in the near term. For the more ambitious scenarios, from the mid to late 2020s, the underlying assumption is that EVs will become ubiquitous. Therefore, the growth in demand for EVs and EV chargers across all areas aligns in the longer term, regardless of affluence, off-street parking provision, rurality or other near-term factors.

Relevant assumptions from National Grid FES 2021:

Assumption number	4.2.13 - Level of Home Charging and other stated assumptions
Steady Progression	Charging at home is limited by a lack of via solution for those without off-street parking.
System Transformation	Emphasis on public rollout of fast chargers to allow rapid charging. More rapid and fast public charging is demanded from consumers.
Consumer Transformation	Charging predominately happens at home. Emphasis on home chargers, taking advantage of consumer engagement levels in flexibility. Leads to some disruption (e.g. reinforcing local networks).
Leading the Way	Charging happens similarly to how it happens today, with various types receiving investment to support an accelerated uptake of electric vehicles. Accelerated rollout of charging infrastructure at home and in public places. BEV cars smart charge at home or at the office, frequently pairing with on-site EV and batteries to encourage self-consumption.

References:

Department for Transport data, Climate Emergency declaration data, Regen consultation with local stakeholders, Census 2011.

Hydrogen electrolysis in the East Midlands licence area

Summary of modelling assumptions and results

Technology specification:

This analysis covers the capacity of hydrogen electrolysers connected to the distribution network in the East Midlands licence area. The analysis does not include electrolysers that are directly powered by renewable energy without a dedicated grid connection ('behind-the-meter') or large-scale electrolysers connected to the transmission network. Nor does it include CCUS-enabled hydrogen produced via the reformation of natural gas or other fossil fuels.

This technology pertains to Building Block ID number Dem_BB009 in the FES 2021 data; however, due to a lack of GSP-level data for this building block, WPD DFES 2021 projections have been compared to FES 2021 figures at a national level.

Data summary for hydrogen electrolysis in the East Midlands licence area:

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	0	2	45	107	107	107	107
System Transformation		12	32	92	131	199	246
Consumer Transformation		4	31	434	572	1,035	1,428
Leading the Way		17	274	583	757	1,001	1,265

Summary:

- There is significant uncertainty around the development of hydrogen electrolysis as an emerging technology. The main sources of uncertainty are:
    - The split of capacity on the distribution network compared to the transmission network
    - The contribution of electrolytic hydrogen to national hydrogen aims, compared to CCUS-enabled hydrogen
    - The range of end-uses for hydrogen, including transport, industrial processes, aviation and shipping, power generation, and heating
    - Major government policy decisions that are still to be finalised
    - How far and how quickly hydrogen costs will fall.
- There is a current lack of funding for hydrogen electrolysers, which may delay any 'first-of-a-kind' developments; however, this could change in light of the UK Hydrogen Strategy.
- Despite significant development not anticipated until after 2025, Ofgem's announcement of their minded-to decisions related to the Access SCR could be beneficial for hydrogen electrolysers, due to reduced network charges. This is modelled to be a factor under **Leading the Way** and **Consumer Transformation**.

- The East Midlands 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 "freeport" status and decarbonisation targets.
- The largest capacity of distribution-connected hydrogen electrolysers in 2050 in the East Midlands licence area is modelled under **Consumer Transformation** (1.4 GW) and **Leading the Way** (1.2 GW). This reflects a focus on electrolytic hydrogen as a widespread zero carbon fuel for use in transport, industrial processes and heating.
- In contrast, the least capacity is modelled under **Steady Progression** (107 MW) reflecting limited government policy support for this technology and the assumption that high construction, production and commodity costs limit the rollout of electrolysis.

Modelling assumptions and results:

Baseline (up to 31st March 2021)

- There is no capacity currently connected to the distribution network in the East Midlands licence area.
- West Beacon Farm[14] in Nottingham housed a 34 kW electrolyser as part of the HARI project in the early 2000s. The electrolyser converted surplus electricity from the on-site renewable generation into hydrogen, which was then stored until it was needed to generate electricity and hot water for the farm. This has since been decommissioned.

Near term (April 2021 – March 2025)

- In the near term, **Leading the Way** and **System Transformation** see the highest levels of capacity growth due to strong government support for hydrogen. This will likely be focussed on transport, including the introduction of hydrogen buses and HGVs.
- There are plans for a hydrogen refuelling station in Derby as part of the HyTap project[15].
- There are a number of innovation trials in the East Midlands focussed on electrolytic hydrogen production, including:
  - East Midlands Hydrogen Innovation Zone[16], a project launched by the University of Nottingham, aiming to demonstrate how inland areas can make the most efficient use of hydrogen. The project is looking to take advantage of the East Midland's "freeport" 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 via electrolysis is to be explored.
  - H2GVMids[17] demonstration programme which has 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 to enable the demonstrator. The project is due to run until March 2022 and is hoped to be followed with a full demonstrator stage.

Medium term (April 2025 – March 2035)

- Electrolytic hydrogen will be used for transport across all scenarios, favoured over CCUS-enabled hydrogen due to its purity.
- As a result, hydrogen electrolysis capacity is likely to increase in the medium term across all scenarios, driven by the uptake of hydrogen-fuelled heavy vehicle fleets and the introduction of mainstream hydrogen fuel cell public transport. This transition to low carbon heavy vehicles will be further incentivised by wider transport decarbonisation policy measures, such as the ban on the sale of new petrol and diesel cars by 2030.

- The East Midlands Airport has committed to achieving net zero status by 2038, with hydrogen expected to play a key role. The Airport has formed a consortium to create a Hydrogen Hub supplying green hydrogen for airport vehicles and aircraft[18].
- Under **Consumer Transformation** and **Leading the Way**, it is expected that hydrogen electrolysis will achieve cost parity with CCUS-enabled hydrogen by the mid-2030s.
- From consultation with electrolyser manufacturers, 5 MW and 10 MW electrolyser units are anticipated to become commercially viable in the medium term. This will allow existing and new sites to scale up their installed capacity.
- **System Transformation** does not see electrolysis reaching cost parity in the same timeframe, so CCUS-enabled hydrogen is the favoured production method, particularly for decarbonising industrial clusters.
- Under **Steady Progression**, there is very little policy support for hydrogen production in general.
- As a result of these sector developments, **Consumer Transformation** and **Leading the Way** see unprecedented growth in capacity between 2025 and 2035, with 430 MW and 566 MW of additional capacity, respectively. This growth in capacity is in line with the UK government's target of 5 GW clean hydrogen capacity by 2030.
- In contrast, **System Transformation** and **Steady Progression** see limited growth in capacity in the medium term, with 80 MW and 105 MW of additional capacity, respectively. In these scenarios, growth in capacity is primarily driven by hydrogen demand for transport, given the East Midland's position as a logistics, haulage and transport hub.

Long term (April 2035 – March 2050)

- In the long term, electrolysers are expected to scale their capacity by increasing the number of modules connecting to a compressor, which means that the development of new sites is likely to slow, and instead, existing locations are likely to be expanded to cater for higher demand.
- **Leading the Way** and **Consumer Transformation** continue to experience significant growth in hydrogen electrolyser deployment, seeing more than a doubling of capacity in each scenario between 2035 and 2050. This is due to a number of factors, including:
  - wider hydrogen sector developments, i.e., the repurposing of large-scale storage facilities for hydrogen and a decrease in upfront costs, as hydrogen electrolyser capacity increases across the UK
  - demand for electrolytic hydrogen from a variety of sectors, including heating, industrial demand, road transport, power, shipping, and aviation
  - the coupling of hydrogen electrolysis with renewable generation in these high-renewables scenarios.
- In **Consumer Transformation**, electrolysers are located close to demand as a national hydrogen network is not expected. This results in more, small-scale electrolysers connecting to the distribution network, close to demand. In 2050, electrolyser capacity reaches 1.4 GW, the highest of the four scenarios.
- In **Leading the Way**, a national hydrogen transmission network allows production capacity to increase rapidly. This could favour transmission-scale production, resulting in the growth of hydrogen electrolyser capacity on the distribution network in this scenario tapering off from 2035, resulting in 1.2 GW connected by 2050.
- **System Transformation** and **Steady Progression** have significantly lower electrolyser capacity connecting by 2050, due to a focus on CCUS-enabled hydrogen.

Key modelling assumptions:

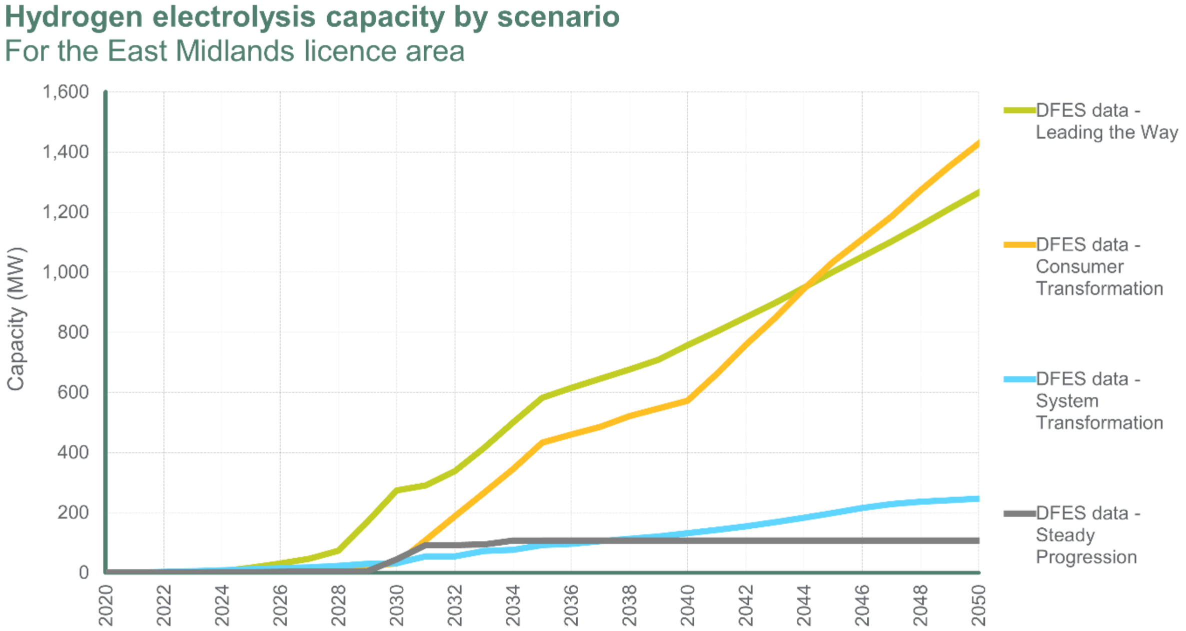
- **Leading the Way**, **Consumer Transformation** and **System Transformation** have been modelled with total GB capacity split between the transmission and distribution networks. In 2050, distribution connected capacity is modelled to account for 25%, 70% and 10% of the total capacity, respectively.
- **Steady Progression** is the only scenario to have all grid-connected hydrogen electrolysis capacity (100%) modelled on the distribution network.
- All scenarios project electrolytic hydrogen to be used in transport applications. Hydrogen refuelling infrastructure is likely to be co-located with existing petrol stations, particularly ones with large HGV fuelling demand.
- In scenarios where CCUS-enabled hydrogen is also present in the energy mix, it is assumed this is used to decarbonise existing high-carbon hydrogen production and the majority of industrial clusters.
- As a new technology, it is not clear how electrolysers co-located with renewable generation will connect to the grid. It is therefore assumed that hydrogen production co-located with renewable generation will connect to the same network as the renewable generation site itself.
- Storage is an important factor in the scaling up of hydrogen production; however, co-locating with large-scale storage facilities is more likely to result in transmission scale hydrogen electrolysers, thus this factor is not as heavily weighted as others for distribution-scale electrolysis.

From engaging electrolyser developers, a number of factors influencing the location of sites were identified, as seen in Table 3. These factors were weighted based on the assumptions underpinning the four FES scenarios and used to create licence area projections.

Table 3 - Locational factors used in the modelling of hydrogen electrolysis capacity, by scenario

Factor	Leading the Way	Consumer Transformation	System Transformation	Steady Progression
Industrial energy demand/clusters	X	X		
Heavy transport demand (HGVs)	X	X	X	X
Large-scale hydrogen storage options	X	X	X	
Location of major ports and maritime activity	X	X	X	
Access to the gas network	X		X	X
Distributed wind generation	X	X	X	
Distributed solar generation	X	X	X	
Rail network and associated infrastructure	X	X	X	
Existing grey hydrogen production	X	X		
Innovation/production projects	X	X	X	X

Figure 16



Reconciliation with National Grid FES 2021:

This technology pertains to Building Block ID number Dem_BB009 in the FES 2021 data; however, due to a lack of GSP-level data for this building block, reconciliation is difficult. Instead, WPD DFES 2021 projections have been calculated as the distribution network proportion of FES 2021 grid-connected hydrogen electrolysis capacity at a national level. These were calculated based on the locational factors outline in Table 3, including the location of existing hydrogen production sites, large industrial clusters and heavy transport demand.

- As a result, WPD DFES 2021 hydrogen electrolysis capacity in 2050 in the East Midlands licence area under **Leading the Way** equates to 2% of the FES 2021 national grid-connected hydrogen electrolysis capacity. **Consumer Transformation** (4%) and **System Transformation** (1%) have assumed there is capacity on both the transmission and distribution networks.
- **Steady Progression** models 9% of FES national capacity to be connected to the distribution network in the East Midlands licence area, with all capacity in this scenario assumed to be connected to the distribution network.

Factors that will affect deployment at a local level:

The spatial distribution of hydrogen electrolysers is highly uncertain, due to a number of unknowns, including:

- the potential for hydrogen electrolysers to be co-located with existing or new distributed renewable generation
- the split of electrolysis capacity on the distribution network compared to the transmission network
- whether or not there will be construction of a national hydrogen network that would be able to transport hydrogen around the UK
- the location of large-scale storage facilities, which have not currently been explored for hydrogen storage.

Stakeholder engagement:

As part of the WPD DFES stakeholder engagement process, Regen delivered a series of webinars with WPD in June 2021. Participants fed back that co-location with renewable generation is the most likely hydrogen business model and is likely to gain traction in the near and medium term. Small-scale electrolysers based at transport hubs were also considered to be a viable business model in the medium term. This feedback influenced the DFES analysis by confirming the influence of renewable generation and transport hubs on the location of hydrogen electrolysers on the distribution network.

As part of the WPD DFES 2021 analysis, ITM Power, one of the UK's leading hydrogen electrolyser manufacturers, was consulted. They highlighted the potential for electrolysis production units to be used in industrial clusters, at transport hubs and in the shipping and aviation sector. They also highlighted a longer-term opportunity to co-locate with offshore wind. There was strong agreement with the modelling approach in the DFES, particularly the focus on matching electrolytic hydrogen supply to a number of end use sectors.

Relevant assumptions from National Grid FES 2021:

Assumption number	4.2.19 - Hydrogen (electrolysis exc. from nuclear)
Steady Progression	High costs limit rollout of electrolysis – used mainly in transport.
System Transformation	Competition from SMR* limits rollout of electrolysis – used mainly in transport. Electrolysis mainly from curtailed wind. SMR covers heat.
Consumer Transformation	Electrolysis used to decarbonise heat, transport and some industrial and commercial – medium as begins later than in **Leading the Way**.
Leading the Way	Electrolysis used to decarbonise heat, transport and industrial and commercial, but rollout starts in the mid-2020s.

*Steam Methane Reformation – a process of producing hydrogen from natural gas or other fossil fuels.

References:

IEA hydrogen project database, FES 2021 data workbook, Network Rail Traction Decarbonisation Strategy, consultation with ITM Power, University of Nottingham, UK Hydrogen Strategy, National Atmospheric Emissions Inventory, BEIS energy consumption dataset, Department for Transport local authority vehicle miles data, UK Carbon Capture and Storage Research Centre, 2011 Census data.

Air conditioning in the East Midlands licence area

Summary of modelling assumptions and results

Technology specification:

Number of domestic air conditioning units, based on a typical portable or window-mounted air conditioner.

Technology building block: Lct_BB014 – A/C Domestic units

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

Air conditioning units (thousands)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	24	41	81	160	353	733	1,482
System Transformation		38	68	134	252	473	868
Consumer Transformation		38	68	121	239	449	824
Leading the Way		24	24	24	24	24	24

Summary:

- Air conditioning is currently rare in domestic settings in the UK, with just over 1% of homes currently containing an air conditioning unit.
- In the East Midlands licence area, modelling suggests around 0.9% of homes currently have an air conditioning unit.
- Increased summer temperatures, extended heat waves and reducing costs of air conditioning units may contribute to increased uptake over the coming decades.
- The UK building stock is not optimised for passive cooling. This could drive increased levels of active cooling, such as air conditioners, as temperatures increase.
- Air conditioning uptake is likely to be focussed in urban areas such as Nottingham, due to the 'heat island effect' causing increased temperatures in built-up areas[19].
- Given the minimal baseline and uncertainty around future cooling demand and cooling methods, there is a broad range of scenario outcomes. This results in minimal uptake under **Leading the Way**, and air conditioning becoming commonplace under **Steady Progression**.

Modelling assumptions and results:

Baseline

- 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[20], equating to around 200,000-800,000 air-conditioned homes.
- A global assessment of the air conditioner market[21] suggested 110,000 'Room Air Conditioners' were sold in the UK in 2018, following year-on-year growth of 12% over the previous six years. However, this figure does not only account for new domestic air conditioners, but also small-scale commercial air conditioning and the replacement of existing units.
- For the purposes of this assessment, we have aligned with the National Grid FES 2021 air conditioning demand data, from which we have derived a national baseline of 292,000 domestic air conditioner units.
- Using regional temperature data, numbers of urban homes, and total number of homes, this national figure was disaggregated to determine a regional baseline.
- This results in baseline of 23,500 domestic air conditioning units in the East Midlands licence area.
- The baseline modelling assumptions have been updated since the WPD DFES 2020. This results in fewer air conditioning units in the licence area baseline. Compared to previous studies, a higher proportion of the national baseline is modelled to be located in London and South East England, reflecting temperature data and urban density.

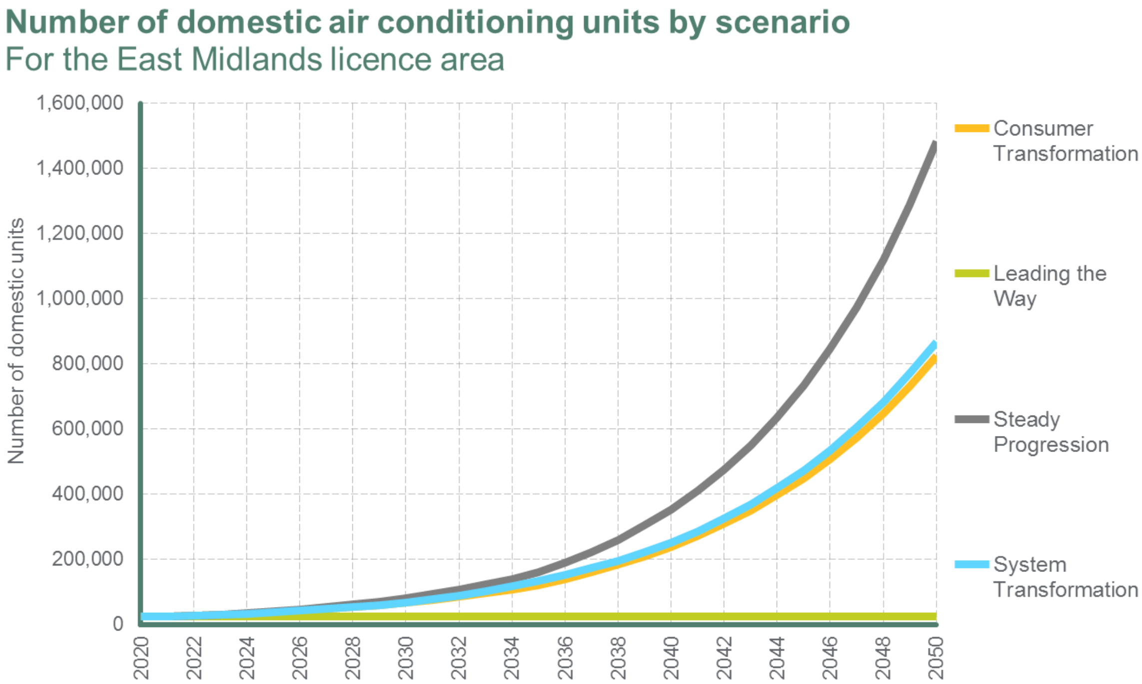
Near-term (April 2021 to March 2026)

- Near-term uptake of domestic air conditioning remains limited, reflecting the relative lack of demand for active cooling in the current climate.
- Domestic air conditioning is associated with high upfront and running costs, restricting uptake while it is seen as a luxury.

