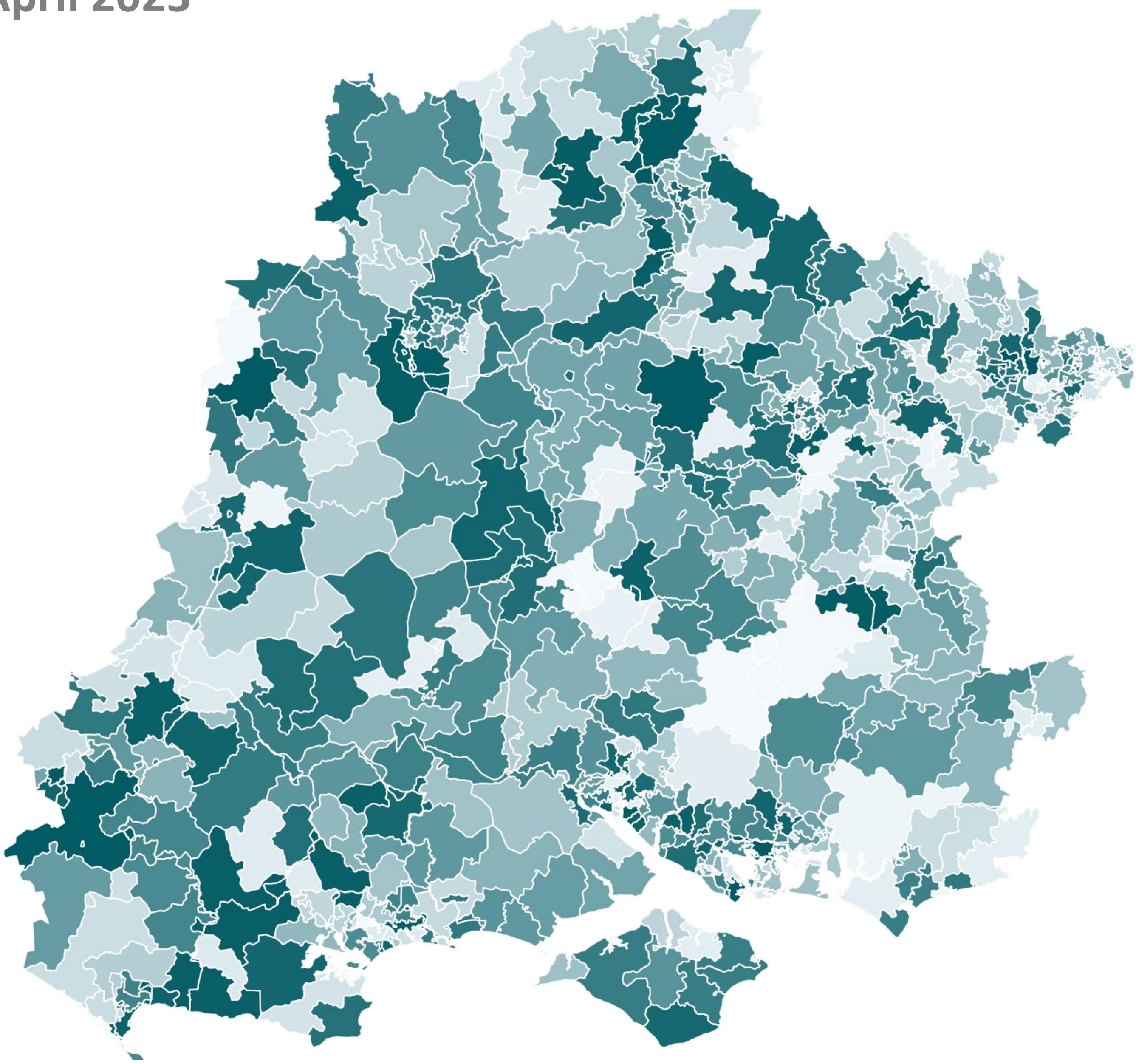
Distribution Future Energy Scenarios 2022

Results and methodology report

Southern England licence area

April 2023



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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. Our role has never been more important. 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 and we are also working to deliver the infrastructure to create a net zero tomorrow. That 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 welcome the UK and Scottish Governments' commitments to this transition, including their targets to decarbonise by 2050 and 2045 respectively, which provide clarity to both the market and consumers and allow SSEN to plan for the anticipated three-fold increase in electricity demand that new technologies will bring. SSEN is working to anticipate the location and timing of new demand to ensure the measures are in place to flex supply and demand to balance the grid, or to reinforce the network. The work that Regen has undertaken here and for previous reports is crucial in supporting informed decision making, which enables timely and cost-effective network management.

Our Business Plan for the current regulatory price control period, which started in April 2023, draws on these DFES figures to establish the building blocks that must be put in place to facilitate net zero by 2050. We will 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 8GW of distributed generation and storage. This will be supported by development of new market models to allow consumers to interact with the energy system and manage their own usage and costs. We are also working to empower local communities and propose mechanisms to enable strategic investment in our network.

Lastly, SSEN is committed to a fair transition that leaves nobody behind. The net zero future offers considerable opportunities but also the risk that new forms of unfairness will be embedded into the system. With the right data, forecasting, regulations, skills and investment, we can ensure a transition that is smart and fair. I'd 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

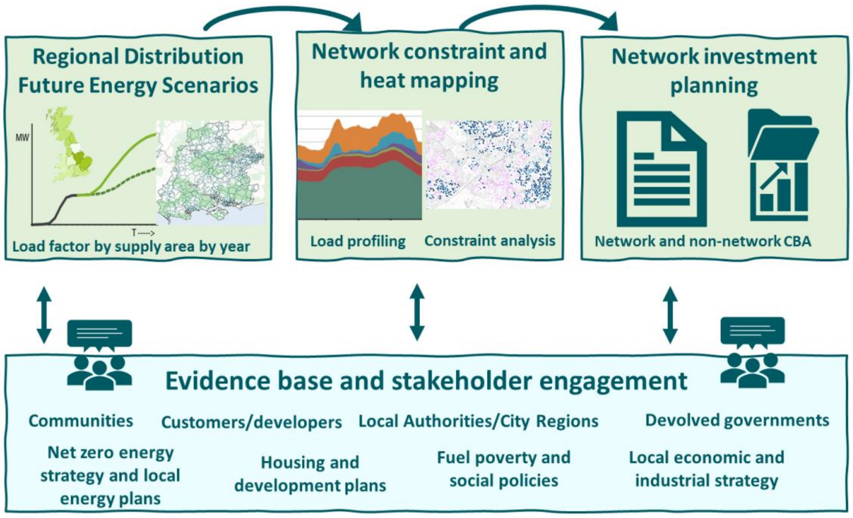
Introduction

This report summarises the methodology and results of the 2022 edition of the Distribution Future Energy Scenarios (DFES) for the Southern England electricity distribution network licence area[1], operated by Scottish and Southern Electricity Networks (SSEN).

The DFES analysis provides high-granularity scenarios for the energy generation (low carbon and conventional), demand and storage technologies connecting to the distribution network. In addition, this analysis helps SSEN understand how the demands on their networks will likely change over the next decade and beyond.

The DFES forms part of an integrated network planning and investment appraisal process (see Figure 1). The projections allow SSEN's network planning teams to model and analyse future load scenarios in specific geographic areas. Producing future energy scenarios is now a business-as-usual activity for electricity networks as part of their requirement to produce Network Development Plans. The 2021 DFES process supported the development and evidence base underpinning SSEN's RIIO-ED2 business plan[2].

Figure 1: Wider network and investment planning process that DFES analysis feeds into



DFES uses four national energy scenarios based on the National Grid ESO Future Energy Scenarios 2022 publication[3]. The DFES provides a granular, bottom-up assessment of the impact of the net zero energy transition and is heavily influenced by local and regional stakeholders. A detailed analysis of the pipeline of projects within SSEN's Southern England licence area underpins the scenario projections, building on the DFES 2021 publication[4].

This report provides an overview of Regen's DFES methodology, a summary of the stakeholder engagement and scenario projections for the Southern England licence area. The report also includes individual technology summaries detailing the results, evidence drawn on and assumptions used.

[1] Also referred to as the Southern Electric Power Distribution (SEPD) licence area

[2] See SSEN *Powering Communities to Net Zero* ED2 business plan website and document: https://ssenfuture.co.uk/

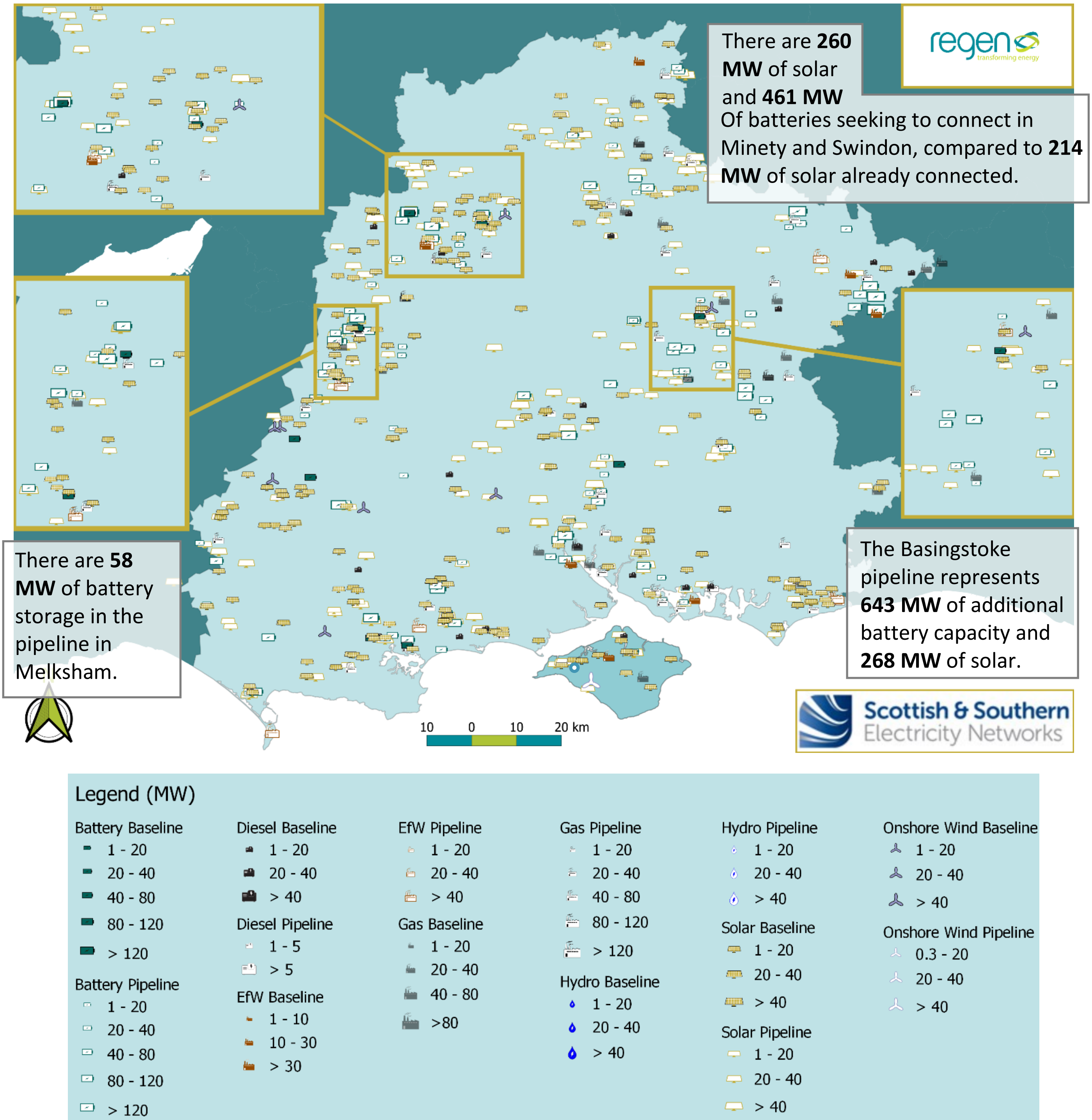
[3] National Grid 2022, *Future Energy Scenarios 2022.* https://www.nationalgrideso.com/future-energy/future-energy-scenarios

[4] Regen 2021, *SSEN Distribution Future Energy Scenarios 2021.* https://www.regen.co.uk/project/ssen-distribution-future-energy-scenarios-2021/

The SSEN Southern England Licence Area

The Southern England electricity distribution licence 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.

The licence area includes urban areas such as Oxford, Swindon, Reading and Southampton, national parks and rural areas such as the South Downs, New Forest, the Chiltern Hills and parts of the Cotswolds.



The licence area includes (either wholly or partially) 53 local authority areas, including city regions such as Oxford City and large district/borough councils such as Wiltshire. The total capacity of distribution network connected generation in the licence area is just over 3.3 GW as of the end of 2021.

Baseline by Technology

Renewable Generation

Solar	2.4 GW	wind	11 MW	marine	0 MW	hydropower	2 MW

With the licence area having some of the best solar irradiance levels in the UK, just under **2.4 GW** is solar PV. There is a low deployment of onshore wind (**12 MW**) and hydropower (**2 MW**).

Waste and Bioenergy Generation

biomass	1 MW	waste	142 MW	renewable engines	99 MW

Waste energy makes up c. **240 MW** and takes several different forms. Of the three renewable engine sub-technologies, landfill gas makes up around half of the installed capacity at **43 MW**, followed by anaerobic digestion (**33 MW**) and sewage gas (**23 MW**).

Fossil and Gas Generation

diesel	316 MW	gas	332 MW	hydrogen generation	0 MW

The licence area also hosts a notable amount of fossil fuel generation, with a little under **650 MW** of natural gas, gas oil and diesel generation. Cowes Power Station is the largest generation site connected to the distribution network in the licence area, a **140 MW** plant fuelled by marine gas oil located on the Isle of Wight[5].

Sources of Demand / Battery Storage

Sources of Demand						Battery Storage	
EVs	91,000	heat pumps	29,000	H_2 electrolysis	2 MW	battery	190 MW

Electricity demand in the licence area is fairly typical, with an average proportion of homes heated via the gas network[6] and a mixture of urban and rural areas. Some unique aspects of the licence area include shipping and marine industrial areas such as Southampton and Portsmouth, as well as the island community of the Isle of Wight. The take up of low carbon technology is starting to speed up in the licence area with **c. 91,000** non-hybrid battery electric cars currently registered in 2021. In addition, **29,000** households and businesses have a heat pump installed.

One of Europe's largest operational battery storage projects (100 MW), brought online towards the end of 2020, aims to extend its capacity to 150 MW in 2022[7]. It is managed by Independent Distribution Network Operator Eclipse Power.

[5] See Wikipedia summary of Cowes Power Station: https://en.wikipedia.org/wiki/Cowes_Power_Station
[6] See Non Gas Map: https://www.nongasmap.org.uk/
[7] Eclipse Power n.d., *Minety Battery Storage: Minety, Wiltshire.* https://eclipsepower.co.uk/project/minety-battery-storage/

Projection headlines

The distribution network in Southern England in 2030

Renewable Generation

	solar		wind		marine		hydropower	
Leading the Way		6.8 GW		50 MW		20 MW		3 MW
Consumer Transformation		6.0 GW		56 MW		25 MW		3 MW

Distribution network connected **solar**, **wind**, **hydro** and **marine** generation capacity nearly triples from c. 2.4 GW in 2021 to c. **6.0 GW** in 2030 under **Consumer Transformation**. Solar PV deployment accounts for almost all of the increase in connected capacity.

Waste and Bioenergy Generation

	biomass		waste		renewable engines	
Leading the Way		1.7 MW		194 MW		94 MW
Consumer Transformation		1.7 MW		286 MW		91 MW

Waste and bioenergy generation capacity in Southern England increases from 242 MW in 2021 to **379 MW** in 2030 under the **Consumer Transformation**. 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		gas		hydrogen generation	
Leading the Way		0 MW		251 MW		14 MW
Consumer Transformation		104 MW		427 MW		19 MW

316 MW of unabated baseline **diesel generation** decommissions more quickly under **Leading the Way**, with **0 MW** by 2030. **Fossil gas generation** increases from c. 332 MW in 2021 to **836 MW** in 2030 under **Falling Short**, driven by the connection of new gas reciprocating engines and CHPs. Low carbon **hydrogen-fuelled generation** begins to connect to the distribution network in the licence area, with **19 MW** modelled to come online by 2030 under **Consumer Transformation**.

Sources of Demand

	EVs		heat pumps		data centres		H_2 electrolysis	
Leading the Way		1,501,000		775,000		1.4 GW		206 MW
Consumer Transformation		1,536,000		521,000		1.4 GW		63 MW

The number of **electric vehicles** registered in the Southern England licence area also increases significantly in all scenarios by 2030. Under **Consumer Transformation**, c. **474,000 homes** and c. **47,000 non-domestic properties** operate **heat pumps** by 2030. Under the **Leading the Way** scenario, the capacity of distributed **hydrogen electrolysis** in the licence area reaches **206 MW**. A small number of very energy-intensive **data centres** are modelled to come online in the next. The import demand capacity of these sites totals c. **1.4 GW** by 2030.

Battery Storage

	battery	
Leading the Way		2.8 GW
Consumer Transformation		2.7 GW

From a 190 MW 2021 baseline, **battery storage** capacity (of varying asset classes/business models) significantly increases in all scenarios by 2030, reaching c. **2.8 GW** under **Leading the Way**.

New Property Developments

domestic		non-domestic	
	241,000		7.3 mil
	216,000		6.5 mil

Up to **216,000 new houses** could be built, and just under c. **6,500,000 sqm** of **non-domestic floorspace** could be developed by 2030 in **Consumer Transformation**.

The distribution network in Southern England in 2050

Renewable Generation

Scenario	solar	wind	marine	hydropower
Leading the Way	10.3 GW	220 MW	20 MW	6 MW
Consumer Transformation	9.0 GW	241 MW	90 MW	9 MW

Solar, **wind**, **hydro** and **marine** generation capacity in the licence area increases to c. **9.3 GW** in 2050 under the **Consumer Transformation** scenario. Large-scale solar PV continues to be the dominant technology in the licence area, with over **9 GW** online by 2050. Onshore wind also sees some support under this scenario, with **235 MW** online by 2050.

Waste and Bioenergy Generation

Scenario	biomass	waste	renewable engines
Leading the Way	0 MW	138 MW	88 MW
Consumer Transformation	0 MW	178 MW	83 MW

Waste and bioenergy generation sees landfill gas, waste incineration and biomass capacity all decommissioning from the network under **Consumer Transformation**. In contrast, generation capacity from the anaerobic digestion and ACT increases to **261 MW** by 2050 under this scenario.

Fossil and Gas Generation

Scenario	diesel	gas	hydrogen generation
Leading the Way	0 MW	0 MW	792 MW
Consumer Transformation	0 MW	0 MW	221 MW

No unabated **diesel** nor **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. Under **Falling Short**, **822 MW** of fossil gas remains online, a mixture of gas OCGT, peaking plants (400 MW) and CHPs, and **140 MW** of diesel remains connected. Low carbon **hydrogen-fuelled generation** capacity increases significantly by 2050 in the licence area, reaching c. **221 MW** under **Consumer Transformation**.

Sources of Demand

Scenario	EVs	heat pumps	data centres	H_2 electrolysis
Leading the Way	3,719,000	2,300,000	2.1 GW	782 MW
Consumer Transformation	4,578,000	2,600,000	1.9 GW	448 MW

The number of registered **EVs** in the licence area accelerates by 2050. However, a general reduction in vehicle numbers is seen by 2050 in the net zero scenarios, driven by increased public transport use, average mileage, and the introduction of autonomous vehicles. The number of homes and businesses with a **heat pump** installed significantly accelerates to 2050 under all scenarios. This is highest under **Consumer Transformation**, with c. **2.5 million homes** and c. **105,000 non-domestic properties** operating a type of **heat pump** by 2050. Several high energy-consuming **data centres** are modelled out to 2050. The capacity of these sites totals c. **2.1 GW** under **Leading the Way**. Deployment of **hydrogen electrolysis** by 2050 is highest in **Leading the Way,** with c. **780 MW** operating on the distribution network.

Battery Storage

Scenario	battery
Leading the Way	4.2 GW
Consumer Transformation	3.8 GW

Domestic, commercial and grid-scale **battery storage** assets total c. **4.2 GW** under **Leading the Way**.

New Property Developments

Scenario	domestic	non-domestic
Leading the Way	560,000	8.3 mil
Consumer Transformation	498,000	8.3 mil

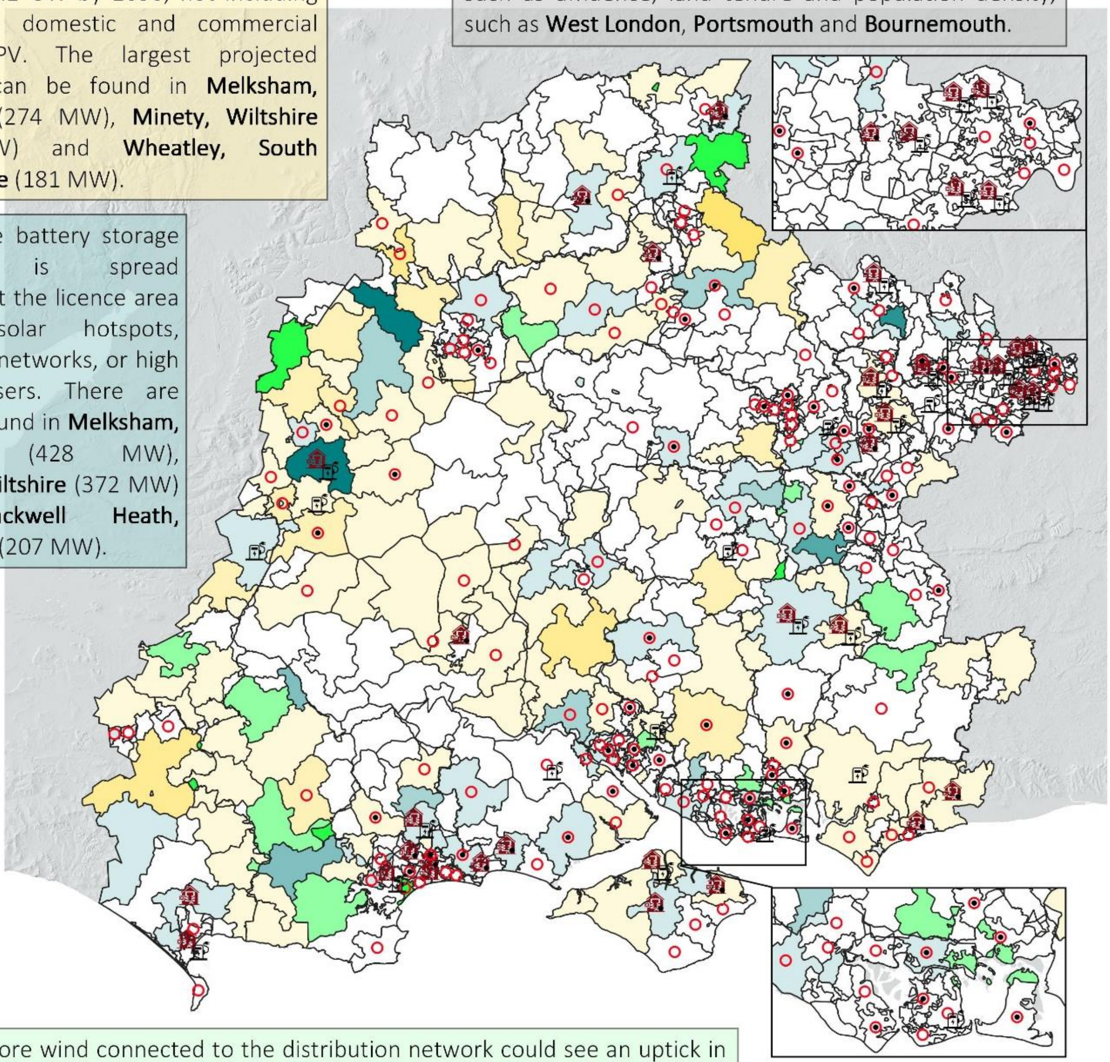
Up to **498,000 new houses** could be built, and just under c. **8,300,000 sqm** of **non-domestic floorspace** could be developed in **Consumer Transformation**.

2050 Technology Projection Headlines - Southern England
Consumer Transformation Scenario

Solar PV is the technology with the highest capacity in the licence area, reaching 6.2 GW by 2050, not including small-scale domestic and commercial rooftop PV. The largest projected capacity can be found in **Melksham, Wiltshire** (274 MW), **Minety, Wiltshire** (198 MW) and **Wheatley, South Oxfordshire** (181 MW).

Low Carbon Technology (LCT) clusters appear in areas of future increased energy demand, influenced by factors such as affluence, land tenure and population density, such as **West London**, **Portsmouth** and **Bournemouth**.

Large-scale battery storage capacity is spread throughout the licence area nearby solar hotspots, electricity networks, or high energy users. There are clusters found in **Melksham, Wiltshire** (428 MW), **Minety, Wiltshire** (372 MW) and **Flackwell Heath, Wycombe** (207 MW).



Onshore wind connected to the distribution network could see an uptick in the long term, reaching **c. 241 MW** by 2050 if costs continue to decrease and more projects gain planning approval. Areas with the most capacity increase are **North Dorset** (30 MW) **Poole** (20 MW), and **Wiltshire (11 MW)**.

Generation and Storage

Large-scale Solar	Large-scale Battery	Large-scale Wind
0 - 5	0 - 5	0 - 1
5 - 50	5 - 50	1 - 10
50 - 100	50 - 100	> 10
100 - 150	100 - 150	
150 - 200	150 - 200	
200 - 250	200 - 250	
> 250	> 250	

Low Carbon Technologies

Domestic EV Chargers
- 4,000 - 8,000 per ESA
- > 8,000 per ESA

Domestic Heat Pumps
- 5,000 - 10,000 per ESA
- > 10,000 per ESA

Note: The above map displays Electricity Supply Areas (ESA) where each technology could be present by 2050 under the Consumer Transformation Scenario. Where an ESA hosts a great deal of several generation technologies, only one, usually the most prominent, is displayed.

Wider context for SSEN DFES 2022

The invasion of Russia in Ukraine has had far-reaching impacts on the energy market, including driving up electricity prices in the UK. Energy and Climate Intelligence Unit analysis estimates that the UK spent an additional £50-60bn on energy.[8] Government policy responses have included the Energy Price Guarantee to cap household energy bills.

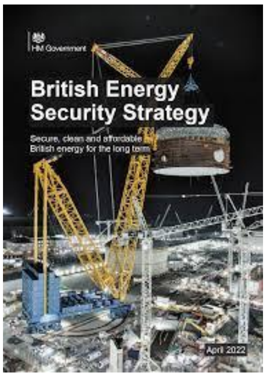
The cost of living crisis pressured consumers to reduce demand and magnified pre-existing fuel poverty issues. Energy costs have also led more consumers to take up low-carbon technologies and more energy-efficient appliances to reduce energy bills, including increased EV sales year-on-year[9]. This, in turn, has impacted the distribution networks, as they must adapt to shifting consumers needs.

Modelling the impacts of short-term market volatility on long-term growth projections for individual technologies is extremely difficult. However, there is a strong argument that the global market has passed a watershed and is now entering a period when gas prices will remain high in the medium term, or at least extremely volatile. This, coupled with the decline of the UK's gas production, should accelerate the transition to all forms of renewable energy.

The political focus on energy in the past year has led to an extensive range of new energy policies and targets issued by the UK government.

Relevant UK Energy Policy and Consultations in 2022

The Government announced new energy policies in 2022 that were considered in the DFES 2022 analysis as potentially impacting the uptake of technologies in scope.



The **British Energy Security Strategy**[10], released in April 2022, included several new commitments. Up to 50 GW of offshore wind is aimed for by 2030, of which 5 GW is to be floating wind. The strategy also increased the UK's ambition for low-carbon hydrogen production from 5 to 10 GW by 2030.

Building on the British Energy Security Strategy, the UK Government and Ofgem published the **Electricity Network Strategic Framework**[11] to ensure that the electricity cables serving the country are upgraded to meet the needs of a growing, decentralised electricity system. The strategic framework outlines plans to develop the Future System Operator, remove barriers to grid flexibility via digitalisation, and unlock infrastructure development through reformed planning and consenting.

In December 2021, the UK released its response to a consultation on Part L and Part F of the **Future Buildings Standard** for non-domestic buildings and on standards for overheating in new residential buildings. As a result, key parts of the Future Buildings Standard were adapted into DFES scenario modelling for 2022. For instance, the approach states that all new builds will incorporate passive cooling, which has had implications for DFES 2022 assumptions used to model air conditioning uptake in new builds.

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[8] Energy & Climate Intelligence Unit 2023, *The Cost of Gas since the Russian Invasion of Ukraine.* https://eciu.net/analysis/reports/2023/the-cost-of-gas-since-the-russian-invasion-of-ukraine

[9] Zap Map 2023, *EV Market Statistics.* https://www.zap-map.com/ev-market-statistics/

[10] Department for Business, Energy & Industrial Strategy 2022, *British Energy Security Strategy.* https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy

[11] Department for Business, Energy & Industrial Strategy & Ofgem 2022, *Electricity Networks Strategic Framework: Enabling a secure, net zero energy system.* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1096283/electricity-networks-strategic-framework.pdf

The UK Government has been consulting on changes to the National Planning Policy Framework under the **Levelling-up and Regeneration Bill**[12]. DFES 2022 scenarios cover the possibility that getting planning permission for onshore wind and a world where those barriers loosen remains difficult.

In 2022, the Government published draft legislation on an **Electricity Generator Levy**[13], which seeks to employ a windfall tax on excessive revenues for renewable, nuclear and biomass generators. Regen has published an insight paper suggesting that the wholesale price threshold is set too low at £75 per MW and lasts too far out into the future until 2028, becoming a disincentive to energy generation investment in the UK and in the medium-term[14]. However, it is too soon to see how the Levy will influence investment in new generation projects.

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[12] Department for Levelling Up, Housing & Communities 2022, *Levelling-up and Regeneration Bill: reforms to national planning policy.* https://www.gov.uk/government/consultations/levelling-up-and-regeneration-bill-reforms-to-national-planning-policy/levelling-up-and-regeneration-bill-reforms-to-national-planning-policy#chapter-8--onshore-wind-and-energy-efficiency

[13] UK Government 2022, *Electricity Generator Levy (draft)*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1125790/Draft-Electricity-Generator-Levy.pdf

[14] Regen 2023, *Electricity Generator Levy.* https://regensw.wpenginepowered.com/wp-content/uploads/Regen-Insight-Electricity-Generator-Levy.pdf

Changes to network connection rules

In May 2022, Ofgem published its final decision on **Access and Forward-Looking Charges Significant Code Review**[15]. From April 2023, connection charges for network reinforcement will be removed for demand customers and reduced for generation connections. The reduction in upfront connection costs could increase the deployment rate of low-carbon projects. A further decision on future distribution use of system charges (DUoS) is yet to be made as of Q1 2023, with a decision expected in 2023[16].

