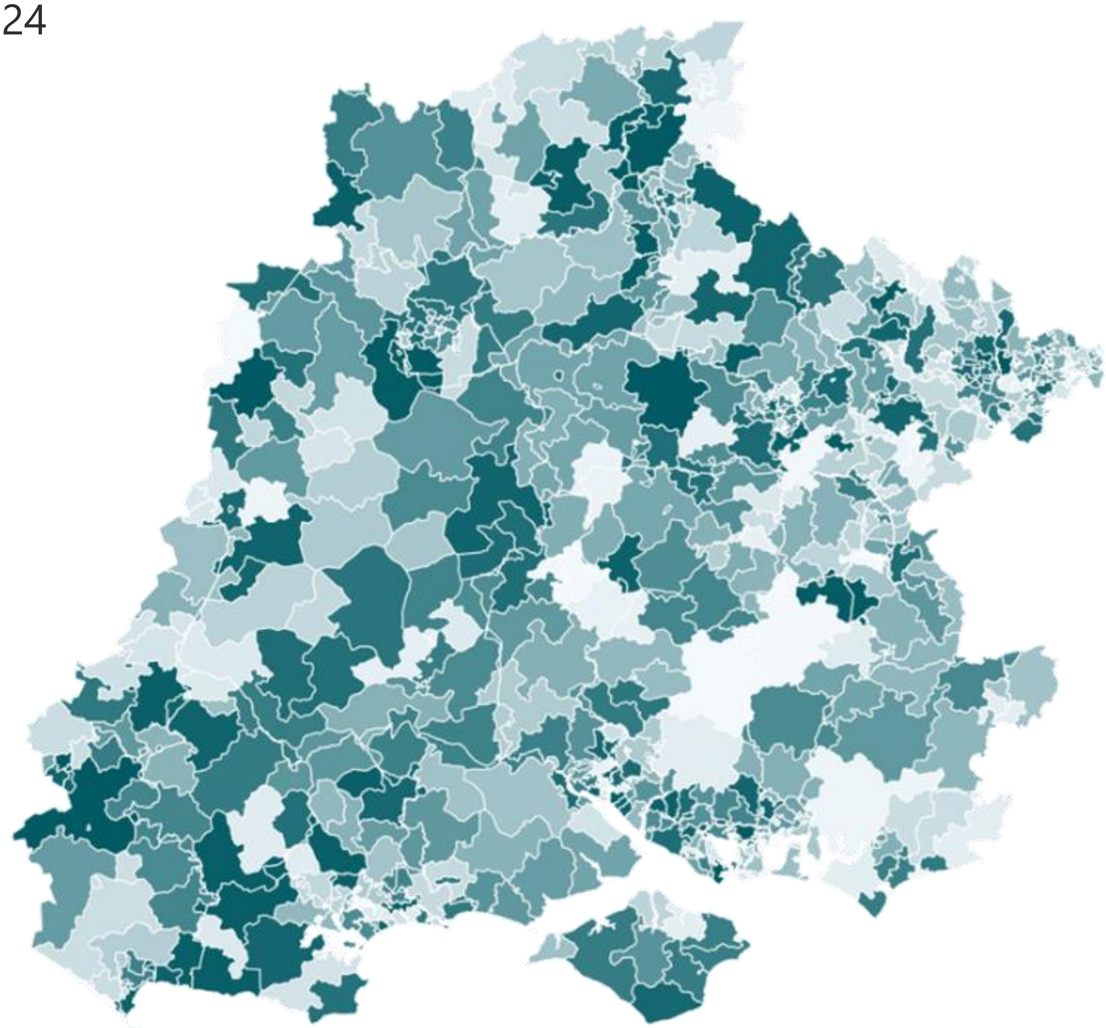
SSEN DISTRIBUTION FUTURE ENERGY SCENARIOS 2023

Results and methodology report for the Southern England licence area

March 2024



About Regen

Regen is an independent centre of energy expertise with a mission to accelerate the transition to a zero-carbon energy system. We have nearly 20 years of experience in transforming the energy system for net zero, delivering expert advice and market insight on the systemic challenges of decarbonising power, heat and transport.

Regen is also a membership organisation, managing the Regen members network and the Electricity Storage Network (ESN) – the voice of the UK storage industry. We have over 150 members who share our mission, including clean energy developers, businesses, local authorities, community energy groups, academic institutions and research organisations across the energy sector.

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Foreword

Scottish and Southern Electricity Networks (SSEN) Distribution is the electricity distribution arm of the FTSE-50 energy company, SSE. We serve over 3.8 million customers across the diverse and unique geographies of the north of Scotland and central southern England.

We deliver a critical role in the decarbonisation of the sector. The communities we serve depend on us to deliver a safe, reliable supply of electricity to their homes and businesses so they can thrive today, while we work to deliver the infrastructure to create a net zero tomorrow. This means readying our network for the uptake in low carbon technologies such as electric vehicles, heat pumps and local renewables, which will need smart connections to be able to interact with the grid.

We have embraced the UK and Scottish Governments' commitments to this transition, including their targets to decarbonise by 2050 and 2045, respectively. These commitments have changed the way we go about developing our networks. We are now taking an even more strategic approach making sure we provide the capacity when needed to help achieve Net Zero. Our strategic approach will allow us to anticipate the location and timing of new demand ensuring measures are in place to flex supply and demand to manage capacity needs, or to reinforce the network. You can read more about our Net Zero strategic development process in our Distribution Networks Options Assessment methodology (DNOA).

The work that Regen has undertaken here and for previous reports underpins this process. Our future proposals draw on DFES figures to establish the building blocks that must be put in place to facilitate Net Zero. As a result in our current price control, we'll invest at least £3.5bn in our network, which means by 2028 we will be able to facilitate 1.3 million electric vehicles and 800,000 heat pumps on our network, as well as 8 GW of distributed generation and storage. This is being supported by development of new market models to allow consumers to interact with the energy system and manage their own usage and costs. This ensures we are only investing in our networks when it is most efficient.

Your input and involvement in this process is essential to help us appropriately identify and develop the local electricity systems and grids of the future. Regen have engaged with many of you in the development of this year's DFES and I would like to thank you for your time and effort. But our engagement does not stop here. Through innovative tools such as the Local Energy Net Zero Accelerator (LENZA) we are looking to engage with local authorities and other stakeholders through the year both to understand your needs and share our plans as well develop.

Central to this is our commitment to a just transition that leaves nobody behind. This year we have asked Regen to investigate more deeply how the transition to Net Zero is affecting vulnerable consumers, and how DFES can help us understand these impacts and suggest ways to ensure no customers are left behind.

Finally, I would like to thank Regen for their work on this essential and timely report and to thank all our stakeholders, including local and regional authorities, for their ongoing engagement and contributions to our research. We look forward to continuing to work closely with them to deliver Net Zero.

Andrew Roper
Distribution Systems Operations Director
Scottish and Southern Electricity Networks

Introduction

This report outlines the results from the 2023 Distribution Future Energy Scenarios (DFES) analysis for Scottish and Southern Electricity Networks' (SSEN) Southern England electricity distribution network licence area[1]. The DFES analysis produces high granularity forecasts for the growth (or reduction) of energy generation, demand and storage technologies connecting to SSEN's electricity distribution network.

The Future Energy Scenarios (FES) framework, published by the National Grid Electricity System Operator (ESO)[2], outlines four different scenarios for the future of the whole energy system out to 2050 and the assumptions that define these scenarios provide the foundation for the DFES analysis. A wide-ranging evidence base, extensive industry and stakeholder engagement and a thorough investigation into the pipeline of projects, either under construction or seeking development in the Southern England licence area, are all further inputs into the DFES.

SSEN uses the DFES analysis as part of an integrated network planning and investment appraisal process. The DFES forecasts enable SSEN to better understand how the demands on its network are likely to change over time and this facilitates the network planning teams to model and analyse future electricity demand across the Southern England licence area. This feeds into SSEN's Net Zero Strategic Planning process, the aim of which is to "provide the capacity on the network to deliver net zero by 2050 while retaining a clear focus on safety and reliability"[3].

This report summarises the results and scenario forecasts for the 2023 DFES analysis. It provides an overview of the DFES methodology, stakeholder engagement that was undertaken and national and local policies that influenced the analysis. In addition, this report

[1] Also known as the Southern Electric Power Distribution (SEPD) licence area.

[2] National Grid ESO 2023, Future Energy Scenarios 2023 https://www.nationalgrideso.com/future-energy/future-energy-scenarios-fes

[3] SSEN 2023, Distribution Network Options Assessment (DNOA) Methodology https://www.ssen.co.uk/globalassets/about-us/dso/consultation-library/dnoa-methodology.pdf

includes detailed information for each of the energy generation, demand and storage technologies that are included in the analysis.

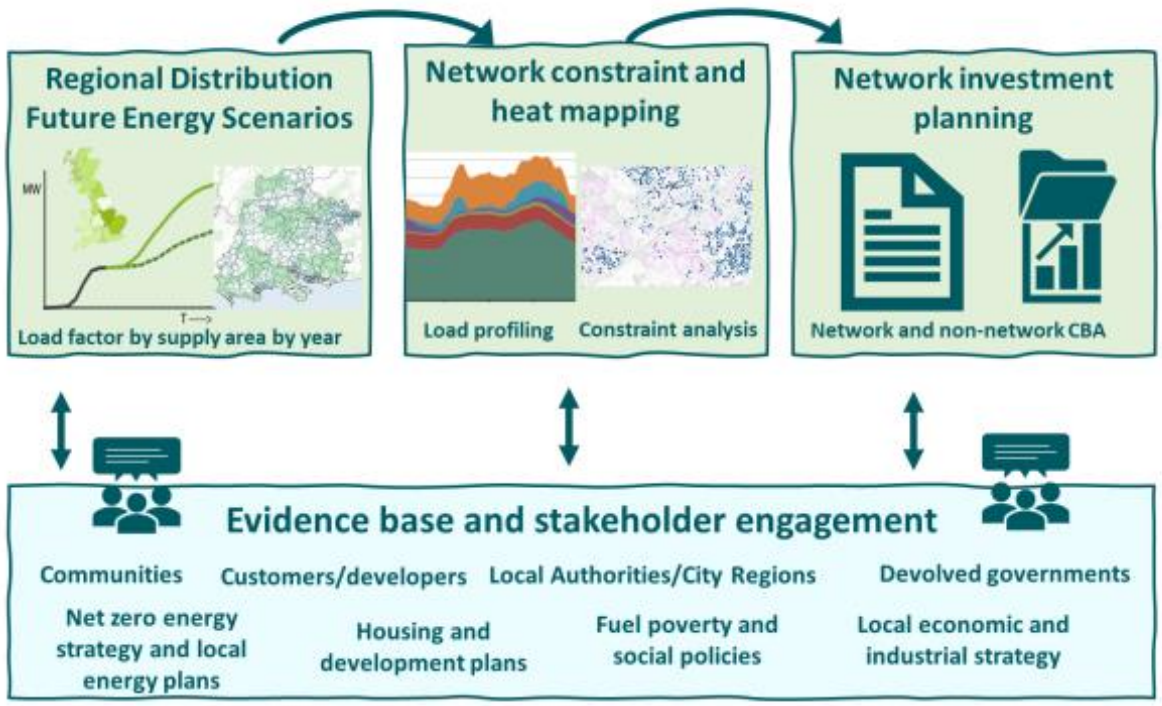

Figure 1 An overview of SSEN's network and investment planning process

SSEN’s Southern England licence area

The Southern England electricity distribution licence area refers to the area served by the low voltage (LV), 11 kV, 33 kV and 132 kV network that is managed by SSEN in the southern central geographical area of England.

This area spans the borders of south Somerset and west Dorset to the west, Five Oaks Ealing and Chiswick to the east, Chipping North and areas of the Cotswolds in the north and the coastal towns of Weymouth, Bournemouth, Southampton and Portsmouth to the south. The Isle of Wight also falls within the licence area, fed by subsea cables managed by SSEN. Within the licence area are the urban centres of Oxford, Swindon, Reading and Southampton, as well as the national parks and rural countryside of the South Downs, New Forest and the Chiltern Hills.

The licence area comprises 53 local authority areas, either wholly or partially, including city regions (such as Oxford) and large district and borough councils (such as Wiltshire).

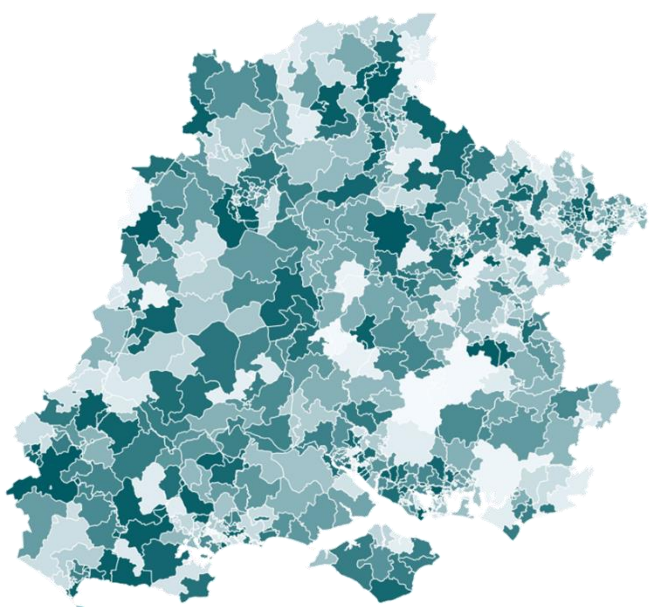

Figure 2 A map of SSEN’s Southern England licence area and the Electricity Supply Area (ESA) boundaries

Southern England licence area baseline

There is currently 3.1 GW of generation and storage capacity connected to SSEN's distribution network in the Southern England licence area[4]. Figure 3 illustrates the geographical distribution of key baseline technologies.

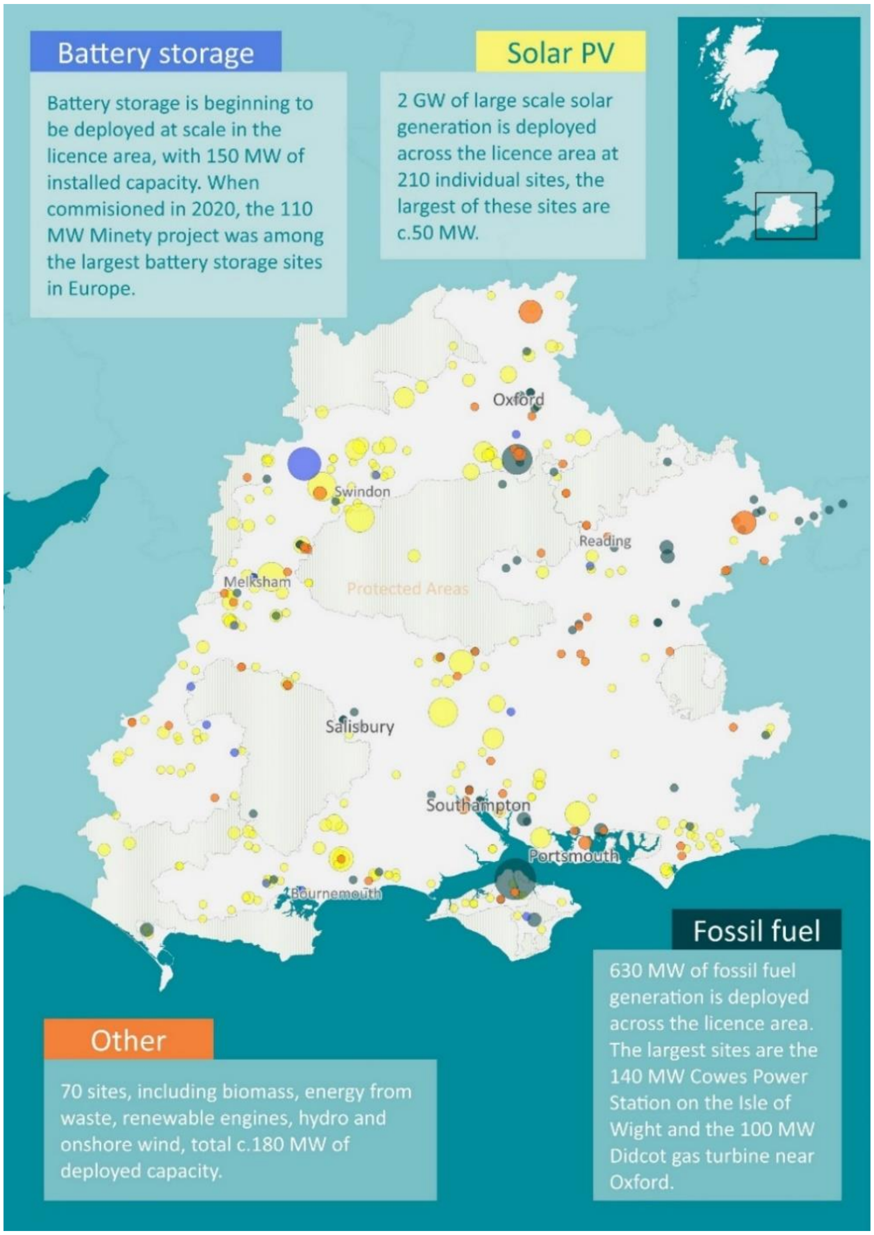

Figure 3 A map of the Southern England licence area and location of key baseline technologies

[4] Data correct as of August 2023 according to SSEN's connections database

Southern England licence area pipeline

There is 18 GW of generation and storage capacity that either has a connection agreement or an offer to connect to SSEN's distribution network[5]. Figure 4 illustrates the geographical distribution of key pipeline technologies.

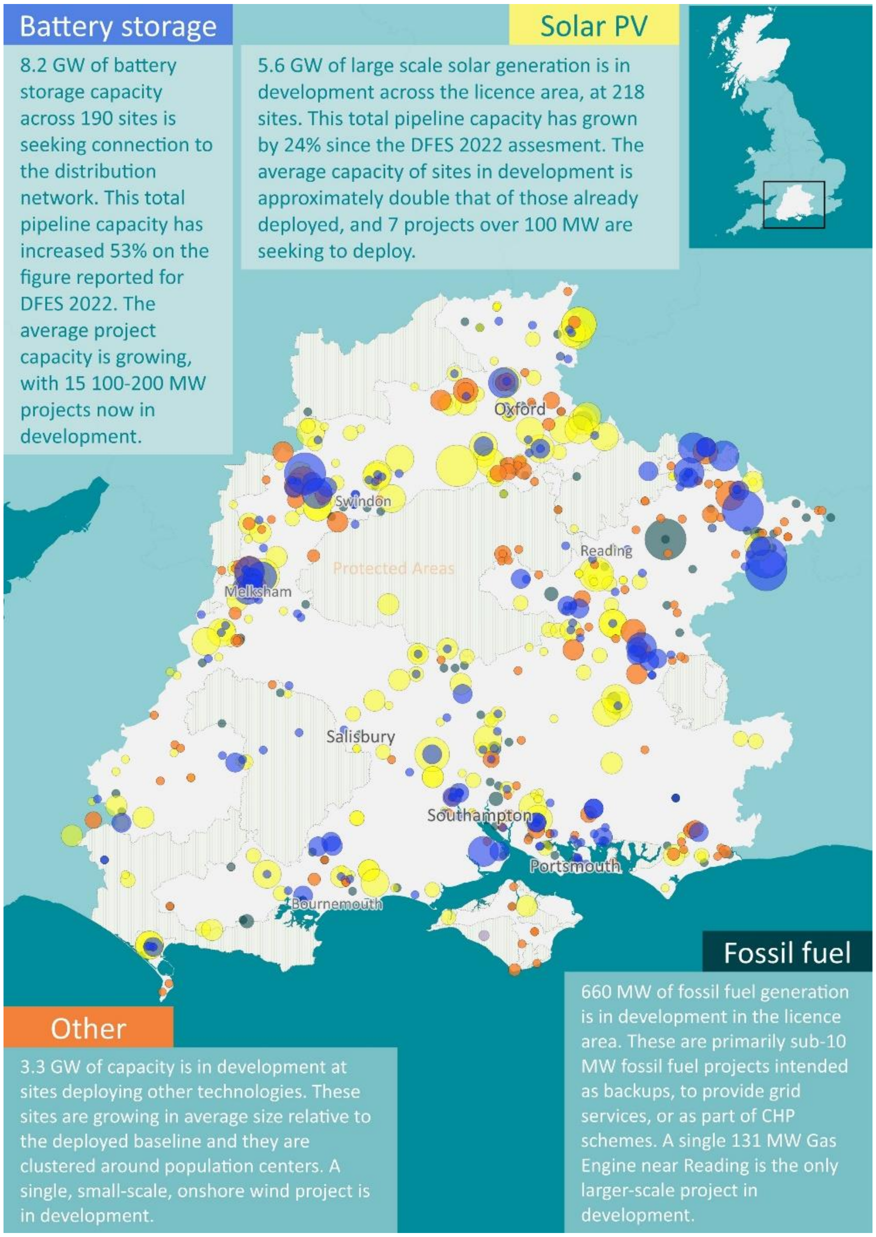

Figure 4 A map of the Southern England licence area and location of key pipeline technologies

[5] Data correct as of August 2023 according to SSEN's connections database

Southern England baseline technology summary

Renewable generation

Solar	Onshore wind	Marine	Hydropower
2.5 GW	12 MW	0 MW	2 MW

2.5 GW of solar capacity is already deployed at both domestic scale and large scale. There is low deployment of onshore wind, marine and hydropower across the Southern England licence area.

Waste and bioenergy generation

Biomass	Waste	Renewable engines
1 MW	142 MW	74 MW

Waste-driven energy generation makes up approximately 217 MW and takes several different forms. Of the three renewable engine sub-technologies, landfill gas contributes 31 MW, anaerobic digestion contributes 30 MW and sewage gas contributes 13 MW.

Fossil and gas generation

Diesel	Gas	Hydrogen generation
300 MW	332 MW	0 MW

There is a notable amount of fossil fuel generation in the Southern England licence area, with 632 MW of natural gas and diesel generation. Cowes Power Station, on the Isle of Wight, is the largest generation site connected to the distribution network in the licence area and is a 140 MW plant fuelled by marine gas oil.

Sources of demand | **Energy storage**

EVs	Heat pumps	Electrolysis	Batteries
158,000	33,000	0 MW	266 MW

The licence area's baseline electricity demand for heat is lower than other areas of the country, with more homes connected to the gas network, especially in dense urban areas such as Greater London, Swindon, Oxford and Southampton [6]. The uptake of low carbon technology in the licence area is starting to speed up with approximately 158,000 non-hybrid battery electric vehicles (EVs) registered in November 2023. In addition, 32,000 households and businesses have a heat pump installed.

Some unique aspects of the licence area include the shipping and marine industrial areas of Southampton and Portsmouth, as well as the island community of the Isle of Wight. The 110 MW Minety battery storage project, that is managed by Independent Distribution Network Operator (IDNO) Eclipse Power and was one of Europe's largest when it was deployed, continues to provide a large portion of the licence area's electricity storage capacity.

Figure 5 2023 baseline capacities for electricity distribution connected sources of energy generation, demand and storage in the Southern England licence area

[6] See Non Gas Map: https://www.nongasmap.org.uk/

The distribution network in Southern England in 2030 under Consumer Transformation

Renewable generation			
Solar 6.3 GW	Onshore wind 49 MW	Marine 20 MW	Hydropower 3 MW

Distribution network connected renewable generation capacity (solar PV, onshore wind, marine and hydropower) more than doubles from approximately 2.5 GW in 2023 to approximately 6.4 GW in 2030. Solar PV deployment accounts most of this projected increase in connected capacity, reflecting the strong solar resources in Southern England.

Waste and bioenergy generation		
Biomass 1.9 MW	Waste 280 MW	Renewable engines 102 MW

Waste and bioenergy generation capacity in Southern England increases from 217 MW in 2023 to 384 MW in 2030. Growth is driven by advanced conversion technology and some anaerobic digestion and sewage gas sites, yet incineration and landfill gas capacity decreases.

Fossil and gas generation		
Diesel 53 MW	Gas 454 MW	Hydrogen generation 0 MW

247 MW of unabated diesel generation decommissions, with 53 MW remaining by 2030. Fossil gas generation increases from approximately 332 MW in 2023 to 454 MW in 2030, driven largely by small-scale flexibility assets. There is no hydrogen generation forecast by 2030 in this scenario.

Sources of demand			
EVs 1.5m	Heat pumps 525,000	H_2 Electrolysis 19 MW	Data centres 957 MW*

The number of EVs registered increases significantly in all scenarios by 2030. 525,000 homes and businesses operate heat pumps by 2030. Hydrogen electrolysis begins to be deployed on the distribution network, with 19 MW in the licence area. Approximately 1 GW of **additional data centre demand* is projected, above the existing deployment.

Energy storage	New developments	
Batteries 2.9 GW	Domestic 186k	Non-domestic 4.7m
Battery storage capacity significantly increases from 266 MW in 2023 and reaches approximately 2.9 GW by 2030.	Up to 186,000 new houses could be built and just under 4.7m sqm of non-domestic floorspace developed by 2030.	

Figure 6 The distribution network in Southern England in 2030 (Consumer Transformation scenario)

The distribution network in Southern England in 2050 under Consumer Transformation

Renewable generation			
Solar 9.9 GW	**Onshore wind** 216 MW	**Marine** 85 MW	**Hydropower** 7 MW
Solar, wind, marine and hydropower generation capacity in the licence area is projected to increase to approximately 10.1 GW by 2050. Large-scale solar PV continues to be the dominant technology in the licence area, with 6.7 GW connecting to the network by 2050. There is further deployment of onshore wind in this scenario, with 217 MW connecting by 2050.			
Waste and bioenergy generation			
Biomass 1 MW	**Waste** 174 MW	**Renewable engines** 99 MW	
Waste and bioenergy generation capacity in Southern England decreases post 2030 to 274 MW. This is driven by decreasing use of landfill gas and rates of waste incineration.			
Fossil and gas generation			
Diesel 0 MW	**Gas** 0 MW	**Hydrogen generation** 353 MW	
No unabated diesel or fossil gas generation is operating on the system by 2050 under any net zero scenario, with generators being replaced with various alternative technologies (including biomass, biomethane, electricity storage and hydrogen-fuelled generation). Low-carbon hydrogen-fuelled generation capacity increases significantly by 2050 in the licence area, reaching approx. 353 MW.			
Sources of demand			
EVs 4.5m	**Heat pumps** 2.7 m	**Electrolysis** 310 MW	**Data Centres** 1.5 GW*
The number of registered EVs in the licence area accelerates by 2050. However, a general reduction in vehicle numbers by 2050 is seen in the net zero scenarios, driven by increased public transport use, higher average mileage, and the introduction of autonomous vehicles. The number of homes and businesses with a heat pump installed accelerates significantly to 2050 under all scenarios. **Additional data centre demand.*			
Energy storage		**New developments**	
Batteries 4.4 GW		**Domestic** 484k	**Non-domestic** 6.9m
Battery storage capacity continues to grow, driven by the need for ample flexibility within a high renewables system. 4.4 GW is deployed by 2050.		Up to 484,000 new houses could be built and just under 6,900,000 sqm of non-domestic floorspace developed by 2050.	

Figure 7 The distribution network in Southern England in 2050 (Consumer Transformation scenario).

2050 spatial deployment of low-carbon technologies under Consumer Transformation

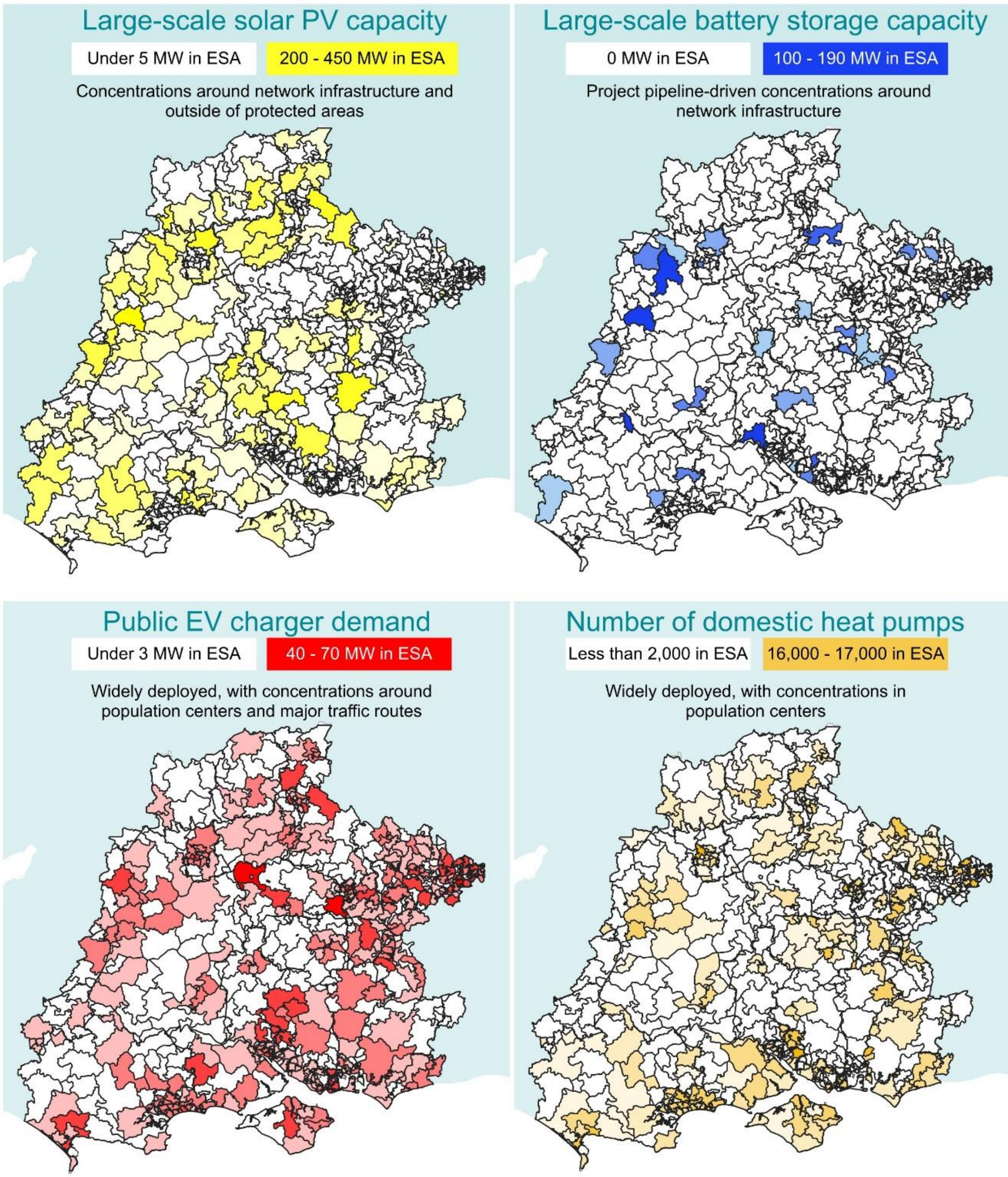

Figure 8 2050 deployment of key technologies in the licence area under a Consumer Transformation scenario

Key influential policy and targets for DFES 2023

Global events continued to impact the UK's energy market in 2023, including the ongoing Russian invasion of Ukraine, the conflict in Gaza and unprecedented extreme weather events. Despite this, the clean energy sector in the UK has continued to develop and build new projects over the last year.

2023 was the hottest year on record in human history[7] with extreme weather patterns seen all over the globe. COP28, in Dubai, resulted in significant commitments to a clean energy transition, with over 130 countries signing the 'Global Renewables and Energy Efficiency Pledge', agreeing to triple renewable energy capacity and double energy efficiency measures by 2030[8], as well as agreeing a roadmap to transition away from fossil fuels.

Steep rises in UK interest rates exacerbated the cost-of-living crisis and pressured consumers to reduce demand, whilst aggravating pre-existing fuel poverty issues. Although this has impacted the viability and choice of low-carbon technologies for some consumers, there has been a continued increase in the uptake of domestic solar PV and EVs across the country. This has driven increased demand on the UK's electricity distribution networks.

The UK government's 'Energy Security Day' in March 2023 brought in a total of almost 50 net zero and energy-related policy documents for the future of energy in the UK. New funding was announced for Carbon Capture and Storage (CCUS), nuclear and hydrogen as well as new oil and gas production in the North Sea. The government also opened applications for the £160m floating offshore wind (FLOW) manufacturing investment scheme to support FLOW to scale up to 5 GW by 2030. However, some previously launched policies were watered-down, including a delay to the ban on the sale of new internal combustion engine cars from 2030 to 2035.

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[7] https://climate.copernicus.eu/2023-track-be-hottest-year-ever-whats-next

[8] https://www.cop28.com/en/news/2023/12/COP28-Presidency-launches-landmark-initiatives-accelerating-the-energy-transition

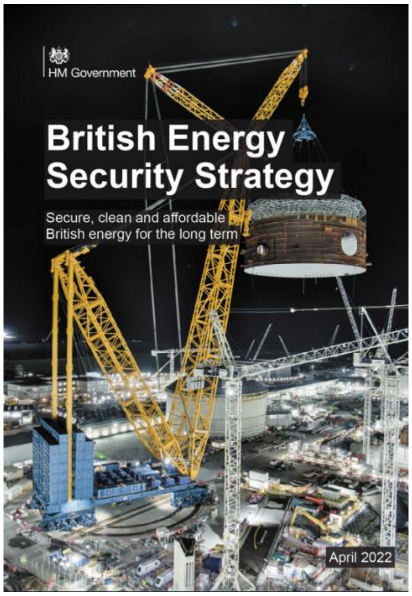
Towards the end of 2023, Ofgem also announced the creation of new regional energy planning organisations, Regional Energy Strategic Planners (RESPs), to support local-level energy planning, which will be overseen by the National Energy System Operator (NESO), formerly known as the Future System Operator (FSO). This new RESP body will have a significant role to play in local and regional energy network planning.

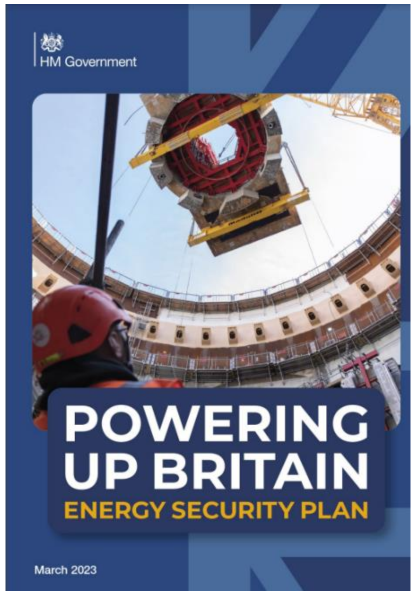
Government policy and its influence on DFES

There has been a continued political focus on energy in 2023, with the announcement of key policies, targets and regulatory reforms, as well as both regional and local government strategies that will impact the UK's energy system. These form key inputs into the DFES analysis and impact the technology projections on both a licence area level and a local level. Examples include:

- **National targets:** deployment targets in national policies are used as reference target figures for national deployment and uptake of specific technologies.
- **National policy:** broader energy policies and mechanisms have been used to justify scenario-specific assumptions for some technologies.
- **Local policy and targets:** local government strategies and targets have also been used to influence the spatial distribution of technologies.
- **Trade body recommendations and non-governmental plans:** for technologies where regulated government targets and ambitions were not available, policy recommendations on technology target setting from influential trade bodies have been reflected in net zero scenarios.

UK government policy highlights





The technology-specific ambitions from the 2022 publication of the **British Energy Security Strategy**.[9] and the closely related **Energy Security Plan**.[10] and **Net Zero Growth Plan**.[11] (both published in March 2023) have been reflected in the three DFES scenarios that are in line with net zero targets. These include targets of:

- 70 GW solar capacity by 2030.
- Up to 50 GW offshore wind by 2030, of which 5 GW is floating wind.
- 10 GW of low-carbon hydrogen, of which 5 GW is produced through electrolysis.
- Up to 1 GW electrolytic 'green' hydrogen operational or in construction by 2025.
- 600,000 heat pumps per year by 2028.
- As many fuel-poor homes as reasonably practicable achieve EPC C by 2030.

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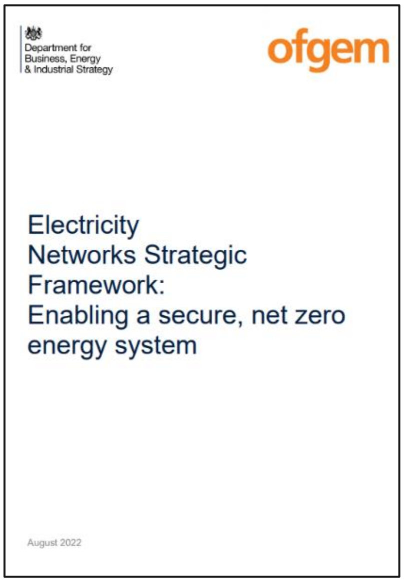
[9] https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy

[10] https://assets.publishing.service.gov.uk/media/642708eafbe620000f17daa2/powering-up-britain-energy-security-plan.pdf

[11] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1147457/powering-up-britain-net-zero-growth-plan.pdf


Department for Business, Energy & Industrial Strategy

ofgem

Electricity Networks Strategic Framework: Enabling a secure, net zero energy system

August 2022

Published in 2022, the **Electricity Network Strategic Framework**[12] outlined plans to develop the FSO and ensure adequate infrastructure is in place to meet the needs of an increasingly decentralised electricity system. The strategic framework included ambitions to remove barriers to grid flexibility via digitalisation and unlock infrastructure development through reformed planning and consenting.

The role of the system operator will be a crucial part of the transition to a net zero power system, and in November 2023, the UK government announced the decision to develop a **RESP** to sit within the FSO. The ambition for the RESP is to work with both the electricity and gas networks, local authorities and wider stakeholders to better enable strategic, whole-system planning of the energy system at a regional level to ensure the inclusion of local needs and ambitions.

The DFES analysis has been using net zero strategies and specific technology targets from local authorities to inform the scenario projection analysis for many years. The announcement of the RESP is a positive step, recognising the importance of local and regional energy planning and how it should work in-tandem with electricity network planning.The implementation of Ofgem's **Access and Significant Code Review**[13] has reduced overall connection charges and introduced non-firm contracts to unlock connections in congested areas of the networks. From April 2023, connection charges for network reinforcement were removed for demand customers and reduced for generation connections. It is likely that these reduced upfront connection costs will accelerate the deployment of some low-carbon technology projects. The implementation of the Access and Significant Code Review has been incorporated into the DFES analysis. More broadly, the allocation of distributed technologies has been modelled in congested ESAs under the three net zero scenarios, reflecting an assumption that this reform will mitigate grid congestion issues in the longer term.

[12] https://www.gov.uk/government/publications/electricity-networks-strategic-framework

[13] https://www.ofgem.gov.uk/publications/access-and-forward-looking-charges-significant-code-review-decision-and-direction

2023 was the first year of the five-year RIIO-ED2 price control period and sees SSEN continue to evolve its **Distribution System Operator (DSO)** capabilities. SSEN has published its 2022 DSO strategy and action plan and subsequently its **DSO acceleration strategy and action plan**[14] in October 2023.

Local Area Energy Plans (LAEPs), led by local authorities, set out the ambitions and resources required to facilitate net-zero energy at a local level. There is not currently a statutory duty for local authorities to produce LAEPs. Of those local authorities who responded to the local energy strategy survey (see page 23), four local authorities across SSEN's two licence areas have LAEPs already in place and a further nine local authorities are in the process of developing a LAEP[15]. DFES analysis seeks to make use of the disclosures in the LAEPs, including specific decarbonisation targets, technology deployment ambitions and regional zoning.

Over the past three years, SSEN has developed the **Local Energy Net Zero Accelerator**[16] (LENZA) tool to assist local authorities in developing LAEPs. LENZA is a geospatial software

[14] https://www.ssen.co.uk/globalassets/about-us/dso/dso-action-plan/ssen-dso-strategy-2023.pdf

[15] These figures refer only to the responses received by Regen from local authorities to the Local Energy Strategy Survey as part of the DFES 2023 analysis.

[16] https://www.ssen.co.uk/our-services/tools-and-maps/lenza/

platform, based on Advanced Infrastructure Technology Ltd's LAEP+ tool. It provides network constraint data to inform local authority planning decisions for the development of new energy assets, both generation and demand. In the future, LENZA may be able to help provide inputs to the DFES process, supporting improved forecasting capability.

A significant number of additional policies were reviewed, analysed and incorporated into the DFES analysis for each of the relevant technology models. Details of these technology-specific policies and targets can be found in each of the technology summary chapters (page 44 onwards in this report).

As can be seen in the technology analysis section of this report, the pipeline of contracted projects (mainly prospective solar and battery storage sites) in SSEN has significantly grown in recent years. This is common across the UK and has created a significant connection queue and a potentially detrimental delay on progress to net zero. Off the back of industry responses to this queue, **reforms to the electricity network connections process** have been outlined by the Energy Networks Association and National Grid ESO, and endorsed by Ofgem. These reforms have begun to be implemented, with Ofgem and National Grid ESO working with UK government and across industry to accelerate the process, with an emphasis on 'first ready, first connected' for sites with contracted connections. The Energy Networks Association has published a three-step plan to speed up connections to the grid[17] and National Grid ESO has also launched a five-point plan of "tactical initiatives to help improve the connections process in the short-term"[18]. One of the objectives within National Grid ESO's five-point plan is to accelerate the connections for energy storage projects, recognising the value that storage brings to the system in times of high demand, by issuing non-firm connection offers to battery sites. As these reforms are still very new, the impact on the connection queue in SSEN's licence area and across GB has not yet been realised. In DFES 2023, Regen and SSEN have opted to directly reflect current Statement of Works reinforcement timelines (where known) under the Falling Short scenario, but it is very likely that the connection pipeline will evolve when DFES 2024 analysis is undertaken, with a number of 'shovel ready' contracted projects moving up the queue and a number of more prospective or dormant sites falling away from the connection pipeline.

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[17] https://www.energynetworks.org/newsroom/energy-networks-launch-action-plan-to-accelerate-grid-connections

[18] https://www.nationalgrideso.com/industry-information/connections/our-five-point-plan

Stakeholder engagement

The DFES analysis incorporates a wide variety of evidence and data inputs. Although based on four national energy scenarios, the DFES is intended to assess future energy scenarios at a regional, sub-regional and local level. Therefore, the analysis is heavily influenced by what is connected today, an assessment of known pipeline projects and stakeholder consultation. To inform the SSEN DFES 2023 analysis, the project team has engaged with a wide range of stakeholders through several different approaches, which include:

Stakeholder engagement for DFES 2023	
	**Interactive online webinars for each licence area,** held in October 2023, where a broad range of regional and energy sector stakeholders were asked their views about the future of energy technologies in their area. In these sessions, SSEN summarised how the DFES outputs are used to inform longer-term network planning. Regen made use of online polling platform Menti to capture both qualitative feedback and quantitative data from stakeholders around specific technology sectors in the relevant licence area.
	An **online data exchange for new developments** was established, liaising with the planning departments of the local authorities within SSEN's licence areas. This data exchange enabled Regen to directly engage with local authority planning and housing teams to gain up-to-date information on domestic property developments (of 100 houses or more in scale) and non-domestic developments (which includes plans for new supermarkets, offices, airports etc.).

An updated **local energy strategy questionnaire** was prepared for 2023 and shared with the environmental and city planning teams for the local authorities across SSEN's two licence areas.

The responses and accompanying documentation received from local authorities included individual council plans and ambitions for zero emissions targets, renewable energy development, low-carbon transport, low-carbon heat, waste collection, hydrogen and LAEPs. These responses and documents were used to inform the spatial distribution factors for scenario projections for relevant technologies.

Technology and sector-specific interviews were conducted with project developers, technology companies and other sector representatives to inform the modelling of pipeline projects and test assumptions made about specific sectors or technologies.

Engagement webinars

Southern England licence area webinar

Regen worked with members of the SSEN team to host interactive stakeholder engagement webinars in October 2023 to collect views and feedback to inform the DFES analysis. These collaborative sessions sought to:

- Provide a summary of the background, method and purpose of the DFES.
- Road-test assumptions around technology capacity growth and locational distribution factors that determine the scenario projections.
- Tap into local sector knowledge, insights and ambitions relevant to the licence area.
- Discuss views and insights on new or disruptive future technologies and how they may impact the electricity network in the licence area.

The **Southern England regional webinar** brought together representatives from local authorities, community energy groups, project and technology developers and other sector-specific representatives. The webinar had 99 on-the-day attendees and over 130 people registered to attend, who all received copies of the presentation material from the event. This year, the largest proportion of stakeholders was from the 'local authority and government' sector.

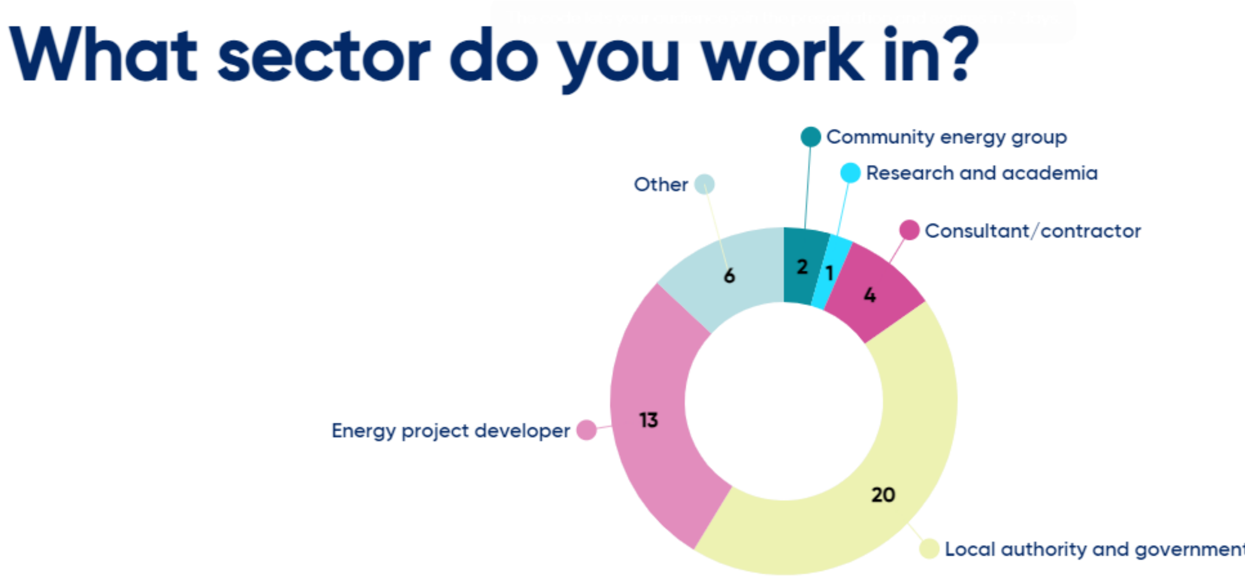

Figure 9 Extract from the Southern England regional webinar showing the industry sector of attendees

In addition to an overview of the DFES methodology, an introduction to each of the key technology areas was given. This included low-carbon demand sources (i.e. heat and transport), renewable generation and energy flexibility (i.e. battery storage and hydrogen). For each technology area, Regen presented:

- An overview of the technology.
- Relevant policy updates.
- Deployment projections for each technology in the licence area.
- A series of technology-specific interactive polling sessions using the online voting and live visualisation platform Menti.[19] to gather both quantitative and qualitative stakeholder feedback that was subsequently used to inform and modify the DFES analysis.