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

- The Future Homes Standard will dictate standards for new build homes. This is expected to include a stipulation that solar gain should be limited through passive measures such as shading, and that the dwelling should not be at risk of overheating. Importantly houses must comply with this standard even if active cooling is installed.
- As a result, all scenarios assume no air conditioning in new build homes.
- In existing homes, uptake of air conditioning accelerates in all scenarios.
    - Under **Steady Progression**, rising summer temperatures and societal reluctance to engage in passive cooling methods leads to exponential uptake of domestic air conditioning. This is seen as the 'easiest' route to comfortable internal temperatures. By 2050, 58% of current homes have an air conditioning unit in this scenario.
    - Under **Consumer Transformation** and **System Transformation**, uptake of domestic air conditioning accelerates, especially in urban 'heat island' areas. However, goals to reduce GHG emissions and electricity consumption limit uptake, with passive cooling measures encouraged and adopted. In these scenarios, 32-34% of homes in the East Midlands licence area have an air conditioning unit by 2050.
    - Under **Leading the Way**, domestic air conditioning remains rare, with cooling requirements met through more sustainable methods such as shading, behaviour change, and higher levels of wider societal change. As a result, across the scenario timeframe (2021 to 2050), only around 1% of homes in the East Midlands licence area have an air conditioning unit.

Figure 17



Reconciliation with National Grid FES 2021:

The FES 2021 does not directly detail numbers of domestic air conditioning units, and as such as direct comparison has not been completed. However, the FES 2021 does provide 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. This allows for reconciliation at a high level.

- The East Midlands licence area figures, in terms of proportion of homes with an air conditioning unit, are generally in-line with the FES 2021 in each scenario.
- The regional scenarios projections are based on analysis of:
    - Cooling degree days at 18.5 °C, where the East Midlands is slightly above the national average. This metric is used in every scenario.
    - Proportion of households in very dense urban areas, with the East Midlands 52% 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 8% below the national average. This metric is used in **Steady Progression**, as air conditioning becomes common even outside of 'heat island' areas.
- The resultant effect of these contrasting factors is that air conditioning uptake in the East Midlands licence area is broadly in line with the FES 2021 national scenario outcomes.

Factors that will affect deployment at a local level:

The spatial distribution of domestic air conditioning units has been based on:

- Affluence, given the high upfront and running costs of domestic units. This is weighted most strongly in the near term, where air conditioning is uncommon in all scenarios.
- Tenure, due to the greater likelihood of homeowners to invest in relatively expensive home improvements such as air conditioning, compared to tenants and landlords. As with affluence, this factor is weighted heavily in the near term where air conditioning uptake is more limited.
- Urban areas, as 'heat islands' are seen as key drivers in the uptake of domestic air conditioning. Urban areas also contain higher proportions of flats, which have a lower ratio of external surface area to floorspace, which prevents heat from escaping effectively at high temperatures.
    - Initial uptake of air conditioning is weighted towards the densest urban areas, where heat island effects are most prevalent.
    - Further uptake, especially under **Steady Progression** and the latter years of **Consumer Transformation** and **System Transformation**, is weighted across all urban areas.

Relevant assumptions from National Grid FES 2021:

Assumption number	3.1.2 - Uptake of Residential Air Conditioning
Steady Progression	Low willingness to change means society takes the easiest route to maintain comfort levels, therefore increased levels of air conditioning.
System Transformation	Medium uptake as society takes a mix of actions to maintain comfort levels (mix of air conditioning, tolerance of higher temperatures, changes to building design)
Consumer Transformation	Medium uptake as society takes a mix of actions to maintain comfort levels (mix of air conditioning, tolerance of higher temperatures, changes to building design)
Leading the Way	Low uptake as society changes to minimise uptake (e.g. personal tolerance of higher temperatures, changes to building design)

References:

National Grid ESO FES 2021 data, UK cooling degree days data, Census 2011, Future Homes Standard consultation documents.

2 The Ten Point Plan for a Green Industrial Revolution
3 Future support for low carbon heat
4 Clean Heat Grant: further policy design proposals
5 English Housing Survey Energy Efficiency, 2018-19
6 Heat networks pipeline
7 Heat Networks Planning Database: quarterly extract
8 Rethinking heat: a utility based approach for ground source heat pumps, Regen
9 The Future Homes Standard: changes to Part L and Part F of the Building Regulations for new dwellings
10 Opportunity areas for district heating networks in the UK
11 Fuel Poor Network Extension Scheme (FPNES) Governance Document
12 Energy Company Obligation (ECO)
13 How much we pay for connecting to the distribution electricity network is changing, Regen
14 West Beacon Farm
15 ITM Power, H2Mobility
16 East Midlands Hydrogen Innovation Zone
17 Hydrogen-powered HGVs set for the Midlands through the H2GVMids programme
18 East Midlands Airport developing hydrogen fuel capabilities
19 Sustainable cooling POSTnote
20 Air conditioning demand assessment, Tyndall Manchester
21 World Air Conditioner Demand by Region

Results and assumptions

Generation technologies

Onshore wind in the East Midlands licence area

Summary of modelling assumptions and results

Technology specification:

Onshore wind generation, including large-scale wind farms and smaller single-turbine sites.

Technology building blocks: Gen_BB015 – Onshore Wind >=1MW; Gen_BB016 – Onshore Wind <1MW.

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

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	408	408	448	482	517	577	600
System Transformation		408	507	590	705	791	867
Consumer Transformation		465	668	955	1,350	1,709	2,044
Leading the Way		463	597	811	1,125	1,402	1,658

Summary:

- The East Midlands licence area has a long history of onshore wind development, hosting some of the first commercial wind farms in the UK. Over two-thirds of baseline capacity was connected between 2011 and 2017.
- The licence area's relatively high wind speeds and large areas of developable land have contributed to a baseline capacity of over 400 MW.
- The pipeline is limited to just one potential new site, due to difficulties in attaining planning permission for onshore wind developments in England, results in relatively low deployment in the near term.
- Proven resource availability and a positive planning environment contribute to strong capacity growth in the medium and long term under **Consumer Transformation** and **Leading the Way**.
- Under **Steady Progression**, lack of progress on decarbonisation results in limited deployment of onshore wind capacity, especially in England as planning policy remains obstructive.

Modelling assumptions and results:

Baseline

- There is a total of 408 MW of onshore wind capacity connected in the East Midlands licence area.
- The majority of this capacity, 368 MW, is provided by 39 large-scale sites of 1 MW or greater.
- There are 128 small-scale sites of less than 1 MW, totalling 40 MW of capacity, with many of these sites consisting of single, kilowatt-scale turbine installations.
- Just under one-third of the capacity in the licence area, totalling 128 MW, connected between 2000 and 2011. These sites, such as the 13-turbine, 26 MW Bicker Fen site, were predominantly developed with support of the ROCs scheme.
- The vast majority of recent development occurred between 2012 and 2017 as a result of government subsidies such as the Feed-in Tariff. Almost 280 MW of capacity was deployed in this timeframe.
- Since the end of 2017, less than 1 MW of onshore wind capacity has connected to the East Midlands distribution network. This is due to changes to the planning system in England resulting in onshore wind struggling to attain permission in the vast majority of cases. Engagement with developers confirmed that Wales and Scotland were currently the focus of onshore wind development in GB.

Near-term (April 2021 to March 2028)

- There is only one pipeline site with an accepted network connection offer, a 54 MW site at Heckington Fen. This site was granted planning permission in 2013, and in 2018 applied to extend the date of commencement from five to ten years.
- The Heckington Fen site also forms a key part of Central Lincolnshire's carbon neutral roadmap, published in March 2021.
- In order to reflect the uncertainty around the site's development timescale, outcomes vary by scenario:
  - Under **Consumer Transformation** and **Leading the Way**, the site is connected by 2025, based on typical construction times for large-scale onshore wind farms after achieving planning permission.
  - Under **System Transformation** the site construction is delayed, commissioning in 2026.
  - Under **Steady Progression**, the site is not developed, as onshore wind development in England remains stagnant in this scenario.
- Analysis of historic wind farm development timescales, crosschecked against engagement with developers, suggests that onshore wind farms typically four-to-five years to go from planning application submission to operation, including several years even after planning permission has been granted.
- As a result, the pipeline of accepted connections, which would include projects in the pre-planning stage of development, is considered to represent potential deployment of large-scale onshore wind between the baseline and early 2028.

Medium-term (April 2028 to March 2035)

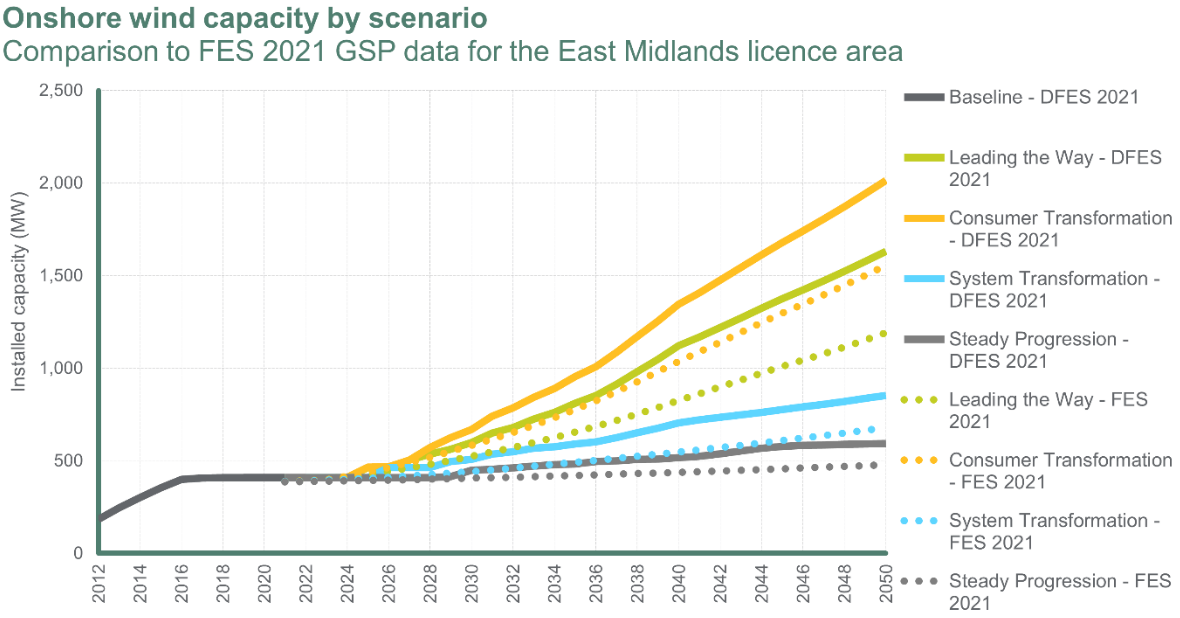
- As proven by the baseline, with a period of significant onshore wind development followed by effectively no deployment, onshore wind is particularly sensitive to changes to the planning environment.
- The planning environment, therefore, forms the key difference between the scenarios.
- Under **System Transformation** and **Steady Progression**, onshore wind continues to see very little deployment in the medium term, as a result of a continued lack of support in the planning system in England.
- Some capacity increase still occurs in these scenarios, mostly driven by repowering of older baseline sites with newer, higher-capacity turbines.

- Repowering has been seen at older onshore wind sites in South West England, showing that baseline sites can be repowered at much higher capacities using fewer turbines, as a result of the advances in onshore wind technology over the past decade.
- The **Consumer Transformation** and **Leading the Way** scenarios feature a much more supportive planning regime for onshore wind in England, with onshore wind seen as a key component in reducing carbon emissions in the medium and long term.
- In these scenarios, the increased capacity is a result of both ambitious repowering of older baseline sites at increased capacities, and new projects developed in areas with good wind resource.
- Feedback from developers suggests that while the inclusion of onshore wind support in the upcoming Contract for Difference auctions is positive, the highly competitive nature of these auctions means that most sites would be developed on a merchant basis, as is already occurring in Scotland.

Long-term (April 2035 to March 2050)

- The medium-term trends continue into the long term for each scenario, with new onshore wind capacity developed in **Consumer Transformation** and **Leading the Way**.
- **Consumer Transformation** sees particularly high levels of onshore wind development, with this scenario featuring greater amounts of distribution-scale renewable generation such as onshore wind. This results in 2 GW of onshore wind capacity in the East Midlands by 2050 under this scenario.
- In all scenarios, baseline sites developed during the Feed-in Tariff years of 2012 to 2017 are assumed to repower at the end of their operational life of 25-30 years.
- To reflect the range of repowering options, repowered capacity ranges from 150% in **Consumer Transformation** (where turbines are replaced by a similar number of newer, more efficient models), to 125% in **Steady Progression** (where sites are repowered with a reduced number of higher capacity turbines).

Figure 18



Reconciliation with National Grid FES 2021:

Results in this section relate to the FES 2021 data for the relevant GSPs within the East Midlands licence area.

- The FES 2021 baseline for the East Midlands licence area is well aligned with the DFES, with 387 MW of baseline capacity compared to 408 MW in the DFES 2021.
- In each scenario, there is some discrepancy in the near-term due to the detailed evaluation of pipeline projects with an accepted connection agreement. This is evident in the three net zero scenarios.
- Across the timeframe of the analysis, the DFES 2021 projections are substantially ahead of the FES 2021 GSP-level data, particularly in **Consumer Transformation** and **Leading the Way**. This is due to differences in how future development of onshore wind capacity has been assessed at a regional level:
  - In the FES 2021, "Generation forecasts are apportioned according to the existing geographical distribution for all technologies except solar."[22]
  - Due to the effective ban on new onshore wind capacity in England since 2017, the DFES analysis considers the existing distribution of onshore wind capacity skewed towards Wales and Scotland, and is not wholly reflective of resource availability.
  - In the DFES 2021, a resource assessment of onshore wind resource has been utilised to guide medium-term and long-term projections.
  - This results in higher levels of onshore wind capacity in English licence areas, such as the East Midlands, due to the resource potential in the licence area relative to GB as a whole.

Factors that will affect deployment at a local level:

- The spatial distribution of new onshore wind sites in the near term is based on the location of the Heckington Fen pipeline site.
- In the medium and long-term, new capacity is distributed on the basis of:
  - Areas close to the existing electricity network, excluding areas that would hinder planning and siting of turbines, such as environmental designations (e.g. AONBs or National Parks), areas of housing or other buildings, and steep gradients.
  - Areas with developable wind resource, based on wind speed analysis.
  - Analysis of historic planning permission records for the local authority.
- The modelled repowering of existing baseline sites naturally leads to further capacity on areas of the network that already host onshore wind.
- Local policies identified by stakeholders are included as positive weightings within the spatial distribution, for example, the East Northamptonshire District 'Wind and Solar Energy Supplementary Planning Document', and several local authorities who have declared a climate emergency and are developing climate energy plans.

Relevant assumptions from National Grid FES 2021:

Assumption number	4.1.3 - Wind generation (onshore)
Steady Progression	Slower pace of decarbonisation.
System Transformation	Focus on renewables but limited by societal preference for offshore turbines (less impact on land use and visibility)
Consumer Transformation	Strong support for onshore wind across all networks. Some of these projects may be in community ownership.
Leading the Way	High growth driven by the decarbonisation agenda and high demands from hydrogen production from electrolysis.

Stakeholder feedback overview:

Onshore wind	
Your comments to us	Our response
Stakeholders fed back that onshore wind deployment is most likely to pick up in late 2020s in England, though a number of stakeholders thought the early-mid 2020s would be possible.	In addition to direct engagement with wind developers, we have used stakeholder feedback from all four webinars to guide the pipeline and post-pipeline assessment of onshore wind projects. The four future energy scenarios used in the DFES have reflected the range of possible timescales identified by stakeholders.
The majority of stakeholders thought that most future onshore wind capacity will tend to be medium-scale, i.e. between 10 and 50 MW, rather than either larger transmission network scale projects or smaller <10 MW wind projects.	We have modelled the onshore wind deployment in the DFES scenarios on the assumption that a significant proportion will be medium-scale.
Consultation with developers confirmed our understanding that projects are likely to be developed without subsidy support, unless in specific circumstances where CfDs have been secured.	The viability of subsidy-free business models justifies the increase in onshore wind in two of the scenarios, where policy and planning environment is supportive of onshore wind in England.
Direct engagement with pipeline project developers suggested that onshore wind development in Wales and Scotland was the focus in the near-term, but that all resource would be investigated in the longer term, if the planning regime was supportive.	Onshore wind takes longer to pick-up in England under all scenarios, with most development occurring from the late-2020s onward. This aligns with both stakeholder feedback and direct developer engagement.

References:

WPD connection offer data, DNO Embedded Capacity Registers, National Grid ESO TEC register, the Renewable Energy Planning Database, Climate Emergency declaration data, Regen consultation with local stakeholders and discussion with developers, Regen questionnaire and consultation with local authorities.

Offshore wind in the East Midlands licence area

Summary of modelling assumptions and results.

Technology specification:

Fixed-foundation offshore wind capacity connected to the distribution network.

This aligns to Building Block ID number Gen_BB014, which covers all offshore wind.

Data summary for marine energy in the East Midlands licence area:

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	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.
- Any future offshore wind capacity in the region would be anticipated to connect to the transmission network.

Results and assumptions:

Baseline (up to 31st March 2021)

- 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 in 2013, but was connected to the nearby transmission-connected Lincs Wind Farm.

Projections (April 2021 – March 2050)

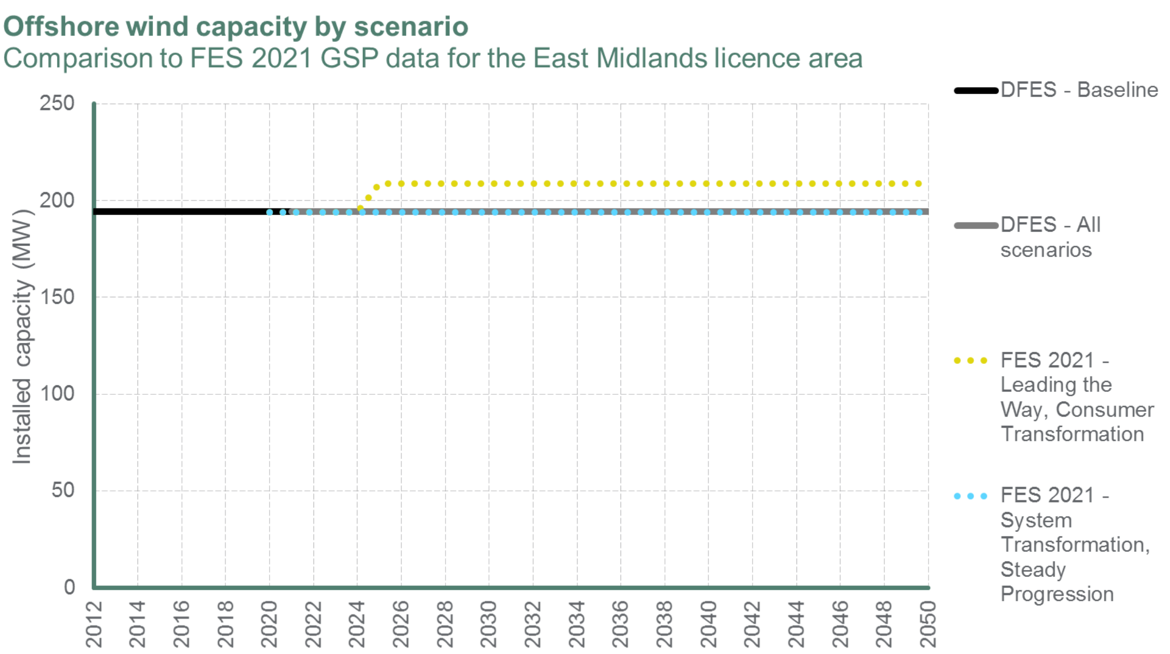
- There are no pipeline sites in this licence area with an accepted network connection offer, in planning, or discovered through additional desk-based research.
- Offshore wind projects are now being developed at much larger scales and ubiquitously connecting to the transmission network in England.
- As such, no new offshore wind capacity is projected to connect at distribution level in any scenario.

Reconciliation with National Grid FES 2021:

As no floating wind capacity is projected to connect in the licence area, these fixed-foundation offshore wind scenario projections have been directly reconciled to FES 2021 data at a GSP level for Building Block ID Gen_BB014.

- The WPD DFES 2021 projections for offshore wind in the East Midlands licence area is directly aligned with FES 2021 for **System Transformation** and **Steady Progression**.
- The FES 2021 data contains a 15 MW increase in capacity in 2026 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.

Figure 19



References:

WPD connections data, Renewable Energy Planning Database, desk-based research, National Grid TEC register, consultation with offshore wind developer.

Small-scale solar generation in the East Midlands licence area

Summary of modelling assumptions and results

Technology specification:

Solar generation sites of installed capacity less than 1 MW. This includes domestic-scale rooftop PV (<10 kW) and small-scale commercial PV (10 kW – 1 MW), which could consist of rooftop installations such as on warehouses, or small ground-mounted arrays.