Figure 2: Illustrative examples of the impact of SCR reforms

User Type	Impact of distribution network connection charging reforms	Impact of distribution network access rights reforms
Small distribution connected solar farm	• Overall connection charge reduced. • Charge for wider distribution network reinforcement (above the voltage level of connection) is removed, with limited exceptions. • Connection charges will remain as they are currently for any required 'extension assets', ie for sole-use.	• Flexible access option available that may enable a quicker and cheaper connection in congested areas of the network. • Curtailment limits and end date provide more certainty about the extent to which the connection may be restricted.
Electric vehicle charging station for fleet delivery vehicles	• Overall connection charge reduced. • Charge for wider distribution network reinforcement is removed altogether, with limited exceptions. • Connection charges will remain as they are currently for any required 'extension assets', ie for sole-use.	• Flexible network access option made available based on an agreed curtailment threshold. • Charging station may be able to agree to some curtailment in exchange for a faster connection. • End date gives certainty of future capacity being made available.
Large distribution connected wind farm	• Overall connection charge reduced. • Charge for wider distribution network reinforcement (above the voltage level of connection) is removed, with limited exceptions. • Connection charges will remain as they are currently for any required 'extension assets', ie for sole-use.	• Flexible access option available that may enable quicker and cheaper connection in congested areas of the network. • Curtailment limits and end date provide more certainty about the extent to which the connection may be restricted.
Domestic household installing a heat pump and electric vehicle charger	• Overall connection charge reduced. • Charge for any wider distribution network reinforcement removed altogether, with limited exceptions. • Connection charges will remain as they are currently for any required 'extension assets', ie for sole-use.	• Flexible access arrangements are complex agreements with varying costs and benefits that must be assessed by individual connecting customers. • We do not think they are suitable for domestic consumers, and they will not be made available for this group.

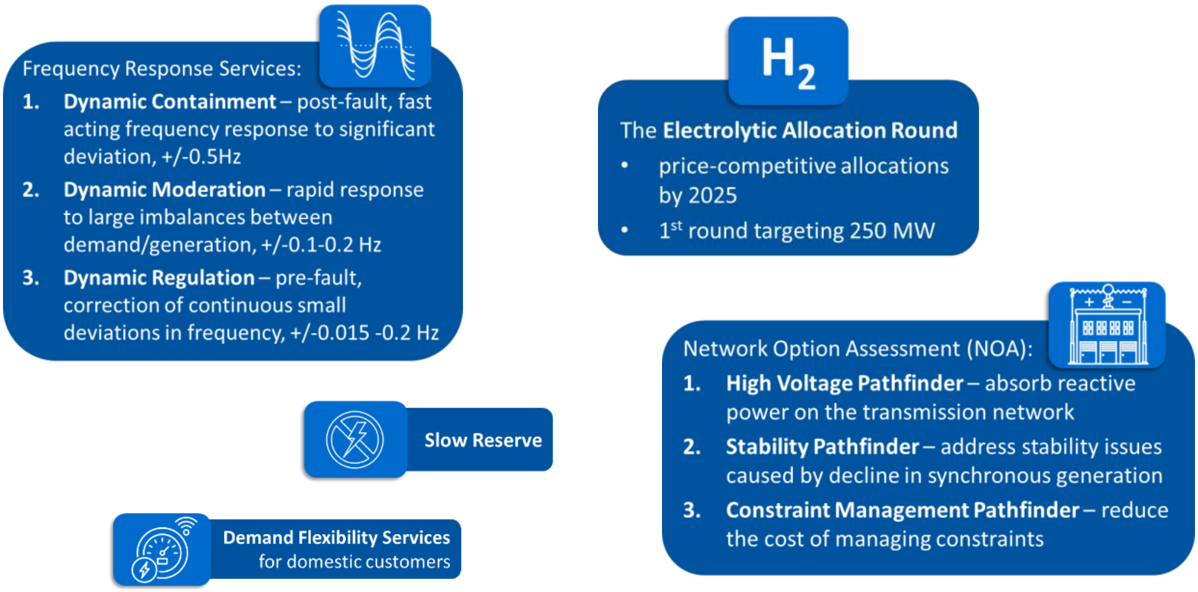
Source: Ofgem 2022, Access and Forward-Looking Charges Significant Code Review: Decision and Direction.

[15] Ofgem 2022, *Access and Forward-Looking Charges Significant Code Review: Decision and Direction.* https://www.ofgem.gov.uk/publications/access-and-forward-looking-charges-significant-code-review-decision-and-direction

Developing markets for flexibility

The support and market mechanisms for flexible generation and demand are developing. This has helped lead to very strong activity in the battery storage development sector. The **Frequency Response Services**[17] offer options for generation and network to react to changes in network frequency. To address stability issues brought about by the increase of renewable and low-carbon assets, the **Network Options Assessment (NOA) Pathfinders**[18] were established. Dedicated subsidy mechanisms have also been announced to fund electrolytic hydrogen and long-duration storage.

Figure 3: Summary of market support mechanisms available to flexible assets



As electricity systems become decentralised, there will also be a demand for local DNO flexibility markets that incentivise flexibility services provided locally. Households and businesses will be a part of these services, often accompanied by aggregators. Services such as these could be instrumental in helping DNOs, and future Electricity System Operators (ESOs) to manage load and flexibility on low-voltage networks[19].

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[16] Ofgem 2022, *Decision to descope the wide-ranging review of Distribution Use of System (DUoS) charges from the current Electricity Network Access and Forward-Looking Charges Significant Code Review (SCR) and take it forward under a dedicated SCR with a revised timescale.* https://www.ofgem.gov.uk/sites/default/files/2022-02/Decision%20on%20DUoS%20SCR.pdf

[17] National Grid ESO n.d., *Frequency Response Services.* https://www.nationalgrideso.com/industry-information/balancing-services/frequency-response-services

[18] National Grid ESO n.d., *Network Option Assessment (NOA) Pathfinders*. https://www.nationalgrideso.com/future-energy/projects/pathfinders

[19] Regen 2018, *Local flexibility markets.* https://www.regen.co.uk/wp-content/uploads/Regen_Local-flexibility-guide.pdf

DFES methodology

The broad DFES methodology can be summarised under five key areas or stages:

	The **technologies** that are in the scope of the future scenario analysis.
	The **scenario framework** defines the overarching societal, technological and economic 'worlds' that DFES scenario projections sit within.
	The **stakeholder engagement evidence and input** were used as direct input to the scenario modelling.
	The **analysis stages** are undertaken for each technology when developing and modelling scenario projections.
	The **geographical distribution** of the projections down to sub-regional (11 kV substation) or local (Low Voltage) levels.

Technologies in-scope

The scope of the SSEN DFES covers technologies and load sources that directly connect to SSEN's electricity distribution network assets in Southern England – see Table 1. Therefore, DFES analysis does not include projections for technologies directly connected to the transmission network.

Table 1: DFES Technologies and demand sources

Electricity generation technology classes	Electricity storage technology classes	Future disruptive sources of electricity demand
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.	**Battery storage:** Grid-scale, commercial and domestic battery storage asset classes. **Liquid air energy storage (LAES)** Also referred to as cryogenic energy storage, demonstrator scale LAES plants connecting to the distribution network.	**Electric vehicles**: cars, vans, motorbikes, LGVs, HGVs and buses. **Electric vehicle chargers**: on-street residential, 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 and commercial and industrial developments.

The National Grid ESO Future Energy Scenarios 2022 framework

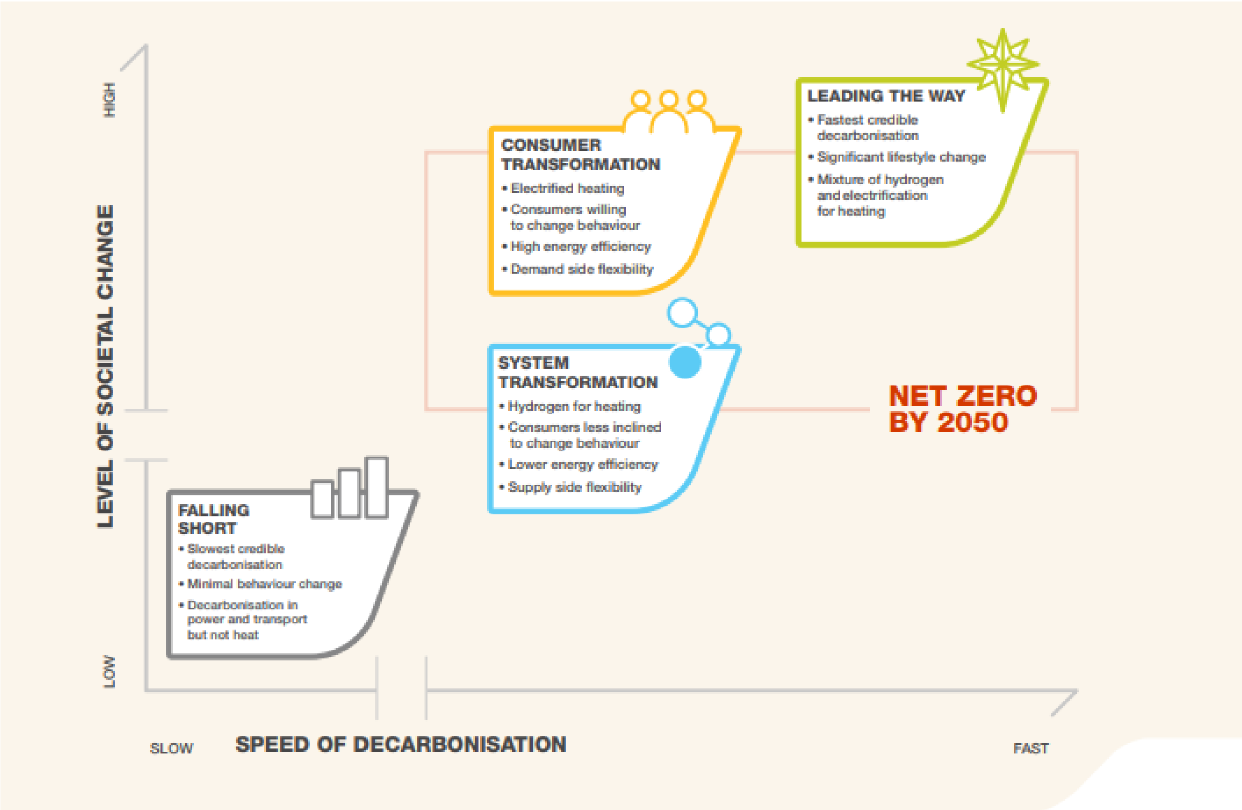
As with previous DFES assessments, the SSEN DFES 2022 has used the National Grid ESO Future Energy Scenarios 2022[20] (FES 2022) as the overarching framework. As well as a scenario framework, the FES 2022 provides:

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

The FES 2022 scenario framework is based on two key axes: decarbonisation speed and societal change level, as summarised in Figure 4. Whilst some scenarios see similar or aligned projections in the near, medium or even long term for some technologies, other aspects of the energy system have very different outcomes. A description of each of the scenarios can be found in Table 2. The technology summary sections within this report also outline specific scenario variances seen under each technology and how the DFES applies them.

Where available, FES 2022 grid supply point (GSP) projection data has been used to provide an SSEN DFES 2022 to FES 2022 reconciliation. Regional building blocks were sometimes unavailable or not directly comparable due to the sub-technology division. In these cases, national FES 2022 projections have been used for reconciliation.

Figure 4: Future Energy Scenarios 2022 framework, National Grid ESO



[20] National Grid ESO, *Future Energy Scenarios 2022*. https://www.nationalgrideso.com/future-energy/future-energy-scenarios

Table 2: FES 2022 scenario descriptions.

National Grid ESO FES 2022 scenario	High level description *Wording sourced from National Grid ESO FES 2022 publication
Leading the Way *Meets GB net zero targets by 2047*	Assumes that Great Britain decarbonises rapidly with high levels of investment in world-leading decarbonisation technologies. FES 2022 assumptions in different areas of decarbonisation are 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 insulation 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 mainly from electrolysis powered by renewable electricity, and no hydrogen production from natural gas.
Consumer Transformation *Meets GB net zero targets by 2050*	The 2050 net zero target is met with measures that have a greater impact on consumers and is driven by greater levels of consumer engagement. A typical homeowner will use an electric heat pump with a low temperature heating system and an EV. 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. The system will have higher peak electricity demands managed with flexible technologies including energy storage, demand-side response and smart energy management
System Transformation *Meets GB net zero targets by 2050*	The typical domestic consumer will experience less disruption than in **Consumer Transformation** as more of the significant changes in the energy system happen on the supply side, away from the consumer. 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 flexibility to the system. Total hydrogen demand is high, mostly produced from natural gas with carbon capture and storage.
Falling Short *Does not meet GB net zero targets by 2050*	There is still progress on decarbonisation compared to the present day; 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. Electric Vehicle (EV) take-up grows more slowly, displacing petrol and diesel vehicles for domestic use; however decarbonisation of other vehicles is slower with continued reliance on diesel for heavy goods vehicles. In 2050 this scenario still has significant annual carbon emissions, short of the 2050 net zero target.

Source, credit and description wording: National Grid ESO FES 2022

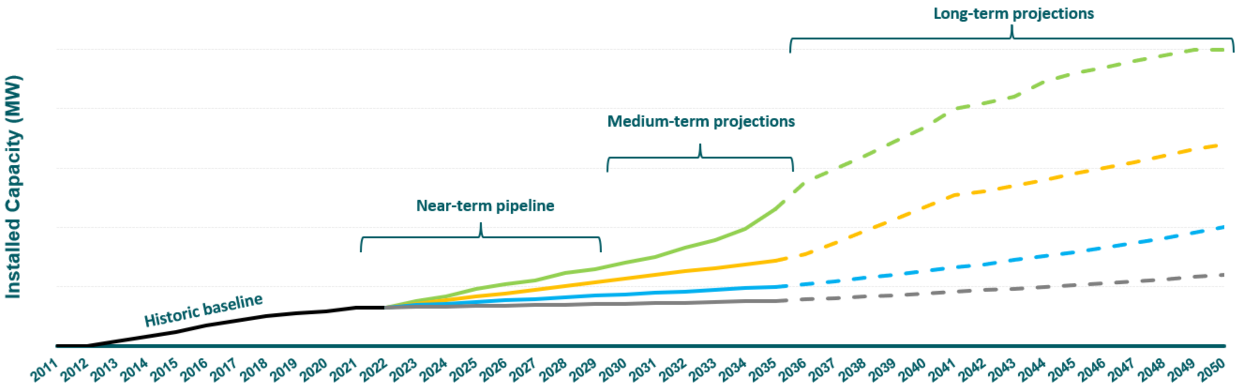
DFES analysis stages

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 2021.
2. The **near-term development pipeline** is then assessed, recording and reviewing projects with network connection offers or planning applications. 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 scenario results over the 2030s and 2040s.
4. Annual licence area projections of either MW of capacity (e.g. onshore wind) or the number of units (e.g. heat pumps) are then **geographically distributed** across the licence areas.

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 5).

Figure 5: 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 through direct discussions with project developers, sector representatives and other stakeholders.

Over the medium and longer term, projections reflect the underlying scenario assumptions defined for each technology through the FES. This is also augmented by levels of certainty provided by, for example, regional and national policies.

Adopting legally binding net zero emissions targets and government net zero and energy strategies clarifies our future energy pathway. The key assumptions made in this analysis include the following:

- Distributed renewable energy generation capacity will significantly increase
- Unabated fossil fuel electricity generation will decline
- The shift to more decentralised energy generation assets will continue (to some degree)
- The electrification of transport is already in progress and will accelerate significantly
- Low-carbon hydrogen will be produced and play a key role in industrial processes and some forms of transport, but the scale and location of production and use are 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.

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

1. The range of different outcomes assumed across the FES 2022 scenarios
2. The national Government, devolved Government, regional and local policy uncertainty
3. Commercial and financial uncertainty
4. Technology development and capability uncertainty
5. Consumer adoption and behaviour uncertainty
6. Local spatial distribution factors
7. Transmission vs distribution network connection uncertainty

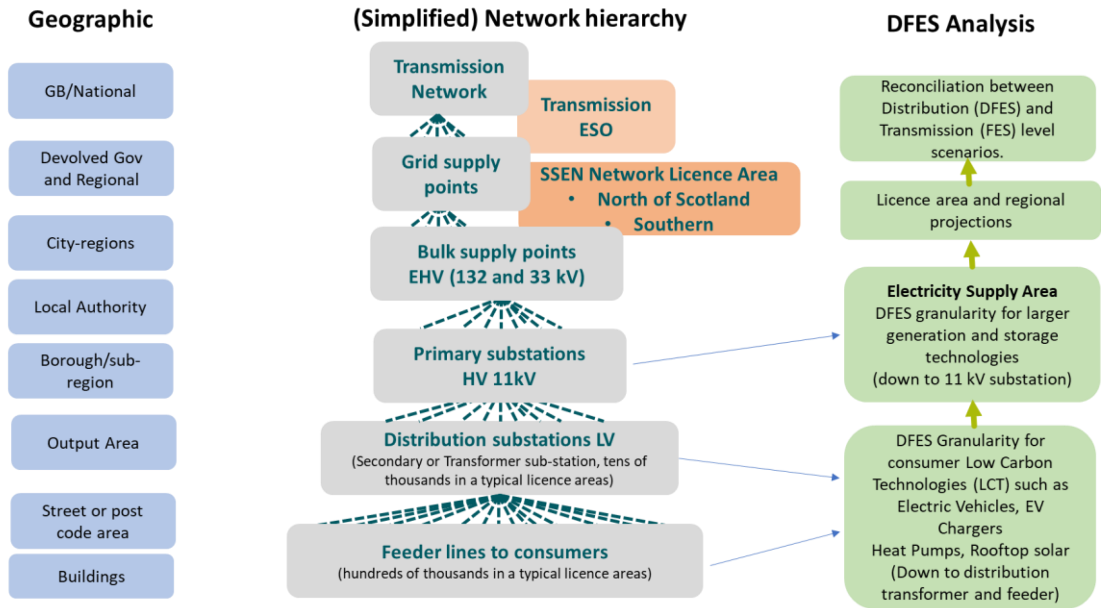
At an individual technology level, uncertainty is considered a key part of the analysis and is reflected in the range of scenario outcomes presented. The technology-specific assumptions that have been made are summarised in each technology summary chapter.

Granularity and geographical distribution of the DFES

A key stage of the DFES analysis is to estimate the geographic spread of the scenario projections across the licence area. This provides granular, locationally broken-down data that the SSEN Network Planning teams can use to inform the need for long-term network investment at specific locations or for individual substation assets.

The DFES geographically distributes licence area projections to **Electricity Supply Areas** (or ESAs). An ESA is a geographical zone representing a block of demand or generation sharing upstream network infrastructure.

Figure 6: Network hierarchy that informs DFES geographic distribution to ESA



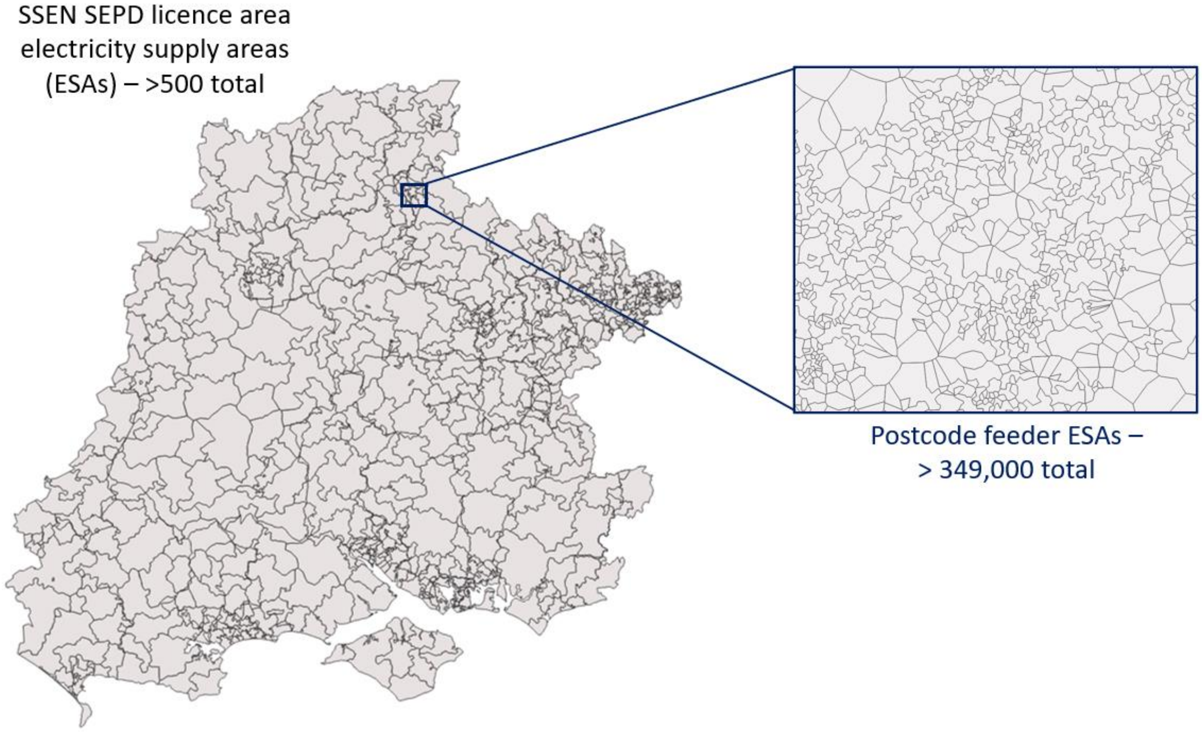
In the Southern England licence area for large generation and storage technologies, projections are distributed to approximately 930 individual 11 kV primary ESAs, which in urban areas such as Swindon or Oxford would equate to a group of postcodes or a small borough. This could equate to a wider area covering part of a county in rural areas. The DFES projection dataset has been designed to be aggregated to support network analysis at higher voltage levels or to local authorities or other regional boundaries.

DFES 2021 scenario projections for EVs, EV charger capacity, domestic heat pumps, rooftop PV and domestic battery storage were 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. This level of analysis was out of scope for DFES 2022 but is expected to be included in future DFES projections.

The spatial distribution factors underpinning this ESA modelling are described in more detail within each technology summary. 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 the Isle of Wight stakeholders has also specifically influenced the spatial distribution factors for the SSEN DFES 2022.

Figure 7: Map of 11 kV and feeder ESAs in the Southern England licence area



Large-scale Battery Storage Planning Scenario

The pipeline of battery storage projects in the UK has exponentially increased over the past 2-3 years[21]. The number of projects, their scale and the geographic spread of battery storage will likely significantly impact how the future electricity system will be shaped. However, the number of these projects that will come to fruition remains uncertain.

There is an unprecedented pipeline of accepted and quoted connection offers for battery storage projects in both SSEN licence areas.

Licence area	DFES 2020 Pipeline	DFES 2021 Pipeline	DFES 2022 Pipeline (incl. Quote Issued)
Southern England	0.8 GW	1.6 GW	5.3 GW
North of Scotland	0.3 GW	0.4 GW	4.2 GW
All SSEN	**1.1 GW**	**2 GW**	**9.5 GW**

As a result, DFES 2022 includes a new scenario in addition to the four scenarios defined under the FES National Grid framework for battery technologies: the **Storage Planning** scenario. This scenario provides a view to 2050 that assumes all the known battery storage pipeline projects will connect.

The **Storage Planning** scenario is based entirely on the pipeline of projects with connection agreements with SSEN. All sites were modelled to come online. Where no SSEN anticipated connection date was available, sites were modelled to connect in randomly assigned years between 2024 and 2030. This approach highlights the growing number of projects seeking a connection compared to the four FES scenarios. Figure 8 represents the proportion of projects modelled to connect under each scenario by planning status.

Figure 8: Proportion of battery storage projects modelled to connect in SSEN licence areas by scenario

	Granted/Under Construction	Application Submitted	Pre-planning	No information/other
Storage Planning	100%	100%	100%	100%
Leading the Way	100%	100%	100%	15%
Consumer Transformation	100%	100%	100%	15%
System Transformation	100%	25%	37%[22]	6%
Falling Short	100%	25%	13%	4%

The **Storage Planning** scenario enables a view of what the electricity system would look like if all sites currently holding a connection agreement were to connect to the network. In reality, not all projects will come to fruition, as financial and planning challenges will cause setbacks, delays, or project abandonment.

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

[22] *Note: Capacity market information is also used to determine if a project is modelled to be built. For example, if a project is found to be in "pre-planning" but has a capacity market agreement, then it may be modelled to connect, while a project with more advanced planning status but no capacity market information may not be modelled.*

Supporting studies

In 2022, Regen led two additional pieces of work to explore load growth on the SSEN network between DFES analysis periods.

Isle of Wight – network investment study

SSEN committed in their ED2 Business Plan to review evidence on the needs case for greater network capacity on the Isle of Wight. Regen has coordinated a yearlong network investment study, steered by a Net Zero Working Group, that has captured evidence about:

- Potential future renewable energy capacity development and developer appetite
- The potential growth of future demand from transport and heat electrification
- Bespoke sources of future electricity demand, such as ferry/shipping electrification
- The role of hydrogen (including electricity demand from hydrogen electrolysis) on the island
- The timescale of the decommissioning of unabated fossil fuel generation on the island

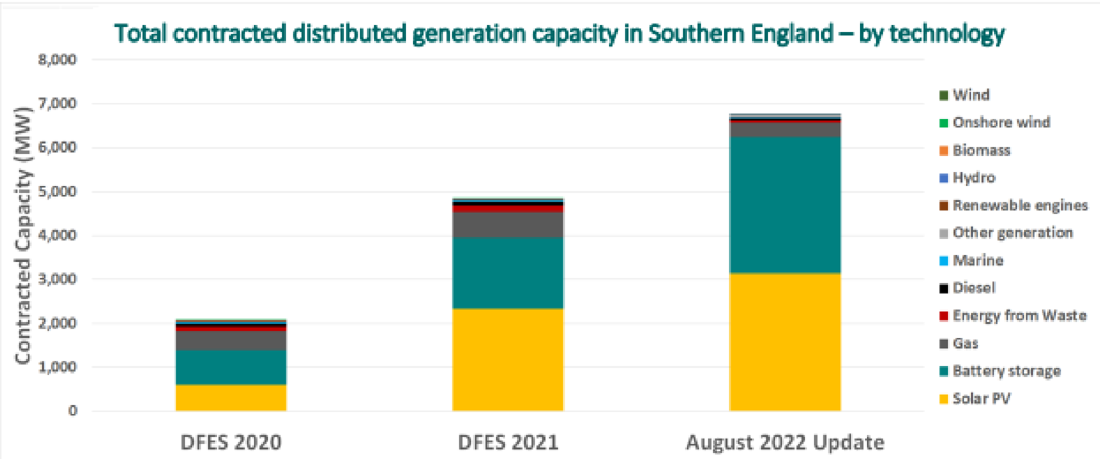
This evidence has been fed into DFES 2022. SSEN will also be using this evidence to engage with Ofgem on the case for investing in expanding the capacity of the Isle of Wight network.

2022 Near-Term Growth Review

In light of the significant changes in the energy sector, SSEN asked Regen to produce a further analysis in-between the 2021 and 2022 DFES analysis periods. Seven key technologies with the biggest load growth potential were reviewed: solar PV, battery storage, hydrogen electrolysis, data centres, electric vehicles, EV chargers and heat pumps. This evidence has contributed to the DFES 2022.

Key findings for the period from September 2021 to August 2022 included:

- The pipeline of generation and storage projects grew from 4.8 GW to 6.8 GW, indicating a continued investor appetite.
- 489 MW of large-scale solar farms and 230 MW of battery storage projects had submitted planning applications and sought a grid connection as of mid-2022.
- Battery electric vehicles in Southern England more than doubled from 51,752 to 107,296 (109% increase), while heat pump installations increased from 1,800 to 4,600 (155% increase).
- Commercial battery storage installations increased by 59%, from 113 MW.
- There is a trend of accelerated, consumer-led uptake of low-carbon technologies despite economic factors that could have slowed growth, such as the cost-of-living crisis.
- Overall, investors and project developers are continuing to focus on low-carbon technologies. No evidence of a slowing in sites seeking grid connections was found. However, the degree of uncertainty around investment is higher compared to 2021.