[19] See https://www.menti.com/ and https://mentimeter.com/

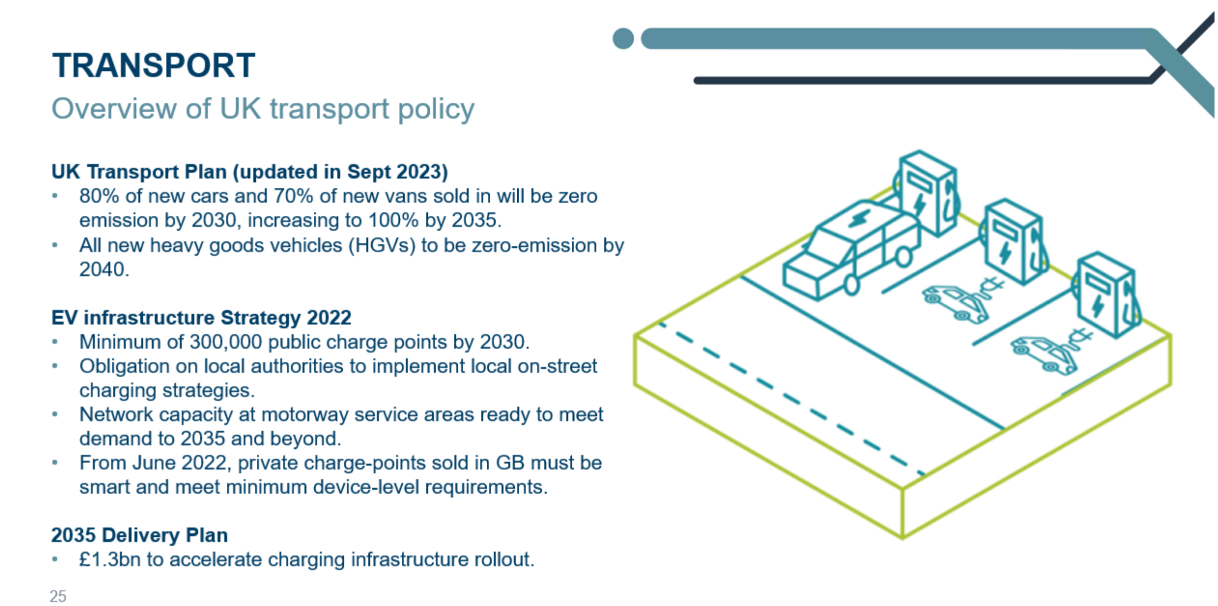

Figure 10 Extract from the Southern England regional webinar showing an overview of UK transport policy

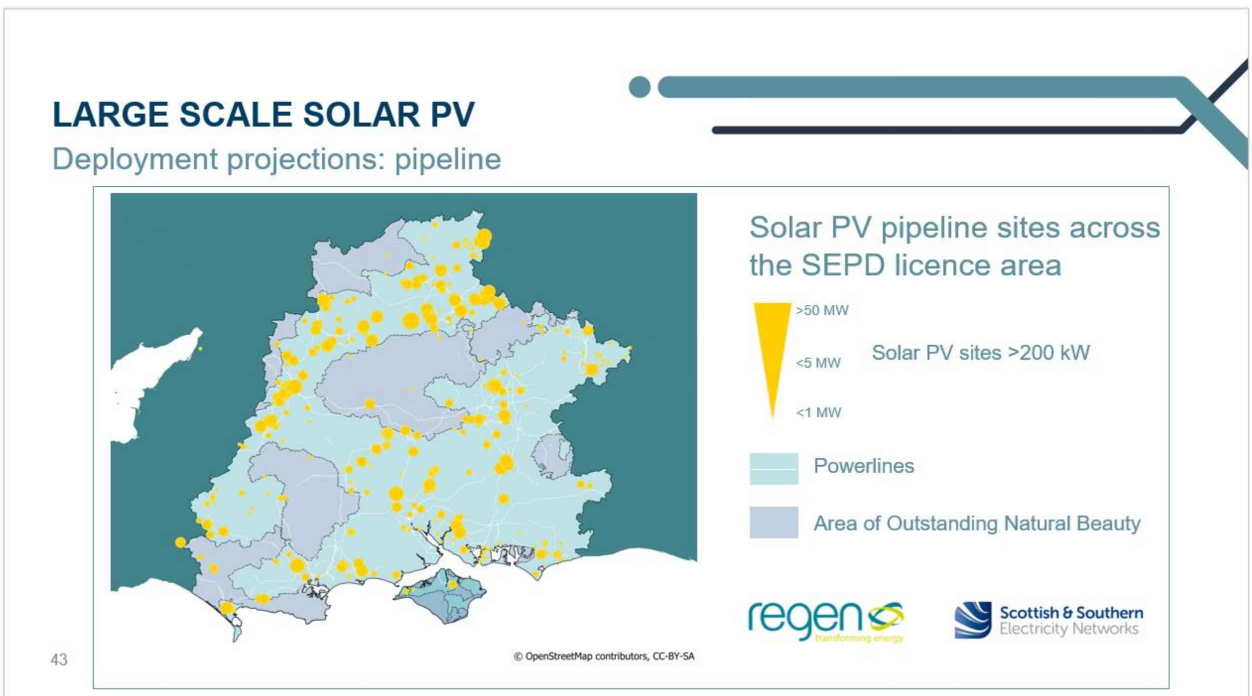

Figure 11 Extract from the Southern England regional webinar showing the projected growth of solar PV across the licence area

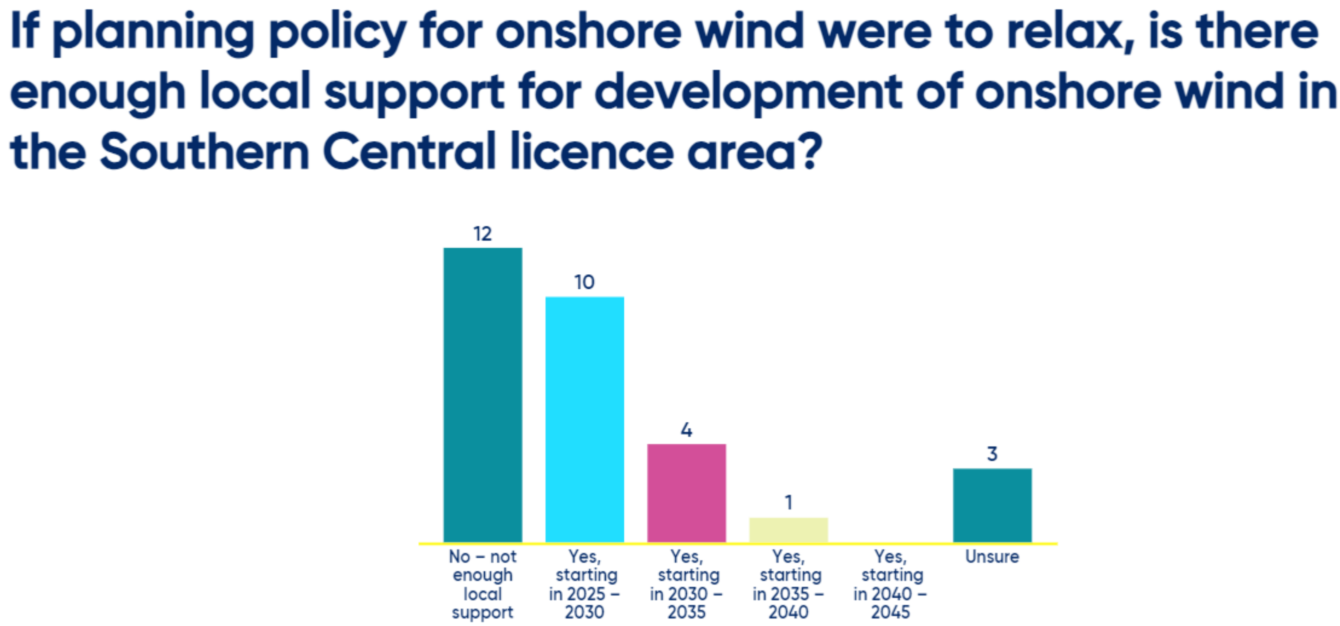

Figure 12 Extract from the Southern England regional webinar showing the quantitative feedback stakeholders gave in answer to a question about onshore wind planning policy

Local authority engagement

To further inform DFES 2023, the analysis team collected data from local authority planning departments in SSEN's Southern England licence area via an online data exchange. This focused on two elements: details of planned domestic and non-domestic new developments and a local energy strategy survey.

New developments

Regen liaised with the planning departments of local authorities within the Southern England licence area and specifically sought to update the registers of:

- **Planned new houses:** limited to strategic housing developments of 100 houses or more.
- **New non-domestic developments (measured in sqm)**: categorised by eight commercial and industrial development archetypes which are: office, retail, factory and warehouse, hospital, hotel, medical, restaurant, school and college, university, sport and leisure and other.

Local energy strategy survey

As with previous years, Regen issued a local energy strategy survey to the environmental and climate change project teams within each of the local authorities. For DFES 2023, three new questions were added to this survey, seeking information on whether local authorities had used DFES modelling before and what elements of the data they found useful, as well as a question about the support that is available for low-income households to adopt low-carbon technologies. All responses and document links received were used to influence and evidence the spatial distribution of individual technology projections in this year's DFES.

A summary of the 2023 responses to the local energy strategy survey questions can be seen in Figure 14 and Figure 15. A total of 30 local authorities responded to the survey in the Southern England licence area. This information was used as a key input for the DFES analysis and spatial distribution.

Your local authority's energy strategies - 2023

Questionnaire

SSEN prepares for changing demands by regularily constructing energy scenarios. The questions below on transport, heat, renewable energy, waste collection, hydrogen and emissions ambitions, helps feed local plans and ambitions into these energy scenarios so the networks can be ready for the new demands.

Click here for an example of last year's DFES report

Instructions: Use the *Yes/No* drop downs to answer the questions. Where the answer is **Yes**, please fill in the applicable additional information using the drop down, notes, geographical reference, document link, and publication year. Alternatively, just put N/A. You may not have planning jurisdication over all of the below factors so please just answer the questions where you do have planning powers.

Any questions? Please contact:

ssennewdevs@regen.co.uk

1a	Do you have a **transport** strategy or a low-carbon transport strategy in your area?	Yes/No	--Select transport strategy priority--
b	Do you have plans for the installation of public electric vehicle charge points?	Yes/No	--Select EV charger priority--
c	Do you have any requirements for EV charge points in planning for new developments?	Yes/No	please provide details -->
2a	Do you have a **heat** strategy or low-carbon heat strategy in your area?	Yes/No	--Select priorities for decentralised heat--
b	Do you have plans to expand or build new district heat networks?	Yes/No	--Select heat source technology--
3a	Do you have a **renewable energy** strategy in your area?	Yes/No	--Select technology type--
b	Have you set a renewable energy capacity or other target?	Yes/No	please provide details -->
c	Have you allocated areas in your local plans for renewables?	Yes/No	please provide details -->
4	Do you have a **waste collection** strategy in your area?	Yes/No	--Select food waste collection status--
5	Do you have a **hydrogen** strategy in your area?	Yes/No	--Select technology type--
6	Do you have **zero emissions** ambitions or plans for your area?	Yes/No	--Select best description of publication--
7	Do you have a Local Area Energy Plan **(LEAP)**?	Yes/No	please provide details -->
8	Have you used SSEN's annual DFES modelling in your local net zero planning processe	Yes/No	If you have, please share details about how it has informed your planning processes -->
9	What do you find to be the most useful data that the DFES captures (eg projected EV numbers, heat pumps, large scale energy storage, projected large and small scale renewable capacity etc)		answer here-->
10	Do you have any retrofit or low carbon technology rollout programmes in your area that consider or target low income households or vulnerable areas?	Yes/No	If so – could you provide details of where, and for which technology(ies) -->

Figure 13 Survey extract from the 2023 local energy strategy survey

Y	= Yes, a strategy **is** in place	N	= No, a strategy **is not** in place	ID	= A strategy is **in development**

* Blank entries indicate **no response** from the Local Authority to the question.

Local Authority	**Transport strategy**	**Public EV charger plans**	**EV charging in new developments**	**Heat strategy**	**Heat networks**	**RE strategy**	**RE targets**	**Development areas**
BCP	N	Y	Y	ID	ID	ID	ID	ID
Buckinghamshire	Y	Y	Y	N	N	ID	N	N
Basingstoke and Deane	Y	Y	ID	N	N	N	N	ID
Bracknell Forest	Y	Y	Y	N	N	N	N	N
Cherwell	Y	Y	ID	ID	ID	ID		N
Dorset	Y	Y	ID	ID	ID	ID	ID	ID
East Hampshire	Y	ID	ID	ID	N	ID	ID	N
Eastleigh		Y		N		N	N	N
Fareham	ID	Y	N	N	N	N	N	N
Gosport	Y	ID	Y	N	N	N	N	N
Guildford	Y	N	Y	N	Y	N	Y	N
Hart		Y	Y	N	ID	N	N	N
Hillingdon	Y	Y	Y	N	N	N	N	N
Isle of Wight	Y		Y	ID	N	ID	ID	N
Mendip*			N	N	N	ID	ID	ID
New Forest	Y	Y	Y	N	N	N	N	N
Oxford	Y	Y	Y	Y	N	N	N	N
Portsmouth	Y	Y	N	N	N	Y	N	N
Reading	Y	Y	Y	Y	Y	Y	N	N
Runnymede	Y	Y	Y	ID	ID	ID	N	N
Rushmoor	N	ID	N	N	N	ID	N	N
Slough	Y	Y	Y	N	Y	N	Y	N
South Oxfordshire	Y	Y	Y		N		ID	ID
South Somerset*	ID	N	Y	N	N	ID	ID	N
Southampton	Y	Y	ID	N	Y	N	ID	N
Surrey Heath	N	Y		N	N	N	N	N
Test Valley	Y	ID	Y	N	ID	N	N	ID
Vale of White Horse	Y	Y	Y		N		ID	ID
Waverley	Y	Y	Y	N	N	N	N	N
West Berkshire	Y	Y		N		N	Y	N
West Oxfordshire	Y	Y	ID	ID	ID	ID	ID	N
Wiltshire	Y	Y						
Wokingham	Y	Y	Y	N	N		ID	ID

* South Somerset and Mendip have now been merged into the 'Somerset' local authority

Figure 14 Summary of the 2023 local energy strategy survey responses

(Note: This is not a complete list of the local authorities in the Southern England licence area. This table only shows the local authorities who responded to the survey as part of the 2023 DFES stakeholder engagement.)

Y	= Yes, a strategy **is** in place	N	= No, a strategy **is not** in place	ID	= A strategy is **in development**

* Blank entries indicate **no response** from the Local Authority to the question.

Local Authority	Waste collection	Hydrogen strategy	Emissions target	Local Area Energy Plan	DFES used in planning	Vulnerable households scheme
BCP	Y	N	N	ID	ID	ID
Buckinghamshire	Y	N	Y	N	N	Y
Basingstoke and Deane	Y	N	Y	N	N	N
Bracknell Forest	N	N	Y	N	N	Y
Cherwell		N	ID	ID	N	Y
Dorset	Y	ID	Y	N	Y	Y
East Hampshire	ID	N	ID	N	N	Y
Eastleigh		N				Y
Fareham	N	N	N	N		N
Gosport	Y	N	Y	N	N	N
Guildford	Y	N	Y	N	N	Y
Hart	Y	N	N	N	N	ID
Hillingdon	N	N	Y	Y	Y	N
Isle of Wight	Y	N	Y	N	N	Y
Mendip*	Y	N	Y	ID	Y	Y
New Forest	Y	N	ID	N	N	ID
Oxford	Y	N	Y	ID	Y	Y
Portsmouth		Y	N	N		
Reading	Y	N	Y	N	N	Y
Runnymede	Y	N	Y	N	N	
Rushmoor	Y	N	Y	N	N	Y
Slough	Y	N	Y	N	N	Y
South Oxfordshire	Y	N	Y	ID	N	
South Somerset*		N	Y	N	Y	N
Southampton	N	Y	Y		N	Y
Surrey Heath		N	Y			Y
Test Valley	ID	N	ID	N	N	Y
Vale of White Horse	Y	N	Y	ID	N	Y
Waverley	Y	N	Y	N	N	N
West Berkshire	Y	N	Y	Y		Y
West Oxfordshire	ID	N	Y	ID	ID	
Wiltshire	Y		Y	N		
Wokingham	iD	N		N		Y

* South Somerset and Mendip have now been merged into the 'Somerset' local authority

Figure 15 Summary of the 2023 local energy strategy survey responses

(Note: This is not a complete list of the local authorities in the Southern England licence area. This table only shows the local authorities who responded to the survey as part of the 2023 DFES stakeholder engagement.)

Targeted sector and development engagement

The Regen project team also engaged directly with individual energy project developers and sector representatives to better understand their plans and ambitions for each of the technology sectors included in the DFES analysis. This engagement included:

- Email exchanges with project developers holding contracted connection offers with SSEN for individual generation or storage projects. Developers were asked about their development progress and timelines. Responses received were used to inform future connection timelines for individual sites, under each of the scenarios.
- Interviews with technology companies, including emerging and innovative technology sectors.

<table>
<tr><th colspan="4">Direct stakeholder feedback</th></tr>
<tr><th>Engagement</th><th>Technology sector</th><th>Organisation engaged</th><th>Summary of input/feedback</th></tr>
<tr><td rowspan="4">Engagement in DFES 2023</td><td>Solar PV</td><td rowspan="3">Dundee City Council, Solar Investment Company Ltd., Wessex Solar Energy and Low Carbon UK, NEScol, Whirlwind Renewables, ESB, Orkney Community Wind, Bluestone energy, Gridserve, Cambridge Power and Voltis.</td><td rowspan="3">Engagement on project-specific status and planned construction and energisation dates. A total of 25 sites have had deployment assumptions informed by developer engagement in DFES 2023. This included information about delays or cancellations, as well as projects that are currently in construction.</td></tr>
<tr><td>Battery storage</td></tr>
<tr><td>Onshore wind</td></tr>
<tr><td>Offshore / marine generation</td><td>Isle of Wight representatives and EMEC (project partner of Perpetuus</td><td>Feedback provided was used to inform the scenario projections for marine energy generation support and build-out timelines.</td></tr>
</table>

		Tidal Energy Centre - PTEC).	
	Hydrogen electrolysis	Storegga, ZeroAvia, Protium, IAAPS and Hyppo.	Regen gathered input from organisations that had published plans for hydrogen projects to request an update on progress. Protium and IAAPS have successfully completed electrolyser projects. The other organisations were at the planning phase with their projects.
	Fossil gas and hydrogen-fuelled generation	Mercia Power Response, Conrad Energy, DESNZ	Developers provided insights into their long-term approach for decarbonising their fossil sites (including switching to battery storage, hydrogen or CCUS). DESNZ provided an update on policy thinking, in particular that its focus is on sites in industrial cluster zones.
Previous engagement that has applied to DFES 2023	**Solar PV** **Battery storage** **Onshore wind**	Innova/Novus, BNRG, Wessex Solar Energy, Aura Power, Solar2, Roadnight Taylor, Grey Associates, Constantine Wind Energy and Boralex	Engagement on project status and planned deployment dates from previous years' DFES was also carried forward. A total of 27 sites have had deployment assumptions informed by engagement with developers in DFES 2022.
	Hydropower	British Hydropower Association	The British Hydropower Association was engaged to confirm resource assessment

			and projection numbers from FES 2022. The engagement confirmed that hydropower highly depends on funding mechanisms and developments in micro-/pico-scale schemes. Feedback influenced the assumption of growth to micro-/pico-scale projects contributing to growth under the Consumer Transformation scenario.
	Hydrogen electrolysis	Storegga	A discussion of hydrogen business models in 2022 revealed that the long-term direction of electrolysis may be prioritised towards large-scale transmission-connected projects and small-scale distribution-connected projects may be more prominent in the near-term.
	Liquid Air Energy Storage (LAES)	Highview Power	Previous engagement with Highview Power highlighted that the location of LAES plants in the Southern England licence area could be based on a potential to co-locate with large-scale renewable energy generation sites or large-scale data centres, due to cooling demand.

Table 1 Summary of sector specific engagement undertaken to inform DFES 2023

Further detail of the sector- and technology-specific engagement undertaken, the feedback received and how it was applied to the DFES modelling can be found in each of the technology summary chapters included in this report. In addition, the Regen project team have continued to engage with the National Grid ESO FES team both as part of the launch of FES 2023 and throughout the ongoing analysis, to discuss and share modelling assumptions and market intelligence.

DFES methodology

The DFES analysis projects the capacity of distribution network connected sources of energy generation, demand and storage across the licence area. The DFES methodology comprises five key areas:

Stage	Description
1	The **technologies** that are in the scope of the future scenario analysis.
2	The **scenario framework** that defines the overarching societal, technological and economic 'worlds' that the DFES scenario projections sit within.
3	The **stakeholder engagement evidence and input** that is used as direct inputs into the scenario modelling.
4	The **analysis stages** undertaken for each technology when developing and modelling scenario projections.
5	The **geographical distribution** of the projections to sub-regional (11 kV substation) or local LV levels.

Table 2 Summary of DFES methodology

Technologies in scope

The scope of the DFES analysis covers technologies and load sources that directly connect to SSEN's electricity distribution network assets in Southern England. The DFES analysis does not include projections for technologies directly connected to the transmission network.

Technology class	Description
Electricity generation technology classes	• **Renewable energy generation technologies:** solar PV, onshore wind, offshore wind, hydropower and marine. • **Waste and bio-resource electricity generation technologies:** biomass, landfill gas, sewage gas and anaerobic digestion from food waste and other feedstocks. • **Fossil fuel electricity generation technologies:** diesel and natural gas-fuelled generators.
Electricity storage technology classes	• **Battery storage: g**rid-scale, commercial and domestic battery storage asset classes. • **Liquid Air Energy Storage (LAES), a**lso referred to as cryogenic energy storage: demonstrator-scale LAES plants connecting to the distribution network.
Future disruptive sources of electricity demand	• **Electric vehicles (EVs)**: cars, vans, motorbikes, LGVs, HGVs and buses. • **EV chargers**: on-street for domestic properties, off-street domestic, car parks, destination, workplace, fleet/depot, en-route local and en-route national. • **Electricity-fuelled heating and cooling technologies:** air source and ground source heat pumps, hybrid heating, direct electric heaters and domestic air conditioners. • **Hydrogen electrolysers.** • **Data centres.** • **New properties:** strategic housing developments as well as new commercial and industrial developments.

Table 3 Summary of technologies in scope of DFES 2023

The National Grid ESO Future Energy Scenarios 2023 framework

The 2023 DFES analysis has continued to use and reconcile to the National Grid ESO Future Energy Scenarios 2023[20] (FES 2023) as the assessment's overarching scenario framework. This framework also provides:

- National system-wide and technology sector-specific assumptions, some that vary by scenario.
- National and, where available, regional projections to reconcile DFES projections against.
- Technology and sub-technology definitions, using industry-standard 'Building Block' definitions.

The FES 2023 scenario framework is based on two key axes: speed of decarbonisation and level of societal change, as seen in Figure 16.

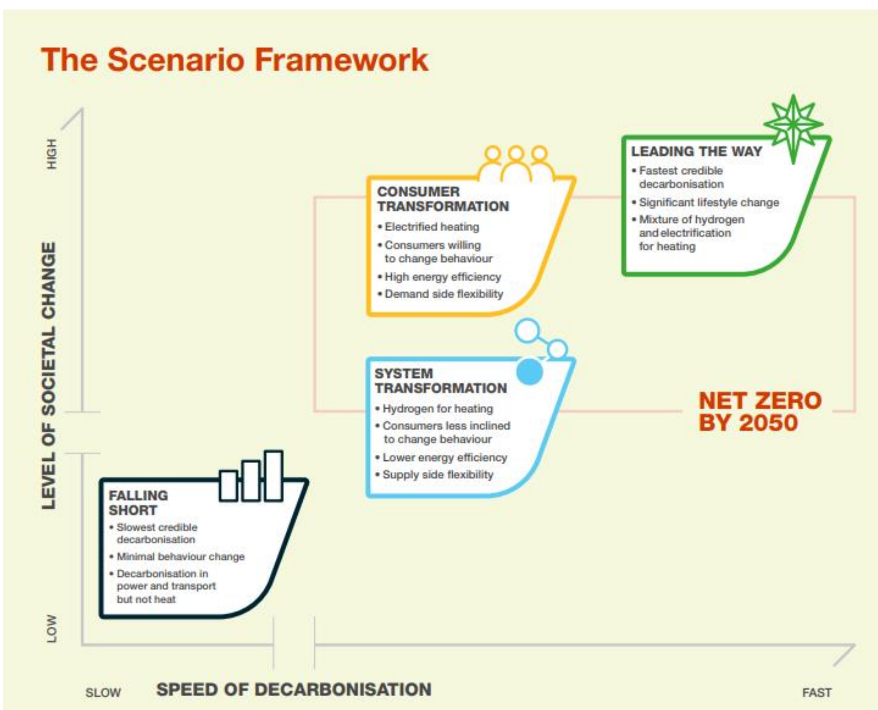

Figure 16 FES 2023 scenario framework (source: National Grid ESO)

[20] National Grid 2023, Future Energy Scenarios 2023 https://www.nationalgrideso.com/future-energy/future-energy-scenarios-fes

For some technologies, the DFES and FES projections are well aligned in the near, medium, or even long term. However, other aspects of the energy system have very different outcomes between the DFES and FES analyses. A description of each of the scenarios can be found in Table 4. The technology summary chapters within this report also outline specific scenario variances seen under each technology and how the DFES applies to them. Where available, FES 2023 Grid Supply Point (GSP) projection data has been used to complete an SSEN DFES 2023 to FES 2023 reconciliation. Regional building blocks were sometimes unavailable or not directly comparable due to sub-technology classifications. In these cases, national FES 2023 projections have been used to undertake a higher-level reconciliation.

Consumer Transformation The net zero target is met in 2050 with measures that have a greater impact on consumers and is driven by higher levels of consumer engagement. They will have made extensive changes to improve their home's energy efficiency and most of their electricity demand will be smartly controlled to provide flexibility to the system. A typical homeowner will use an electric heat pump with a low temperature heating system and EV. The system will have higher peak electricity demands managed with flexible technologies including energy storage, Demand Side Response (DSR) and smart energy management.	**Leading the Way** The net zero target is met by 2046. We assume that GB decarbonises rapidly with high levels of investment in world-leading decarbonisation technologies. Our assumptions in different areas of decarbonisation are pushed to the earliest credible dates. Consumers are highly engaged in reducing and managing their own energy consumption. This scenario includes more energy efficiency improvements to drive down energy demand, with homes retrofitted with measures such as triple glazing and external wall insulation, and a steep increase in smart energy services. Hydrogen is used to decarbonise some of the most challenging areas such as some industrial processes, produced mostly from electrolysis powered by renewable energy.
System Transformation The net zero target is met in 2050. The typical domestic consumer will experience less change than in Consumer Transformation as more of the significant changes in the energy system happen on the supply side. A typical consumer will use a hydrogen boiler with a mostly unchanged heating system and an EV or a fuel cell vehicle. They will have had fewer energy efficiency improvements to their home and will be less likely to provide	**Falling Short** This scenario does not meet the net zero by 2050 target. There is still progress on decarbonisation compared to today, however it is slower than in the other scenarios. While home insulation improves, there is still heavy reliance on natural gas, particularly for domestic heating. EV take-up grows more slowly, displacing petrol and diesel vehicles for domestic use. Decarbonisation of other vehicles is slower still with continued reliance on diesel for

flexibility to the system. Total hydrogen demand is high, mostly produced from natural gas with CCUS.	HGVs. In 2050 this scenario still has significant annual carbon emissions, short of the 2050 net zero target.

Table 4 National Grid ESO FES 2023 scenario descriptions (source: National Grid ESO)

DFES analysis stages

The SSEN DFES analysis follows a four-stage process where, for each of the technologies in scope:

1. The **historic deployment** is investigated and the **existing baseline** of operational or connected projects is established. This assessment defines the baseline year as the end of the 2022 calendar year.
2. The **near-term development pipeline** is then assessed by reviewing projects with network connection offers with SSEN or planning applications with the relevant local authority. For technologies with strong pipeline evidence, the range of outcomes across the scenarios may be quite narrow in the near term.
3. **Medium- and long-term projections** are then modelled under each scenario out to 2050. Depending on the technology, a much higher variation can be seen across the four scenarios over the 2030s and 2040s.
4. Annual licence area projections of either MW of capacity (e.g. of onshore wind) or the number of units (e.g. of heat pumps) are then **geographically distributed** across the licence areas. More detail on the nature and granularity of this spatial distribution is outlined below.

Some scenario variations can increase over time and may depend on the technology. This results in a widening of the projected outcomes across the four scenario results by 2050, see Figure 17.

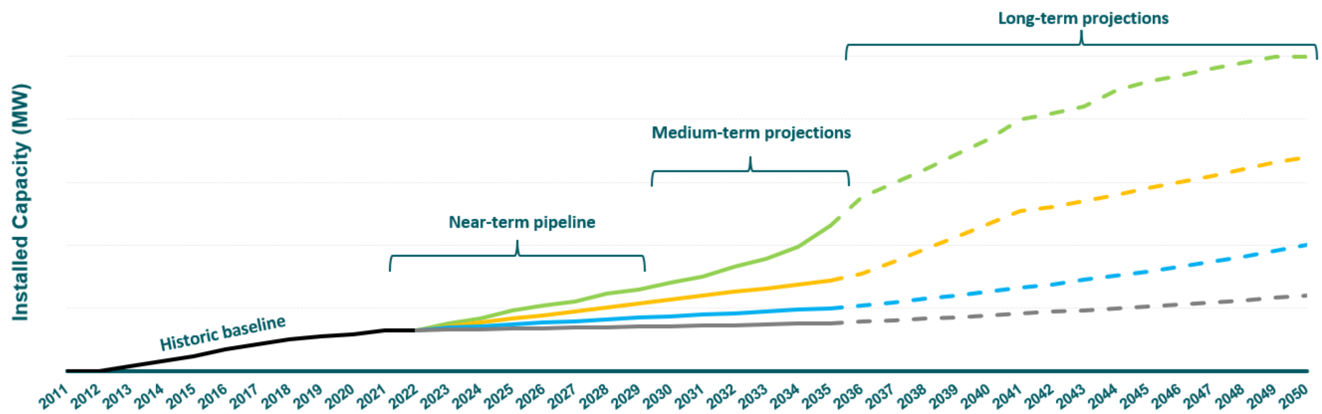

Figure 17 Illustrative stages of DFES scenario analysis

Technology and scenario uncertainty

In the near term, DFES projections are heavily based on analysing known pipeline projects and new developments. Projects are researched using SSEN's connection database, national and local planning portals, Capacity Market auction registers and direct discussions with project developers, sector representatives and other regional and national stakeholders.

Over the medium and longer term, projections reflect the underlying systemic, technological and societal scenario assumptions defined for each technology within the FES framework. This is augmented by levels of certainty provided by, for example, regional and national policies. Adopting legally binding net-zero emissions targets and government energy and net-zero strategies clarifies future energy pathways.

The key assumptions made in this analysis include:

- Distributed renewable energy generation capacity will continue to significantly increase.
- Unabated fossil fuel electricity generation will decline, more rapidly in some areas than others.
- The shift to decentralised energy generation assets will continue (to some degree).
- The electrification of transport is already in progress and will continue to accelerate.
- Low-carbon hydrogen will begin to be produced and could play a key role in decarbonising industrial processes and some forms of transport. The scale and location of hydrogen production and use is unclear.
- Further energy efficiency deployment will take place in both homes and businesses.

- The electrification of heat will increase, although there remains some uncertainty over the role that hydrogen boilers and heat networks could play in some areas, especially in hydrogen innovation zones.

There are, however, a number of uncertainties when undertaking scenario projections for a broad range of technologies and sources of demand. The key uncertainties in the DFES analysis include:

- The range of different outcomes assumed across the FES 2023 scenario framework.
- National, and devolved, government regional and local policy.
- Commercial and financial.
- Technology development and capability.
- Consumer adoption and behaviour.
- Local spatial distribution factors.
- Transmission vs distribution network connection decision.
- Uncertainties related to international markets and impacts of global conflicts.

At an individual technology level, uncertainty is considered a key part of the analysis and is reflected in the range of scenario outcomes presented. The technology-specific assumptions that have been made are summarised in each technology summary chapter.

DFES geographical distribution

The final stage of the DFES modelling is to estimate the geographic spread of the scenario projections across the licence area. This provides granular, locationally distributed data that the SSEN Network Planning teams can use to inform long-term network investment at specific locations or for individual substation assets. The DFES geographically distributes licence area projections to **Electricity Supply Areas** (ESAs). An ESA is a geographical zone representing a block of demand or generation sharing upstream network infrastructure.

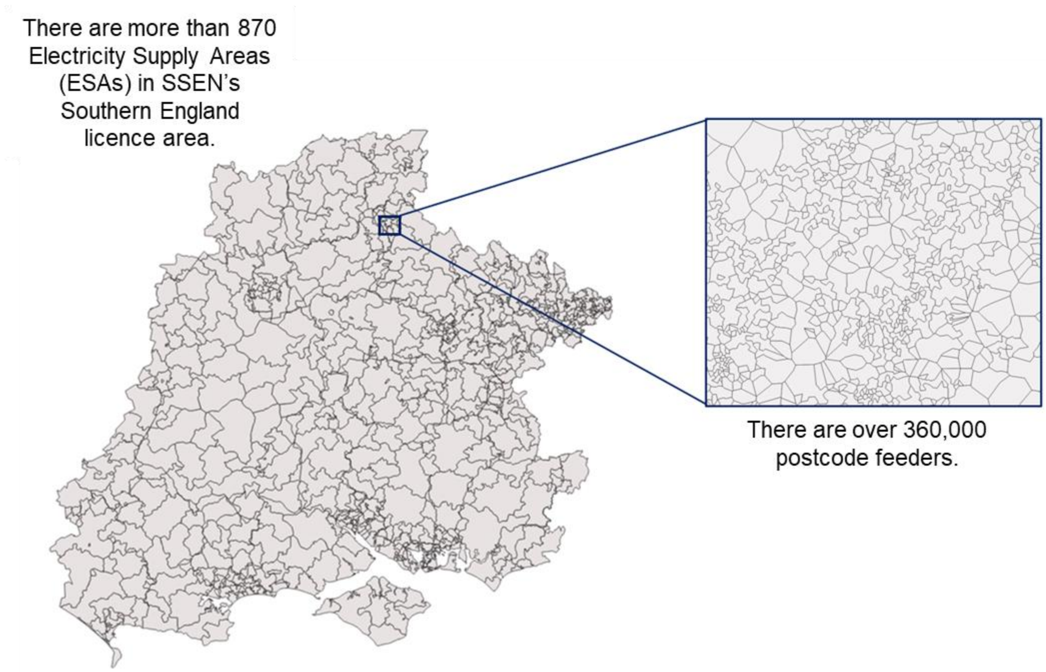

Figure 18 Map of 11 kV and feeder ESAs in the Southern England licence area

In the Southern England licence area, for large generation and storage technologies, projections are distributed to 876 individual 11 kV primary ESAs. ESAs are smaller in size in areas of high population density. Therefore, ESAs falling within urban areas might equate the size of a small urban borough, whereas ESAs situated in rural areas will cover a larger geography. DFES projections have been designed to be aggregated to support network analysis at higher voltage levels or to local authorities or other regional boundaries for local energy planning purposes.

DFES 2023 scenario projections for EVs, EV charger capacity, domestic heat pumps, rooftop PV and domestic battery storage are distributed to either secondary distribution substations or individual LV feeder lines serving small groups of customers. This level of granularity corresponds to roughly a postcode or street-level analysis.

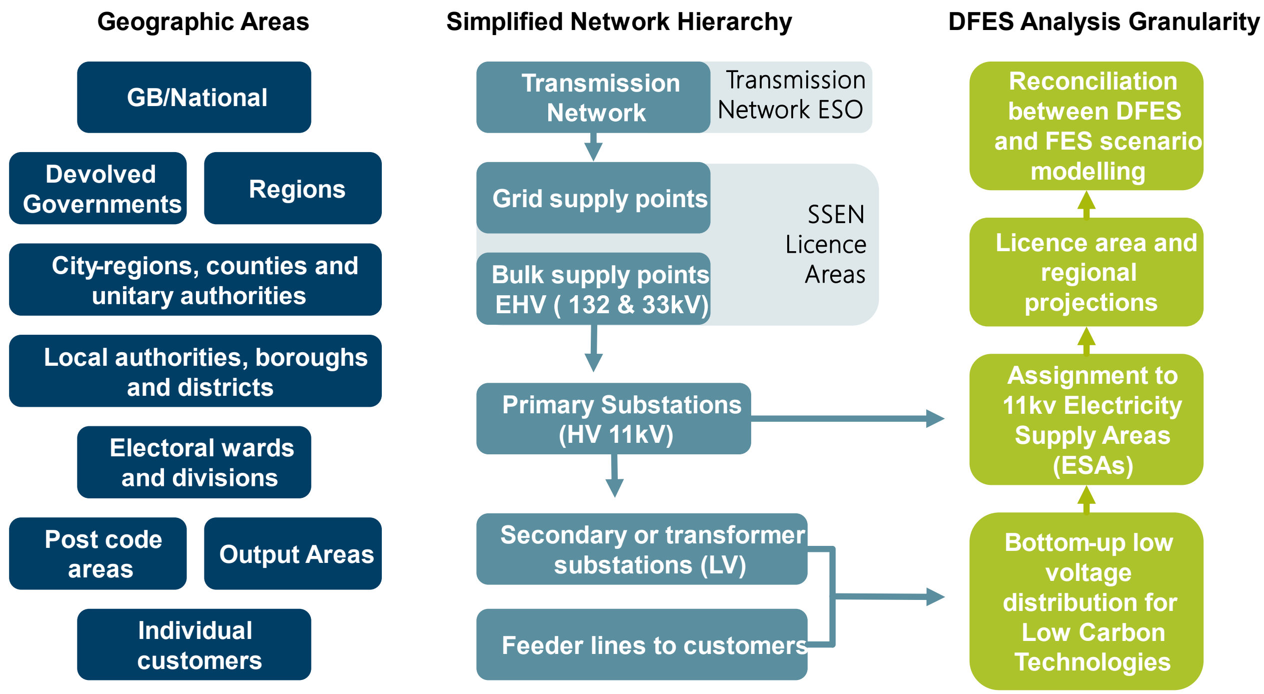

Figure 19 Network hierarchy (and associated geographic area) that determines the DFES analysis granularity for the spatial distribution to ESA

Multi-voltage tier distribution

For DFES 2023, Regen has completed a multi-voltage tier distribution for all known baseline and pipeline projects that hold a connection agreement (or connection offer) with SSEN. These sites are assessed not just for their geographical location, but also for the voltage tier of the distribution network they connect to. The main connection point for lower capacity assets is 11 kV primary substations. Higher capacity assets may connect at higher voltage tiers, such as 33 kV or 66 kV and 132 kV bulk supply points. This multi-voltage tier distribution complements the existing spatial distribution to 11kV and LV ESAs.

Spatial distribution factors

The DFES analysis incorporates key relevant spatial distribution factors for each technology building block. These factors are based on a wide range of datasets, including Ordnance Survey AddressBase, Department for Transport road traffic flow data, Census Output Area data, affluence and demographic data, postcode statistical data and individual property EPC data. Engagement with local authorities, and their targets and strategies for specific technology sectors, has also specifically influenced the spatial distribution factors for the SSEN DFES 2023.

For example, the DFES analysis integrates several spatial distribution factors for domestic EVs, which include:

- The number of vehicles per household (sourced from Census data).
- Affluence levels (sourced from Census data).
- Type of vehicles (sourced from Department for Transport).

The DFES projections currently indicate that households with high affluence, a high number of vehicles per household and pre-existing ownership of a petrol and/or diesel car in an urban area are most likely to have a high uptake of EVs in the future. These factors affect the near-term projections most strongly before moving to a more equitable projection in the medium and long term.

Another example of the spatial distribution factors used in the DFES analysis for 2023 is the EPC and Census data used in Regen's heat model. This models domestic buildings in each feeder area into around 30 archetypes, based on the combination of existing heating technology, building type, tenure, construction age (used as a proxy for energy efficiency) and potential for district heating. The final stage of analysis is to then develop scenario projections for each of the building archetypes, in terms of converting from the current heating technology to a heat pump, district heat connection or resistive electric heating, between now and 2050.

A full list of each of the spatial distribution factors underpinning and included in the modelling are described in more detail within each technology summary chapter (page 43 onwards in this report).

Large-scale battery 'Storage Planning' scenario

The pipeline of battery storage projects with connection offers in the UK has continued to significantly increase over the past 2-3 years[21]. This is reflected in in both SSEN licence areas, currently totalling 16 GW, as shown in Table 5.

The scale of this growth is unprecedented when viewed against other technologies assessed in the DFES. The proportion of this significant development pipeline that will move through to build-out and commissioning is also highly uncertain. As a result, the DFES 2023 analysis continues to include a fifth scenario, in addition to the four defined under the FES National Grid framework, for battery technologies: the '**Storage Planning'** scenario. This scenario provides a view to 2050 that assumes almost all of the known battery storage pipeline projects will connect. In reality, not all projects will come to fruition, as financial and planning challenges will cause setbacks, delays or projects to be abandoned altogether, and this likelihood is reflected in the four main FES scenarios. The Storage Planning scenario enables a view of what the electricity system would look like if all battery storage sites currently holding a connection agreement were to connect to the network.

Licence area	Pipeline			
	DFES 2020	DFES 2021	DFES 2022 *Incl. quote issued*	DFES 2023 *Incl. quote issued*
Southern England	0.8 GW	1.6 GW	5.3 GW	8.2 GW
North of Scotland	0.3 GW	0.4 GW	4.2 GW	7.8 GW
SSEN total	**1.1 GW**	**2 GW**	**9.5 GW**	**16 GW**

Table 5 Summary of prospective battery storage projects in SSEN's licence areas

[21] Electricity Storage Network Conference 2023, *Grid connections – is a revolution or evolution on the horizon for electricity storage?* https://youtu.be/zS73b1X2bdo

	Granted/Under construction	Application submitted	Pre-planning	No information
Storage Planning	100%	92%	100%	99%
Leading the Way	100%	92%	100%	37%
Consumer Transformation	100%	92%	33%	37%
System Transformation	100%	92%	19%	37%
Falling Short	98%	0%	5%	29%

Table 6 Proportion of SEPD battery storage projects modelled to connect in the licence area, by scenario

(Note: other variables such as scale of site, business model, co-located project details and capacity market records also determine if sites are modelled to build out.)

Supporting studies

DFES reports for local authorities

The DFES analysis and engagement has become a key part of SSEN's long-term network planning and investment processes. Both SSEN and Regen recognise the importance that this annual study for both SSEN licence areas must provide context, evidence and trajectories for the evolution of regional and local energy systems. As well as moving to make the DFES data more accessible, two new guidance documents have been produced as part of DFES 2023, specifically for the local authorities in SSEN's two licence areas. These reports provide a summary of how DFES data and analysis can be used by local authorities to inform local planning processes, such as LAEPs and Local Heat and Energy Efficiency Strategies (LHEES). They also include signposts and guidance on how to interact with and make use of DFES data that SSEN is making available on its data portal.

These guides are published here.

Consumer vulnerability and just transition study

Capturing consumer vulnerability within the DFES allows for a more accurate modelling of scenarios and technology uptake, while supporting more effective targeting of vulnerability overall. Accounting for vulnerability also allows questions of fairness to be built into the scenario modelling.

As part of DFES 2023, an additional study has been completed to design a specific vulnerability and just transition distribution within the wider DFES analysis. This builds on the evolution of SSEN's Vulnerability Future Energy Scenarios (VFES) project, which has developed a new tool for predicting vulnerability dynamically over time using machine learning.

Heat has been identified as one of the most pressing issues from a citizen and vulnerability perspective and this study overlaid additional vulnerability metrics and factors to the heat model, within the Consumer Transformation scenario, to understand where changes are likely to impact vulnerable consumers. This analysis was informed by additional direct engagement with fuel poverty charities and social and equalities organisations to get a more in-depth view of the specific needs and barriers that different vulnerable groups face to more accurately model technology uptake and distribution overall.

The output of this analysis can be found here.

SSEN's Data Visualisation Platform and Open Data Portal

SSEN's data portal[22] is a single point of access to all the data SSEN publishes. This catalogue of data will bring visibility to SSEN's network assets, their location, their usage, and their performance.

The aim of the portal is to engage with all data consumers from local authorities, SSEN's supply chain, flexibility providers, energy suppliers as well as anyone with an interest in achieving net zero.

The current open data portal contains a load summary view of SSEN's transformers, starting with baseline loadings and includes low carbon technology growth across the network for all four FES scenarios. The next iteration of the data portal is currently in development and will include the 2023 DFES datasets along with several functionality improvements.

Net Zero Strategic Plans

The aim of SSEN's Net Zero Strategic Planning process is to "provide the capacity on the network to deliver net zero by 2050 while retaining a clear focus on safety and reliability"[23]. These documents aim to communicate long-term network plans at a regional level to local authorities and other stakeholders involved in local area energy planning.

The results of the DFES analysis feed into this process. All four scenarios are considered and Consumer Transformation is currently taken as the most credible 'best view' for future network requirements. SSEN engages with local stakeholders to develop these plans and

[22] https://data.ssen.co.uk/

[23] https://www.ssen.co.uk/globalassets/about-us/dso/consultation-library/dnoa-methodology.pdf

analyses future investment requirements at all voltage levels, to ensure network development meets customer needs and addresses capacity and load constraints.

Technology summaries

The DFES 2023 projections comprise 20 separate technology sector analyses. The following technology summaries detail the specific modelling, assumptions and evidence used to produce the scenario projections for each technology sector as well as the key differences when compared to DFES 2022. Table 7 (below) categorises the technologies included in the DFES analysis into **distributed electricity generation, electricity storage or future sources of disruptive electricity demand**.

Technology category	Technology/sector
Distributed electricity generation	Onshore wind
	Large-scale solar PV
	Small-scale solar PV
	Hydropower
	Marine generation
	Biomass generation
	Renewable engines
	Waste-fuelled generation
	Diesel generation
	Fossil gas-fired generation
	Hydrogen-fuelled electricity generation
	Other generation
Electricity storage	Battery storage
	Liquid air energy storage
Future sources of disruptive electricity demand	Electric vehicles
	Electric vehicle chargers
	Heat pumps and resistive electric heating
	Domestic air conditioning
	Hydrogen electrolysis
	Data centres
	New property developments

Table 7 Categorisation of DFES 2023 technologies

Onshore wind

Summary of modelling assumptions and results

Technology specification

The analysis covers onshore wind generation connecting to the distribution network in the Southern England licence area.