This relates to the following building block:

- Solar generation: Small (G98/G83) – Building block Gen_BB013

Data summary for small-scale solar PV in the East Midlands licence area:

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	497	527	630	766	899	1,033	1,171
System Transformation		606	915	1,282	1,652	2,020	2,390
Consumer Transformation		756	1,395	2,109	2,829	3,570	4,322
Leading the Way		761	1,429	2,188	2,959	3,756	4,568

Summary:

- The East Midlands licence area saw high levels of small-scale solar deployment during the 2010s, as a result of the Feed-in Tariff support scheme.
- While deployment has stagnated over the last few years, a combination of falling installation costs, uptake of electric vehicles and an increasing requirement for renewable generation leads to renewed uptake of small-scale solar in all scenarios.
- By 2050, small-scale solar uptake reaches over nine times today's levels under **Consumer Transformation** and **Leading the Way**, and five times today's levels under **System Transformation**.
- For domestic-scale rooftop solar, under **Consumer Transformation** and **Leading the Way** this would equate to c. 35-40% of homes hosting an average-sized rooftop PV array. However, decreasing installation costs and improvements in panel efficiency are likely to increase average domestic rooftop PV capacities in the future. As such, the true proportion is likely to be slightly lower.

Modelling assumptions and results:

Baseline

- The East Midlands licence area currently has c. 92,000 grid-connected domestic-scale solar PV installations, representing almost 4% of homes, the second highest in WPD's four licence areas. This totals 303 MW, at an average of 3.3 kW per array.
- In addition, there are currently over 2,500 small-scale commercial solar PV sites, totalling 194 MW at an average of 75 kW per array.
- Almost all baseline solar PV was installed through the support of the Feed-in Tariff scheme, which ran from 2010 to 2019.
- The vast majority of historic development occurred between 2010 and 2015, when tariff payments were highest. Over 445 MW of capacity, 90% of the baseline, was deployed in the East Midlands licence area in these five years.
- Since the start of 2016, only 52 MW of small-scale solar PV capacity has connected to the East Midlands distribution network, following a reduction in the subsidy rate and subsequent closure of the Feed-in Tariff in 2019.
- The Smart Export Guarantee[23], launched in January 2020, provides revenue for small-scale low carbon generation exported to the grid, such as rooftop solar. However, rates are currently not lucrative enough to drive significant deployment.
- Additionally, the costs of rooftop solar installations have risen in the past year. This has been attributed to factors such as increased material costs and the Covid-19 pandemic.
- The small-scale solar baseline is marginally lower than the WPD DFES 2020 baseline. This is due to updated modelling excluding off-grid installations that do not interact with the distribution network.

Near-term (April 2021 to March 2024)

- There is minimal deployment in the early 2020s due to the challenging financial case for small-scale solar.
- There is a pipeline of 64 commercial solar sites, totalling 12 MW, which have accepted a grid connection offer, which are projected to connect between 2021 and 2024 in all net zero scenarios.
- Previous stakeholder engagement suggested that rooftop solar PV deployment on new-build housing is between 5%-10%. This range is reflected in the near-term projections across the scenarios.

Medium-term (April 2024 to March 2035)

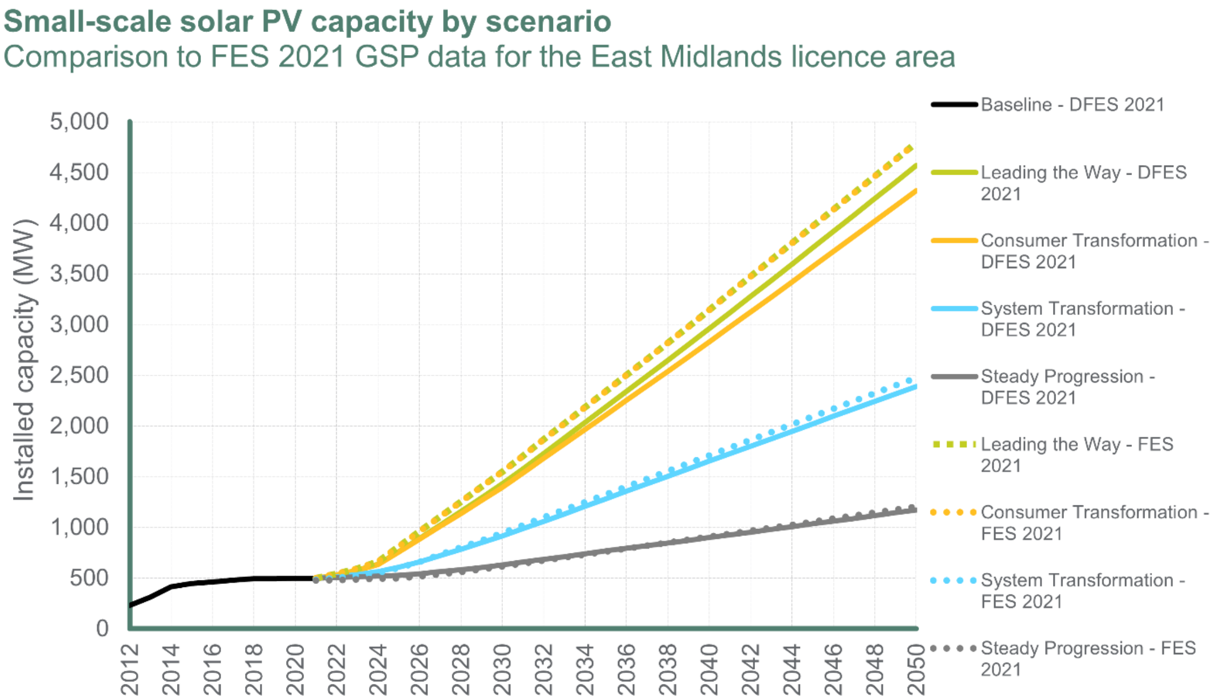
- Small-scale solar PV uptake accelerates from the mid-2020s in all scenarios. This is due to a combination of falling installation costs, and opportunities to increase self-consumption (such as through smart electric vehicle charging).
- Rooftop solar on new-build housing and commercial space is modelled to become more popular, especially under the net zero scenarios. This reflects falling costs, increased standards for new-build properties, and increasing green ambition from consumers.
- Under **Consumer Transformation** and **Leading the Way**, this is augmented by high levels of consumer engagement in smart electricity usage, Time of Use Tariffs, and green ambition.
    - This results in over 2.1 GW of small-scale solar PV connected in the East Midlands licence area by 2035, under these scenarios.
- In contrast, just 0.8 GW of small-scale solar is connected by 2035 under **Steady Progression**. This reflects lower uptake of low carbon technologies, smart tariffs, and less engaged consumers.

Long-term (April 2035 to March 2050)

- The trends established in the medium-term continue out to 2050.

- The uptake of small-scale solar PV is more than nine times the baseline under **Consumer Transformation** and **Leading the Way**, with small-scale solar forming a key part of reaching net zero under **Consumer Transformation** and **Leading the Way**. This represents rooftop solar PV on around 40% of dwellings if installations remain around 3 kW on average.

Figure 20



Reconciliation with National Grid FES 2021:

Results in this section relate to the FES 2021 data for the relevant GSPs within the East Midlands licence area.

- The FES 2021 and WPD DFES 2021 baselines align, with around 500 MW of capacity currently installed in the East Midlands licence area.
- Projections of small-scale solar PV in the WPD DFES 2021 are effectively in-line the FES 2021 projections at a GSP level.
- The DFES 2021 projections are based predominantly on underlying building stock and demographic factors, derived from stakeholder engagement and market insight.
    - The East Midlands licence area has lower than average levels of affluence (20.9% in social grade A/B[24], compared to 22.7% in GB) and social housing (15.9%, compared to 18.2% in GB) which have been identified as key uptake factors.
    - However, levels of home ownership and detached/semi-detached dwellings in the licence area, which are also significant uptake factors, are higher than the national average (66.6% and 65.3%, compared to 63.4% and 53.1% in GB respectively).
- These competing factors result in minimal net impact in the modelling. As a result, the DFES 2021 projections are broadly proportional to the number of homes in the licence area, which represents around 9% of GB homes.
- The East Midlands licence area hosts a similar proportion, around 11%, of the national small-scale solar PV baseline. This could be a factor in the FES 2021 projections being aligned with the DFES 2021 projections, however this is not definitively clear.

Factors that will affect deployment at a local level:

- The spatial distribution of new small-scale solar PV in the East Midlands licence area has been divided into domestic-scale (<10 kW) and commercial-scale (10 kW – 1 MW) solar PV.
- Domestic uptake is dictated by key factors, including tenure, EV ownership, affluence and building type. These factors, and the weighting thereof, were informed through engagement with local and regional stakeholders.
- In the near-term, uptake is weighted towards home ownership, EV ownership and affluence. In the longer term, uptake becomes more prevalent across all affluence levels, especially in **Leading the Way** and **Consumer Transformation**.
- New build housing is also a key influencer of local deployment. New housing developments are modelled specifically based on local planning data.

Relevant assumptions from National Grid FES 2021:

Assumption number	4.1.5 - Solar generation (plant smaller than 1MW)
Steady Progression	Slower pace of decarbonisation.
System Transformation	Transition to net zero results in strong growth in small solar. Supports production of hydrogen by electrolysis.
Consumer Transformation	Very high growth in small solar as it supports the transition to net zero and is highly aligned to the high societal change.
Leading the Way	Very high growth in small solar as it supports the transition to net zero and is highly aligned to the high societal change.

Stakeholder feedback overview:

Small-scale solar PV	
Your comments to us	Our response
Stakeholders identified home ownership, EV ownership and affluence as the key factors in rooftop solar installation in the near term.	We have weighted the distribution of rooftop solar capacity more towards these factors in the near-term years of the analysis.
Stakeholders noted that rooftop solar uptake is often influenced by planning regulations, especially in areas such as conservation zones.	Where possible, we have reflected conservation zones and other protected areas in the geographical distribution of rooftop solar PV and other domestic-scale technologies.
Stakeholders noted the potential for commercial rooftop PV to be deployed on more large commercial and industrial buildings such as warehouses.	When projecting the future distribution of rooftop PV across a licence area, our small-scale commercial PV modelling has considered the amount of various property types, including warehousing and sheds.

Stakeholders asked whether the potential reducing cost of domestic batteries in the future influences the uptake of domestic rooftop PV in our modelling.	The scenario framework assumes varying levels of complementary technology advancement and cost reduction of low carbon technologies. These work in tandem, with the scenarios with higher levels of low carbon technologies also featuring higher levels of rooftop PV. The modelling of domestic battery uptake is directly informed by the small-scale solar PV projections in the DFES.

References:

WPD connection offer data, Feed-in Tariff registers, BEIS solar photovoltaics deployment data, Climate Emergency declaration data, Regen consultation with local stakeholders and discussion with developers, Regen questionnaire and consultation with local authorities.

Large-scale solar generation in the East Midlands licence area

Summary of modelling assumptions and results

Technology specification:

Solar generation sites of installed capacity of 1 MW and above. This relates to the following building block:

- Solar generation: Large (G99) – Building block Gen_BB012

Data summary for large-scale solar PV in the East Midlands licence area:

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	1,094	1,385	2,407	2,953	3,153	3,350	3,546
System Transformation		1,680	2,778	3,737	4,246	4,696	5,187
Consumer Transformation		1,680	2,774	3,733	4,241	4,692	5,183
Leading the Way		2,211	4,093	4,709	5,462	6,106	6,176

Summary:

- The East Midlands has historically seen reasonably high levels of large-scale solar PV deployment, with over 1 GW of capacity connected over the past decade.
- However, this baseline is dwarfed by the extensive pipeline of new projects in various stages of planning. Despite not having irradiance levels as high as the South West or South East, developers have recently seen the Midlands as highly prospective owing to better network availability, areas of cheaper real estate and less competition from high-grade agricultural land.
- The East Midlands is likely to see continued development of solar PV throughout the coming decades to 2050. Solar PV already represents one of the cheapest forms of renewable electricity available, and is expected to further reduce in cost.
- Current business models are based around standalone solar farms, or pairing with co-located battery storage. In the future, solar PV could also potentially be co-located with hydrogen electrolysis.
- Under the four future energy scenarios, large-scale solar PV capacity in 2050 ranges from 2.7 GW under **Steady Progression**, around double existing capacity, to over 6 GW under **Leading the Way**, an almost six-fold increase in existing capacity.

Modelling assumptions and results:

Baseline

- There is a total of 1,094 MW of large-scale solar PV capacity connected in the East Midlands licence area, across 165 sites averaging 6.6 MW.
    - Around half this capacity is attributed to relatively small solar farms (1 MW to 10 MW), totalling 616 MW across 140 sites.
    - The 25 largest baseline sites host 478 MW of capacity between them. This includes four sites of 30 MW or greater, including Wymeswold Solar Farm, which was the largest solar farm in the UK when it was constructed in 2013.
- The vast majority of historic development occurred as a result of the FiT scheme, which supported up to 5 MW of solar PV capacity through tariff payments for generated electricity.
    - Over 943 MW of capacity was deployed between 2012 and 2016, at the height of FiT-supported solar development in the East Midlands. This includes a huge single-year deployment of 550 MW in 2015 alone.
    - Since the start of 2017, with the tapering and eventual closure of the FiT scheme, only 13 MW of large-scale solar PV capacity has connected to the East Midlands distribution network.

Near-term (April 2021 to March 2028)

Pipeline

- There are 116 pipeline sites with an accepted network connection offer, totalling 3,305 MW, with an average capacity of 28.5 MW. This is over four times bigger than a typical baseline site.
- Almost half the pipeline capacity, totalling 1,508 MW, comes from 27 very large sites of 49 MW capacity or greater.
- Analysis of historic solar farm development timescales, crosschecked against engagement with developers, suggests that solar farms typically take just a few months to attain planning permission. After being granted planning permission, solar farms typically become operational in less than 12 months.
- Every project in the pipeline was researched to ascertain the current planning status. This, alongside the length of time since the connection offer was accepted and the scale of the project, was used to determine when the project goes ahead in each scenario. This was supported by direct engagement with project developers.
- The pipeline consists of projects across all stages of development, from imminent construction to not yet having entered the planning system:

Granted planning permission	706 MW across 27 sites
Planning application submitted	655 MW across 16 sites
In pre-planning, with evidence of developments such as seeking a screening opinion from the local planning authority, or conducting a public consultation	709 MW across 17 sites
No evidence found through desk research. These sites are assumed to mainly be in the early stages of pre-planning development	1,136 MW across 51 sites
Rejected or withdrawn in planning, or abandoned by the developer	100 MW across 5 sites

- Under **Leading the Way**, it is assumed that all pipeline sites are built out, with the exception of sites that have been rejected in or withdrawn from in planning, or abandoned.
  - This results in projects with planning permission, in planning, or in advanced stages of pre-planning, connecting before 2028. This represents around two-thirds of the pipeline, totalling 2,073 MW.
- Under **Consumer Transformation**, **System Transformation** and **Steady Progression**, only sites that have progressed to submission of a planning application, or have already attained planning permission, have been reflected directly in the modelling.
  - This is key to ensuring that the future energy scenarios for large-scale solar PV reflect not just current headroom on the distribution network, but also where solar developers may look to deploy capacity in the future.
  - Under **Consumer Transformation** and **System Transformation**, this results in 1,374 MW of new large-scale solar PV capacity being built between 2022 and 2028.
  - Under **Steady Progression**, this results in 773 MW of new large-scale solar PV capacity in this timeframe.
- Most stakeholders felt that large-scale solar PV deployment would start picking up from 2025 onwards. However, a significant number felt that development could occur earlier, from 2023. This range of possible near-term outcomes is reflected in the scenarios.

Business models

- There are a number of near-term uncertainties that may make or break emerging solar PV business models. The size of the pipeline, in terms of capacity, reflects the upper range of potentially rapid solar farm development in the near-term. However, the stagnation over recent years could linger in some conditions. Key near-term aspects considered are:
  - **Engineering, procurement and construction** (EPC) costs for utility-scale solar farms. These costs have trended rapidly downwards over recent years, enabling merchant solar PV to become more viable. However, the trend has been bucked in 2021, with increasing prices of raw materials for solar modules increasing EPC costs for the first time in many years.
  - **Routes to market** for new solar farms. While there are various routes to market being explored, including corporate power purchase agreements (PPAs), private wires and potential Contract for Difference (CfD) auctions, merchant business models appear to be the intended route to market for the majority of pipeline solar PV capacity.
  - **Economies of scale.** As evidenced by the pipeline, the most viable merchant solar projects are large-scale, sometimes upwards of 50 MW, taking advantage of economies of scale to drive down the levelised costs of electricity produced. As a result, in the pipeline analysis, it has been assumed that larger projects progress sooner, including through planning. This is reflected in the analysis of pipeline projects, with larger-scale projects typically being further through the planning process than similarly aged smaller projects.
  - **Co-located solar and battery storage** features in a significant number of pipeline projects, providing an element of risk-sharing against merchant solar risk and opening up energy storage revenue streams for the project.
  - **The impact of Ofgem's minded-to decision on the Significant Charging Review**, which if implemented from April 2023 as proposed, would likely result in reduced network charges for assets connecting to the distribution network, such as large-scale solar generation. This could result in a tipping point for project viability in some cases.

Medium-term (April 2028 to March 2035)

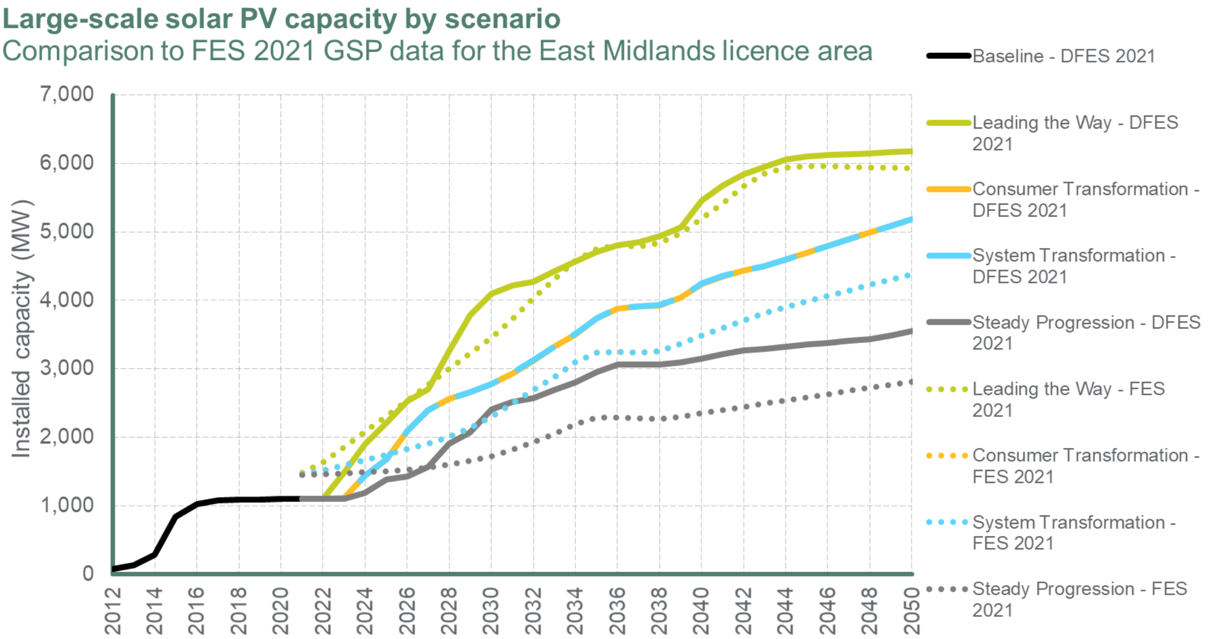
- The capacity of solar PV deployed in each scenario, and the distribution of this new capacity, varies significantly by scenario.

- Future solar capacity in the licence area has been modelled using a resource assessment, reflecting criteria used by developers to locate suitable sites for large-scale solar PV deployment. This includes, but is not limited to:
    - Land that is proximal to the existing distribution network, based on analysis of existing sites to determine maximum viable connection cable distances.
    - Land that is flat or with a south-facing aspect.
    - Agricultural land grades, focussing on lower value Grade 3-5 agricultural land
    - Exclusion of built-up areas
    - Exclusion of protected areas, such as National Parks and AONBs.
    - Exclusion of flood zones
    - Levels of solar irradiance.
- Under **Leading the Way**, less advanced pipeline projects (namely projects that have not yet applied for planning permission) are modelled to connect throughout the late 2020s and early 2030s.
    - This results in a total of 4.7 GW of large-scale solar PV capacity connected by 2035 under this scenario.
- Under **System Transformation** and **Consumer Transformation**, deployment of large-scale solar PV continues at the rate seen in the near-term.
    - This results in a total of c. 3.7 GW of large-scale solar PV capacity connected by 2035 under this scenario.
- Under **Steady Progression**, while deployment of large-scale solar PV is limited, the East Midlands licence area hosts c. 3 GW of capacity by 2035.