Stakeholder engagement

Various inputs, evidence and data inform DFES analysis. Whilst based on four national energy scenarios, the DFES is intended to assess future energy scenarios at a regional, sub-regional and local level. The modelling is heavily influenced by what is connected today and an analysis of known pipeline projects. Consultation and stakeholder engagement are critically important to inform the modelling of individual technologies. To support the SSEN DFES 2022 analysis, the project team has engaged with a wide range of stakeholders. This includes:

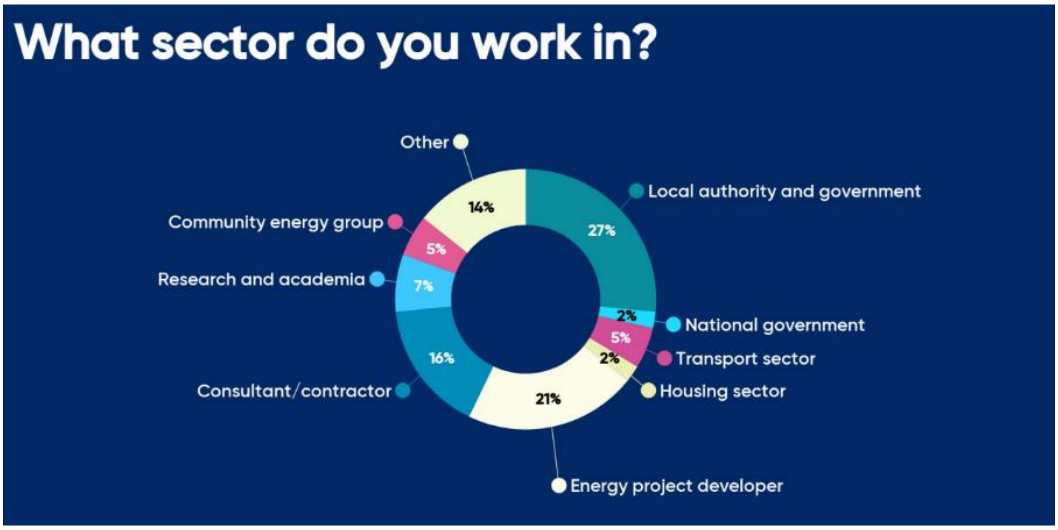
	Interactive online webinars held in November and December 2022[23] with a broad range of regional and energy sector stakeholders and members of the SSEN team. *This session used an online polling platform to capture specific views and statistical data about the future of several energy technologies.*
	A **new developments online data exchange**, 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 larger domestic property developments (100 houses or more) and non-domestic developments, such as new supermarkets, offices or airports.*
	A **local energy strategy questionnaire** was completed by wider environmental and city planning teams from a number of the regional local authorities. *Asking questions about individual council strategies and plans for zero emissions targets, renewable energy development, low carbon transport, low carbon heat, waste collection and hydrogen. The responses and accompanying documents supplied by the councils were used to inform the spatial distribution of some scenario projections.*
	Technology and sector-specific interviews with project developers, technology companies and other sector representatives. *These interviews informed the modelling of pipeline projects and testing assumptions made about specific sectors or technologies. Interviews included solar PV and battery storage project developers, ITM Power and the European Marine Energy Centre.*

[23] Regen 2022, *SSEN Distribution Future Energy Scenarios 2022- Stakeholder Consultation Webinars*. https://www.regen.co.uk/event/ssen-distribution-future-energy-scenarios-2022-stakeholder-consultation-webinars/

Regional engagement webinars

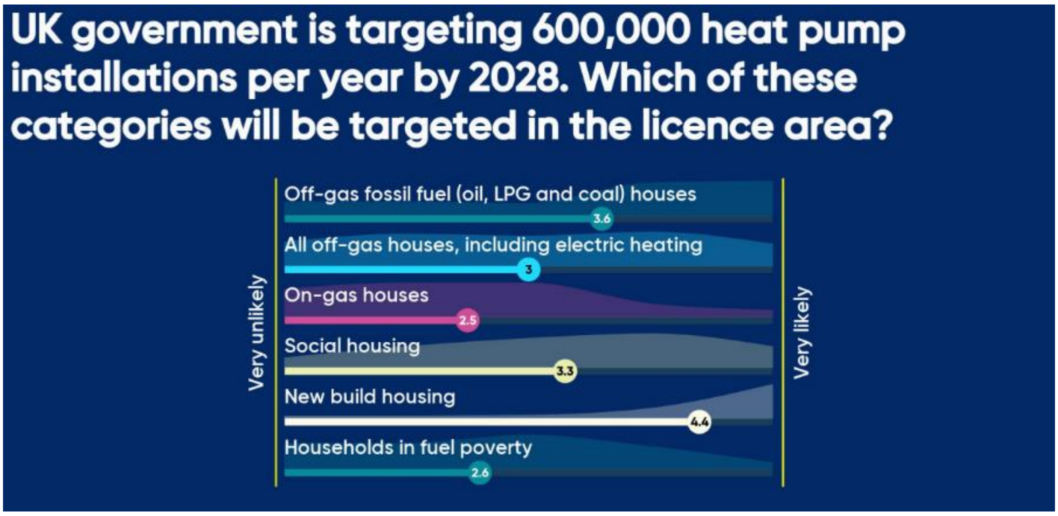
Across November and December 2022, Regen worked with members of the SSEN team to host interactive stakeholder engagement webinars. These collaborative sessions sought to:

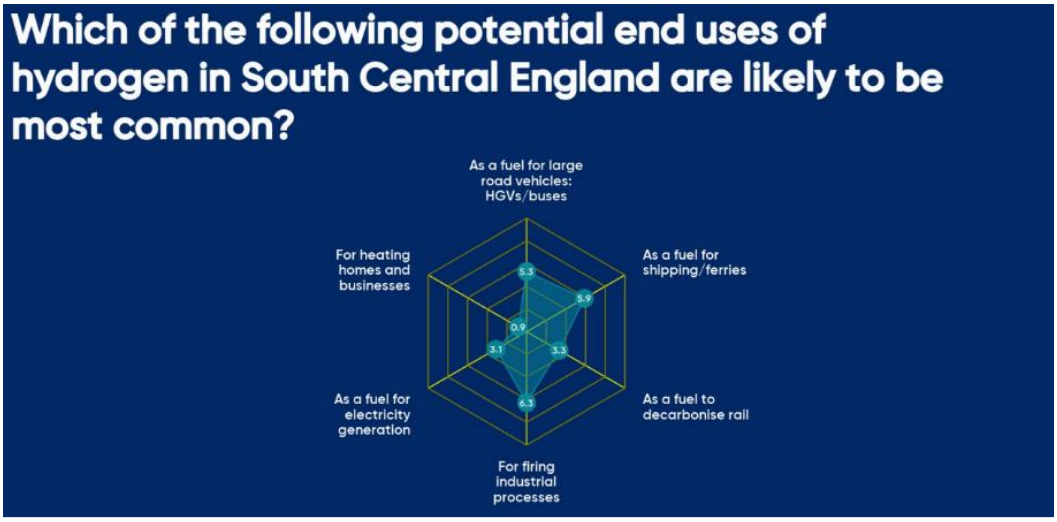
- Provide a summary of the background, method and purpose of DFES.
- Road-test assumptions around technology capacity growth and locational distribution factors that determine the scenario projections.
- Tap into local and sector knowledge, insights and ambitions relevant to the licence area.
- Discuss views and insights on new or disruptive future technologies, such as hydrogen, heat pumps and EVs, 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, with 139 people registering to attend and 72 on-the-day attendees. The session sought views from stakeholders that could directly apply to the scenario modelling, covering:

- An overview from SSEN around their RIIO-ED2 plan and the general purpose and use of DFES.
- An introduction to the high-level methodology and technology building blocks that form the scope of the 2021 DFES analysis.
- A series of technology-specific interactive polling sessions using the online voting and live visualisation platform ***Mentimeter***[24].





Engagement with local authorities

Building on engagement undertaken for 2019, 2020 and 2021 DFES assessments, a core data input to this year's analysis came from an online portal of new property developments planned in the Southern England licence area. Regen liaised with the planning departments of those local authorities within the licence area, updating registers of:

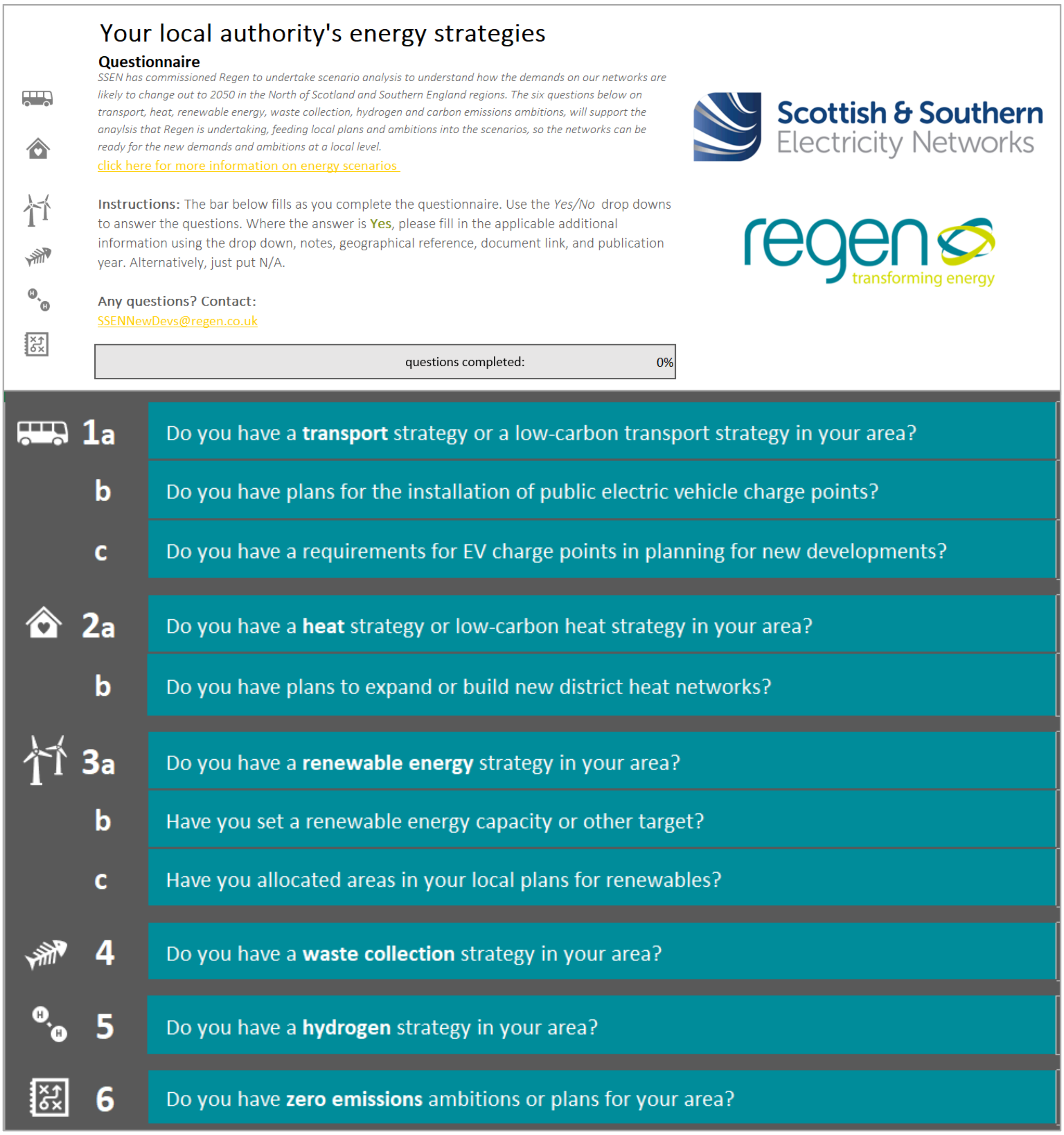
- **Planned new houses**, limited to strategic housing developments of 100 houses or more.
- **New non-domestic developments**, measured in sqm, are categorised by eight commercial and industrial development archetypes: *Office, Retail, Factory and warehouse, Hospital, Hotel, Medical, Restaurant, School & College, University, Sport & Leisure* and *Other*.

Included in this year's data were a small number of very large developments (of 50,000 sqm or more), including an Airport Business Park within the Hounslow area.

A bespoke modelling approach was applied to these developments through follow-up discussions with relevant local authorities, translating the full development land space to a reduced operational development area to understand future energy demand.

The project team also issued a **local energy strategy survey** to broader environmental and climate change project teams within the local authorities. The response data from this survey (see Figure 9) was used to influence the spatial distribution of individual technology projections.

Figure 9: SSEN local energy strategy survey, developed by Regen for DFES 2021 analysis



Your local authority's energy strategies

Questionnaire

SSEN has commissioned Regen to undertake scenario analysis to understand how the demands on our networks are likely to change out to 2050 in the North of Scotland and Southern England regions. The six questions below on transport, heat, renewable energy, waste collection, hydrogen and carbon emissions ambitions, will support the anaylsis that Regen is undertaking, feeding local plans and ambitions into the scenarios, so the networks can be ready for the new demands and ambitions at a local level.

click here for more information on energy scenarios

Instructions: The bar below fills as you complete the questionnaire. 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.

Any questions? Contact:
SSENNewDevs@regen.co.uk

questions completed: 0%

Scottish & Southern Electricity Networks

regen transforming energy

1a	Do you have a **transport** strategy or a low-carbon transport strategy in your area?
b	Do you have plans for the installation of public electric vehicle charge points?
c	Do you have a requirements for EV charge points in planning for new developments?
2a	Do you have a **heat** strategy or low-carbon heat strategy in your area?
b	Do you have plans to expand or build new district heat networks?
3a	Do you have a **renewable energy** strategy in your area?
b	Have you set a renewable energy capacity or other target?
c	Have you allocated areas in your local plans for renewables?
4	Do you have a **waste collection** strategy in your area?
5	Do you have a **hydrogen** strategy in your area?
6	Do you have **zero emissions** ambitions or plans for your area?

The responses to the 2021 and 2022 questionnaires are summarised in Figure 10. The number of councils that responded and the number of sector strategies that have been published, or are in development, have increased since the survey was completed to support the 2021 DFES analysis.

Figure 10: High-level responses to the 2022 and 2021 local energy questionnaire submitted by local authorities in Southern England (Yes, No, or In Development)

Y = Yes   N = No   ID = In Development

Local Authority	Transport strategy	Public EV charger plans	EV charging in new developments	Heat strategy	Heat networks	RE strategy	RE targets	Development areas	Waste collection	Hydrogen strategy	Emissions target	Local Area Energy Plan
Arun		Y	Y	N	N	N	N				Y	
Bournmouth			Y				Y	N				
Christchurch			Y				Y	N				
Poole			Y				Y	N				
Basingstoke and Deane												
Bracknell Forest	Y	Y	Y	N	N	Y	Y	Y		N	Y	
Cherwell												
Chichester		Y		N	N	N	N			N	Y	N
Chiltern	Y	ID	Y	N	N	ID	N	N	Y	N	Y	
Cotswold	ID	Y	ID	N								
Dorset	Y	Y	ID	Y	N	ID	ID	ID	Y	N	Y	N
Ealing												
East Hampshire												
Eastleigh												
Fareham	ID	N	N	N	N	Y	N	N	N	N	ID	N
Gosport	Y	Y	ID	N	N	N	N	N	Y	N	Y	N
Guidford	Y	Y	Y	N	Y	N	N	N	Y	N	Y	
Hart	N		Y									
Havant	N	N	Y	N	N	N	N	N	N	N	N	
Hillingdon			Y	N	N	N	N	N	N	N	Y	Y
Horsham	N	Y	ID	N	N	N	N	N	ID	N	ID	N
Hounslow	Y	Y	Y	N	Y	Y	N	N	Y	N	Y	Y
Isle of Wight	ID	Y	Y	ID	N	ID	ID	N	Y	N	Y	ID
Mendip												
New Forest	Y	Y	Y	N	N	N	N	N	Y	N	ID	N
Oxford												
Portsmouth	Y	ID	Y	Y	Y	N	N	N	Y	N	Y	N
Reading												
Runnymede	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y	N
Rushmore	N	Y	N	N	N	ID	N	N	Y	N	Y	N
Slough												
South Bucks	Y	ID	Y	N	N	ID	N	N	Y	N	Y	
South Oxfordshire	Y	Y	Y		N		ID	ID	Y	N	Y	ID
South Somerset	Y	Y	Y	ID	N	ID	N	ID	Y	N	Y	
Southampton	Y	ID	ID	ID	ID	ID	ID	N	ID	N	Y	
Spelthorne												
Surrey Heath	N	ID	N	Y	ID	ID	ID	ID	Y	N	ID	N
Swindon												
Test Valley	N	ID	ID	N	N	ID	N	ID	Y	N	ID	
Vale of White Horse	Y	Y	Y		N		ID	ID	Y	N	Y	ID
Waverley	Y	Y	Y	N	N	N		N	Y	N	Y	N
West Berkshire	Y	Y	Y	ID	ID	ID	ID	N	Y	N	Y	
West Oxfordshire	Y	ID	Y	N	ID	ID	N	ID	Y	N	Y	ID
Wiltshire												
Winchester												
Windsor and Maidenhead	ID	ID	Y									
Wokingham												
Wycombe	Y	ID	Y	N	N	ID	N	N	Y	N	Y	

Targeted sector and development engagement

The project team also engaged individual companies and sector representatives. These consultations included:

- Email exchanges with project developers holding contracted connection offers for individual generation or storage projects to determine plans to build out their projects.
- Interviews with technology companies, developing emerging or innovative technologies such as cryobatteries, hydrogen electrolysers or energy from waste site operators.

The project team have also engaged with the National Grid ESO FES Team to discuss and reconcile some shared assumptions and market intelligence around individual technologies, such as data centres and battery storage assets.

An overview of some of the sector-specific consultations is shown in Table 3.

Table 3: Summary of sector-specific stakeholder engagement undertaken to inform DFES 2022 analysis

DFES building block technology	Organisation Engaged	Summary of the feedback received and how it was applied to the DFES analysis
Large-scale (>1 MW) solar PV	Renewable Connections, Bluestone Energy, Novergy, Wessex Solar Energy, Hive Energy, Aura Power, Bath and West Community Energy, Voltalia, Bluefield Development, Westbridge Energy, Gloucestershire County Council, Lightsource BP, RES, Ridge Clean, Low Carbon, Marlow Energy Group, Novus, Roadnight Taylor, Green Nation, Aberdeenshire Council, Dundee Council and ECO Sustainable Solutions	Provided information about deployment timelines for specific solar projects. Also discussed general challenges facing the solar sector, including network capacity, planning and local objections/NIMBYism. Discussed potentially viable sites on land in AONBs, green belt, high-grade agricultural land and flood zones etc. This feedback supported the pipeline analysis and reinforced Regen's solar methodology and in-house solar resource assessment, considering several spatial factors and land classification constraints.
Hydropower	British Hydropower Association, University of Birmingham, Raasay Renewables, Low Carbon Hub and Project LEO	Discussion around small hydropower as a business model and the barriers facing it. Feedback highlighted a lack of subsidy support after closing the Feed in Tariff programme. This is a consensus amongst hydropower developers. Other barriers included upstream transmission constraints, legal fees and unfair additional costs to community developers. This insight supported the resultantly conservative DFES capacity projections.
Onshore wind	Ecotricity, Aquatera, Orkney Community Energy, Orkney Council, Walters Group, AWEL Co-op, Infingergy/Boralex, Gray Associates, Constantine Wind Energy	As with solar and battery storage, several wind developers with identified projects in the region were contacted by email to provide additional pipeline site information. Several responded with clarifications that directly influenced the modelling of sites.
Battery storage	Foresight, Eelpower, Ili Energy, Low Carbon, RES, Noriker, Eclipse Power, Penso Power, Statera Energy, Conrad Energy, BM Solar, Balance Power, Tag UK, Clearstone Energy, Infinergy and Novus, XRenewable, Low Carbon Alliance	Provided information about the timeline and broader intention to progress individual large-scale (>40 MW) battery storage projects that have recently accepted connection offers with SSEN. The feedback guided the pipeline analysis and spatial distribution of the large battery storage pipeline across the licence area.

DFES building block technology	Organisation Engaged	Summary of the feedback received and how it was applied to the DFES analysis
Liquid air energy storage (LAES)	Highview Power	Information about broad interest in connecting LAES projects to the distribution network in SSEN's licence areas. This included specific insights around an appetite to target National Grid ESO's stability pathfinders[25] and the potential to co-locate LAES projects data centres as a potential off-taker of cooling load. This insight drove the inclusion of LAES as a separate technology projection, the scale of capacity projected, and the spatial location of future LAES sites across both SSEN's licence areas.
Hydrogen electrolysis	ITM Power, RWE	Discussed the general progress of the low carbon hydrogen sector, future electrolysis business models and any existing operational electrolyser sites. The discussion also updated views on typical electrolyser capacity scale (MW) and future use cases. This feedback was used to develop Regen's hydrogen electrolysis scenario modelling in several areas.
Offshore wind and marine generation	Simply Blue Group, UK Marine Energy Council, European Marine Energy Centre, Perpetuus Tidal Energy Centre, Offshore Renewable Energy Catapult and Hexicon	Direct engagement with marine sector professionals drew attention to post-pipeline sites likely for future development. Insight was also gathered on the future of floating offshore wind and the degree of potential development given ideal market conditions.

[25] See National Grid ESO NOA Stability Pathfinder – Phase 3 updates: https://www.nationalgrideso.com/future-energy/projects/pathfinders/stability/Phase-3

Technology sector scenario analysis – index

The DFES 2021 projections comprise 20 separate technology sector analyses. The following technology summary sections detail the specific modelling, assumptions and evidence used to produce the scenario projections for each technology sector, categorised 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

Onshore wind

Summary of modelling assumptions and results

Technology specification

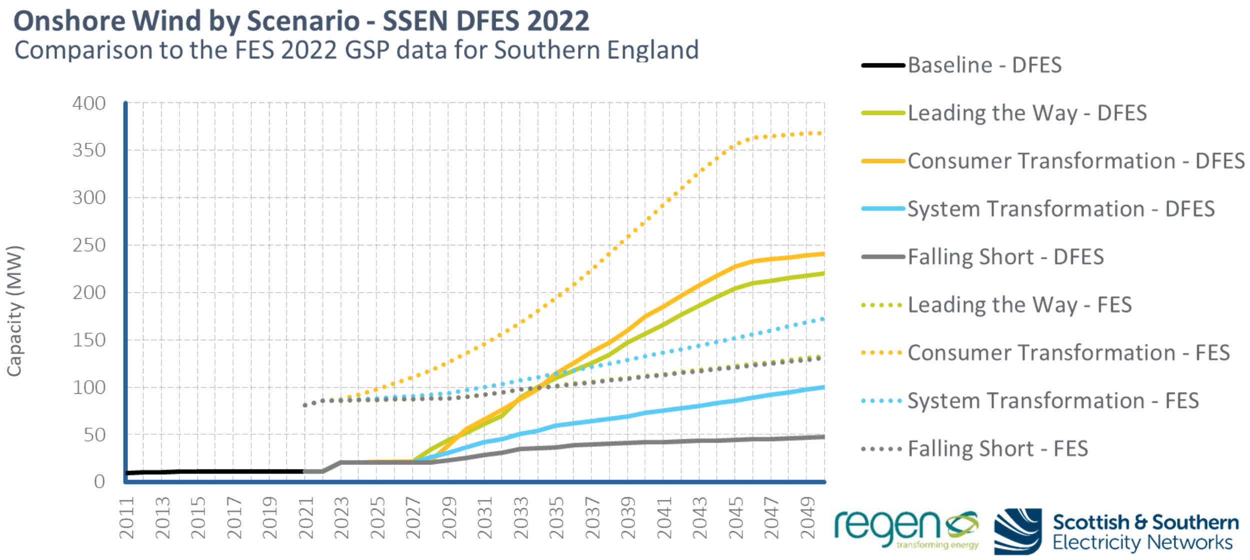
The analysis covers any onshore wind generation connecting to the distribution network in the Southern England licence area.

Network technology data 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	22	33	39	41	44
	System Transformation		18	33	56	67	80	93
	Consumer Transformation		18	51	106	160	206	213
	Leading the Way		18	48	104	146	190	200
Small Scale (<1 MW)	Falling Short	2.5	3	3	3	3	3	4
	System Transformation		3	3	3	5	6	7
	Consumer Transformation		3	5	8	15	21	28
	Leading the Way		3	4	6	11	15	20

Figure 11: Onshore wind projections for the Southern England licence area, compared to National Grid FES 2022 regional projections



Summary

- The Southern England licence area has a minimal baseline of onshore wind deployment due to a combination of relatively low wind resource, spatial constraints and historic challenges for wind projects successfully securing planning permission in the region
- There is little new project development in the pipeline, the connection of the Alaska Wind farm on the Isle of Wight being the only potential near-term development.
- UK Government has been consulting on changes to the National Planning Policy Framework under the Levelling Up and Regeneration Bill[i]; onshore wind planning policy falls within this consultation. Should this consultation lead to loosened onshore wind planning law, deployment could be accelerated within the licence area as depicted in the more ambitious net zero scenarios. However, such an acceleration is unlikely if planning restrictions remain as they are. Both possibilities have been reflected in the range of scenarios.
- In addition, the impact of Ofgem's recent Access SCR[ii] on reducing overall connection charges and introducing non-firm contracts, enabling projects to connect in congested areas of the network, could encourage a future acceleration.
- In ambitious scenarios such as **Consumer Transformation**, an accelerated buildout begins in the late 2020s; up to 241 MW is deployed by 2050. Under **Falling Short**, growth is low and 48 MW is deployed by 2050.

Modelling and assumptions

Baseline (2021)			
Scale	**Number of Sites**	**Total Capacity**	**Description**
Total	**8**	**11**	The baseline of 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, spatial constraints and historic challenges for wind projects successfully securing 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	2.5	Small-scale sites connected between 2011 and 2014, taking advantage of the higher early rates of the Feed-in-Tariff.

Pipeline (2022-2030)	
Number of pipeline sites	**Total capacity**
2	9.5

As in DFES 2021, the Cheverton Down Wind Warm (operated under the 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. In 2021 this site had two entries in the connections data at 0.3 MW each; this is now a single entry. 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[iii]. While this site does not appear in SSEN connections data, it is modelled to come online in 2023 under all scenarios.

Repowering				
Description				
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 5MW threshold are treated differently, with higher repowering potential for sub-5 MW sites.				
	Falling Short	**System Transformation**	**Consumer Transformation**	**Leading the Way**
Year delay	30	25	25	25
Large-scale repowering	+25%	+25%	+50%	+40%
Small-scale repowering	--	+50%	+100%	+100%
Total capacity added by repowering by 2050 (MW)	1.6	3.9	7.8	7.1

Scenario Projections (2030 to 2050)

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, there have been failed planning applications for onshore wind totalling 253 MW. This provides some evidence that, in scenarios where onshore wind planning permission is unlocked such as **Consumer Transformation** and **Leading the Way**, 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 Pot 1 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 accounts for protected areas, proximity to homes, and availability of suitable wind speeds and network.

Scenario	Description	Capacity by 2035	Capacity by 2050
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.	36 MW	48 MW
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 farms and transmission scale connections, which are likely to be concentrated in other licence areas with more wind resource. While development does moderately accelerate, only 100 MW of distributed wind is deployed in the licence area by 2050.	59 MW	100 MW

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 this 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 the onshore wind resource and less by the historical baseline and planning restrictions. As a result, 241 MW is connected by 2050.	114 MW	241 MW
Leading the Way	Under **Leading the Way**, similar assumptions are made to **Consumer Transformation**; 220 MW is connected.	110 MW	220 MW

Reconciliation with National Grid FES 2022

Modelling Stage	Reconciliation
Baseline	The National Grid FES 2022 baseline does not align with the DFES 2022 baseline. FES 2022 has an 82 MW baseline (a significant increase on FES 2021) compared to the 11 MW seen in the DFES 2022 analysis, based on SSEN's connection data. The reason for this c. 70 MW variance is unclear.
Pipeline	In ambitious scenarios, The FES 2022 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 has been modelled to pick up in the late 2020s.
Projections	Post-2030 growth is similar across the FES and DFES projections. This alignment was not present in previous years, with DFES hinging more upon resources 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 2022 and DFES 2022 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[iv] 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 2022

Scenario	4.1.3 - Wind generation (onshore)	
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[v], local stakeholders responded to two polls on the future of onshore wind development in the licence area. 51 respondents considered whether there would be enough local support for significant onshore wind development should planning policy relax. 19 respondents believed there would be insufficient local support to result in significant onshore wind development. 21 respondents believed that support would be sufficient and enable a significant development starting between 2025 and 2030, while the remaining respondents saw a later development as more likely.	Project developers and renewables experts were more inclined to believe there would be enough local support for wind. This 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.** On the importance of battery co-location in unlocking the future uptake of onshore wind in the licence area, there was a consensus that this was not a very important factor for onshore wind. This reflected the higher importance of other factors such as planning policy, local support and wind resource.

[i]Department for Levelling Up, Housing & Communities 2022, *Levelling-up and Regeneration Bill: reforms to national planning policy*. https://www.gov.uk/government/consultations/levelling-up-and-regeneration-bill-reforms-to-national-planning-policy/levelling-up-and-regeneration-bill-reforms-to-national-planning-policy#chapter-8--onshore-wind-and-energy-efficiency
[ii]Ofgem, 2022, *Access SCR decision and direction*. https://www.ofgem.gov.uk/publications/access-and-forward-looking-charges-significant-code-review-decision-and-direction
[iii] Swanage.news, 2022, *"Controversial wind farm pushed back…"*https://www.swanage.news/controversial-purbeck-wind-turbines-delayed-by-another-year/
[iv] Climate Emergency UK, 2022, *Council Climate Plan Scorecards.* https://councilclimatescorecards.uk/
[v]Regen, 2022, *SSEN DFES stakeholder consultation webinars* https://www.regen.co.uk/event/ssen-distribution-future-energy-scenarios-2022-stakeholder-consultation-webinars/

Large-scale solar PV

Summary of modelling assumptions and results

Technology specification

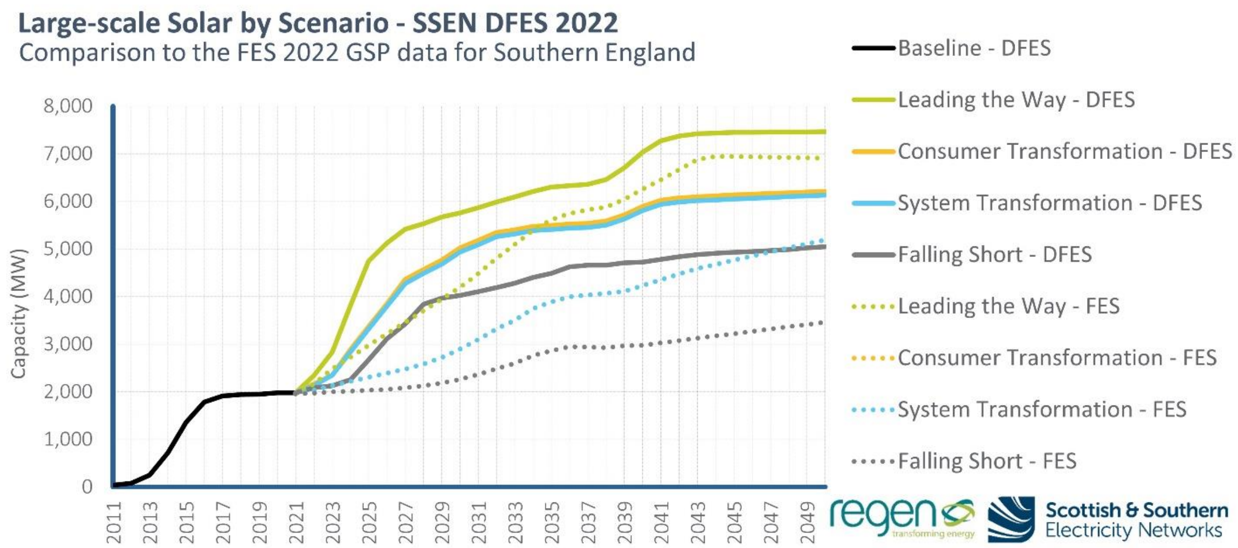
The analysis covers any solar generation sites of installed capacity of 1 MW and above connecting to the distribution network in the Southern England licence area.

Network technology data building block: **Gen_BB012 – Large solar generation (G99)**

Data summary for offshore wind in the Southern England licence area

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	1,975	2,671	4,027	4,487	4,727	4,928	5,045
System Transformation		3,318	4,940	5,413	5,808	6,052	6,128
Consumer Transformation		3,368	5,024	5,497	5,892	6,137	6,213
Leading the Way		4,746	5,760	6,301	7,040	7,451	7,462

Figure 12: Large-scale solar PV projections for the South Central England licence area, compared to National Grid FES 2022 regional projections



Summary

- The Southern England licence area has a historically high uptake of solar, comparable to other DNO licence areas in the south and middle of England and Wales, reaching nearly 2 GW by 2021. This is because this licence area has some of the highest solar irradiance levels in the UK.
- Despite low historic levels of installed capacity, there is a strong pipeline of projects with granted planning applications, including a number commissioned across 2022 or currently under construction, making up 1.5 GW (33%) of the total 4.6 GW pipeline.
- 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[i], improvements in solar panel efficiency[ii] and the development of more dynamic and lucrative power purchase agreements[iii] 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, in the future, as some projects are already exploring, solar PV could be co-located with hydrogen electrolysis to mitigate generation constraints or export limitations.
- Historic planning friendliness towards solar installations is high, with c. 81% of projects being accepted in the licence area. In addition, one-third of local authorities responding to Regen's DFES local energy strategy survey have set ambitious renewables targets, indicating high medium-term growth across the licence area and beyond.
- The British Energy Security Strategy[iv] has set an ambitious goal of 70 GW of solar capacity by 2030, a five-fold increase from the 14 GW of installed domestic and large-scale solar when the strategy was released.
- 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**.
- Under the most ambitious scenario, **Leading the Way**, solar reaches c. 4.6 GW by 2030, and continues to c. 7.3 GW by 2050. Under **Consumer Transformation**, c. 3.4 GW is reached by 2030 and c. 6.2 GW by 2050.
- Across the UK, a main barrier for 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 Statement of Works. These delays have been reflected solely in the **Falling Short** scenario since delays will need to be alleviated to meet net-zero goals.