Technology building blocks: **Gen_BB015 - Large-scale (≥1 MW) onshore wind; Gen_BB016 - Small-scale (<1 MW) onshore wind**

Data summary for onshore wind in the Southern England licence area

Technology	Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Large scale (≥1 MW)	**Falling Short**	8.5	18	20	25	29	34	38
	System Transformation		18	28	45	57	66	75
	Consumer Transformation		18	42	82	131	182	189
	Leading the Way		18	35	61	91	124	132
Small scale (<1 MW)	**Falling Short**	3.3	3	3	3	3	4	4
	System Transformation		3	3	4	4	6	7
	Consumer Transformation		4	7	11	16	21	28
	Leading the Way		3	4	6	9	13	18

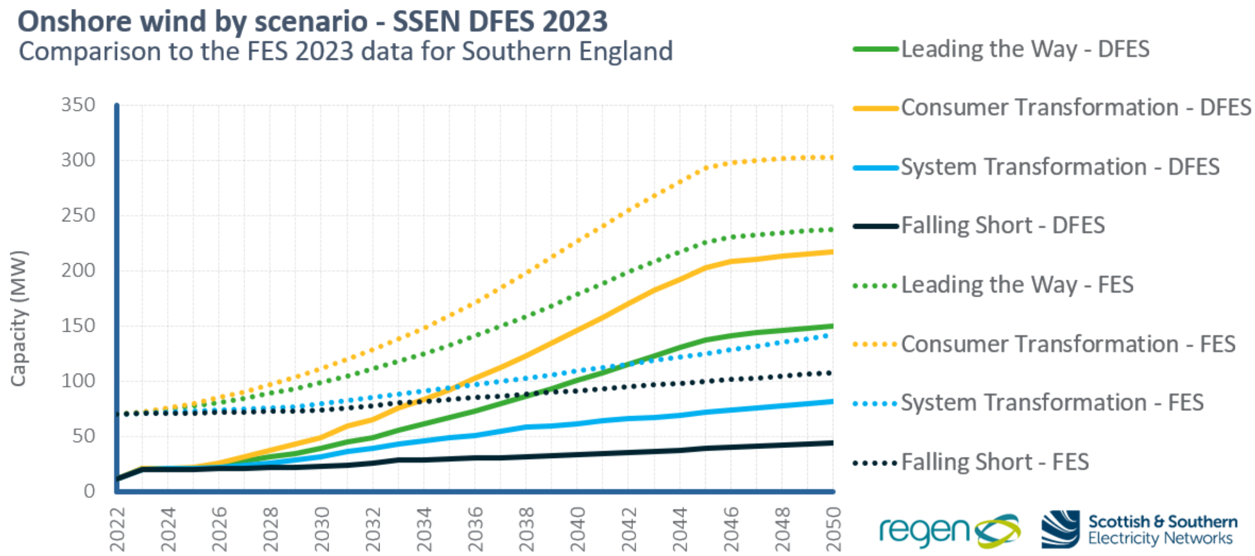

Figure 20 Onshore wind projections for the Southern England licence area, compared to National Grid FES 2023 regional projections

Summary

- The Southern England licence area has a minimal baseline of onshore wind deployment, with only a very small increase in capacity since 2012. This is due to a combination of relatively low wind resource, spatial constraints and historic challenges to wind projects securing planning permission in the region.
- There are few new project developments in the pipeline, the connection of the Alaska Wind Farm in Dorset being the only potential near-term onshore wind development in the pipeline.
- The Contracts for Difference (CfD) allocation round 5 was favourable for onshore wind across the UK, allocating nearly 1.5 GW of capacity across 24 sites. However, all onshore wind sites are in Scotland and Wales, with no successful projects in England.
- In ambitious scenarios such as **Consumer Transformation**, a renewed development of onshore wind begins in the late 2020s in the licence area, with up to 217 MW deployed by 2050.
- Under **Falling Short**, development is much lower, with only 45 MW deployed by 2050.
- In all scenarios, the projected onshore wind capacity by 2050 is lower than what was forecasted in DFES 2022. This reflects a decrease in projections for onshore wind connecting to the distribution network between FES 2022 and FES 2023.

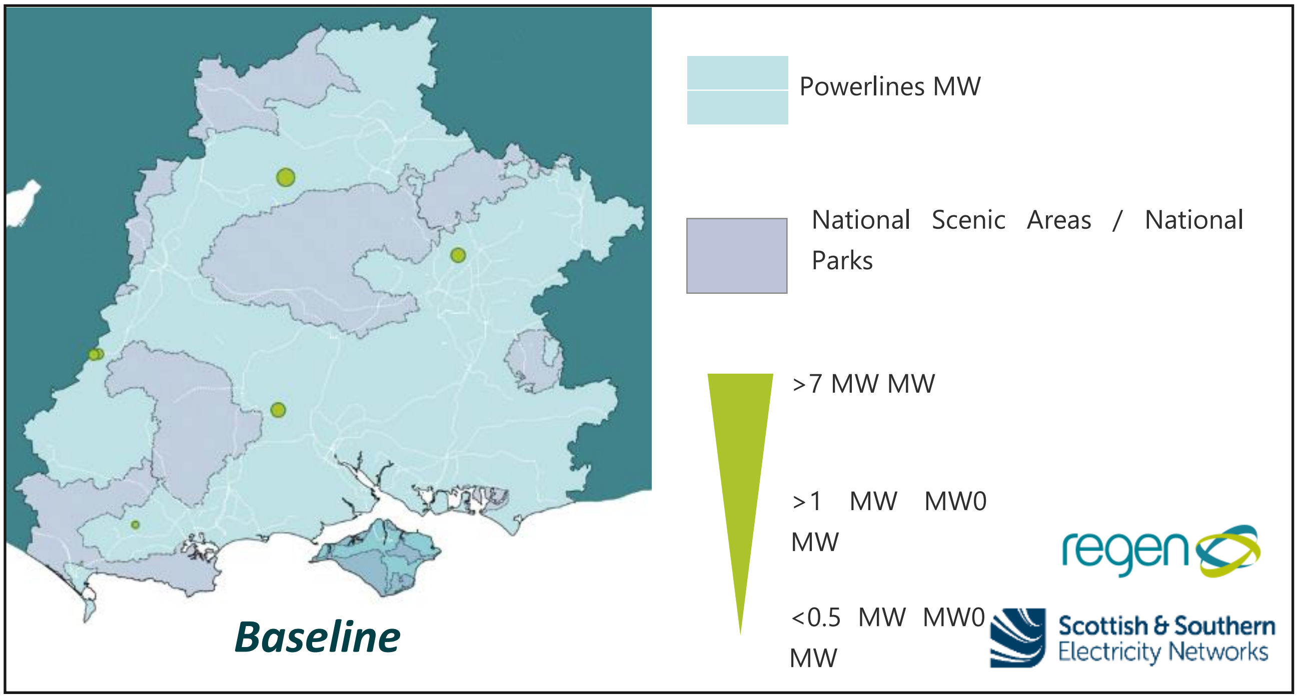

Figure 21 Baseline onshore wind deployment in the Southern England

Modelling stages

Baseline (2022)			
Scale	**Number of sites**	**Total capacity (MW)**	**Description**
Total	8	11.8	The baseline of onshore wind sites deployed in the licence area has not changed since DFES 2021. This low deployment has been due to a combination of relatively low wind resource in the region, spatial constraints and historic challenges against wind projects seeking planning permission in the region.
Above 1 MW	2	8.5	The 6.2 MW Westmill Windfarm, near Swindon, remains the largest site in the licence area, connecting in 2008.
Below 1 MW	6	3.3	Some small-scale sites connected between 2011 and 2014, taking advantage of the higher early rates of the Feed-in-Tariff.

Pipeline (2023-2033)	
Number of pipeline sites	**Total capacity (MW)**
2	9.5

Pipeline analysis

Status	Description	Sites	Capacity
As in DFES 2022, the Cheverton Down Wind Warm (operated under SSEN's Active Network Management scheme), located on the Isle of Wight, is the sole onshore wind site in the licence area with a contract to connect. There is no recent evidence of this site in planning, and as a result, it has only been modelled to build out in **Leading the Way**. The 9.2 MW Alaska Wind Farm in Dorset is currently being constructed, while this site does not appear in SSEN connections data, it is modelled to come online in 2024 under all scenarios.[i].			

Repowering logic

The repowering of baseline sites has been modelled for sites reaching the end of their operational life and repowering with more efficient and larger turbines. This drives some capacity growth from 2030 to the mid-2040s. The four scenarios vary by how soon a site will be repowered after commissioning and to what additional capacity percentage. Sites below and above a 5 MW threshold are treated differently, with higher repowering potential for sub-5 MW sites. Since DFES 2021 these assumptions have been updated to reflect recent stakeholder feedback and market insights.

	Falling Short	System Transformation	Consumer Transformation	Leading the Way
Repowering year delay	25	25	25	25
Large-scale repowering	+25%	+25%	+50%	+40%
Small-scale repowering	100%	+50%	+200%	+200%
Repowering capacity by 2050 (MW)	1.6	2.6	5.3	4.6

Scenario Projections

The medium and long-term projections hinge strongly on which scenarios have the highest levels of societal change and acceptance of onshore renewables. While the Southern England licence area does not have high wind resource, there are areas with feasible windspeeds that have seen project development activity in the past and could provide the basis for future projects. According to the Renewable Energy Planning Database (REPD), there have been 253 MW of failed planning applications

for onshore wind in the licence area. This provides some evidence that, in scenarios where onshore wind planning permission is unlocked such as **Consumer Transformation** and **Leading the Way**, the development of previously abandoned projects could be revived. As these medium-term projects will likely be developed as subsidy-free projects, due to the expected highly competitive nature of CfD auctions containing onshore wind and solar PV, only the sites with the highest wind speeds are projected to the built out before 2035 under any scenario. Regen's longer-term analysis is driven by an onshore wind resource assessment. This analysis accounts for protected areas, proximity to homes, and availability of suitable wind speeds and network.			
Scenario	**Description**	**Capacity by 2035 (MW)**	**Capacity by 2050 (MW)**
Falling Short	Under **Falling Short**, the low level of societal change means that projects struggle to attain planning permission in the licence area and capacity growth is restricted to only the least impactful optimal sites. As a result, development of onshore wind does not pick up significantly above the current level in this scenario, reaching 35 MW by 2050.	29	43
System Transformation	While reflecting a higher pace of decarbonisation and societal change than **Falling Short**, **System Transformation** reflects a preference for large scale offshore wind and transmission scale connections, which are likely to be concentrated in other licence areas with more wind resource. However, distributed onshore wind development does moderately accelerate, with 82 MW modelled to be deployed in the licence area by 2050.	49	80
Consumer Transformation	Under **Consumer Transformation**, planning approval for onshore wind is unlocked, allowing historically refused or stalled projects to be revived in the medium term. As technology progresses and costs reduce, more of these previous sites are revived, as well as additional future projects in areas of wind resource that previously did not see developer interest. In the longer term, out to 2050, the onshore wind capacity in the licence area is driven more by wind	92	216

	resource and less by the historical baseline and planning restrictions. As a result, 216 MW is connected by 2050 in this scenario.		
Leading the Way	Under **Leading the Way**, it is assumed more onshore wind will be connected to the transmission network and so across the Southern licence area c.150 MW is modelled to connect.	67	150

Reconciliation with National Grid FES 2023

Modelling stage	Reconciliation
Baseline	The National Grid FES 2023 baseline does not align with the DFES 2023 baseline. FES 2023 has 71 MW in the connected baseline (a small decrease since FES 2022). This compares to 11 MW seen in the SSEN connection data. The reason for this c.60 MW variance is unclear.
Pipeline	In more ambitious scenarios, the FES 2023 shows an accelerated deployment from 2025, suggesting a pipeline of projects ready to deploy in the short-to-medium term. However, the DFES analysis has not found evidence of such a pipeline, so deployment is less and has been modelled to pick up in the late 2020s/2030s.
Projections	Post-2030 growth is similar across the FES and DFES projections. This alignment was not present in previous years, with DFES modelling being based more on wind resource assessment, while the FES projections were more impacted by the existing baseline. The significant baseline and pipeline variance makes an accurate reconciliation difficult.
Overarching trend	Whilst annual growth rates in each scenario are similar in the FES 2023 and DFES 2023 projections, the inconsistent baseline assessment makes annual uptake rates and resultant projections significantly different in all scenarios.

Geographical factors affecting deployment at a local level

Geographical factors	Description
Onshore wind resource assessment	New projected onshore wind capacity, not including the repowering of existing sites, is based on Regen's onshore wind resource assessment. This assessment considers relevant factors such as wind speed, landscape designations, dwelling proximity, peat land, etc.
Planning friendliness and local ambition	Analysis of the REPD identified local authorities which have historically approved a higher percentage of onshore wind planning applications. This was used to inform the near-term scenario projections in which pipeline projects may be successfully built. However, as this is a snapshot that may not fully reflect local authority ambition in the long term, it was not used as a major factor in the projections in the medium and long term. Council Climate Action Scores.[ii] were used in the medium and short-term projection years with an understanding that current local government initiatives may not reflect long-term local authority ambition.

Relevant assumptions from National Grid FES 2023

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

Incorporation of stakeholder feedback

Stakeholder feedback provided	How this has influenced our analysis
At the Southern England stakeholder engagement webinar,.[iv] local stakeholders responded to a poll on the future of onshore wind development in the licence area. 30	Project developers and renewables experts were more inclined to believe there would be enough local support for wind. This

respondents considered whether there would be enough local support for significant onshore wind development should planning policy relax. 12 respondents believed there would be insufficient local support to result in significant onshore wind development. 10 respondents believed that support would be sufficient and enable a significant development starting between 2025 and 2030, while the remaining respondents were unsure or saw a later development as more likely.	range of views is reflected in outcomes across the four scenarios, with an accelerated deployment modelled to begin in the late 2020s under **Consumer Transformation** and **Leading the Way**.

[i] Swanage News, https://www.swanage.news/twenty-year-battle-to-build-purbeck-wind-farm-is-finally-over/

[ii] Climate Emergency UK, 2022, *Council Climate Plan Scorecards.* https://councilclimatescorecards.uk/

[iii] ESO FES 2024 assumptions workbook.

[iv] Regen, 2023, *SSEN DFES stakeholder consultation webinars*.

Large scale solar PV

Summary of modelling assumptions and results

Technology specification

The analysis covers solar generation sites of installed capacity of 1 MW and above connecting to the distribution network in the Southern England licence area.

Technology building block: **Gen_BB012 – Large solar generation (G99)**

Data summary for large-scale solar PV in the Southern England licence area

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	2,050	2,673	3,933	4,277	4,463	4,544	4,630
System Transformation		3,038	5,114	6,235	6,666	6,742	6,762
Consumer Transformation		3,038	5,114	6,235	6,666	6,742	6,762
Leading the Way		3,859	5,361	7,456	7,625	7,726	7,731

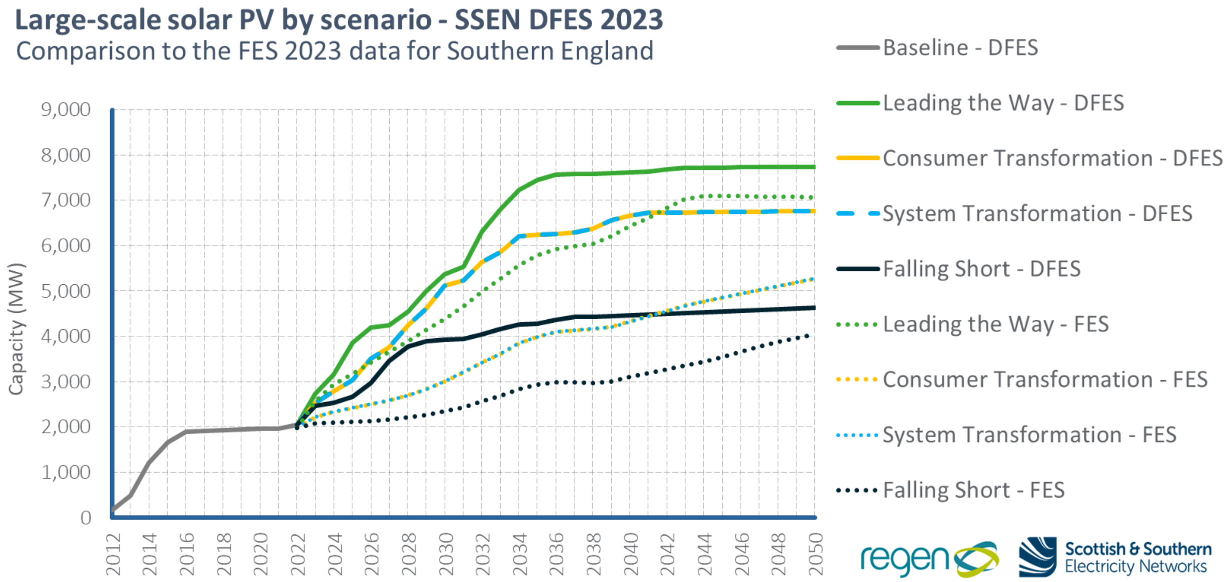

Figure 22 Large scale solar PV projections for the Southern England licence area, compared to National Grid FES 2023 regional projections. Note: Consumer Transformation and System Transformation projections are equal within the FES and DFES for this technology.

Summary

- With some of the highest solar irradiance levels in the UK, the Southern England licence area has a historically high uptake of solar compared to other licence areas in southern and central areas of England and Wales. The majority of capacity was deployed between 2012 and 2018, reaching over 2 GW in 2022.
- Despite the low growth seen since 2018, there is now a 5.6 GW pipeline of projects in the licence area with accepted connection offers or quotes issued to developers. This includes 1.8 GW of capacity which, as of August 2023, is either operational, under construction or with a granted planning permission.
- Solar PV remains one of the cheapest forms of renewable energy, with further equipment cost reductions helping the technology to realise economies of scale. Ongoing reductions in capital costs,[v] improvements in solar panel efficiency[vi] and the development of more dynamic and lucrative power purchase agreements[vii] are driving new interest to deploy potentially significantly more capacity of large scale solar PV nationally.
- Current business models are based around larger-scale standalone solar farms and some co-location with battery storage. However, some solar PV developers are already

exploring co-location with hydrogen electrolysis to mitigate generation constraints and/or export limitations.

- Historic planning friendliness towards solar installations is high, with c. 81% of projects being approved by local authorities in the licence area.
- In 2022, the British Energy Security Strategy[viii] set an ambitious goal of 70 GW of solar capacity by 2030, a five-fold increase from the 14 GW of domestic and large scale solar connected at the time it was published.
- Across the UK, the main barrier for new solar sites connecting to the network is the large connections queue at both transmission and distribution level voltages. Many developers have been given connection dates in the late 2020s and, in some cases, into the 2030s due to upstream transmission network constraints. These delays, reflected in a 'Statement of Works' delivery year, have been reflected solely in the **Falling Short** scenario. There are, however, policy reforms and queue management strategies being enacted nationally, such as Ofgem and National Grid ESO's November 2023 'Joint Connections Action Plan',[ix] to address the delays.
- In the three net zero compliant scenarios, it is assumed that these connection policy reforms are successful in tackling the queue, fast-tracking viable projects and reducing overall connection timeframes.
- Considering the current project pipeline and these contributing factors, DFES 2023 makes a range of projections. Under the most ambitious scenario, **Leading the Way**, large scale solar deployment reaches c. 5.4 GW by 2030, and increases further to reach c. 7.7 GW by 2050.
- Under **Consumer Transformation**, c. 5.1 GW is reached by 2030 and c. 6.8 GW by 2050.
- Repowering of baseline sites accounts for 1 GW of added capacity under **Leading the Way** and 0.5 GW under **Consumer Transformation** and **System Transformation**.

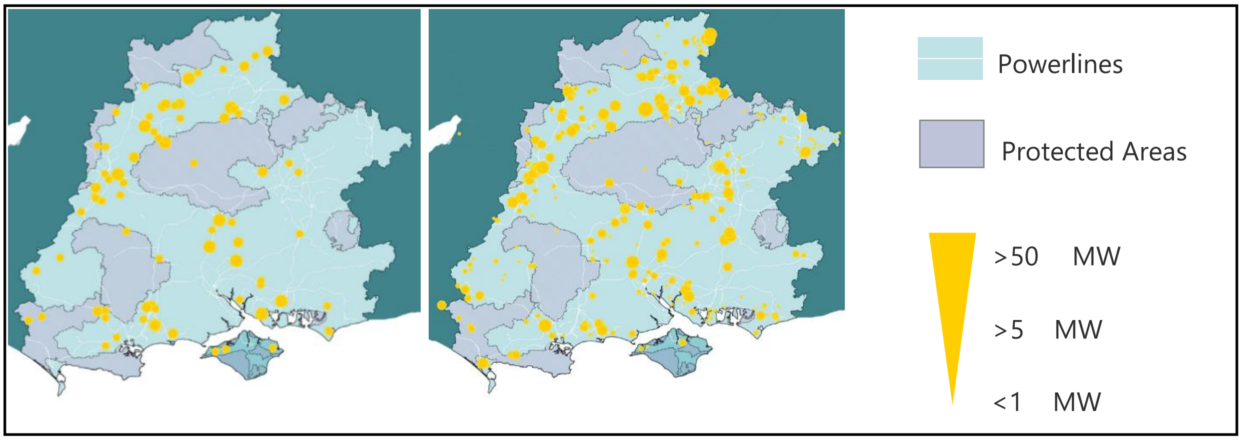

Figure 23 Baseline and pipeline large scale solar PV sites in the Southern England licence area, August 2023

Modelling stages

Baseline (2022)		
Number of sites	**Total capacity (MW)**	**Description**
210	2,050	Since the previous DFES study (2022), the connected baseline of sites has increased by 75 MW. This is due to the connection of the 40 MW Russel Farm site, 30 MW Three Maids Hill site, and 10 MW East Farm site. The 7 MW Braydon PV sites has been disconnected. Verification of site capacities across a few other sites in SSEN's connections data has resulted in the small remaining adjustment.

Pipeline (2023-2035)			
	Total	**Contracted**	**Grid connection offered**
Number of sites	218	199	19
Capacity (MW)	5,599	4,927	671

For each annual DFES analysis, the pipeline of large scale solar projects has grown. This year is no exception; the pipeline of contracted/offered sites has increased from 4.7 GW (204 sites) in DFES 2022, to 5.6 GW (218 sites). This represents a c.24% growth in pipeline capacity in a year. Over 90% of the sites in the current connections pipeline are contracted, accounting for c.4.9 GW (88%) of the total pipeline capacity.

Of note in this pipeline is the addition of the 130 MW site at Pembridge Farm in Buckinghamshire, and the 180 MW site at Hyde Farm site in Vale of White Horse, both with accepted connection offers. By a significant margin, Wiltshire is the local authority within the SEPD licence area with the most large scale solar capacity in development, with over 1 GW of primarily contracted sites.

12 of the pipeline sites in the licence area successfully secured a Contract for Difference under the fourth and fifth allocation rounds, while 67 are currently subject to a Statement of Works connection date related to upstream transmission constraints. These connection delays have been directly reflected in the **Falling Short** scenario.

Pipeline analysis

Status	Description	Sites	Capacity (MW)
Operational	14 sites are deemed to be operational by Q3 2023. This has been based on evidence from the Renewable Energy Planning Database (REPD) and supported by recent satellite imagery and engagement with developers.	14	181
Under construction	14 sites totalling 358 MW were under construction as of Q3 2023. The largest of these are the 52MW Cirencester Solar Park and 50 MW Haseley Solar farm. Also of note is the Eynsham Estate site in Cowley, pairing 20 MW of solar PV with 7 MW battery storage. This pipeline of projects undergoing construction c. 150MW (2 sites) larger than the equivalent seen in DFES 2022.	14	358
Planning permission granted	There is 1.3 GW of large scale solar PV capacity with planning permission in the licence area. Middel farm and Middel Energy Park, situated near the Melksham substation, are the largest developments at this planning stage, at 100 MW each and both include co-located battery storage on-site. This more progressed subsection of the project pipeline is very similar to that seen in DFES 2022. 10 of these 51 projects (c.20%) are co-located with energy storage.	51	1,300
Planning application submitted	The 49.4 MW Pitt Farm site in Wokingham, and the 60 MW Cowley site in Abingdon are significant solar developments which have submitted planning applications. This less progressed project pipeline is significantly smaller than the equivalent seen in DFES 2022. This is partially explained by a reallocation of some sites into 'Pre-planning'; those which have	16	397

	submitted only screening applications or environmental impact assessment, for example. 3 of these 15 sites (20%) are co-located with battery storage.		
Pre-planning	There are 29 solar sites, totalling c.660 MW which have submitted screening, scoping, environmental impact assessments or other documents as a precursor to a full planning application in the licence area. 7 of these sites (c.25% of pre-planning capacity) are co-located with battery storage. This is a greater proportion of co-located sites than is seen in the more advanced sections of the pipeline. This is evidence of a potentially increased interest to co-locate storage at solar PV sites.	29	661
No information	For 57 sites, no planning information was able to be found online. This indicates very early stage, or speculative, projects. This less well evidenced portion of the pipeline is significantly smaller than was seen in DFES 2022. This is as a result of improved DFES planning research tools rather than an indication that the project pipeline has become significantly more mature in planning over the course of the year.	57	1676
Abandoned, expired, refused	3 sites have been refused planning permission, the largest being a 50 MW site in Oxford. The remaining sites in this group have been abandoned or are currently holding expired planning permissions.	10	170
Other	19 sites (totalling 671 MW) of the 27 'other' solar sites have not accepted their connection offers and are not assessed in planning. The remainder of sites with this status are believed to be superseded connection agreements or duplications.	27	861

Planning logic and assumptions

An analysis of solar PV sites within the REPD is used to estimate the time from a project's current stage of development to buildout. These timeframe estimates are specific to the capacity of the project, with larger projects having longer development timeframes. Less ambitious scenarios also assume longer development timeframes.

Less ambitious scenarios also consider that less well evidenced sites, such as those which have submitted only pre-planning documents, or those with no planning documents at all, do not build out.

A secondary stage of scenario-based logic considers the success rates of the remaining projects; given their current development stage. In **Falling Short**, it is assumed that sites which have submitted a planning application do not see deployment in their existing development cycle. Similarly, in **System Transformation** and **Consumer Transformation**, sites in pre-planning are subject to an additional delay. The length of this additional delay ranges from 2-8 years and is impacted by the historic planning friendliness of the local authority, again a metric derived from REPD analysis.

This approach allows a moderation in the near-term buildout rate of the large project pipeline, while reflecting the possibility that, in ambitious net zero scenarios, locations of interest to developers now will eventually host a project.

Repowering

From the mid-2030s onwards, existing baseline sites could begin to repower. The modelling accounts for the possibility that uprated/higher yield solar panels or extensions to panel numbers will increase overall site capacities.

By 2050, nearly 1 GW of capacity is added through repowering under **Leading the Way** and 0.5 GW is added in **System Transformation** and **Consumer Transformation**. Sites remain at their original capacity under **Falling Short** and are not modelled to decommission. Future repowering of pipeline sites could play a role in later projection years but has not been modelled in the DFES 2023 due to significant uncertainty of repowering rates for future sites.

	Falling Short	System Transformation	Consumer Transformation	Leading the Way
Year Delay	--	25 years		
Repowering	--	+25%		+50%
Added Capacity	--	0.5 GW		1 GW

Scenario projections

Scenario	Description	Capacity by 2035 (MW)	Capacity by 2050 (MW)
Falling Short	Whilst still representing a significant increase from the baseline, with 4.6 GW of total solar capacity by 2050, slower progress towards decarbonisation targets is made under this scenario. This relates to planning barriers becoming more of a factor in the licence area and fewer opportunities for co-location, leading to less investment in new solar projects overall. This 2050 projection is approximately 500 MW lower	4,277	4,630

	than the DFES 2022 equivalent. This is due to the reallocation of a number of sites from 'Planning submitted' to 'Pre-planning', and a subsequent assumption that these sites do not build out under **Falling Short**.		
System Transformation	These scenarios have equal projections across the period to 2050. This has been done to mirror the FES 2023 assumption that these scenarios see equal growth and is consistent with DFES 2022. There is significant near-term capacity deployed, with 3 GW of the 5.6 GW pipeline of sites connecting by 2030 and resulting in c. 5 GW of deployed capacity. This is a very similar rate of near-term deployment to that which was projected under these scenarios in DFES 2022. However, where in DFES 2022 the growth rate decreased post-2030, for DFES 2023 the higher growth rate is maintained out to 2035, this due to the increased scale of the project pipeline. 6.2 GW is deployed by 2035 under these scenarios, which is a moderate increase on the 5.5 GW projected by 2035 in DFES 2022. Growth in deployed capacity between 2035 and 2050 is significantly lower than in the preceding period, as it is assumed that distributed solar capacity reaches its full economic and technical potential in the licence area in the late 2030s. Repowering of older sites contributes to additional solar PV capacity coming online in the 2040s.	6,235	6,762
Consumer Transformation		6,235	6,762
Leading the Way	As with other net zero scenarios, high near term growth rates are maintained until 2035. **Leading the Way** assumes the current pipeline is built out almost entirely and this results in 7.5 GW of deployed capacity by 2035, a 1.1 GW increase on the DFES 2022 projection. Growth in deployed capacity between 2035 and 2050 is significantly lower than in the preceding period, as it is assumed that distributed solar capacity reaches its full economic and technical potential in the licence area. Repowering of old sites contributes to additional solar	7,456	7,731

	PV capacity coming online in the 2040s. Total large scale solar capacity reaches c.7.7GW in the licence area by 2050.		

Reconciliation with National Grid FES 2023

Modelling stage	Reconciliation
Baseline	The DFES 2023 baseline of 2,010 MW is comparable to the FES 2023 baseline of 1,987 MW.
Pipeline	In all scenarios, the DFES projections deviate from the FES 2023 by projecting a higher near-term deployment. This is justified by the significant connection pipeline, detailed site-specific research and the identification of sites that will likely be commissioned in the near term.
Projections	While the current project pipeline results in a higher near-term installed capacity relative to FES 2023, the DFES 2023 post pipeline projections (between 2035 – 2050) sees comparatively lower capacity growth. This results in an alignment between the DFES 2023 and FES 2023 projections for total deployed capacity by 2050. In **Leading the Way** and **Falling Short**, this deviation is c. 0.5-1 GW, in **Consumer Transformation** and **System Transformation** the deviation is greater, at c. 1.5 GW. This larger difference is explained by DFES assumptions over how much pipeline capacity builds out in the near to mid-term. With 25% of the pipeline found to have secured planning permission, and input from stakeholder engagement (summarised below), these assumptions are well justified. It is also true that this is consistent with the FES assumption for “strong growth in large solar” under these scenarios.
Overarching Trend	Relative to FES 2023, DFES 2023 projects a much larger rollout of new solar out to 2035. Post 2035, FES 2023 projections reflect higher uptake rates than DFES, causing an eventual alignment in the scenarios. Similar 2050 deployed capacity is projected in **Falling Short** and **Leading the Way**, while in **System Transformation** and **Consumer Transformation** DFES projects higher deployment, reflecting pipeline evidence and scenario logic applied around deployment and repowering.

Geographical factors affecting deployment at a local level

Geographical factors	Description
Unconstrained solar resource	Regen's in-house solar resource assessment considers solar irradiance, land availability and planning constraints in the licence area.
Climate score cards.[x]	Local ambition, reflecting the local authority policy landscape and proclivity to renewable energy deployment and net zero goals.
Renewable Energy Planning Database (REPD)	The proportion of solar sites that are/have been successful with a planning application in the local planning authority.

Relevant assumptions from National Grid FES 2023

Scenario		4.1.15 – Solar generation (plant greater than 1MW)
Falling Short	Low	Slower pace of decarbonisation.
System Transformation	Medium	Transition to net zero results in strong growth in large solar.
Consumer Transformation		
Leading the Way	High	Very high ambition to decarbonise drives a focus on low carbon technologies. Supports the production of hydrogen by electrolysis.

Incorporation of stakeholder feedback

Stakeholder feedback provided	How this has influenced our analysis
During the SEPD webinar event, stakeholders were asked how much of the current large scale solar pipeline would connect and in what timeframe. Stakeholders responded with a large range of answers, with an average suggesting more than half of the current 5 GW contracted pipeline would connect by the early 2030s.	The four scenarios modelled reflect this spread in stakeholder views. The average of the responses received is most closely reflected in **Consumer Transformation** and **System Transformation.**
Solar developers were contacted by email and	Feedback from developers was incorporated into the

phone to supplement desk-based research on progress with planning applications and the expected commissioning years of individual projects in SSEN's connection pipeline.	pipeline analysis. Direct feedback was prioritised over online publicised information when assigning pipeline commissioning years in each scenario, while preserving the commercial confidentiality of projects that have not publicly released information.

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[v] Power Engineering International 2021, *IRENA: Wind and solar costs will continue to fall.* https://www.powerengineeringint.com/renewables/irena-wind-and-solar-costs-will-continue-to-fall/

[vi] NREL n.d., *Best Research-Cell Efficiency Chart* https://www.nrel.gov/pv/cell-efficiency.html

[vii] Solar Power Portal 2023, *Vodafone, Mytilineos and Centrica sign second solar PPA for 232MW.* https://www.solarpowerportal.co.uk/news/vodafone_mytilineos_and_centrica_sign_second_solar_ppa_for_232mw

[viii] UK Government 2022, *British Energy Security Strategy.* https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy#renewables

[ix] Ofgem & DESNES, 2023, *"Joint connections action plan".* https://www.ofgem.gov.uk/publications/ofgem-and-desnz-announce-joint-connections-action-plan

[x] *Council Climate Plan Scorecards 2022*, https://councilclimatescorecards.uk/

Small scale solar PV

Summary of modelling assumptions and results

Technology specification

The analysis covers any solar generation sites of installed capacity less than 1 MW connecting to the distribution network in the Southern England licence area.

- Technology building block: **Gen_BB013 - Domestic solar PV**
- Technology building block: **Gen_BB012 - Commercial solar PV (10 kW – 1 MW)**

Data summary for small scale solar PV in the Southern England licence area

Installed domestic capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	299	367	464	633	793	941	1,089
System Transformation		383	606	881	1,117	1,338	1,557
Consumer Transformation		459	841	1,290	1,670	2,036	2,400
Leading the Way		467	871	1,322	1,720	2,109	2,496
Installed commercial capacity (MW)	**Baseline**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Falling Short	151	266	289	333	376	420	463
System Transformation		267	316	379	442	504	567
Consumer Transformation		286	361	449	538	629	720
Leading the Way		286	361	449	538	629	720

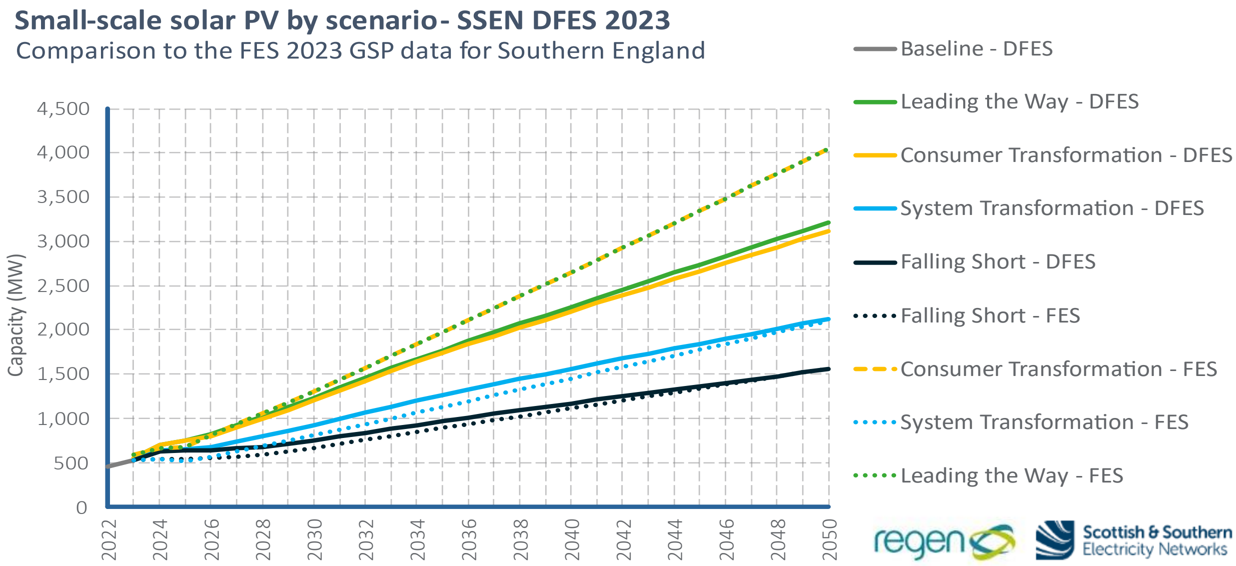


Figure 24 Small-scale solar PV projections for the Southern England licence area, compared to National Grid FES 2023 regional projections

Summary

- Growth in the deployment of domestic rooftop solar capacity in the UK has reached its highest level since the early Feed-in-Tariff era (2010s). According to the Department for Energy Security & Net Zero (DESNZ), the whole UK added just under 630 MW in 2023 of small-scale solar (< 50kW).[xi]
- The baseline for small scale solar in the Southern England licence area reflects this growth and is now 450 MW, up from 396 MW in DFES 2022, with most of this 54 MW increase from domestic installations.
- In addition to the 54 MW baseline increase, the Southern England licence area has seen 51 MW of installed capacity already connect in the first half of 2023.
- The DFES 2023 pipeline has seen substantial growth, more than doubling the installed capacity size from DFES 2022. The number of sites has increased from 297 (DFES 2022) to 1,445, including 313 domestic sites, up from zero in the previous year.
- Future deployment of small-scale solar varies strongly by scenario. Under **Consumer Transformation** and **Leading the Way** the electrification of transport and heating makes the business case for rooftop solar more attractive. In **Leading the Way**, 2.5 GW of domestic and 720 MW of commercial solar PV is deployed by 2050 – nearly ten times today's connected capacity.

- Despite being a scenario with lower levels of electrification, **System Transformation** still sees high deployment levels, reaching five times today's level by 2050. Reducing costs and uptake of electric vehicles are key factors influencing solar PV uptake under every scenario.
- **Falling Short** sees relatively low deployment, with annual growth remaining at the levels seen in the post FiT era-2021 and 2050 deployment reaching 1.4 GW.

Modelling and assumptions

Baseline (2022)		
Scale	**Total capacity (MW)**	**Description**
Domestic (<10 kW)	299	There is 299 MW of domestic-scale solar PV in the Southern England licence area, equivalent to rooftop arrays on 3.7% of domestic buildings, slightly below the GB-wide average figure of 4.1%. 2022 has seen a significant increase in domestic solar, which has not been seen since the FiT period. This period now accounts for 13% of total baseline installed capacity. This is greater than the installed capacity between 2017-2021 (11%).
Commercial (10 kW – 1 MW)	151	There is 151 MW of commercial rooftop PV baseline in the Southern England licence area. This represents an 8% increase in the commercial baseline, the largest yearly increase since the ending of the FiT scheme in 2016.

Pipeline (2023-2030)	
There are 1,132 sites totalling 114 MW of commercial scale (10 kW – 1 MW) solar arrays. This is an increase from the 297 sites totalling 55 MW from DFES 2022. In addition to the growth in commercial scale DFES 2023 has 313 sites totalling 1.73 MW of domestic scale (< 10 kW), with accepted or quoted connection offers in the licence area, where the DFES 2022 had no sites of this scale.	
Already connected	43 MW of domestic and 8.3 MW of commercial sites have already connected in 2023 the first year of the pipeline. Since these sites connected post-2022, they are not considered in the DFES 2023 baseline or pipeline, but rather modelled to connect in all four scenarios to reflect their current status.
Contracted	432 sites, totalling 61 MW of capacity, have accepted connection agreements in the Southern England licence area. Sites with accepted connection offers older

	than 3 years (65 sites, 10.7 MW) were removed from analysis if no planning evidence could be found. Unless planning evidence was found for a refused or expired planning application all sites were modelled to connect in **2024** under all four scenarios.
Quote Issued	1,013 sites, totalling 55 MW, have a connection quote issued, which have not yet been accepted. These sites were modelled in the same manner as 'Contracted' sites to connect in **2024** under all four scenarios, where planning evidence such as planning permission, was available to support connection.

Rooftop solar PV on new homes

Rooftop PV on new build homes is modelled using the outputs of the DFES projections for new housing developments. It is estimated that around 10% of recently built homes in England have been built with rooftop solar PV installed.[xii] This proportion of homes with rooftop solar is anticipated to increase as changes to Building Regulations (Part L) seeking to reduce carbon emissions for new-build homes were introduced in June 2022, with further changes expected in 2025. The impact of these regulations has been modelled to vary by scenario.

In **Consumer Transformation** and **Leading the Way**, deployment of rooftop solar on new build homes increases to 70% of all new homes by 2050. However, deployment remains lower at 40% and 20% of new homes in **System Transformation** and **Falling Short**, respectively. The percentage of new builds with **domestic scale PV** has increased from DFES 2022, most notably in **Consumer Transformation** and **Leading the Way**. This is evidenced by continued growth in small scale solar, driven by factors including the decrease in installation costs.

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

Scenario projections

The impacts of government policy have been considered in the modelling for every scenario, to a varying degree. An example being changes to Building Regulations (Part L).[xiii] that relate to the reduction in carbon emissions for new build homes. On existing domestic and commercial rooftops, small scale solar uptake accelerates due to the falling installation costs of both solar modules and domestic batteries, and the increased use for solar to power electrified heat and transport. A contributor to the reduction in cost was the 2022 Spring Statement from BEIS,[xiv] which removed the 5% VAT on solar panels and other energy saving materials. This VAT reduction will be applicable until April 2027.

Changes to the minimum energy efficiency standards (MEES) took effect in April 2023 that will impact rental properties in the non-domestic sector. Privately rented non-domestic properties will need to comply with an EPC band of E or higher.[xv] Although stakeholder engagement and Minimum Energy Performance of Buildings (No. 2) Bill[xvi] indicate these standards will likely change in 2027 to band B, and in 2030 to band C.

By 2050 a significant range is seen across the scenarios for small scale solar in the licence area, ranging from 1.5 GW under **Falling Short** to 3.2 GW under **Leading the Way**.

Scenario	Description	Capacity by 2035 (MW)	Capacity by 2050 (MW)
Falling Short	**Falling Short** reflects a lower uptake of low-carbon technologies, smart tariffs, and less engaged consumers. This results in a much lower demand for small-scale solar on homes and businesses, reaching 1.5 GW by 2050	965	1,552
System Transformation	Due to the need to decarbonise electricity demand quickly to meet carbon reduction targets, solar PV uptake is also high under **System Transformation**. However, greater use of larger-scale solutions and a reliance on low carbon hydrogen for space heating (rather than electrification) results in an overall lower uptake in small scale solar than in the other two net zero scenarios. In this scenario, total small scale solar capacity reaches 2.1 GW by 2050. This is a 107 MW lower projection than given in DFES 2022.	1,247	2,106
Consumer Transformation	Under **Consumer Transformation** and **Leading the Way**, high consumer ambition and engagement, coupled with high levels of electrification in transport and heat sectors, all drive a large increase in new small scale solar PV capacity. Peaking at 3.2 GW in **Leading the Way**.	1,738	3,120
Leading the Way		1,771	3,216

Reconciliation with National Grid FES 2023

Modelling stage	Reconciliation
Baseline	The 2023 FES baseline is 140 MW higher than the 2023 DFES baseline (a 32% difference). This could be due to the method that the FES uses to assign solar farms to GSPs on the edge of the licence area.
Projections	In DFES 2023, **Falling Short** and **System Transformation** scenarios align strongly with FES 2021 projections for the licence area throughout the projection period. The DFES 2023 **Consumer Transformation** and **Leading the Way** scenarios are lower than those in the FES 2023 The DFES modelling for these scenarios results in a deployment rate similar to the early years of the Feed-in Tariff (FiT) and equal to the current deployment rate, where payments were well above the retail price of electricity for domestic customers..[xvii] The FES projections assume a notably higher uptake rate than peak FiT deployment, which DFES has opted not to reflect. There is an argument that reduced installation costs for rooftop PV, electrification of transport, heat and cooling, and increased consumer engagement and ambition could drive higher deployment rates, such as those forecast in FES 2023. However, it is unlikely that installation deployment rates will exceed the levels seen in 2010 when FiT rates exceeded 50 p/kWh for domestic retrofit solar PV installations.
Overarching trend	There is close alignment between DFES and FES in the baseline and in the **Falling Short** and **System Transformation** scenario projections. DFES **Consumer Transformation** and **Leading the Way** projections see approximately 25% lower growth than the FES 2023 equivalents, based on the different assumptions around deployment rates reaching above FiT levels in the FES 2023.

Geographical factors affecting deployment at a local level

Small scale solar PV geographical factors	
Geographical factors	**Description**
Domestic uptake	Domestic uptake is mainly influenced by affluence, home ownership, and social housing. In the early years, uptake is weighted towards affluent areas and social housing, where solar is installed by housing associations and becomes more spread across all affluence levels towards 2050, especially in **Leading the Way** and **Consumer Transformation**. The impact of these variables reduces over time as rooftop solar PV deployment becomes increasingly ubiquitous.
New developments	Approximately 500,000 new homes are projected to be built in the licence area between now and 2050. In **Consumer Transformation** (the highest deployment scenario), 70% of the new build homes could have a total of 1 GW of rooftop solar capacity installed by 2050. The location of existing new build sites influences the distribution of this capacity.

Relevant assumptions from National Grid FES 2023

Scenario		4.1.5 – Solar generation (smaller than 1 MW)
Falling Short	Low	Slower pace of decarbonisation.
System Transformation	Medium	Transition to net zero results in strong growth in small solar. Supports production of hydrogen by electrolysis.
Consumer Transformation	Medium	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	High	Very high growth in small solar as it supports the transition to net zero and is highly aligned to the high societal change.

Incorporation of stakeholder feedback

Small scale solar stakeholder feedback	
Stakeholder feedback provided	**How this has influenced our analysis**
DFES 2023 engaged with solar developers Eden Sustainable on their commercial scale developments.	The DFES team engaged with solar developers Eden Sustainable about their commercial scale sites, to identify any constraints or allowances on the industry that can be reflected in scenario projections. Skill shortages and connection applications were among the largest barriers to growth. This has been considered a broader influencing factor for delayed uptake of commercial scale solar under **Falling Short**. They also indicated the current obligations of the minimum energy efficiency standards (MEES) in the domestic sector were aiding growth. This, along with the potential changes to non-domestic MEES in the coming years were reflecting under the **Leading the Way** and **Consumer Transformation**.
DFES 2023 draws on engagement with solar developers Sungift on their commercial and domestic scale sites.	The DFES team engaged with solar developers Sungift on their commercial and domestic scale sites to review the current trends in the roof top solar market and any policy changes in the area. This highlighted that local grid issues and export restrictions are having the biggest impact on sector growth. This has been considered a broader influencing factor for delayed uptake of commercial-scale solar under **Falling Short**.

[xi] Solar photovoltaics deployment, 2023 See: https://www.gov.uk/government/statistics/solar-photovoltaics-deployment

[xii] Solar Energy UK, 2021, Future homes are solar homes. https://solarenergyuk.org/future-homes-are-solar-homes/

[xiii] Building Regulation (Part L). https://www.gov.uk/government/publications/conservation-of-fuel-and-power-approved-document-l

[xiv] BEIS in the Spring Statement 2022 See: https://www.gov.uk/government/news/beis-in-the-spring-statement-2022

[xv] Non-domestic private rented property: minimum energy efficiency standard - landlord guidance See: https://www.gov.uk/guidance/non-domestic-private-rented-property-minimum-energy-efficiency-standard-landlord-guidance

[xvi] Minimum Energy Performance of Buildings (No. 2) Bill See: https://publications.parliament.uk/pa/bills/cbill/58-02/0150/210150.pdf

[xvii] Ofgem, 2022, *Feed-in Tariffs*. https://www.ofgem.gov.uk/environmental-programmes/fit/fittariff-rates

Hydropower

Summary of modelling assumptions and results

Technology specification

The analysis covers hydropower generation connecting to the distribution network in the Southern England licence area.

The analysis does not include pumped hydropower, which is considered an energy storage technology.