Long-term (April 2035 to March 2050)

- Large-scale solar PV continues to be deployed in the long term, as one of the cheapest forms of low carbon electricity generation.
- At very high levels of solar deployment, seen under **Leading the Way** in the long term, self-cannibalisation could threaten the capture prices of solar PV generation.
    - This is where high levels of simultaneous generation by solar PV, especially on sunny summer days when demand is low and generation is high, leads to oversupply of electricity and low or even negative electricity prices.
    - This contributes to a deceleration of solar deployment from the mid-2040s onwards in this scenario.
- However, the threat of self-cannibalisation is mitigated by:
    - Co-location with electricity storage to defer exports to more profitable times of peak demand.
    - Potential co-location with hydrogen electrolysis to convert low value solar PV output into high value green hydrogen.
    - Demand increasing to match periods of high renewable generation, such as through smart EV chargers, smart appliances, and Time of Use Tariffs.
- Additionally, repowering of solar farms at the end of their operational life could result in an increase in solar PV capacity at existing baseline sites in the three net zero scenarios.
    - Current solar modules have around twice the power density (in terms of Watts per square meter), as modules deployed during the 2010s. Existing sites could therefore be repowered to higher capacities, and higher capacity factors, without changing the site layout or number of panels, simply through replacement with higher efficiency modules.
    - However, it could be more profitable to simply extend the life of baseline sites, rather than incur the capital costs of replacing the solar modules.
- As a result, a range of outcomes has been modelled, ranging from repowering at 150% capacity under **Leading the Way** to no capacity increase under **Steady Progression**.
- By 2050, large-scale solar PV capacity reaches over 6.2 GW under **Leading the Way**, approximately six times the baseline capacity. This compares to 3.5 GW under **Steady Progression**, still over three times the baseline capacity.

Figure 21



Reconciliation with National Grid FES 2021:

Results in this section relate to the FES 2021 data for the relevant GSPs within the East Midlands licence area.

- The FES 2021 baseline for the East Midlands licence area is significantly higher than the DFES 2021 baseline (by around 35%). The reason for this discrepancy is unclear. Previously, the DFES and FES baselines were consistent, totalling around 1,100 MW in capacity.
- In the near term, the DFES evaluates pipeline projects with an accepted connection agreement. This results in faster capacity increase in the DFES compared to the FES 2021 in the near term, as there is an extensive number of pipeline projects in all stages of planning. As a result, the DFES projections increase ahead of the FES 2021 projections in all scenarios throughout the 2020s.
- Beyond the pipeline period, the DFES 2021 projections are consistently in-line with the FES 2021 GSP-level data. This reflects similarities in how future development of large-scale solar PV capacity has been assessed at a regional level, specifically:
  - In the FES 2021: “Our solar spatial forecast is designed to reflect the fact that as solar installed capacity increases it will spread more evenly across the country. Today solar is most prevalent in the South and East of England.”
  - In the DFES 2021: A resource assessment of large-scale solar PV resource has been utilised to guide medium-term and long-term projections. This reflects land with good potential for solar PV deployment, with a relatively minor weighting towards areas with higher irradiance in the south of GB.

Factors that will affect deployment at a local level:

- Near-term distribution of new solar PV capacity is dictated by the exact location of pipeline sites.
- Beyond the pipeline of accepted connections, new large-scale solar PV capacity is distributed based on Regen’s large-scale solar PV resource assessment. This considers irradiance, designated land areas, physical constraints, network proximity, ground slope and aspect.

- Modelled repowering of solar farms in the long-term results in new capacity at existing baseline sites.
- Each local authority's planning history is assessed to augment the solar resource assessment. Local policies, identified by stakeholders, are also included as positive weightings within the spatial distribution.

Relevant assumptions from National Grid FES 2021:

Assumption number	4.2.15 – Solar generation (plant greater than 1 MW)
Steady Progression	Slower pace of decarbonisation.
System Transformation	Transition to net zero results in strong growth in large solar.
Consumer Transformation	Transition to net zero results in strong growth in large solar.
Leading the Way	Very high ambition to decarbonise drives a focus on technologies that are low carbon. Supports production of hydrogen by electrolysis.

Stakeholder feedback overview:

Large-scale solar PV	
Your comments to us	Our response
The majority of stakeholders thought the pipeline of new solar projects would begin connecting within the next 3-5 years, but some responses suggested the later 2020s.	After confirmation with solar developers, we have used the engagement from all four webinars to guide the logic and assumptions we have applied to assessing the pipeline of solar PV projects. The four future energy scenarios should broadly reflect the range of possible timescales identified by stakeholders.
When asked why the solar PV pipeline was particularly large in the Midlands, rather than the South West where development has historically been focussed, stakeholders identified the proximity to energy demand and lower cost of land as the likely drivers.	We have considered these aspects as major distribution factors in the modelling. The distribution of solar PV uses Regen's in-house solar resource assessment, which accounts for these (and various other) factors. The weighting of irradiance in the solar resource assessment is now minimal.

References:

WPD connection offer data, DNO Embedded Capacity Registers, National Grid ESO TEC register, the Renewable Energy Planning Database, Climate Emergency declaration data, Regen consultation with local stakeholders and discussion with developers, Regen questionnaire and consultation with local authorities.

Hydropower in the East Midlands licence area

Summary of modelling assumptions and results

Technology specification:

This analysis covers any hydropower generation connecting to the distribution network in the East Midlands licence area, excluding pumped hydro storage. Includes a comparison to FES 2021 data, as reported for Building Block ID number Gen_BB018.

Data summary for hydropower in the East Midlands licence area:

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	5	5	5	5	6	6	6
System Transformation		6	6	6	6	6	6
Consumer Transformation		6	6	7	7	8	8
Leading the Way		6	6	6	6	6	6

Summary:

- The East Midlands licence area has a number of existing sites, comprising 19 sites less than 1 MW and a single large-scale site of 3.7 MW.
- There are two small-scale sites (totalling 136 kW) in the pipeline with an accepted connection offer, each less than 100 kW.
- Consultation with stakeholders suggests low deployment beyond the pipeline in the near term in all scenarios, due to current high development costs and challenges of planning and siting of new hydropower developments.
- **Consumer Transformation** sees the highest level of hydropower deployment, particularly after 2030, in line with the FES 2021.

Modelling assumptions and results:

Baseline (up to 31st March 2021)

- There is 5.4 MW of installed and operational hydropower capacity in the East Midlands licence area. The largest site (3.7 MW) is at Chatsworth House in the Peak District National Park. This site was first installed in the late 19th century and was repowered in 2017.
- The WPD connection data has been supplemented with 11 sites identified that are accredited under the FiT and ROC schemes, totalling 567 kW.

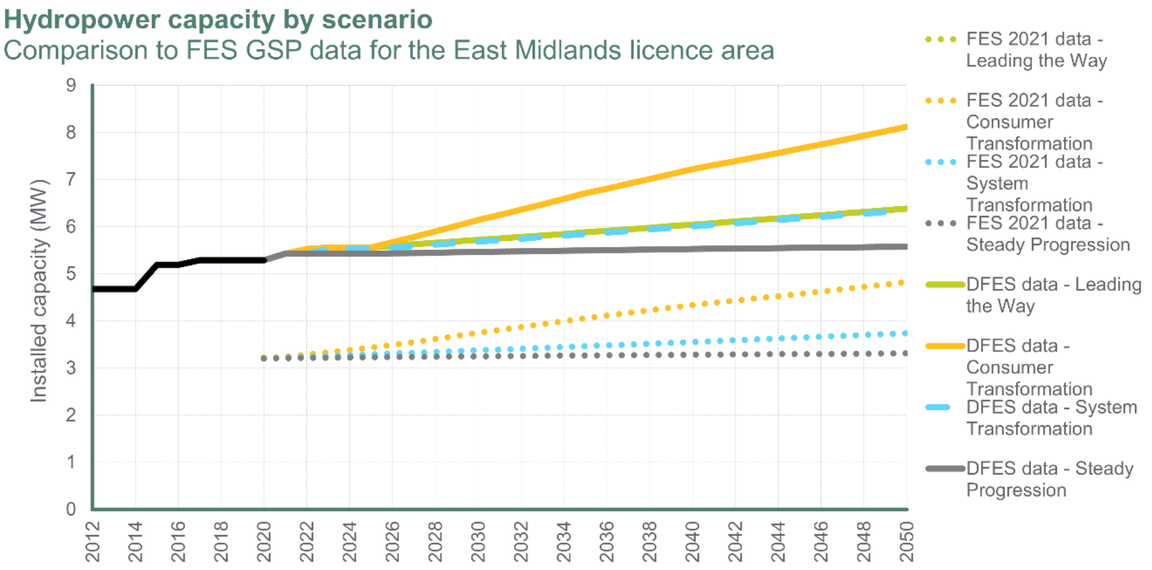
Near term (April 2021 – March 2025)

- There are two small-scale hydropower schemes that have accepted a connection offer that may connect in the near term as at a combined capacity of 136 kW. It is expected to take between three and five years from accepting a connection agreement to become operational under **Leading the Way** and **Consumer Transformation**, based on the development timescales of existing hydropower sites.

Medium to long term (April 2025 – March 2050)

- Further deployment is modelled to occur across all scenarios, although this is expected to be limited to the pipeline in the near term.
- In the medium and long term, additional capacity of between 0.2 MW and 2.8 MW is installed, based on historic deployment rates.
- The civil infrastructure installed for existing sites tends to be long lasting, meaning that sites can be expected to repower when the machinery reaches the end of its useable life. Where sites need to repower, it has been assumed that they repower at the same capacity: as a mature technology, hydropower has limited cost reduction potential.
- Sites are likely to be limited to onsite generation, private wire connections or through developments where wider objectives override the need for return on investment, for example sites with a link to tourism, heritage, or corporate sustainability objectives.

Figure 22



Reconciliation with National Grid FES 2021:

Results in this section relate to the FES 2021 data as reported for Building Block ID number Gen_BB018.

- The current installed capacity of hydropower in the East Midlands licence area is larger in the WPD DFES 2021 data than in FES 2021. Further work is needed to understand the differences in data for small-scale generation at a licence area level.
- The near-term projections capture only the baseline and pipeline capacity identified. This captures the expectation that hydropower sites typically take between three and five years to become operational.
- Relative to their respective baselines, the WPD DFES 2021 projections have followed the FES 2021 national trend in hydropower deployment in each scenario from 2025. This analysis was then supplemented with a hydropower resource assessment.

Factors that will affect deployment at a local level:

- The distribution of new hydropower capacity is based on the indicative location of rivers, dams and reservoirs that could potentially host a hydropower site, as well as the microgeneration sites in the pipeline.
- The analysis considers the maximum head and thus the potential power capacity of bodies of water across England and Wales.

Relevant assumptions from National Grid FES 2021:

Assumption number	4.1.2 - Other renewables including marine and hydro generation
Steady Progression	Low support and therefore other renewables cannot compete with low cost solar and wind generation.
System Transformation	Support for large-scale renewable technologies (i.e., tidal marine).
Consumer Transformation	Potential for many small-scale projects that will have larger societal impact coupled with support for marine technologies across all scales.
Leading the Way	Focus on rapid decarbonisation results in prioritising renewables that are available at lowest cost today (i.e., solar and wind). Innovation in other flexible solutions results in less need for a wide range of renewables.

References:

WPD connection offer data, the Feed-in-Tariff database, Renewable Obligations Certificates database, the Environment Agency, the Renewable Energy Planning Database, Regen consultation with local stakeholders and discussion with developers.

Biomass generation in the East Midlands licence area

Summary of modelling assumptions and results

Technology specification:

Biomass generation – including biomass for power generation and biomass CHP. Excludes biomass used solely for heat, and bioenergy with carbon capture and storage. The common feedstocks for biomass generation in the UK are plants, such as corn and soy, and wood, in the form of straw or wood chips.

This technology pertains to Building Block ID number Gen_BB010 in the FES 2021 data.

Data summary for biomass generation (including CHP) in the East Midlands licence area:

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	117	137	153	153	153	153	153
System Transformation		137	153	127	127	62	50
Consumer Transformation		137	112	112	47	35	17
Leading the Way		137	112	112	47	35	17

Summary:

- In **Leading the Way**, **Consumer Transformation** and **System Transformation**, there are significant capacity reductions between 2040 and 2050 in biomass used for power generation. This is due to existing large-scale sites coming offline, which are not replaced due to competition for sustainable feedstocks.
- BECCS is expected to be the largest use of feedstocks in the long term, but this is assumed to connect at transmission level.
- Smaller scale biomass generation sites, such as those that have local feedstock supply chains and/or provide heat as well as power, are assumed to continue generating out to 2050 in all scenarios.

Modelling assumptions and results:

Baseline (up to 31st March 2021)

- There are 15 biomass sites operational in the East Midlands licence area, totalling 117 MW of power generation capacity.
- The largest of these is Sleaford Renewable Energy Plant in Kirkby la Thorpe (45 MW), which connected in 2013. This plant generates electricity through the combustion of straw.
- There are seven sites over 1 MW and eight below 1 MW, with the smallest operational site having 70 kW capacity (2020).
- Over 85% of all operational sites connected in the 2010s.

Near term (April 2021 – March 2025)

- There are five sites with an accepted connection agreement, totalling 36 MW.
- Two of these sites have planning permission granted (one in 2011 and one in 2018).
- Based on analysis of REPD, historically biomass projects take 3.4 years from gaining planning permission to become operational. As a result, these two projects connect between 2022 and 2025, depending on the scenario.
- The remaining three sites have no planning information.
- Historically, about 50% of biomass planning applications in the East Midlands licence area have received planning permission, with 40% progressing to be operational. Hence, these sites are only modelled to connect under **System Transformation** and **Steady Progression**.

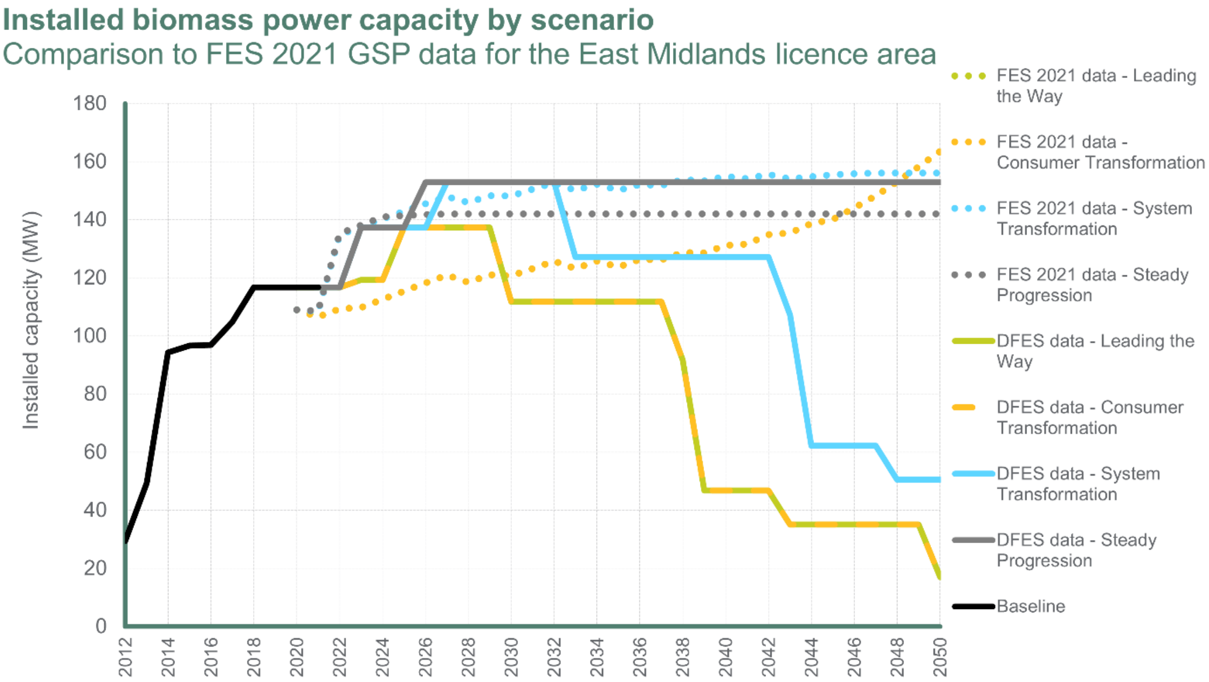
Medium term (April 2025 – March 2035)

- In the net zero compliant scenarios, biomass fuel sources are assumed to be prioritised for other uses such as in increased carbon sinks and for use in construction. This reflects the recommendations from the Committee on Climate Change in their report 'Biomass in a low-carbon economy'[25].
- As a result, transmission scale BECCS is prioritised over large scale distributed biomass generation sites. Carbon capture technology is also considered to only be economically viable for transmission scale assets.
- The lifetime of any plant is uncertain; however, a new biomass plant is likely to be operational for between 20 and 30 years, according to the Centre for Climate and Energy Decision Making[26].
- Under **Leading the Way** and **Consumer Transformation**, this is modelled as 25 years, while **System Transformation** assumes a 30-year operational life. Site capacity is not modelled to disconnect before 2050 under **Steady Progression**.
- Sites are not modelled to disconnect before 2030 under any scenario. This reflects conservative assumptions around network connections on the distribution network, and that WPD currently have no mechanism to be able to reclaim capacity from existing customers held in existing connection agreements.
- Smaller scale biomass generation sites, such as those that have local feedstock supply chains and/or provide heat as well as power, are assumed to continue generating out to 2050 in all scenarios.

Long term (April 2035 – March 2050)

- It is assumed that only small-scale biomass generation continues to operate in the long term, with large scale sites prioritised for BECCS. This is assumed to be connected at the transmission level.

Figure 23



Reconciliation with National Grid FES 2021:

Results in this section relate to the FES 2021 data as reported for the Building Block ID number Gen_BB010.

- In the near term WPD DFES 2021 projections are in line with FES 2021, with the pipeline of potential projects assumed to be built successfully under all scenarios.
- In the medium and long term however, the WPD DFES 2021 projections are below FES 2021 for all scenarios except **Steady Progression**. This reflects the assumption that plants decommission at the end of their operational lifetime and are not repowered. In these cases, it is assumed that the feedstocks are prioritised for other applications, namely BECCS.
- The WPD DFES 2021 have followed national FES trends for distributed biomass generation capacity, reflecting the assumption that CCS and BECCS technology will connect at the transmission level. This results in a decline in biomass generation capacity across all net zero compliant scenarios.
- It is not clear why the GSP-level projections for the East Midlands are so different to the national FES trends, and WPD DFES 2021 has taken the decision to follow national trends instead.
- The limited number of sites in the baseline results in larger 'step' changes in capacity in the WPD DFES projections, in comparison to the FES 2021, as single sites reach the end of their assumed operational life and disconnect.

Factors that affect deployment at a local level:

The spatial distribution of biomass generation is based on the location of existing baseline and pipeline sites connecting to the distribution network in the East Midlands licence area.

Relevant assumptions from National Grid FES 2021:

Assumption number	4.1.13 - Biomass and Energy from Waste (EfW) generation with CCUS
Steady Progression	Limited support for BECCS due to less of a drive to decarbonise and slowest deployment of CCUS. Some growth in decentralised biomass without CCUS.
System Transformation	High growth driven by the decarbonisation agenda. Linked to CCUS as this results in negative emissions.
Consumer Transformation	High growth driven by the decarbonisation agenda. Linked to CCUS as this results in negative emissions.
Leading the Way	Uptake driven by the decarbonisation agenda. Linked to CCUS as this results in negative emissions.

References:

WPD connection offer data, the Renewable Energy Planning Database, Regen consultation with local stakeholders and sector representatives, the CCC.

Renewable engines (landfill gas, sewage gas, biogas) in the East Midlands licence area

Summary of modelling assumptions and results for anaerobic digestion

Technology specification:

Installed capacity of biogas renewable engines, using biomethane for electricity generation only. This is the 'biogas' component of the building block technology "Renewable engines (landfill, sewage, biogas)" under Building Block ID number Gen_BB004 in the FES 2021 data and is referred to as Anaerobic Digestion (AD) in the WPD DFES 2021.

Data summary for Anaerobic Digestion in the East Midlands licence area:

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	43	43	46	47	48	49	50
System Transformation		44	56	68	71	73	75
Consumer Transformation		44	66	96	107	113	119
Leading the Way		44	67	97	110	124	137

Summary:

- The East Midlands licence area has 43 MW of operational AD capacity.
- Further deployment of AD plants requires sufficient local feedstock either from agricultural or food waste.
- There are two pipeline sites with an accepted connection agreement, with a total capacity of 1 MW. Neither of these have planning information, so they are only modelled to connect in the net zero compliant scenarios.
- Additional capacity could be developed to produce biomethane for use in transport or injection into the gas network, rather than burnt for electricity generation. These competing business models makes for an uncertain future for AD, and results in a range of future projections under the four scenarios.