Figure 13: Large-scale solar PV baseline sites in the South Central England licence area

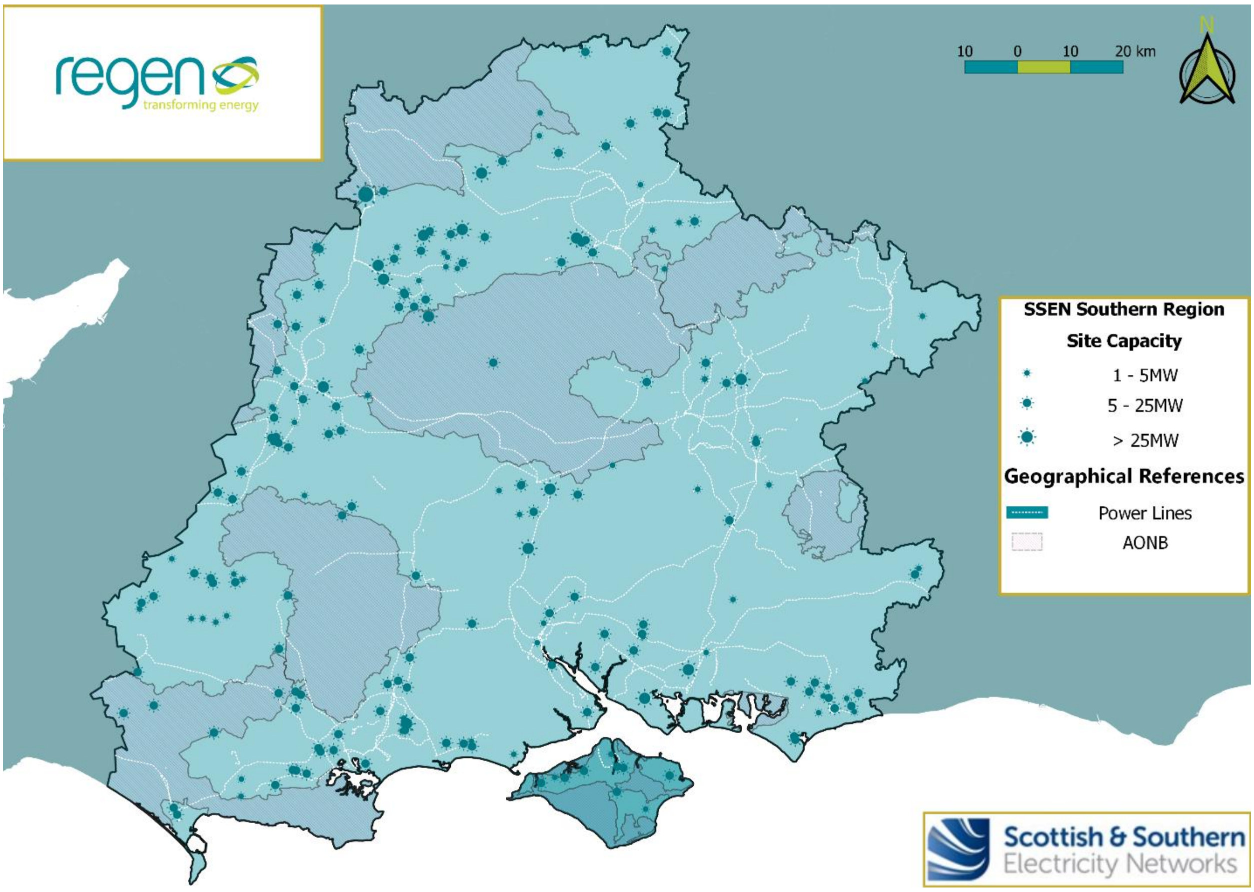
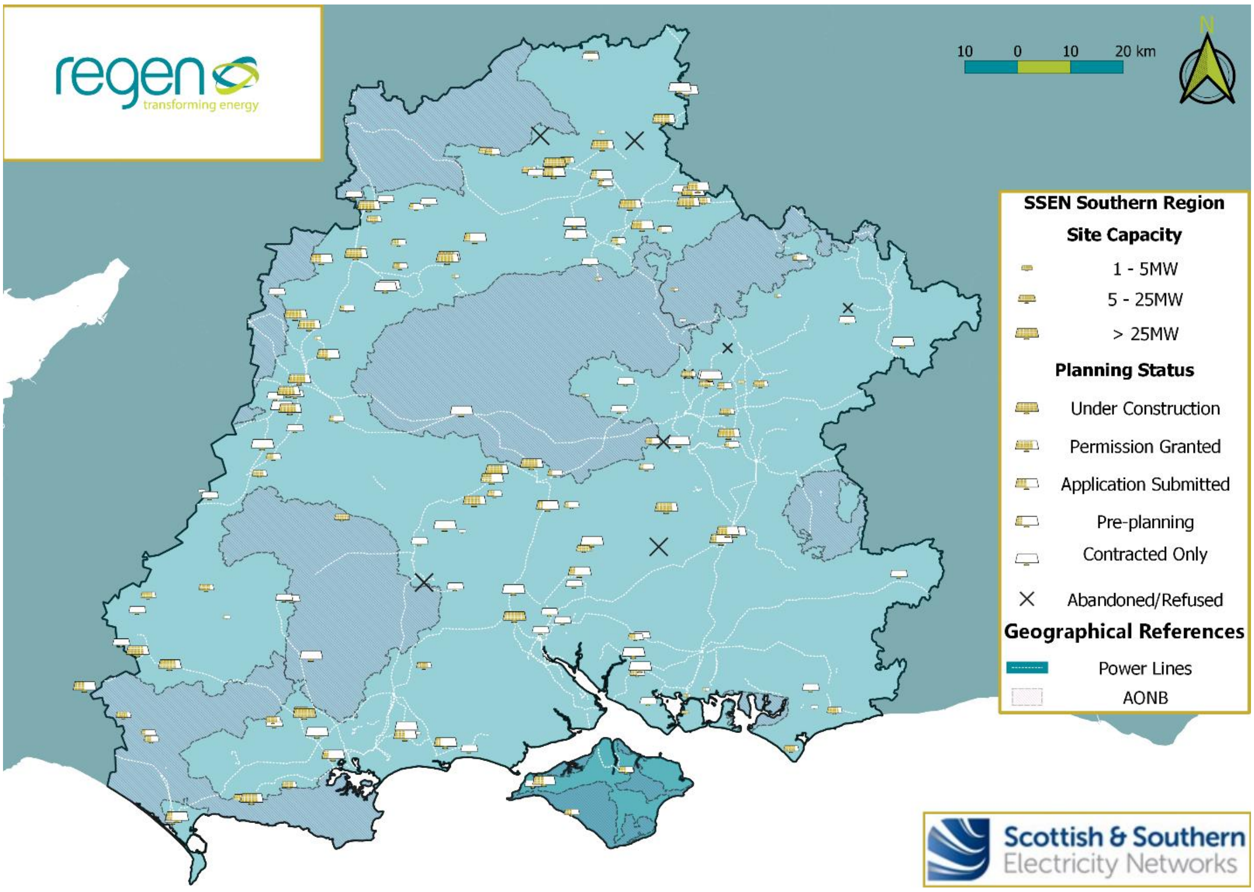


Figure 14: Large-scale solar PV pipeline sites by planning stage in the South Central England licence area



Modelling and assumptions

Baseline (2021)		
Number of Sites	Total Capacity	Description
205	1,975	There is a small net decrease in the connected baseline capacity in the licence area compared to DFES 2021. This is the result of an extensive data verification process. Seven baseline sites totalling 39 MW have been removed from the baseline database, identified as duplicates, pipeline sites wrongly identified as baseline sites, or otherwise misclassified as large-scale solar PV. Two new sites were commissioned in 2021: the Funtley former landfill[v] site (15 MW) and a 2 MW site at Efford Lane in Lymington, New Forest. In addition to this, one pipeline site was confirmed to have been commissioned in 2015.

Pipeline (2022-2030)				
	Total	Contracted	Grid connection offered	In planning only
Number of sites	204	167	13	24
Total Capacity (MW)	4,733	3,916	400	417

For each new DFES analysis, the solar pipeline has consistently grown. The number and capacity of pipeline sites has increased this year to 201 sites (4,733 MW), of which 49 are new sites recorded in DFES 2022, equating to 1,582 MW. This represents an increase of pipeline capacity by c. 50% compared to DFES 2021, which included 2.3 GW of accepted sites and 885 MW of sites with grid connection offers that have not yet been accepted. In addition to sites from the SSEN connections data, the DFES 2022 analysis has also included sites identified in the Renewable Energy Planning Database[vi] that have not yet applied for a distribution network connection, this accounts for an additional 417 MW of pipeline capacity. Around 400 MW have been awarded a Contract for Difference (CfD).

Another reason for the larger amount of pipeline sites included in the analysis is the decision to include those that have not yet accepted a grid connection offer. These represent 400 MW from 13 sites. The volume of grid connection offers that SSEN process is significant and not all are accepted. This data represents a snapshot of sites with outstanding connection offers, but it is understood that some of these sites may have changed since the data was received in mid/late 2022. As such, offered but not accepted sites are only modelled to come online in **Consumer Transformation**, **System Transformation** and **Leading the Way** if found to have granted planning permission. In some cases they are modelled to come online under **Falling Short** where planning and pre-planning evidence was found. Where sites have been identified as affected by Statement of Works delays for transmission network reinforcement, they have been delayed to the expected year of works being completed under the **Falling Short** scenario only.

Pipeline analysis			
Status	**Description**	**Sites**	**Capacity**
Operational	Through an analysis of the SSEN connections data, three sites have been found to have commissioned in 2022. The largest of these sites was the Cirencester Solar Park (25 MW).	3	31 MW
Under Construction	12 sites totalling 200 MW were under construction as of Q3 2022. The largest of these sites is Woodington Farm (40 MW) in Test Valley. A further two are under construction in Wokingham, of which one is an extension of the first (6 MW). There are two sites in Portsmouth, that also include an extension (2.2 MW), two in Winchester (25 and 15 MW[vii]) and two additional sites in Dorset (40 and 14 MW).	12	200 MW
Planning Permission Granted	There is over 1.2 GW of solar PV capacity with planning approval in the licence area. The authority with the most amount of granted projects is Wiltshire, with 8 projects totalling 269 MW. This is followed by Test Valley with 6 projects totalling 169 MW. The largest granted project in the licence area is the 100 MW Moundsmere Solar Farm, south of Basingstoke.	49	1,277 MW
Planning Application Submitted	Wiltshire is also the local authority with highest number of submitted planning applications (6 sites, 136 MW). This is followed by South Oxfordshire, with 4 sites totalling 149 MW. There are five sites with live planning applications of 50 MW, two in South Oxfordshire and one each in East Hampshire, Wiltshire and Test Valley.	36	727 MW

Pre-planning	Four sites totalling 130 MW are in pre-planning stages, including Pitt Farm in Winchester (50 MW).	23	511 MW
No information/Other	67 sites had no planning information available online, indicating early project planning stages. At least 13 pre-screening applications were identified.	72	1,877 MW
Abandoned	3 sites, totalling 13 MW sites have been assumed to be abandoned and 6 sites totalling 97 MW were refused or have withdrawn their planning application, and have therefore not been modelled to connect.	9	110 MW

Planning Logic and Assumptions (percentage of projects modelled to come online)

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

Scenario	Planning Granted or Under Construction	Planning Application Submitted	Pre-planning	No information	Years from Planning Submitted to completion
Falling Short	100%	50%	Removed from analysis	Removed from analysis	2-9 years
System Transformation	100%	75%	25%	Removed from analysis	1-9 years
Consumer Transformation	100%	75%	25%	Removed from analysis	1-9 years
Leading the Way	100%	90%	50%	40%	1-7 years

Repowering

From the mid-2030s onwards, existing baseline sites begin to repower their site capacity. The modelling accounts for the possibility of new upgraded solar panels as well as the extension of existing sites. Several legacy solar farms have been modelled to repower in the early-2040s, resulting in a late surge of increased capacity at existing sites.

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 repower.

	Falling Short	System Transformation	Consumer Transformation	Leading the Way
Year delay	--	25		
Repowering	--	+25%		+50%
Added capacity (GW)	--	0.5		1

Scenario projections (2030 to 2050)			
Scenario	**Description**	**Capacity by 2035**	**Capacity by 2050**
Falling Short	Whilst still representing a significant increase from the baseline with 5 GW of capacity by 2050, slower progress towards decarbonisation targets is made under this scenario. Solar PV business models remain limited as developers focus on regions with higher solar irradiance. There are fewer opportunities for co-location, leading to less investment in new solar projects overall.	4,487 MW	5,045 MW
System Transformation	There is significant growth in both scenarios, seeing a similar amount of uptake, reaching as much as 5.5 GW by 2035 – an increase of c. 1.2 GW by this same year compared to DFES 2021. This increase is justified by a larger development pipeline, which sees post-pipeline projections out to 2050 starting from a higher position. The effect of this is a shifting of projections to earlier years to meet decarbonisation targets faster, while less growth is seen in later years. Repowering of old sites contributes to additional solar PV capacity coming online in the 2040s.	5,413 MW	6,128 MW
Consumer Transformation		5,497 MW	6,213 MW
Leading the Way	As with other net zero scenarios, projections are increased in the medium term, considering that most sites with planning evidence are built, regardless of current local planning regimes. In the late-2030s, this scenario also sees a continued ambitious deployment of large-scale solar farms, exploiting higher-performance solar technology and the potential for new business models from co-location with electricity storage and hydrogen electrolysis. Approaching the mid-2040s, projections start to taper off as it is assumed that distributed solar capacity reaches its full economic and technical potential in the licence area.	6,301 MW	7,462 MW

Reconciliation with National Grid FES 2022

Modelling Stage	Reconciliation
Baseline	The DFES 2022 baseline of 1,975 MW is comparable to the FES baseline of 1,954 MW.
Pipeline	The DFES 2022 pipeline deviates from the FES 2022 immediately under **Leading the Way** and from 2024 onwards in **System Transformation** and **Consumer Transformation** and **Falling Short**. This is justified by the significant connection pipeline seen in the DFES data and the analysis method applied to identify sites that will likely be commissioned in the near term out to the late 2020s.
Projections	**Falling Short** deviates more strongly from the FES than DFES 2021, reflecting a more optimistic view of the lowest ambition scenario, primarily related to a significant number of pipeline sites that have granted planning applications, indicating strong demand from developers and a growing industry in all futures. Post-pipeline solar buildout under **Consumer Transformation** and **System Transformation** levels out, whereas the FES 2022 scenarios see more linear growth. Figures by 2050 deviate by c. 1 GW under these two scenarios. Under **Leading the Way**, overall projection trends align with FES 2022 until the late 2030s, where the DFES sees an acceleration as projections meet national UK solar deployment targets by 2050.
Overarching Trend	The main trend in the DFES followed a more stepped approach, simulating a near-term uptick in growth with periods of flattening out, based on evidence of known projects seeking to connect in the near term and considerations around network capacity saturation. This contrasts with the FES, which sees a more steady, linear growth to 2050.

Geographical Factors affecting deployment at a local level

Geographical Factors	Description
Unconstrained solar resource	Regen's in-house solar resource assessment considers solar irradiance/resource, land availability and planning constraints in the licence area.
Climate score cards[viii]	Local ambition, reflecting the local authority policy landscape and proclivity to renewable energy deployment and net zero goals.
Renewable Energy Planning Database	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 2022

Scenario		4.2.15 - 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 webinar events, stakeholders were asked whether small-scale distributed solar, large-scale distributed solar, or transmission projects would be more prominent in the licence area. Responses were spread, with the highest average response for transmission-scale projects being more likely, followed closely by large-scale distribution-connected projects. When asked how important batteries are for enabling solar PV development, stakeholders generally responded that it was a very important factor. This was also the case when we isolated responses from renewable energy developers.	The responses indicated a spread of views around the types of solar business models likely to be commissioned in the coming years. The DFES 2022 has modelled various possible uptake trends across the four scenarios, modelling **Leading the Way** as having a higher connected capacity than **System Transformation**. This assumes that transmission-scale projects take up a larger proportion of total commissioned solar projects in Southern England under **System Transformation**. In response to views that storage is an important factor for unlocking solar generation, the analysis has assessed the presence of co-located solar and battery projects in the licence area and has considered large-scale solar as a geographical distribution factor for the co-location of storage as a specific business model for battery projects.
Solar Developers were contacted by email and phone to supplement desk-based research on progress with planning applications and the expected commissioning years of individual projects.	Feedback from developers was incorporated into the 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.

[i] 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/
[ii] NREL n.d., *Best Research-Cell Efficiency Chart* https://www.nrel.gov/pv/cell-efficiency.html
[iii] 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
[iv] UK Government 2022, *British Energy Security Strategy.* https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy#renewables
[v] Hampshire Live 2021, *Backlash over Fareham Solar panel farm project that would see 84 HGV trips a day* https://www.hampshirelive.news/news/hampshire-news/backlash-over-fareham-solar-panel-6362119
[vi] Renewable Energy Planning Database https://www.gov.uk/government/publications/renewable-energy-planning-database-monthly-extract
[vii] https://lhpc.org.uk/three-maid-hill-solar-farm-installation-of-connection-to-the-substation-off-stockbridge-road
[viii] Council Climate Plan Scorecards 2022, https://councilclimatescorecards.uk/

Small-scale solar PV

Summary of modelling assumptions and results

Technology specification

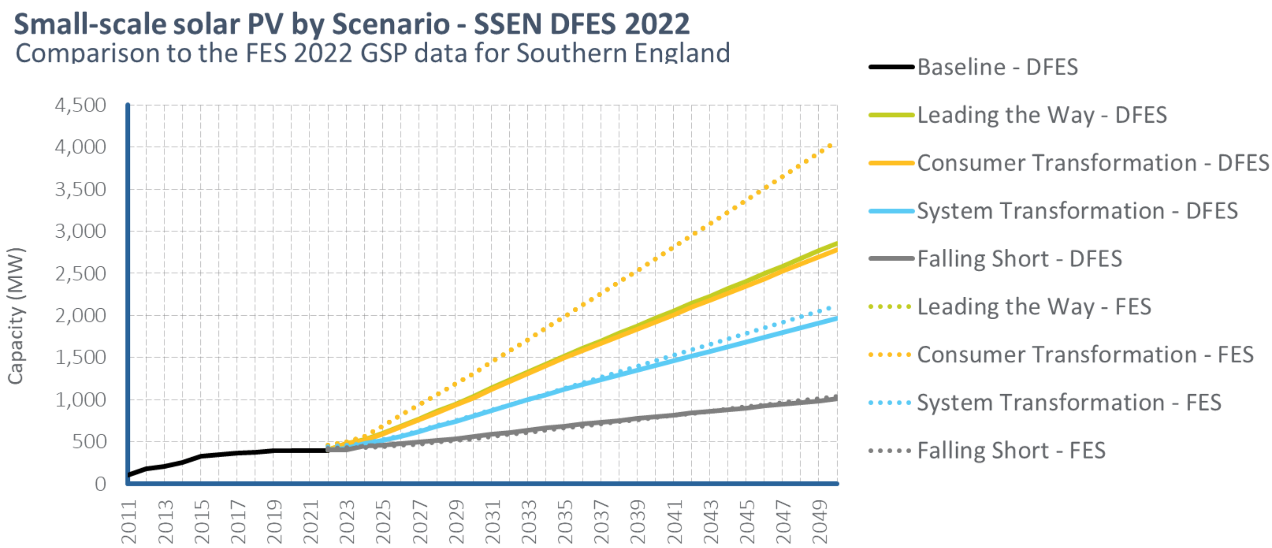
The analysis covers any solar generation sites of installed capacity less than 1 MW connecting to the distribution network in the Southern England licence area.

- 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 capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Domestic (<10 kW)	Falling Short	264	284	370	473	565	654	742
	System Transformation		323	560	829	1,063	1,291	1,516
	Consumer Transformation		380	737	1,128	1,476	1,827	2,178
	Leading the Way		384	754	1,150	1,519	1,885	2,252
Commercial (10 kW – 1 MW)	Falling Short	132	176	191	211	230	248	265
	System Transformation		190	240	293	345	396	447
	Consumer Transformation		211	287	366	445	525	604
	Leading the Way		211	287	366	445	525	604

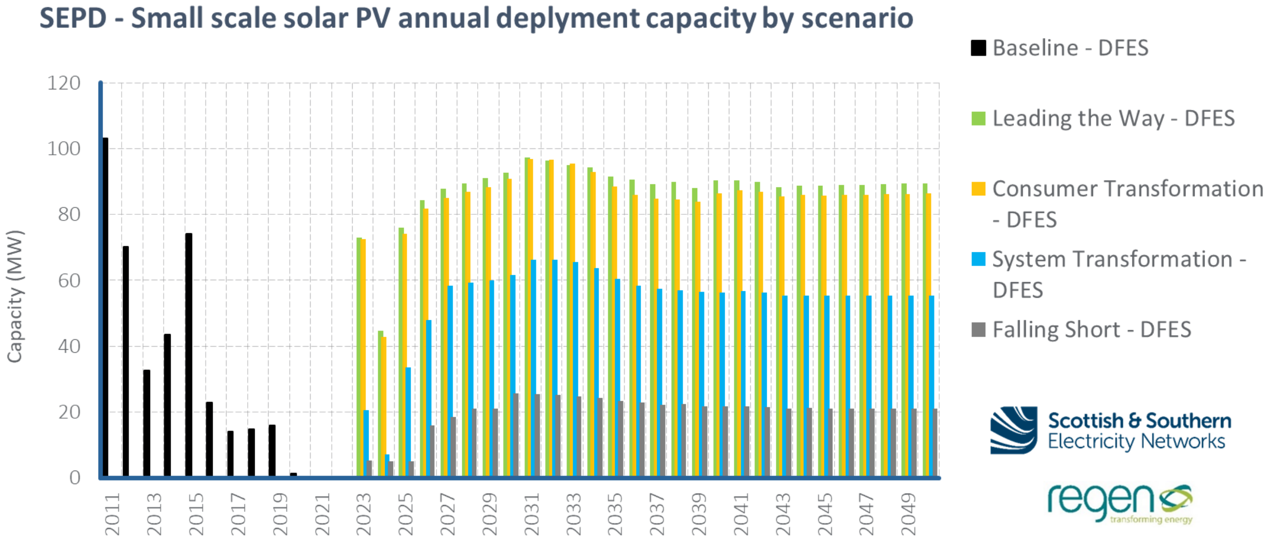
Figure 15: Small-scale solar PV projections for the Southern England licence area, compared to National Grid FES 2022 regional projections



Summary

- Domestic-scale solar PV in the Southern England licence area has historically seen uptake levels in line with the national average, despite having higher irradiance levels than the rest of the country. Historical deployment is characterised by particularly high rates in the early years of the Feed-in Tariff and subsequently stalled following the scheme's closure.
- While the current baseline now stands at 396 MW, whereas DFES 2021 had estimated 365 MW, these figures are not directly comparable. Therefore, an updated method of considering connections data and Feed-in Tariff data at the ESA level has been included in this year's baseline analysis.
- The trajectory for small-scale solar in the near term may depend strongly on the uptake of the Smart Export Guarantee[i], the attractiveness of rooftop solar for homeowners regarding installation costs, and savings from reduced wholesale electricity consumption.
- There is evidence that rooftop installations, especially on commercial premises, are undergoing a surge in demand, with developers highlighting a significant increase in demand for 0.05 – 0.15 MW commercial systems, retailers and trade bodies highlighting surging sales and installations.[ii] This could relate to businesses seeking to reduce their electricity imports and reduce exposure to very high electricity costs.
- Future deployment of small-scale solar varies strongly by scenario. Under **Consumer Transformation** and **Leading the Way**, as the scenarios reflecting the highest decarbonisation ambition, high electrified transport and heating levels drive small-scale solar uptake. In **Leading the Way**, 2.3 GW of domestic and 604 MW of commercial solar PV is deployed by 2050 – nearly six times today's connected capacity.
- Despite being a scenario with lower levels of electrification, **System Transformation** still sees high deployment levels, reaching four times today's level by 2050. Reducing costs and uptake of electric vehicles drives solar PV uptake under every scenario.
- **Falling Short** sees relatively low deployment, with annual growth remaining at the levels seen since the end of the Feed in Tariff and 2050 deployment reaching 1 GW.

Figure 16: Annual small-scale solar PV projections for the Southern England licence area scenarios relative to the baseline annual deployment rate



Modelling and assumptions

Baseline (2021)		
Scale	**Capacity**	**Description**
Domestic (<10 kW)	264 MW	There are 264 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%. Around 85% of these installations occurred between 2010 and 2015, supported by the Feed-in Tariff (FiT). The installation rate for rooftop solar in the licence area peaked at 80 MW installed in 2012. Deployment slowed notably as the FiT reduced and came to an end. To date, the Smart Export Guarantee has not significantly increased small-scale solar PV deployment beyond the levels seen after the closure of the FiT in 2015. This represents a marginal decrease from the 273 MW DFES 2021 baseline due to the updated baseline methodology used in DFES 2022.
Commercial (10 kW – 1 MW)	132 MW	There are 132 MW of commercial rooftop PV baseline in the Southern England Licence area. As per domestic-scale installations, the FiT supported this deployment, and development has equivalently tailed off since 2016. This baseline is significantly higher than the 92 MW recorded in DFES 2021. Where previously, FiT data was used to evidence pre-2015 deployment only, after which connections data was considered, DFES 2022 now uses a layered method, considering both datasets through the entire baseline period. A resultant maximum annual deployment on each ESA is taken forward into the baseline summation.

Pipeline (2022-2030)	
There are 297 sites totalling 55 MW with accepted or quoted connection offers in the licence area. These are **all commercial scale (10 kW – 1 MW) solar arrays**.	
Contracted	227 sites, totalling 42 MW of capacity, have accepted connection agreements in the Southern England licence area. All sites with accepted connection offers are modelled to connect in all scenarios. This is assumed to happen by 2023 under **Leading the Way** and **Consumer Transformation**, by 2024 under **System Transformation**, and by 2025 under **Falling Short**.
Quote Issued	70 sites, totalling 13 MW, have a connection quote issued, which have not yet been accepted. These sites are modelled to connect by 2024 under **Leading the Way**, **Consumer Transformation** and **System Transformation**. None of these sites are modelled to connect under **Falling Short**.

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. Currently, around 10% of recently built homes in England have been built with rooftop solar PV installed[iii]. This proportion of homes with rooftop solar is anticipated to increase as changes to Building Regulations (Part L)[iv] 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.

Under **Consumer Transformation** and **Leading the Way**, deployment of rooftop solar on new-build homes increases to half of all new homes by 2050. However, deployment remains lower at 30% and 20% of new homes under **System Transformation** and **Falling Short**, respectively.

Scenario	The proportion of new-build homes with rooftop solar PV		
	2025	2030	2050
Falling Short	6%	8%	20%
System Transformation	10%	20%	30%
Consumer Transformation	15%	30%	50%
Leading the Way			

Scenario Projections

Beyond the near term, small-scale solar PV uptake depends strongly on national trajectories and less on licence area-specific factors.

While the Southern England licence area has amongst the highest irradiance levels in the UK, the evidence from the baseline (where historic uptake is in line with the overall GB trajectory) suggests the licence area will remain aligned with national deployment trends in the medium term. In addition to solar irradiances, social housing, affluence and available roof space were also considered to inform scenario projections.

Beyond 2030, the volume of new housing developments is expected to reduce. Therefore, the impact of solar PV on new build housing resultantly decreases over time.

In line with the FES 2022, the overall scenario trends established in the medium term continue to 2050, with annual deployment rates remaining relatively constant between 2026 and 2050.

There is a reduction in 2050 projections relative to DFES 2021, resulting from the updated method to determine new housing developments. This updated method has produced scenario-specific projections for new homes that are universally lower than the DFES 2021 new build projections. The resultant loss of projected domestic PV capacity is more significant in **Leading the Way** and **Consumer Transformation** – scenarios which assume higher percentages of new builds with solar PV. Small-scale solar capacity reaches c. 2.8 GW under **Leading the Way** and c. 1 GW under **Falling Short**.

Scenario	Description	Capacity by 2035	Capacity by 2050
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 GW by 2050. The DFES 2022 projection is 42 MW lower in 2050 than in DFES 2021.	684 MW	1,007 MW

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 capa city reaches just under 2 GW by 2050. This is a 107 MW lower projection than given in DFES 2021.	1,123 MW	1,963 MW
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 2.8 GW under **Leading the Way**. These projections are 163 MW and 89 MW (respectively) lower than those seen in the DFES 2021 equivalents.	1,494 MW	2,782 MW
Leading the Way		1,516 MW	2,856 MW

Reconciliation with National Grid FES 2022

Modelling Stage	Reconciliation
Baseline	The updated DFES 2022 baseline aligns closely with the FES 2022 baseline.
Projections	The DFES 2022, **Falling Short** and **System Transformation** scenarios align strongly with FES 2021 projections for the licence area throughout the projection period. The DFES 2022 **Consumer Transformation** and **Leading the Way** scenarios are lower than those in the FES 2022. The DFES modelling for these scenarios results in a deployment rate similar to the early years of the Feed-in Tariff, where payments were well above the retail price of electricity for domestic customers[v]. 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 2022. 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 2022 equivalents, based on a difference in assumptions.

Geographical Factors affecting deployment at a local level

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 580,000 new homes are projected to be built in the licence area between now and 2050. In **Consumer Transformation** (the highest deployment scenario), 50% of the new build homes could have a total of 630 MW 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 2022

Scenario		4.1.5 – Solar generation (plant smaller than 1MW)
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	High	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

Stakeholder feedback provided	How this has influenced our analysis
The DFES team engaged solar developers AbSolar on their commercial scale sites, enabling the analysis to reflect their build-out estimates in the scenarios.	The DFES team engaged solar developers AbSolar on their commercial scale sites, enabling the analysis to reflect their build-out estimates in the scenarios. AbSolar identified the G99 process as their main source of delay in bringing their sites through to connection; this has been considered a broader influencing factor for delayed uptake under **Falling Short**. AbSolar also stressed the high demand they were experiencing for 0.05 – 0.15 MW systems for commercial rooftops, which indicates the current appetite for commercial solar deployment, reflecting the cost of living crisis and the very high electricity prices that are affecting businesses.

[i] Ofgem, 2022, *Smart Export Guarantee.* https://www.ofgem.gov.uk/environmental-and-socialschemes/smart-export-guarantee-seg
[ii] Business Green, 2023, *"Solar industry celebrates spectacular surge…"* https://www.businessgreen.com/news/4076504/solar-industry-celebrates-spectacular-surge-rooftop-installations
[iii] Solar Energy UK, 2021, *Future homes are solar homes.* https://solarenergyuk.org/future-homes-are-solar-homes/
[iv] UK government, 2023, *Conservation of fuel and power, Approved Document L.* https://www.gov.uk/government/publications/conservation-of-fuel-and-power-approved-document-l
[v] 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 any hydropower generation connecting to the distribution network in the Southern England licence area.