Technology building block: **Gen_BB018 – Hydro**

Data summary for hydropower in the Southern England licence area

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	1.7	1.7	1.7	1.7	1.7	1.7	1.7
System Transformation		2.1	2.1	2.1	2.1	2.1	2.1
Consumer Transformation		2.4	2.7	3.4	4.2	5.5	6.7
Leading the Way		2.4	2.7	3.4	4.2	4.9	5.7

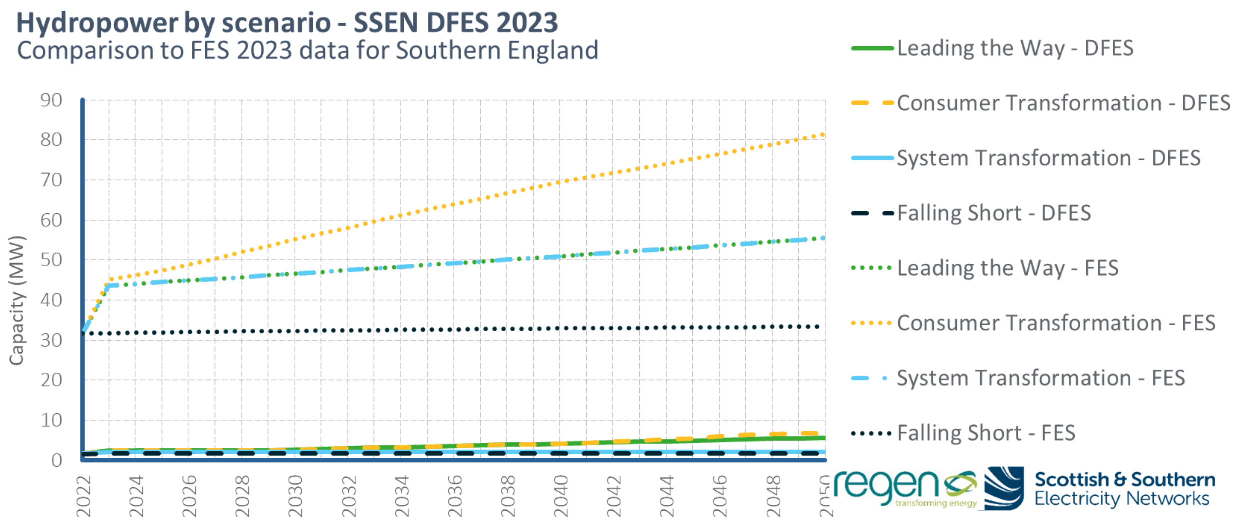


Figure 25 Hydropower projections for the Southern England licence area, compared to National Grid FES 2023 regional projections

Summary

- The Southern England licence area has very low levels of hydropower resource and historic deployment.
- As a result, connected capacity currently only totals 1.7 MW across 52 sites, which hasn't changed from DFES 2022. The average capacity for hydropower sites in the licence area baseline sites is very small, at c. 27 kW.
- The pipeline of new contracted hydropower sites consists of only three sites, the largest of which is Sandford Hydropower (421 kW), which is a part of the Project LEO pilot[xviii] and is only a temporary capacity addition to an existing site, which will be removed after the trial period.
- The Southern Licence area has a *theoretical potential* of 33.4 MW of hydropower, based on the 2010 Hydropower Opportunities Mapping Project.[2] The analysis lists Windsor and Maidenhead as the local authority area with the highest hydropower potential, totalling some 6.97 MW. However, estimates of theoretical potential do not account for any external constraints such as economic feasibility and technical site-by-site analysis, meaning that the actual economic potential is likely to be much lower.
- All sites in the Southern England licence area, baseline, and pipeline, are mini hydropower sites (100 kW-1 MW) or smaller, suggesting that future hydropower projects will likely remain at this very small scale.

- Economic conditions are much less attractive now for technology than when the technology received support under the Feed-in Tariff. However small-scale sites are seeing efficiency improvements as technology develops, and a co-located battery could increase their economic viability.[xix]
- As a result, distributed hydropower capacity has been modelled to quadruple under the **Consumer Transformation** scenario, totalling c. 6.7 MW by 2050.
- No new development has been modelled under **Falling Short**; this reflects higher abstraction licence costs that came into force in 2022[xx] and reduced policy support for small-scale renewables.

Modelling and assumptions

Baseline (2022)			
Scale	**Number of sites**	**Total capacity (MW)**	**Description**
Total	52	1.7	Most baseline sites were installed between 2010 and 2016, likely supported by the Feed-in Tariff scheme. Four sites completed after 2016 total only 42 kW of all installed capacity. South Oxfordshire has the highest operational site capacity, at 567 kW, c. 34% of the total baseline in the licence area.

Pipeline (2023-2030)	
Number of pipeline sites	**Total capacity (kW)**
3	711

Pipeline analysis			
Status	**Description**	**Sites**	**Capacity (kW)**
Operational	Of the two pipeline sites found to be operational, the largest is a capacity extension to Sanford Hydro, a Project LEO site. While this is a temporary capacity increase during a trial, the project was used in **Consumer Transformation** **System Transformation** and **Leading the Way**, but not **Falling Short**. The	2	427

	other site is added capacity at Osney Lock Hydro modelled to connect in 2023 in all scenarios.		
Planning permission granted	A single project was found to have planning approval but has seen little progress since the initial planning was approved in 2017. The site is modelled to come online in 2023 under **Consumer Transformation** and **Leading the Way**.	1	284

Planning logic and assumptions (percentage of capacity modelled to come online)
Due to the limited number of hydropower sites in the Southern licence area, each site is assessed on a site-by-site basis.

Scenario projections (2030 to 2050)			
Scenario	**Description**	**Capacity by 2035 (MW)**	**Capacity by 2050 (MW)**
Falling Short	Under this scenario, other than temporary capacity extensions, no additional capacity growth has been modelled out to 2050. This reflects limited support for small-scale renewables and low resource availability.	1.7	1.7
System Transformation	As a scenario that places more support for large-scale renewable energy projects, small renewable projects like micro hydropower are largely not supported under **System Transformation**. As a result, whilst operational pipeline projects were reflected, projects with planning permission only were not modelled to progress through to development. Only moderate growth is modelled out to 2050. Without small-scale hydropower subsidy support, projects are supported by the Smart Export Guarantee.[xxi]	2.1	2.1
Consumer Transformation	The highest development of additional hydropower in the licence area is modelled with an emphasis on policy and financial support to small-scale renewable projects. All pipeline projects are modelled to come online in the near term, and a moderate but sustained growth in hydropower capacity is projected out to 2050.	3.4	6.7

	Favourable government policies and support for small-scale renewable energy projects unlock sector growth.		
Leading the Way	All known pipeline sites connect in the near term, and a continued but less ambitious growth in hydropower capacity out to 2050 than seen in **Consumer Transformation**. This is comparable to the projections seen in DFES 2022.	3.4	5.7

Reconciliation with National Grid FES 2023

Modelling stage	Reconciliation
Baseline	The FES 2023 has 32 MW of hydropower capacity as a baseline, compared to the 1.7 MW from the DFES 2022 baseline. The DFES analysis includes a more in-depth assessment of live connection registers held by SSEN's network planning teams, and therefore has a more up to date view of baseline sites following rigorous site checking and version control of past and present SSEN capacity databases.
Pipeline	The FES 2023 shows an immediate increase to at least 43 MW of hydropower across three scenarios within the first year of the pipeline; the reason for this is unknown and contrasts with the small DFES 2023 pipeline.
Projections	Under FES 2023, **Falling Short** shows limited growth to 2050, which is in line with the DFES 2023, despite the discrepancy in the baseline, however, **Consumer Transformation** shows much more ambitious growth than DFES. The reason for this is a difference in modelling methodology that accounts for regional resource potential. The DFES methodology considers results from the most recent UK hydropower resource potential assessments that show a total theoretical potential for the region at 30 MW largely made up of small scale projects (under 1 MW). The FES assumption adopted in DFES is that there is very limited growth in 'micro hydro'. Applying these assumptions to the resource potential results in a projection of much more limited growth.
Overarching trend	Beyond the baseline variance and near-term projections, the FES projects a more ambitious trajectory for small hydropower in the southern licence area, while the DFES has much lower potential growth due to evidence as to the total economically available resource potential assumptions.

Geographical factors affecting deployment at a local level

Hydropower geographical factors	
Geographical factors	**Description**
Resource distribution	The distribution of capacity beyond the known pipeline is based on the location of known projects and resource availability. Additional small-scale, medium- and long-term projections will be distributed geographically based on areas of theoretical hydropower potential.

Relevant assumptions from National Grid FES 2023

Scenario		4.1.2 - Other renewables, including marine and hydro generation
Falling Short	Low	Low support and therefore other renewables cannot compete with low-cost solar and wind generation.
System Transformation	High	Support for large-scale renewable technologies (i.e., tidal marine).
Consumer Transformation	High	Potential for a lot of small scale projects that will have a larger societal impact coupled with support for marine technologies across all scales.
Leading the Way	Medium	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.

Incorporating stakeholder feedback

Stakeholder feedback provided	How this has influenced our analysis
Engagement with the British Hydropower Association	The British Hydropower Association were engaged to confirm resource assessment and high projection numbers from FES 2022. They confirmed that hydropower highly depends on funding mechanisms and developments in micro/pico scale schemes. This feedback influenced the assumption of growth to micro/pico scale projects contributing to growth under the **Consumer Transformation** scenario. The constraints on resources in the Southern Licence area were confirmed with this engagement and helped justify the maximum capacity of under 10 MW in this licence area. Given the resource in the area, 8.5 MW is a realistic upwards estimate, reflecting the limited available theoretical capacity.

[xviii] Project LEO 2017, Sandford Hydro trials. See: https://project-leo.co.uk/case-studies/sandford-hydro-trials/

[xix] British Hydro Association 2022, UK Hydropower Resource Assessment See: https://zenodo.org/record/7229023/files/BHA%20report%20draft%20v1.0.2.pdf?download=1

[xx] See Environment Agency abstraction licence costs: https://www.gov.uk/government/publications/environmental-permits-and-abstraction-licences-tables-of-charges

[xxi] Ofgem 2022, Smart Export Guarantee. See: https://www.ofgem.gov.uk/environmental-and-social-schemes/smart-export-guarantee-seg

Marine generation

Summary of modelling assumptions and results

Technology specification

The analysis includes marine generation projects (tidal stream, wave power, tidal lagoon) that connect to the distribution network in the Southern England licence area. The SSEN DFES analysis has focused on known small scale developments, supplemented by engagement with the European Marine Energy Centre and the Marine Energy Council to identify potential pipeline projects that may connect to the distribution network out to 2050.

The technologies included in the DFES marine energy analysis are:

- **Wave energy:** smaller pre-commercial arrays that typically connect to the distribution network.
- **Tidal stream energy:** this technology harnesses kinetic tidal flows around headlands and in channels. Most projects are now at commercial scale with some connecting to the distribution network and some connecting to the transmission network.

Note: there are no tidal lagoon projects in the licence area, but these may connect at transmission network level.

Technology building block: **Gen_BB017 – Marine (Tidal Stream, Wave Power, Tidal Lagoon)**

Data summary for marine generation in the Southern England licence area

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	0	0	0	0	0	0	0
System Transformation		0	0	20	32	32	32
Consumer Transformation		0	20	85	85	85	85
Leading the Way		0	20	20	20	20	20

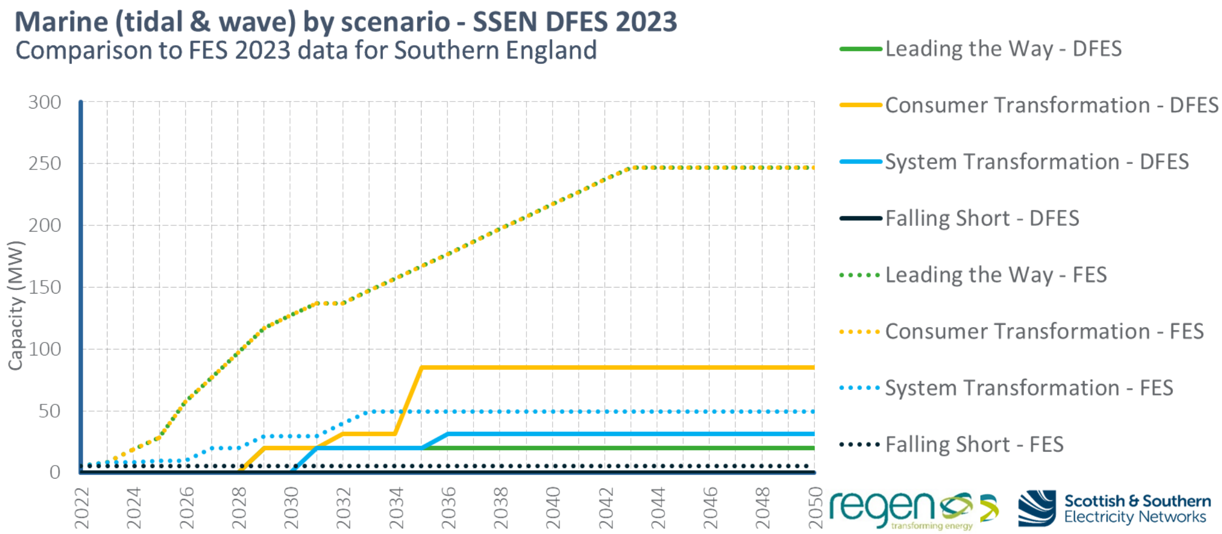


Figure 26 Marine generation projections for the Southern England licence area, compared to National Grid FES 2023 regional projections

Summary

- While there are no operational grid-connected marine energy generation projects in the Southern England licence area to date, there is activity through marine generation development zones and a small pipeline of developing projects.
- One pipeline site seeking to connect to the distribution network on the Isle of Wight is being led by the Perpetuus Tidal Energy Centre (PTEC). This site has secured a connection agreement for 32 MW and has obtained full consent for a 30 MW development. Further development and network connection is likely dependent upon securing a Contract for Difference (CfD). This site did not feature in Allocation Round 5 (AR5) so success in the next round (AR6) would mean a project delivery year of 2028/29.
- In July 2023, the results of the CfD AR5 were announced, which included a minimum budget of £10m for tidal stream.[xxii] 53 MW of projects succeeded in winning a CfD at a strike price of £198/MWh (2% lower than the administrative strike price of £202/MWh). These results have strengthened the renaissance of the UK marine generation industry, but further development will depend on the industry's ability to reduce technology costs and continued policy support – particularly as tidal stream's CfD success in AR5 was predicated upon an absence of bids from offshore wind

projects. Orbital Marine Power (OMP) – a CfD winner at both AR4 and AR5 for its European Marine Energy Centre (EMEC) site in Scotland – submitted a joint application with PTEC into the CfD AR4 that was unsuccessful.[xxiii] They also did not win a CfD in AR5. OMP and PTEC are expected to bid into future rounds.[xxiv]

- As the tidal stream sector expands, larger-scale projects are expected to connect to the transmission network and distribution network-connected projects will likely remain limited to smaller-scale commercial demonstration projects, trial sites and testing facilities.
- The wave energy industry is yet to demonstrate/prove successful as a commercially viable technology, but it could see significant scaling once it does.

Modelling and assumptions

Baseline (2022)	
Number of sites	**Total capacity (MW)**
--	--

Pipeline (2023-2030)	
Number of pipeline sites	**Total capacity (MW)**
1	32

Pipeline analysis	
Status	**Description**
Planning permission granted	The PTEC site is located south of the Isle of Wight. In 2020, PTEC partnered with EMEC to support reconsenting work and manage its grid connection application.[xxv] PTEC has also partnered with technology developer Orbital Marine Power (OMP) to deliver an initial phase of 20 MW capacity that is eligible for CfD contracts.[xxvi] Modelled commissioning timelines are: • Phase 1 (20 MW) is modelled to connect in 2029 in **Leading the Way** and **Consumer Transformation** and 2031 in **System Transformation**. • Phase 2 (increase to 32 MW total capacity) connects in 2032 under **Consumer Transformation** and 2036 under **System Transformation**.

Scenario projections (2030 to 2050)			
Scenario	**Description**	**Capacity by 2035 (MW)**	**Capacity by 2050 (MW)**
Falling Short	There is low support for tidal stream overall. No further ring-fenced budgets for tidal stream are considered to be included in future CfD Allocation Rounds. As a result, projects in Southern England do not receive government support, and no development occurs.	0	0
System Transformation	Support for larger-scale marine generation technologies and projects is modelled in this scenario, likely via future CfD rounds. This leads to a phased build-out of PTEC to 32 MW. The Yarmouth Tidal Test Centre modelled in DFES 2022 is expected to be an off-grid project so is no longer included, resulting in a 2050 capacity projection that is 5 MW lower than DFES 2022.	20	32
Consumer Transformation	Marine technologies receive good support across all scales, and there is consistent industry development out to 2050. Similar developments under **System Transformation** are brought online earlier. The PTEC site has been modelled to expand its site capacity further to c. 85 MW in the longer term. The Yarmouth Tidal Test Centre modelled in DFES 2022 is expected to be an off-grid project so is no longer included, resulting in a 2050 capacity projection that is 5 MW lower than DFES 2022.	85	85
Leading the Way	Prioritising solar and wind generation technologies reduces the need for tidal energy under this scenario. As a result, only PTEC's 20 MW development on the Isle of Wight is modelled to connect.	20	20

Reconciliation with National Grid FES 2023

Modelling stage	Reconciliation
Baseline	The FES 2023 baseline is 5.4 MW, compared to a zero baseline in the DFES 2023. The DFES analysis has confirmed that there are no operational marine projects in the Southern England licence area, so it is unclear where the FES figure originates from.

Pipeline	The FES 2023 shows a much faster rise in marine generation capacity than DFES 2023, particularly under **Leading the Way** and **Consumer Transformation**. In the FES, all expansion is connected to the Melksham GSP, which is not considered a connection point for marine projects.
Projections	The FES 2023 models increasing marine generation capacity out to 2043 under **Leading the Way** and **Consumer Transformation**, peaking at 247 MW – almost three times the DFES 2023 **Consumer Transformation** projection. As with the near term, all FES capacity is projected to be connected to the Melksham GSP, which is not considered a connection point for marine projects.
Overarching trend	DFES 2023 projections for **System Transformation** and **Falling Short** are comparable to FES 2023 projections, but project lower and later development pipelines. Projections for **Leading the Way** and **Consumer Transformation** are significantly higher in the FES 2023 than in the DFES. In the FES, all capacity is projected to connect to a GSP that is not considered a connection point for marine generation projects as it is landlocked.

Geographical factors affecting deployment at a local level

Geographical factors	Description
Location of known pipeline projects and industry knowledge	The DFES analysis for marine generation uses stakeholder engagement to focus on the location of known pipeline developments along the south coast and the Isle of Wight.

Relevant assumptions from National Grid FES 2023

Scenario		4.1.2 - Other renewables including marine and hydro generation
Falling Short	Low	Low support and therefore other renewables cannot compete with low-cost solar and wind generation.
System Transformation	High	Support for large-scale renewable technologies (i.e. tidal marine).
Consumer Transformation	High	Potential for a lot of small-scale projects that will have a larger societal impact coupled with support for marine technologies across all scales.
Leading the Way	Medium	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.

Incorporation of stakeholder feedback

Stakeholder feedback provided	How this has influenced our analysis
Representatives from the Isle of Wight, EMEC, MEC and the marine energy development sector were engaged.	Feedback provided was used to inform the scenario projections.

[xxii] UK Government 2023, *Contracts for Difference (CfD) Allocation Round 5: results.* https://www.gov.uk/government/publications/contracts-for-difference-cfd-allocation-round-5-results

[xxiii] Current 2021, *Orbital Marine Power confirms applications into the CfD*. https://www.current-news.co.uk/orbital-marine-power-confirms-applications-into-the-cfd/

[xxiv] Perpetuus Tidal Energy Centre n.d., *Timeline.* https://perpetuustidal.com/the-project-to-date/timeline/

[xxv] European Marine Energy Centre Ltd. (EMEC) 2020, *Press Release: EMEC Enters Partnership With PTEC To Grow UK Tidal Energy Market*. https://www.emec.org.uk/press-release-emec-enters-partnership-with-ptec-to-grow-uk-tidal-energy-market/

[xxvi] Perpetuus Tidal Energy Centre n.d., *Partners.* https://perpetuustidal.com/partners/

Biomass generation

Summary of modelling assumptions and results

Technology specification

The analysis covers biomass-fuelled generation connecting to the distribution network in the Southern England licence area. This includes both biomass for power generation and biomass Combined Heat and Power (CHP). However, the analysis does not include biomass used solely for heat or bioenergy generation with carbon capture and storage (BECCS).

Technology building block: **Gen_BB010 – Biomass & Energy Crops (including CHP)**

Data summary for biomass in the Southern England licence area

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	0.8	1.9	1.9	1.9	1.9	1.9	1.9
System Transformation		1.9	1.9	1.9	1.9	1.9	1.0
Consumer Transformation		1.9	1.9	1.9	1.9	1.0	1.0
Leading the Way		0.8	0.8	0.8	0.8	--	--

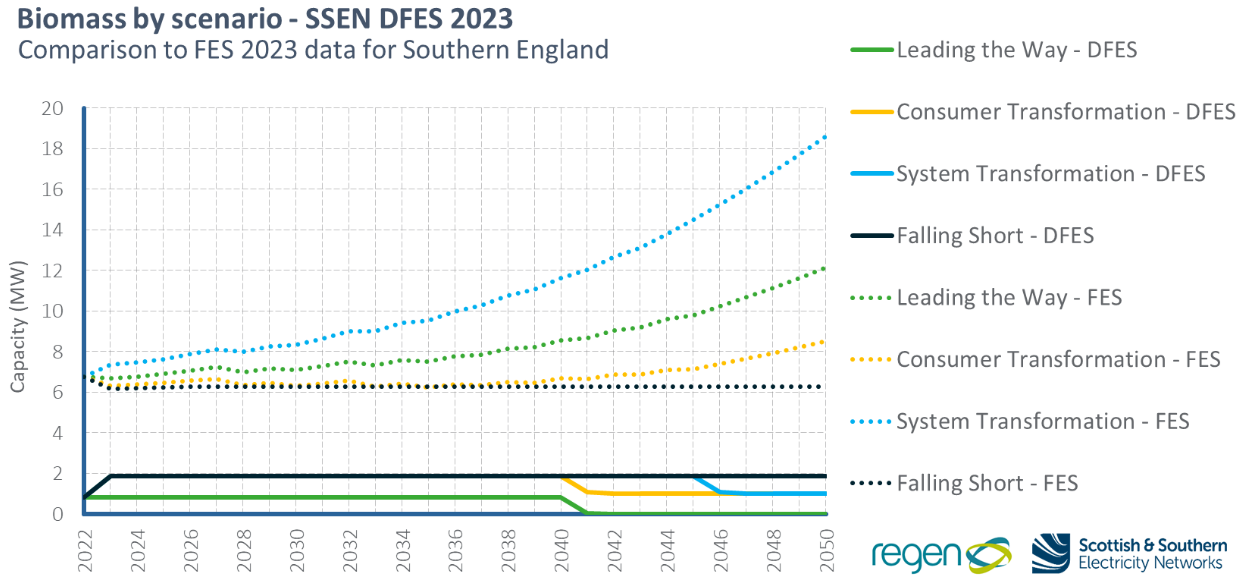


Figure 27: Biomass generation projections for the Southern England licence area, compared to National Grid FES 2023 regional projections

Summary

- The Southern England licence has a historically low baseline of distribution-connected biomass-fuelled electricity generation, likely due to the region's absence of large-scale forestry or biomass crop production.
- The key difference between DFES 2022 and DFES 2023 is that in 2023, a 40 MW pipeline site is no longer included in the analysis, thereby decreasing projections under **System Transformation** where it was previously modelled to connect. This is due to lack of further evidence of project development.
- Due to economies of scale, most BECCS-enabled sites are likely to connect to the transmission networks where the significant investments required for carbon capture technologies are more feasible.
- Another reason for low levels of development to date could be due to anti-biomass campaigning at a local level, which has played a role in projects not successfully securing planning approval in the past.[xxvii]
- The National Grid ESO FES 2023 assumes that, in the medium term, many of the larger sites on the distribution network decommission and are replaced by larger, transmission-connected biomass plants with co-located carbon capture and storage (CCS) technologies. The SSEN DFES 2023 has adopted this assumption for the Southern England licence area in the net zero scenarios.

- Under the UK Biomass Policy Statement,[xxviii] most off-gas grid small-scale biomass sites are to be reserved for heating purposes. The DFES reflects this in its approach to decommissioning existing sites.
- In 2021, the UK Government issued a call for evidence on the proposed removal of the 300 MW threshold for Decarbonisation Readiness (DR) requirements for combustion power plants, which went to consultation in 2023 and will come into force for new and refurbished plants by July 2024 in England alone.[xxix] The DR will require sites to set aside space for carbon capture technology. If this removal goes through the business model will become increasingly challenging without further subsidy support, unless in rare cases it is exempt from the environmental permitting regime.[xxx]
- **Leading the Way**, **System Transformation** and **Consumer Transformation** see only small pipeline sites connecting to the distribution network before most sites disconnect to meet longer-term net zero targets.
- **Falling Short** remains stagnant, with no new sites connecting after 2024.

Modelling and assumptions

Baseline (2022)		
Number of sites	**Total capacity (MW)**	**Description**
2	0.8	Biomass capacity in the Southern licence area is limited to two sites that are recognised as connected in the SSEN connections database. These are the SCE wastepaper site in Basingstoke and Deane (800 kW) and Moorhayes Farm Biomass (46 kw).

Pipeline (2023-2030)	
Number of pipeline sites	**Total capacity (MW)**
2	1
There are two biomass generation pipeline sites included in the analysis; a 632 kW site in South Somerset and a 389 kW site at Four Dell farm buildings in Winchester. Both are assumed to become operational by 2023 due to being small-scale under all scenarios except **Leading the Way**.	

Decommissioning logic
Because most small-scale biomass plants will not find it economically viable to fit CCUS technologies, existing sites are modelled to decommission and not be replaced with new assets in the three net zero scenarios.

Under **Falling Short**, existing sites are modelled to remain online well past the 2050 target for a net zero electricity system. All pipeline sites modelled to connect are assumed to remain connected out to 2050.			
Falling Short	**System Transformation**	**Consumer Transformation**	**Leading the Way**
Does not decommission before 2050	30 years	25 years	25 years

Scenario Projections (2030 to 2050)			
Scenario	**Description**	**Capacity by 2035 (MW)**	**Capacity by 2050 (MW)**
Falling Short	Biomass capacity remains very low in the licence area under all scenarios out to 2050. The DFES decommissions existing biomass in the three net zero scenarios over the period to 2050 and does not model any further uptake. This echoes the UK's Biomass Policy Statement, which stipulates that most off-gas biomass sites should be reserved for heating. As a result, under **Consumer Transformation** and **System Transformation** there is only 1 MW of operational biomass-fuelled electricity generation in the licence area by 2050. Under **Leading the Way**, all biomass capacity is modelled to decommission by 2040.	1.9	1.9
System Transformation		1.9	1
Consumer Transformation		1.9	1
Leading the Way		0.8	--

Reconciliation with National Grid FES 2023

Modelling stage	**Reconciliation**
Baseline	The DFES 2023 baseline of 0.8 MW is lower than the FES baseline of 7 MW. The reason for this variance is unclear, although it could relate to differences in technology classifications across connection registers or the FES accounting for small, behind-the-meter sites.
Pipeline	The DFES 2023 pipeline is very small which aligns with minimal FES 2023 uptake in late 2020s and early 2030s.
Projections	The FES 2023 models a slight increase in distributed biomass in some scenarios in the medium and long-term. This differs from the DFES 2023, which focuses on decommissioning existing sites from 2030 in the three net zero scenarios, to be in line with net zero targets. Any abated biomass with CCUS technologies is expected to be transmission-level and therefore out of scope for the DFES.

Geographical factors affecting deployment at a local level

Geographical factors	Description
Baseline and pipeline sites	The geographical location of future capacity is based entirely on known baseline and pipeline locations.

Relevant assumptions from National Grid FES 2023

Assumption number	4.1.11 - Unabated Biomass and Energy from Waste (EfW) generation	
Falling Short	High	Unabated biomass generation does not convert as rapidly to BECCS. No significant change in waste management from society; leaving waste available as a fuel source for unabated generation.
System Transformation	Medium	Unabated biomass is supported for longer than in **Leading the Way** as slower to adopt CCS. Less waste to burn in general due to a highly conscious society adapting to low waste living.
Consumer Transformation	Medium	
Leading the Way	Low	Unabated biomass drops away rapidly as BECCS and other uses for biomass increases. Less waste to burn in general due to a highly conscious society adapting to low waste living.

Incorporation of stakeholder feedback

Stakeholder feedback provided	How this has influenced our analysis
No stakeholder feedback was captured for this technology in DFES 2023.	

[xxvii] The Electricity Forum n.d., *Bristol rejects 50-MW biomass plant*. https://www.electricityforum.com/news-archive/mar10/Bristolrejectsbiomassplant

[xxviii] Department for Business, Energy & Industrial Strategy 2021, *Biomass Policy Statement*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1031057/biomass-policy-statement.pdf

[xxix] https://assets.publishing.service.gov.uk/media/640efb5ad3bf7f02f4c7682c/decarbonisation_readiness_consultation.pdf

[xxx] See page 27 of the consultation: https://assets.publishing.service.gov.uk/media/640efb5ad3bf7f02f4c7682c/decarbonisation_readiness_consultation.pdf

Renewable engines

Summary of modelling assumptions and results

Technology specification

The analysis covers electricity generated from renewable engines connected to the distribution network in the Southern England licence area. This technology sector is broken down into three renewable gas generation sub-technologies: landfill gas, sewage gas and biogas from other anaerobic digestion (AD) (e.g. food waste). The analysis focuses on CHP plants that generate electricity and excludes plants that are solely used for heat and biomethane production.

Technology building block: **Gen_BB004 – Renewable Engines (Landfill Gas, Sewage Gas, Biogas)**

Data summary for renewable engines in the Southern England licence area

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	74	94	76	70	70	64	64
System Transformation		80	72	68	68	62	62
Consumer Transformation		94	102	102	103	98	99
Leading the Way		88	100	101	103	99	99

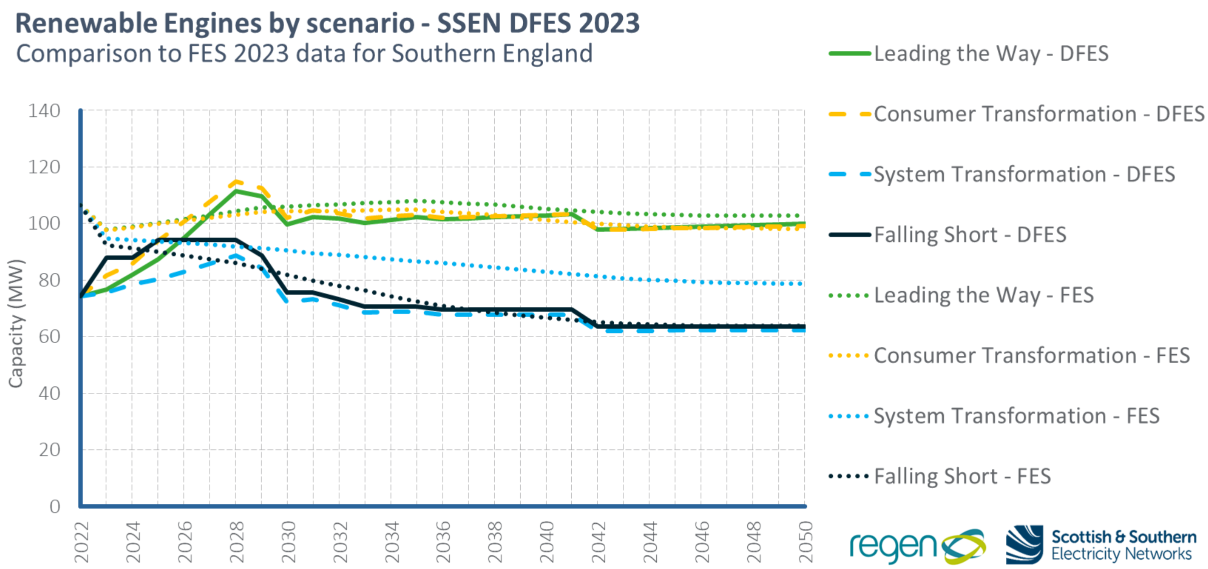


Figure 28 Renewable engines projections for the Southern England licence area, compared to National Grid FES 2023 regional projections

Summary

- As of the end of 2022, there was 74 MW of installed renewable engine capacity in the licence area, of which 30 MW was anaerobic digestion (AD), 31 MW was landfill gas, and 13 MW was sewage gas. This is 25 MW less than DFES 2022, due to a reclassification of the connection status of some landfill and sewage gas sites.
- Total capacity projected by 2050 under **Leading the Way** and **Consumer Transformation** is higher in DFES 2023 than was seen in DFES 2022, reflecting a more detailed assessment of resource availability. This aligns more closely with the FES 2023 regional projections.
- The future of AD in Southern England depends heavily on feedstock availability. As most councils already collect food waste, food industry and agricultural and animal husbandry by-products are most likely to serve as future feedstocks.
- Agricultural Land Grade in the Southern England licence area is good, hosting 7.1% of all viable high-grade agricultural land in GB (English land grade 1 & 2).
- Landfill gas is expected to decrease over time as a legacy technology with limited lifetimes, and as landfill sites are destined for natural restoration.[xxxi] This leads to a gradual decommissioning of all sites by 2042 under all scenarios. Only some pipeline sites are modelled to connect under **Falling Short**.

- Sewage gas remains at similar levels under all scenarios, with a proportion of regional sewage gas resource already being captured and used for electricity and CHP generation.
- Increased demand for green gas is expected in the medium and long term for transport, heat networks and gas grid injection. However, electrolytic hydrogen and electrification are also expected to play a role in decarbonising these end-use sectors, limiting the future role of renewable engines across all scenarios.
- The injection of green gas into the gas network is currently incentivised via the Green Gas Support Scheme,[xxxii] funded through payments made by licenced gas suppliers under the Green Gas Levy. This may further limit the amount of future electricity distribution network-connected sites.
- Projected increase in anaerobic digestion from redistributed FES projections across all DNO licence areas results in a net increase in total capacity out to 2028 under the three net zero scenarios. After 2028, decommissioning logic leads to a decrease in capacity as legacy landfill gas sites begin coming offline.
- Under **Leading the Way** and **Consumer Transformation**, overall renewable engine capacity gradually increases compared to the baseline, reaching c. 100 MW by 2050. This is largely due to resource availability.
- The other two scenarios see a small net decrease from the baseline due to decommissioning of landfill gas, decreasing to 62 and 64 MW by 2050 under **System Transformation** and **Falling Short** respectively.

Modelling and assumptions

Baseline (2022)		
Number of sites	**Total capacity (MW)**	**Description**
42	74	The baseline consists of 74 MW from 42 sites, 30 MW of which is from AD, 31 MW from landfill gas, and 13 MW from sewage gas. The majority of sewage gas capacity was added from 2015 onwards (likely supported by the Renewables Obligation scheme, which closed in 2017). In contrast, AD capacity has grown steadily since pre-2010 to reach current levels. All landfill gas sites were connected prior to 2012, most of which were commissioned in the 1990s. Compared to DFES 2022, the renewable engines baseline has

		decreased by 25 MW. The change in baseline capacity is partially a result of new information about four sites (c. 13 MW) previously thought to have commissioned in 2021. These sites have been reallocated to the near-term pipeline. Additionally, five sites (c. 12 MW) previously identified in the Renewable Energy Planning Database have been included in the DFES renewable engines baseline in previous years of analysis, although they were not included in the SSEN connections data. This year, they have been removed from the analysis, following the assumption that their absence from SSEN connections data means they are either gas grid connected, connected to other DNOs or not grid-connected at all.

Pipeline (2023-2030)

Number of pipeline sites	Total capacity (MW)
19	45

There are 19 renewable engine sites with connection offers, across the three sub-technologies, in various stages of planning, of which 0.3 MW is made up on three sites that have been issued a quote but not yet received a connection agreement. This results in an 11 MW increase in the pipeline compared to DFES 2022.

Three baseline landfill gas sites at Whiteparith Landfill, Sutton Courtenay and Fairoak have new additional capacities in the pipeline. It is unclear if these sites will increase in export capacity or remain at their original capacities. Therefore, they have only been modelled to connect in **Falling Short**.

Pipeline sites

Status	Description	Sites	Capacity (MW)
Under construction / operational	There are four sites, totalling 8 MW, that are assumed to be under construction or already operational. Three of these are added capacities to existing baseline sites, but have only been modelled to be enacted under **Falling Short**, as they are landfill gas sites and it is unclear as to whether these will result in renewed or extended capacity to the existing sites.	4	8
Planning permission granted	Four sites totalling 9 MW have been granted planning approval. The largest is a 6 MW AD site at Sparsholt College[xxxiii] but this has been delayed, as although planning permission was granted in 2018 the application has since been resubmitted. This site is only modelled to connect in **Consumer Transformation**. No sites were found to be submitted in planning but still awaiting a decision notice.	4	9

Pre-planning	A single site at Fulscot farm was found with an environmental pre-screening agreement. This site had a higher connection agreement of 7.5 MW in DFES 2022 but is now re-applying for a 3.2 MW connection.	1	3
Refused	Two sites totalling 15 MW have been refused in planning and are therefore not modelled to connect under any scenario.	2	15
No information	The remaining eight sites had no information found in planning. A select few with more recent "accepted to connect" dates were modelled to connect in later pipeline years under **Leading the Way** and **Consumer Transformation**.	8	9

Decommissioning logic

Landfill gas sites are modelled to disconnect after 30 years in all scenarios. This is because landfill gas is considered a legacy technology, since waste management is expected to shift to incineration and Advanced Combustion Technologies (ACT) moving forward. There is also the assumption that a more waste conscious society under **Leading the Way** and **Consumer Transformation** will lead to less volumes of waste being treated overall. AD and sewage gas sites are modelled to stay online in all scenarios.

Scenario projections (2030 to 2050)

AD sites are the only renewable engine sub-technology modelled to see any long-term projected capacity growth in the licence area after the known pipeline. Projections are based on locations close to agricultural land that could produce biogenic waste products as feedstocks. Since most councils already collect food waste, councils that have not yet implemented a food waste collection strategy are more likely to install additional biogas capacity. Total capacity by 2050 resultantly reaches 100 MW under **Leading the Way**, as legacy landfill gas sites decrease while AD plants increase. Sewage gas sites are expected to remain at current levels in all scenarios.

Scenario	Anaerobic digestion capacity (MW) by		Landfill gas capacity (MW) by		Sewage gas capacity (MW) by	
	2035	2050	2035	2050	2035	2050
Falling Short	32	32	21	16	17	17
System Transformation	45	46	6	0	17	17
Consumer Transformation	76	79	6	0	20	20
Leading the Way	75	80	6	0	20	20

Reconciliation with National Grid FES 2023

Modelling stage	Reconciliation
Baseline	The FES 2023 baseline for the licence area (106 MW) does not align with the DFES 2023 baseline (74 MW). The reduced DFES baseline was because of site-specific research completed this year. Also, a decrease to 92-98 MW after the baseline in the FES suggests a near-term capacity decrease that is not seen in the SSEN connections data.
Pipeline	Projections in the DFES and FES in the 2020s differ, specifically under FES **Falling Short** and **System Transformation** scenarios, there is an immediate decrease in capacity, while the DFES models a moderate near-term uptake in these scenarios, reflecting pipeline sites that are assumed to be connected across all four scenarios.
Projections	By 2050, the DFES projections are very closely aligned to FES projections, except for **System Transformation** which sees more renewable engine sites remaining connected to the network. This is due to the strict decommissioning logic that has been applied to landfill sites under the DFES analysis, justified by the short lifetime of existing baseline sites.

Geographical factors affecting deployment at a local level

Geographical factors	Description
Baseline and pipeline sites	Distribution is determined by the location of known baseline and pipeline sites.
Agricultural land grade	Areas with high levels of sufficient agricultural land grade are used to pinpoint locations where agricultural by-products could be used for future AD sites.

Relevant assumptions from National Grid FES 2023

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

Incorporation of stakeholder feedback

Stakeholder feedback provided	How this has influenced our analysis
Local authority questionnaire	As part of the DFES analysis, Regen issues a questionnaire to local authorities each year to get an update on local net zero ambitions. All local authorities responding from the Southern England licence area had a waste collection strategy, whereas most but not all collected food waste. This suggests that some local authorities in Southern England have ambitious waste management targets. As a result, councils found to not yet collect food waste were weighted more positively in favour of AD uptake along with areas that have high levels of agricultural land and animal husbandry.

[xxxi] Let's Recycle 2016, Viridor's Calne landfill site accepts final load. https://www.letsrecycle.com/news/viridorscalne-landfill-site-accepts-final-load/

[xxxii] Ofgem 2021, *The Green Gas Support Scheme and Green Gas Levy*. https://www.ofgem.gov.uk/environmental-and-social-schemes/green-gas-support-scheme-and-green-gas-levy#:~:text=The%20Green%20Gas%20Support%20Scheme%20(GGSS)%20is%20a%20government%20environmental,four%20years%20from%20autumn%202021

[xxxiii] Sparsholt Parish 2023, *Sparsholt College Proposed Anaerobic Digester*. https://www.sparsholtparish.org/index.php?pg=Sparsholt_College_Proposed_Anaerobic_Digester

Waste-fuelled generation

Summary of modelling assumptions and results

Technology specification

The analysis covers all forms of electricity generation from waste, including incinerators and Advanced Conversion Technologies (ACT) that are connected to the distribution network in the Southern England licence area.

Technology building block: **Gen_BB011 – Waste Incineration (including CHP)**

Data summary for waste-fuelled generation in the Southern England licence area

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	142	312	377	377	357	341	291
System Transformation		256	280	264	214	174	174
Consumer Transformation		260	280	264	214	174	174
Leading the Way		248	228	212	162	122	122

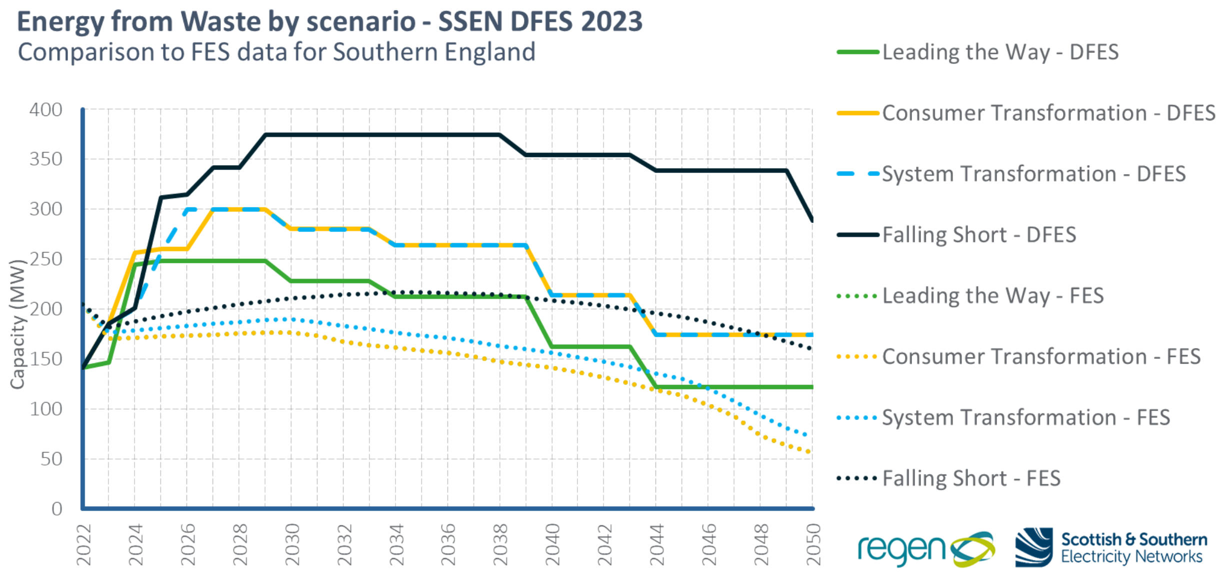


Figure 29 Waste-fuelled generation projections for the Southern England licence area, compared to National Grid FES 2023 regional GSP projections

Summary

- There is currently 142 MW of waste fuelled generation operating in the licence area, most of which is from incineration plants. There is a pipeline of 303 MW of potential additional waste fuelled generation, of which 247 MW is from incineration plants and 56 MW from ACT.
- The carbon emissions from older unabated waste incineration plants are inconsistent with net zero emissions targets. As a result, DFES 2023 scenarios that meet net zero targets assume that connected incineration plant capacity reduces after 2030 as older facilities reach the end of their lifetime.
- The DFES 2023 analysis includes updated assumptions around the operating lifespan of energy from waste sites based on recent planning applications, which are now modelled to remain online for up to 40 years after commissioning.
- Some decommissioned incineration capacity is expected to be replaced by new ACTs. ACT technology is relatively new and expensive, and therefore projects are modelled to connect in the 2030s and 2040s as costs are assumed to drop. Examples of ACTs include:

- Anaerobic digestion,[24] which breaks down organic waste material using bacteria to produce biogas.
    - Gasification, which uses high temperatures to convert solid waste into a gas.
    - Pyrolysis, which heats waste materials in the absence of oxygen to produce a liquid oil that can be used as a fuel, as well as other useful by-products.
    - Plasma arc gasification, which uses plasma (a high-temperature, ionised gas) to convert waste into a gas that can be used for energy production.
- Key uncertainties include the extent to which energy from waste technologies are considered consistent with decarbonisation objectives, planning issues related to air quality and the volume of waste that could be reduced or recycled, thereby reducing feedstock for energy from waste projects. There is also uncertainty as to whether projects will be distribution-network connected.
- By 2050, **Falling Short** has the most waste fuelled generation, with 291 MW of installed capacity remaining in operation, with only one legacy incineration site modelled to disconnect. This is followed by **System Transformation** and **Consumer Transformation** at 174 MW, reflecting a higher level of decommissioning.
- **Leading the Way** sees lower levels of installed capacity by 2050 (122 MW), as high levels of societal change mean that less waste is produced. All net zero scenarios see high uptake of ACTs by the early 2030s as incinerators come offline more quickly.

Modelling and assumptions

Baseline (2022)			
Sub-technology	**Number of sites**	**Total capacity (MW)**	**Description**
Total	7	142	Most baseline capacity comes from incineration sites that were operational before 2015. More recent projects coming online have all been smaller ACT plants.

[24] Note that anaerobic digestion is considered in the DFES as part of the Renewable Engines technology chapter.

Pipeline (2023-2030)	
Number of pipeline sites	**Total capacity (MW)**
16	311
There is a mix of incineration and ACT sites in the connection pipeline in the licence area, totalling 311 MW. These sites have been assessed for planning and development evidence.	