Modelling assumptions and results:

Baseline (up to 31st March 2021)

- There are 33 operational AD sites connected to the distribution network in the East Midlands licence area, totalling 42.7 MW.
- The largest of these is a 4 MW site in Colwick that connected in 2014.
- The most recent connection was a 45 kW site in December 2018.

Near term (April 2021 – March 2025)

- Despite challenges due to the COVID-19 pandemic, the UK AD sector grew by 11% in the year to April 2021[27].
- There are two pipeline sites with an accepted connection agreement, with a total capacity of 1 MW, both at Wormslade farm.

- Neither of these have planning information, so they are only modelled to connect in the net zero compliant scenarios.
- Based on analysis of REPD, historically AD projects take 2.7 years from submitting a planning application to becoming operational. As a result, these sites connect between 2024 and 2026, depending on the scenario.

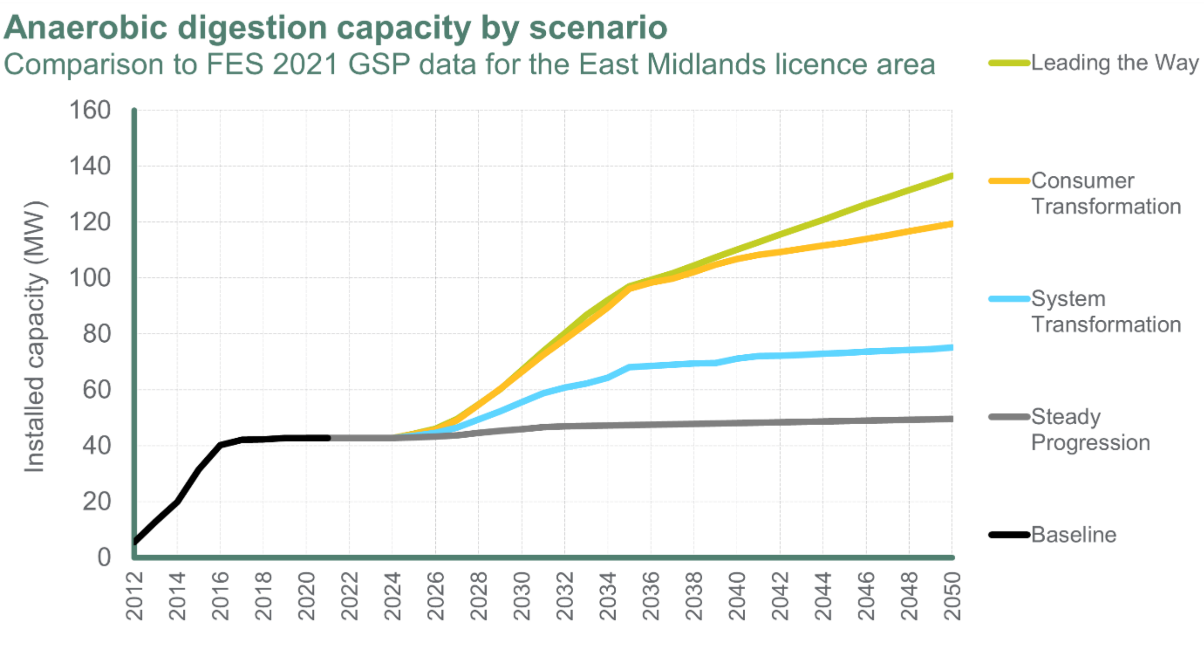
Medium term (April 2025 – March 2035)

- There is scope for an increase in the availability of household food waste as a feedstock in the near term, as currently only c. 22% of the East Midlands licence area is covered by a food waste collection scheme.
- Considering the government's commitment to roll out separate household food waste collection across the country by 2023[28], there could be an increase in feedstock in the mid-2020s. This feedstock is unlikely to significantly increase post-2025.
- Increases in AD capacity are likely to be driven by farm-based AD. The East Midlands has an above-average amount of high-grade agricultural land (ALC 1&2[29]), hence there is good potential for future growth in AD capacity.
- The removal of government support mechanisms for electricity generation from biomethane, and implementation of the Green Gas Support Scheme (designed to accelerate the decarbonisation of the gas grid), is likely to improve the business case for AD plants to sell their biomethane – dampening growth in biomethane-fuelled electrical capacity in the mid-term across the three net zero scenarios.
- Deployment of capacity is very limited under **Steady Progression**, due to an assumed lack of incentives for biomethane production and a focus on its use for gas-to-grid.

Long term (April 2035 – March 2050)

- The main sources of AD feedstock are food waste, agricultural waste, such as crop waste and manure, and energy crops. These are all under risk of depleting in the long term, with changes to land use and societal shifts (per person food waste is assumed to decrease towards 2050); however, this is still uncertain.
- Through stakeholder engagement, it was concluded that deployment of AD plants for electricity generation is expected to remain low in the long term, although there is still likely to be deployment on rural farms, as currently only 3% of agricultural waste produced in the UK annual is used to fuel AD plants.
- Under **System Transformation**, government may focus incentives for biomethane on gas-to-grid injection rather than power generation. Under this scenario, it is assumed that the electricity grid is decarbonised by other renewable technologies, including large-scale BECCS.
- Significant increases in electricity generation capacity from AD are most likely to occur in high-renewables scenarios, notably **Leading the Way** and **Consumer Transformation**, focussing on burning biomethane as a form of dispatchable flexible generation. Operators would be able to capture high electricity prices in periods of low renewable generation or high demand.
- Under these scenarios, improvements in engine technology are also likely to reduce the overall cost of projects, meaning operators are less reliant on subsidies.
- **Steady Progression** has limited deployment across the projection period, representing a lack of incentives for biomethane production and a focus on its use for gas-to-grid.

Figure 24



Factors that will affect deployment at a local level:

- The location of all new capacity out to 2025 is based on the existing pipeline sites with an accepted grid connection offer. After this pipeline deployment, local factors have been used to weight projections from 2025 onwards, such as:
    - agricultural land grades 1 & 2, relative to the GB average
    - food waste collection potential by local authority
    - anaerobic digestion resource assessment, which considers the energy generation potential from manure (including waste from poultry, cattle and pigs, but excluding sheep).

Stakeholder engagement:

As part of the WPD DFES stakeholder engagement process, Regen delivered a series of webinars with WPD in June 2021. In the webinars, the long-term role of distribution-scale bioenergy electricity generation was considered. 81% of respondents thought that these sites would have a similar or expanded role to bioenergy electricity generation today. This feedback has directly influenced the WPD DFES 2021 analysis for all licence areas, by confirming the focus on anaerobic digestion as a form of low carbon, dispatchable, flexible electricity generation.

Summary of modelling assumptions and results for landfill gas.

Technology specification:

Landfill gas installed capacity used for electricity generation only.

Data summary for landfill gas in the East Midlands licence area:

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	133	133	133	133	133	133	133
System Transformation		133	133	133	127	90	56
Consumer Transformation		133	133	133	127	90	56
Leading the Way		133	133	133	90	56	23

Summary:

- Landfill gas capacity for electricity generation is expected to decline over time in all net zero compliant scenarios, based on the assumption that society transitions towards a low/zero waste lifestyle.
- Baseline sites are modelled to decommission in line with scenario specific operational lifetimes.

Modelling assumptions and results:

Baseline (up to 31st March 2021)

- There are 75 operational sites connected to the distribution network in the East Midlands licence area, totalling 133 MW.
- The largest site is the 17.9 MW Calvert landfill site in Buckinghamshire.
- There are 46 sites above 1 MW in size.
- The most recent site to connect was a 9 MW site in 2019.

Near term (April 2021 – March 2025)

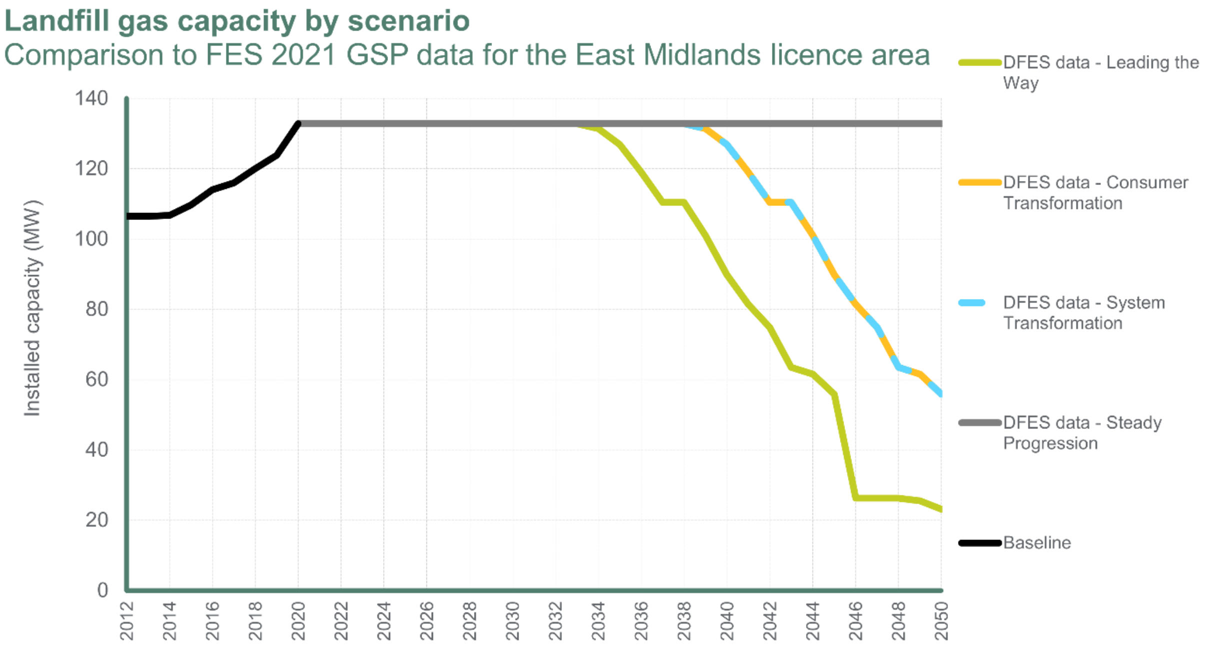
There are no sites with an accepted connection agreement in the WPD connection data in the East Midlands licence area. Hence, there is no change in capacity projected in the near term.

Medium and long term (April 2025 – March 2050)

- Electricity generation from landfill gas is at odds with net zero targets, due to the level of associated carbon emissions. Hence, it is assumed that capacity reduces after 2030 in **Leading the Way**, **Consumer Transformation** and **System Transformation**, as older facilities reach the end of their operational lifetime.
- Although there is likely to be a gradual decline in waste resources in the net zero compliant scenarios, it is assumed that sites will not disconnect until the end of their operational life.
- In **Leading the Way**, sites are modelled to have a 35-year operational lifetime, while the operational life under **Consumer Transformation** and **System Transformation** is modelled to be 40 years.

- To ensure DFES captures the near-term worst-case conditions on the distribution network within the scenarios, sites have been modelled to remain connected in **Steady Progression**, even if it is projected that they may cease operation or reduce operational hours.

Figure 25



Factors affecting deployment at a local level

The spatial distribution of landfill gas capacity is based on the location of existing baseline and pipeline sites connecting to the distribution network in the East Midlands licence area.

Summary of modelling assumptions and results for sewage gas.

Technology specification:

Sewage gas installed capacity used for electricity generation only.

Data summary for sewage gas in the East Midlands licence area:

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	9	9	4	4	0	0	0
System Transformation		9	9	6	4	4	0
Consumer Transformation		9	9	9	9	9	9
Leading the Way		9	9	9	9	9	9

Summary:

- There are currently no pipeline sites in the East Midlands for sewage gas, hence future deployment is limited.
- There is no increase in distribution connected sewage gas capacity in the East Midlands under any scenario, due to industry feedback that sewage gas for gas to grid injection is the favoured future business model.
- Any increase in sewage sludge resource, either due to the tightening of environmental permits or an increase in population, is expected to be used for gas-to-grid rather than electricity generation.
- **System Transformation** and **Steady Progression** represent future scenarios in which sewage sludge resource is prioritised for other low carbon options.

Modelling assumptions and results:

Baseline (up to 31st March 2021)

- There are eight operational sewage gas sites connected to the distribution network in the East Midlands licence area, totalling 8.7 MW.
- The largest baseline site is a 3 MW sewage gas site in Canwick, which connected in 1997.
- The most recent site to connect was an 800 kW site in 2015.

Near term (April 2021 – March 2025)

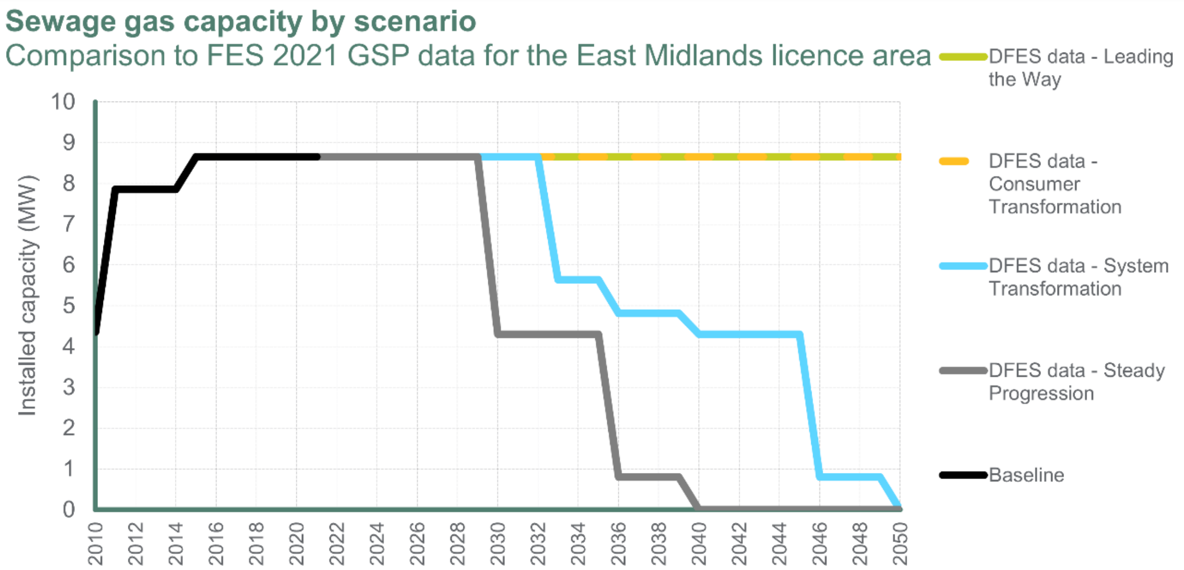
- There is no change projected in the output capacity or connections out to 2025.

Medium to long term (April 2025 – March 2050)

- There is no additional capacity projected under **Consumer Transformation** or **Leading the Way**, while capacity reduces under **System Transformation** and **Steady Progression**.
- This is due to industry feedback on the future of sewage gas, highlighting that any increase in capacity in sewage gas sites will likely be for gas to grid injection, biomethane production or bio-hydrogen production ahead of electricity generation, due to:

- the larger decarbonisation impact
- the expiration of ROCs and minimal activity in the CfD programme, which may make electricity generation from sewage gas less attractive
- support for green gas production, such as through the green gas levy, which may result in a decline for electricity generation in **System Transformation** and **Steady Progression**
- prioritisation of the decarbonisation of heat and transport via 'green gas'.

Figure 26

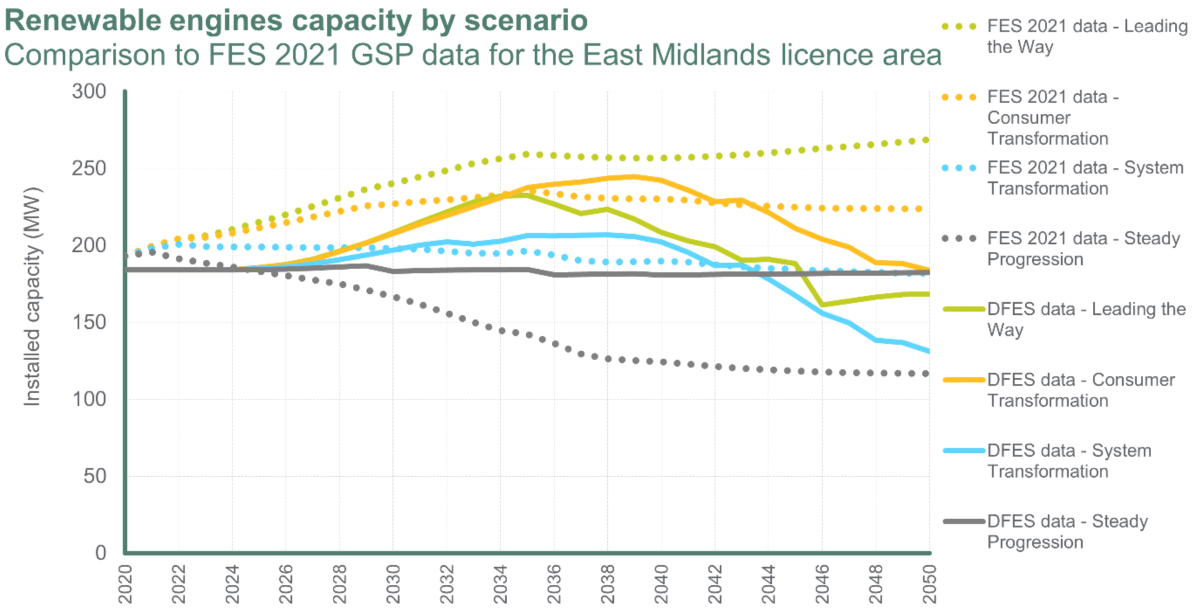


Factors affecting deployment at a local level

The spatial distribution of sewage gas capacity is based on the location of existing baseline and pipeline sites connecting to the distribution network in the East Midlands licence area.

Summary of anaerobic digestion, landfill gas and sewage gas compared to the FES 2021 'Renewable engines (landfill, sewage, biogas)' building block.

Figure 27



Reconciliation with National Grid FES 2021:

Results in this section relate to the FES 2021 data as reported for the Building Block ID number Gen_BB004.

- The increase in renewable engines capacity in the East Midlands licence area in the medium term comes primarily from an increase in anaerobic digestion capacity as landfill gas and sewage gas capacity remains constant or decreases over time.
- In the long term, the trend is dominated by landfill gas capacity coming offline, which results in a decrease in overall renewable engines capacity in the WPD DFES 2021.
- The WPD DFES 2021 projections are generally below FES 2021 under **Leading the Way**, **Consumer Transformation** and **System Transformation**, as it has been assumed that the landfill gas sites are disconnected after an operational life of 35 – 40 years, due to a reduction in available waste resource.
- The long-term maximum capacity of renewable engines is based on assumed declining levels of waste production. Additional deployment in this sector is expected to be focussed on gas to grid biomethane injection rather than electricity generation, which is not in the scope of WPD DFES 2021.

Relevant assumptions from National Grid FES 2021:

Assumption number	1.1.5 - Support: incentive regime for biomethane (and other ‘green gas’) production.
Steady Progression	Support is focussed on areas with greater potential volumes (UKCS/shale).
System Transformation	Bigger push for renewable gas as required to meet longer term decarbonisation targets.
Consumer Transformation	Bigger push for renewable gas as required to meet longer term decarbonisation targets.
Leading the Way	All sources of renewable fuels encouraged and biomethane used in niche areas in transport/industry.

References:

WPD connection offer data, local authority food waste collection status, Regen resource assessment, land grade statistics, water sector representatives, the Renewable Energy Planning Database, Regen consultation with local stakeholders and discussion with developers.

Fossil gas-fired power generation in the East Midlands licence area

Summary of modelling assumptions and results

Technology specification:

Fossil gas-fired power generation connected to the distribution network, covering four known fossil gas generation technology types:

- Close cycle gas turbines (CCGT) – Building block Gen_BB009
- Open cycle gas turbines (OCGT) – Building block Gen_BB008
- Gas reciprocating engines – Building block Gen_BB006
- Gas combined heat and power plants (gas CHP) – Building block Gen_BB001

The analysis does not include back-up gas CHPs or engines located on some commercial and industrial sites that only operate when mains supply failure occurs and do not export.