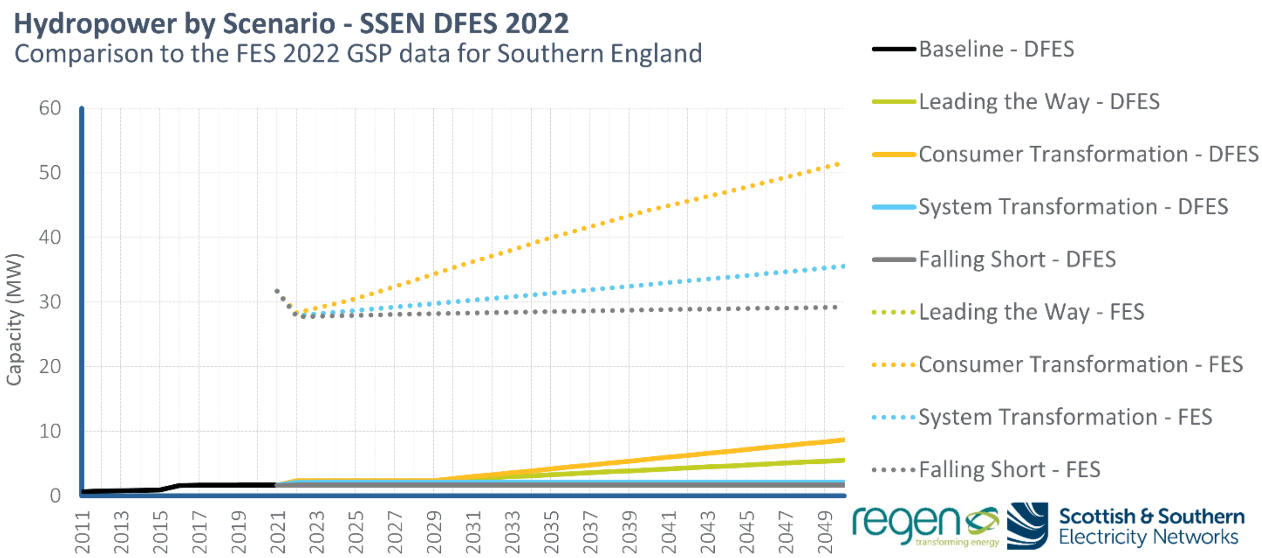
The analysis does not include pumped hydropower, which is considered an energy storage technology.

Network technology data 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	4.2	5.7	7.2	8.7
Leading the Way		2.4	2.5	3.3	4.0	4.8	5.5

Figure 17: Hydropower projections for the Southern England licence area, compared to National Grid FES 2022 regional projections



Summary

- The Southern England licence area has very low levels of hydropower resource and historical deployment.
- As a result, connected capacity currently only totals 1.7 MW across 52 sites. The average capacity for hydropower sites in the licence area baseline sites is resultantly 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[i] 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.
- 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.
- Small-scale sites are seeing continued efficiency improvements as technology increases, and the possibility of a co-located battery could increase their economic viability[ii].
- As a result, a moderate level of additional distributed hydropower capacity has been modelled under the **Consumer Transformation** scenario, totalling c. 11 MW by 2050.
- In contrast, no new development has been modelled under **Falling Short**; this reflects higher abstraction licence costs that came into force in 2022[iii] and reduced policy support for small-scale renewables.

Modelling and assumptions

Baseline (2021)

Scale	Number of Sites	Total Capacity	Description
Total	52	1.67 MW	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. The DFES 2022 baseline data differs from the DFES 2021 by 0.1 MW, likely due to the classification of Feed-in Tariff site data rather than any newly commissioned sites.

Pipeline (2022-2030)

Number of pipeline sites	Total capacity
3	711 kW

Pipeline analysis

Status	Description	Sites	Capacity
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** and **Leading the Way**, but not **System Transformation** or **Falling Short**, as the project could extend the connection to meet future energy needs.	2	427 kW

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.	1	284 kW

Planning Logic and Assumptions (percentage of capacity modelled to come online)

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

Scenario	Operational	Planning granted
Falling Short	Not modelled to come online	Not modelled to come online
System Transformation	The added capacity site was modelled as operating at capacity; however, the test site was not modelled in this scenario.	Not modelled to come online
Consumer Transformation	Initial year of pipeline	Five years
Leading the Way	Initial year of pipeline	Six years

Scenario projections (2030 to 2050)

Scenario	Description	Capacity by 2035	Capacity by 2050
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 MW	1.7 MW
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[iv].	2.1 MW	2.1 MW
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. Favourable government policies and support for small-scale renewable energy projects unlock sector growth.	4.2 MW	8.7 MW

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 2021.	3.3 MW	5.5 MW

Reconciliation with National Grid FES 2022

Modelling Stage	Reconciliation
Baseline	The FES 2022 has 32 MW of hydropower capacity as a baseline, compared to the 1.7 MW from the DFES 2022 baseline. This significant difference is also considerably higher than the FES 2021 baseline of 2.8 MW. The FES references SSEN's Embedded Capacity Register for baseline data, which is prone to errors in technology type allocation. In contrast, the DFES analysis entails a more in-depth assessment of live connection registers held by SSEN's network planning teams. Upon investigation, the DFES team has confirmed that the SSEN Embedded Capacity Register incorrectly labelled four sites with a combined capacity of 29 MW as hydropower when downloaded in January 2023.
Pipeline	The FES 2022 shows an immediate decrease in 2 MW of hydropower across all scenarios within the first year of the pipeline; the reason for this is unknown. After the initial drop, **Consumer Transformation** increases by c. 1 MW per year in the near term in the FES 2022, compared to a slower rate of uptake in the DFES.
Projections	Under FES 2022, **Falling Short** shows limited growth to 2050, which is in line with the DFES 2022, despite the discrepancy in the baseline. The steady 1 MW growth per year in the FES 2022 **Consumer Transformation** scenario is mirrored in DFES 2022. **System Transformation** and **Leading the Way** scenarios are projected along the same path in the FES 2022. However, the DFES 2022 **Leading the Way** scenario puts more emphasis on small-scale projects contributing to achieving net zero. Thus it deviates from the **System Transformation** in the late-term projections.
Overarching Trend	Beyond the baseline variance and near-term projections, the trends of the DFES and FES 2022 projections align well across the four scenarios.

Geographical Factors affecting deployment at a local level

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 2022

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
British Hydropower Association was contacted 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.

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[i] Project LEO 2017, *Sandford Hydro trials.* https://project-leo.co.uk/case-studies/sandford-hydro-trials/
[ii] British Hydro Association 2022, *UK Hydropower Resource Assessment.* https://zenodo.org/record/7229023/files/BHA%20report%20draft%20v1.0.2.pdf?download=1
[iii] Environmental Agency 2022, *Environmental permits and abstraction licences: tables of charges.* https://www.gov.uk/government/publications/environmental-permits-and-abstraction-licences-tables-of-charges
[iv] 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 predominantly on known small-scale project developments, supplemented by engagement with the European Marine Energy Centre (EMEC) to identify potential pipeline projects that will likely connect to the distribution network out to 2050. If the technology proves successful at a commercial scale, additional marine generation capacity could connect to the transmission network.

The technologies included in the DFES marine energy analysis are:

• **Wave energy** – typically connected to the distribution network as small pre-commercial arrays and demonstration projects.

• **Tidal stream energy** – harnessing kinetic tidal flows around headlands and in channels.

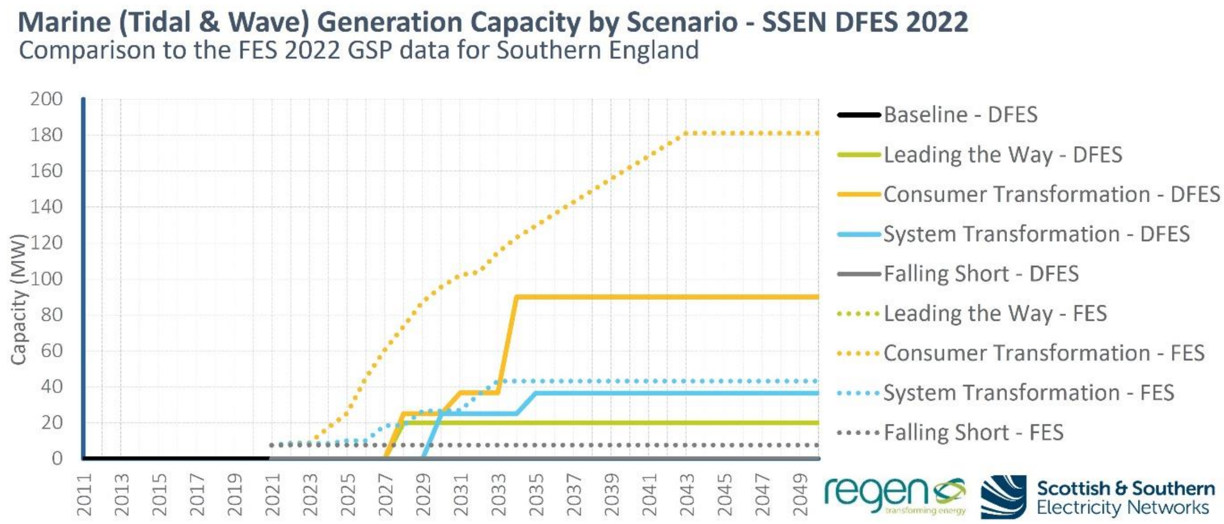
Note: there are no tidal lagoon projects in the licence area, but these would connect at transmission network level.

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	25	37	37	37	37
Consumer Transformation		0	25	90	90	90	90
Leading the Way		0	20	20	20	20	20

Figure 18: Marine generation projections for the Southern England licence area, compared to National Grid FES 2022 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 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.
- In July 2022, the results of the Contracts for Difference (CfD) Allocation Round 4 (AR4) were announced, which included a ring-fenced budget of £20m for tidal stream[i]. This has reignited activity within the marine generation industry, but further development will depend on continued policy support and the industry's ability to reduce technology costs.
- Over 40 MW of projects succeeded in winning their first CfD at a strike price of £178.54/MWh (15% lower than the administrative strike price of £211/MWh). OMP submitted a joint application with PTEC into the CfD AR4 that was unsuccessful,[ii] but OMP and PTEC are preparing to bid into CfD AR5 and future rounds[iii].
- As the tidal stream sector expands, larger-scale projects are expected to connect to the transmission network. However, distribution network-connected projects will likely be limited to smaller-scale commercial projects, demonstration projects, trial sites and testing facilities.
- The wave energy industry is yet to demonstrate a commercially viable technology, but it could see significant scaling once it does.

Modelling and assumptions

Baseline (2021)	
Number of Sites	**Total Capacity**
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Pipeline (2022-2030)	
Number of pipeline sites	**Total Capacity**
1	32 MW

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[iv]. 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[v]. Modelled commissioning timelines are: Phase 1 (20 MW) is modelled to connect in 2028 in **Leading the Way** and **Consumer Transformation** and 2030 in **System Transformation**. Phase 2 (32 MW total capacity) connects in 2031 under **Consumer Transformation** and 2035 under **System Transformation**.

Scenario Projections (2030 to 2050)			
Scenario	Description	Capacity by 2035	Capacity by 2050
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 MW	0 MW
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 and grid connection at Yarmouth, Isle of Wight (5MW). Yarmouth Tidal Test Centre is a site developed by QED Naval Ltd in collaboration with Yarmouth Harbour Commission. As part of the TIGER project, QED is completing the design, engineering and procurement of their next-generation Subhub technology (Gen-02) at an industrial scale before using this variant in their first commercial project of 3-5 MW[vi,vii].	37 MW	37 MW
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. PTEC expands further to c. 85 MW.	90 MW	90 MW
Leading the Way	Prioritising solar and wind generation technologies reduces the need for tidal energy. As a result, only PTEC's 20 MW phase development on the Isle of Wight is modelled to connect.	20 MW	20 MW

Reconciliation with National Grid FES 2022

Modelling Stage	Reconciliation
Baseline	The FES 2022 baseline is 8 MW, compared to a zero baseline in the DFES 2022. 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 baseline figure originates from.
Pipeline	The FES 2022 shows a much faster rise in capacity than DFES 2022, particularly in Leading the Way and Consumer Transformation. Almost 60% of this expansion is connected to the Melksham GSP, which is not considered a connection point for marine projects. The remaining c. 40% of capacity is split between Chickerell and Fawley GSPs. Chickerell will likely connect to any tidal stream generation at Portland Bill, but the site is not currently being developed.
Projections	The FES 2022 projects increasing marine generation capacity out to 2043 under Leading the Way and Consumer Transformation, peaking at 181 MW – double the DFES 2022 Consumer Transformation projection. C. 60% (107 MW) of FES capacity is projected to be connected to the Melksham GSP, which is not considered a connection point for marine projects. In addition, c. 37 MW is to be connected to the Fawley GSP, which aligns with 32 MW at PTEC and 5 MW at Yarmouth, as per the DFES 2022 System Transformation scenario.

Overarching Trend	DFES 2022 projections for **System Transformation** and **Falling Short** are comparable to FES 2022 projections but project slightly lower and later development pipelines. FES 2022 projections for **Leading the Way** and **Consumer Transformation** are significantly higher in the FES 2022 than the DFES. A significant amount of capacity is projected to connect to GSPs are unlikely for marine generation sites.

Geographical Factors affecting deployment at a local level

Geographical Factors	Description
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 2022

Scenario		4.1.2 - Other renewables including marine and hydro generation
Falling Short	Low	Low support and therefore other renewables cannot complete 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 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 and the marine energy development sector were engaged.	Feedback provided was used to inform the scenario projections.

[i] UK Government 2022, *Contracts for Difference (CfD) Allocation Round 4: results.* https://www.gov.uk/government/publications/contracts-for-difference-cfd-allocation-round-4-results
[ii] Current 2021, *Orbital Marine Power confirms applications into the CfD*. https://www.current-news.co.uk/orbital-marine-power-confirms-applications-into-the-cfd/
[iii] Perpetuus Tidal Energy Centre n.d., *Timeline.* https://perpetuustidal.com/the-project-to-date/timeline/
[iv] 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/
[v] Perpetuus Tidal Energy Centre n.d., *Partners.* https://perpetuustidal.com/partners/
[vi] QED Naval Limited n.d., *Our Projects.* https://qednaval.co.uk/projects/#tiger
[vii] The Crown Estate n.d., *Archived Notes.* https://www.thecrownestate.co.uk/en-gb/media-and-insights/seabed-and-coastal-notices/archived-notices/

Biomass generation

Summary of modelling assumptions and results

Technology specification

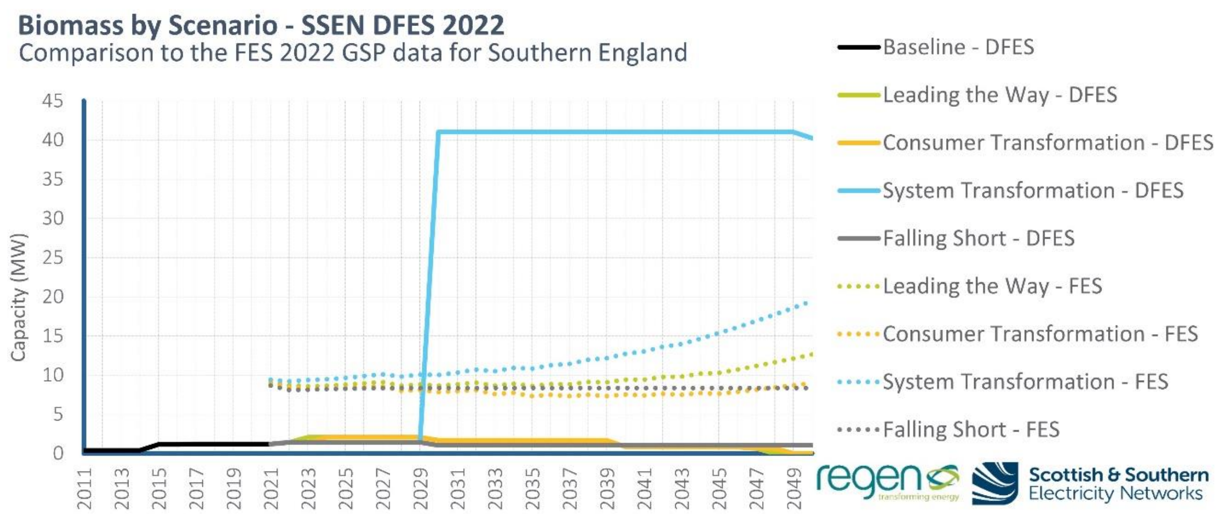
The analysis covers biomass-fuelled generation connecting to the distribution network in the Southern England licence area. This includes both biomass for power generation and biomass CHP. However, the analysis does not include biomass used solely for heat or bioenergy generation with carbon capture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

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

Data summary for offshore wind in the Southern England licence area

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	1	1	1	1	1	1	1
System Transformation		1	41	41	41	41	40
Consumer Transformation		2	2	2	1	1	0
Leading the Way		2	2	2	1	1	0

Figure 19: Biomass generation projections for the Southern England licence area, compared to National Grid FES 2022 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.
- 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[i].
- The National Grid ESO FES 2022 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 2022 has adopted this assumption for the Southern England licence area in the relevant scenarios.
- Under the UK Biomass Policy Statement[ii], 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 to consult on the removal of the 300 MW threshold for Carbon Capture Readiness requirements. If this removal goes through, small-scale distributed biomass as a business model will become increasingly challenging without further subsidy support.
- **Leading the Way** and **Consumer Transformation** see only small pipeline sites connecting to the distribution network before all sites disconnect to meet longer-term net zero targets.
- **Falling Short** remains stagnant, with no new sites connecting.
- **System Transformation** is the only scenario to see growth in new biomass generation capacity at the proposed Southampton biomass site, related to setbacks in planning for this development.

Modelling and assumptions

Baseline (2021)		
Number of Sites	**Total Capacity**	**Description**
3	1.2 MW	Biomass baseline capacity has increased since DFES 2021 due to more information enabling a reclassification of the SCA Waste Paper site in Basingstoke that was previously marked as 'Other generation'. Additionally, a 389 kW site at Four Dell Farm in Winchester was identified in planning and is assumed to be operational since planning was granted in 2016.

Pipeline (2022-2030)	
Number of pipeline sites	**Total capacity**
2	832 kW
There are two biomass generation sites included in the analysis. A 632 kW site in south Somerset has secured a connection agreement with SSEN, and another 200 kW site at Hillbury House in Wiltshire was identified in the Renewable Energy Planning Database (REPD). The latter was found to have granted planning permission and is modelled to come online in all scenarios. In contrast, the former had no planning evidence and was thus modelled to connect in less ambitious scenarios.	

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. As a result, under **Falling Short**, existing sites stay online well past the 2050 target for a net zero electricity system.			
Falling Short	**System Transformation**	**Consumer Transformation**	**Leading the Way**
50 years	35 years	25 years	25 years

<table>
<tr><th colspan="4">Scenario Projections (2030 to 2050)</th></tr>
<tr><th>Scenario</th><th>Description</th><th>Capacity by 2035</th><th>Capacity by 2050</th></tr>
<tr><td>Falling Short</td><td rowspan="4">Biomass capacity remains next to nothing under all scenarios except System Transformation, under which a 40 MW site at the formerly proposed Southampton[iii] biomass facility is modelled to come online to reflect past developer interest in the area.

The DFES decommissions existing biomass in the net zero scenarios over the period out 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 Leading the Way, there is no operational biomass-fuelled electricity generation in the licence area by 2050.</td><td>1 MW</td><td>1 MW</td></tr>
<tr><td>System Transformation</td><td>41 MW</td><td>40 MW</td></tr>
<tr><td>Consumer Transformation</td><td>2 MW</td><td>0 MW</td></tr>
<tr><td>Leading the Way</td><td>2 MW</td><td>0 MW</td></tr>
</table>

Reconciliation with National Grid FES 2022

Modelling Stage	Reconciliation
Baseline	The DFES 2022 baseline of 1 MW is lower than the FES baseline of 9 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 2022 pipeline is very small, and development is practically zero, which aligns with the FES 2022. However, this diverges in 2029 when a 40 MW site in Southampton is modelled to connect in the DFES under System Transformation, which is not reflected in the FES.
Projections	The FES 2022 models a slight increase in distributed biomass from the end of the 2040s. This differs from the DFES 2022, which focuses on decommissioning sites from 2030 to be in line with net zero targets.

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 2022

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 2022.	

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

[ii] 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

[iii] BBC News 2015, *Southampton and Avonmouth biomass plants shelved*. https://www.bbc.com/news/uk-england-32016109

Renewable engines

Summary of modelling assumptions and results

Technology specification

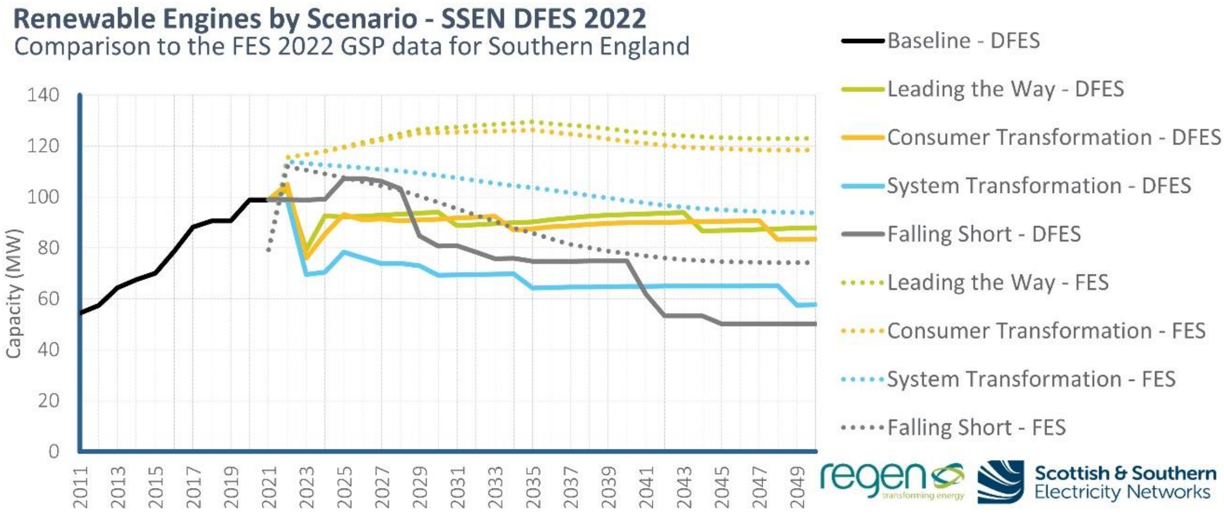
The analysis covers electricity generated from renewable engines connected to the distribution network in the Southern England licence area. This technology sector is broken down into three renewable gas generation sub-technologies: landfill gas, sewage gas and biogas from other anaerobic digestion (AD) (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.

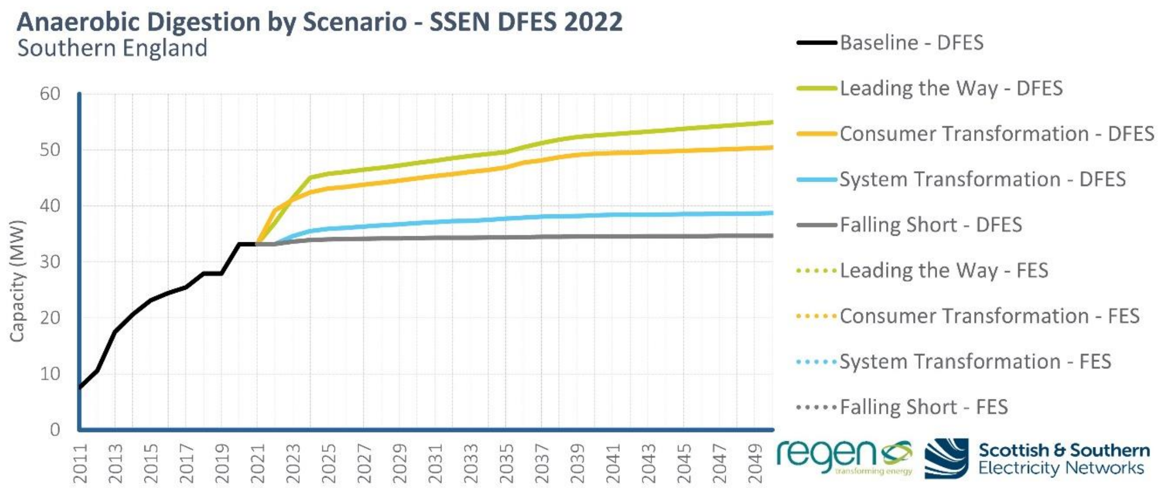
Technology building block: **Gen_BB004 – Renewable Engines (Landfill Gas, Sewage Gas, Biogas)**

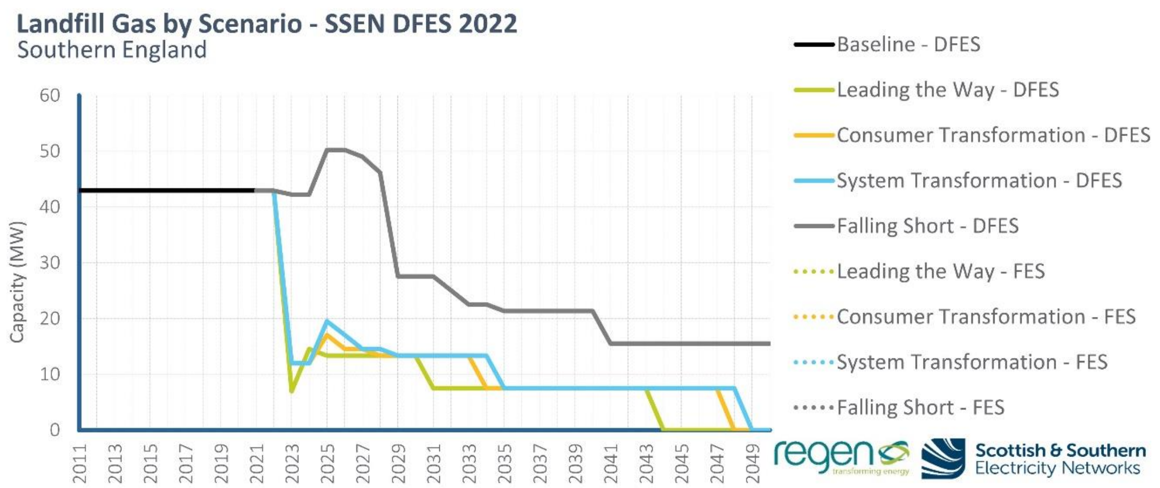
Data summary for renewable engines in the Southern England licence area

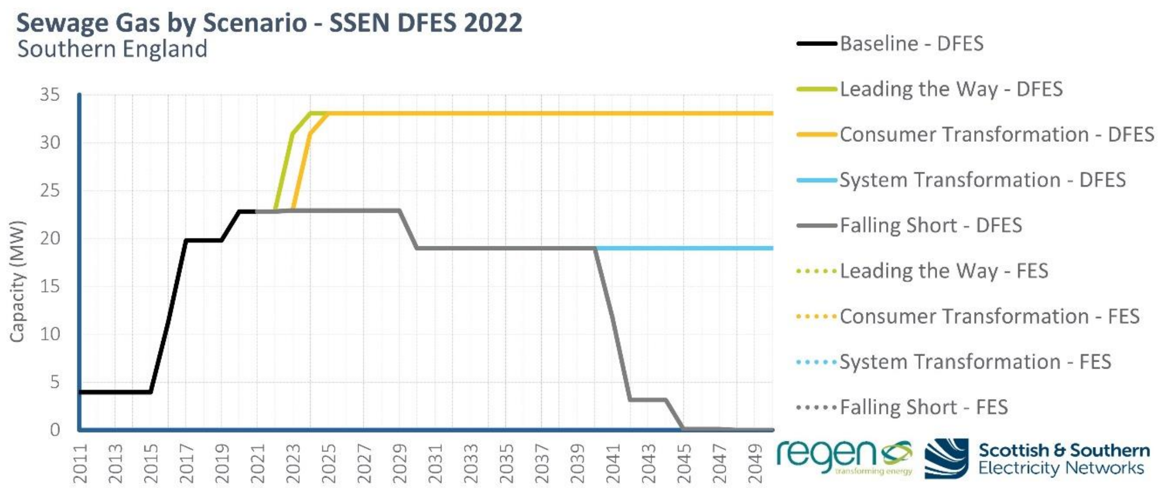
Technology	Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Renewable Engines	Falling Short	99	107	81	75	75	50	50
	System Transformation		78	69	64	65	65	58
	Consumer Transformation		93	91	87	90	90	83
	Leading the Way		92	94	90	93	87	88

Figure 20: Renewable Engines projections for the Southern England licence area, compared to National Grid FES 2022 regional projections







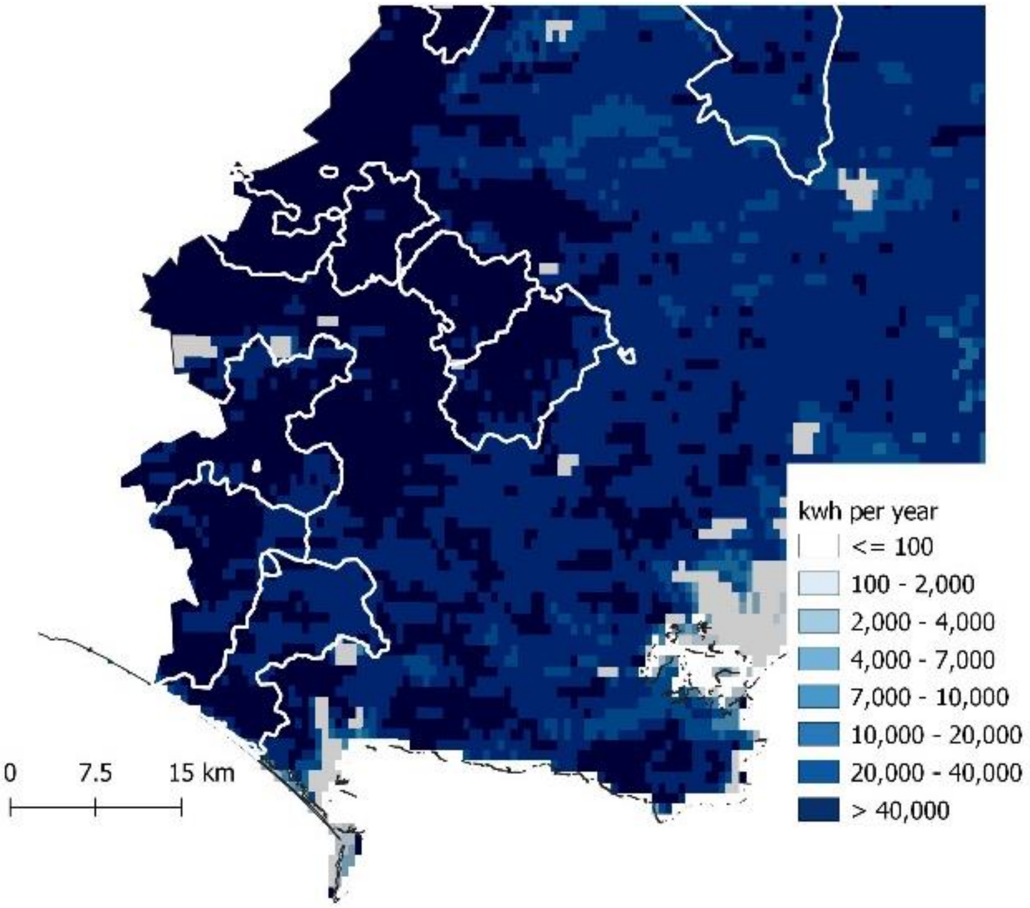


Summary

- As of the end of 2021, there was 99 MW of installed renewable engine capacity in the licence area, of which 33 MW was anaerobic digestion (AD), 43 MW was landfill gas, and 23 MW was sewage gas.
- 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 quite low, representing 2% of all viable high-grade agricultural land in GB.
- According to Regen's manure resource assessment analysis, there is a high concentration of resource in Dorset, Somerset and the Cotswolds. However, more analysis would be needed to discover how much of this potential is technically and economically recoverable.
- Landfill gas is expected to decrease over time as a legacy technology with limited lifetimes, and landfill sites are destined for natural restoration[i], leading to a gradual decommissioning of all sites by 2047 under all scenarios.
- Sewage gas remains at similar levels under net zero scenarios but is decommissioned over time under **Falling Short**.
- 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.
- The injection of green gas into the gas network is currently incentivised via the Green Gas Support Scheme[ii], funded through payments made by licenced gas suppliers under the Green Gas Levy. This may limit the amount of future electricity distribution network-connected sites.
- Under **Leading the Way** and **Consumer Transformation**, overall renewable engine capacity gradually decreases, reaching 88 and 83 MW respectively by 2050.
- The other two scenarios see some decommissioning of landfill gas without any significant replacement of this capacity with new AD sites, decreasing to 58 and 50 MW by 2050 under **System Transformation** and **Falling Short** respectively.