Pipeline analysis

Status	Description	Sites	Capacity (MW)
Under construction	One incineration site was identified as currently under construction in Slough (56 MW).[xxxiv] This site will repurpose on-site natural gas turbines. It is modelled to come online by 2025 in all scenarios. Two ACT sites with a combined capacity of 32 MW in Bournemouth Christchurch and Poole and Wiltshire are also modelled to come online in all scenarios.	3	56
Planning Permission Granted	Seven sites with a total capacity of 109 MW have secured planning approval. Two are ACT sites with a combined capacity of 25 MW. Under **Leading the Way**, incineration projects are not modelled to connect due to restrictions on greenhouse gas emissions.	7	109
Planning Application Submitted	One incineration site in Wiltshire has been identified as having a planning application submitted. Due to the carbon emissions from incineration plants, this site has only been modelled to connect under **Falling Short**.	1	33
Withdrawn or refused	Four sites have been refused or withdrawn in planning and, therefore, not modelled to connect under any scenario.	4	73
No information	One ACT site in the grid connections pipeline was unable to be positively identified and is only modelled to connect in **Leading the Way** and **Consumer Transformation**.	1	0.3

Decommissioning logic

According to the hierarchy of waste management best practice, energy from waste comes in fourth place after waste prevention, waste preparation for reuse and waste recycling. Electricity generation from unabated waste incineration has a high level of carbon emissions, making it at odds with net zero targets. Therefore, the DFES models waste incineration technologies to decommission in all scenarios to align with net zero ambitions and reflect a more waste-conscious society. According to the Department for Environment, Food and Rural Affairs (DEFRA),[xxxv] the operational life of an incineration facility is typically between 20 and 30 years. However, recent planning application evidence has suggested a 40-year operating life for energy from waste sites. This has been incorporated into the decommissioning modelling assumptions for each scenario. For DFES 2023, it has been assumed that only baseline sites

will decommission within the modelling period (2050) whereas pipeline sites will still be operational after this.				
	Falling Short	**System Transformation**	**Consumer Transformation**	**Leading the Way**
Baseline	40 years	30 years	30 years	30 years

Scenario projections (2030 to 2050)			
IEA Bioenergy, in its paper entitled 'Waste Incineration for the Future',[xxxvi] recommends that the waste sector move towards innovation in energy technologies and look towards new business models to continue to create value in a carbon-efficient circular economy. At distribution voltages, ACT technologies have already come forward as low carbon replacements to traditional combustion plants and could replace legacy and new sites in years to come.			
Scenario	**Description**	**Capacity (MW) by**	
		2035	**2050**
Falling Short	Waste incineration sites operate for 40 years, with the earliest site (20 MW) decommissioning in 2038. All pipeline sites that are modelled to connect remain online beyond 2050. Fewer ACT sites are modelled to connect than in the net zero scenarios.	377	291
System Transformation	A shift towards a more sustainable society means less need for waste generation. At the same time, innovative technologies such as ACT become more widespread as investments in cleaner technologies are prioritised at a municipal level. Incinerators are modelled to be replaced by ACT facilities at a faster rate in **Consumer Transformation** and **Leading the Way** and **System Transformation**. Some incinerators remain online and are decommissioned shortly after 2050 or fitted with carbon capture technologies.	264	174
Consumer Transformation		264	174
Leading the Way		212	122

Reconciliation with National Grid FES 2023

Modelling stage	Reconciliation
Baseline	The baseline for waste fuelled generation is 63 MW higher in the FES 2023, at 205 MW, compared to 142 MW identified from SSEN connections data. The reason for this is unclear but could be related to the technology classification of some connected sites.
Pipeline	DFES 2023 deviates from FES 2023 in all scenarios in the near term, with DFES 2023 connecting up to 375 MW under **Falling Short**, whereas FES only sees 217 MW maximum under the same scenario. This variance is due to the DFES pipeline evidence, which takes a site-by-site analysis approach to determine the projects

	most likely to connect. Where planning permission is granted or sites are identified to be already under construction, projects are generally modelled to connect under all scenarios in the DFES.
Projections	In the 2030s, DFES and FES projections are broadly aligned, with DFES showing a wider range between scenarios. Both DFES and FES also model a reduction in capacity under all scenarios. However, the DFES scenarios see higher capacities in all scenarios by 2050 than the FES due to the sites in the pipeline still being online.

Geographical factors affecting deployment at a local level

Geographical factors	Description
Known baseline and pipeline sites	Distribution is determined by known baseline and prospective sites. ACT sites are modelled to connect either at their proposed location in planning applications or at decommissioned incineration sites.

Relevant assumptions from National Grid FES 2023

Assumption number	4.1.11 - Unabated Biomass and Energy from Waste (EfW) generation	
Falling Short	High	Unabated biomass generation does not convert as rapidly to BECCS. No significant change in waste management from society; leaving waste available as a fuel source for unabated generation.
System Transformation	Medium	Unabated biomass is supported for longer than in **Leading the Way** as slower to adopt CCS. Less waste to burn in general due to a highly conscious society adapting to low waste living.
Consumer Transformation	Medium	
Leading the Way	Low	Unabated biomass drops away rapidly as BECCS and other uses for biomass increases. Less waste to burn in general due to a highly conscious society adapting to low waste living.

Incorporation of stakeholder feedback

Stakeholder feedback provided	How this has influenced our analysis
As part of the DFES analysis on new property developments, Regen issues a questionnaire to all local authorities in the licence area to get an update on local net zero ambitions. All local	This suggests that local authorities in Southern England have ambitious waste management targets, with a high level of devolved governance on the future of waste. This has been taken into consideration in the analysis by limiting the reduction in waste-to-energy capacity out until 2050.

authorities responding from the Southern England licence area had a waste collection strategy in place.	

[xxxiv] Slough Multifuel and AECOM 2022, *Environmental Impact Assessment: PEI Report – non-technical summary*. https://www.ssethermal.com/media/fpdpiz3v/pei_sloughmf_nts_with_figures_rev0.pdf

[xxxv] Department for Environment Food & Rural Affairs 2014, *Energy from waste: a guide to the debate*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/284612/pb14130-energy-waste-201402.pdf

[xxxvi] IEW Bioenergy 2019, *Waste Incineration for The Future: scenario analysis and action plans*. https://www.ieabioenergy.com/wp-content/uploads/2019/04/Waste-Energy-for-the-Future-IEA-version.pdf

Diesel generation

Summary of modelling assumptions and results

Technology specification

This analysis covers diesel-fuelled electricity generation, including standalone diesel plants and behind-the-meter diesel backup generators that can export to the distribution network, in the Southern England licence area.

The analysis does not include dedicated backup diesel engines located on commercial and industrial premises that are only operated when mains supply failure occurs and cannot export to the network.

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

Data summary for diesel generation in the Southern England licence area

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	300	342	288	193	140	140	140
System Transformation		309	193	140	0	0	0
Consumer Transformation		309	53	0	0	0	0
Leading the Way		188	0	0	0	0	0

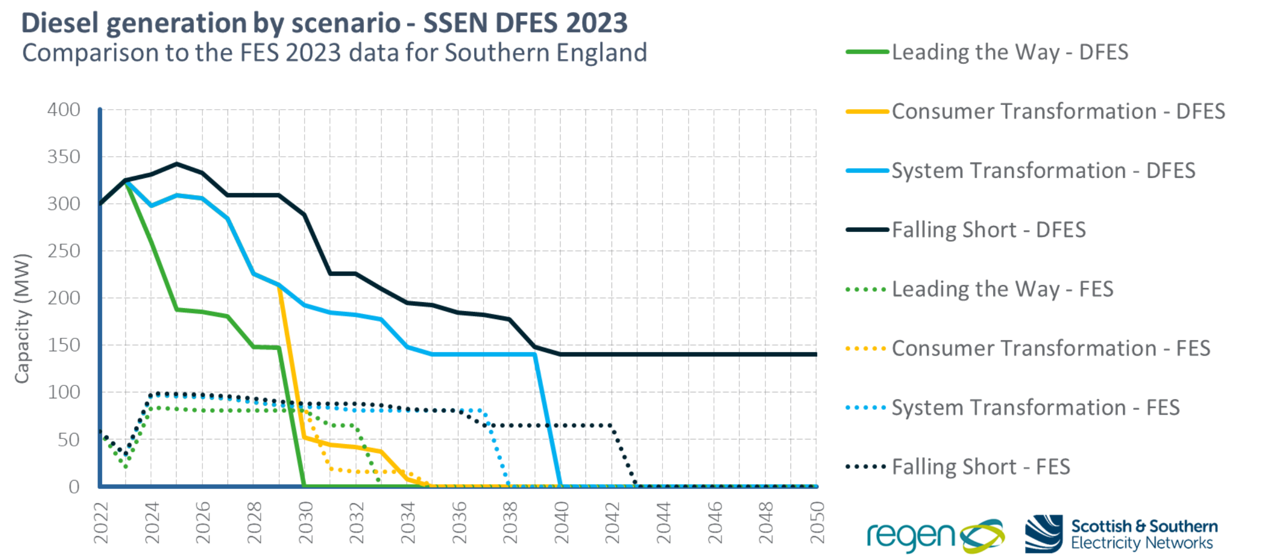


Figure 30 Diesel generation projections for Southern England licence area, compared to National Grid FES 2023 regional projections

Summary

- As of the start of 2023, the Southern England licence area has 300 MW of operational diesel generation, of which 140 MW is located at Cowes Power Station (a large closed-cycle turbine power station located on the Isle of Wight that is fuelled by marine diesel).
- This installed capacity is a combination of standalone, commercial diesel generation sites and behind-the-meter generators, co-located with large energy users.
- The baseline has fallen by 15 MW after a site included in the DFES 2022 baseline was identified as not currently generating by SSEN.
- With 42 MW of capacity from sites with accepted connection offers, several new diesel sites could connect to the distribution network in the near term. Of this, 5 MW has received planning approval.
- Of this pipeline, 19 sites, totalling 34 MW, have been identified as likely behind-the-meter generators and 5 sites, totalling 8 MW, identified as standalone diesel generation sites.
- All proposed new behind-the-meter diesel generators are located onsite at various business premises, such as water treatment works, shopping centres and hospitals.
- Unabated diesel generation has a higher carbon intensity compared to almost all other forms of generation. These generators also emit higher levels of particulate emissions

that impact local air quality. Therefore, the continued use and development of unabated diesel plants is inconsistent with the UK net zero and clean air targets.

- Regulations restricting the use of diesel generators, such as the Medium Combustion Plant Directive (MCPD),[xxxvii] have already been implemented into UK law. This requires combustion plants to adhere to stringent air quality limits by securing environmental permits unless a plant is exempt or only operates for less than 500 hours per year (i.e. backup generators).
- Unabated diesel generation that is covered by the MCPD will, therefore, no longer be allowed to operate from 2025[xxxviii] without exhaust abatement technologies (such as catalytic reduction technology). Fitting abatement technology is unlikely to be financially viable in the near term, especially for smaller plants. Diesel generators whose business model requires semi-regular operation are, therefore, unlikely to be in operation beyond 2025. However, backup generators are presumed to be exempt from these restrictions, due to lower annual operating hours and have, therefore, been modelled to remain online for longer.
- The potential for low-carbon diesel or biodiesel to enable backup generators to operate for longer under some scenarios has been considered. However, without sufficient evidence of fuel-transition programmes this has not been modelled in SEPD for DFES 2023.
- As a result of these assumptions, diesel generation capacity in the licence area falls sharply between 2025 and 2030 in **Leading the Way** and **System Transformation**, as standalone plants decommission. **Consumer Transformation** forecasts a similar timeline for the decommissioning of standalone plants, except for Cowes Power Station, which is modelled to remain online for longer, reflecting previous engagement with RWE. **Falling Short** forecasts a slower phase out of diesel generation, with all existing/projected generators decommissioning by 2040, except for Cowes Power Station, which remains online beyond 2050.
- Cowes Power Station remains a strategically important site in providing black start capability and other grid balancing and resilience services. To align with the Isle of Wight's Net-Zero target of 2040, identified in Regen's study on the Isle of Wight[xxxix], the analysis reflects a number of decarbonisation outcomes for this site, therefore resulting in it being decommissioned as an unabated diesel engine in 2030 in both **Consumer Transformation** and **Leading the Way**, and in 2040 under **System Transformation**. This brings the total installed diesel capacity in the licence area to zero by 2030-2040, broadly aligning with the FES projections. Cowes Power Station is presumed to remain online beyond 2050 under **Falling Short**, reflecting a future

where the dispatchable capacity and strategic importance of the power station remains essential to the wider energy system. There is currently no evidence of a specific decarbonisation plan or timeline for Cowes Power Station published by RWE and engagement in 2022 highlighted that a number of options were being considered, as part of the decarbonisation of their wider asset portfolio.

Modelling and assumptions

Baseline (2022)		
Number of sites	**Total capacity (MW)**	**Description**
27	300	The Southern England diesel baseline consists of both behind-the-meter and standalone generators. The baseline has fallen by 15 MW after a site accounted for in DFES 2022 was identified as erroneous by SSEN. Some sites have been reclassified as standalone generators, but the overall capacity is dominated by the 140 MW Cowes Power Station site on the Isle of Wight, with all other sites being at or less than 20 MW.

Planning logic and assumptions

There is 42 MW of prospective new diesel generation with accepted connection offers in the licence area. Of this, 5 MW has received planning approval. In **Consumer Transformation** and **System Transformation** 9 MW of new diesel capacity is modelled to connect by 2025. Under **Leading the Way**, no new unabated diesel generation sites are modelled to connect. **Falling Short** assumes that any site with a post-2017 connection agreement capacity will become operational.

Decommissioning logic

DFES analysis for diesel generation focuses largely on the decommissioning of existing known baseline and pipeline sites. Between now and the mid-2030s, depending on the scenario, the scenario analysis considers:

- The type of diesel site (standalone or behind-the-meter).
- The year each site was installed.
- How each scenario reflects environmental permitting requirements under the MCPD and wider progress towards net zero targets.
- The potential for low-carbon diesel or biodiesel to enable backup generators to operate for longer under some scenarios. This has only been modelled where fuel-transition programmes have been discussed with the site operators or otherwise evidenced. For SEPD no fuel-transition is modelled.

Scenario projections (2030 to 2050)			
Scenario	**Description**	**Capacity by 2035 (MW)**	**Capacity by 2050 (MW)**
Falling Short	Diesel generation is expected to peak in the mid-2020s, with multiple sub-5 MW sites and the 20 MW 'PeakGen PW Itchen' site (a backup for Portsmouth Water) connecting before older sites begin to decommission. All standalone sites and behind-the-meter generation are modelled to disconnect through to 2040. Only the 140 MW Cowes Power Station site remains connected, continuing to provide restoration, balancing and resilience services to the network beyond 2050.	193	140
System Transformation	Diesel capacity remains constant through to 2027 before standalone and behind-the-meter diesel sites decommission out by 2035, apart from Cowes Power Station, which decommissions in 2040.	140	--
Consumer Transformation	Diesel capacity remains constant through to 2027 before all projects are modelled to decommission by 2035.	--	--
Leading the Way	All diesel sites are modelled decommission by 2030.	--	--

Reconciliation with National Grid FES 2023

Modelling stage	Reconciliation
Baseline	The FES 2023 baseline is significantly lower (59 MW) than the FES baseline (300 MW). Part of this variance is due to the reclassification of the 140 MW Cowes Power Station as marine diesel for the DFES. Some additional baseline sites in the SSEN connections data have also been classified based on site-specific desktop research.
Pipeline	DFES 2023 has identified 42 MW of diesel sites in the pipeline, each of which have been researched in planning, resulting in some new capacity coming online in the next year. FES 2023 sees a near-term fall in capacity followed by a rise under all scenarios, with capacity peaking between in the mid-2020s.
Projections	Under **Leading the Way**, FES sees zero capacity by 2030, which is three years earlier

	than DFES forecasts. Under **Consumer Transformation**, all diesel is forecast to decommission by 2035 in both DFES and FES. Both FES and DFES follow a similar pattern under **System Transformation**, with capacity reducing to zero in the late 2030s (2038 under FES and 2040 under DFES). There are differences between DFES and FES under **Falling Short**, with FES forecasting all diesel capacity disconnecting by 2043, whilst DFES sees 140 MW remaining connected through to and beyond 2050. This is due to differences in how Cowes Power Station has been classified across both assessments.
Overarching trend	Diesel generation capacity is expected to drop to zero in all net zero scenarios in the medium term, this is reflected in both FES and DFES. Only DFES **Falling Short** sees any diesel connected in 2050, related to a large strategic power station remaining online.

Geographical factors affecting deployment at a local level

Geographical factors	Description
Baseline and pipeline locations	The DFES analysis for diesel generation focuses entirely on modelling and decommissioning existing known baseline and pipeline sites. Therefore, spatial distribution references the locations of these individual sites.

[xxxvii] European Commission, 2015, *The Medium Combustion Plant Directive*. https://ec.europa.eu/environment/industry/stationary/mcp.htm

[xxxviii] BEIS, 2019, *MCPD guidance on permitting and compliance dates*. https://www.gov.uk/guidance/medium-combustion-plant-when-you-need-a-permit#permitting-and-compliance-dates

[xxxix] Regen, 2023, *Isle of Wight Net Zero Network Investment Study*. https://www.regen.co.uk/project/isle-of-wight-network-study/

Fossil gas-fired generation

Summary of modelling assumptions and results

Technology specification

Fossil fuel gas-fired electricity generation connected to the distribution network in the Southern England licence area, covering four gas generation sub-technologies. The analysis does not include backup gas CHPs or engines located on some commercial and industrial sites that do not export to the network and only operate when mains supplies fail.

Technology building block: **Combined 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**

Data summary for fossil gas generation in the Southern England licence area

Installed capacity (MW)		Baseline	2025	2030	2035	2040	2045	2050
OCGT	Falling Short	100	100	100	100	100	100	100
	System Transformation		100	100	100	0	0	0
	Consumer Transformation		100	100	100	0	0	0
	Leading the Way		100	0	0	0	0	0
Reciprocating engines	Falling Short	145	337	554	551	465	434	434
	System Transformation		199	207	204	8	0	0
	Consumer Transformation		195	207	204	8	0	0
	Leading the Way		142	127	0	0	0	0
Gas CHP	Falling Short	87	167	168	167	101	94	94
	System Transformation		147	147	132	0	0	0
	Consumer Transformation		147	147	132	0	0	0
	Leading the Way		81	66	0	0	0	0

Note: there are no CCGT baseline or pipeline sites, or future projections in the licence area.

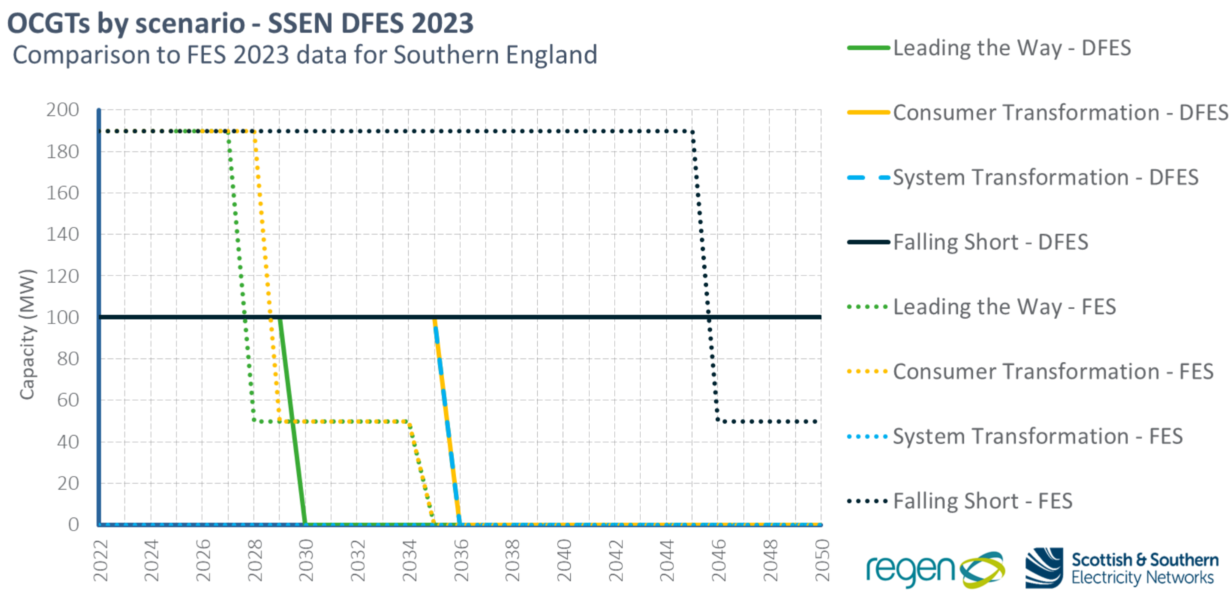


Figure 31 OCGT projections for the Southern England licence area, compared to National Grid FES 2023 regional projections

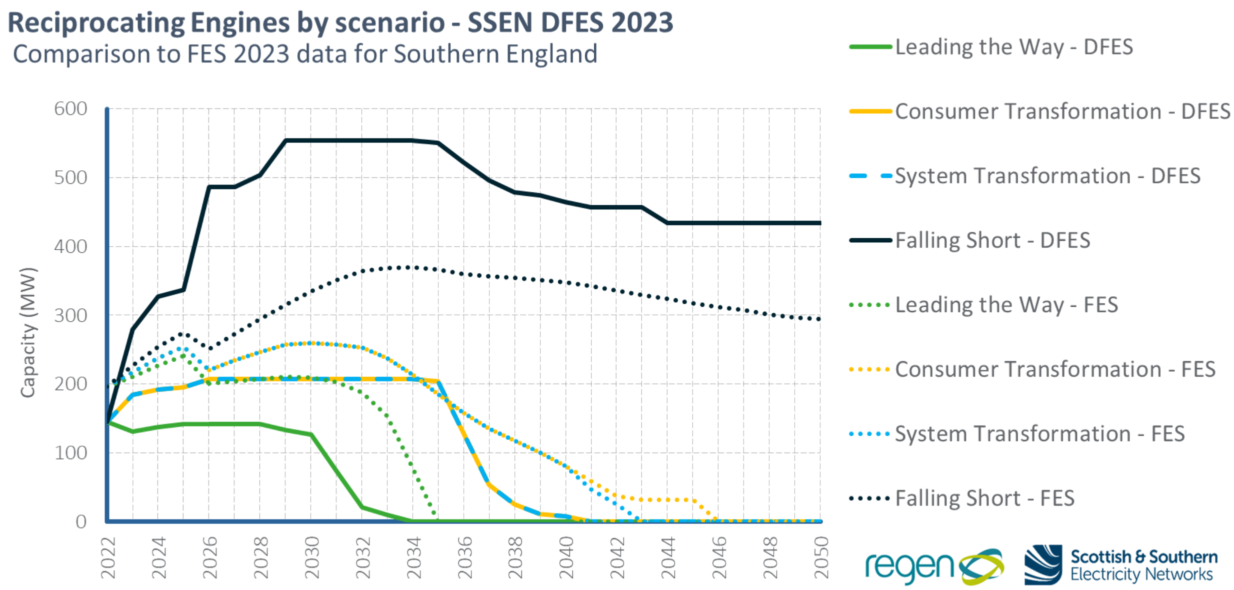


Figure 32 Reciprocating engines projections for the Southern England licence area, compared to National Grid FES 2023 regional projections

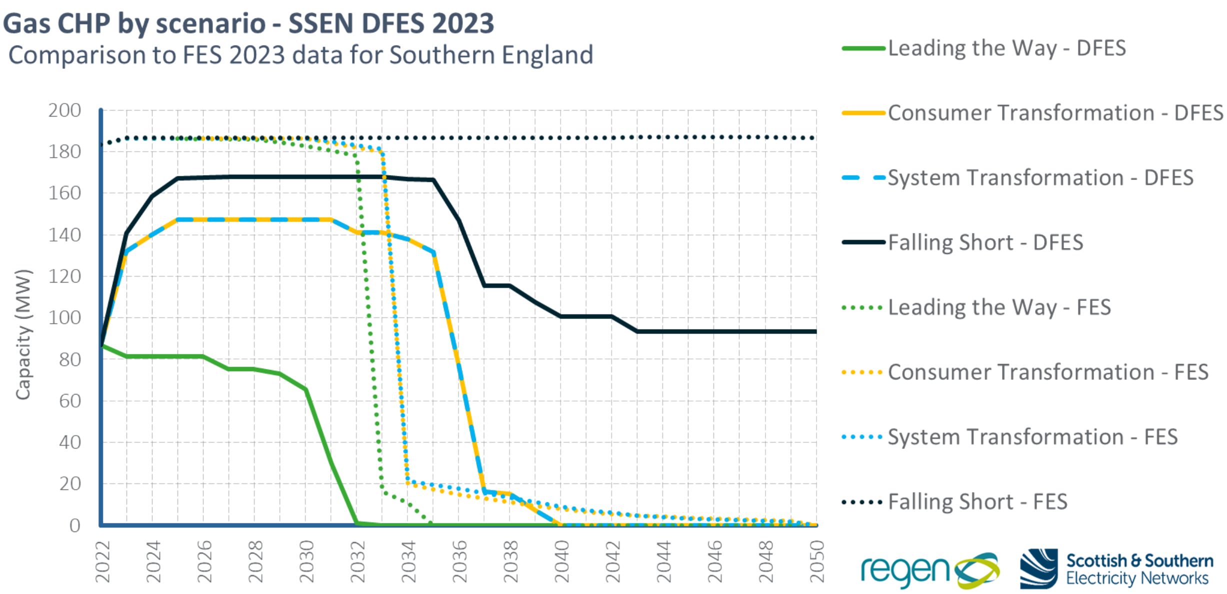


Figure 33 Gas CHP projections for the Southern England licence area, compared to National Grid FES 2023 regional projections

Summary

- There are currently 41 fossil gas sites connected to the distribution network in the Southern England licence area, totalling 332 MW. This baseline ranges in scale and generation technology type, including:
    - The 100 MW Didcot OCGT site.
    - 14 gas reciprocating engine sites, totalling 145 MW, ranging from 1 MW to 21 MW sites.
    - 26 gas CHP sites, totalling 87 MW, ranging from small <100 kW engines to 20-35 MW sites.
- This baseline includes three additional sites compared to DFES 2022, due to the addition of three additional Gas CHP projects. These projects are small and result in a growth in baseline capacity of less than 0.5 MW.
- In addition to this baseline, there is a pipeline of 68 prospective new fossil gas sites with accepted connection offers, totalling 517 MW. Of this, 17 sites totalling 126 MW have planning permission.
- Sites with planning approval or those that have successfully contracted in recent Capacity Market auctions[xl] have been modelled to come online in the near term, depending on the scenario. The majority of the pipeline is modelled to connect under **Falling Short**.

- Unabated fossil gas-fired generation is a technology that is at odds with net zero targets. As a result of this, under the three net zero scenarios, fossil gas capacity in the licence area sees a decline in the near and medium term, and all generators are modelled to come offline by the late 2030s.
- Continuing volatility in gas prices[xli] could also impact the financial viability of new gas peaking plants and gas-fired generation assets. This further justifies the limited capacity growth modelled in the three net zero scenarios.
- Contrary to this, the UK government's granting of additional North Sea oil and gas licences in July 2023[xlii] indicates a level of continued fossil gas use over the coming decade, with no targets set for a full phase out.
- Under **Falling Short**, whilst some older sites decommission, unabated fossil fuel generation remains a significant part of the electricity system overall, with most sites modelled to come online and further capacity growth of gas reciprocating engines providing flexibility services throughout the scenario timeframe. Total fossil gas generation capacity in this scenario reaches 628 MW by 2050.

Modelling stages

Baseline (2022)			
Technology	**Number of sites**	**Total capacity (MW)**	**Description**
Total	41	332	There are 41 fossil-gas generation sites connected in the SEPD licence area, totalling 332 MW.
OCGT	1	100	The Didcot Power Station is the sole operating OCGT plant in the licence area. It connected in 2012 and provides system support and flexibility services.
Reciprocating engines	14	145	There have been no additional reciprocating engines commissioned since DFES 2022. The majority of this baseline capacity connected between 2014 and 2019.
Gas CHP	26	87	The Gas CHP baseline is made up of a mixture of small engines located at hospitals, university campuses, hotels and manufacturing facilities, as well as larger-scale CHP generation at farms and industrial estates. While three additional sites have been added to this baseline since DFES 2022, total capacity has only increased by c. 0.5 MW.

Pipeline (2023-2030)	
Number of pipeline sites	**Total capacity (MW)**
68	517

The pipeline of fossil gas capacity in the licence area is 3 MW smaller than that seen in DFES 2022, despite being comprised of ten more sites. This is a continuation of the trend seen in DFES 2022; a shift to a higher number of smaller scale reciprocating engines and CHP plants.

Pipeline analysis

Status	Description	Sites	Capacity (MW)
Planning permission granted	Two 20 MW reciprocating engines, 'Budds Plantation' in Fleeting and 'Farnborough Gas generation', alongside an 18 MW Gas CHP sites in Oxford, 'Steventon Road', are the largest future fossil gas sites with planning approval. The remaining pipeline is comprised of <10 MW sites.	17	126
Planning application submitted	The 4 MW 'Bilsham Power Generation Plant', in Arun, applied for planning permission in October 2022, decision is still shown to be pending.	1	4
Rejected	The 16 MW 'Axminster flexible gas generating plant' in South Somerset is the highest capacity site to have been refused planning permission. Two additional small-cale sites in Arun and Maidenhead have also had planning applications rejected.	3	20
No information/ other	The majority of sites in this category are sub 1 MW Gas CHP sites. Notably, a gas peaking plant contracted for 131 MW and a 50 MW 'PV + Gas + Hydrogen' site in Tetsworth, withdrew their planning applications.	47	367

Planning logic and assumptions

The assumptions around the proportion of pipeline sites and capacity that is modelled to connect under each scenario, are based on an analysis of planning applications and activity in recent Capacity Market T-1 and T-4 auctions:

- Sites with planning approval or Capacity Market agreements are modelled to connect under all scenarios.
- Sites prequalified in the Capacity Market are modelled under all scenarios except **Leading the Way**.
- Sites with planning permission refused or that did not prequalify in the Capacity Market are not modelled to progress under any scenario
- Sites with little or no development information are only modelled to progress under **Falling Short**.

Decommissioning logic

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

Under the three net zero scenarios, the DFES analysis for fossil gas generation focuses heavily on the decommissioning of existing baseline sites and pipeline sites that are modelled to come online in the near term. Between now and the mid-2030s, depending on the scenario, the scenario analysis considers the following factors:

- The type of gas sub-technology (OCGT, reciprocating engines or gas CHPs).
- The age of the site and reasonable operating lifetime assumptions.
- How each scenario reflects policies such as the Industrial Emissions Directive, how flexibility is treated in the scenarios, progress towards a net zero power system and wider net zero targets.

Scenario projections

Technology	Scenario	Description	Capacity by 2035 (MW)	Capacity by 2050 (MW)
OCGT	**Falling Short**	The 100 MW Didcot Power Station OCGT is modelled to remain operational out to 2050. This reflects a continued reliance on the site to provide emergency backup power and system flexibility services. This is the same projection as seen in DFES 2022.	100	100
	System Transformation	Didcot Power Station OCGT is modelled to decommission in the three net zero scenarios. This occurs in the mid-2030s under **Consumer Transformation** and **System Transformation** where a 25-year operating life is assumed. Under **Leading the Way**, 2030 has been defined as the latest date for all OCGT capacity to decommission. These projections are aligned with DFES 2022.	100	0
	Consumer Transformation		100	0
	Leading the Way		0	0

Reciprocating engines	**Falling Short**	A significant proportion of the pipeline of reciprocating engine sites are modelled to build out under this scenario, reflecting a future in which rapid-response fossil-fuel based technologies continue to secure balancing service and flexibility contracts. Capacity peaks at 554 MW in the 2030s, a significant increase on the c. 150 MW baseline. Decommissioning of older baseline sites occurs across the 2040s. This aligns closely with the projection seen in DFES 2022.	551	434
	System Transformation	Several reciprocating engine sites with connection offers with SSEN are modelled to connect across the 2020s and early 2030s, due to planning and Capacity Market evidence. Total reciprocating engine capacity nearly doubles as a result across this period. Capacity then steadily reduces as fossil gas sites decommission from the network, with no capacity online by 2039. This reflects a relatively slower transition to low carbon flexibility than seen in **Leading the Way**. These projections align closely with DFES 2022.	204	0
	Consumer Transformation		204	0
	Leading the Way	Only sites with approved planning applications and those that pre-qualified or secured a contract in the Capacity Market are modelled to connect in the near term under this scenario. This is followed by a rapid transition to low carbon flexibility and fossil gas sites rapidly	0	0

<table>
<tr><td></td><td></td><td>decommissioning. This results in no capacity remaining online in the licence area by 2034.
Less near-term growth is projected compared to DFES 2022 under this scenario, this is a result of an updated assessment of planning status.</td><td></td><td></td></tr>
<tr><td rowspan="3">Gas CHP</td><td>Falling Short</td><td>Under this scenario, a number of new CHP sites are modelled to connect in the near term. This results in growth of a similar pace and scale to that seen in the period 2014 to 2017. The baseline of gas CHP engines continue to operate in the medium term.

Only a small number of older sites are modelled to disconnect. 94 MW remains operational by 2050.

This aligns with the projection in DFES 2022.</td><td>167</td><td>94</td></tr>
<tr><td>System Transformation</td><td rowspan="2">A number of sites commission in the near term resulting in a growth in the total deployed capacity. This is a similar pace and scale of development to that seen in the period 2014 to 2017. A notable number of the gas CHP sites in the licence area are located onsite at businesses and commercial premises. These have not been modelled to disconnect in the near term due to the onsite/backup services they are providing.

Capacity begins to decommission from the 2030s, resulting in all capacity being modelled to disconnect by 2040 under both scenarios.

Less near-term growth is projected compared to DFES 2022, due to an</td><td>132</td><td>0</td></tr>
<tr><td>Consumer Transformation</td><td>132</td><td>0</td></tr>
</table>

		updated assessment of planning status.		
	Leading the Way	Some of the smaller onsite gas CHP pipeline sites are modelled to connect in the 2020s, though of negligible total capacities. Alongside this, older baseline sites begin to decommission. All gas CHP capacity is modelled to disconnect by the mid-2030s. Less near-term growth is projected relative to DFES 2022, a result of the updated planning assessment.	0	0

Reconciliation with National Grid FES 2023

Modelling stage	Reconciliation
Baseline	The FES 2023 baseline for OCGTs is 90 MW higher than DFES, similarly the FES 2023 gas CHP baseline is 100 MW higher than recorded in DFES. The baseline for reciprocating engines is more closely aligned, with FES recording an additional 50MW of deployed capacity. The reason for these variances is unclear. However, for the fossil gas sub-technologies, the DFES analysis has sought to classify each of the baseline and pipeline sites connected through site specific research and reconciliation with Capacity Market registers and planning data.
Pipeline	The 2023 DFES and FES both reflect no pipeline OCGT sites in the licence area. For the three net zero scenarios, the FES and DFES are also well aligned on near term deployment of reciprocating engines. In **Falling Short** however, the 2023 DFES projects a significantly higher increase in near-term capacity than seen in the FES. The DFES projection has been based on an assessment of planning and Capacity Market activity for individual sites in SSEN's latest connections data. The DFES models additional gas CHP capacity connecting in the near term under all scenarios other than **Leading the Way**, whereas the FES has no growth in gas CHP capacity at all. The DFES projections are based on a site-specific analysis of planning and Capacity Market activity for sites with accepted connection offers.
Projections	Under **Leading the Way**, the 2023 DFES and FES align, modelling a decommissioning of all OCGT capacity around 2030. For **Consumer**

	Transformation and **System Transformation** however, the DFES projects OCGT capacity will remain online until the mid-2030s, later than is projected under FES 2023. This is a result of an assumption of a 25-year asset life span for Didcot OCGT under these scenarios. Under **Falling Short**, the 2023 FES and DFES both project that OCGTs remain online in the longer term. However, where the FES has all OCGT capacity coming offline by 2046, the DFES considers that OCGT sites may continue to operate beyond 2050. The DFES and FES both model the continued operation of gas reciprocating engines under **Falling Short** and a full decommissioning under the three net zero scenarios. The FES has modelled moderately later years than the DFES for this decommissioning to be fulfilled, which could partially be related to the larger baseline reflected in the FES. The FES models no change at all in gas CHP capacity across the period to 2050 under **Falling Short**, whereas the DFES has modelled some older baseline sites decommissioning in the 2040s. Under the three net zero scenarios, the DFES and FES both model decommissioning of CHP sites across the 2030s and 2040s.

Geographical factors affecting deployment at a local level

Geographical factors	Description
Location of baseline and pipeline sites	The majority of the fossil gas distribution modelling is based on the location of the known baseline and pipeline sites.
Proximity to electricity and gas network infrastructure	Where some additional capacity is projected under **Falling Short**, the combined location of gas and electricity network infrastructure and industrial land determines the potential location of future fossil gas peaking plants and CHPs.

Relevant assumptions from National Grid FES 2023

Scenario		4.1.6 – Unabated large scale fossil fuelled generation
Falling Short	High	Low gas price and lower focus on decarbonisation promotes gas as the source of flexible generation.
System Transformation	Medium	High levels of decarbonisation, plus other sources of flexibility reduce the need for unabated gas.
Consumer Transformation	Medium	High levels of decarbonisation, plus other sources of flexibility reduce the need for unabated gas.

Leading the Way	Low	Highest level of decarbonisation significantly reduces the amount of unabated gas.
Scenario		**4.1.32 – Dispatchable peaking generation**
Falling Short	High	Initial strong growth in unabated gas reciprocating engines and stays high as gas generations (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	Medium	Initial slow growth (low deployment of gas reciprocating engines). Later strong growth in hydrogen plant to support system flexibility.
Consumer Transformation	Medium	Initial slow growth (low deployment of gas reciprocating engines). Later moderate growth in hydrogen to support system flexibility.
Leading the Way	Low	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.

Incorporation of stakeholder feedback

Stakeholder feedback provided	How this has influenced our analysis
At the Southern England engagement webinar,[xliii] local stakeholders responded to a poll on how volatility in gas prices might affect the current pipeline of gas generation projects. The most common answer given was 'Unsure', while a similar number believed this would result in reduced fossil gas deployment. The least common answer given was that the volatility would have no impact on deployment.	This result has justified the spread in the projections across the net zero scenarios, where only a select few of the known pipeline sites are modelled to build out, followed by a long-term decommissioning of all fossil gas generation.

[xl] National Grid ESO n.d., *Capacity Market Registers.* https://www.emrdeliverybody.com/CM/Registers.aspx
[xli] See Trading Economics, UK natural gas price 2022-23: https://tradingeconomics.com/commodity/uk-natural-gas

[xlii] UK Government, 2023, *Hundreds of new North Sea oil and gas licences to boost British energy independence and grow the economy:* https://www.gov.uk/government/news/hundreds-of-new-north-sea-oil-and-gas-licences-to-boost-british-energy-independence-and-grow-the-economy-31-july-2023

[xliii] Regen, 2022, *SSEN DFES stakeholder consultation webinars*. https://www.regen.co.uk/event/ssen-distribution-future-energy-scenarios-2022-stakeholder-consultation-webinars/

Hydrogen-fuelled electricity generation

Summary of modelling assumptions and results

Technology specification

This analysis covers hydrogen fuelled electricity generation connected to the distribution network in the Southern England licence area. It focuses on the conversion of existing fossil fuel peaking plants to be fuelled by low carbon hydrogen. This technology is, therefore, intrinsically linked to the DFES analysis for fossil fuel electricity generation.

Aside from re-powering fossil gas peaking plants, new large-scale hydrogen-fuelled power stations could also be developed. However, in the absence of any pipeline evidence and the lack of low carbon hydrogen supply infrastructure development to date, it has been assumed that large-scale plants would more likely connect to the transmission network.

Technology building block: **Gen_BB023 – Hydrogen fuelled generation**

Data summary for hydrogen-fuelled generation in the Southern England licence area

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	0	0	0	0	0	0	0
System Transformation		0	0	116	307	452	452
Consumer Transformation		0	0	3	71	179	353
Leading the Way		0	0	169	355	508	508

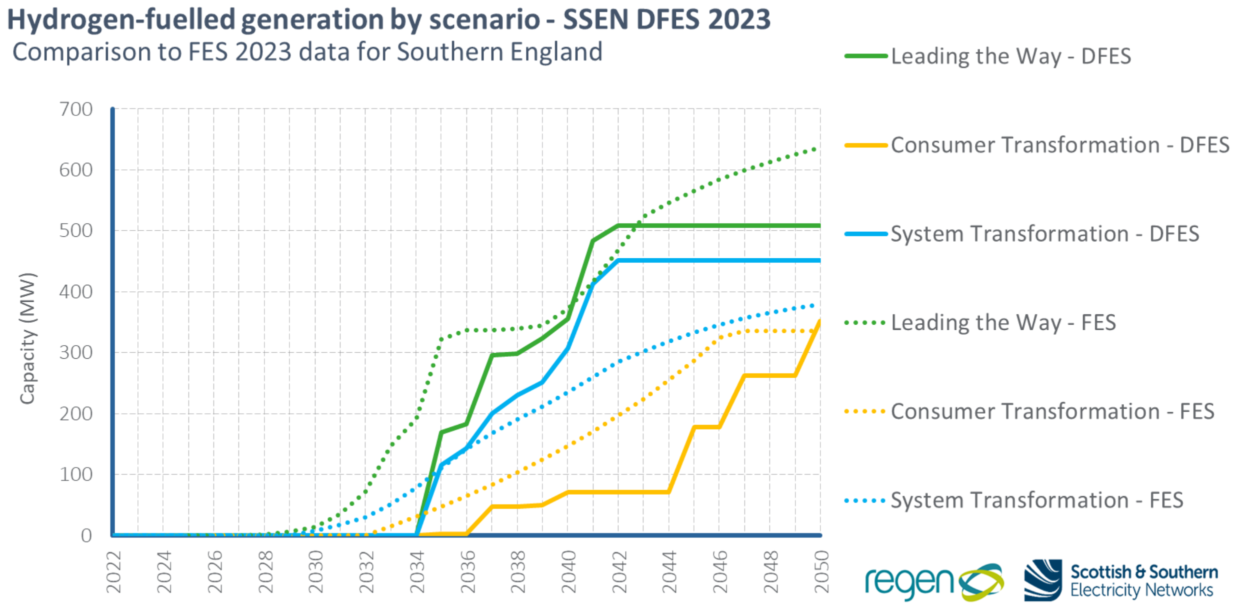


Figure 34 Hydrogen-fuelled electricity generation projections for the Southern England licence area, compared to National Grid FES 2023 regional projections

Summary

- Regen's 'A day in the life 2035' analysis[xliv] with National Grid ESO highlighted the potential role of hydrogen-fuelled generation in a net zero electricity system, as a form of low carbon dispatchable generation. This analysis specifically suggested a cold, calm and cloudy winter day might require between 10-15 GW of hydrogen-fuelled generation to be available to balance the system.
- Engagement with National Grid ESO highlighted that they expect most of the UK's dedicated hydrogen fuelled generation to be new-build (albeit located at existing sites) and optimised for peak running. The DFES has, therefore, modelled the potential for existing and contracted commercial gas generation sites to convert to run hydrogen generation instead of fossil gas in the future.
- This is supported by the existence of a number of turbine manufacturers, including Siemens and GE,[xlv] that already offer hybrid hydrogen/methane turbines and have committed to providing 100% hydrogen plants in the near future.
- The modelling of hydrogen repowering considers the following factors:
    - Scenario and technology specific assumptions are made for the lifetime of gas generation assets. Lifetimes range from 15 years in **Leading the Way** to 45 years in **Falling Short**.
    - Only sites over 1 MW in capacity are assumed to repower with hydrogen.

  - The Southern England licence area hosts a length of the gas National Transmission System which, under National Gas' Project Union plan,[xlvi] would be converted to deliver 100% hydrogen. Sites located in close proximity to this network repower earlier.
  - The industrial cluster of Southampton is within the licence area. Sites located close to this cluster repower earlier.
- Baseline and pipeline gas generation sites in the licence area have been considered against these factors; the earliest deployments of hydrogen generation are projected in 2035.
- In the longer term, under **Leading the Way** and **System Transformation**, a national hydrogen network is assumed to be developed which enables more of the licence area to have access to hydrogen supply and therefore more opportunity for hydrogen generation sites to be developed.
- As a general consideration, the business case for hydrogen-fuelled electricity generation is likely to be challenging and may require new markets to incentivise uptake. Hydrogen is also likely to be an expensive fuel, with production at scale unlikely to be developed until the 2030s at the earliest.
- However, there is strong support for the role of low carbon hydrogen in providing flexible power generation, as stated in the UK Hydrogen Strategy.[xlvii] In October 2023, the UK government published its response to the consultation on the Hydrogen Production Business Model (HPBM),[xlviii] which intends to incentivise the production and use of low carbon hydrogen.
- Engagement with hydrogen sector stakeholders suggests that developers are awaiting further policy support before committing to plans for hydrogen fuelled generation. Many projects will be targeting large-scale sites and conversion of existing fossil fuel generation facilities connected to the transmission network.
- As a result of these areas of uncertainty, projected hydrogen generation capacity in the licence area by 2050 ranges significantly, from no capacity at all under **Falling Short** (due to fossil fuel generation remaining operational) to 508 MW in **Leading the Way**.
- These projections differ from those presented in DFES 2022 due to updated analysis methods which better consider the likely drivers of low carbon hydrogen fuelled generation. Specifically, this revised modelling considers the location of the proposed core hydrogen network proposed by National Gas.

Modelling and assumptions

Baseline (2022)
There are no existing hydrogen-fuelled generation sites operating in the licence area. Low carbon hydrogen is still a nascent sector and operational equipment running on hydrogen is limited to trial and pre-commercial demonstrator sites in the UK and beyond. However, there is 332 MW of fossil gas generation capacity currently connected to the network in the licence area, some of which has been modelled to repower to be hydrogen peaking plant in the future under the three net zero scenarios.

Pipeline (2023-2030)
There are no hydrogen-fuelled generation sites with accepted connection offers in the licence area. It is unlikely that any fossil fuel plants will convert to be powered by low carbon hydrogen in the near term. Some pilot schemes have begun to appear, including large-scale gas power station operators trialling the injection of hydrogen at existing sites.[xlix] and turbine manufacturers are already beginning to develop and sell hydrogen-ready generation technologies.[l] Developers contacted as part of wider DFES engagement suggested that they were actively evaluating future plans but were unwilling to make final decisions before the government announces new policy support/ positions around low carbon hydrogen. A government consultation on market interventions required to incentivise the shift away from unabated gas towards hydrogen-fuelled generation is expected soon.

Hydrogen repowering
The DFES analysis reflects the potential for a proportion of existing fossil gas plants to repower as hydrogen-fuelled generation assets in the future. A spatial assessment based on the National Gas' Project Union,[xlvi] core hydrogen network and industrial clusters informs this modelling. The Southern England licence area is well placed for hydrogen repowering, with the proposed core hydrogen network running though the licence area from west of Oxford to Southampton. 15 sites totalling 249 MW of current and planned gas generation capacity is located within 10km of this core hydrogen network. The Southampton industrial cluster could also promote the usage of low carbon hydrogen for electricity generation. However, there are currently only six sites totalling 15 MW of current or planned gas generation capacity within 10km of this cluster. Hydrogen generation sites are modelled to repower at 100% of existing fossil fuel site capacity under **Consumer Transformation** and **System Transformation**, and at 150% of existing site capacity under **Leading the Way**.