Data summary for fossil gas-fired power in the East Midlands licence area:

Installed capacity (MW)		Baseline	2025	2030	2035	2040	2045	2050
CCGT (non-CHP)	Steady Progression	407	407	407	0	0	0	0
	System Transformation		407	0	0	0	0	0
	Consumer Transformation		407	0	0	0	0	0
	Leading the Way		0	0	0	0	0	0
OCGT (non-CHP)	Steady Progression	36	36	36	36	36	36	36
	System Transformation		36	36	16	0	0	0
	Consumer Transformation		36	36	16	0	0	0
	Leading the Way		36	16	0	0	0	0
Reciprocating engines (non-CHP)	Steady Progression	321	473	654	753	717	652	602
	System Transformation		389	477	414	223	75	0
	Consumer Transformation		389	477	414	223	75	0
	Leading the Way		389	411	0	0	0	0
Gas CHP	Steady Progression	257	277	277	274	270	263	186
	System Transformation		268	265	236	117	40	0
	Consumer Transformation		268	265	158	97	58	0
	Leading the Way		268	249	107	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 is also a significant pipeline of new prospective fossil gas generation sites (c.221 MW) in the licence area. Some of these sites have positive activity in Capacity Market auctions and have resultantly been modelled to come online in the near-term.
- All types of fossil gas-fired power generation significantly decrease in the three net zero scenarios out to 2050. The installed capacity of gas reciprocating engines and gas CHPs increases under **Steady Progression** in the medium/long term.
- The primary role of distribution-scale fossil gas-fired generation is to provide flexibility and back-up services. Whilst the installed capacity may remain stable in some scenarios, the annual operating hours and energy output, decreases significantly by 2050 in all scenarios as the electricity system is decarbonised.
- At a national level, after 2030 hydrogen generation becomes a potentially economical source of supply-side flexibility in some scenarios. This results in some existing fossil gas generation site locations 'repowering' to become hydrogen-fuelled generation sites in between 2035 and 2050. The hydrogen generation scenario analysis and results are outlined in a separate dedicated technology summary sheet.

Results:

Baseline (up to 2020)

- There are 112 fossil-gas generation sites connected in the East Midlands licence area, totalling 1,257 MW. This is broken down into the following fossil gas technologies:
    - A large CCGT site (Corby Power Station) that has a capacity of 407 MW
    - Two OCGT sites totalling 36 MW
    - 41 gas reciprocating engines totalling 321 MW
    - 67 gas CHP sites totalling 257 MW.

Near term (April 2021 – March 2025)

- Consultation with stakeholders suggested that fossil gas-fired generation will see limited development beyond the current pipeline, due to its carbon intensity.
- There are 30 pipeline sites, totalling 221 MW, which have an accepted network connection offer in the licence area:
    - These are mostly gas reciprocating engine sites, accounting for 200 MW of the pipeline. The rest are small CHP sites ranging between 16 kW and 6 MW.
    - Four sites totalling 21 MW have secured planning permission and capacity agreements in recent Capacity Market auctions. These sites were modelled to connect in all scenarios in their respective Capacity Market delivery years.
    - Two additional sites totalling 8 MW have planning approval, but no Capacity Market evidence. These were modelled to connect in all scenarios 5 years after they secured their connection agreement.
    - Eight additional sites totalling 50 MW had no planning evidence, but secured capacity agreements or successful pre-qualification in recent Capacity Market auctions. These sites were also modelled to connect in all scenarios in their Capacity Market delivery years.
    - Eight sites totalling 55 MW did not successfully pre-qualify in recent Capacity Market auctions and were not modelled to come online in any scenario.
    - For the remaining ten sites (95 MW), no development evidence was found.
- This analysis of planning and Capacity Market activity determines the year of connection in the near term for each of the scenarios.

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

Medium term (April 2025 – March 2035)

For CCGT:

- Corby Power Station is modelled to decommission in all scenarios. This happens by 2025 in **Leading the Way**, by 2028 in **Consumer Transformation** and **System Transformation** and by 2035 in **Steady Progression**.

For OCGT:

- All OCGT capacity is modelled to decommission in the three net zero scenarios. This happens by 2035 in **Leading the Way** and by 2038 in **Consumer Transformation** and **System Transformation**.
- Under **Steady Progression**, with no new OCGT sites in the pipeline, the existing 36 MW capacity is modelled to remain operational across the period to 2050. This reflects gas turbine technology providing system flexibility alongside more responsive gas engine technologies, and less action on decarbonisation.

For gas reciprocating engines:

- Under **Leading the Way**, gas reciprocating engine capacity sees a steady reduction across the medium term, with all capacity decommissioned by 2035 in this scenario. This reflects a rapid switch to alternative low carbon sources of flexibility.
- Under **System Transformation** and **Consumer Transformation**, a moderate amount of reciprocating engine capacity continues to connect to the distribution network in the early 2030s, reflecting a moderately slower transition to lower carbon flexibility.
- Under **Steady Progression** 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 service contracts.

For gas CHP sites:

- Most of the gas CHP sites in the licence area are small-to-medium assets located onsite at commercial buildings such as factories, universities, hospitals or industrial sites.
- There is no additional increase in gas CHP capacity beyond the mid-2020s.
- Under **Leading the Way** all of the gas CHP capacity decommissions between 2026 and 2035. This reflects businesses seeking low-carbon alternatives to meet onsite demand.
- Under **Consumer Transformation** and **System Transformation** gas CHP decommissions slower, reflecting a slower transition away from gas in this scenario.
- Under **Steady Progression** the gas CHP baseline continues to operate in the medium term.

Long term (April 2035 – March 2050)

For OCGT:

- Under **Steady Progression**, the 36MW existing capacity remains operational out to 2050.

For gas reciprocating engines:

- Under **Leading the Way**, all gas reciprocating engine capacity is decommissioned by 2035.
- Under **System Transformation** and **Consumer Transformation**, capacity steadily decommissions between 2032 and 2050, with no capacity on the network by 2050.
- Under **Steady Progression** reciprocating engine capacity peaks in 2035 at c.753 MW. Some capacity is modelled to decommission between 2035 and 2050, reflecting some transition away from fossil-fuel flexibility. However, 602 MW of reciprocating engine capacity remains operational on the distribution network by 2050 under this scenario.

For gas CHP sites:

- Under **Leading the Way**, all gas CHP capacity is decommissioned by 2036.
- Under **System Transformation** and **Consumer Transformation**, decommissioning of CHP sites continues between 2035 and 2050. This culminates in no gas CHP capacity operating on the distribution network in either scenario by 2050.
- Under **Steady Progression** only a small a number of baseline gas CHPs decommission, with most of the baseline capacity (186 MW) still operating in 2050 under this scenario.

Figure 28

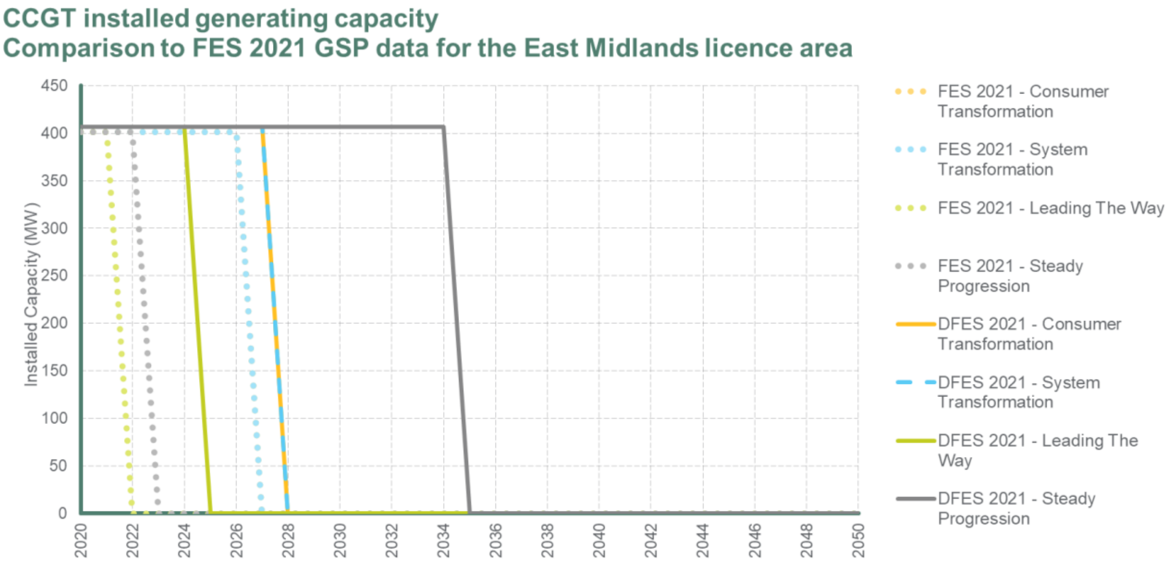


Figure 29

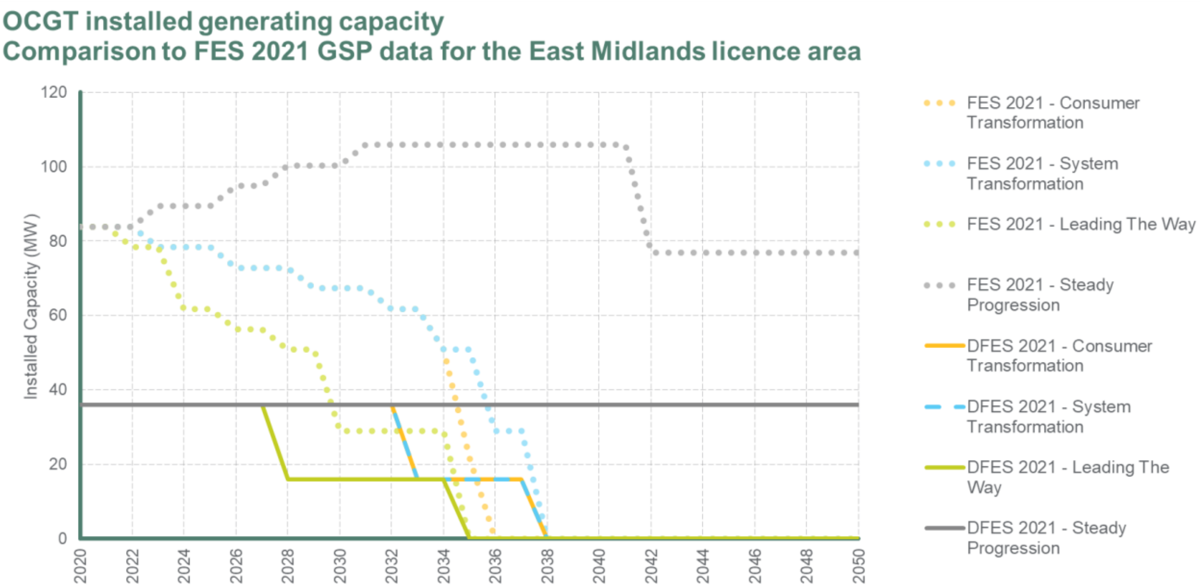


Figure 30

Gas reciprocating engine installed generating capacity
Comparison to FES 2021 GSP data for the East Midlands licence area

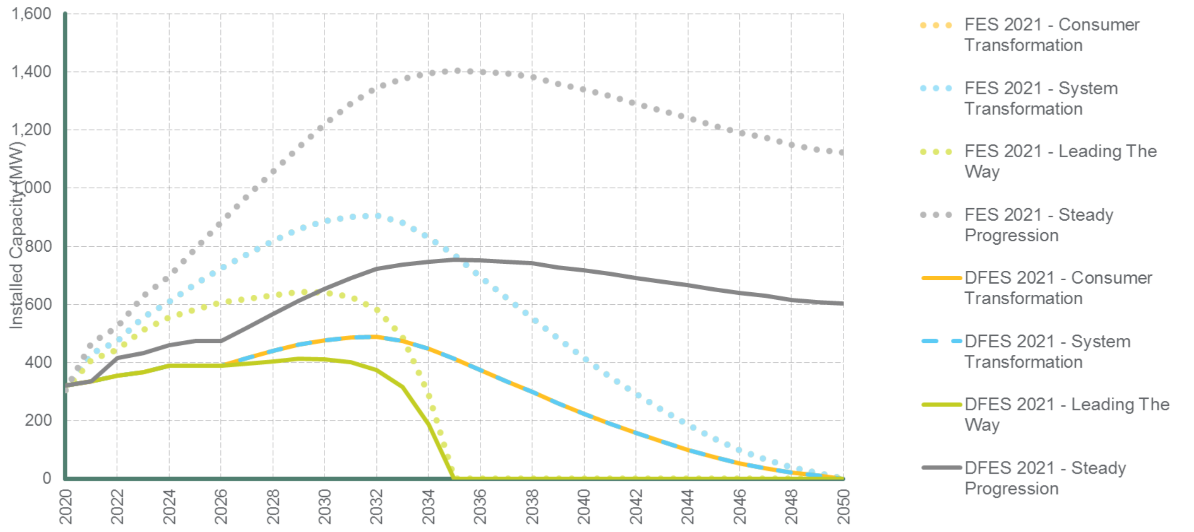
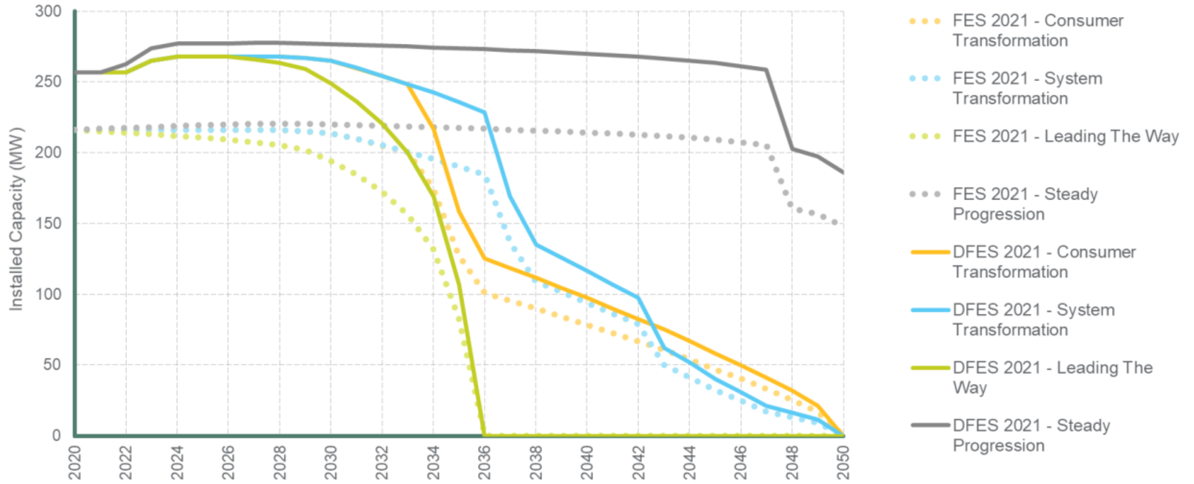


Figure 31

Gas CHP engine installed generating capacity
Comparison to FES 2021 GSP data for the East Midlands licence area



Reconciliation with National Grid FES 2021:

- For all of the fossil gas technologies included, the DFES has sought to classify each of the baseline sites based on connection data held by WPD and through site-by-site reconciliation with Capacity Market registers published by the EMR Delivery Body.
- The pipeline of sites with accepted connection offers were also individually assessed for evidence of development through reviewing online planning portals for planning activity and Capacity Market registers for capacity auction activity.
- These analyses have resultantly caused some variances between the FES and the DFES in the 2021 baseline and in the near-to-medium term projections.
- Beyond the known pipeline, the DFES has trended more towards the FES out to 2050 for all of the gas fired generation technologies.

For CCGT and OCGT:

- The FES 2021 identifies Corby Power Station CCGT capacity as 401 MW, but WPD connection data shows it to be 407 MW.
- The DFES has 48 MW less OCGT capacity in the 2021 baseline than the FES, the reason for this is unclear. With no new OCGT sites in the pipeline, the DFES sees no increase in OCGT capacity in the licence area, remaining flat at 36 MW to 2050.

For reciprocating engines:

- The DFES has identified 16 MW more reciprocating engine capacity in the 2021 baseline than the FES. The reason for this is unclear but could be related to differences in gas generation technology classification.
- The analysis of the pipeline in the DFES has resulted in a wider spread of projections between **Steady Progression** and the other three scenarios than seen in the FES.
- Beyond the known pipeline, the DFES trends towards the FES out to 2050, but results in a significantly lower residual capacity operating in 2050 under **Steady Progression**.

For gas CHPs:

- The DFES has identified 41 MW more gas CHP capacity in the 2021 baseline than the FES. The reason for this is unclear but could be related to differences in gas generation technology classification.
- The DFES has identified gas CHP pipeline sites with positive development evidence, which results in some near-term increase in capacity, which is not shown in the FES.
- The DFES and FES both assume minimal decommissioning of gas CHPs up until the late 2020s. Beyond this, the DFES sees a similar disconnection of CHP sites in all scenarios, though the DFES applies a more aggressive decommissioning rate in the 2020s and 2030s than the FES.
- A moderately higher residual gas CHP capacity is modelled to continue operating in 2050 under **Steady Progression** in the DFES than the FES, due to the much higher baseline.

Factors that will affect deployment at a local level:

- The spatial distribution of new gas-fired generation capacity is based on:
  - The location of the known pipeline sites
  - Proximity to electricity network and gas network infrastructure.

Relevant assumptions from National Grid FES 2021:

Assumption number	4.1.6 - Level of installed capacity of large unabated fossil-fuelled generation (e.g. CCGTs)
Steady Progression	Low gas price and lower focus on decarbonisation promotes gas as the source of flexible generation.
System Transformation	High levels of decarbonisation, plus other sources of flexibility reduce the need for unabated gas.
Consumer Transformation	High levels of decarbonisation, plus other sources of flexibility reduce the need for unabated gas.
Leading the Way	Highest level of decarbonisation significantly reduces the amount of unabated gas.

Assumption number	4.1.32 - Level of installed capacity of peaking generation (e.g. gas reciprocating engines and later hydrogen plant)
Steady Progression	Initial strong growth in unabated gas reciprocating engines and stays high as gas generation (small and large) plays an increasingly important role as flexible generation in the absence of strong growth in other technologies (e.g. storage, interconnection)
System Transformation	Initial slow growth (low deployment of gas reciprocating engines). Later strong growth in hydrogen plant to support system flexibility.
Consumer Transformation	Initial slow growth (low deployment of gas reciprocating engines). Later moderate growth in hydrogen plant to support system flexibility.
Leading the Way	Low throughout: initial growth of gas reciprocating engines is low as not aligned to decarbonisation and low long-term growth as other flexible solutions dominate in this scenario.

Stakeholder feedback overview:

Fossil gas-fired generation	
Your comments to us	Our response
A strong majority of stakeholders thought that flexible fossil gas-fired generation would see limited development beyond the current pipeline, due to it being a fossil fuel.	We have modelled little-to-no new unabated gas-fired generation development beyond current pipeline projects in the three net zero compliant scenarios.
Stakeholders asked whether hydrogen could replace fossil gas as a fuel for peaking generation.	Hydrogen-fired peaking plants are under the scope of the DFES 2021 analysis and is covered in a separate dedicated technology summary. There is significant uncertainty around the feasibility of using hydrogen for significant amounts of power generation in the future. As a result, hydrogen-fired peaking generation sees a wide range of outcomes across the future energy scenarios, reflecting this range of uncertainty.
Stakeholders said that future development of fossil gas-fired peaking plants could be limited due to their carbon intensity.	In the net zero scenarios we typically assume a much less favourable environment for high carbon technologies such as fossil gas-fired peaking plants. The modelling has therefore limited the pipeline sites that go ahead to those with significantly positive development evidence in the three net zero scenarios in the near-term. In the medium-term and out to 2050 connected capacity of fossil gas generation declines to zero in these three scenarios.

References:

WPD connection offer data, Capacity Market auction results and data, local authority planning portals, Nationally Significant Infrastructure Projects (NSIP) register, Embedded Capacity Register (WPD) and the results from the WPD DFES consultation events.

Hydrogen-fuelled generation in the East Midlands licence area

Summary of modelling assumptions and results

Technology specification:

This analysis covers hydrogen-fuelled electricity generation, which has been modelled to connect to the distribution network in areas where there is the potential for hydrogen supply. This links to the analysis undertaken for fossil gas capacity in the East Midlands licence area.

This technology pertains to Building Block ID number Gen_BB023 in the FES 2021 data.