Figure 21: Anaerobic Digestion potential from animal manure in Dorset and Somerset.



Note: ESAs with the highest concentration of energy generation capacity from animal manure have been outlined in white.

Modelling and assumptions

Baseline (2021)		
Number of Sites	**Total Capacity**	**Description**
51	99 MW	The baseline consists of 99 MW from 51 sites, 33 MW of which is anaerobic digestion, 43 MW from landfill gas, and 23 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, anaerobic digestion capacity has grown steadily since pre-2010 to reach current levels. All landfill gas sites were connected prior to 2012, and 31 MW (72% of the landfill gas baseline) was commissioned in the 1990s.

Pipeline (2022-2030)	
Number of pipeline sites	**Total capacity**
8	34 MW
There are eight pipeline sites, across the three sub-technologies, in various stages of planning. Two sites were identified through analysis of the Renewable Energy Planning Database (REPD) and have not yet applied for a connection agreement with SSEN. It remains uncertain whether the two sites without connection offers will connect to the distribution network or operate as off-grid sites for on-site electricity generation or biofuel production facilities.	

Pipeline sites			
Status	**Description**	**Sites**	**Capacity**
Under Construction	A 2 MW site in Basingstoke has been identified in planning as being under construction. It is modelled only under **Leading the Way**, as it has not yet applied to SSEN for a grid connection.	1	2 MW
Planning Permission Granted	Three sites totalling 14 MW have been granted planning. The largest is a 7.5 MW landfill gas site at Fulscot Farm, which is modelled to go through in all scenarios. A 6 MW anaerobic digester at Sparsholt College[iii] has been delayed, as planning permission was granted in 2018, but the application has since been resubmitted. This site is only modelled to connect in **Consumer Transformation**. Finally, a 100 kW sewage site at Wargrave Sewage Treatment Works was granted permission in 2015 and has likely been commissioned but is too small to be reflected in available data. This site is modelled to connect in 2023 in all scenarios.	3	14 MW
Planning Application Submitted	Two sites with connection agreements were found to have been submitted in planning: one sewage gas CHP site at Berry Hill Sludge Treatment Centre[iv] (2.1 MW) and one anaerobic digester (550 kW) in Wiltshire.	1	3 MW
No information	No online or planning information could be attributed to the remaining two sites, totalling 15 MW. Only the landfill gas (8 MW) site was modelled to connect in **Falling Short**.	1	15 MW

Decommissioning Logic				
Landfill gas and sewage gas, in less ambitious scenarios, are modelled to disconnect after a certain timeframe, depending on the scenario. Anaerobic digestion is modelled to stay online in all scenarios. Landfill gas sites are modelled to decommission rapidly as a legacy technology, since waste management is expected to shift to incineration and Advanced Combustion Technologies (ACT).				
	Falling Short	**System Transformation**	**Consumer Transformation**	**Leading the Way**
Landfill gas	30 years	24 years	23 years	20 years
Sewage gas	25 years	35 years	--	--

Scenario Projections (2030 to 2050)

Anaerobic digestion 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 sites with high concentrations of animal husbandry and agricultural land that could produce manure and biogenic waste products as feedstocks. Since most councils already collect food waste, councils that have not yet implemented a food waste collection strategy are targeted. Capacity by 2050 reaches 88 MW under **Leading the Way**, as legacy landfill gas sites are replaced with new anaerobic digestion plants. **Falling Short** reflects a world where feedstocks remain limited and anaerobic digesters that commission are either off-grid or reserved for fuel production. Sewage gas sites are expected to remain at current levels under **Leading the Way** and **Consumer Transformation** but decommission at the end of their current operational lifetimes under **System Transformation** and more rapidly under **Falling Short**.

Scenario	Anaerobic digestion capacity by		Landfill gas capacity by		Sewage gas capacity by	
	2035	**2050**	**2035**	**2050**	**2035**	**2050**
Falling Short	34 MW	35 MW	21 MW	16 MW	19 MW	0 MW
System Transformation	38 MW	39 MW	8 MW	0 MW	19 MW	19 MW
Consumer Transformation	47 MW	50 MW	8 MW	0 MW	33 MW	33 MW
Leading the Way	50 MW	55 MW	8 MW	0 MW	33 MW	33 MW

Reconciliation with National Grid FES 2022

Modelling Stage	Reconciliation
Baseline	The FES 2022 baseline for the licence area (79 MW) does not align with the DFES 2022 baseline (99 MW). A sharp increase to 112-116 MW in 2022 in the FES suggests a near-term capacity uplift that is not evidenced in the DFES data. The reasons for this variance are unclear but could relate to the technology classification of thermal generation sites.
Pipeline	Projections in the DFES and FES in the 2020s are largely comparable, except for variances related to individual site commissioning and decommissioning under the DFES. For instance, legacy landfill sites are modelled to come offline under all scenarios in the early 2020s, whereas FES projections reflect a smoother decommissioning trend. A more gradual decline in capacity is also reflected in the FES in **Falling Short** and **System Transformation**.
Projections	By 2050, the DFES models less ambitious uptake in all scenarios due to the assumption that not all anaerobic digestion facilities connect to the distribution network to replace decommissioning landfill gas and sewage 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.
Regen manure feedstock resource assessment	The Regen in-house manure feedstock resource assessment uses a rasterised geospatial dataset[v] to estimate the density of livestock and manure produced in the licence area. Conversion factors[vi] are then used to estimate the theoretical potential energy produced in kWh.
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 2022

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
As part of the DFES analysis for new property developments, 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, only councils found to not yet collect food waste were included in the AD distribution, plus councils with high levels of agricultural land and animal husbandry.

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

[ii] 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

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

[iv] Daily Echo 2018, *Biogas plant in green belt would produce fuel from Bournemouth's sewage.* https://www.bournemouthecho.co.uk/news/16683934.biogas-plant-green-belt-produce-fuel-bournemouths-sewage/

[v] Harvard Dataverse 2010, *Gridded Livestock of the World database (GLW 3).* https://dataverse.harvard.edu/dataverse/glw

[vi] Scarlat et al 2018, *A spatial analysis of biogas potential from manure in Europe.* https://www.sciencedirect.com/science/article/pii/S1364032118304714

Waste-fuelled generation

Summary of modelling assumptions and results

Technology specification

The analysis covers all forms of electricity generation from waste, including both incinerators and Advanced Conversion Technologies 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

Technology	Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Incineration	Falling Short	126	236	330	314	264	224	224
	System Transformation		194	244	204	204	204	136
	Consumer Transformation		194	148	108	108	108	--
	Leading the Way		182	56	56	56	--	--
Advanced Conversion Technologies (ACT)	Falling Short	16	67	67	83	133	133	133
	System Transformation		72	138	138	138	138	138
	Consumer Transformation		72	138	138	138	138	178
	Leading the Way		72	138	138	138	138	138

Figure 22: Waste-fuelled generation projections for the Southern England licence area, compared to National Grid FES 2022 regional projections

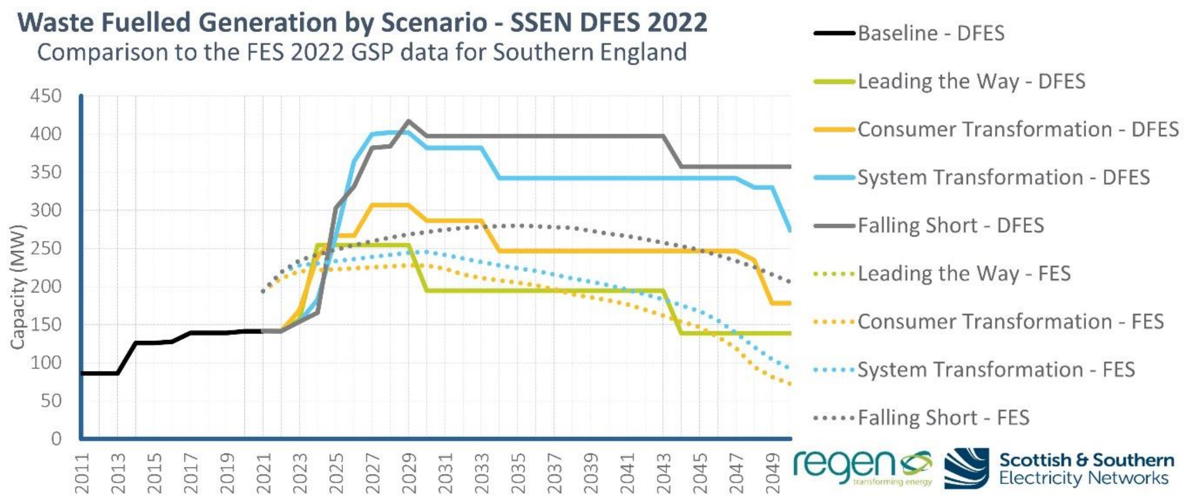
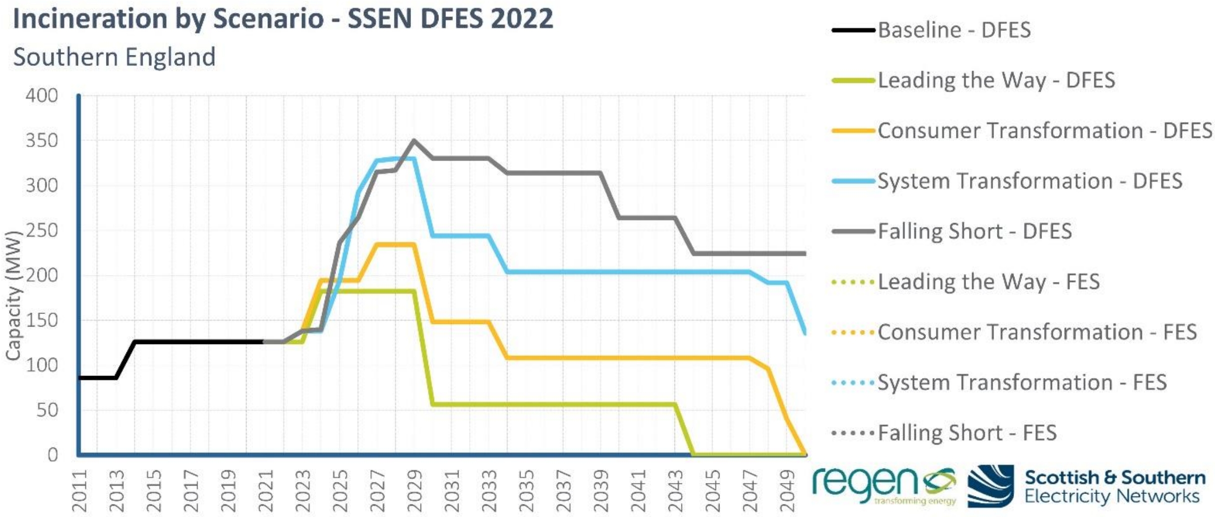
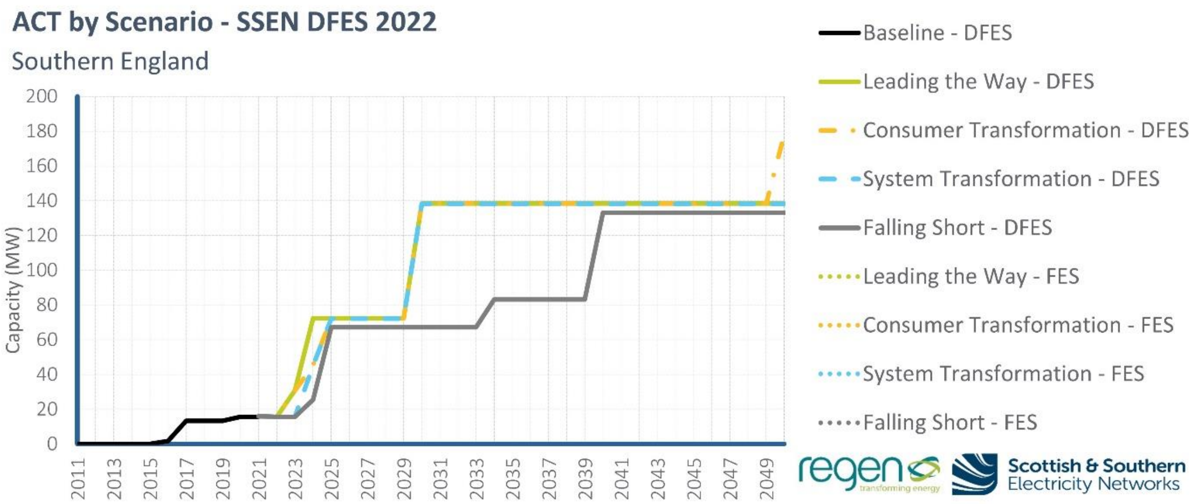


Figure 23: Waste-fuelled generation projections for the Southern England licence area, by subtechnology





Summary

- There is currently 139 MW of waste fuelled generation operating in the licence area, most of which is from incineration plants. There is a pipeline of 311 MW of potential additional waste fuelled generation, of which 216 MW is from incineration plants and 95 MW from ACT.
- The carbon emissions from older unabated waste incineration plants are inconsistent with net zero emissions targets. As a result, in the DFES 2021 scenarios that meet net-zero targets, it was assumed that connected incineration plant capacity reduces after 2030 as older facilities reach the end of their lifetime. Some of these sites were considered to be replaced with newer, lower-carbon ACT installations.
- Baseline incineration sites are modelled to decommission between 25 and 30 years after commissioning, depending on the scenario, with the first sites decommissioning from 2029 onwards. The planned commissioning of new incineration sites in the pipeline means some sites decommission quite late into the 2040s. Only new incineration sites with positive planning evidence are modelled to connect.
- Some capacity will be replaced by new ACTs, which is in line with emissions targets so long as residual emissions are abated. ACT technology is relatively new and expensive, and therefore growth is delayed to the 2030s and 2040s as costs are assumed to drop. Examples of ACTs include:

- Anaerobic digestion[26], 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 related to waste technology include the extent to which they are considered consistent with decarbonisation objectives, planning issues related to air quality and the volume of waste that could be reduced or recycled, and limited resources for future ACT sites. There is an additional uncertainty as to how much capacity will be distribution-network connected.
- By 2050, **Falling Short** is the highest scenario for waste fuelled generation, with 320 MW of installed capacity remaining in operation, with only one legacy incineration site modelled to disconnect. This is followed by **System Transformation** at 274 MW, reflecting a moderately higher level of decommissioning.
- **Consumer Transformation** and **Leading the Way** see lower levels of installed capacity by 2050 (216 MW and 176 MW respectively), 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 (2021)			
Sub-technology	**Number of Sites**	**Total Capacity**	**Description**
Total	7	142	Most baseline capacity is taken up by incineration sites that were operational before 2015, after which newer baseline sites coming online have all been smaller ACT plants.
Incineration	4	126	The oldest site in the licence area is the 20 MW Hilsea Incinerator at Fratton Park, which connected in 1999. In 2010, the Lakeside[i] energy from waste facility was commissioned, and it remains the largest baseline site at 50 MW. According to the developer, this site has held an export capacity agreement since 2010.
ACT	3	16	The first ACT site in the licence area was commissioned in 2016 at Charlton Lane Eco Park in Spelthorne (1.8 MW). This was followed in 2017 by the Park Grounds Farm ACT plant in Wootton Bassett (11.6 MW). The most recent connection was in 2022, an Amey Waste Recovery Park (2.2 MW)[ii] in Newport on the Isle of Wight.

Pipeline (2022-2030)		
Sub-technology	**Number of pipeline sites**	**Total capacity (MW)**
Total	16	311
Incineration	10	254
ACT	6	57
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.		

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

Pipeline analysis			
Status	**Description**	**Sites**	**Capacity**
Under Construction	One incineration site was identified as currently under construction in Slough (56 MW)[iii]. This site will re-purpose on-site natural gas turbines. It is modelled to come online by 2025 in all scenarios.	1	56 MW
Planning Permission Granted	Six sites with a total capacity of 109 MW have secured planning approval. Four are ACT sites, representing around half of the approved capacity (57 MW). All sites are modelled to connect, except for the two incineration sites under **Leading the Way**, where it is assumed that the sites are stalled due to restrictions on greenhouse gas emissions.	6	109 MW
Planning Application Submitted	Three sites have been identified as having a planning application submitted, all incineration plants. Due to the polluting nature of incineration plants, these sites have only been modelled to connect under **Falling Short**.	3	50 MW
Withdrawn or refused	Two sites, one small ACT plant (115 kW) and one incineration plant (30 MW) in Cherwell and Arun respectively, have been withdrawn from planning. The incineration site has been modelled to connect under **Falling Short** by 2026 at the earliest, following developer feedback attained in DFES 2021, allowing for the possibility that the site will submit a revised planning application and go through to build out.	2	30 MW
No information	No additional online information could be found for the remaining four sites in the pipeline. Two of these sites correspond to the Northacre Resource Recovery Plant[iv], which was initially refused planning but subsequently appealed with conditions. The site was originally planned as an ACT site but now targets incineration and thus may need to re-apply for planning.	4	66 MW

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 associated carbon emissions, making it at odds with net zero targets. Therefore, the DFES 2022 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)[v], the operational life of an incineration facility is typically between 20 and 30 years. This has been incorporated into the decommissioning modelling assumptions for each scenario.

	Falling Short	System Transformation	Consumer Transformation	Leading the Way
Baseline	30 years	20 years	20 years	15 years
Pipeline	30 years	25 years	25 years	20 years

Scenario Projections (2030 to 2050)

IEA Bioenergy, in its paper entitled 'Waste Incineration for the Future'[vi], 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 proven contenders for low carbon replacements to traditional combustion plants and could replace legacy and new sites in years to come. The DFES models additional post-pipeline ACT cites to replace existing incineration sites once they decommission at the same location as the previous site.

Scenario	Description	Incineration capacity by		ACT capacity by	
		2035	2050	2035	2050
Falling Short	Waste incineration sites operate for 30 years, with the earliest site (20 MW) decommissioning in 2030 after construction in 1999. All pipeline sites that are modelled to connect remain online beyond 2050. Fewer post-pipeline ACT sites are modelled to displace incineration sites as a result.	314 MW	224 MW	83 MW	133 MW
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 under **Consumer Transformation** and **Leading the Way**. Under **System Transformation**, some incinerators remain online and are decommissioned shortly after 2050 or fitted with carbon capture technologies.	204 MW	136 MW	138 MW	138 MW
Consumer Transformation		108 MW	--	138 MW	178 MW
Leading the Way		56 MW	--	138 MW	138 MW

Reconciliation with National Grid FES 2022

Modelling Stage	Reconciliation
Baseline	The baseline for waste fuelled generation is 52 MW higher in the FES 2022, at 194 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 2022 deviates from FES 2022 in all scenarios in the near term, with up to 400 MW connecting under **System Transformation**, whereas FES only sees 272 MW maximum under **Falling Short**. This variance is due to the DFES pipeline evidence and assessment methodology, 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 due to a strong likelihood for sites to build out.
Projections	In the 2030s, projections are aligned in DFES and FES, remaining flatlined in all scenarios. Both DFES and FES also model a reduction in capacity in the 2040s under the three net zero scenarios, reflecting the assumption of a waste-conscious society. However, the DFES scenarios see higher capacities in all scenarios by 2050 than the FES due to the pipeline sites modelled to connect in earlier years.

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. Incineration sites connect only with positive planning information. ACT sites are modelled to connect either at their proposed location in planning or at decommissioned incineration sites.

Relevant assumptions from National Grid FES 2022

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 authorities responding from the Southern England licence area had a waste collection strategy in place.	This suggests that local authorities in Southern England have ambitious waste management targets in place, with a high level of devolved governance on the future of waste. The valuation of food waste in separate waste streams suggests that a reduction of waste to incinerators is likely to come from non-biogenic waste reduction in the future. This has been taken into consideration in the analysis and has limited the reduction in waste-to-energy capacity out until 2050, assuming that some sites will need to remain online or convert to cleaner technologies.

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[i] Lakeside EFW n.d., *Lakeside Energy from Waste (EfW).* https://www.lakesideefw.co.uk/
[ii] Let's Recycle 2021, *Amey's Isle of Wight EfW almost 'fully operational'*. https://www.letsrecycle.com/news/ameys-isle-of-wight-efw-almost-fully-operational/
[iii] 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
[iv] Northacre Renewable Energy n.d., *FAQ* https://northacre-energy.co.uk/faqs/
[v] 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
[vi] 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

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

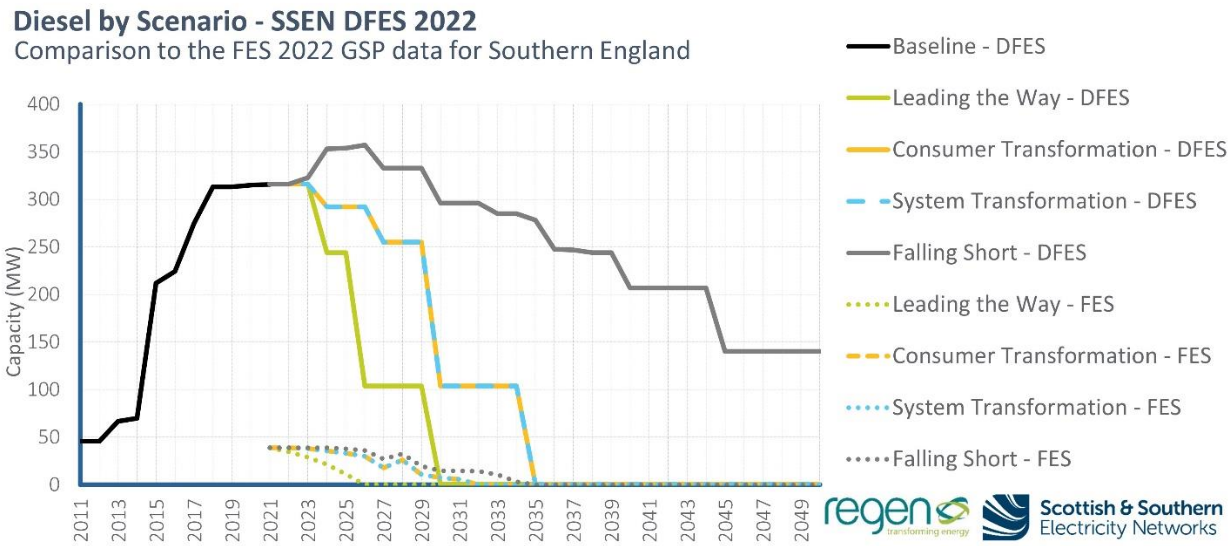
The analysis does not include dedicated backup diesel engines located on some commercial and industrial premises that are only operated when mains supply failure occurs and cannot export to the network.

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	316	354	296	278	207	140	140
System Transformation		292	104	0	0	0	0
Consumer Transformation		292	104	0	0	0	0
Leading the Way		244	0	0	0	0	0

Figure 24: Diesel generation projections for Southern England licence area, compared to National Grid FES 2022 regional projections



Summary

- As of the start of 2022, the Southern England licence area had 316 MW of operational diesel generation, of which 140 MW is taken up by Cowes Power Station (fuelled by marine diesel).
- This installed capacity combines standalone commercial diesel generation sites and behind-the-meter backup generators, co-located with large energy users.
- Several potential new diesel sites could connect to the distribution network in the near term, with close to 70 MW with accepted connection offers in the licence area. Of this, 5 MW has had planning permission granted.
- Of this pipeline, 25 sites totalling 43 MW have been identified as likely backup generators and a 26 MW standalone diesel generation site.

- All behind-the-meter diesel backup generators are located onsite at various business premises, such as water treatment works, shopping centres and hospitals.
- In terms of standalone sites, diesel generators have a higher carbon intensity compared to other forms of flexible generation plants. They 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)[i], 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 only operates for a few hours per year (i.e. backup generators).
- Unabated commercial diesel generation connected to the distribution network falls within this regulation and will, therefore, no longer be allowed to operate from 2025[ii] without exhaust abatement technologies (such as catalytic reduction technology). This type of companion technology is unlikely to be financially viable in the near term.
- As a result, no diesel generation remains connected by 2050 under the three net zero scenarios. Under **Falling Short**, only the large 140 MW Cowes Power Station on the Isle of Wight remains online.

Modelling and assumptions

Baseline (2021)

Number of Sites	Total Capacity	Description
27	316 MW	The Southern England diesel baseline consists of backup and standalone generators. This baseline has increased since DFES 2021, mainly due to the reclassification of the 140 MW Cowes Power Station on the Isle of Wight, which has been identified as using marine fuel oil. It was previously classified as a gas OCGT plant, but it is not fed by fossil gas, so has been defined as diesel generation. The remaining 176 sites are all 24 MW or smaller.

Planning Logic and Assumptions

Under **Leading the Way, Consumer Transformation** and **System Transformation,** no new unabated diesel generation sites become operational. **Falling Short** assumes that any site with an accepted connection capacity after 2017 will become operational.

Decommissioning Logic

DFES analysis for diesel generation focuses entirely 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 backup)
- The year it 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.

Scenario Projections (2030 to 2050)

Scenario	Description	Capacity by 2035	Capacity by 2050
Falling Short	Diesel generation is expected to peak in the late 2020s, with some pipeline sites connecting before older sites begin to decommission.	278 MW	140 MW

	Even as the least ambitious scenario for removal of fossil fuel generation, no operational diesel generation remains by 2045, apart from Cowes Power Station which remains connected due to continuing to provide national balancing services.		
System Transformation	All diesel generation decommissions under these scenarios by 2035 being replaced by other low carbon generation technologies such as bioenergy or battery storage.	--	--
Consumer Transformation		--	--
Leading the Way	All diesel sites decommission by 2030 under this scenario, also being replaced by other low carbon technologies.	--	--

Reconciliation with National Grid FES 2022

Modelling Stage	Reconciliation
Baseline	The FES 2022 baseline is significantly lower (40 MW) than DFES (316 MW). Part, but not all, of this variance is due to the reclassification of the 140 MW Cowes Power Station as diesel. Other sites in the DFES baseline were also classified based on site-specific desktop research.
Pipeline	DFES 2022 has sight of 70 MW of diesel sites in the pipeline, 41 MW of which is modelled to connect under **Falling Short** only. The FES 2022 does not seem to have sight of a similar level of pipeline capacity and models no increase. In **Consumer Transformation** and **System Transformation** there is an 8 MW decrease and subsequent increase in the late 2020s; the reason for this is unclear. No pipeline sites connect under **Leading the Way** in FES or DFES.
Projections	Under **Leading the Way**, FES 2022 sees all generation decommissioning by 2026, compared to 2029 in DFES 2022. **Consumer Transformation** & **System Transformation** remain ambitious, decommissioning all sites in the early 2030s under FES and mid-3030s in the DFES. The FES sees all diesel generation decommissioned in the licence area by 2035 under **Falling Short** in the FES. In contrast, the DFES models the large-scale Cowes Power Station site to remain online past 2050 under this scenario.
Overarching Trend	Diesel generation is expected to drop to zero in all net zero scenarios in the medium term, reflected in both FES and DFES. Under **Falling Short**, the DFES 2022 has reclassified an OCGT site and modelled this to remain online beyond 2050

Geographical Factors affecting deployment at a local level

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

[i] European Commission n.d., *The Medium Combustion Plant Directive*. https://ec.europa.eu/environment/industry/stationary/mcp.htm
[ii] 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

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.