Scenario Projections (2030 to 2050)			
DFES 2023 is using an updated modelling approach which has resulted in changes to overall capacity projections compared with DFES 2022. The most significant impact is a delay in the deployment of hydrogen fuelled generation to post-2035. This approach is based on updated evidence and consideration of hydrogen network development plans. This revised approach also reflects current technology barriers and continuing uncertainty over the future role of hydrogen in the UK power system. A similar update has been included in the FES 2023 projections.			
Scenario	**Description**	**Capacity by 2035 (MW)**	**Capacity by 2050 (MW)**
Falling Short	Due to unabated fossil fuel generation continuing to operate under this scenario out to 2050, no sites are modelled to convert to be fuelled by low carbon hydrogen.	0	0
System Transformation	This scenario sees high policy support for hydrogen and development of a national hydrogen transportation network. • While existing and pipeline fossil gas sites in proximity to industrial cluster zones are assumed to convert to hydrogen from 2030, no sites in proximity to the Southampton industrial cluster meet the capacity threshold to repower with hydrogen in this period. • This means that sites in proximity to the hydrogen core network (as proposed by National Gas) are the first sites to convert from 2035. This includes the 100 MW Didcot OCGT, the largest fossil gas site, by capacity, in the licence area. This site is modelled to be repowered as a 100 MW low carbon hydrogen generation site. • Remaining sites are assumed to convert from 2040, by which point hydrogen is assumed to be widely available through a national hydrogen network. • By 2042 all eligible sites in the licence area have repowered; no additional growth has been modelled.	116	452
Consumer Transformation	Hydrogen networks are assumed to be less developed in this scenario and hydrogen is produced near to	3	353

	demand in industrial clusters. The Didcot OCGT repowers to 100 MW in 2045.		
Leading the Way	This scenario sees moderate to high levels of policy support for hydrogen and a national hydrogen transportation network is developed. Hydrogen-fuelled generation is assumed to dominate the low running hours segment of the flexibility market. To reflect the lower capacity factors, sites are assumed to convert to hydrogen at 50% greater capacity. As with **System Transformation**, the capacities and locations of existing and pipeline gas sites mean that no deployment is modelled before 2035. Similarly, by 2042, all eligible sites in the licence area have repowered; no additional growth has been modelled.	169	508

Reconciliation with National Grid FES 2023

Modelling stage	Reconciliation
Baseline	Both the DFES and FES are aligned on there being are no existing operational hydrogen-fuelled generation sites, or near-term developments before 2030 in the licence area.
Pipeline	
Projections	The DFES and FES are aligned on no hydrogen generation capacity being modelled to come online by 2050 under **Falling Short**. The FES projections include growth in hydrogen generation capacity from 2030, whereas the DFES projections show sites beginning to convert/connect from 2035. This is due to DFES assumptions about minimum plant operating lives, hydrogen repowering capacity threshold and locational drivers. Both assessments reflect a similar development of hydrogen generation under **Leading the Way**, **System Transformation** and **Consumer Transformation**, albeit with the DFES modelling a more stepped increase in capacity between 2030 and 2040. This is due to the DFES analysis modelling the repowering of specific fossil gas sites. It should be noted that for both DFES and FES projections, there is a high degree of uncertainty regarding the potential role that low carbon hydrogen-fuelled electricity generation could play in a net zero energy system.

Geographical factors affecting deployment at a local level

Geographical factors	Description
Location of baseline and pipeline sites	The DFES projections for hydrogen-fuelled electricity generation are directly linked to connected and contracted fossil fuel (gas and diesel) sites located in the licence area.
Hydrogen supply areas	Spatial analysis of industrial cluster locations and National Gas plans for a core hydrogen network.[xlvi]

Relevant assumptions from National Grid FES 2023

Scenario		4.1.32 – Dispatchable plant generation
Falling Short	High	Initial strong growth in unabated gas reciprocating engines stays high as gas generations (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	Medium	Initial slow growth (low deployment of gas reciprocating engines). Later strong growth in hydrogen plant to support system flexibility.
Consumer Transformation	Medium	Initial slow growth (low deployment of gas reciprocating engines). Later moderate growth in hydrogen plant to support system flexibility.
Leading the Way	Low	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.

[xliv] Regen, 2022, *A day in the life 2035*, https://www.regen.co.uk/project/a-day-in-the-life-2035/
[xlv] General Electric n.d., *Hydrogen fueled gas turbines*. https://www.ge.com/gas-power/future-of-energy/hydrogen-fueled-gas-turbines?utm_campaign=h2&utm_medium=cpc&utm_source=google&utm_content=rsa&utm_term=Hydrogen%20gas%20turbine&gclid=EAIaIQobChMIh5amwIiq9QIV2Y1oCR2nHgqZEAAYAiAAEgLtXvD_BwE
[xlvi] National Gas, 2022, *Project Union*. https://www.nationalgas.com/document/139641/download
[xlvii] UK Government, 2021, *UK Hydrogen Strategy*. https://www.gov.uk/government/publications/uk-hydrogen-strategy

[xlviii] UK Government, 2023, *Hydrogen production and carbon capture business models*. https://assets.publishing.service.gov.uk/media/654103cc46532b000d67f630/hydrogen-production-icc-business-models-government-response.pdf

[xlix] See article about Centrica injecting hydrogen into Brigg Gas Station in Lincolnshire, *Guardian*: https://www.theguardian.com/environment/2022/oct/23/peak-power-hydrogen-injected-uk-station-centrica

[l] See GE and Siemens hydrogen gas turbines: https://www.ge.com/gas-power/future-of-energy/hydrogen-fueled-gas-turbines | https://www.siemens-energy.com/global/en/priorities/future-technologies/hydrogen/zehtc.html

Other generation

Summary of modelling assumptions and results

Technology specification

The ‘other generation’ technology category covers unidentified connections - *this class does not have a corresponding FES technology building block.*

Data summary for ‘other generation’ in the Southern England licence area

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
All Scenarios	0.8	3.8	3.8	3.8	3.8	3.8	3.8

Summary

- There are six sites of unidentified generation technology in the Southern England licence area, totalling 791 kW of installed capacity. This is down from DFES 2022 (3.3 MW), due to investigative analysis of sites using satellite imagery, developer outreach, news articles and in-depth desk research to identify site technologies, reducing other generation sites from twenty to six.
- At an average capacity of 132 kW, these sites are predominantly micro-CHP plants within hotels, hospitals, farms and recreational centres. However, the fuel type is uncertain and so these sites cannot be allocated a technology. The largest site is a farm at 263 kW.
- There are 19 contracted pipeline sites where the generation technology is unknown, totalling 3.1 MW. These have been modelled to connect in 2024 in all scenarios.
- Other generation is not projected beyond the baseline and pipeline, and there is no variance between the scenarios for this technology.

Geographical factors affecting deployment at a local level

Other generation geographical factors
Distribution is entirely based on the location of baseline and pipeline sites, as referenced in the SSEN connections database.

References: SSEN connection offer data, developer outreach, desk research, Grid Reference Finder, Renewable Energy Planning Database

Battery storage

Summary of modelling assumptions and results

Technology specification

Battery storage, comprising four business models:

- Domestic batteries: typically 5-20 kW scale batteries that households buy to operate alongside rooftop PV or provide home backup services. This aligns to the FES building block: **Srg_BB002**

For larger battery storage projects we review three 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 projects, sited at large energy-user operational sites to support on-site energy management or to avoid high electricity cost periods.

We then combine these into “large scale” battery storage that aligns with the FES building block: **Srg_BB001**

Storage Planning: This scenario demonstrates the scale of the current large-scale battery storage pipeline within SSEN’s licence areas. In this scenario, all sites with connection agreements are modelled to build out, regardless of lack of evidence of progress through planning.

Data summary for battery storage in the Southern England licence area

	Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Standalone network services	**Falling Short**	197	873	1,371	1,621	1,621	1,621	1,621
	System Transformation		1,210	1,982	2,082	2,082	2,082	2,082
	Consumer Transformation		1,547	2,330	2,330	2,330	2,330	2,330
	Leading the Way		1,949	2,605	2,901	2,901	2,901	2,901
	Storage Planning		1,949	4,012	7,136	7,136	7,136	7,136
Generation co-location	**Falling Short**	12	148	304	323	327	338	341
	System Transformation		148	346	679	703	708	709
	Consumer Transformation		188	428	716	760	786	790
	Leading the Way		286	509	796	844	874	878
	Storage Planning		266	538	877	877	877	877
Behind the meter - high energy user	**Falling Short**	4	28	28	51	58	93	101
	System Transformation		28	28	75	138	210	229
	Consumer Transformation		28	36	122	165	298	325
	Leading the Way		28	68	122	205	298	325
	Storage Planning		28	68	122	205	298	325
Domestic batteries	**Falling Short**	53	59	61	72	77	121	209
	System Transformation		59	97	117	134	245	276
	Consumer Transformation		67	150	238	364	577	911
	Leading the Way		87	178	281	423	656	1,124

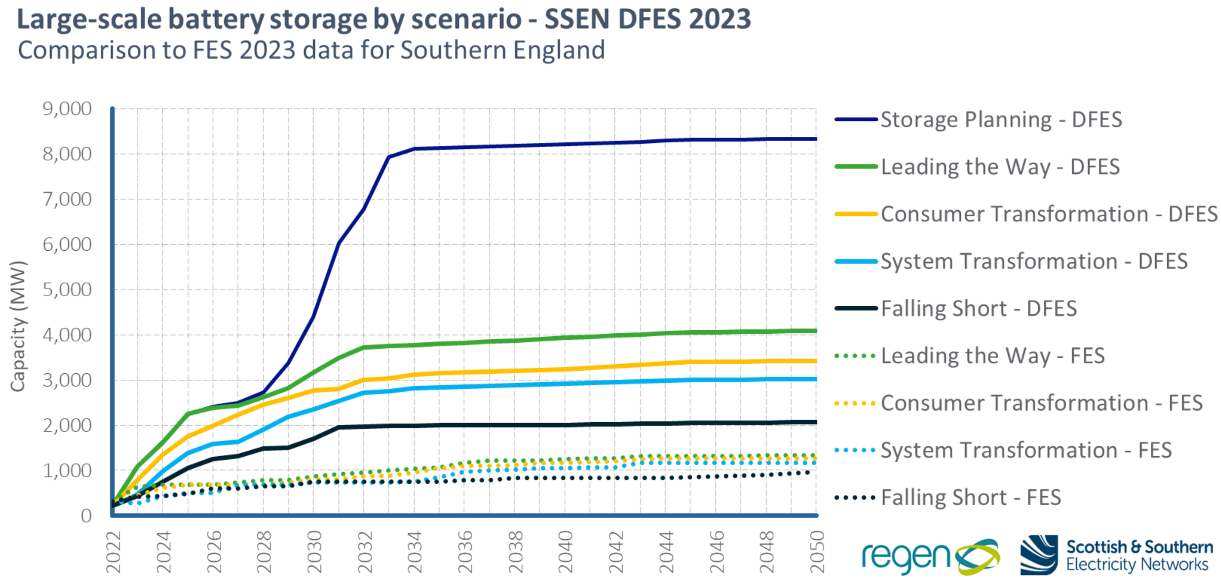


Figure 35 Large-scale battery storage projections for the Southern England licence area, compared to National Grid FES 2023 regional projections. Including the 'Storage Planning' scenario.

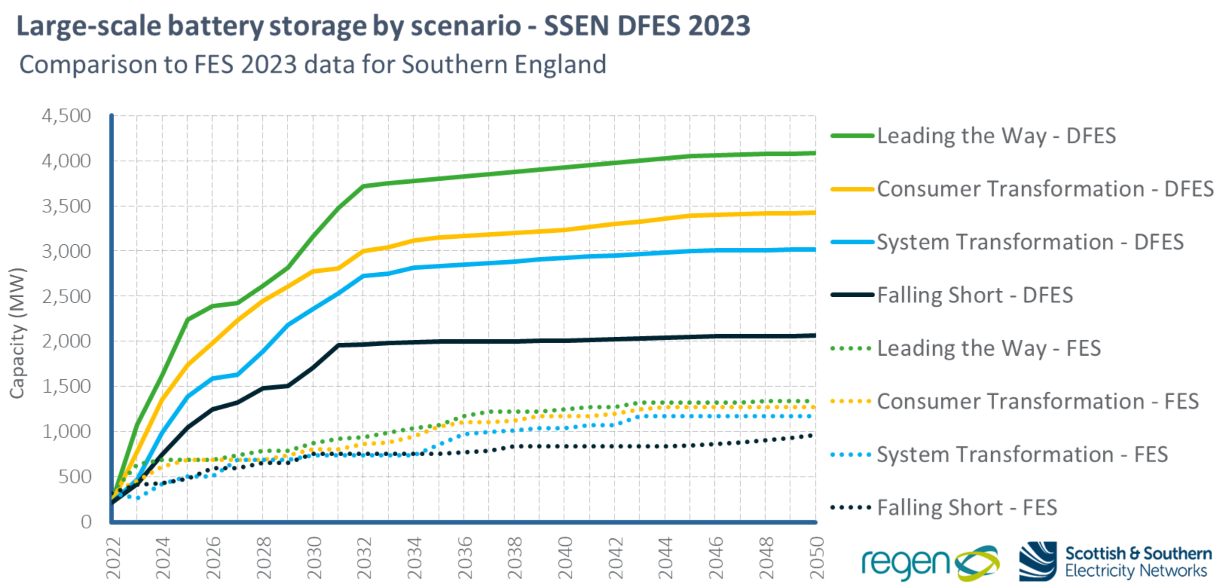


Figure 36 Large-scale battery storage projections for the Southern England licence area, compared to National Grid FES 2023 regional projections. Excluding the 'Storage Planning' scenario.

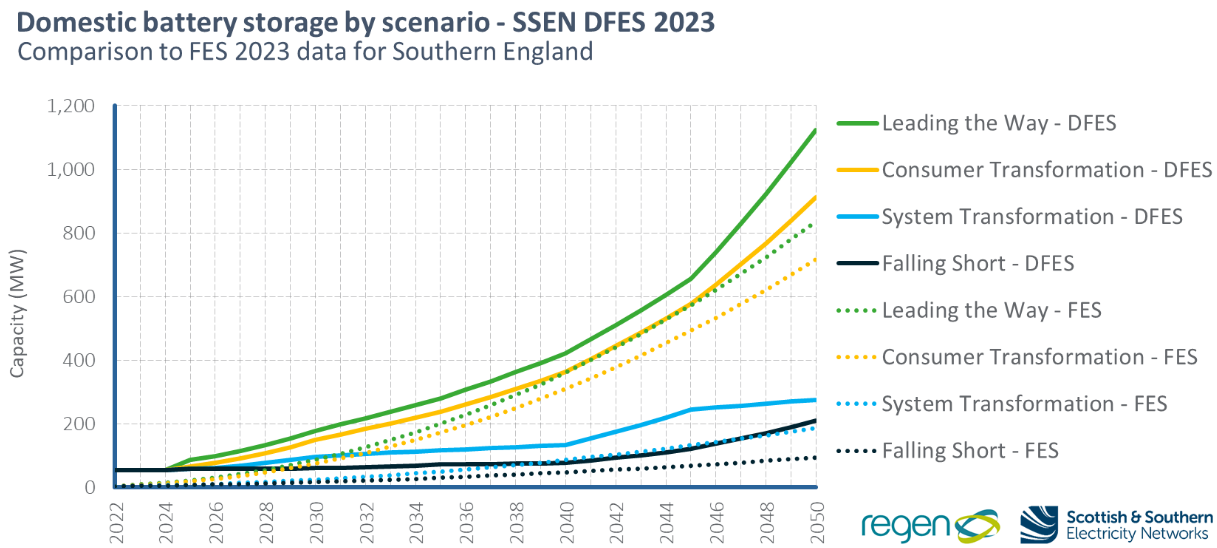


Figure 37 Domestic battery storage projections for the Southern England licence area, compared to National Grid FES 2023 regional projections.

Summary

- Battery storage has developed rapidly across the UK electricity network since the first commercial-scale projects in 2016. Regen analysis,[li] in partnership with the ESO, suggested that 80-100 GW of flexibility capacity will be needed nationally by 2035 with 20-25 GW provided by electricity storage.
- The Southern England licence area (SEPD) currently has 17 operational large-scale battery storage sites, totalling 210 MW. This compares to the 14 sites and 190 MW identified in DFES 2022.
- Of all technologies in the DFES analysis, battery storage has the largest pipeline of projects. There are now 16 GWs of projects with a connection quote issued or accepted connection offer across the two SSEN licence areas, nearly double the 9.6 GW recorded for DFES 2022.
- This 16 GW is relatively evenly split between SSEN's licence areas, with 7.8 GW located in the North of Scotland licence area (SHEPD) and 8.2 GW in SEPD. (For comparison, SSEN currently manages a portfolio of c. 6.75 GW of operational fossil fuel and renewable generation assets across both licence areas.)
- In SHEPD, 81% of the pipeline by capacity has a connection agreement. This is higher in SEPD at 91%.
- Overall deployment scenarios for large scale battery storage capacity in 2050 in SEPD range from 2.1 GW in **Falling Short** to 4 GW in **Leading the Way**.

- Due to the unprecedented pipeline of large-scale battery storage projects across SSEN's licence areas, the DFES has included an additional scenario, **Storage Planning**. This fifth scenario demonstrates the absolute scale of the current contracted/quoted connection pipeline. Under this scenario, 8.2 GW of large-scale storage connects in SEPD by 2050.
- Solutions to network constraints, large connection queues, and resulting long connection times are being sought at a national level by Ofgem and the UK Government; detailed within the November 2023 'Joint Connections Action Plan'.[lii] In DFES 2023, the three net zero compliant scenarios assume varying degrees of success in reducing connection timeframes, while a **Falling Short** scenario assumes project connection times remain long. Where 'Statement of Works' information has been available as an indication of delay to connection, this has been reflected in **Falling Short**.
- SEPD has significant potential for long-term growth in connected storage capacity. This is due to the following:
  - Having amongst the highest levels of solar irradiance in the UK and strong potential for large scale solar PV and battery storage co-location.
  - Batteries are usually installed in domestic properties alongside rooftop PV. The SEPD licence area has significant potential for rooftop PV deployment. If, therefore, rooftop PV deployment remains high, it is likely to be associated with high numbers of domestic battery installations.
  - Many commercial and industrial premises have the potential for behind-the-meter batteries (including industrial areas such as Oxford, Reading and Swindon and marine industry/port areas such as Southampton, Bournemouth and Portsmouth).
  - Several large data centres in development in the region could potentially install on-site energy storage.
- Whilst the DFES analysis has focused on the MW power rating of battery storage, the analysis also shows that battery storage capacity duration (MWh) is also increasing with progressively more 2-4 hour duration storage in the pipeline.
- Long Duration Energy Storage (LDES) is now receiving government policy support, including the LDES demonstration competition.[liii] This could give rise to new storage technologies and trial demonstration sites, which could seek to connect to the distribution network in the licence area. These technologies will be considered for inclusion in future DFES assessments.

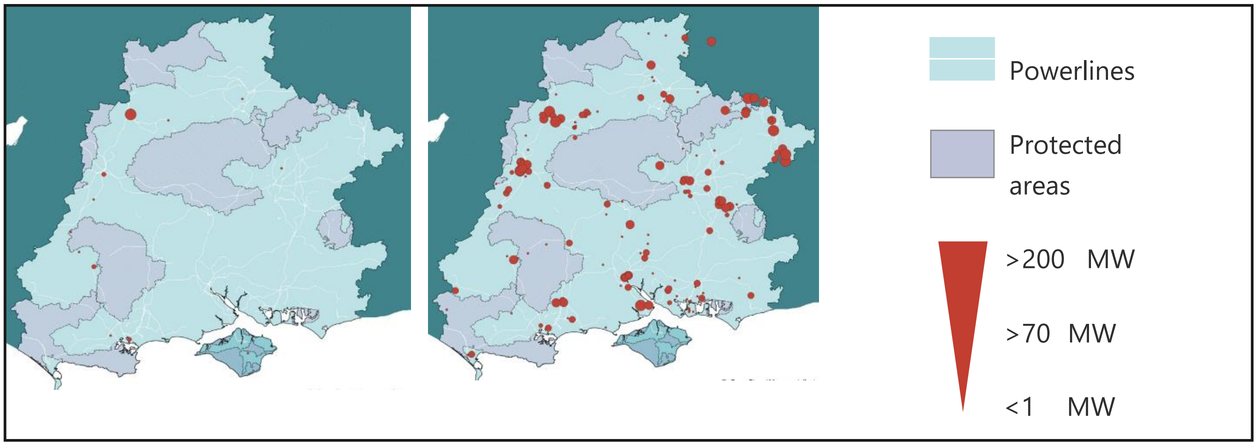


Figure 38 Baseline and pipeline battery storage sites in the Southern England licence area, August 2023.

Modelling stages

Baseline (2022)			
Business model	**Number of sites**	**Total capacity (MW)**	**Description**
Total	12,366	266	The current battery storage deployment is an increase from the 131 MW recorded for DFES 2022. This significant increase has resulted from new standalone sites connecting and additional data being available for domestic and commercial deployments.
Standalone network services	8	197	In the year since DFES 2022 was completed, the 20 MW 'Hawkers Hill' site in Shaftsbury, developed by TAG Energy, has connected. The 110 MW Minety/Stonehill storage project, in Wiltshire, remains the largest battery storage project currently connected to the SEPD distribution network, and among the largest nationally. There are three 10-30 MW sites in Swindon, Maiden Newton and Basingstoke.
Generation co-location	6	12	No new co-located projects have connected since DFES 2022. The 10 MW 'Roundponds Gas & Battery' site in Melksham accounts for most co-located capacity, with the remaining

			sites all sub – 1 MW and connected primarily in the North and East of the licence area.
Behind the meter - high energy user	109	4	Newly implemented in the DFES for 2023, SSEN low carbon technology (LCT) data has been used to provide a more accurate baseline of small scale technologies. 106 behind the meter - high energy user sites, have been identified in SEPD data, providing 3 MW of distributed storage capacity. This is in addition to three sites found within SSEN's connections data, providing 1 MW.
Domestic	12,243	53	SSEN LCT data identifies 12,243 domestic batteries in the licence area. These provide 53 MW of distributed storage capacity.

Large-scale pipeline (2023-2035)

	Total	Contracted	Grid connection offered
Number of sites	190	181	9
Capacity (MW)	8,228	7,491	738

The total pipeline capacity of 8.2 GW is 54% increase on the 5.3 GW recorded for DFES 2022. Every site in this pipeline was assessed for its current development status and timeline through research into local planning portals, Capacity Market T-4 and T-1 registers, project webpage summaries, and direct engagement with individual battery project developers.

Planning assessment

Status	Description	Sites	Capacity (MW)
Operational	Three sites, totalling 65 MW of storage capacity, are deemed to be operational as of November 2023 and not captured within the August 2023 cut of SSEN connections data. The main contributor to this new capacity is a 50 MW extension to the Minety/Stonehill project.[liv]	3	65
Under construction	Four sites, totalling 162 MW of storage capacity are under construction. This includes the 100 MW 'Upton Lane' project in Southampton, being developed by Balance Power. Two 50 MW sites, including another in the vicinity of the existing and extended Minety/Stonehill project, are also under construction.	4	162
Planning permission granted	42 sites totalling 1.7 GW, 21% of total pipeline capacity, have secured planning permission; all the sites have connection agreements and 37 have Capacity Market agreements commencing between 2023 and 2026. This group includes eight sites with capacities in the range of	42	1,744

	99-150 MW, indicating that average site capacities are growing rapidly. The area around Melksham is seeing high developer interest. Three 100 MW sites and the 150 MW 'Norrington Gate Farm' [lv] site are all in the vicinity. This is alongside over 100 MW of solar PV capacity with planning permission. Six sites are subject to a Statement of Works connection year, the earliest being 2025 and the latest being 2037; reflected in **Falling Short**. This 'construction ready' portion of the project pipeline has grown by 20% in site number and 60% in capacity since DFES 2022, strong evidence that developers are making progress through the planning system with projects of increasing scale.		
Planning application submitted	12 sites totalling 580 MW of storage capacity have submitted for full planning permission; all but one site have accepted connection offers. The largest of these sites are the 100 MW 'Turks Farm' and 'Burcot Farm' projects in Malmesbury and Abingdon. Two projects are subject to Statement of Works connection years of 2026 and 2028; reflected in **Falling Short**. This is similar in scale to what was recorded for DFES 2022. This indicates that local authority planning processes are currently coping with this volume of sites; a backlog of storage sites awaiting decisions is not building up at this stage.	12	580
Pre-planning	21 sites totalling 954 MW of storage capacity are in earlier stages of planning; all but two of these have accepted connection offers. Seven of these 21 sites are co-located, a large proportion of sites compared to the more mature groups of the pipeline. This indicates growing interest in co-located business models. Four sites are subject to Statement of Works connection years of 2027 and 2028; reflected in **Falling Short**. This group of early-stage sites is significantly larger than was	21	954

	recorded for DFES 2022. This is due to improved DFES planning research tools allowing a re-allocation of sites previously classified as 'Planning application submitted'.		
No information	The largest single category in this assessment is made up of those sites which have not yet entered the planning process; 89 sites totalling 3.7 GW, or 44% of the pipeline by capacity. All but six of these sites have accepted connection agreements. As a percentage of the total pipeline, this group has decreased compared to DFES 2022, where 67% had no planning information. This is in part due to improved DFES planning research tools. In volume terms, this group is comparable to what was recorded in DFES 2022. This is explained by the relatively well evidenced group of sites which have entered the connections data over the past year. For over half of these new sites, planning evidence has been found. This is a departure from the SHEPD licence area where greater numbers of sites are entering into connection agreements without prior planning progress.	89	3,662
Refused, expired, other	Seven sites have had planning applications refused or planning permissions expire. Following on from additional checks completed in DFES 2022, 25 sites totalling 850 MW of capacity has been identified as duplicates or superseded by more recent connection agreements.	19	1,061

Scenario-based deployment logic (2023-2025)

Sites with no Capacity Market information, co-located site information, or developer feedback were subject to scenario-based logic defining various potential deployment outcomes and timeframes, detailed below. In addition, under **Falling Short**, any site with a Statement of Works completion year was assumed to connect on or after that year (if assumed to build out).

Scenario	**Planning assessment status and assumed deployment years**				
	Under construction	**Planning application granted**	**Planning application submitted**	**Pre-planning**	**No information**
Falling Short	2024	Granted year +7 years	-	-	-
System Transformation	2024	Granted year +5 years	Submitted year +7 years	-	-

Consumer Transformation	2024	Granted year +3 years	Submitted year +6 years	-	-
Leading the Way	2023	Granted year +1 years	Submitted year +5 years	Submitted year +7 years	-
Storage Planning	2023	Granted year +1 year delay	Submitted year +5 year delay	Submitted year +7 to 9 year delay	Contracted date +8 to 11 year delay

Scenario projections

Business model	**Description**	**Scenario**	**Capacity by 2035 (MW)**	**Capacity by 2050 (MW)**
Standalone network services	Standalone storage sites in the currently visible pipeline dominate large scale storage growth by 2035. This results in c. 2.9 GW of standalone capacity deployed by 2035 under **Leading the Way**. The growth in capacity stalls beyond the late 2030s out to 2050, reflecting market saturation following a rapid roll-out in the 2020s. These projections do not vary hugely from DFES 2022 projections, despite the considerably enlarged project pipeline. This is a result of only 43% of this pipeline capacity having planning evidence; only these sites are modelled to deploy.	**Falling Short**	1,621	1,621
		System Transformation	2,082	2,082
		Consumer Transformation	2,330	2,330
		Leading the Way	2,901	2,901
		Storage Planning	7,136	7,136
Generation co-location	A significant capacity of large-scale solar generation is projected to connect in the Southern England licence area in all scenarios. This is most significant in **Leading the Way** with 4 GW of solar PV modelled to connect by	**Falling Short**	323	341
		System Transformation	344	374
		Consumer Transformation	696	771

	2050. The capacity of co-located battery storage in this scenario reaches 789 MW by 2050. Since DFES 2022, there has been a slight reduction in co-located capacity projected across the net zero scenarios. This is driven by a decrease in the currently identified pipeline of co-located sites.	**Leading the Way**	705	789
		Storage Planning	877	877
Behind the meter - high energy user	Over 100,000 commercial and industrial properties could potentially host behind-the-meter battery storage assets in the licence area. This includes retail, military, port/marine and logistics premises and several new large-scale data centres. Feedback from stakeholders that these high-energy users could drive electricity storage deployment in the medium term has resulted in strong growth across all scenarios by 2035. Annual capacity deployment in this business model begins to increase further in the longer term out to 2050 under **Consumer Transformation** and **Leading the Way**, as more businesses seek to manage their onsite energy use and costs through flexibility technologies. These projections have increased since DFES 2022. This is due to the consideration of SSEN LCT data for DFES 2023, resulting in an updated and enlarged baseline.	**Falling Short**	51	101
		System Transformation	75	229
		Consumer Transformation	122	325
		Leading the Way	122	325
		Storage Planning	122	325

Domestic batteries	The licence area also has over 1.6 million domestic properties. With strong potential for domestic rooftop PV, there is a potentially significant opportunity for domestic battery uptake under **Consumer Transformation** and **Leading the Way**. By 2050, total domestic battery storage capacity reaches 1.1 GW (equivalent to 214,000 homes) under **Leading the Way** and 209 MW (equivalent to 31,107 of homes) under **Falling Short**. Projections have increased relative to DFES 2022 equivalents. This is driven by the increased baseline evidenced by SSEN LCT data, as well as an uplifted assumption on the percentage of new builds which will feature solar PV. The projections for domestic batteries are directly tied to domestic solar PV uptake in all four scenarios.	**Falling Short**	72	209
		System Transformation	117	276
		Consumer Transformation	238	911
		Leading the Way	281	1,124

Reconciliation with National Grid FES 2023

Modelling stage	Reconciliation – large scale batteries
Baseline	The 213 MW baseline recorded for DFES 2023 is lower than the FES 2023 baseline of 324 MW. This FES baseline has increased from 0 MW reported for FES 2022. As a result there is now closer alignment between FES and DFES baselines. It is possible that one of the four sites identified as 'Under construction' in the DFES is considered operational in the FES.
Pipeline	The DFES 2023 projections diverge from FES 2023 projections in all scenarios. The higher projections are driven by the very significant pipeline of accepted connection offers evidenced in SSEN's connection data. Variance between FES and DFES becomes significant in the medium term in the more ambitious scenarios, reaching a 2.2 GW difference by 2030 under **Leading the Way**.

	The DFES pipeline analysis is based on a detailed assessment of planning status, Capacity Market auction activity and direct engagement with battery project developers.
Projections	Variance between DFES and FES remains in all scenarios but does not increase significantly post-2030 due to lower rates of deployment projected out to 2050. The DFES 2023 has a wider spread of outcomes by 2050 for large-scale battery storage, which is a direct result of the large near-term pipeline and differing build-out assumptions applied under each scenario.
Overarching trend	In all scenarios, DFES 2023 projects significantly higher installed capacity in the licence area than the FES 2023. Variance is larger in the more ambitious scenarios. This results from the scale of the contracted pipeline and a site-specific pre-2030 pipeline assessment.
Modelling stage	**Reconciliation – domestic batteries**
The DFES 2023 projections for domestic batteries are higher than FES 2023 across the analysis period and in all scenarios. This reflects the significant rooftop PV capacity projected in the licence area and the potential for co-located domestic batteries.	

Geographical factors affecting deployment at a local level

Geographical factors	Description
Pipeline distribution	Location of existing and known pipeline sites in the Southern England licence area.
Standalone network services	Location of pipeline sites with no development evidence and suitable land proximate to the 33 kV and 132 kV 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 2023.

Relevant assumptions from National Grid FES 2023

Scenario		4.2.24 - Short duration electricity storage
Falling Short	Medium	Moderate levels of flexibility requirements encourage new storage. Not as much deployed compared to other scenarios.
System Transformation	Low	Not as much deployed as other scenarios due to high use of Hydrogen within this scenario.
Consumer Transformation	High	High levels of variable clean generation and flexibility requirements encourage new storage technologies to emerge.
Leading the Way	High	Even higher levels of flexibility requirements encourage new storage technologies to emerge at distributed and transmission levels.
Scenario		**4.2.24 – Medium duration electricity storage**
Falling Short	Low	Lower flexibility requirements means that this technology does not come forward at the volumes seen in the other scenarios.
System Transformation	Medium	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	Medium	Flexibility requirements encourage new storage.
Leading the Way	High	High levels of flexibility requirements encourage new storage.

Incorporation of stakeholder feedback

Stakeholder feedback provided	How this has influenced our analysis
At the Southern England stakeholder engagement webinar, local stakeholders responded to a poll on the scale of deployment of battery storage in the licence area. When asked how much of the contracted 7.5 GW pipeline of *contracted* large-scale batteries were likely to connect in the Southern England, there was little consensus among the 23 respondents on the amount of capacity that would connect. However, there was more consensus that this capacity would connect by the early 2030s.	The uncertainty around the current pipeline is reflected in the spread of scenario outcomes modelled. Feedback on the speed of deployment outcome is reflected in **Leading the Way**, with known pipeline sites modelled to connect by 2034 at the latest.
Developers with projects in the pipeline were individually contacted to discuss the likely commissioning dates of their	Engagement resulted in modifications to the modelling of sites. A small number of

projects.	sites were identified as operational, and others were updated to reflect plans for increased capacities.

[li] Regen and National Grid ESO, "Bridging the gap to Net Zero – a Day in the Life 2035 report"
[lii] Ofgem & DESNES, 2023, *"Joint connections action plan"*. https://www.ofgem.gov.uk/publications/ofgem-and-desnz-announce-joint-connections-action-plan
[liii] UK Government, 2021, "*Long Duration Energy Storage Competition*". https://www.gov.uk/government/collections/longer-duration-energy-storage-demonstration-lodes-competition
[liv] https://stateraenergy.co.uk/news/minety-south-storage-2-enters-commercial-operations
[lv] https://development.wiltshire.gov.uk/pr/s/planning-application/a0i3z000018G8aOAAS/pl202203914

Liquid Air Energy Storage

Summary of modelling assumptions and results

Technology specification

The analysis covers liquid air energy storage (LAES), sometimes referred to as cryogenic electricity storage, connected to the distribution network in the Southern England licence area.

No direct equivalent technology building block currently exists, but the analysis could be reconciled in part to building block: **Srg_BB004 – Other energy storage.**

Data summary for liquid air energy storage in the Southern England licence area

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	0	0	0	0	0	0	0
System Transformation		0	0	0	0	0	0
Consumer Transformation		0	0	0	0	0	0
Leading the Way		0	0	50	100	100	100

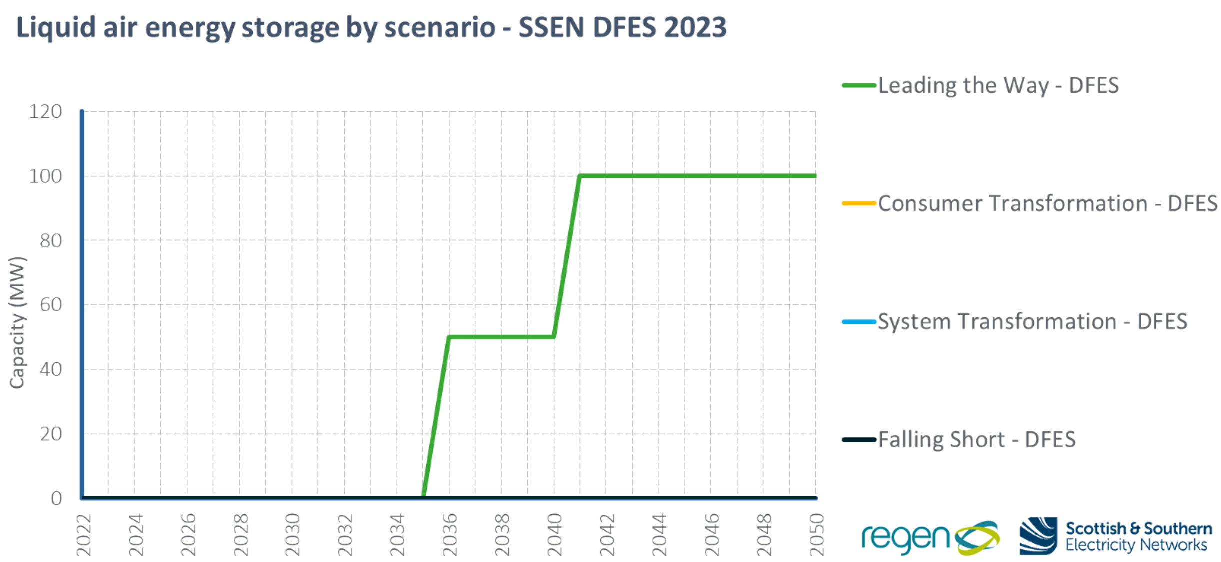


Figure 39 Liquid air energy storage projections for the Southern England licence area

Summary

- LAES uses electricity to power compression and refrigeration equipment to cool air until it liquefies. This liquid air is then stored in cryogenic energy storage tanks for the duration required. When electricity is needed, the liquid air is exposed to ambient temperature air (or waste heat from industrial processes) to convert it back to a gaseous state. This resultant expanded gas is used to turn a turbine to generate electricity.
- Battery storage technologies dominate the UK storage pipeline (see the Battery storage chapter of this report). LAES is a relatively recent technology development and is considered one of the technologies that could provide longer-duration storage services (and other support services) to the electricity system. However, many technology innovators and project developers are looking to move from small-scale trials to full commercial-scale plants in the UK and beyond.
- This technology could be supported by future UK grant and innovation funding schemes, following on from UK Government's Long Duration Storage Competition.[lvi] fund in 2021 and 2022.
- One of the leading LAES developers in the UK is Highview Power, which is developing trial and pre-commercial plants, including one in Greater Manchester.[lvii]

- No LAES plants are yet operational in the Southern England licence area. There are also no known pipeline projects with connection offers to connect to the distribution network in the licence area.
- However, through direct consultation with representatives from Highview Power to inform previous DFES analysis, some LAES business models are being considered, including:
    - Co-location with renewable energy generation technology (as a source of low-cost, low-carbon input electricity).
    - Co-location with large-scale data centres that require a significant cooling load (this aligns with the cryogenic aspect of the LAES storage cycle).
    - Provision of flexibility services via future grid balancing contracts, such as those issued by National Grid ESO's Stability Pathfinder.[lviii]
- As a result of this feedback and the significant capacity of large-scale solar PV and data centre demand in the Southern England licence area, both DFES 2022 and DFES 2023 modelled 50 MW of new distributed LAES capacity to come online by 2035 and 100 MW by 2050, under **Leading the Way**. There is also the potential for additional LAES capacity to connect to the transmission network.
- A more diverse group of storage technologies has the potential to see development in future, as highlighted by the results of the Long Duration Storage competition.[lvi] Variations of redox flow batteries, thermal energy storage, gravitational energy storage, as well as power-to-X projects making use of surplus energy have all received funding to develop prototypes or push towards commercialisation. Successful development of these trial projects and continued policy support could see these technologies significantly impacting the distribution network in the future. This may also mean the non-battery storage technology analysis in the DFES may adapt to allow for a more diverse range of technologies in future assessments.

Geographical factors affecting deployment at a local level

Based on engagement with LAES technology developers Highview Power, the location of LAES plants in the Southern England licence area could be based on a potential to co-locate with large-scale renewable energy generation sites or large-scale data centres.

[lvi]UK Government, 2021, *Long Duration Energy Storage Competition* https://www.gov.uk/government/publications/longer-duration-energy-storage-demonstration-programme-successful-projects/longer-duration-energy-storage-demonstration-programme-stream-1-phase-1-details-of-successful-projects

[lvii] Highview Power, 2023, https://highviewpower.com/plants/

[lviii] National Grid ESO, 2023, *Stability Pathfinder*. https://www.nationalgrideso.com/future-energy/projects/pathfinders/stability

Electric vehicles and EV chargers in the Southern England licence area

Summary of modelling assumptions and results

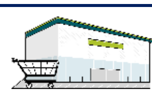
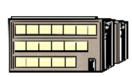
Technology specification

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

Electric vehicle chargers (EV chargers) – the DFES analyses the uptake of several EV charger archetypes, as shown in the table below.

Technology building blocks: **Lct_BB001 – Pure Electric (vans, cars & motorbikes); Lct_BB002 – Plug-in-hybrid (vans, cars and motorbikes); Lct_BB003 – Pure Electric (road vehicles other than vans, cars and motorbikes); Lct_BB004 – Plug-in-hybrid (road vehicles other than vans, cars and motorbikes).**

Note: No FES building blocks are available for EV chargers.

Regen transport model EV charger archetypes			
Domestic EV chargers	**Off-street domestic**		Homes with somewhere to park a private vehicle off-street
Non-domestic EV chargers	**On-street residential**		Charging at roadside car parking spaces
	Car parks		Charging at areas provided for parking only, hence excludes supermarkets
	Destination		Supermarkets, hotels and other destinations where parking is provided
	Workplace		Parking for commuters at places of work

	Fleet/depot		Charging for vehicles that return to a depot to park
	En-route local		Charging service stations excluding motorway or A-road services
	En-route national		Motorway or A-road charging stations outside of urban areas

Note: The projection units for domestic and non-domestic EV chargers in the DFES 2023 analysis are different. To illustrate the scale of EV charger uptake, domestic off-street EV chargers are displayed as numbers of chargers, while non-domestic EV chargers are displayed in total connected capacity (MW).

For non-domestic EV chargers, different numbers of chargers could be required to deliver the same amount of EV charging energy, making capacity a better indicator of future uptake and network impact. While this is also true of domestic chargers, since there is assumed to be much less variability in their individual capacity, the number of chargers is considered a more useful indicator of the scale of future uptake, as it enables comparisons of chargers on a per household and per EV basis.

Data summary for EVs in the Southern England licence area

Number of vehicles (thousands)		Baseline	2025	2030	2035	2040	2045	2050
Battery EVs (Total, numbers, thousands)	**Falling Short**	158	303	600	1496	3080	4463	4899
	System Transformation		322	785	2273	4170	4760	4498
	Consumer Transformation		474	1474	3560	4694	4764	4526
	Leading the Way		466	1466	3776	4681	4460	3669
Plug-in hybrid EVs (Total, numbers, thousands)	**Falling Short**	77	125	178	300	450	309	119
	System Transformation		122	163	248	187	80	0
	Consumer Transformation		115	125	157	108	44	0
	Leading the Way		121	151	131	69	0	0

Data summary for EV chargers in the Southern England licence area

EV chargers		Baseline	2025	2030	2035	2040	2045	2050
Domestic off-street EV chargers (Total, numbers, thousands)	Falling Short	94	205	422	951	1733	1858	1847
	System Transformation		217	534	1345	1851	1919	1907
	Consumer Transformation		323	997	1867	1901	1929	1957
	Leading the Way		318	1004	1882	1918	1951	1984
Non-domestic EV chargers[25] (Total, MW)	Falling Short	218	372	571	1198	2308	3222	3819
	System Transformation		417	799	1992	3372	3642	3716
	Consumer Transformation		521	1239	2677	3317	3368	3503
	Leading the Way		537	1296	2928	3501	3560	3797

[25] Non-domestic figures include on-street domestic, also called on-street residential, figures to reflect the commercial nature of on-street domestic charging.

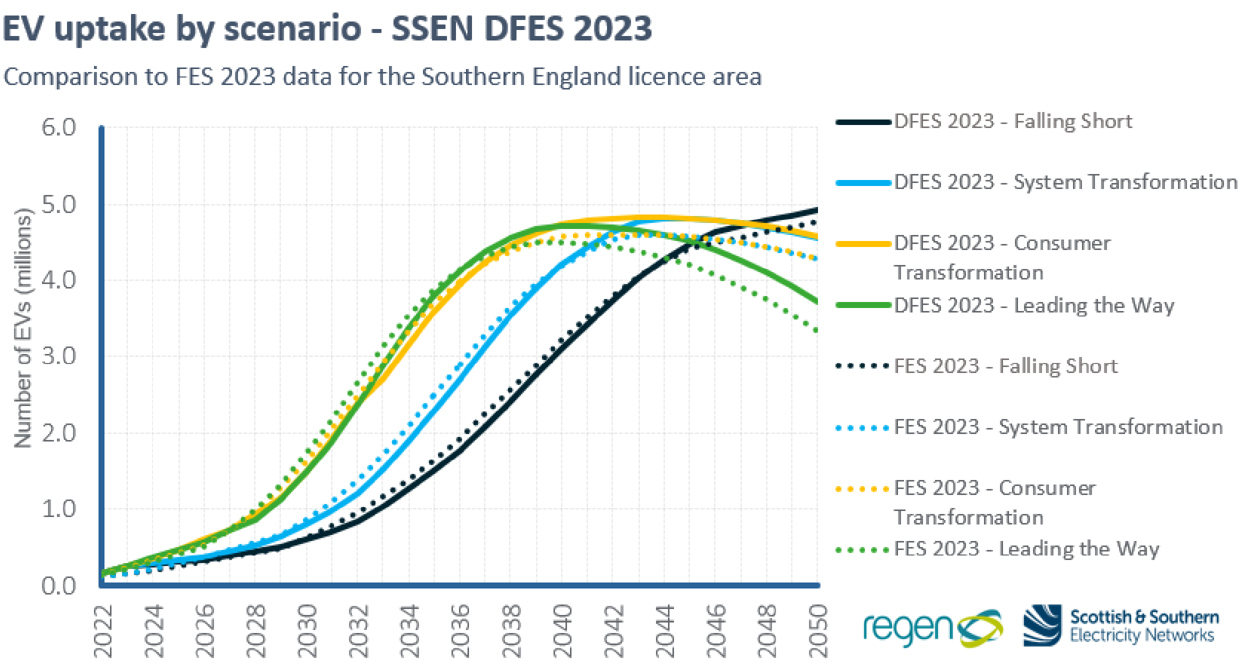


Figure 40 EV projections for the Southern England licence area, compared to National Grid FES 2023 regional projections

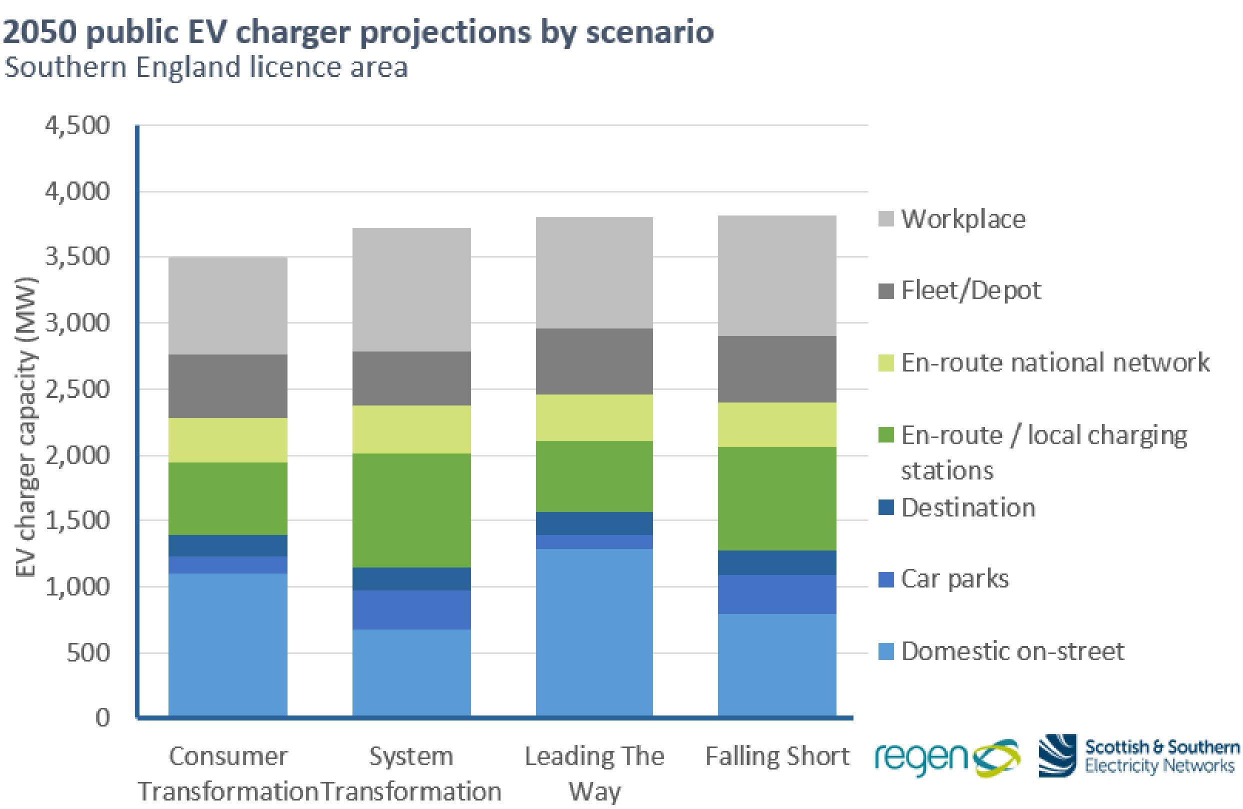


Figure 41 Non-domestic EV charger projections for the Southern England licence area

Summary

- The uptake of EVs in the Southern England licence area continues to advance at pace, with the number of Battery EVs increasing from approximately 91,000 in DFES 2022 to 158,000 in DFES 2023. Furthermore, the current installed capacity of non-domestic EV chargers has more than doubled, from 95 MW in DFES 2022 to 218 MW in DFES 2023, with a particular jump in chargers located at en-route service station and local petrol station locations.
- At the end of 2022, 3.2% of vehicles (and 3.7% of cars) in the Southern England licence area were battery EVs and 0.6% of all vehicles were plug-in hybrids. The uptake of battery EVs and plug in hybrids in the licence area is above the national uptake rate (of 1.5% and 1%, respectively).
- EV uptake rate is anticipated to increase substantially in the licence area and across the UK under every scenario as the UK looks to decarbonise the transport sector.
- In September 2023, the UK government announced plans to push back the ban on the sale of new petrol and diesel cars and LGVs to 2035.[lix] EV uptake assumptions in the FES remain close to the CCC's 6th Carbon Budget[lx] and this policy change is already considered within the envelope of the FES scenario assumptions (particularly for EV uptake under **Falling Short**) so no changes to the DFES assumptions have been made.
- The uptake of EV chargers is projected to increase substantially under every scenario to facilitate EV uptake. There is uncertainty regarding the split between off-street home charging versus public charging as well as the market share between ultra-fast charging hubs versus lower voltage on-street, neighbourhood and municipal charging. The DFES projections, therefore, aim to represent the envelope of the possible spread and rate of deployment of EV chargers in the licence area, and how this will manifest as electricity demand (in MW) on the distribution network.
- While long and medium-term projections of EVs and EV charger capacity in the licence area are closely aligned with DFES 2022 projections, short-term projections see a greater variance. To date, the uptake of EVs in the licence area is slightly below the average of the four scenarios, and consequently short-term projections for **Falling Short** have increased, while uptake in **Consumer Transformation** have reduced.
- In this year's DFES, more granular data on average annual mileage of buses and coaches was used than in previous studies. This has identified that the average mileage of buses and coaches in the Southern England licence area is below average and consequently projections of total fleet EV charging capacity across the licence area has reduced by approximately 15%.