Data summary for hydrogen-fuelled generation in the East Midlands licence area:

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	0	0	0	0	0	0	0
System Transformation		0	28	128	271	448	1,069
Consumer Transformation		0	0	31	31	128	281
Leading the Way		0	41	154	369	634	1,363

Summary:

- This technology considers the potential for some existing and known commercial gas and diesel generation sites to convert their generator assets to be able to run on hydrogen instead of fossil gas.
- This conversion has been modelled to occur in regions within the licence area that have been identified as potential hydrogen supply zones.
- 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. 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.
- The analysis then sought to identify the relevant ESAs that fall within these potential future hydrogen supply zones. Existing natural gas and diesel sites have then been modelled to re-purpose as hydrogen-fuelled generation sites in the 2030s and 2040s.
- The East Midlands has a significant amount of existing gas and diesel generating capacity (c. 1 GW) along with a substantial pipeline (220 MW). Therefore, in high hydrogen scenarios, it is likely to be a key region for hydrogen-fuelled generation in the future.
- As a general consideration, the business case for hydrogen-fuelled electricity generation is likely to be challenging, with hydrogen almost certainly set to be more expensive than natural gas is today.
- However, there is strong support for the role low carbon hydrogen can play in providing flexible power generation, which is covered in the UK Hydrogen Strategy. In July 2021, the UK government published a call for evidence on 'decarbonisation readiness' for new power generation. It is expected that from 2030, plants would be capable of accepting 100% hydrogen.

- Hence, WPD DFES 2021 showcases a large range of possible future scenarios, representing the significant uncertainty of this technology.

Results:

Baseline (up to 31st March 2021)

- As a technology, hydrogen-fuelled generation is a future consideration, which is not currently 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 1 GW of gas-fired power generation and 63 MW of diesel generation connected to the distribution network in this licence area.
- These sites under some scenarios have the potential to convert their input fuel to low carbon hydrogen.

Near term (April 2021 – March 2025)

- 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 focussed 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, and the availability of hydrogen as a fuel.
- Industry is anticipating the potential market opportunity for hydrogen-fuelled generation. This can be seen by engine and turbine manufacturers already selling 'hydrogen-ready' equipment.

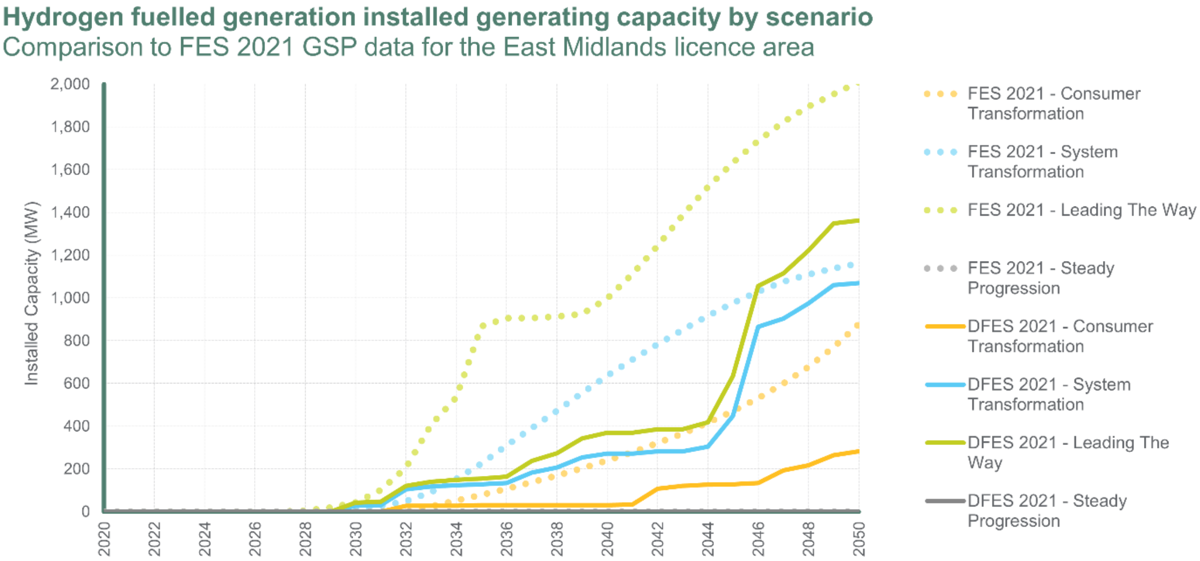
Medium term (April 2025 – March 2035)

- 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, such as Teesside and Grangemouth.
- There are key sites in the East Midlands, highlighted in the East Midlands Hydrogen Innovation Zone project[30], 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 the East Midlands Airport.
- Existing commercial gas and diesel sites in ESAs proximal to these areas could convert to hydrogen as soon as the early 2030s in **System Transformation** and **Leading the Way**, given the commercial landscape and national hydrogen strategy in these scenarios.
- This analysis culminates in the total hydrogen-fuelled generation capacity reaching 154 MW in **Leading the Way**, 31 MW in **Consumer Transformation** and 128 MW under **System Transformation** by 2035. Capacity remains at zero in **Steady Progression**.

Long term (April 2035 – March 2050)

- Existing and pipeline fossil fuel sites in identified hydrogen zones are modelled to convert to hydrogen between 2030 and 2045 in **Leading the Way**, **Consumer Transformation** and **System Transformation**.
- Sites falling outside of these zones are modelled to convert in the late 2040s under **Leading the Way** and **System Transformation** only, where hydrogen supply is more abundant.
- Under **Leading the Way**, medium-scale sites (< 50 MW) are modelled to repower with 50% more capacity, representing the most ambitious scenario for hydrogen-fuelled generation on the distribution network. This results in **Leading the Way** having the most capacity connected across the projection period (1 GW by 2050), reflecting the highest need for distributed low carbon flexibility.
- Under **System Transformation**, it is assumed that sites currently on the distribution network repower at the same capacity for hydrogen-fuelled generation, but significant capacity of hydrogen-fuelled generation in this scenario is expected on the transmission network.
- There is no hydrogen-fuelled generation capacity projected to connect under **Steady Progression**, due to limited uptake of low carbon hydrogen, while fossil gas-fired flexible generation continues to operate out to 2050.

Figure 32



Reconciliation with National Grid FES 2021:

- At an individual scenario level, the WPD DFES 2021 echoes the FES 2021 assumptions outlined at a national level.
- In FES 2021, under **Leading the Way**, hydrogen-fuelled generation experiences a surge in capacity in the 2030s; however, this is not reflected in WPD DFES 2021. This could be expected to occur in early hydrogen adopting regions, such as Teesside and Grangemouth. However, it is unlikely to apply to the East Midlands, due to a lack of hydrogen supply in this time period.

- FES 2021 has modelled a much smoother, more gradual increase in connected capacity between 2030 and 2050, particularly in **System Transformation** and **Consumer Transformation**. In contrast, WPD DFES 2021 has modelled discrete sites to convert within potential hydrogen supply areas, resulting in a more stepped increase in capacity across the 2030s and 2040s.
- The method by which the DFES allocates project capacity results in a slightly lower overall capacity connecting under **Leading the Way** and **Consumer Transformation**, while **System Transformation** is slightly higher than FES 2021.
- These regional differences are likely due to the WPD DFES 2021 approach of repowering existing and pipeline gas and diesel sites.

Factors that will affect deployment at a local level:

- To model the connection of hydrogen-fuelled generation in the 2030s and 2040s, a spatial analysis of potential hydrogen supply areas was completed and compared to commercial baseline and pipeline fossil-fuelled generation sites.
- The identification of these hydrogen supply areas considered the location of:
  - existing hydrogen trials
  - large industrial clusters
  - proximity to the gas network
  - proximity to major roads and motorways
  - potential hydrogen storage facilities.
- The location of projected hydrogen-fuelled generation sites is based on the location of existing and known commercial gas and diesel sites. This is in accordance with our engagement with National Grid ESO who said that they "expect most of the dedicated hydrogen generation to be new build (albeit located at existing sites) and optimised for peak running".

Stakeholder engagement:

As part of the WPD DFES stakeholder engagement process, Regen delivered a series of webinars with WPD in June 2021. In the webinars, the likely impact of the MCPD on commercial medium-scale diesel generation sites was considered. 83% of respondents thought that these sites would cease operation as a diesel generation site, with two-thirds thinking that they would transition to another technology, such as hydrogen-fuelled generation. This feedback has directly influenced the WPD DFES 2021 analysis for all licence areas, with the assumption made that existing and known fossil fuel sites will transition to other technologies that have lower carbon emissions, but still provide grid flexibility.

Relevant assumptions from National Grid FES 2021:

Assumption number	4.1.32 – Dispatchable peaking generation
Steady Progression	Initial strong growth in unabated gas reciprocating engines and stays high as gas generation (small and large) plays an increasingly important role as flexible generation in the absence of strong growth in other technologies (e.g., storage, interconnection).
System Transformation	Initial slow growth (low deployment of gas reciprocating engines). Later strong growth in hydrogen plant to support system flexibility.
Consumer Transformation	Initial slow growth (low deployment of gas reciprocating engines). Later moderate growth in hydrogen plant to support system flexibility.
Leading the Way	Low throughout: initial growth of gas reciprocating engines is low as not aligned to decarbonisation and low long-term growth as other flexible solutions dominate in this scenario.

References:

WPD connections and offers data, WPD DFES 2021 fossil gas, diesel and hydrogen electrolysis analysis, UK Hydrogen Strategy, consultation with East Midlands Hydrogen Innovation Zones and ITM Power.

Diesel generation in the East Midlands licence area

Summary of modelling assumptions and results

Technology specification:

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

Technology building block: Gen_BB005 – Non-renewable engines (diesel) (non-CHP).

Data summary for diesel in the East Midlands licence area:

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	63	41	13	0	0	0	0
System Transformation		17	0	0	0	0	0
Consumer Transformation		17	0	0	0	0	0
Leading the Way		0	0	0	0	0	0

Summary:

- The East Midlands licence area has a number of existing operational diesel engines. This is a mixture of both standalone commercial diesel generation sites and behind-the-meter back-up generators co-located with larger energy user buildings.
- There are no diesel sites with accepted connection offers in the licence area.
- Unabated diesel generation has a very limited lifespan in the licence area, due to being at odds with net zero emissions targets and the stringent emissions level requirements of relevant environmental permitting.
- As a result, all diesel capacity disconnects from the network in all scenarios by 2034.
- **Leading the Way** sees the most rapid disconnection of diesel capacity in the licence area, with all sites decommissioning within the early 2020s.

Modelling assumptions and results:

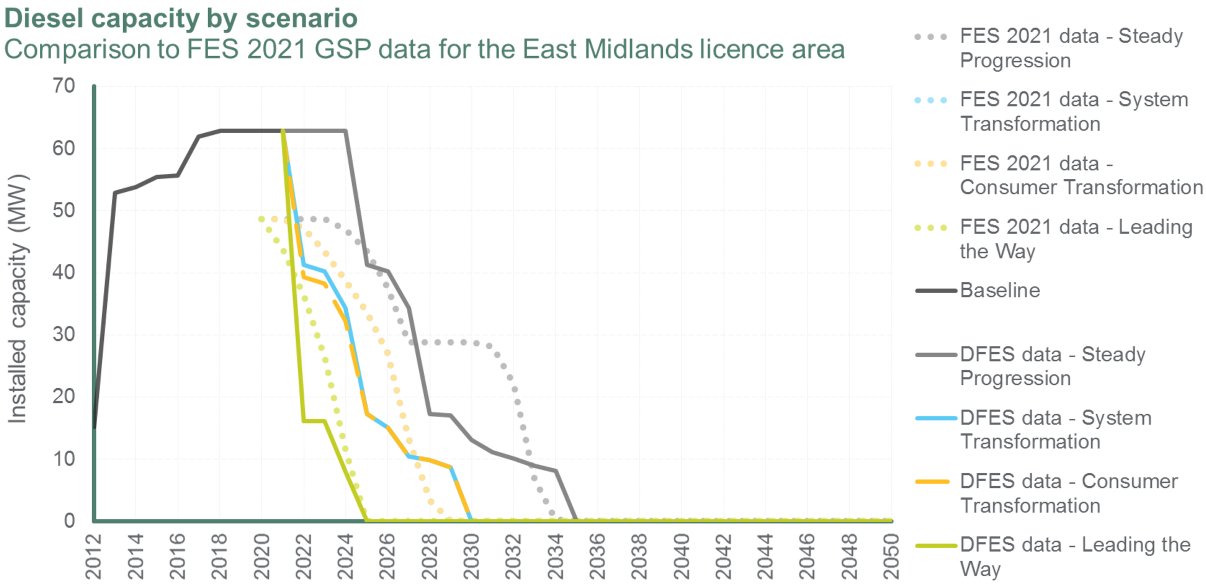
Baseline

- There are 20 diesel-fuelled generation sites in the East Midlands licence area, totalling 63 MW.
- This is a mixture of larger commercial-scale diesel plants (7 sites, 50 MW) and smaller back-up diesel generators (13 sites, 13MW).
- The larger plants have historically targeted commercial electricity network reserve services (such as Short Term Operating Reserve (STOR) or the Capacity Market).
- The smaller back-up generators are located onsite at a number of larger energy consumer buildings such as water industry sites, supermarkets, national rail sites and hospitals.

Projections (April 2021 to March 2050)

- There are no pipeline sites with an accepted connection offer in the licence area.
- As a fossil fuel, the operation of unabated diesel fired electricity generation is considered to contribute carbon emissions. Therefore, both the continued operation of existing diesel plants and the development of new plants are at odds with UK net zero targets.
- In addition to this, a piece of EU legislation known as the Medium Combustion Plant Directive (MCPD) has been passed into UK law. This requires plants to adhere to stringent air quality limits through environmental permitting, unless they only operate for a few hours per year (i.e. back-up generators only).
- Unabated commercial diesel generation falls within this regulation and will therefore no longer be able to operate from 2025[31] without exhaust abatement technologies (such as catalytic reduction technology). This type of companion technology is unlikely to be financially viable in the near term.
- The DFES analysis therefore focuses on the decommissioning of all baseline diesel generators within the licence area. Between now and the mid-2030s, depending on the scenario, the decommissioning model considers the following factors:
    - The type of diesel site (standalone or back-up)
    - The year it was installed
    - How each scenario reflects environmental permitting requirements under the MCPD and progress towards net zero targets.
- This results in all diesel generation capacity being decommissioned from the distribution network in the licence area. This removal of all diesel generation happens by 2025 in **Leading the Way**, by 2030 in **Consumer Transformation** and **System Transformation** and by 2035 in **Steady Progression**.
- Following feedback from engaging sector stakeholders, this decommissioning is based on the assumption that standalone flexibility moves to lower carbon alternatives. These include electricity storage, demand side response and cleaner ‘dispatchable’ generation technologies such as anaerobic digestion.
- There is a short-term consideration that low-carbon diesel or biodiesel could still play a role for back-up generators, as a result this extends the operation of existing plants out to the 2030s specifically under **Steady Progression**.

Figure 33



Reconciliation with National Grid FES 2021:

Results in this section relate to the FES 2021 data as reported for the Building Block ID number Gen_BB005:

- The current installed capacity of diesel generation in the East Midlands licence area is c.8 MW higher in the WPD DFES data than in the FES 2021 publications. The reason for this is unclear.
- The DFES projections align to the FES assumptions that all unabated diesel capacity is decommissioned from operating on the distribution network by:
  - 2025 in **Leading the Way**
  - 2030 in **Consumer Transformation** and **System Transformation**
  - 2035 in **Steady Progression**

Factors that will affect deployment at a local level:

As the analysis solely focuses on decommissioning existing known baseline sites, the spatial distribution references site location of the 20 existing diesel generation sites.

Stakeholder feedback overview:

Diesel-fuelled generation	
Your comments to us	Our response
When discussing the future of diesel-fuelled generation with stakeholders, the majority of respondents fed back that diesel-fuelled generation sites impacted by air quality regulations would transition to another technology. A minority felt sites would simply fully decommission instead.	Existing diesel-fuelled generation sites will be used as distribution factors for other technologies such as battery storage and hydrogen-fuelled generation, where feasible.

References:

WPD connection offer data, Environment Agency, Regen consultation with local stakeholders and discussion with asset owners.

Waste (incineration) in the East Midlands licence area

Summary of modelling assumptions and results

Technology specification:

This analysis covers Energy from Waste (EfW) technologies, including incineration and Advanced Conversion Technologies (ACT).

This technology pertains to Building Block ID number Gen_BB011 in the FES 2021 data.

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

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	156	254	284	284	284	284	284
System Transformation		254	254	254	252	233	231
Consumer Transformation		254	254	254	252	233	231
Leading the Way		254	252	233	231	218	124

Summary:

- Significant capacity of unabated incineration generation is at odds with net zero targets, due to the level of associated carbon emissions. Hence, it is assumed that incineration capacity reduces after 2030 in **Leading the Way**, **Consumer Transformation** and **System Transformation**, as older facilities reach the end of their operational lifetime.
- In **Consumer Transformation** and **System Transformation**, developments in CCUS technology are expected to enable most incineration capacity to remain connected and operational.
- ACT gasification plants (which account for 26.5 MW of operational capacity) have lower associated carbon emissions, and any residual emissions can be abated.
- All ACT sites on WPD's network connected in the last decade and are not expected to decommission before 2050.

Modelling assumptions and results:

Baseline (up to 31st March 2021)

- There are 12 waste sites in the WPD connection database totalling 156 MW.
- This comprises three ACT sites, totalling 26.5 MW, and nine incineration sites, totalling 129.2 MW.
- One third of all operational sites connected in 2017, with the most recent development occurring in August 2019.

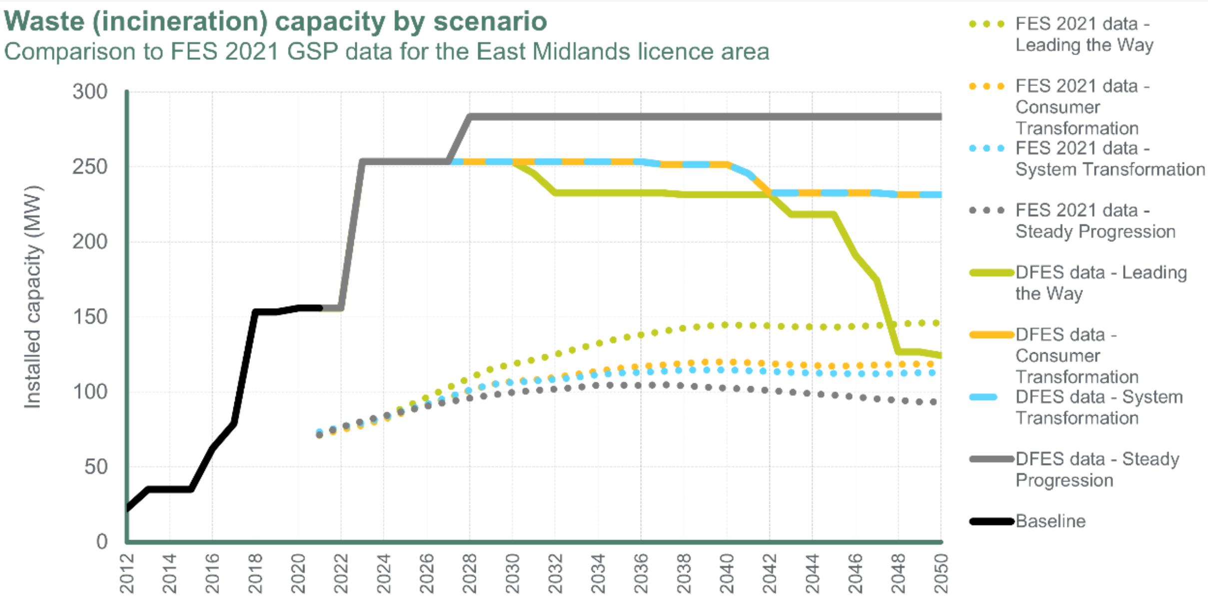
Near term (April 2021 – March 2025)

- There are seven pipeline sites in WPD's connection database totalling 139.6 MW. This comprises two ACT sites and five incineration sites.
- Two ACT and two incineration sites have planning permission granted (one in 2014 and three in 2016).
- Based on analysis of REPD, historically incineration plants take 4.7 years from gaining planning permission to becoming operational, while ACT sites take 4.8 years. As a result, these sites connect in 2022 under all scenarios.
- One incineration site (11.8 MW) was found to be abandoned in planning; hence, it does not connect under any scenario.
- The other two sites do not have any planning information; therefore, they are only modelled to connect in **Steady Progression** due to limited movement in the sector.

Medium and long term (April 2025 – March 2050)

- No additional sites have been projected to connect beyond the pipeline in any scenario, as unabated EfW is at odds with net zero targets, due to the level of associated carbon emissions.
- For ACT:
    - All ACT sites on WPD's network have connected in the last decade and are not expected to decommission before 2050.
    - No further ACT capacity is modelled to connect due to difficulties in making the technology viable, and subsequent lack of activity in the sector. This is reflected by the lack of pipeline projects.
- For incineration:
    - All incineration sites are modelled to stay online until at least 2030.
    - The medium- and long-term projections are determined by the end-of-life decommissioning of existing sites (both currently operational and sites in the pipeline).
    - The operational life of an incineration facility is typically between 20 and 30 years[32]; however, the connection agreement may not be relinquished immediately. Incineration facilities have been modelled to disconnect after 30 years in **Leading the Way** and 40 years in **Consumer Transformation** and **System Transformation**, in order to model the operational life range and the potential delay between decommissioning and relinquishing a connection agreement.
    - To explore the worst-case distribution network conditions, no sites are modelled to come offline in **Steady Progression**.