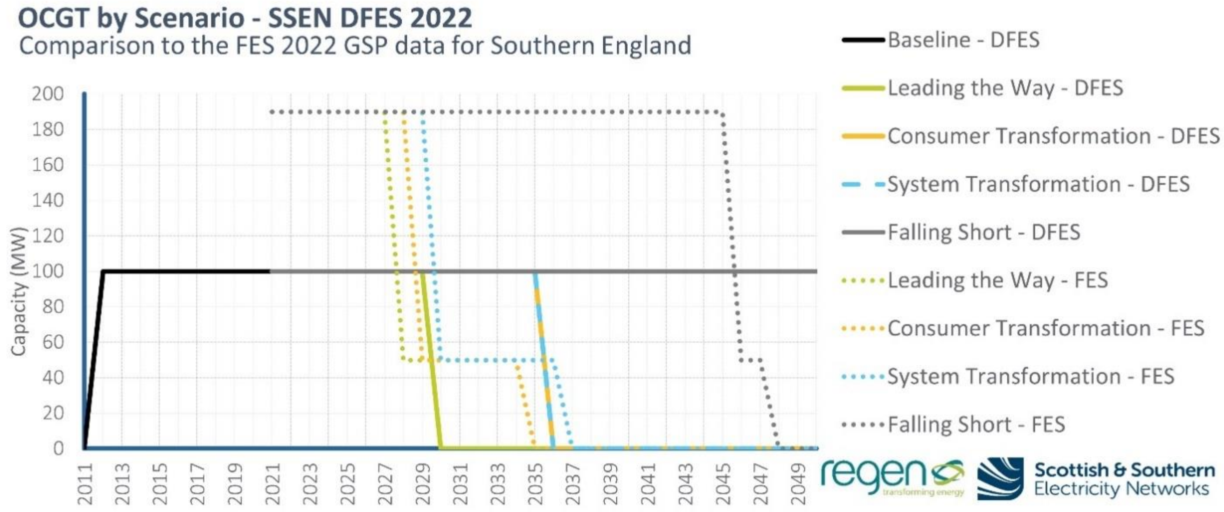
Technology building block: **Combined cycle gas turbines (CCGT) – Building block Gen_BB009**; **Open cycle gas turbines (OCGT) – Building block Gen_BB008**; **Gas reciprocating engines – Building block Gen_BB006**; **Gas combined heat and power plants (gas CHP) – Building block Gen_BB001**

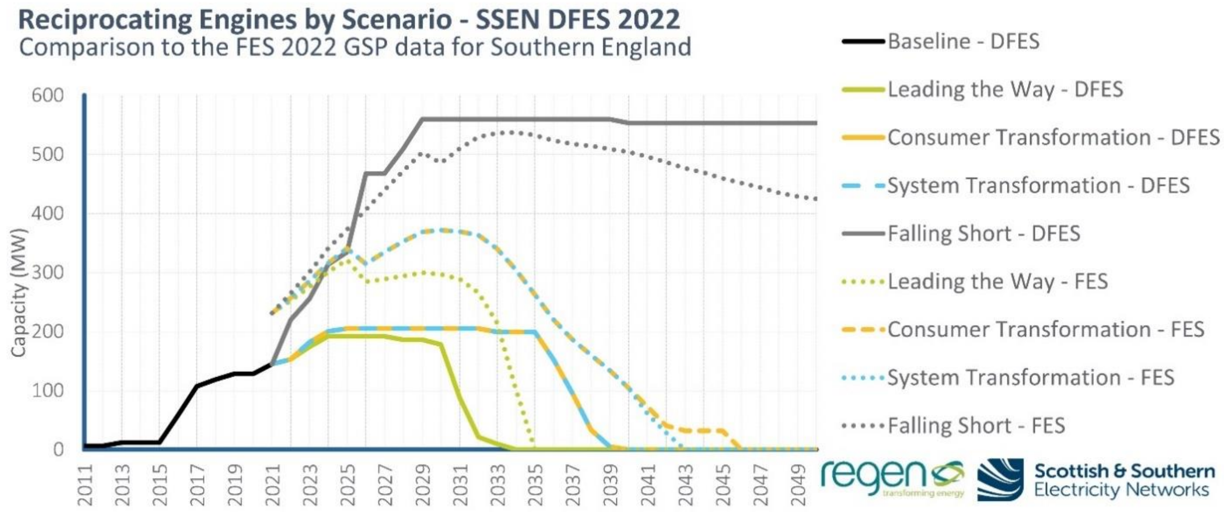
Data summary for fossil gas generation in the Southern England licence area

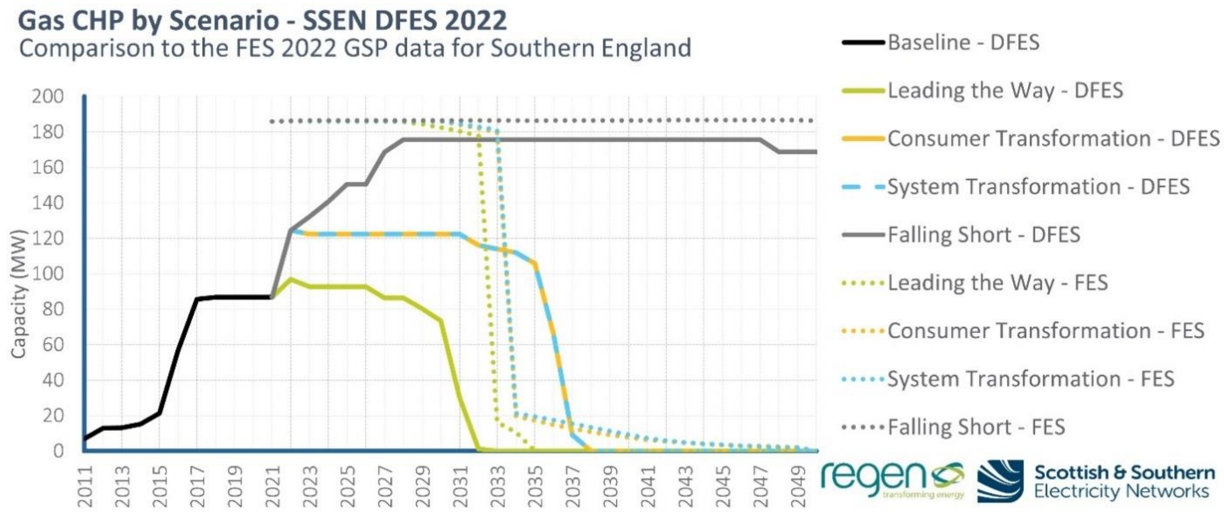
Installed capacity (MW)		Baseline	2025	2030	2035	2040	2045	2050
OCGT	Falling Short	100	100	100	100	100	100	100
	System Transformation		100	100	100	0	0	0
	Consumer Transformation		100	100	100	0	0	0
	Leading the Way		100	0	0	0	0	0
Reciprocating Engines	Falling Short	145	335	560	560	553	553	553
	System Transformation		205	205	200	0	0	0
	Consumer Transformation		205	205	200	0	0	0
	Leading the Way		192	178	0	0	0	0
Gas CHP	Falling Short	87	151	176	176	176	176	169
	System Transformation		122	122	106	0	0	0
	Consumer Transformation		122	122	106	0	0	0
	Leading the Way		93	73	0	0	0	0

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

Figure 25: Fossil gas projections for the Southern England licence area, compared to National Grid FES 2022 regional projections







Summary

- There are currently 38 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
  - 23 gas CHP sites, totalling 87 MW, ranging from small <100 kW engines to 20-35 MW sites
- This is lower than the baseline seen in DFES 2021, predominantly due to the reclassification of the 140 MW Cowes Power Station OCGT site on the Isle of Wight, which has been reclassified as diesel generation due to it being fuelled by marine fuel oil.
- In addition to this baseline, there is a large pipeline of 58 prospective new fossil gas sites with accepted connection offers, totalling 520 MW. Of this:
  - 26 are reciprocating engine sites, totalling c. 431 MW
  - 32 are gas CHP sites, totalling c. 89 MW.
- Sites with planning approval or contracted in recent Capacity Market auctions[i] 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, all fossil gas generators see a decline in the near and medium term, and all generators are modelled to come offline by the late 2030s.
- The conflict in Ukraine and significant increases in UK gas prices[ii] could 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.
- However, the Energy Security Strategy[iii] has renewed the possibility for extraction of natural gas in the north sea, reflecting a world in which gas supply is maintained via new domestic extraction.
- Under **Falling Short**, whilst some older sites decommission, unabated fossil fuel generation remains a significant part of the electricity system overall, with the majority of pipeline sites modelled to come online and further capacity growth of gas reciprocating engines to provide flexibility services throughout the scenario timeframe. Total fossil gas generation capacity in this scenario reaches 822 MW by 2050.

Modelling and assumptions

Baseline (2021)			
Scale	Number of Sites	Total Capacity	Description
Total	38	332 MW	The baseline of sites totals 332 MW, a decrease compared to DFES 2021 due to technology reclassification rather than any significant decommissioning.
OCGT	1	100 MW	The 140 MW Cowes Power Station OCGT site has been reclassified as diesel generation in the DFES 2022, due to the site using marine fuel oil and not networked fossil gas. This leaves Didcot Power Station as the sole operating OCGT plant in the licence area.
Reciprocating Engines	14	145 MW	The baseline of reciprocating engine capacity has increased by 10 MW due to added capacity at the Calne Power Station in Wiltshire.
Gas CHPs	23	87 MW	The gas CHP baseline has moderately reduced, compared to DFES 2021. This is due to some sites decommissioning and some sites being reclassified as other technologies. These baseline sites are 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.

Pipeline (2022-2030)	
Number of pipeline sites	**Total capacity**
58	520 MW

Pipeline analysis

Sub-technology	Description	Sites	Capacity
CCGT & OCGT	There are no OCGT or CCGT sites in the pipeline in the licence area. In DFES 2021, a 132 MW site in Windsor and Maidenhead was identified, and has since been reclassified as a reciprocating engine based on new information from the Capacity Market register. Similarly, what was thought to be a 56 MW OCGT plant in Slough has now been allocated as Energy from Waste[iv]. This indicates a move towards smaller-scale assets and reciprocating engines as the norm for future gas sites, operating as peaking plants to perform flexibility services.	--	--
Reciprocating Engines	There are several gas reciprocating engine sites with accepted connection offers, the majority of which are >5 MW capacity. This represents a higher overall capacity than in the DFES 2021 pipeline.	26	431 MW
Gas CHP	The number of gas CHP sites in the pipeline has increased since DFES 2021, although the combined capacity of these sites has decreased from c. 150 MW in 2021, to the current pipeline capacity to 89 MW. This is due to some sites dropping out of the planning process, one new site in 2022, and several sub-technology reclassifications.	32	89 MW

Planning Logic and Assumptions

The assumptions around the proportion of pipeline sites and capacity that are 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 the **Falling Short** scenario.

Decommissioning Logic

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
- How each scenario reflects policies such as the Industrial Emissions Directive, how flexibility is treated in the scenarios, and wider progress towards net zero targets.

The following table summarises the years in which sites are modelled to decommission by sub-technology and scenario.

Sub-technology	Falling Short	System Transformation	Consumer Transformation	Leading the Way
OCGT	Post-2050	By 2036	By 2036	By 2030

Reciprocating engines	2040–post-2050	2023–2039	2023–2039	2023–2034
Gas CHPs	2048–post-2050	2023–2047	2023–2047	2023–2035

Scenario Projections (2030 to 2050)

Sub-technology	Scenario	Description	Capacity by 2035	Capacity by 2050
OCGT	**Falling Short**	The 100 MW Didcot Power Station is modelled to remain operational out to 2050. This reflects gas turbine technology continuing to provide system flexibility and an overall lower level of action on system decarbonisation.	100 MW	100 MW
	System Transformation	Didcot Power Station is modelled to decommission in the three net zero scenarios. This occurs in the mid-2030s under **Consumer Transformation** and **System Transformation**, and by 2030 under **Leading the Way**.	100 MW	0 MW
	Consumer Transformation		100 MW	0 MW
	Leading the Way		0 MW	0 MW
Reciprocating engines	**Falling Short**	A significant proportion of the reciprocating engine site pipeline is modelled to build out under this scenario, reflecting a future in which rapid-response technology continues to secure balancing service and flexibility contracts. Capacity peaks at 560 MW in the 2030s, followed by some older baseline sites decommissioning in the 2040s.	560 MW	553 MW
	System Transformation	Several reciprocating engine sites with connection offers with SSEN are modelled to connect across the 2020s and early 2030s. This reflects a relatively slower transition to low carbon flexibility than seen in **Leading the Way**. Capacity then steadily reduces as fossil gas sites decommission from the network, with no capacity remaining online by 2039.	200 MW	0 MW
	Consumer Transformation		200 MW	0 MW
	Leading the Way	Only sites with approved planning applications and at that are least pre-qualified in the capacity market are modelled to connect in the near term. This is followed by a rapid transition to low carbon flexibility and fossil gas sites rapidly decommissioning. This results in no capacity remaining connected to the network in the licence by 2034.	0 MW	0 MW

Gas CHP	Falling Short	Under this scenario, the baseline of gas CHP engine sites continue to operate in the medium term, in addition to a number of new CHP sites that are modelled to connect. Only a small number of older sites are modelled to disconnect, with 169 MW remaining online by 2050.	176 MW	169 MW
	System Transformation	A notable number of the gas CHP sites are located onsite at businesses and commercial premises. These are therefore not modelled to disconnect in the near term, due to the onsite/backup services they are providing. In addition, whilst some pipeline sites with planning approval are also modelled to connect, there is little growth in gas CHP capacity modelled to come online. Capacity begins to decommission from the 2030s, resulting in all capacity being modelled to disconnect by 2040.	106 MW	0 MW
	Consumer Transformation		106 MW	0 MW
	Leading the Way	Some of the smaller onsite gas CHP pipeline sites are modelled to connect in the 2020s, but alongside this older baseline sites begin to decommission. All gas CHP capacity is modelled to disconnect by the mid-2030s.	0 MW	0 MW

Reconciliation with National Grid FES 2022

Modelling Stage	Reconciliation
Baseline	The FES 2022 baseline is 90 MW higher than the DFES, at 190 MW. The reason for this is unclear and is not accounted for by the reclassification of Cowes Power Station OCGT (140 MW). The FES 2022 baseline is 86 MW higher than the DFES, at 232 MW. The reason for this is unclear. 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. The FES 2022 baseline is 99 MW higher than the DFES, at 186 MW. The reason for this is unclear. As with reciprocating engines, the DFES analysis has classified each of the baseline and pipeline sites connected through online research and a reconciliation to Capacity Market registers and planning data.
Pipeline	The DFES and FES both reflect no pipeline OCGT sites in the licence area. Baseline variance aside, the FES and DFES are well aligned on reciprocating engines, reflecting some near-term growth in reciprocating engine capacity in all scenarios, with more connecting under **Falling Short** than the three net zero scenarios. The DFES models a number of gas CHP pipeline sites connecting in the near term under all scenarios, 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	Baseline variance aside, the FES and DFES are fairly aligned in terms of OCGT remaining online in the longer term under **Falling Short**, though the FES has all OCGT capacity coming offline by 2048, whereas the DFES considers OCGT sites may repower their engines and continue to operate beyond 2050 under this scenario. Under the three net zero scenarios, the DFES and FES largely align with the near-term decommissioning of all OCGT capacity. 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. The DFES analysis reaches zero capacity slightly earlier than the FES, but this could partially be related to the larger CHP baseline reflected in the FES.

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 2022

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 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.

Incorporation of Stakeholder Feedback

Stakeholder feedback provided	How this has influenced our analysis
At the Southern England engagement webinar[v], local stakeholders responded to a poll on how current gas price increases might affect the current pipeline of gas generation projects. The majority of respondents (87%) highlighted that the increases would either delay development (30%) or drive a shift away from fossil gas peaking plants (57%).	This result has justified the net zero scenario projections, where only a select few of the known pipeline sites are modelled to build out and the long-term decommissioning of fossil gas generation that follows.

[i] National Grid ESO n.d., *Capacity Market Registers.* https://www.emrdeliverybody.com/CM/Registers.aspx
[ii] See Trading Economics, UK natural gas price 2022-23: https://tradingeconomics.com/commodity/uk-natural-gas
[iii] UK Government 2022, *British Energy Security Strategy.* https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy
[iv] AECOM 2020, *Environmental Permit Variation Application: Slough Heat and Power Station Application Supporting Document.* https://consult.environment-agency.gov.uk/psc/sl1-4tu-slough-heat-power-limited/supporting_documents/Application%20%20Variation%20%20Supporting%20Information.pdf
[v] 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

Hydrogen fuelled electricity generation connected to the distribution network in the Southern England licence area. The analysis focuses on the conversion of existing fossil fuel peaking plants to hydrogen-fuelled generation. This technology is, therefore, intrinsically linked to the DFES analysis for fossil fuel generation.

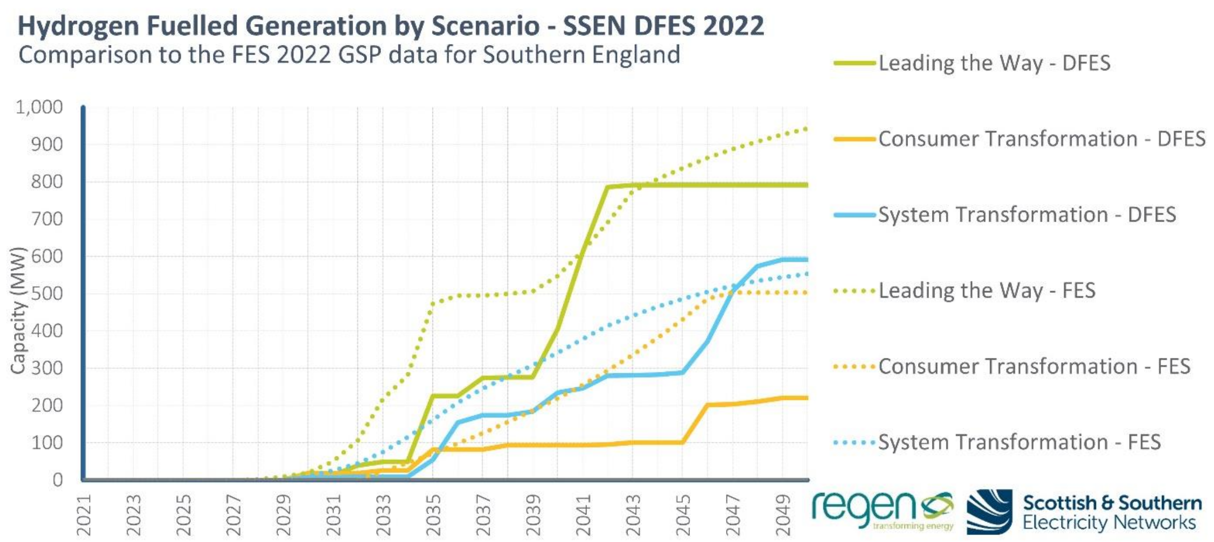
New large-scale hydrogen-fuelled power stations could also be developed. However, in the absence of any pipeline evidence and the lack of low carbon hydrogen supply infrastructure development to date, it has been assumed that these plants would more likely connect to the transmission network.

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	7	54	235	289	592
Consumer Transformation		0	19	82	93	101	221
Leading the Way		0	14	226	406	792	792

Figure 26: Hydrogen-fuelled electricity generation projections for the Southern England licence area, compared to National Grid FES 2022 regional projections



Summary

- A net zero electricity system will see significant levels of variable renewable energy generation, a major increase in electricity demand from low carbon technology adoption, and a diverse mix of flexible technologies to enable system operability and balancing of demand and supply.
- Currently, many of these balancing services are provided by fossil gas generation plants, ramping up generation in response to system balancing price signals. In a net zero electricity system, unabated fossil fuel generation will be unable to continue to provide flexibility services. Therefore technologies like battery storage, bioenergy generation and other dispatchable assets will need to meet the system flexibility needs. Low carbon hydrogen-fuelled electricity generation (engines or turbines) could become one of these options.
- The DFES analysis for hydrogen-fuelled electricity generation predominantly considers the potential for existing fossil gas and diesel generation to repower or replace their generation assets to run on low carbon hydrogen in the future when it becomes available.
- Southern England is a transport hub, comprising road and rail networks, Heathrow Airport, and multiple ports along the southern coast. Combined with large industrial clusters such as Southampton, oil refineries currently producing hydrogen and potential hydrogen storage facilities in Portland, Southern England has the potential to host several hydrogen hubs.
- Hydrogen generation capacity in the licence area by 2050 ranges significantly, from no capacity under **Falling Short** (due to fossil fuel generation remaining operational) to 792 MW under **Leading the Way**.

Modelling and assumptions

Baseline (2021)
There are no baseline 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 are is 332 MW of fossil gas and 316 MW of diesel baseline 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 net zero scenarios..
Pipeline (2022-2030)
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 on low carbon hydrogen in the near term. Some pilot schemes have begun to appear, including large-scale gas power stations are trialling the injection of hydrogen at existing sites[i] and turbine manufacturers are already beginning to develop hydrogen generation technologies[ii]. However, it remains unlikely that any commercial-scale hydrogen generation sites will connect to the distribution network before 2030 under any scenario. There is 520 MW of fossil gas and 70 MW of diesel capacity with accepted connections; some are modelled to come online in the near term and could repower as hydrogen-fuelled generation in the long term.
Hydrogen repowering
The DFES analysis reflects the potential for a proportion of existing fossil gas and diesel plants repowering as hydrogen-fuelled generation assets in the future. This potential is based on a geographic assessment of likely hydrogen hubs in the licence area, including Swindon, Oxford, Portsmouth and Southampton. The scale of capacity repowering as hydrogen generation varies by scenario, based on repowering factors and development phasing. 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)			
Scenario	Description	Capacity by 2035	Capacity by 2050
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 MW	0 MW
System Transformation	Fossil fuel sites located in hydrogen development zones and some sites outside of these zones repower as hydrogen-fuelled generation in the 2030s and 2040s. This reflects a high availability of low-carbon hydrogen, but also considers that a significant capacity of hydrogen-fuelled generation capacity connects at transmission scale.	54 MW	592 MW
Consumer Transformation	Only fossil fuel sites located in hydrogen development zones repower as hydrogen-fuelled generation in the 2030s and 2040s. This reflects a lack of a national hydrogen network, requiring hydrogen to be produced close to sources of demand.	82 MW	221 MW
Leading the Way	This scenario represents the most ambitious deployment of distributed hydrogen-fuelled generation. Medium-scale fossil gas and diesel sites (baseline and pipeline) are modelled to repower their thermal generation plant to be fuelled by hydrogen, with 50% more capacity. Both existing and pipeline sites in and outside of known hydrogen development zones are modelled to repower, reflecting the widespread availability of hydrogen through a national network. This scenario also reflects a higher proportion of hydrogen-fuelled generation sites connecting to the distribution network, with just under 800 MW operating in the network by 2050.	226 MW	792 MW

Reconciliation with National Grid FES 2022

Modelling Stage	Reconciliation
Baseline **Pipeline**	Both the DFES and FES are aligned that there are no existing operational hydrogen fuelled generation sites, or near-term developments before 2030 in the licence area.
Projections	The DFES and FES are aligned on no hydrogen generation capacity being modelled to come online by 2050 under **Falling Short**. Both assessments reflect a similar development of hydrogen generation under **Leading the Way** and **System 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 and diesel generation sites in the licence area. The DFES models less capacity connecting under **Consumer Transformation** than the FES. This is potentially due to the assumptions made in the DFES around distributed vs transmission-connected hydrogen-fuelled generation capacity under **Consumer Transformation** and **System Transformation**.

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) generation sites located in the licence area.
Hydrogen supply areas	Regen undertook a spatial analysis of potential hydrogen supply areas and hydrogen development hubs in the licence areas. This considers locations of existing hydrogen trials and initiatives, larger industrial areas, proximity to gas network infrastructure, proximity to major roads, ports and potential hydrogen storage facilities.

Relevant assumptions from National Grid FES 2022

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. [27]

[i] 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

[ii] 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

[27] These assumptions represent dispatchable hydrogen-fuelled generation assets connecting at both distribution and transmission levels. By 2050, under **Leading the Way**, 11 GW of hydrogen-fuelled electricity generation connects to the distribution network and 5.5 GW to the transmission network. Therefore, the DFES analysis has reflected a moderately higher adoption of distributed hydrogen generation under this scenario than indicated by the above scenario assumption suggests.

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 technology building block.*

Data summary for offshore wind in the Southern England licence area

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
All Scenarios	0.8	3.3	3.3	3.3	3.3	3.3	3.3

Summary

- Eight unidentified generation technology sites are in the Southern England Licence area, totalling 791 kW of installed capacity. This is a decrease since DFES 2021 (1 MW) due to investigative analysis of sites using satellite imagery, developer outreach, news articles and in-depth desk research to identify the technologies.
- At an average capacity of 132 kW, these sites are predominantly micro CHP plants within schools, hotels, farms and recreational centres; however, the fuel type is uncertain. Hence these sites cannot be allocated a technology. The largest site is 263 kW.
- There are 14 pipeline sites of varying capacity, totalling 2.5 MW, of which the largest is 800 kW in Basingstoke and Deane. All sites are CHP plants with unknown fuel sources and are modelled to connect in all scenarios by 2023.
- 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.

Battery storage

Summary of modelling assumptions and results

Technology specification

Battery storage, comprising four business models:

- **Standalone network services** – typically multiple megawatt-scale projects that provide balancing, flexibility and support services to the electricity network
- **Generation co-location** – typically multiple megawatt-scale projects, sited alongside renewable energy (or occasionally fossil fuel) generation projects.
- **Behind-the-meter high-energy user** – typically single megawatt or smaller projects, sited at large energy-user operational sites to support on-site energy management or to avoid high electricity cost periods.

These three business models combine to form "large scale" battery storage, which aligns with the FES building block: **Srg_BB001**

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

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	177	764	1,106	1,206	1,206	1,206	1,206
	System Transformation		1,142	1,481	1,511	1,555	1,629	1,703
	Consumer Transformation		1,462	1,922	1,979	2,037	2,095	2,152
	Leading the Way		1,623	1,922	2,076	2,210	2,345	2,441
	Storage Planning		2,221	3,346	3,610	3,610	3,610	3,610
Generation co-location	Falling Short	12	145	360	381	384	401	417
	System Transformation		305	393	416	427	448	450
	Consumer Transformation		401	659	670	718	723	725
	Leading the Way		401	693	711	735	743	744
	Storage Planning		500	756	774	798	806	807
Behind the meter - high energy user	Falling Short	1	25	30	32	35	38	38
	System Transformation		41	51	56	62	68	68
	Consumer Transformation		57	73	80	143	156	156
	Leading the Way		73	116	127	143	156	156
	Storage Planning		124	169	179	195	209	209
Domestic batteries	Falling Short	0	4	5	14	16	47	106
	System Transformation		2	40	59	76	184	217
	Consumer Transformation		11	84	161	274	470	778
	Leading the Way		26	100	181	298	491	877

Figure 27: Large scale battery storage projections for the Southern England licence area, compared to National Grid FES 2022 regional projections

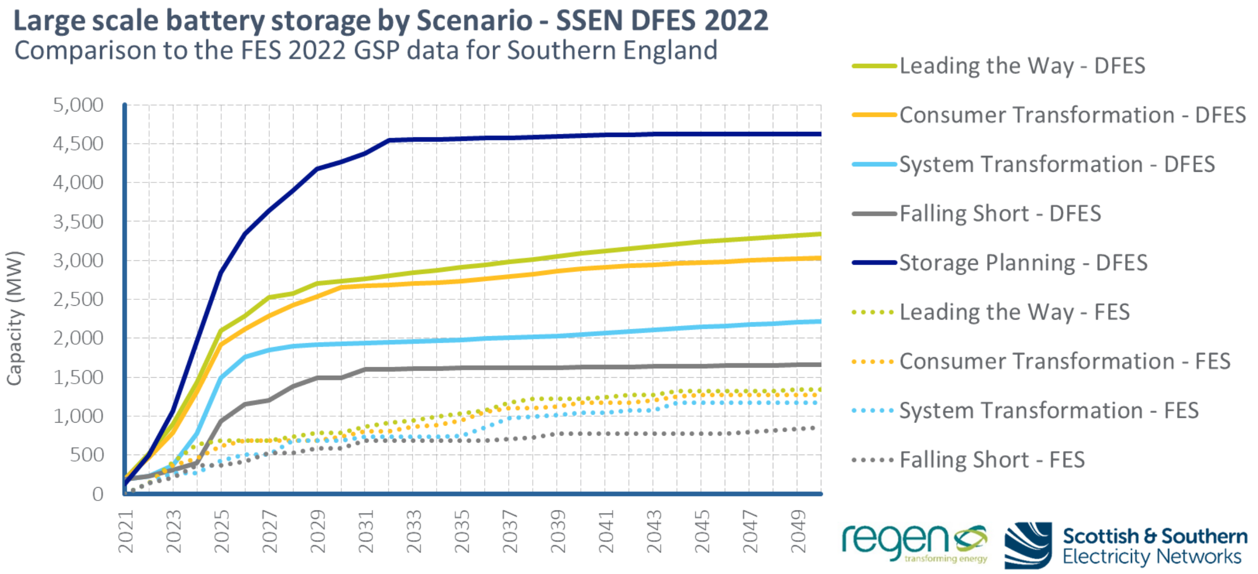
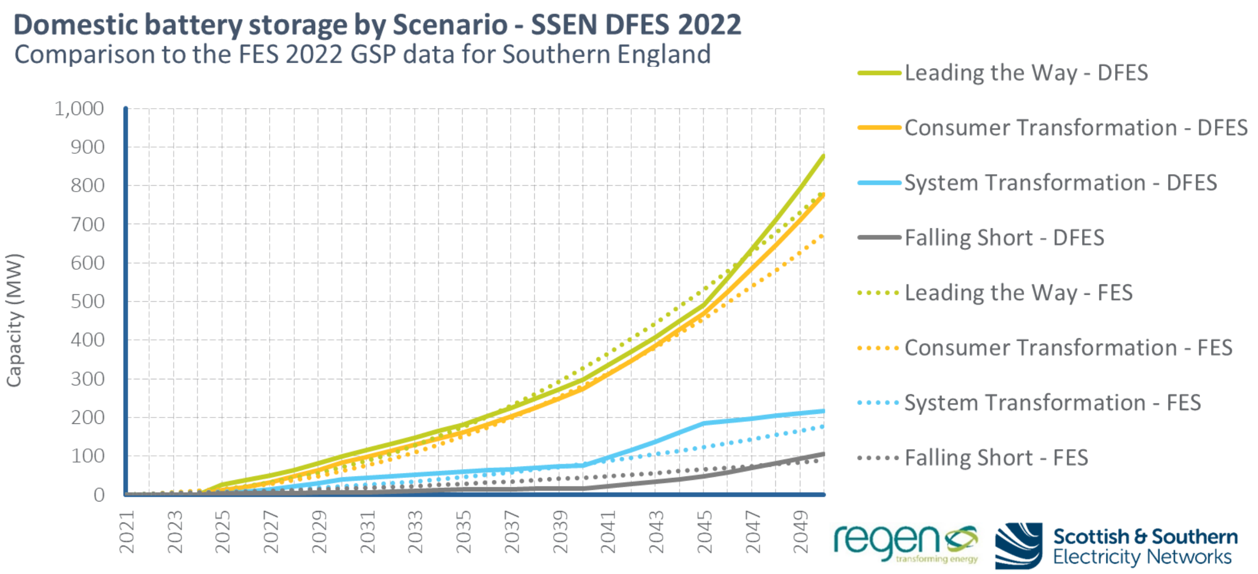