Modelling and assumptions

Baseline (2022)		
Vehicle archetype	**Thousands of vehicles**	**Description**
Pure electric car	147	EV uptake in the Southern England licence area is currently ahead of the national average, the uptake of battery EVs is increasing rapidly, from approximately 91,000 in DFES 2022 to 158,000 in DFES 2023. This is due to several factors, including: • Favourable tax benefits for ultra-low emissions vehicles. • Increasing consumer confidence and awareness of EVs. • Electrification of commercial vehicle fleets. • Financial benefits of high annual mileage vehicles compared to petrol or diesel vehicles. While most EV uptake has centred on cars, other electric vehicles such as LGVs and buses are also beginning to increase in prevalence. EV uptake in the licence area is proportionally higher in urban areas like West London, Reading, Oxford and Swindon. However, evidence suggests uptake rates in urban and rural areas are beginning to align.
Plug-in hybrid car	77	
Pure electric LGV	10	
Plug-in hybrid LGV	0	
Other electric vehicles	2	

EV charger baseline (2022)		
Archetype	**Capacity or numbers**	**Description**
Non-domestic EV chargers	218 MW	As the number of EVs has increased, the capacity and number of operational EV chargers have also steadily grown. In addition to most domestic EV owners having a home charging port,[lxi] non-domestic chargers in car park chargers, workplace charging and rapid en-route chargers on forecourts have seen an increasing rollout in recent years. The baseline of non-domestic EV chargers has more than doubled, from 95 MW to 218 MW between DFES 2022 and DFES 2023, with a particular jump in chargers located at en-route service stations and local petrol station locations.
Domestic EV chargers	93,654 chargers	

EV scenario projections			
Scenario	**Description**	**Battery EVs by 2035 (thousands)**	**Battery EVs by 2050 (thousands)**
Falling Short	The electrification of transport is slowest in this scenario due to lower consumer engagement. Nevertheless, a high proportion	1,496	4,899

<table>
<tr><td></td><td>of new car and LGV sales are EVs by the early 2030s. Approximately 1 million EVs will be registered in the licence area by 2032, four years later than the most ambitious scenarios. Plug-in hybrid vehicles see moderate uptake, but battery electric vehicles are the dominant EV technology across all vehicle classes. Harder-to-electrify vehicles such as buses and HGVs see limited uptake in the medium term.

By 2050 the vast majority of vehicles are electrified, but a high proportion of this electrification is modelled to occur in the 2040s, and there are still petrol and diesel vehicles on the road in 2050 in this scenario.</td><td></td><td></td></tr>
<tr><td>System Transformation</td><td>Although the ban on new sales of new petrol and diesel passenger vehicles has been pushed back to 2035, this net zero scenario assumes passenger vehicles such as cars and LGVs are rapidly electrified and the ban on the sales of new petrol and diesel vehicles is from 2032. In this scenario, the licence area reaches 1 million registered EVs just two years later than the most ambitious scenarios, in 2030.

Plug-in hybrid vehicles see moderate uptake under this scenario, but battery EVs are the dominant EV technology.

Around half of the HGVs are also electrified under this scenario, with the remainder fuelled by low-carbon hydrogen. Nevertheless, over 90% of vehicles are electrified by 2050.</td><td>2,273</td><td>4,498</td></tr>
<tr><td>Consumer Transformation</td><td rowspan="2">Although the ban on new sales of new petrol and diesel passenger vehicles has been pushed back to 2035, this scenario assumes passenger vehicles such as cars and LGVs are rapidly electrified and the ban on the sales of new petrol and diesel vehicles comes into full effect from 2030. Non-passenger vehicles, such as HGVs and buses, also electrify, but over a longer timeframe. By 2050, almost all road vehicles are electrified in these scenarios. However, increased use of active travel, public transport and shared vehicles facilitates a substantial reduction in the total number of EVs between the early 2040s and 2050.</td><td>3,560</td><td>4,526</td></tr>
<tr><td>Leading the Way</td><td>3,776</td><td>3,669</td></tr>
</table>

EV charger scenario projections					
For non-domestic EV chargers, the DFES EV modelling determines the EV charger capacity required to charge the number of vehicles projected in each of the four DFES scenarios. This capacity is converted to a subsequent number of EV chargers, split across several domestic and non-domestic charger types, such as rapid en-route chargers and slow and fast chargers in public car parks. This allocation is driven predominantly by the number of each vehicle type from the projections and assumptions around mileage driven and how EVs may be primarily charged under each FES scenario. Where possible, the National Grid ESO FES data has been used to inform charging behaviour assumptions in the DFES. Domestic EV charger uptake is modelled based on EV uptake in households with off-street parking. It is assumed most households with off-street parking and an EV will install a domestic EV charger.					
Scenario	**Description**	**Domestic chargers by 2035 (thousands)**	**Domestic chargers by 2050 (thousands)**	**Non-domestic capacity by 2035 (MW)**	**Non-domestic capacity by 2050 (MW)**
Falling Short	EV adoption, and subsequent EV charger capacity, increases out to 2050 in this scenario, with almost all road vehicles modelled to be electrified. EV charger uptake is relatively rapid in en-route locations, facilitated by local authority leadership. However, uptake across all EV charger archetypes is slower compared to other scenarios.	951	1,847	1,198	3,819
System Transformation	Both EV adoption and associated EV charger capacity peak in the late 2040s under this scenario. By this point, almost all passenger vehicles, LGVs, buses and coaches are electrified, while half of HGVs are electrified. While domestic charging is most common, rapid en-route charging also sees high uptake under this	1,345	1,907	1,992	3,716

	scenario.				
Consumer Transformation	Both EV adoption and associated EV charger capacity peak in the early 2040s. By this point, almost all road transport is electrified. **Leading the Way** sees the uptake of EV cars slow and significantly reduce, as consumers adopt new transport methods such as public transport, shared vehicles and autonomous vehicles (AVs). However, while the number of EV cars reduces, utilisation and milage per AV increases significantly. The reduction in overall energy demand is, therefore, less significant. Consequently, installed EV charger capacity remains high.	1,867	1,957	2,677	3,503
Leading the Way		1,882	1,984	2,928	3,797

Reconciliation with National Grid FES 2023

- Baseline EV numbers in the DFES 2023 are sourced from DfT vehicle licencing data and are slightly different to the FES 2023 baseline figures, most likely due to the time of data extraction.
- As the EV market and provision of EV charging infrastructure is heavily driven by national factors, the DFES projections for EVs and EV chargers in the licence area strongly mirror the national FES outcomes.
- The SSEN DFES 2023 projections are broadly in line with the FES 2023 projections for this licence area as reported for the Building Block ID numbers Lct_BB001, Lct_BB002, Lct_BB003 and Lct_BB004.
- The different EV charger archetypes are not broken down in the FES 2023 data at a GSP, licence area or national level. As such, a reconciliation is not possible. For vehicle efficiencies, mileage and vehicle numbers, FES projections and assumptions were used to inform the DFES analysis, where available.

Geographical factors affecting deployment at a local level

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

Relevant assumptions from National Grid FES 2023

1.1.6 - Transport: Ultra Low Emission Vehicle (ULEV) subsidies	
Falling Short	Plug-in Grant for cars & vans modelled as ending in 2022.
System Transformation	Private ULEV subsidies extended to combat low consumer willingness to change. Plug-in Grant for cars & vans ends in 2023.
Consumer Transformation	Plug-in Grant for cars & vans modelled as ending in 2022.
Leading the Way	Private ULEV subsidies extended to achieve policy ambitions. Plug-in Grant for cars & vans ends in 2023.
1.3.4 - Transport: Public Road Transport	
Falling Short	Air pollution acts as a driver for urban investment but on the whole consumers are reluctant to shift from private transport.
System Transformation	Consumers are somewhat more reluctant to shift from private vehicles and reduce household car ownership, limiting growth.
Consumer	Consumers demand for public transport increases as attitudes change. Some two car

Transformation	households shifting to one car leads to further growth.
Leading the Way	Consumers demand for public transport increases as attitudes change. Growth is limited by the growth in Robotaxis for urban transport in this scenario.
3.3.2 - Autonomy	
Falling Short	Uptake limited by technology readiness and consumer trust. Has no effect on car ownership. Vehicle does more miles due to ease of travel. Some efficiency gains, particularly through improved off-peak motorway traffic flow.
System Transformation	Significant uptake of private vehicles. Enables some urban households to switch from two to one car families with a corresponding increase in miles for the autonomous vehicle.
Consumer Transformation	Consumer acceptance leads to earlier uptake. Allows a significant number of urban households to become one car families with a corresponding increase in miles. Cars do increased miles e.g. serving underserved populations. Significant vehicle efficiency gains through improved traffic flow and appropriate vehicle sizing.
Leading the Way	Urban areas adopt shared autonomous taxis, allowing some urban households to go car free. Vehicle does significantly more miles as a highly utilised asset. High efficiency gains.
3.3.5 - Battery electric vehicles (BEVs)	
Falling Short	BEV adoption is slow and doesn't meet policy ambitions. By 2035, 100% of car sales are ULEV. By 2040, 100% of van sales are ULEV. For both sectors this is dominated by BEVs. Slower uptake of BEVs in the Bus and HGV sectors out to 2050.
System Transformation	The right conditions are not fully achieved to create the consumer confidence needed for the market to achieve 100% sales of ULEVs. This is achieved for cars and vans in 2032 and 2035 respectively and dominated by BEVs. Uptake in the HGV >26t sector is limited by strong Hydrogen Fuel Cell Vehicle uptake.
Consumer Transformation	The government target of 100% of new car and van sales being ULEV by 2030 is met and dominated by BEVs. There's significant uptake in the bus sector and across all HGVs.
Leading the Way	The government target of 100% of new car and van sales being ULEV by 2030 is met and dominated by BEVs. Uptake in the HGV sector is strong across all weight classes. There's significant uptake in the bus sector.
4.1.25 - Plug-in hybrid electric vehicles (PHEVs)	
Falling Short	Availability from manufacturers to meet EU emissions standards is met from demand by fleets looking to gradually reduce emissions and drivers who are unwilling to shift to BEVs. No new sales from 2040.
System Transformation	Higher demand for PHEVs as a transitional vehicle due to a higher proportion of consumers reluctant to transition to BEVs. No new sales from 2035.

Consumer Transformation	Subsidy environment, falling battery costs and increased consumer willingness to accept BEVs limits PHEV growth. No new sales from 2035.
Leading the Way	Higher initial demand for PHEVs (in addition to BEVs) as society seeks to decarbonise quickly. Subsidy environment, falling battery costs and increased consumer willingness to accept BEVs limits PHEV growth. No new sales from 2032.
4.2.13 – Level of home charging	
Falling Short	There is a lack of solutions to residential charging for those without off-street parking and which consumers are willing to adopt. These consumers charge at destinations such as work.
System Transformation	There is a lack of solutions to residential charging for those without off-street parking and which consumers are willing to adopt. Emphasis on public rollout of fast chargers allows near-home rapid charging.
Consumer Transformation	Emphasis on home and on-street residential chargers (for those with adequate on-street parking), taking advantage of consumer engagement levels in flexibility. Emphasis on public rollout of fast chargers also allows near-home rapid charging.
Leading the Way	Widespread innovation and behaviour change allows majority of those with on-street parking to charge overnight. This limits market for near home rapid charging

Incorporation of stakeholder feedback

EVs and EV chargers stakeholder feedback	
Stakeholder feedback provided	**How this has influenced our analysis**
The Southern England stakeholders viewed several factors as barriers to the widespread uptake of EVs in the licence area. However, no standout factor was viewed as significantly more impactful than other barriers.	This validated existing DFES modelling assumptions that reflects a range of factors that could limit EV uptake under some scenarios, so no further action was taken based on this feedback.
Stakeholders were asked whether the future of EV charging infrastructure would be more widely dispersed in more decentralised locations (such as a higher level of on-street residential chargers) or be less dispersed and more centralised (such as a higher level of charging hubs and en-route charging). Stakeholders were divided in their responses, with 30% voting for a balanced approach, 42% a widely distributed and 28% a more centralised approach to EV charging infrastructure deployment.	Stakeholder feedback highlighted the uncertainty of the shape and scale of a future EV charger network, as well as future consumer behaviour. Therefore, to reflect this feedback, the DFES scenarios model variability in the proportion of EV charging at dispersed locations and more centralised locations, and the amount of EV charging that occurs both near and far away from home.

[lix] DfT, *Government sets out path to zero emission vehicles by 2035*. https://www.gov.uk/government/news/government-sets-out-path-to-zero-emission-vehicles-by-2035

[lx] CCC, *6th Carbon Budget Surface Transport*. https://www.theccc.org.uk/wp-content/uploads/2020/12/Sector-summary-Surface-transport.pdf

[lxi] Department for Business, Energy and Industrial Strategy, January 2023, *Electric Vehicle Smart Charging Action Plan*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1129728/electric-vehicle-smart-charging-action-plan.pdf

Heat pumps and resistive electric heating

Summary of modelling assumptions and results

Technology specification

The analysis covers all variants of electrically-powered heating technologies within the scope of the SSEN DFES 2023. This includes electric heat pump systems providing space heating and hot water to domestic and non-domestic buildings and direct electric heating systems using electricity to provide primary space heat and hot water to domestic buildings, typically via night storage or direct radiant electric heater.

Technology building blocks: **Lct_BB005 – Domestic non-hybrid heat pumps**; **Lct_BB006 – Domestic hybrid heat pumps**; **Lct_BB007 – Non-domestic non-hybrid heat pumps**; **Lct_BB008 - Non-domestic hybrid heat pumps**; **No corresponding DFES building block - Domestic resistive electric heating**.

Data summary for heat pumps in the Southern England licence area

<table>
<tr><th colspan="3">Number of homes (thousands)</th><th>Baseline</th><th>2025</th><th>2030</th><th>2035</th><th>2040</th><th>2045</th><th>2050</th></tr>
<tr><td rowspan="7">Domestic</td><td rowspan="4">Non-hybrid heat pumps</td><td>Falling Short</td><td rowspan="4">26</td><td>55</td><td>162</td><td>354</td><td>663</td><td>1,024</td><td>1,440</td></tr>
<tr><td>System Transformation</td><td>65</td><td>167</td><td>253</td><td>351</td><td>501</td><td>784</td></tr>
<tr><td>Consumer Transformation</td><td>93</td><td>486</td><td>1,176</td><td>1,919</td><td>2,325</td><td>2,553</td></tr>
<tr><td>Leading the Way</td><td>93</td><td>574</td><td>1,301</td><td>1,757</td><td>1,893</td><td>2,051</td></tr>
<tr><td rowspan="3">Hybrid heat pumps</td><td>Falling Short</td><td rowspan="3">0</td><td>0</td><td>3</td><td>10</td><td>17</td><td>26</td><td>31</td></tr>
<tr><td>System Transformation</td><td>2</td><td>9</td><td>24</td><td>302</td><td>587</td><td>783</td></tr>
<tr><td>Consumer Transformation</td><td>2</td><td>10</td><td>21</td><td>33</td><td>45</td><td>59</td></tr>
</table>

Number of homes (thousands)			Baseline	2025	2030	2035	2040	2045	2050
		Leading the Way		2	12	85	190	270	301

Number of properties (thousands)			Baseline	2025	2030	2035	2040	2045	2050
Non-domestic	Non-hybrid heat pumps	Falling Short	6	8	13	18	24	31	37
		System Transformation		10	22	46	67	79	81
		Consumer Transformation		10	24	51	75	90	96
		Leading the Way		12	31	56	78	85	90
	Hybrid heat pumps	Falling Short	0	0	1	1	3	6	10
		System Transformation		1	7	15	30	39	45
		Consumer Transformation		1	5	11	19	24	27
		Leading the Way		1	5	12	22	28	35

Data summary for domestic resistive electric heating in the Southern England licence area

Number of homes (thousands)		Baseline	2025	2030	2035	2040	2045	2050
Resistive electric heating	Falling Short	345	352	323	300	269	248	220
	System Transformation		352	307	275	208	158	104
	Consumer Transformation		345	322	295	279	249	219
	Leading the Way		348	325	291	269	239	230

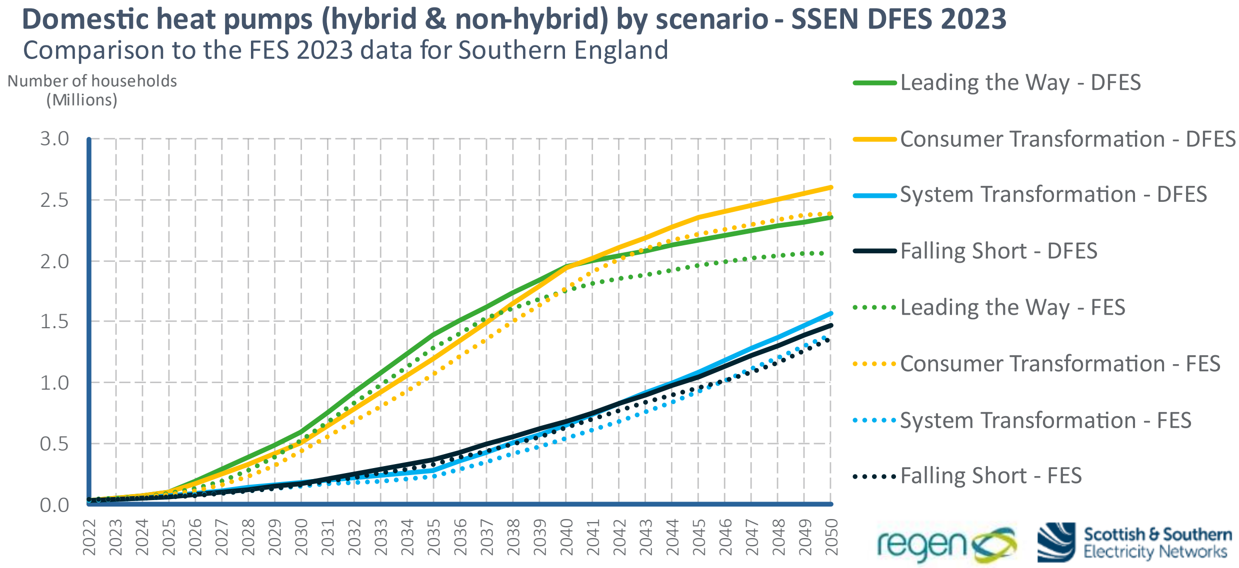


Figure 42 Domestic heat pumps (non-hybrid and hybrid).26 projections for the Southern England licence area, compared to National Grid FES 2023 regional projections

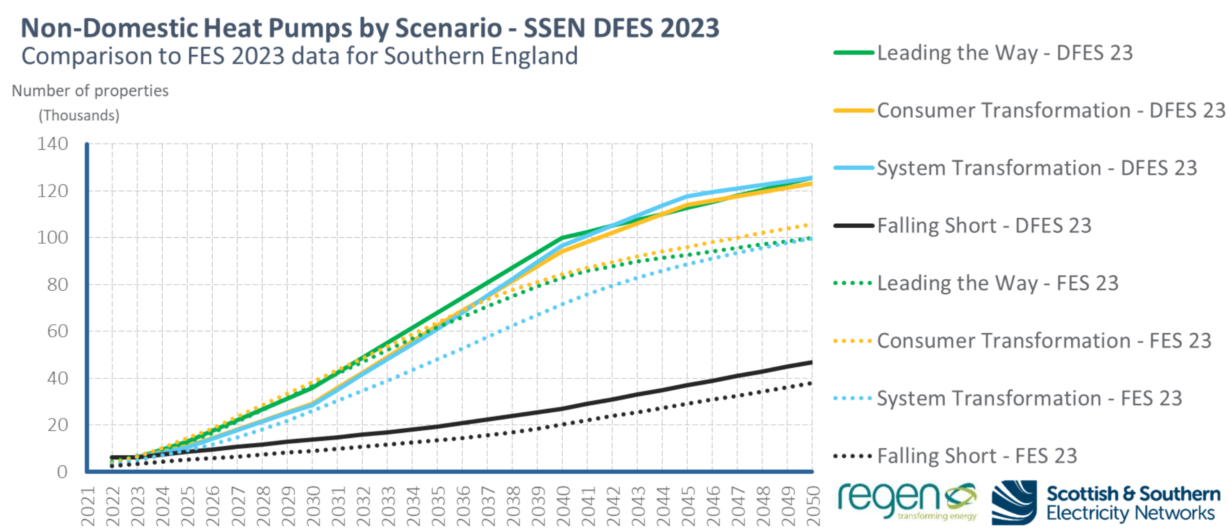


Figure 43 Non-domestic heat pumps (non-hybrid and hybrid) projections for the Southern England licence area, compared to National Grid FES 2023 regional projections

26 The Building Block data provided in the FES 2023 classifies an 'ASHP with a resistive heating element' as a hybrid heat pump, whereas the DFES analysis considers this to be a variation of a non-hybrid heat pump. Accordingly, the reconciliation between FES and DFES 2023 results has been undertaken using combined figures for both non-hybrid and hybrid heat pumps together.

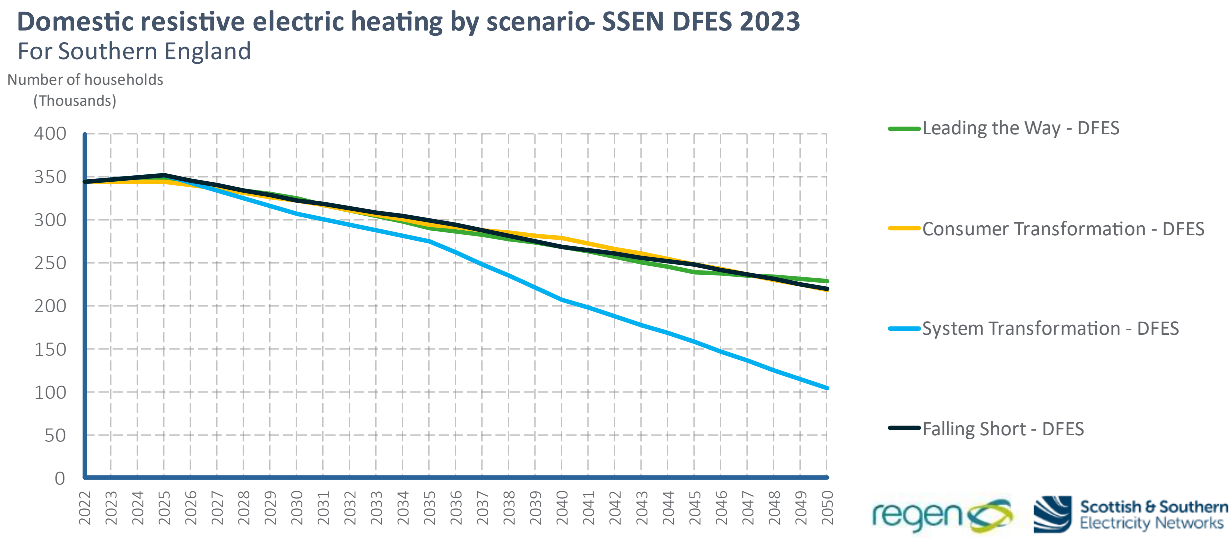


Figure 44 Domestic resistive electric heating projections for the Southern England licence area

Summary

- The Southern England licence area has a high proportion of on-gas homes and businesses, particularly around dense urban areas such as Greater London, Swindon, Oxford and Southampton. These properties will require conversion to low carbon heating by 2050 to meet the UK government's net zero targets.
- At the end of 2022, there were c. 32,000 homes and businesses with a heat pump currently installed.
- Under **Consumer Transformation** and **Leading the Way**, space heating is primarily decarbonised via heat pumps in both the Southern England licence area and nationally. Initial uptake is mostly modelled to occur in off-gas, and well-insulated buildings before a wider-scale rollout of heat pumps across most of the housing stock is modelled out to 2050. For the Southern England licence area, this results in c. 2.5 million homes and c. 125,000 non-domestic buildings operating a heat pump by 2050 in **Consumer Transformation**.
- Under **System Transformation**, the decarbonisation of heat is driven primarily by low-carbon hydrogen, fuelling a mixture of standalone hydrogen boilers and hybrid heat pumps. With a high proportion of on-gas areas, the vast majority of buildings in the Southern England licence area convert to hydrogen boilers or hydrogen hybrid heat pumps by 2050 under this scenario. However, c. 775,000 homes and c. 80,000 non-domestic buildings are still modelled to operate a non-hybrid heat pump in 2050 in this scenario.

- The number of properties on resistive electric heating, which includes direct electric heating and night storage heaters, decreases in all scenarios, replaced by heat pumps and district heating solutions. As the most expensive heating method, direct electric heating provides a financial driver for consumers to switch in all four scenarios. There is also a shift from direct electric heating to next-generation storage heaters in homes where a boiler or heat pump is less suitable, such as in very low energy efficiency properties.
- The majority – around 85% – of homes and businesses in the Southern England licence area use fossil fuel heating systems. These will require conversion to a zero-emissions heating system by 2050 if UK carbon reduction targets are to be met.
- The deployment of non-domestic heat pumps shows a similar trend, by scenario, as domestic; a high number of businesses look to decarbonise their space heating and replace fossil gas and direct electric heating with heat pump variants in all scenarios, to a varying degree, by 2050.

Modelling and assumptions

<table>
<tr><th colspan="4">Baseline (2022)</th></tr>
<tr><th colspan="4">Domestic heat pumps</th></tr>
<tr><th>Sub-technology</th><th>Number of homes (thousands)</th><th>% of homes</th><th>Description</th></tr>
<tr><td>Non-hybrid air source heat pumps (ASHP)</td><td>23</td><td>0.8%</td><td rowspan="3">Most heat pumps in existing homes were supported by the Renewable Heat Incentive (RHI) scheme, which ran from 2014 to 2022. This has since been succeeded by the Boiler Upgrade Scheme,[lxii] which moves support to an upfront grant payment to reduce the capital costs of installing a heat pump.

The RHI was particularly popular in the South of England, with around 21% of all RHI accredited heat pumps being in the Southern England licence area. 1% of homes in the licence area now have a heat pump, which aligns with the national average.

As of the end of 2022, an estimated 26,500 homes were heated by domestic heat pumps, compared to 26,000 in 2021, reflecting the slow rate of uptake of heat pumps across the country.</td></tr>
<tr><td>Non-hybrid ground source heat pumps (GSHP)</td><td>4</td><td>0.1%</td></tr>
<tr><td>Hybrid heat pump</td><td>-</td><td>-</td></tr>
</table>

Domestic resistive electric heating			
Night storage heaters	218	7.5%	Resistive electric heating is more common in the Southern England licence area compared to the national average, heating almost 12% of homes, compared to 8% nationally, according to FES 2023. As of the end of 2022, approximately 345,000 homes were heated by resistive electric heating, compared to c. 351,000 in 2021. The licence area has a slightly higher-than-average proportion of off-gas homes and a higher than the average number of flats, which are more likely to be electrically heated. These predominantly appear in urban areas such as West London, Swindon, Oxford and Southampton.
Direct electric heaters	127	4.4%	

Non-domestic heating			
Non-hybrid heat pumps	6,232	-	An estimated 6,230 non-domestic properties are currently heated by a non-hybrid heat pump. As with domestic properties, there are no non-domestic hybrid heat pumps in the baseline.
Resistive heating	82,525	-	An estimated 82,500 non-domestic properties currently also use resistive electric heaters, likely focused in off-gas industrial areas.

Near-term projections (2023-2025)

The modelling of the future uptake of different types of electric heating in the licence area is based on several key factors, such as building types and sociodemographic factors. Under the three net zero scenarios, the uptake of heat pumps in the licence area is projected to increase significantly by 2025, particularly in off-gas homes heated by oil and liquefied petroleum gas (LPG). Conversely, the number of homes heated by resistive electric heating is projected to slowly decrease under every scenario in the near term.

Domestic heat pumps

Scenario	Description	Proportion of homes with a heat pump in 2025	
		Southern England	GB (FES)

Falling Short	Under these scenarios, near-term decarbonisation and electrification of heat is low. Heat pump uptake is restricted to areas of off-gas housing, replacing oil, LPG and resistive electric heating, and well-insulated homes. There are many examples of these properties in the licence area, resulting in c. 55,000-67,000 homes with a heat pump by 2025 under these scenarios. The more restricted uptake compared to other net zero scenarios is, however, linked to a longer-term strategy to introduce low-carbon hydrogen supply and hydrogen boilers under **System Transformation**.	2%	2%
System Transformation		2%	2%
Consumer Transformation	The Southern England licence area has numerous heavily populated areas, meaning that it has a strong potential to contribute to national heat pump targets.	3%	3%
Leading the Way	Under the **Consumer Transformation** and **Leading the Way** scenarios, ASHPs and GSHPs are the low carbon heating technologies that see the highest adoption, as GB progresses strongly towards the target of 600,000 heat pump installations per year by 2028, which is part of the Heat and Buildings Strategy (2021).[lxiii] In the Southern England licence area, areas of off-gas and well-insulated homes are modelled to see particularly high levels of heat pump deployment. In addition to this, some on-gas houses and flats also convert to heat pumps due to the regional adoption of the Boiler Upgrade Scheme.[lxii] Based on previous FiT data, larger semi-detached and detached homes are assumed to convert more readily. The Southern England licence area uptake is slightly above the GB average.	3%	7%

Domestic resistive electric heating

Scenario	Description	Proportion of homes with resistive electric heating in 2025	
		Southern England	GB (FES)

Falling Short	Under these scenarios, only a very small proportion of homes with resistive electric heating are modelled to convert to a heat pump in the near term. However, while current gas prices remain high, with the licence area hosting a high number of on-gas households, some additional houses move onto the mains gas network to reduce heating costs. Some properties are also modelled to install next-generation night storage heaters.	12%	8%
System Transformation		12%	8%
Consumer Transformation	Under these scenarios, around 1% of houses and flats in the licence area with direct electric heaters are modelled to convert to a heat pump by 2025. Some direct electric heated homes also convert to night storage heaters to reduce heating costs.	12%	8%
Leading the Way		12%	8%

Non-domestic heat pumps

Scenario	Description	Installations in 2025	
		Non-hybrid	**Hybrid**
Falling Short	The uptake of non-domestic heat pumps varies slightly by scenario by 2025. The highest uptake occurs in **Leading the Way**, where smaller-scale businesses rapidly adopt low carbon heating to reduce their carbon footprint and energy costs.	8,392	252
System Transformation		9,546	989
Consumer Transformation		10,088	825
Leading the Way		11,764	1,246

Medium and long-term projections (2025-2050)

Heat decarbonisation accelerates in the Southern England licence area in the medium term, especially in the three net zero scenarios, as the country seeks to meet heat decarbonisation targets.

Under **Consumer Transformation** and **Leading the Way**, heat pumps are modelled to become the main heating technology in both on-gas and off-gas properties. District heat networks are modelled to come online in some urban areas in the Southern England licence area, such as West London, Swindon, Oxford and Southampton. These are driven by heat pumps or from waste heat in dense urban areas or areas near a waste heat source, such as thermal or heavy industry.

Under **Falling Short** and **System Transformation**, heat pump uptake remains low in both households and businesses. Under **Falling Short**, decarbonisation of heat is generally slower across the country, resulting in heat pump uptake mainly being limited to off-gas homes in the medium term. Under **System Transformation**, hydrogen boilers become the preferred heating technology for on-gas homes, limiting heat pump adoption.

New build homes are modelled to increasingly include low-carbon heating appliances. In every scenario, this includes both heat pumps and connections to district heat networks. There are 410,000-510,000 projected new houses modelled to be built by 2050 in the Southern England licence area. In general, heat pump uptake is modelled to be strongly adopted in new build homes from 2025 under **Consumer Transformation** and **Leading the Way**, reflecting the successful implementation of the Future Homes Standard.[lxiv]

Domestic heat pumps

Scenario	Description	Proportion of homes with a heat pump			
		2035		2050	
		Southern England	GB (FES)	Southern England	GB (FES)
Falling Short	Under **Falling Short**, overall progress towards net zero remains low, and fossil gas heating remains the most common form of heating out to 2050. The majority of heat pump uptake is in off-gas houses under this scenario.	12%	11%	45%	41%
System Transformation	In **System Transformation**, a small subset of properties are modelled to install hydrogen hybrid heat pumps, reflecting low carbon hydrogen being available in some areas and replacing the fossil gas network in the 2030s and 2040s. As a result, by 2050, a third of all heat pumps modelled under this scenario are hydrogen hybrid systems. Non-hybrid heat pump uptake is focused on off-gas houses and new build homes. Hydrogen boilers heat the remainder of homes under this scenario.	9%	7%	47%	44%
Consumer Transformation	Southern England remains broadly in line with the medium-term national trajectory for heat pump uptake under both **Consumer Transformation** and **Leading the Way**. Under these scenarios, many more on-gas homes convert to a heat pump by 2035 (38-43%); a national shift in heating technologies drives this.	38%	35%	78%	73%

Leading the Way	By 2050, almost all properties are heated by standalone heat pumps, district heating or resistive electric heating in both scenarios. Standalone heat pump uptake is slightly ahead of the GB average trend in the Southern England licence area. This is due to the number of properties that are outside built-up areas and, thus, less likely to have access to a district heat network. Under **Leading the Way**, hydrogen boilers become available in some population centres, modelled to be installed in 10% of domestic properties in 2050. As a result, c.2.05-2.55 million properties are operating a type of heat pump by 2050 under these scenarios.	43%	42%	69%	64%

Domestic resistive electric heating

Scenario	Description	Proportion of homes with resistive electric heating			
		2035		2050	
		Southern England	GB (FES)	Southern England	GB (FES)
Falling Short	The number of resistive heated homes decreases in the medium term under these scenarios, with homes connecting to the fossil gas or hydrogen network. Direct electric heated homes that cannot convert to these technologies have been assumed to shift to next-generation night storage heating, which enables them to shift their electricity demand to lower cost periods. **System Transformation** sees a more rapid decrease out to 2050 due to a higher uptake of hydrogen	10%	6%	7%	5%
System Transformation		9%	6%	3%	2%

	boilers and hybrid heat pumps.				
Consumer Transformation	The number of resistive heated homes continues to decrease in the medium and long term under these scenarios. Homes in denser urban areas and flats connect to district heat networks, and other homes install standalone heat pumps. By 2050, direct electric heated homes that cannot convert to these technologies generally shift to next-generation night storage heating. As a result, c.219,000 – 230,000 homes (7%) are operating a resistive electric heater by 2050 in these scenarios.	9%	7%	7%	5%
Leading the Way		9%	6%	7%	5%

Non-domestic heat pumps

Scenario	Description	Installations in 2035		Installations in 2050	
		Non-hybrid	Hybrid	Non-hybrid	Hybrid
Falling Short	The majority of non-domestic heat pumps are pure electric in all scenarios by 2050. **System Transformation** sees a more ambitious uptake than with domestic heat pumps by 2050, as well as a moderately higher	17,654	1,492	37,093	9,707
System Transformation		46,139	14,616	80,949	44,525
Consumer Transformation		50,989	11,240	95,821	27,136

Leading the Way	uptake of hybrid heat pumps overall. Under Consumer Transformation and Leading the Way, >40,000 non-domestic premises install a type of heat pump by 2050, reflecting more businesses focusing on electrification to meet their net zero plans.	55,772	10,810	90,220	35,255

Reconciliation with National Grid FES 2023

Modelling stage	Reconciliation
Baseline	**Domestic and non-domestic heat pumps:** The baselines for DFES and FES are closely aligned.
Near-medium term projections	**Domestic heat pumps:** DFES shows broad agreement with FES in the medium term, though slightly higher year-on-year uptake in all scenarios. This is due to the licence area having several attributes that suggest a slightly-above GB average uptake. **Non-domestic heat pumps:** DFES shows a similar trajectory and number of non-domestic heat pumps to the FES in the near term.
Medium-long term projections	**Domestic heat pumps:** Beyond the variance in the medium-term, the DFES shows broad alignment with longer-term uptake of the FES, with slightly higher heat pumps by 2050 in all scenarios, reflecting positive factors present in the licence area for heat pump adoption. **Non-domestic heat pumps:** DFES has a higher overall uptake of non-domestic heat pumps than seen in the FES. The reason for this is unclear but could be related to a more ambitious level of commercial business decarbonisation from direct engagement with some major energy users.
Overarching trend	The DFES outcomes for total heat pumps in each scenario are broadly aligned with the FES 2023 data, albeit with slightly higher overall outcomes in every scenario by 2050. This could be due to differences in the total housing stock modelled in the FES and DFES. In all scenarios, the DFES non-domestic heat pump projections are higher than the FES 2023. The slightly higher DFES outcomes are likely due to small differences in the modelled number of non-domestic properties in the licence area, which are based on SSEN customer data.

Geographical factors affecting deployment at a local level

Geographical factors	Description
Current heating technology is categorised into on-gas, resistive electric heating, and off-gas (predominantly heating oil). This is the main geographical factor for the modelling of non-domestic heat pumps.	EPC data,[lxv] ONS Census[lxvi]
Building type is categorised into semi-detached and detached houses, terraced houses, and flats.	EPC data, ONS Census
Tenure is categorised into owner-occupied, privately rented and socially rented.	EPC data, ONS Census
Current and potential future levels of energy efficiency, based on building age (pre/post-1930 construction).	EPC data

Relevant assumptions from National Grid FES 2023

Scenario	3.1.3 – Heat pump adoption rates	
Falling Short	Low	Low disposable income and low willingness to change lifestyle means consumers buy similar appliances to today.
System Transformation	Medium	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	High	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	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.
Scenario	**4.2.27 – Uptake of hybrid heating system units***	
Falling Short	Low	Gas boilers still dominant and very low levels of hybridisation.
System Transformation	Medium	Hydrogen boilers dominant. Higher amounts of hybrid hydrogen boilers + ASHP systems than FES21. However, low levels of other hybrid technologies.

Consumer Transformation	Medium	Moderate levels of heating hybridisation. Even in a highly electrified heat landscape, the availability of other fuels makes hybridisation cost optimal in certain localities.
Leading the Way	High	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.

Incorporation of stakeholder feedback

Stakeholder feedback provided	How this has influenced our analysis
In the context of the UK government's 2030 target for heat pump uptake, stakeholders highlighted that heat pump deployment would be focused on new homes, off-gas homes and social housing.	Heat pump uptake is weighted towards these housing types and demographics in the near- and medium-term.
Local authorities were engaged to ascertain those with a low carbon heat strategy established or in development. However, this formed a minority of local authorities.	Heat pump uptake is accelerated in local authorities with low-carbon heat strategies in the near-to-medium term.

[lxii] UK Government 2022, *Notice: The Domestic Renewable Heat Incentive (DHRI) closure, and its successor, the Boiler Upgrade Scheme.* https://www.gov.uk/government/publications/changes-to-the-renewable-heat-incentive-rhi-schemes/closure-of-the-domestic-renewable-heat-incentive-dhri-and-its-successor-the-boiler-upgrade-scheme

[lxiii] UK Government 2021, *Heat and Buildings Strategy.* https://www.gov.uk/government/publications/heat-and-buildings-strategy

[lxiv] UK Government 2019, *Consultation outcome: The Future Homes Standard: changes to Part L and Part F of the Building Regulations for new dwellings.* https://www.gov.uk/government/consultations/the-future-homes-standard-changes-to-part-l-and-part-f-of-the-building-regulations-for-new-dwellings

[lxv] Open Data Communities 2022, *Energy Performance of Buildings Data England and Wales.* https://opendatacommunities.org/home

[lxvi] Nomis 2021, *2021 Census.* https://www.nomisweb.co.uk/sources/census_2021

Domestic air conditioning

Summary of modelling assumptions and results

Technology specification

This analysis covers domestic air conditioning units, based on a typical portable or window-mounted unit in the Southern England licence area.

Network technology data building block: **Lct_BB014 – A/C domestic units**

Data summary for air conditioning in the Southern England licence area

Air conditioning units (thousands)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	42	62	129	275	549	1,102	2,173
System Transformation		58	106	196	374	669	1,192
Consumer Transformation		58	106	196	374	669	1,192
Leading the Way		47	49	52	54	57	60

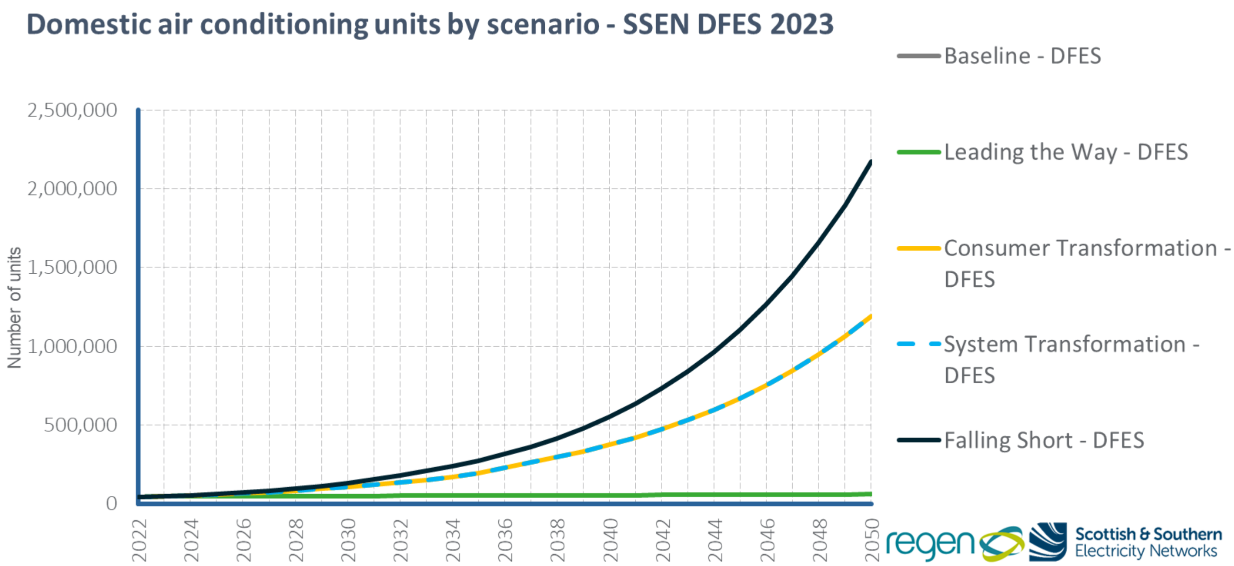


Figure 45 Air conditioning projections for the Southern England licence area

Summary

- Currently, approximately 42,000 air conditioning (AC) units are installed in properties in the Southern England licence area. This represents 1.59% of homes in the licence area and is an increase of 0.13% from DFES 2022. This is also higher than the national baseline of c. 1% of UK homes currently containing AC units.[lxvii]
- The number of cooling degree days[lxviii] at 18.5 °C in the Southern England licence area was the second highest in the UK.
- Based on assumptions in relevant Building Regulations,[lxix] it has been assumed that domestic AC units will not be added to new developments in the licence area.
- There is a very broad range of scenario outcomes for air conditioning in this licence area due to the high uncertainty around the future of domestic cooling. **Leading the Way** sees the lowest uptake of AC units (approximately 59,875) by 2050 whilst **Falling Short** models domestic AC becoming much more common, with a projection of over 2 million new units by 2050.

Modelling stages

Baseline (2022)	
Number of domestic units	**The proportion of homes with AC unit**
41,782	1.59%

Modelling assumptions

We have aligned with the National Grid FES 2023[i] data, which provides a national baseline of around 296,000 domestic air conditioning units, equivalent to around 1%.[lxx] of homes in the UK.

The national figure was distributed based on regional temperate data and housing density to estimate the baseline for the licence area. For example, the Southern England licence area was found to be the UK licence area with the second-highest days at or above 18.5 °C (163 days) and the fifth-highest population density.[lxxi] As a result, a baseline that is slightly higher than the national average (1.45%) was modelled, equating to approximately 42,000 AC units. This cooling degree days metric was used as a factor to determine domestic AC projections in all scenarios.

Future Home Standards

The Future Homes Standard Document O[iii] stipulates high energy efficiency for air conditioning and limits oversizing cooling systems in new homes. As a result, the DFES 2023 modelling assumes that the vast majority of domestic AC uptake is retrofitted in existing homes under every scenario.