Figure 34



Reconciliation with National Grid FES 2021:

Results in this section relate to the FES 2021 data as reported for Building Block ID number Gen_BB011.

- WPD connections data has 156 MW of capacity connected to their distribution network in the East Midlands licence area, which is significantly higher than the FES 2021 baseline. This discrepancy may be caused by WPD DFES' inclusion of all generators with valid connection agreements, regardless of absent supply contracts.
- The WPD DFES 2021 assumptions align with FES 2021; however, the results may differ due to local spatial distribution.
- Although nationally, FES 2021 projections show **Steady Progression** to have the highest capacity of waste, GSP data for the East Midlands has this as the lowest scenario, with **Leading the Way** having the most capacity. This is assumed to be an error in the dataset, and instead, the overall FES 2021 assumptions have been followed.
- The FES 2021 data shows a continued increase out to 2040, before capacity reduces; however, WPD DFES 2021 has modelled the connection of the six pipeline sites in the near term and then the decommissioning of sites from 2030 onwards. This results in a staggered projection, which more realistically represents the likely reduction in capacity.

Relevant assumptions from National Grid FES 2021:

Assumption number	4.1.11 - Unabated Biomass and Energy from Waste (EfW) generation
Steady Progression	No significant change in waste management from society; leaving waste available as a fuel source for unabated generation.
System Transformation	Less waste to burn in general due to a highly conscious society adapting to low waste living.
Consumer Transformation	Less waste to burn in general due to a highly conscious society adapting to low waste living.
Leading the Way	Less waste to burn in general due to a highly conscious society adapting to low waste living.

References:

WPD connection offer data, Renewable Energy Planning Database, Regen consultation with local stakeholders and discussion with developers.

Other generation in the East Midlands licence area

Summary of modelling assumptions and results

Technology specification:

All operational generation sites and accepted connection offers that are unidentified as one of the generation technology types in-scope of the DFES 2021 analysis.

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

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	17	29	29	29	29	29	29
System Transformation		29	29	29	29	29	29
Consumer Transformation		29	29	29	29	29	29
Leading the Way		29	29	29	29	29	29

Summary:

- There are 15 sites (totalling 17 MW) connected to the distribution network in the East Midlands licence area that have no identifiable technology type.
- In some cases, this is because of a lack of available information, meaning the connected site could not be located. In other cases, it is because the sites are likely thermal or fossil fuel generators, whose fuel type cannot be confidently identified.
- There are 14 additional sites with unclear technology types in the East Midlands licence area with an accepted network connection offer, totalling 12 MW.
- The projected connection year for these sites is the same across all scenarios. They are projected to connect 3 years after accepting a connection offer, meaning all pipeline sites are projected to connect before 2024.

Reconciliation with National Grid FES 2021:

There is no equivalent technology type in National Grid FES 2021 to be compared against.

References:

WPD connection agreement and offer data.

[22] FES Modelling Methods 2021
[23] Smart Export Guarantee (SEG)
[24] Social Grade, National Readership Survey
[25] Biomass in a low carbon economy, CCC
[26] Advanced Biomass Power, CEDM
[27] Is there still a future in AD plants for UK farmers?, Farmers Weekly
[28] Environment Bill sets out vision for a greener future
[29] Agricultural Land Classification
[30] East Midlands Hydrogen Innovation Zone
[31] Medium combustion plant: when you need a permit
[32] Energy from waste: a guide to the debate

Results and assumptions

Energy storage technologies

Battery storage in the East Midlands licence area

Summary of modelling assumptions and results.

Technology specification:

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 3 business models combine to form the FES building block **Batteries Srg_BB001**

- **Domestic batteries –** typically 5-20 kW scale batteries that households buy to operate alongside rooftop PV or to provide backup services to the home. This business model aligns with the FES building block **Domestic Batteries (G98) Srg_BB002**.

The analysis also considered other forms of electricity storage, Srg_BB003 (pumped hydro), Srg_BB004 (other technologies, liquid air, compressed air). However, no evidence was found for these technologies seeking to connect on the distribution network in the licence area. The building block Srg_BB005 (Vehicle-to-Grid) was not within the scope of the analysis.

Data summary for battery storage in the East Midlands licence area:

Installed power capacity (MW)		Baseline	2025	2030	2035	2040	2045	2050
Standalone network services	Steady Progression	45	65	66	67	69	70	72
	System Transformation		115	142	149	156	187	225
	Consumer Transformation		190	213	244	288	346	415
	Leading the Way		190	228	273	328	393	472
Generation co-location	Steady Progression	1	1	3	7	9	19	21
	System Transformation		1	25	33	45	49	54
	Consumer Transformation		6	39	52	105	119	134
	Leading the Way		6	65	88	126	142	148

Behind-the-meter high-energy user	**Steady Progression**	3	15	15	15	15	17	19
	System Transformation		21	21	23	27	31	35
	Consumer Transformation		28	29	33	63	73	83
	Leading the Way		41	46	53	63	73	83
Domestic batteries	**Steady Progression**	0.27	3	4	11	13	38	89
	System Transformation		20	33	49	65	163	195
	Consumer Transformation		43	85	134	229	439	715
	Leading the Way		54	110	210	363	623	1,146

Summary:

- The East Midlands licence area has the second highest level of operational battery storage capacity in the WPD network, with 60 sites totalling over 49 MW.
- The licence area also has by far the largest pipeline of battery storage projects with accepted connection offers across WPD's network; 41 projects totalling c. 690 MW.
- The licence area has the strong potential for long-term growth in connected storage capacity across WPD's network. This is due to:
    - 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 200 MW in **Steady Progression** to 1.8 GW in **Leading the Way**.

Modelling assumptions and results:

Baseline

- There are 56 battery storage projects totalling 49 MW currently connected in the East Midlands licence area, all of which have come online since 2016.
- This comprises:
    - 5 standalone battery projects totalling 45 MW
    - 2 generation co-location projects totalling 1 MW
    - 6 behind-the-meter high energy user projects totalling 3.2 MW
    - 47 domestic-scale batteries, totalling 266 kW.

Near term (April 2021 – March 2025)

- The East Midlands licence area has a significant pipeline of battery storage sites with accepted connection offers: 41 projects totalling 690 MW.
- This comprises:
    - 19 standalone battery sites, totalling 520 MW
    - 6 generation co-location battery sites, totalling 163 MW
    - 3 behind-the-meter high energy user batteries, totalling 7 MW
    - 13 domestic batteries, totalling 70 kW.
- This pipeline includes 8 projects that are 50 MW or higher.

- Reviewing the development activity of these projects:
    - 6 sites (106 MW) have secured planning approval recently (2017-2021)
    - 2 sites (70 MW) have successfully pre-qualified in recent Capacity Market auctions
    - For 33 sites (528 MW) no development information could be found.
- The planning history and capacity market activity of the pipeline sites are key weighting factors that determine when these sites are modelled to connect under the four scenarios.
- By 2025, connected battery storage capacity in the East Midlands licence area is highest (290 MW) under **Leading the Way** and lowest (84 MW) under **Steady Progression**.

Medium term (April 2025 – March 2035)

- The four business models for battery storage are modelled separately, and potential deployment in the licence area is driven by different factors.
- Standalone storage accounts for a significant proportion of the existing or known near-term storage pipeline capacity and this business model continues to see an increase across all scenarios by 2035.
- Generation co-location capacity sees a similarly strong uptake in the East Midlands licence area, due to having the highest combined ground mounted solar PV and onshore wind development by 2035 across WPD's network.
- The East Midlands licence area has the second highest number of non-domestic properties with the potential for a battery, 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 near and medium term.
- The 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. However, still reflecting stakeholder feedback that domestic storage will be the business model with the lowest uptake in the near-to-medium term.
- By 2035 total battery storage capacity in the licence area reaches 625 MW under **Leading the Way** and 99 MW under **Steady Progression**.

Long term (April 2035 – March 2050)

- In the long term, the biggest increase in projected battery storage capacity is seen in **Leading the Way**, reflecting strong potential across all four storage business models.
- The **Steady Progression** scenario sees the lowest overall storage deployment in the licence area. This reflects a lesser need for electricity system flexibility, a lower renewable energy adoption and ongoing use of fossil fuel generation. This environment has been reflected in the longer term out to 2050, across all storage business models.
- Installed battery storage capacity in the licence area reaches c.1.8 GW in **Leading the Way** and 200 MW in **Steady Progression** by 2050.

Figure 35

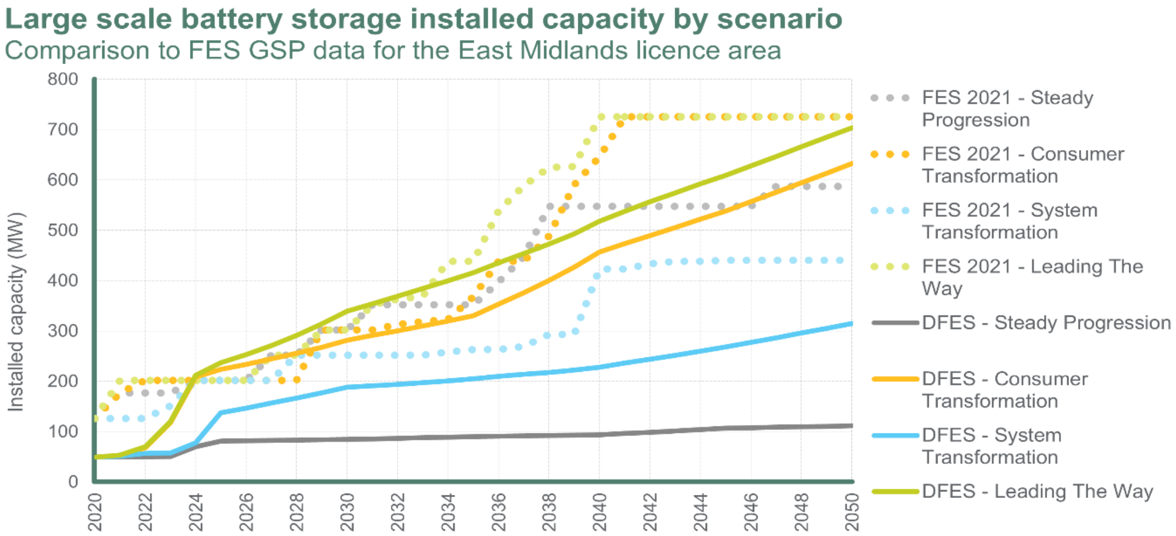
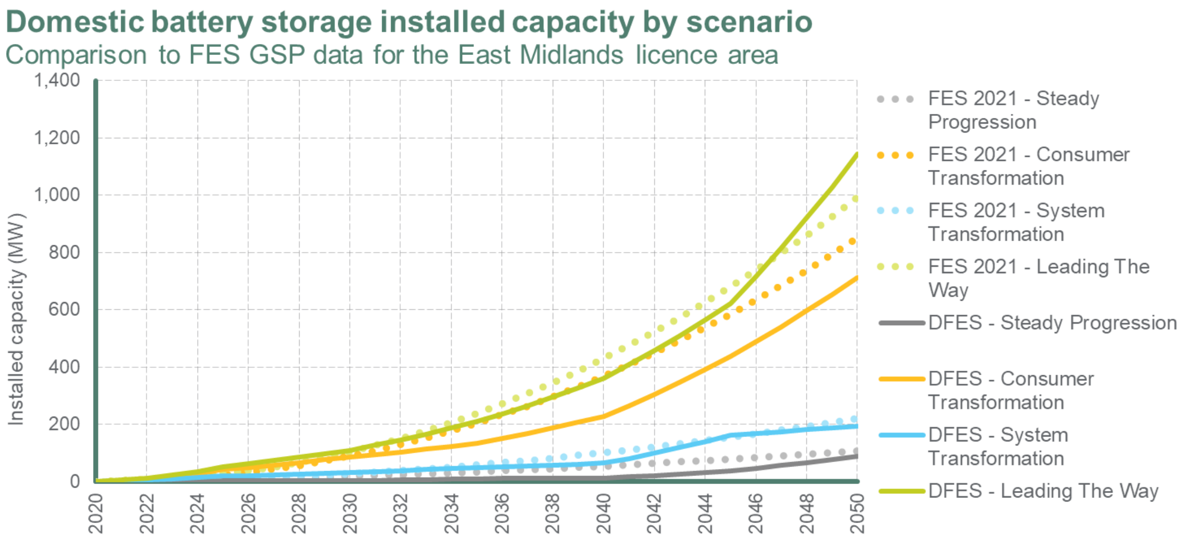


Figure 36



Reconciliation with National Grid FES 2021:

Results in this section relate to the FES 2021 data as reported for the Building Block ID number Srg_BB001 and Srg_BB002:

- The FES 2021 data has 77 MW more capacity in the baseline in the East Midlands than the DFES. The reason for this is unclear but could be due to the method of assigning FES GSP capacity across the borders of the East and West Midlands, as in the West Midlands the FES 2021 baseline is equivalently moderately lower than the DFES.
- Reflecting the large near-term pipeline, the WPD DFES 2021 projections align to the FES 2021 projections across the early/mid-2020s.
- The WPD DFES 2021 has a broader spread of outcomes by 2050 for large-scale battery storage. The DFES broadly aligns to the 2050 outcome in **Consumer Transformation** and **Leading the Way**. However, the DFES has reflected a much more challenging market environment for new storage projects across all four business models out to 2050 under **System Transformation** and **Steady Progression**, than the FES.

- In addition, whereas the WPD DFES 2021 models **Steady Progression** as the scenario with the lowest potential need for battery storage across the analysis period, the FES 2021 models **System Transformation** as the scenario with lowest overall deployment in the licence area. The reason for this variance is unclear, as this goes against the outcome seen in other licence areas and GB national projections.
- The DFES 2021 projections for domestic batteries align well with FES 2021 across the analysis period and in all scenarios.

Factors that will affect deployment at a local level:

- The spatial distribution of new battery storage projects in the near and medium term is based on the location of the pipeline sites.
- In the longer term, spatial distribution varies according to the four battery storage business models used in the modelling. These local factors are:
  - **Standalone:** Developable land proximate to the 33kV and 132kV electricity network.
  - **Generation co-location:** Proximity to existing and future ground mounted solar PV and onshore wind projects within the licence area.
  - **Behind-the-meter high-energy user:** Proximity to industrial estates and commercial buildings that could be suitable for battery storage installations.
  - **Domestic batteries:** Domestic dwellings with rooftop PV as projected in the DFES.

Relevant assumptions from National Grid FES 2021:

Assumption number	4.2.24 - Level of installed capacity of (non-domestic) storage technologies with a duration of less than 2 hours (e.g. batteries)
Steady Progression	Moderate levels of flexibility requirements encourage new storage. Not as much deployed compared to other scenarios.
System Transformation	Not as much deployed compared to other scenarios due to high use of hydrogen within this scenario.
Consumer Transformation	High levels of variable clean generation and flexibility requirements encourage new storage technologies to emerge.
Leading the Way	Even higher levels of flexibility requirements encourage new storage technologies to emerge at distributed and transmission levels.

Assumption number	4.2.25 - Level of installed capacity of (non-domestic) storage technologies with a duration of between 2 and 4 hours (e.g. medium batteries, compressed or liquid air storage)
Steady Progression	Lower flexibility requirements means that this technology does not come forward at the volumes seen in the other scenarios.
System Transformation	Moderate levels of flexibility requirements encourage new storage. Not as much deployed compared to other scenarios due to high use of hydrogen within this scenario.
Consumer Transformation	Flexibility requirements encourage new storage.
Leading the Way	High levels of flexibility requirements encourage new storage.

Stakeholder feedback from the consultation events:

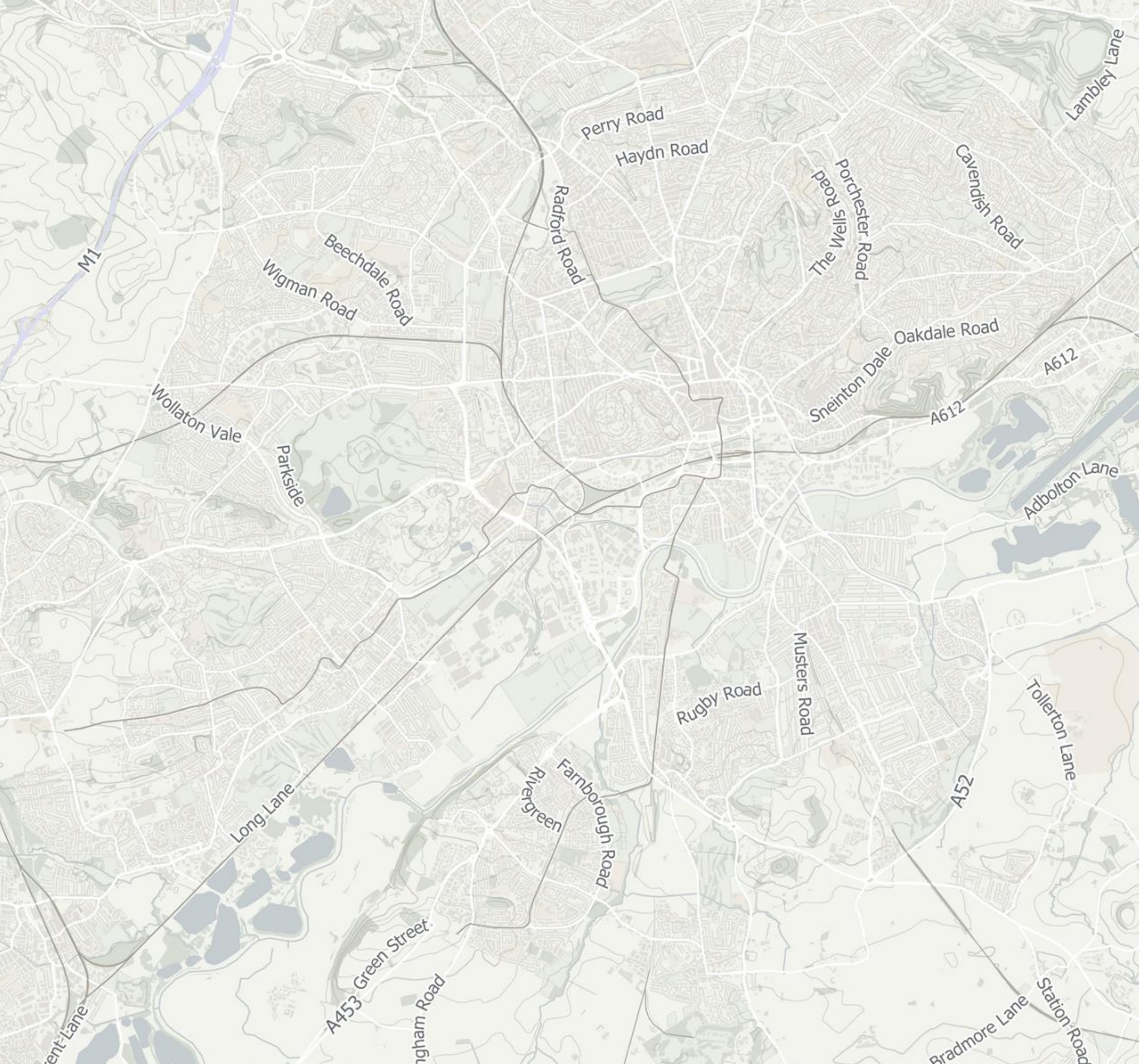
Battery storage Your comments to us	Our response
Stakeholders felt that electricity storage co-located with generation would be the business model with the biggest increase in capacity, followed by standalone storage projects providing grid services. Domestic electricity storage was seen as having less potential.	We use existing and potential renewable generation sites as distribution factors for future storage capacity, alongside the proximity to 33 kV and 132 kV networks. We have focussed the uptake of domestic batteries towards the longer term.
In the East and West Midlands, a much higher proportion of stakeholders felt that high-energy users, such as industrial customers, would drive electricity storage deployment in the near and medium term.	We applied this regional consideration in the modelling of the high-energy user business model in the East and West Midlands licence areas.
You asked whether there was much development of battery storage co-located with renewable energy generation.	The DFES specifically models co-located storage as one of the four business models for energy storage, and as such renewable generation is a key factor in the location of future energy storage.
Some stakeholders pointed out that in a heavily decarbonised electricity grid, energy storage providing system inertia could be another key revenue stream.	We are aware of these types of power-quality services, and they are one of the factors and services that underpins the ‘Standalone Grid Services’ business model. We accept that other business models may also have this as a revenue stream.

References:

WPD connection offer data, the Renewable Energy Planning Database, various local authority online planning portals, EMR Delivery Body Capacity Market registers.

Distribution Future Energy Scenarios 2021

Results and assumptions reports have been published for all four WPD licence areas and are available on the WPD DFES website, along with interactive maps and data download options.



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