Scenario projections

Scenario	Description	In 2035		In 2050	
		Homes with AC units (1000s)	% Of housing stock in Southern England	Homes with AC units (1000s)	% Of housing stock in Southern England
Falling Short	Uptake in domestic AC units increases in the near term under this scenario, due to more frequent summer heat waves. Most of these units are assumed to be in denser urban areas due to the "heat island effect". In the medium and long term, the increasing frequency of	275	10.5%	2,173	82.8%

	heat waves and societal reluctance to change to adopt passive cooling leads to a more significant uptake of domestic AC, even in colder regions, as the 'easiest' route to comfortable internal temperatures.				
System Transformation **Consumer Transformation**	Uptake in domestic AC units increases in the near term due to more frequent summer heat waves under these scenarios. Most units are assumed to be in denser urban areas due to the "heat island effect". In the medium and long term, the uptake of domestic AC continues to accelerate in urban areas due to heat island effects and the prevalence of smaller dwellings such as flats.	196	7.5%	1,192	45.4%
Leading the Way	In the near term, the uptake of domestic AC is minimal, with households opting for passive cooling methods such as shading, ventilation and insulation. As a result, approximately 5,000 AC units are installed between 2022 and 2025 under this scenario. This scenario aims to limit carbon emissions and electricity consumption using passive cooling measures. As a result, additional AC uptake is minimal in the licence area by 2050.	52	2.0%	60	2.3%

Reconciliation with National Grid FES 2023

- The FES 2023 does not directly detail the numbers of domestic AC units; thus, a comparison is not possible. However, annual electricity demand for domestic AC is provided at a national level, alongside typical annual electricity consumption values of 500 kWh/year for domestic AC units. This allows for high-level reconciliation against national figures.
- The Southern England licence area has more cooling degree days and a higher population density compared to other parts of the UK. As a result, the licence area is significantly higher than the FES 2023 national average in every scenario.

Geographical factors affecting deployment at a local level

Geographical factors	Description
Population density	Urban areas experience a 'heat island effect' as asphalt, pavement, and other built areas replace natural landscapes, causing heat to be absorbed rather than reflected. Therefore, population density (persons per hectare, pph) was used to determine the proportion of the licence area considered urban. Three density factors were used: • Very Dense: >100 pph. Used in every scenario. ○ 10% of the Southern England licence population lives in very densely populated areas, including areas just outside of London, within Bournemouth and parts of Southampton and Portsmouth • Fairly Dense: >50 pph - Used in every scenario except **Leading the Way**. ○ 42% of the population resides in fairly dense areas, including most of Swindon and Oxford. • Dense: >25 pph - Only used in **Falling Short** ○ Most of the Southern England licence area (67%) lives in dense areas. This includes Salisbury and the northern outskirts, Marlborough, and Weymouth. In the DFES analysis, early uptake of air conditioning units is focused in denser urban areas because of the 'heat island effect'. Later uptake then expands to areas of lower housing density in scenarios where domestic AC becomes more prevalent.

Relevant assumptions from National Grid FES 2023

Scenario		Uptake of residential air conditioning[lxxii]
Falling Short	High	Low willingness to change means society takes the easiest route to maintain comfort levels, therefore increased levels of air con.
System Transformation	Medium	Medium aircon as society takes a mix of actions to maintain comfort levels (mix of aircon, tolerance of higher temperatures, changes to building design).
Consumer Transformation		
Leading the Way	Low	Low aircon as society changes to minimise uptake (e.g. personal tolerance of higher temperatures, changes to building design).

[lxvii] National Grid FES 2023, *Data workbook V003, ED2 worksheet Data Item for Residential Air Conditioning*. https://www.nationalgrideso.com/future-energy/future-energy-scenarios/documents

[lxviii] Stark 2022, *Degree Days for Free*. https://www.stark.co.uk/degree-days-for-free/

[lxix] HM Government 2021, *Building Regulations 2010 Overheating: Approved Document O*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1057374/ADO.pdf

[lxx] Figure for number of households in the UK taken from Office of National Statistics, Families and Households in the UK: 2022 https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/families/bulletins/familiesandhouseholds/2022

[lxxi] ONS Census 2011-Usual Resident Population. See: https://www.nomisweb.co.uk/census/2011/ks101uk

[lxxii] National Grid FES 2023 Scenario Assumptions, Assumptions worksheet, *Data Item for Residential Air Conditioning*. https://www.nationalgrideso.com/future-energy/future-energy-scenarios/documents

Hydrogen Electrolysis

Summary of modelling assumptions and results

Technology specification

The analysis covers hydrogen electrolysers connected to the distribution network in the Southern England licence area. The analysis does not include electrolysers that are directly powered by renewable energy without a grid connection ('off-grid'), electrolysers connected to the transmission network, or Carbon Capture, Utilisation and Storage (CCUS)-enabled hydrogen produced via the reformation of fossil fuels.

Network technology data building block: **Dem_BB009 - hydrogen electrolysis**

Data summary for hydrogen electrolysis in the Southern England licence area

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	0	4	20	45	47	52	103
System Transformation		4	56	113	187	295	398
Consumer Transformation		4	19	86	158	230	310
Leading the Way		9	98	144	245	392	538

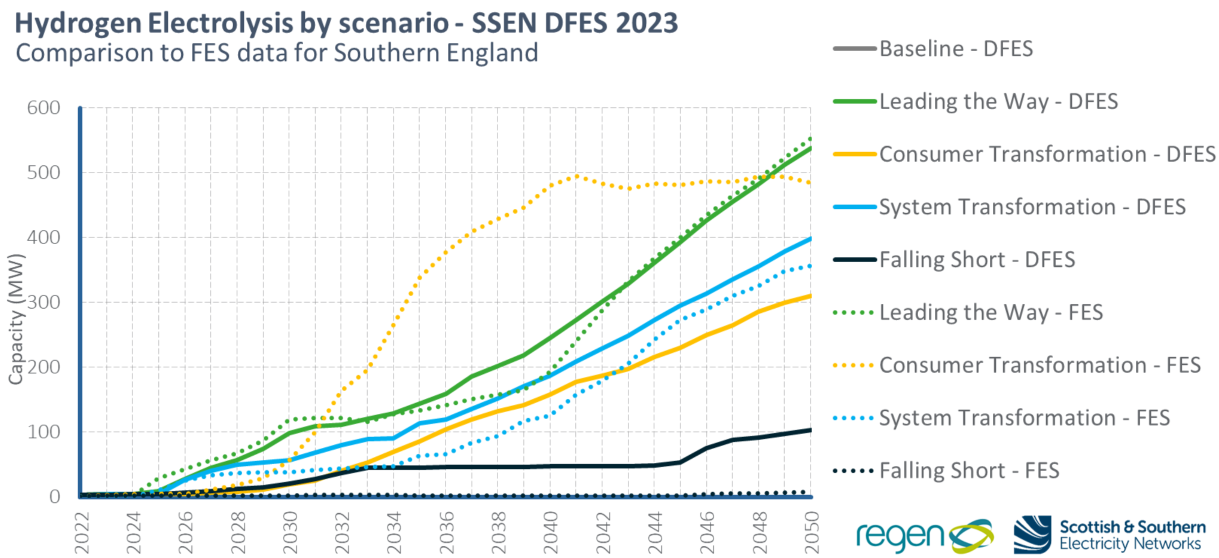


Figure 46 Hydrogen electrolysis projections for the Southern England licence area, compared to National Grid FES 2023 regional projections

Summary

- The British Energy Security Strategy [lxxiii] outlines a target of 10 GW of low carbon hydrogen, of which 5 GW is to be from electrolysis, by 2030. However, hydrogen electrolysis is an emerging technology and uncertainty around its future role in the energy system results in a wide range of projections at the licence area level in the three net zero scenarios, and limited growth in **Falling Short**. These sources of uncertainty include:
    - The split between distribution and transmission-connected electrolysis capacity.
    - The production of low carbon hydrogen via electrolysis versus CCUS-enabled methane reformation.
    - The degree to which electrolysers will be located near storage facilities or sites associated with potential end-users: transport, industrial processes, aviation, shipping, power generation and heat.
    - The presence of import connection agreements for hydrogen electrolysers, where projects co-locate with on-site renewable generation behind-the-meter.
    - How far and how quickly hydrogen production costs will fall.
- The UK government's Electrolytic Allocation Round (2022) [lxxiv] will provide government subsidy support from 2023 onwards for both capital expenditure (CAPEX), via capital grants, and operational expenditure (OPEX), via ongoing revenue payments. Projects

over 5 MW are eligible for support. Successful applicants were announced in early 2023 and have been considered in the analysis.

- FES 2023 projections in the South of England licence area have decreased significantly, and as a result, DFES 2023 projections are also decreased and more closely aligned to the FES under **Leading the Way** and **System Transformation**.
- Using locational factors (set out in tables below) we have allocated FES 2023 distribution-connected projections to DNO licence areas. Southern England is modelled to host between 7-8% of distribution-connected hydrogen electrolysis across GB by 2050, depending on the scenario.
- Southern England is a transport hub comprising road and rail networks, Heathrow Airport, and multiple ports along the south coast. Combined with large industrial clusters, including Southampton, oil refineries currently producing hydrogen and potential hydrogen storage facilities in Portland, Southern England has the potential to host hydrogen hubs.
- Regional Transport Strategy of England's Economic Heartland subnational transport body highlights the future role of electric hydrogen in road and rail transport.[lxxv]
- The largest capacity of distribution-connected hydrogen electrolysers in 2050 is modelled under **Leading the Way** (538 MW) and **System Transformation** (398 MW). This reflects the large-scale rollout of hydrogen as a low-carbon fuel for transport, industry and heat and the establishment of a national hydrogen network to deliver the low-carbon hydrogen to end consumers in the licence area.

Modelling and assumptions

Baseline (2022)		
Number of sites	**Total capacity (MW)**	**Description**
0	0	As of the end of 2022, there were three known hydrogen electrolysis sites connected to the grid totalling 2.4 MW, all of which were hydrogen refuelling stations. Two stations in Swindon and Beaconsfield, owned by ITM power, have since closed down. The third station, operated by BOC and Honda, was recently obtained by Panattoni who are not likely to restart hydrogen production after purchasing the site. The baseline capacity has, therefore, been set to 0.[lxxvi]

Pipeline (2023-2030)	
Number of pipeline sites	**Total capacity (MW)**
3	9

Three prospective hydrogen electrolysis projects are identified in the pipeline where the capacity is known.

A further six sites have been identified with unknown capacity that are reflected in the near-term pipeline projections. In cases where sites are not grid connected or are operating under existing import connections, they have been modelled as 0 kW capacity but recorded for completeness. Grid connected sites with unknown capacities are reflected through the near-term projections for new electrolysis capacity, co-located alongside areas with hydrogen hubs. These pipeline sites include:

- Port of Southampton Superhub
- Kemble airport
- Oxford Hydrogen Hub
- Ealing hydrogen refuelling facility
- Eastleigh hydrogen refuelling units
- New hydrogen facility at former Honda site in Swindon now owned by Panattoni

One uncertainty is the extent to which hydrogen electrolysis sites will rely on on-site generation or whether they will also have a grid import agreement. [27]

There is a further uncertainty as to whether hydrogen electrolysis will be largely transmission connected in the licence area or whether distribution network-connected electrolysers will continue to be developed after initial pilot and demonstration projects.

Networked pipeline projects

Pipeline project	Description	Scenario	Connection year
Science Museum Group's Science and Innovation Park, [lxxvii] 5-7.5 MW	This project combines on-site generation from an existing solar plant with a grid import connection. Designs envision a 5 MW electrolyser, possibly extending to 7.5 MW. The site is modelled to connect under the three net zero scenarios. The additional 2.5 MW is modelled to connect with a 2-year delay in **Leading the Way** and **System Transformation**.	**Falling Short**	--
		System Transformation	2027
		Consumer Transformation	2029
		Leading the Way	2025

[27] Where sites were unable to be identified as having an import connection, they were not modelled. However, as the industry evolves, the Regen DFES team will look to revise this assumption if it becomes clear that most sites, regardless of on-site generation, will apply for grid network import agreements.

	The 2.5 MW expansion does not connect in **Consumer Transformation**.		
Dorset Green H2,[lxxviii] 1.5 MW	A grant for this Dorset-first green hydrogen production facility has been agreed upon, co-located with solar energy. It is expected that this site will couple renewable generation with grid imports.	**Falling Short**	2024
		System Transformation	2023
		Consumer Transformation	2023
		Leading the Way	2023

Scenario projections (2030 to 2050)

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

Hydrogen could become a key technology to balance future electricity supply and demand on the distribution network. The arrival of policy support mechanisms, such as the first electrolytic hydrogen allocation round (2022) provides some impetus for the sector.[lxxiv] Successful projects, which must be 5 MW minimum to be eligible to apply, were announced in 2023.

While Southern England hosts a number of regional hydrogen innovation hubs, many projects are expected to be transmission connected or not to be electricity grid connected. For example, sites like the Southampton Hydrogen Superhub could be entirely transmission-connected or off the electricity grid.
Hydrogen electrolysis capacity is projected to increase in the medium term across all scenarios. This is driven by the uptake of hydrogen-fuelled heavy vehicle fleets and the introduction of mainstream hydrogen fuel cell public transport.

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

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

Scenario	Description	Capacity by	Capacity by

		2035 (MW)	2050 (MW)
Falling Short	Industrial and transport demand see some small hydrogen growth in Southern England.	45	103
System Transformation	Moderate growth is mainly driven by the renewable generation in the licence area and by industrial demand, marine and heavy transport. The establishment of a national hydrogen network boosts electrolysis uptake. Uptake is considerably lower than in DFES 2022 due to the reduction in network-connected electrolysis under the FES.	113	398
Consumer Transformation	Factors determining the uptake of hydrogen electrolysis are diversified, with industrial customers and clusters being the strongest factor, followed by heavy transport and marine transport demand. Electrolysers are located close to demand as a national hydrogen network is not expected to be rolled out.	86	310
Leading the Way	GB-wide hydrogen targets are met, and cost parity with hydrogen reformation is reached early on. By 2045, hydrogen is expanded to support export capabilities. The establishment of a national hydrogen network boosts electrolysis projections. Uptake is considerably lower than seen in DFES 2022 due to the reduction in network-connected electrolysis under the FES 2023.	144	538

Network-connected electrolysis projections – methodology overview

To determine licence-area projections beyond known projects, FES 2023 projections for distribution-connected hydrogen electrolysis at a GB-level were reallocated to each DNO licence area based on propensity for hydrogen electrolysis derived from several locational factors.

These regional factors, weighted based on the FES scenarios' assumptions, represent a range of possibilities across regional uptake. The result has been a re-allocation of FES projections to each licence area, considering the locational factors present within each. The factors below have been updated since DFES 2022 as the model evolved to capture new market information of this emerging technology.

Hydrogen Distribution Factors					
Factor	**Leading the Way**	**Consumer Transformation**	**System Transformation**	**Falling Short**	Presence of this factor in Southern England
Industrial energy demand	High	High	High	High	High
Heavy transport demand	Low	Medium	Medium	High	Low
H2 transmission network coverage	Medium	Low	Medium	Low	Low
Location of maritime activity	Medium	High	High	Low	Medium
Gas distribution network coverage	High	Low	High	Low	High
Gas powered electricity generation	Medium	High	Medium	Medium	Low
Renewable energy resource	Medium	Low	Low	Low	Medium
Hydrogen innovation projects	High	High	High	High	Low
Location of aviation activity	Low	Low	Low	Low	High
Existing grey hydrogen sites	Medium	Low	Low	High	Medium

Reconciliation with National Grid FES 2023

Modelling stage	Reconciliation
Baseline	The DFES and FES 2023 are aligned.
Pipeline	Early pipeline years have a very similar uptake in Southern England in both the DFES and the FES. The DFES analysis method considers licence area proportions of the FES GB level projections.
Projections	Medium and long-term growth is linear across the two leading scenarios in DFES 2023. In contrast, the FES 2023 splits with a high acceleration in **Consumer Transformation** and limited growth in leading the way and **System Transformation**, respectively. The reason for strong growth under **Consumer Transformation** in the FES is unclear, as assumptions around distributed electrolysers are not outlined in the FES.
Overarching trend	FES **Consumer Transformation** projections are much higher in Southern England compared to the North of Scotland, where **Leading the Way** and **System Transformation** perform better for distributed electrolysis. This will be further investigated in DFES 2024.

Geographical factors affecting deployment at a local level

Geographical factors	Description
Industrial demand	Industrial demand is determined using the National Atmospheric Emissions Inventory (NAEI) point source CO_2 emissions data as a proxy for industrial demand.
Heavy transport demand	Uses information on the location of heavy transport fuelling hubs and road traffic count for light commercial vehicles, heavy goods vehicles, coaches and buses.
Renewable resource	Based on in-house Regen large-scale solar and wind resource assessments.
Hydrogen ESAs and regional hub locations	As part of the analysis, Regen identifies electricity supply areas known to be situated in areas where proposed hydrogen hubs and innovation areas are likely to be located beyond the known pipeline projects.

Relevant assumptions from National Grid FES 2023

Scenario		4.2.19 - Hydrogen (electrolysis exc. from nuclear)
Falling Short	Low	High-cost limits rollout of electrolysis - used mainly in transport.
System Transformation	Medium	Competition from SMR limits rollout of electrolysis – used mainly in transport. Hydrogen is produced from both networked and non-networked electrolysers, increasing with time as green hydrogen becomes more attractive compared with blue.
Consumer Transformation	Medium	Electrolysis used to decarbonise heat, transport and some I&C – medium as begins later than in the High Case.
Leading the Way	High	Electrolysis used to decarbonise heat, transport and I&C but rollout starts in the mid 2020's.

Incorporation of stakeholder feedback

Stakeholder feedback provided	How this has influenced our analysis
Storegga	A discussion of hydrogen business models in 2022 revealed that some hydrogen industry actors believe the future direction of electrolysis is in large-scale transmission-connected projects. In contrast, small-scale distribution-connected projects may be most prominent in the early years.
EMEC	Engagement with EMEC in 2022 revealed that many small-scale innovation projects intend to be run on offshore renewable energy.

	However, many of these sites will seek a separate import grid connection to secure a stable electricity supply with low on-site electricity generation. This could be the case for other developers as well.
Stakeholder webinars	In the 2023 stakeholder webinar, participants were asked "Which of the following potential end uses of hydrogen in Southern Central England are likely to be most common?" Participants answered that the best use of hydrogen would be for decarbonising industrial processes first and foremost, followed by heavy transport and shipping. No participant selected hydrogen for heating of homes and businesses as their first choice. In the 2022 webinar, 15 respondents identified the area around Portsmouth as the likely first hydrogen hub in Southern England, while seven selected Southampton and three selected Oxford.

[lxxiii] British Energy Security Strategy 2022, https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy

[lxxiv] Hydrogen Business Model and Net Zero Hydrogen Fund: Electrolytic Allocation Round 2022, https://www.gov.uk/government/publications/hydrogen-business-model-and-net-zero-hydrogen-fund-electrolytic-allocation-round-2022

[lxxv] England Economic Heartland: Regional Transport Strategy: Connecting People, Transforming Journeys 2021, https://eeh-prod-media.s3.amazonaws.com/documents/Connecting_People_Transforming_Journeys_av.pdf

[lxxvi] Station Closures 2022, https://motivefuels.com/news/gatwick-swindon-closure-31-july-2022

[lxxvii] Feasibility study – Green Hydrogen Production at the Science Museum Group's Science and Innovation Park' 2022, https://www.swenergyhub.org.uk/wp-content/uploads/2022/05/Green-Hydrogen-for-Transport-Feasibility-Study.pdf

[lxxviii] Grant agreed for first Dorset hydrogen fuel plant 2021, https://www.bbc.com/news/uk-england-dorset-57986600

Data centres

Summary of modelling assumptions and results

Technology specification

The analysis projects the growth of new data centre capacity connecting in the Southern England Licence area.

Technology building block: **Uses FES data and assumptions for 'EC.C.07 - net additional annual electricity demand for data centres' in the FES 2023 data workbook.**

Data summary for data centre demand growth in the Southern England licence area

Demand growth (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	--	326	909	1229	1307	1332	1344
System Transformation		326	928	1254	1358	1441	1465
Consumer Transformation		326	957	1294	1425	1473	1493
Leading the Way		326	963	1318	1500	1568	1595

**An assessment of the data centre baseline has not been completed for SSEN DFES 2023. As a result, only future growth in connected demand capacity is presented.*

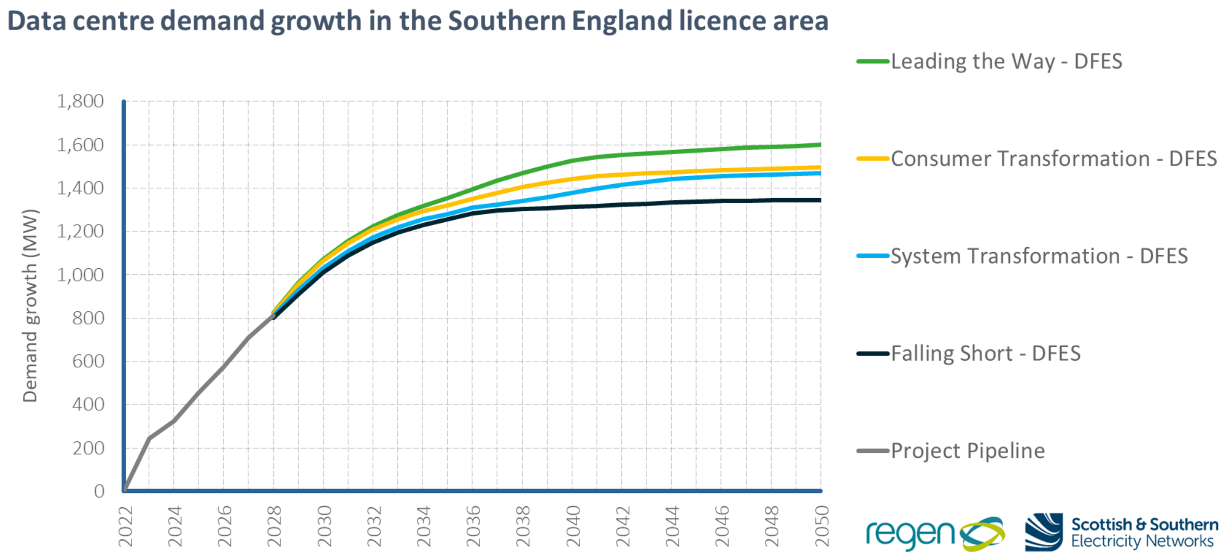


Figure 47 Data centre demand growth projections for the Southern England licence area

Figure 48 Data centres contracted to connect to the SEPD distribution network, with a concentration in West London

Summary

- Large-scale commercial data centres have featured as a specific source of disruptive demand in the DFES analysis since 2020. This is due to a significant pipeline of new commercial data centre sites applying for large import connections in the Southern England licence area.
- The development of data centres is reflective of an increasing need for data, with more people downloading and streaming online content, working remotely and generating more online processing.
- The DFES 2023 analysis focuses on 26 data centre sites, totalling c. 1.34 GW, that have secured connection agreements with SSEN in the Southern England licence area. Six of these sites are targeting import capacities of 100 MW or higher (the largest being 175 MW). Eight of these data centres, totalling 268 MW, have been identified as having secured planning approval.
- Many of the larger sites aim to undertake a staged build-out of servers and associated equipment (such as cooling plant). This means that some pipeline sites could increase their operational demand capacity over 3-5 years. By 2035, all sites in the pipeline have, therefore, been modelled to complete a staged build-out.
- This portfolio of new data centre sites represents significant new electricity demand on a small number of 33 kV and 132 kV substations in the Southern England licence area. Potentially partially related to access to high-speed internet connectivity, many of these sites are in and around Slough and West London.
- Through a sector deep-dive publication, the National Grid ESO FES team classified several different types of data centre asset classes that could seek to connect to the electricity network:
    - **Enterprise data centres** – organisations use significant IT infrastructure onsite.
    - **Co-location data centres** – host organisations rent out commercial data centre building areas, providing building and support infrastructure like cooling, external internet connection and site security etc., and the renting organisation installs their own IT infrastructure.
    - **Cloud data centres** – host organisations provide and rent out all onsite infrastructure, and the renting organisation pays for usage.
    - **Hyper-scale data centres** – very large-scale sites in terms of physical footprint and data centre capacity, usually owned by a data-driven commercial organisation. These are used for big data storage and large-scale, high-speed, cloud-based services.

- The pipeline sites in the SSEN licence area will likely be a combination of these data centre types. Due to a lack of site-specific information, they have not been specifically classified. However, some large capacity connections suggest they could likely be hyper-scale data centres.
- Due to the proximity to London (the UK's data centre and internet connectivity hub), the Southern England licence area is amongst the most active for new hyper-scale data centres.
- How many more sites may seek to connect to the distribution network is unclear. Competition for developable land and site locations to access high-speed internet connectivity, could limit the deployment of new sites on the distribution network.
- The DFES 2023 has used the staged development timelines of the 26 known data centre sites to project near-term demand growth.
- The DFES also produces scenario-specific projections for data centre capacity out to 2050, projecting beyond the pipeline capacity. This has been based on scenario projections in the FES 2023 for data centre energy consumption (GWh).
- By 2050, c. 1.6GW of additional data centre demand capacity is connected under **Leading the Way**, whereas an additional c. 1.3 GW is connected by 2050 under **Falling Short**.

Modelling and assumptions

Baseline (2022)
Several existing data centres of various sizes already operate in the licence area, but data on this is incomplete. Therefore, DFES analysis has focused solely on the pipeline of new sites that hold accepted connection offers and an analysis of longer-term capacity, based on national trends from FES 2023.

Pipeline (2023-2030)
The pipeline of new data centre connections accepting connection offers has increased year-on-year since 2020. In 2020 there were 13 proposed data centre developments, totalling 665 MW. In DFES 2021, this significantly increased to 27 sites totalling 1,264 MW. In DFES 2022, this increased further to 1,343 MW from 26 sites. An updated view of this contracted pipeline has not been assessed for DFES 2023, but the 26 sites have been researched for planning and development progress. This scale of this pipeline demand capacity is equivalent to the diversified demand of c. 600,000 domestic homes without electric heating or c. 38,000 domestic homes with three-phase electric heating. Many of these sites are individually over 100 MW. Feedback from SSEN's engagement with site developers suggests that many of these data centres will stage their deployment over several years, increasing data server infrastructure and associated import demand (through cooling equipment) incrementally up to their contracted capacity. In 2021, five data centre sites, totalling 207 MW, had successfully secured planning approval. As of the end of 2023, this has increased to eight sites totalling 267 MW, the largest being the 120 MW Bashley Road data centre in Park Royal, near Wembley.

Scenario projections (2030 to 2050)

Description of approach	Scenario	Additional Capacity by 2035 (MW)	Additional Capacity by 2050 (MW)
The DFES analysis has sought to develop projections for data centre *capacity growth* in the licence area beyond the current pipeline of sites. The FES 2023 references the general growth of annual data centre energy consumption (in GWh) for the whole of GB in a pull-out publication,[lxxix] as well as a set of specific scenario projections out to 2050 in their main FES 2023 data workbook.[lxxx] This data shows that whilst overall there is significant future growth of new data centre capacity, a notable majority of future sites could be directly connected to the transmission network in all scenarios.	**Falling Short**	1,229	1,344
	System Transformation	1,254	1,465

<table>
<tr>
<td rowspan="2">FES 2023’s GB energy consumption projections for data centres connecting at the distribution network level are still significant. These vary by scenario, with Leading the Way highest at c. 8,000 GWh per year by 2050 and Falling Short lowest at c. 5,000 GWh per year.

The DFES 2023 uses the FES’ national data centre energy consumption figures, to drive future data centre demand capacity (MW) in the Southern England licence area. This approach assumes current usage profiles and load factors are maintained until 2050 and that the Southern England licence area broadly represents the national development of new data centres on the distribution network. This results in scenario projections beyond the current pipeline to 2050.

In the medium term, data centre deployment continues at a similar rate to the current project development pipeline in all scenarios. However, this growth slows by the mid-2030s, after which the scenarios diverge. Falling Short sees 1.3 GW of additional demand growth by 2050, while in Leading the Way, approximately 300 MW is added post 2030, leading to 2.1 GW of additional demand capacity by 2050.</td>
<td>Consumer Transformation</td>
<td>1,294</td>
<td>1,493</td>
</tr>
<tr>
<td>Leading the Way</td>
<td>1,318</td>
<td>1,595</td>
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Geographical factors affecting deployment at a local level

Data centres geographical factors
80% of the pipeline capacity is associated with sites connecting at single customer substations. This trend is assumed to continue in the longer term, with 80% of the post-pipeline projected capacity assumed to be connecting directly to 132kV substations where known pipeline sites are being developed. The remaining 20% of the post-pipeline capacity is assumed to be in similar industrialised areas of the licence area, where existing pipeline developments are located, but connecting to adjacent substation supply areas (ESAs). This reflects the likelihood that future data centres will continue to be located close to existing technology companies, industrial estate locations along the M4 corridor and close to West London, as one of the UK’s data centre and internet connectivity hubs.

Relevant assumptions from National Grid FES 2023

Scenario		4.1.33 Data centre commissioning probabilities
Falling Short	Low	Lowest level of societal change/decentralisation, personal electronic devices, and data services so lowest likelihood of being commissioned.
System Transformation	Medium	Medium level of societal change/decentralisation, personal electronic devices, and data services so medium likelihood of being commissioned.
Consumer Transformation	Medium	Medium level of societal change/decentralisation, personal electronic devices, and data services so medium likelihood of being commissioned.
Leading the Way	High	Highest level of societal change/decentralisation, very high level of personal electronic devices, and data services needs so high likelihoods of being commissioned.
Scenario		**4.1.34 - Data centre electrical energy efficiency improvements**
Falling Short	Low	Low level of decarbonisation, hence minimal rate of energy efficiency improvements, set according to research and policy papers.
System Transformation	Medium	Medium level of decarbonisation, hence minimal rate of energy efficiency improvements, set according to research and policy papers.
Consumer Transformation	Medium	Medium level of decarbonisation, hence minimal rate of energy efficiency improvements, set according to research and policy papers.
Leading the Way	High	High level of decarbonisation, hence minimal rate of energy efficiency improvements, set according to research and policy papers.
Scenario		**4.1.34 - Data centre maximum load factor**
Falling Short	Low	Lowest level of societal change/decentralisation, personal electronic devices, and data services so lowest number of data-centre servers and storage devices, and hence power consumption/load factor.
System Transformation	Medium	Medium level of societal change/decentralisation, personal electronic devices, and data services so medium number of data-centre servers and storage devices, and hence power consumption/load factor.
Consumer Transformation	High	High level of societal change/decentralisation, personal electronic devices, and data services so high number of data-centre servers and storage devices, and hence power consumption/load factor.
Leading the Way	High	High level of societal change/decentralisation, personal electronic devices, and data services so high number of data-centre servers and storage devices, and hence power consumption/load factor.

[lxxix] National Grid ESO, 2022, *Data Centres*. https://www.nationalgrideso.com/document/246446/download
[lxxx] National Grid ESO, 2023, *FES 2023 data workbook*. https://www.nationalgrideso.com/future-energy/future-energy-scenarios#fullsuite

New property developments

Summary of modelling assumptions and results

Technology specification

New domestic, commercial and industrial developments can have a significant impact on local electricity demand and, therefore, forecasts of new housing, and commercial and industrial builds have been included in the DFES analysis. New developments are categorised as new domestic developments (houses) and non-domestic sites (e.g. factory/warehouse, offices, retail premises, sports & leisure etc.). The relevant FES technology building blocks are:

- **Gen_BB001a – number of domestic customers**
- **Gen_BB002b – meters squared of I&C (commercial and industrial) customers**

Data on planned domestic and non-domestic developments for the SSEN licence areas have been gathered through data exchange with all local authorities in the Southern England licence area. This process used an online data portal and individual engagement with local authority planning teams and data providers. Desk-based research and site investigation have validated and augmented the data supplied.

Alongside historic build rates and Office for National Statistics (ONS) household projections,[lxxxi] the data provided by the local authorities are used to inform licence area projections for future housing numbers and non-domestic floorspace (sqm).

Data summary for new domestic developments in the Southern England licence area

Houses (cumulative; thousands)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	--	53	156	260	338	391	440
System Transformation		65	186	297	369	428	484
Consumer Transformation		65	186	297	369	428	484
Leading the Way		76	220	327	405	473	538

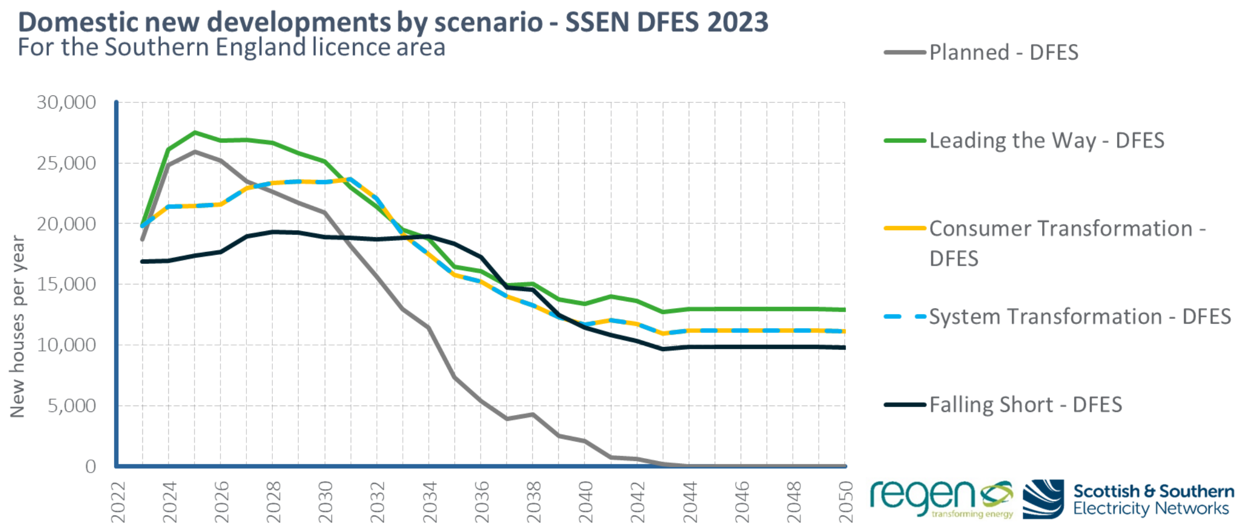

Figure 49 Non-cumulative new domestic development projections for the Southern England licence area

Data summary for new non-domestic developments in the Southern England licence area

Floorspace (sqm; millions)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	--	1.3	3.5	5.5	6.6	6.9	6.9
System Transformation		1.8	4.7	6.5	6.8	6.9	6.9
Consumer Transformation		1.8	4.7	6.5	6.8	6.9	6.9
Leading the Way		2.1	4.8	6.0	6.7	6.9	6.9

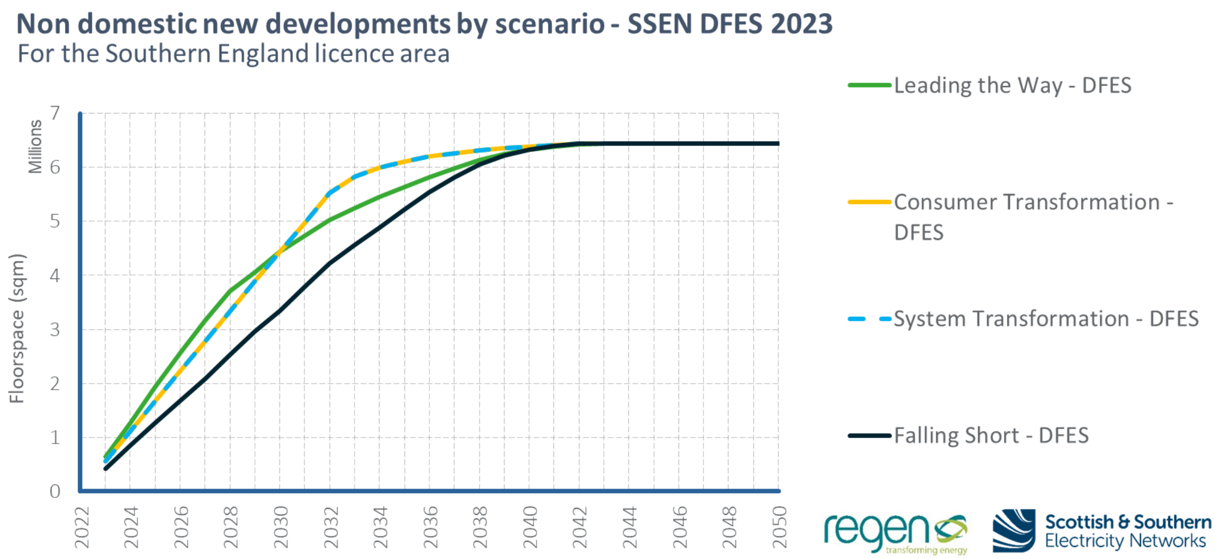

Figure 50 Cumulative non-domestic development projections for the Southern England licence area

Summary

- The development of new housing and non-domestic sites represents future hotspots of conventional electricity demand, as these new developments are constructed and occupied over the scenario timeframe.
- The modelling of new developments is based on direct engagement with local authorities planning departments and analysis of local planning documents submitted to Regen via a SharePoint data exchange.
- These documents detail the planning stages of each new development, i.e., 'under construction', 'full planning permission', or allocated packets of land for future use.

- The local planning documents provided data for new developments until 2042, so new longer-term housing developments out to 2050 were modelled based on an analysis of ONS household projections.
- This modelling results in between 409,000 and 508,000 new homes in the Southern England licence area, representing a 13%-17% increase in domestic customers by 2050.
- An additional 6.4 million square meters of non-domestic floorspace is also modelled to be in the licence area by 2050 under each DFES scenario.

Modelling stages

Baseline (2022)	
The analysis of new developments in the DFES is on additional future domestic and non-domestic buildings. Therefore, no baseline is defined for this technology.	
Methodology for planned developments analysis (October 2023 to September 2050)	
Data exchange with all local authorities in the licence area	A SharePoint database hosts individual data sheets for all local authorities within the Southern England licence area. Regen engages with the local authority planning departments to ensure the datasheets are updated, where possible. 84% of local authorities within the Southern England licence area have updated their datasheets within the last three years. This is up from 65% in 2022.
Database update	The data provided by the local authority is checked, supplemented where necessary from other online data sources and added to the DFES database. Where updates were not provided, data was obtained from publicly available planning documents such as 5-year housing land supplies and local plans.
Database cleaning	The new developments dataset is then cleaned by removing the following: • Site developments that have already been completed. • Domestic developments with less than 100 homes (total or left to build). • 'Windfall' sites with no location data or not currently under construction - these are used for modelling by the council and not actual developments. • Non-domestic developments of less than 1000 sqm.
ESA assignment	All sites are assigned an Electricity Supply Area (ESA) and spatially mapped to the Southern England SSEN network infrastructure based on locational data. Where locational data is not provided, address information or manual searchers are used to assign new sites.

Scenario projections	The buildout profile of the new developments is modelled to produce three scenarios, **High** (**Leading the Way**), **Central** (**System Transformation** and **Consumer Transformation**) and **Low** (**Falling Short**).

Domestic housing pipeline

Number of development sites identified	Total number of houses
643	274,666

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

Local authority	Number of homes	Number of sites	Largest development site
South Oxfordshire	18,763	16	Culham Science Village (3,500 houses)
Wiltshire	18,624	49	Trowbridge (2,475 houses)
Hounslow	18,532	51	West Cross Campus (1,800 houses)

South Oxfordshire has 16 housing sites planned. These can be split into large scale developments, with seven large sites (over 1,000 homes) averaging 2,226 homes per site, and nine smaller scale developments (under 1000 homes) that average 353 homes per site.

- The large sites have a cumulative total of 15,583 homes planned.

There are 49 planned sites in **Wiltshire,** with an average of 380 homes per site.

- Three sites are 1,000 homes or greater.

There are 51 housing sites planned in **Hounslow**.

- The West Cross Campus is the largest of the planned sites at 1,800 homes.
- There are three other sites of greater than 1,000 homes.
- Developments average 363 homes per site.

Outside of these three local authorities, the Southern England licence area has 46 other planned housing sites greater than 1,000 homes, accounting for nearly 113,646 new homes in total.

Non-domestic development pipeline

Regen category	Non-domestic sites		Non-domestic floorspace (sqm)	
	Number	Proportion	Total per category	Proportion of total
Factory and warehouse	242	37.0%	3,279,750	47.3%
Office	187	28.6%	2,478,634	35.7%
School and college	61	9.3%	344,065	5.0%
Retail	57	8.7%	256,308	3.7%

Other (e.g., medical, hotel, restaurant, sport & leisure)	107	16.4%	574,560	8.3%

Most planned non-domestic developments in the Southern England licence area consist of 'employment land'. These sites, designated as factory and warehouse or office space, account for 83.1% of the planned non-domestic developments. **Hounslow** is the local authority with the most floorspace of planned non-domestic developments, at 776,208 sqm from 76 sites.

The licence area has 29 individual developments that are greater than 50,000 sqm. Some notable large sites are the Dorset Innovation Park, which has 83,000 sqm allocated for offices and factory and warehouse space. Similarly, the M3 Junction 7 area in **Basingstoke and Deane** and, the Station Hill and Friars Walk development in **Reading** have floorspaces of 122,000 sqm each. There is no development stage information provided for these sites, but they are indicated to start construction from 2023 and 2026 in the provided buildout timeline.

Planning logic and assumptions

Buildout-timeline: The buildout start year is assigned based on the status and development stage provided by the local authorities. A construction year was assigned to each site within an assumed year range, depending on the development stage. Below shows the year range for each development stage.

Development stage	Under construction	Full planning permission	Outline planning permission	Land allocated	No information
Year range	2023	2024-2026	2027-2029	2030-2032	2023-2032

Buildout rate: The rate at which a site is constructed is modelled using data from the pipeline site data provided. For both domestic and non-domestic sites, the average annual buildout rate was calculated for each site. For domestic sites, the average annual buildout rate by the local authority was used to model the data where buildout timelines were not provided. For non-domestic sites, the average annual buildout rate was determined through analysis by Regen, categorised by development type, i.e. Factory and warehouse, office etc. and applied.

Non-domestic floorspace buildout: Each non-domestic site was assigned a Regen category based on the development name and categories provided by the local authority. Using current and historical DFES data for sites with both a site area and floorspace, a ratio was calculated for each development category. This ratio was then used to assign a floorspace to any site where this was not directly provided by dividing the given site size (converted to sqm) by the individual category's ratio.

Delay factors: The timeline and build out rate of new developments is a key source of uncertainty. Regen applies scenario-specific delay factors to allow for varying degrees of delay in the completion of local authority plans. Average 'as-planned' buildout rates over varying periods are used to help define the three trajectories. For domestic developments:

- **Low Trajectory**, with near term alignment to the licence area's first quartile of historic housebuilding rates.

- **Central Trajectory**, with near term alignment to the licence area's mean of historic housebuilding rates.
- **High Trajectory**, with near term alignment to the licence area's third quartile of historic housebuilding rates.

For non-domestic development:

- **Low Trajectory**, with near term alignment to the 15-year average buildout rate of planned developments.[lxxxii]
- **Central Trajectory**, with near term alignment to the 10-year average buildout rate of planned developments.
- **High Trajectory**, with near term alignment to the 8-year average buildout rate of planned developments.

By creating three trajectories, very ambitious development can be captured in the **Leading the Way** scenario, and heavy unforeseen delays are captured in the **Falling Short**.

Long term modelled developments (October 2023 to September 2050)
Domestic housing

Two forms of new housing are not captured through reviewing current planned developments. As such, these are modelled to ensure the scenarios capture a range of housebuilding trends between 2023 and 2050.

Residual developments	These are small-scale developments of less than 100 homes, which is under the threshold of the data that is collected from local authorities. Analysis of previous new developments data suggests that these developments could account for approximately 5% of total new-build housing. As a result, a 5% uplift was applied to the planned projections throughout the scenario timeframe to account for these residual developments.
Post-planned developments	This accounts for housing developments that could occur in the medium and long term, beyond the current timescales of local authority planning. As planned developments tail off in the 2020s and 2030s, post-plan developments are modelled to account for additional future housebuilding out to 2050. These post-plan development projections are tailored to each local authority based on ONS household projections.

Non-domestic

The non-domestic scenario projections are based on planned developments only.

Reconciliation to DFES 2022

The number of non-domestic sites evidenced by local authorities across the Southern England licence area has decreased by 238 since DFES 2022. There has been a shift from office space being the largest category in 2022 to 'factory and warehouse' being the largest category in 2023. As a result, scenario projections have dropped, with a decrease for the maximum additional floorspace by 2050 from 8.3 million in 2022 to 6.3 million in 2023. Hounslow remains the local authority with the largest planned floorspace of non-domestic developments at 776,208 sqm. The local authority with the smallest planned floorspace for non-domestic developments is Chiltern at only 3120 sqm, followed closely by Windsor and Maidenhead at 3488 sqm. Between these two local

authorities only four sites are planned and in terms of floorspace they make up only 0.08% of all planned non-domestic sites across the entire licence area. This is a significant change from DFES 2022 in which Windsor and Maidenhead had a planned non-domestic floorspace pipeline of 51,997 sqm suggesting either the completion of large projects or an updated plan was received from the local authority. There has also been a reduction, of around 25,000 houses, in the total number of homes in the local authority evidenced pipeline. These reductions have resulted in a decrease on the DFES 2022 domestic projections. South Oxfordshire and Hounslow remain within the top three local authorities for numbers of new homes, with Wiltshire replacing Swindon as the other top three local authority. The local authority with the least planned domestic developments is Mendip with only 130 homes planned before 2050, totalling 0.04% of the total planned domestic developments across the entire licence area. This is the same as the 2022 DFES indicating either no new planned homes or no updated data from the local authority.

Reconciliation with National Grid FES 2023

- The FES scenarios do not include a section on new developments that can be directly reconciled against. The FES building block **DEM_BB001a** for new domestic customers shows a similar proportional growth of new housing compared to the DFES analysis of new domestic developments. In the DFES, a range of scenario outcomes have been modelled to aid distribution network planning, as new domestic customers can represent key bulk loads of conventional demand on the network.
- Non-domestic floorspace is not detailed in the FES data and cannot be compared.

Geographical factors affecting deployment at a local level

Geographical factors	Description
Known planned sites	Through local authority engagement, planned sites are located based on their address or the description of their location and directly assigned to the ESA that they fall in.
Housing density	The DFES analysis also incorporates long term theoretical development (based on historic build trends in the area) once the current pipeline of new developments is complete. This is to ensure that housing development doesn't come to a halt once the current pipeline is complete but instead assumes development will continue out to 2050. Domestic developments that do not yet have locational data (including this long-term theoretical development) are distributed across all areas, weighted to areas with

	moderate housing density, such as town and city suburbs. Analysis of historic housing development shows these areas see higher levels of housebuilding than denser city centres or highly rural areas.

Incorporation of stakeholder feedback

Stakeholder feedback provided	How this has influenced our analysis
Local authority data exchange	A central part of the new developments data collection relies on continued engagement with local authorities in the licence area. 24 of the 44 local authorities provided updated or new data through a SharePoint site or directly to the project team in 2023. For the remaining local authorities, Regen's existing project database was used.

[lxxxi] Office for National Statistics, 2018, *Household Projections by Local Authority*. https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/bulletins/householdprojectionsforengland/2018based

[lxxxii] Office of National Statistics, 2023, *House building, UK: permanent dwellings started and completed by local authority* https://www.ons.gov.uk/peoplepopulationandcommunity/housing/datasets/housebuildingukpermanentdwellingsstartedandcompletedbylocalauthority