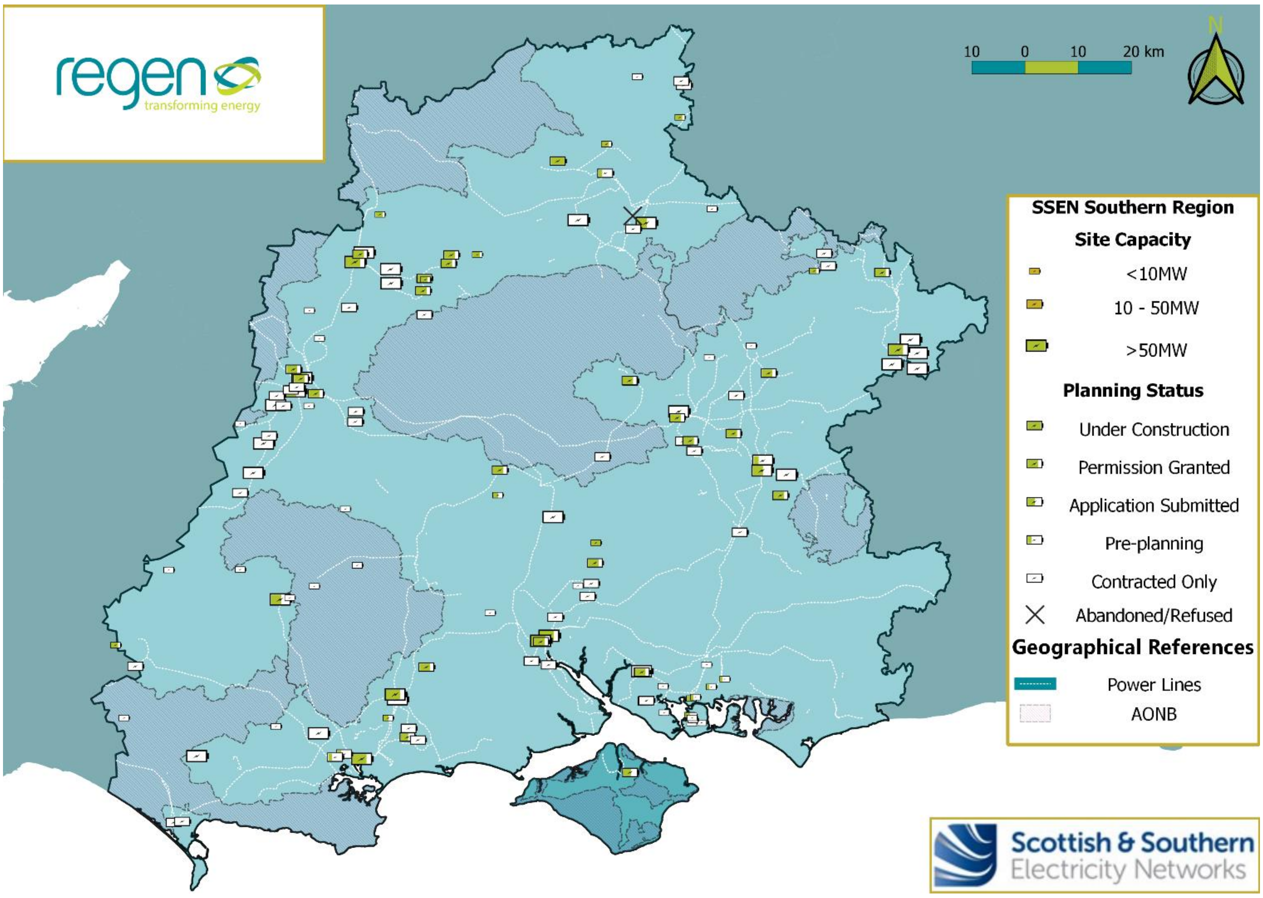
Figure 28: Domestic battery storage projections for the Southern England licence area, compared to National Grid FES 2022 regional projections



Summary

- As a sector that saw its first commercial-scale projects in 2016, battery storage has rapidly developed into an active and significant development sector across the UK electricity network.
- The Southern England licence area has 14 operational battery storage sites, totalling 190 MW. This includes the Stonehill battery project in Wiltshire, a 110 MW site with plans to expand to 150 MW, one of the largest battery projects in Europe.
- Of all technologies included in the DFES analysis, battery storage is the largest pipeline of projects with a quote issued or accepted connection offer - totalling 9.6 GW across the two SSEN licence areas. Of this, 147 sites totalling 5.3 GW fall within the Southern England licence area.
- Putting this into context, currently, SSEN manages a portfolio of c. 6.5 GW of operational fossil fuel and renewable generation assets.
- Many organisations have raised concern over the scale of the national connection pipeline, the number of potentially speculative applications[i] , how they contribute to lengthy connection queues and potential grid constraints.
- The Southern England licence area does have significant potential for long-term growth in connected storage capacity. This is due to the following:
    - The Southern licence area has amongst the best solar irradiance in the UK and, thus, strong potential for significant battery storage co-location.
    - A significant number of properties and solar resource for domestic rooftop PV could see a high number of domestic battery installations under some scenarios.
    - 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 be associated with 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.
- Overall battery storage capacity in 2050 in the Southern England licence area ranges from 1.7 GW in **Falling Short** to 4.2 GW in **Leading the Way**.
- Upstream constraints (and associated Statement of Works processes) on the transmission network can impact the deployment timescale of distribution network projects. These have been reflected in the **Falling Short** scenario only, based on the completion year of the transmission upgrade works. This allows the scenarios to represent a realistic range of potential connections to the distribution network.
- This year, 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 currently visible contracted/quoted connection pipeline.
- After removing duplicates, under this **Storage Planning** scenario, 4.6 GW of large-scale storage is modelled to connect in the Southern England licence area by 2050.
- Alongside battery storage, Long Duration Energy Storage (LDES) is a subsector seeing growing government interest and policy support, including the LDES demonstration competition[ii]. This could give rise to several 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 29: Pipeline battery storage sites in the Southern England licence area



Modelling and assumptions

Baseline (2021)			
Business Model	**Number of Sites**	**Total Capacity**	**Description**
Total	**14**	**190**	--
Standalone network services	7	177	This includes the Stonehill battery project in Wiltshire, a 110 MW site connected in 2020 and is one of the largest battery projects in Europe. The operators have highlighted plans to expand this site to 150 MW. The remaining capacity is primarily contributed by three 10-30 MW sites in Swindon, Maiden Newton and Basingstoke
Generation co-location	6	12	The 10 MW 'Roundponds Gas & Battery' site in Melksham accounts for most of this capacity, with the remaining sites all <1MW connected mainly across the North and East of the licence.
Behind the meter - high energy user	1	1	A single 1 MW site is co-located with a B & Q outlet in Swindon, which was connected in 2019.

Pipeline (2022-2030)

The battery pipeline in the Southern England licence area is larger than any other technology pipeline seen in SSEN’s DFES analysis. Every site in this significant pipeline was assessed for its current development status and timeline through online research in local planning portals EMR Delivery Body Capacity Market T-4 and T-1 registers, online project webpage summaries, and direct engagement with individual battery project developers.

Number of pipeline sites	Total capacity
147	5.3 GW

Pipeline analysis

Planning status	Description	Sites	Capacity
Under Construction	Three sites co-located with solar generation are currently under construction, the largest being a 35 MW battery at Eynsham Estate solar farm. This site is subject to a transmission statement of works upgrade, which could delay connection to 2028; this has been reflected under **Falling Short**. In the three net zero scenarios, all sites currently under construction are modelled to connect in 2022 or 2023.	4	53 MW
Planning Permission Granted	With an average capacity of 30 MW, 35 sites totalling c. 1 GW have planning approval, most of which are standalone battery sites. Among these sites is the 100 MW Westlands Farm battery site in Melksham. This site secured a capacity agreement in the 2025 T-4 Capacity Market auction and has been resultantly modelled to connect in 2025 under all scenarios. Another 11 sites totalling 417 MW, have Capacity Market agreements to connect in 2023-2025, which have been reflected under all scenarios. Six sites totalling 305 MW are subject to a transmission network Statement of Works, which could delay connection to the late 2020s or early 2030s. These completion years have been reflected in the **Falling Short** scenario only.	35	1,065 MW
Planning Application Submitted	Eight sites totalling 430 MW, have submitted a planning application. Whilst having an average capacity of 50 MW, three sites are 100 MW or more, reflecting the trend for increasing the scale of battery projects across the network. The 150 MW Norrington Gate Farm battery site is notable, having successfully prequalified under the T-4 2022 Capacity Market auction. It is modelled to connect in 2022 under **Consumer Transformation** and **Leading the Way**, while a delay to 2024 is assumed under **System Transformation**. **Falling Short** does not model this site to connect, reflecting the potential that it does not secure planning permission. Again, the transmission network Statement of Works is a significant factor, potentially delaying the deployment of this site, and the 100 MW Shaftsbury Road site, to the mid-2030s. However, as these sites have been excluded from the **Falling Short** scenario, the Statements of Works do not impact the projections in the other scenarios.	8	430 MW
Pre-planning	An additional eight sites totalling 167 MW, are in pre-planning. A 99MW site in Hart is the largest site in this group. No capacity market activity could be found, so it has been modelled to deploy in the late 2020s under **Consumer Transformation** and **Leading the Way** only.	8	167 MW

	A 26MW battery site in Purbeck secured a capacity agreement under the 2023 T-4 Capacity Market auction and is resultantly modelled to come online in 2022 under all scenarios. Six co-located sites account for the remaining capacity, with their assumed deployment defined by an assessment of the generation site they are co-locating with. In most cases, this is between 2024 and 2026.		
No information / Other	Due to the rapidly growing pipeline of new prospective battery projects, a significant volume remains (3.6 GW) with no evidence of activity in planning or the Capacity Market auctions. This is a significant group of sites (67% of the total pipeline capacity) with a high degree of uncertainty in their potential future development, despite having a connection agreement with SSEN. As a result, they are not modelled to build out under any of the standard DFES scenarios. The new **Storage Planning** scenario seeks to demonstrate the scale of potential deployment in the licence area if all contracted or quote-issued sites were to eventually connect. Therefore all sites are modelled to come online based on a fixed delay after developers accept their connection offers. Where no SSEN anticipated connection date was available, sites have been modelled to connect in randomly assigned years between 2024 and 2030. Some sites which have been identified as duplicate enquiries or sites that have had planning refused. In these cases, they were removed from the analysis and were not modelled to connect under any scenario.	80	3,550 MW

Planning Logic and Assumptions

Sites with no Capacity Market information, co-located site information, or developer feedback were subject to scenario logic reflecting the varying likelihood of delays to connection time. 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	Under Construction	Planning Application Granted	Planning Application Submitted	Pre-planning	No information
Falling Short	2023	Granted year +7	-	-	-
System Transformation	2023	Granted year +5	-	-	-
Consumer Transformation	2023	Granted year +5	Submitted year + 7	Submitted year + 9	-
Leading the Way	2023	Granted year +3	Submitted year + 5	Submitted year + 7	-
Storage Planning	2023	Granted year +3	Submitted year + 5	Submitted year + 7	Random year 2024-2030

Scenario Projections (2030 to 2050)

The four business models for battery storage are modelled separately, and different factors drive potential deployment in the licence area under these business models:

The significant development of standalone sites projected in the near term may lessen over time as the grid and balancing markets are saturated with flexible assets. As a result, low growth is projected for standalone batteries following the modelled connection of the visible pipeline. This reflects developers looking at other business models for storage assets.

It is assumed that the business case for behind-the-meter batteries co-located at high-energy user sites may increase, under some scenarios, as businesses look to manage their on-site energy consumption, reduce energy costs, maximise their self-use of on-site renewable generation and move from being consumers to prosumers.

In addition, there is the potential for an increased uptake of home batteries under some scenarios, with more homeowners deploying rooftop PV and seeking to increase self-consumption and a proliferation of domestic-level flexibility, time-of-use-tariffs and community-level demand side response.

In the long term, the biggest increase in projected battery storage capacity in the licence area is seen under the **Leading the Way** scenario, totalling 4.2 GW by 2050. This reflects a strong potential deployment landscape of batteries across all four business models.

Falling Short sees the lowest overall storage deployment in the licence area, reaching 1.7 GW by 2050. This reflects a lesser need for electricity system flexibility, a lower renewable energy adoption and ongoing use of fossil fuel generation as a source of flexibility. This reduced development outlook for battery storage is reflected in the longer term, out to 2050, across all four business models.

The **Storage Planning** scenario demonstrates the size of the contracted or quote-issued pipeline. Beyond the modelled connection of the full pipeline, additional co-located storage and 'behind the meter – high energy user' capacity was modelled out to 2050, mirroring the assumptions seen in a **Leading the Way** scenario. As a result, large-scale battery storage capacity under this scenario reaches 4.6 GW by 2050.

Business model	Description	Scenario	Capacity by 2035	Capacity by 2050
Standalone network services	Standalone storage sites in the currently visible pipeline dominate growth by 2035. The capacity growth reduces beyond the late 2030s to 2050, reflecting a saturation of distribution network capacity and flexibility markets, reducing the number of large-scale standalone projects seeking to connect in the longer term.	**Falling Short**	1,206	1,206
		System Transformation	1,511	1,703
		Consumer Transformation	1,979	2,152
		Leading the Way	2,076	2,441
		Storage Planning	3,610	3,610
Generation co-location	The significant capacity of large-scale solar generation is projected to connect to the distribution network in all scenarios in the Southern England licence area, reflecting strong solar resource. This is most significant in **Leading the Way** with 7.5 GW modelled to connect by 2050. In addition, the potential for co-located battery storage under this scenario is notable, reaching 744 MW by 2050. The **Storage Planning** scenario, in this case, has assumed that an additional three co-located pipeline sites, totalling 63 MW, are built out by 2030. With no evidence of these sites progressing through planning, they are not modelled to connect in any other scenario.	**Falling Short**	381	417
		System Transformation	416	450
		Consumer Transformation	670	725
		Leading the Way	711	744
		Storage Planning	774	807

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. As a result, by 2050, high energy user battery storage capacity ranges from 38 MW under **Falling Short** to 156 MW under **Leading the Way**. The **Storage Planning** scenario, in this case, assumes that five behind-the-meter sites, including the 50MW 'Dorset Poultry ESS' site, connect by 2030. However, with no evidence of these sites progressing through planning, they are not modelled to connect in any other scenario.	**Falling Short**	32	38
		System Transformation	56	68
		Consumer Transformation	80	156
		Leading the Way	127	156
		Storage Planning	179	209
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 877 MW (equivalent to 193,000 homes) under **Leading the Way** and 106 MW (equivalent to c. 21,200 homes) under **Falling Short**. Across all scenarios, other than **Leading the Way**, this is a slight increase in the DFES 2021 projections. This is due to some updated assumptions around the average rooftop solar and domestic battery unit capacity and an updated method of projecting future developments.	**Falling Short**	14	106
		System Transformation	59	217
		Consumer Transformation	161	778
		Leading the Way	181	877

Reconciliation with National Grid FES 2022

Modelling Stage	Reconciliation – Large-scale batteries
Baseline	The 190 MW of primarily standalone storage capacity identified in the DFES baseline is not mirrored in FES 2022, which sees zero current installed capacity. This suggests that the 110 MW Stonehill Minety battery project has not been included in the FES 2022 baseline. The reason for this is unclear. The DFES 2022 baseline analysis is based on an extract of SSEN connections data provided to Regen in late 2022.
Pipeline	By 2030 the DFES 2022 projections significantly exceed the FES 2022 projections in all scenarios. This is likely due to the constantly increasing pipeline of accepted connection offers evidenced in SSEN's connection data. This variance between FES and DFES becomes significant in the medium term in the more ambitious scenarios, reaching a maximum difference of 1.9 GW by 2030 in **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	The scale of variance between DFES and FES is maintained or reduced post-2030, with higher growth projected in FES 2022 between 2030 and 2050. This is due to DFES modelling assumptions around a saturation of distribution network capacity and flexibility markets and little post-2030 growth. By 2050, a 1.5 – 2 GW variance is seen between the FES 2022 and DFES 2022 under the **Consumer Transformation** and **Leading the Way** scenarios, respectively. The DFES 2022 has a wider spread of outcomes by 2050 for large-scale battery storage due to the large near-term pipeline and build-out assumptions applied under each scenario.
Overarching Trend	In all scenarios, DFES 2022 projects significantly higher installed capacity in the licence area than the FES 2022. The difference is larger in the more ambitious scenarios, with **Leading the Way** and **Consumer Transformation** projecting more than double the equivalent FES projections by 2050. This results from the scale of the contracted pipeline and a site-specific pre-2030 pipeline assessment. Post-2030 growth is higher under FES 2022 than DFES 2022.
Modelling Stage	**Reconciliation – Domestic Batteries**
The DFES 2022 projections for domestic batteries align well with FES 2022 across the analysis period and in all scenarios. In addition, the DFES projects slightly more capacity by 2050. This reflects the notable future projected capacity of rooftop PV in the licence area projected in the DFES and the associated potential for co-located domestic batteries.	

Geographical Factors affecting deployment at a local level

Modelling aspect	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	Identified domestic dwellings with rooftop PV, as projected in the DFES 2022.

Relevant assumptions from National Grid FES 2022

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[iii], local stakeholders responded to a poll on the deployment of battery storage in the licence area. When asked how much of the 5.3 GW pipeline of large-scale batteries were likely to connect in the Southern England licence area, the 48 respondents gave a wide range of responses. An equal number of respondents voted for above and below 50% of the pipeline going through. However, the most popular single response was that just 30% of the pipeline would be built out. On the expected speed of deployment of the project pipeline, respondents were similarly widely spread but more evenly distributed, with 70% of respondents believing the pipeline would connect by the early 2030s.	The uncertainty around the current pipeline is reflected in the spread of scenario outcomes modelled. For example, the Storge Planning scenario demonstrates the connection of most of the licence area's project pipeline. The feedback around the speed of deployment is reflected in all scenarios, with any known pipeline sites modelled to connect assumed to do so by 2032 at the latest.
Developers with projects in the pipeline were individually contacted to discuss the likely commissioning dates of their projects. The DFES team engaged positively with Innova / Novus on two co-located pipeline sites in Winchester and Test Valley. However, they highlighted uncertainty around transmission network reinforcement works, which would impact the delivery of their projects.	These delays out to 2027/2028 were highlighted and have therefore been reflected directly under **Falling Short**.

[i]Energy Storage News, 2021, *"Large-scale battery storage in the UK".* https://www.energy-storage.news/large-scale-battery-storage-in-the-uk-analysing-the-16gw-of-projects-in-development/
[ii]UK Government, 2021, *Long Duration Energy Storage Competition.* https://www.gov.uk/government/collections/longer-duration-energy-storage-demonstration-lodes-competition
[iii]Regen, 2022, *SSEN DFES stakeholder consultation webinars.* https://www.regen.co.uk/event/ssen-distribution-future-energy-scenarios-2022-stakeholder-consultation-webinars/

Liquid air energy storage

Summary of modelling assumptions and results

Technology specification

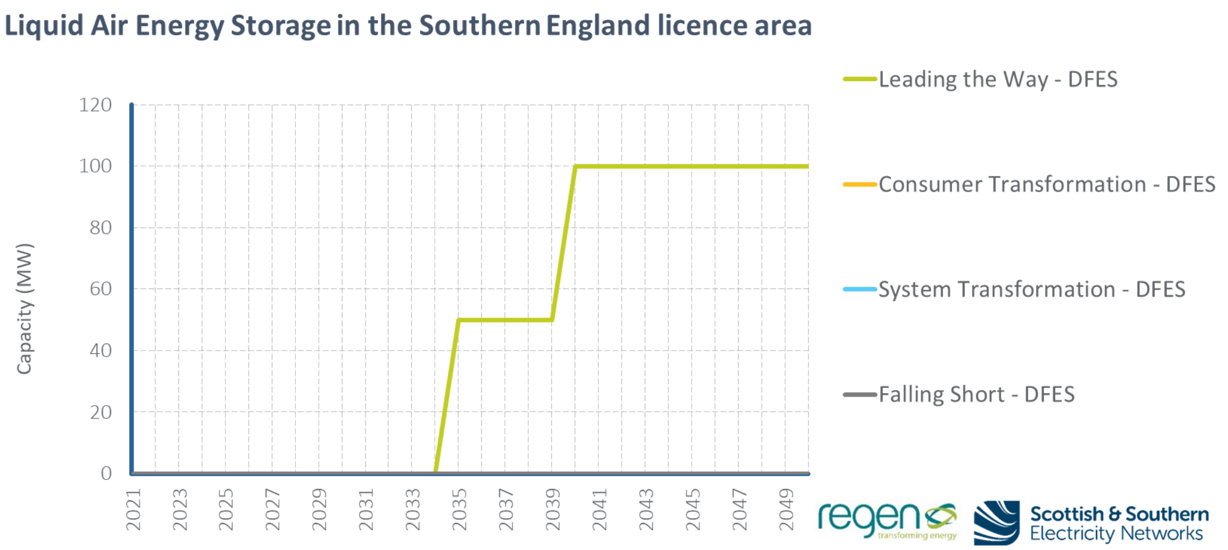
The analysis covers liquid air energy storage (LAES), sometimes referred to as cryogenic electricity storage, connected to the distribution network in the Southern England licence area.

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 30: Liquid air energy storage projections for the Southern England licence area



Summary

- Liquid air energy storage (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 required, 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 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 the Long Duration Storage Competition[i] fund, delivered and managed by (then) BEIS.
- One of the leading LAES developers in the UK is Highview Power, who are developing trial and pre-commercial plants in Greater Manchester[ii].
- No LAES plants are 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[iii].
- 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, the DFES 2022 has 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. 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.

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[i] 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
[ii] Highview Power, 2023, https://highviewpower.com/plants/
[iii] National Grid ESO, 2023, *Stability Pathfinder.* https://www.nationalgrideso.com/future-energy/projects/pathfinders/stability

Electric vehicles and EV chargers

Summary of modelling assumptions and results

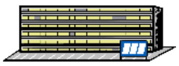
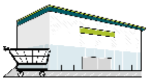
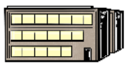
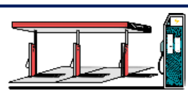
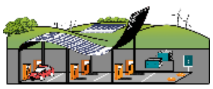
Technology specification

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).**

No 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 2022 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	91	216	572	1,499	3,088	4,476	4,923
	System Transformation		238	761	2,285	4,198	4,801	4,547
	Consumer Transformation		479	1,536	3,572	4,722	4,806	4,578
	Leading the Way		442	1,501	3,789	4,712	4,506	3,719
Plug-in hybrid EVs (Total, numbers, thousands)	Falling Short	60	97	171	300	450	309	119
	System Transformation		94	155	248	187	80	-
	Consumer Transformation		86	117	157	108	44	-
	Leading the Way		96	147	131	69	-	-

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	42	138	369	909	1,743	1,832	1,836
	System Transformation		151	474	1,311	1,828	1,832	1,836
	Consumer Transformation		314	978	1,850	1,871	1,892	1,913
	Leading the Way		288	950	1,850	1,871	1,892	1,904
Non-domestic EV chargers[28] (Total, MW)	Falling Short	95	224	501	1,170	2,303	3,247	3,876
	System Transformation		277	746	2,006	3,429	3,715	3,789
	Consumer Transformation		452	1,260	2,743	3,437	3,502	3,639
	Leading the Way		446	1,294	2,968	3,580	3,644	3,884

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

Figure 31: EV projections for the Southern England licence area, compared to National Grid FES 2022 regional projections

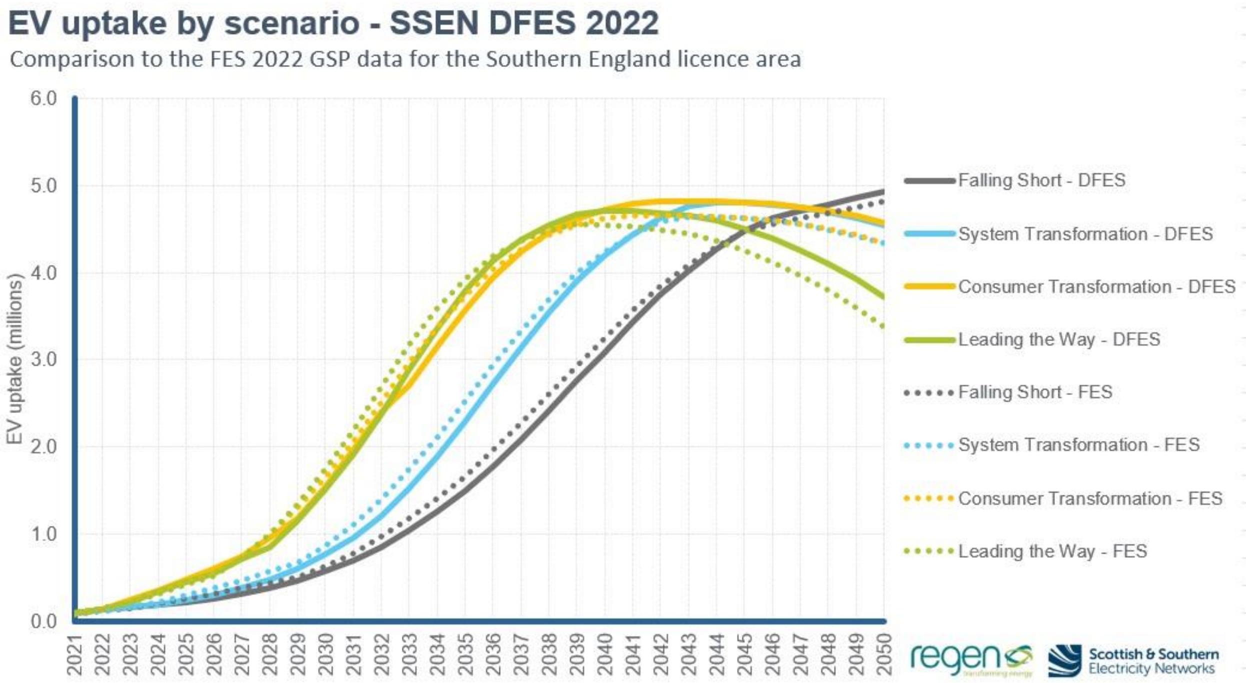
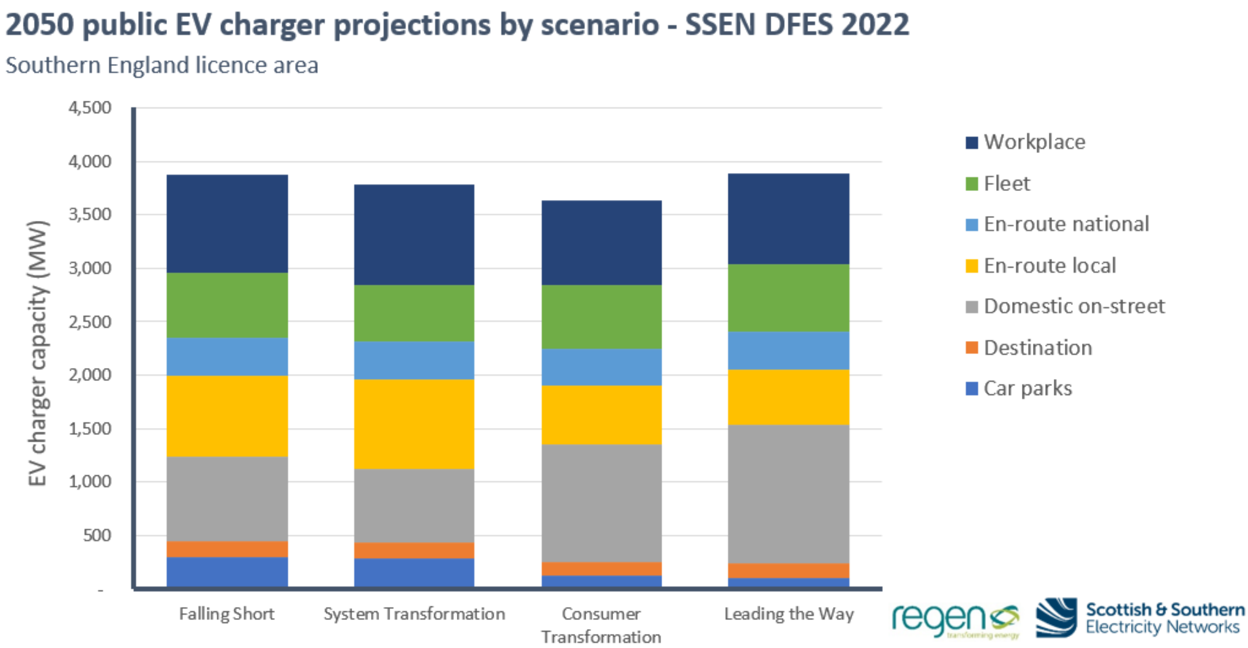


Figure 32: Non-domestic EV charger projections for the Southern England licence area

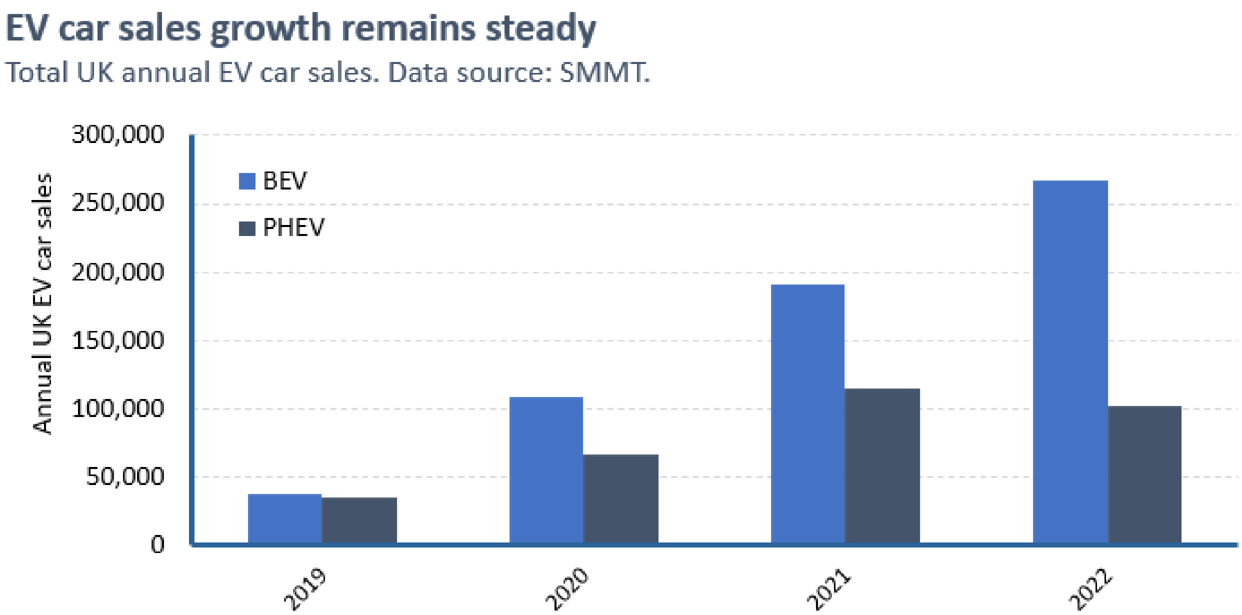


No comparison to the FES 2022 is made for EV charger projections, as FES 2022 data does not provide sufficient regional or GSP level information to reconcile DFES EV charger projections with.

Summary

- 2.8% of cars in the Southern England licence area are currently battery EVs, while 1.5% are plug-in hybrids; both are above national uptake rates for these vehicles of 1.5% and 1%, respectively. This is anticipated to increase substantially under every scenario as the UK looks to decarbonise the transport sector.
- In all net zero scenarios, petrol and diesel vehicles are replaced by low emissions vehicles between now and 2050. This is in line with the UK Transport Decarbonisation Plan, which sets out to ban the sale of new petrol and diesel cars by 2030, announced in November 2020[i]. In addition, in all scenarios, over 90% of petrol and diesel vehicles are replaced with battery EVs, with all plug-in hybrid EVs being phased out in all scenarios but **Falling Short**.
- The uptake of EV chargers is projected to increase substantially under every scenario to facilitate EV uptake. Nevertheless, there is significant uncertainty regarding the scale and geographical distribution of a future EV charger network and future consumer behaviour; the split between off-street home charging versus public charging, 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.
- Compared to the DFES 2021 report and FES 2021, the long-term projected uptake of EVs in DFES 2022 is slightly higher due to an increase in the proportion of HGVs, LGVs, buses and coaches that are battery electric rather than other low-carbon fuels in the long term. Consequently, there is also a slight increase in EV charger capacity to accommodate the increased electricity demand from additional EVs.
- Compared to the DFES 2021 report and FES 2021, the short-term projected uptake of EVs in DFES 2022 is slightly lower than previously projected due to the passage of a further year since the last study in which EV uptake has not aligned with the ambitious net zero scenarios.

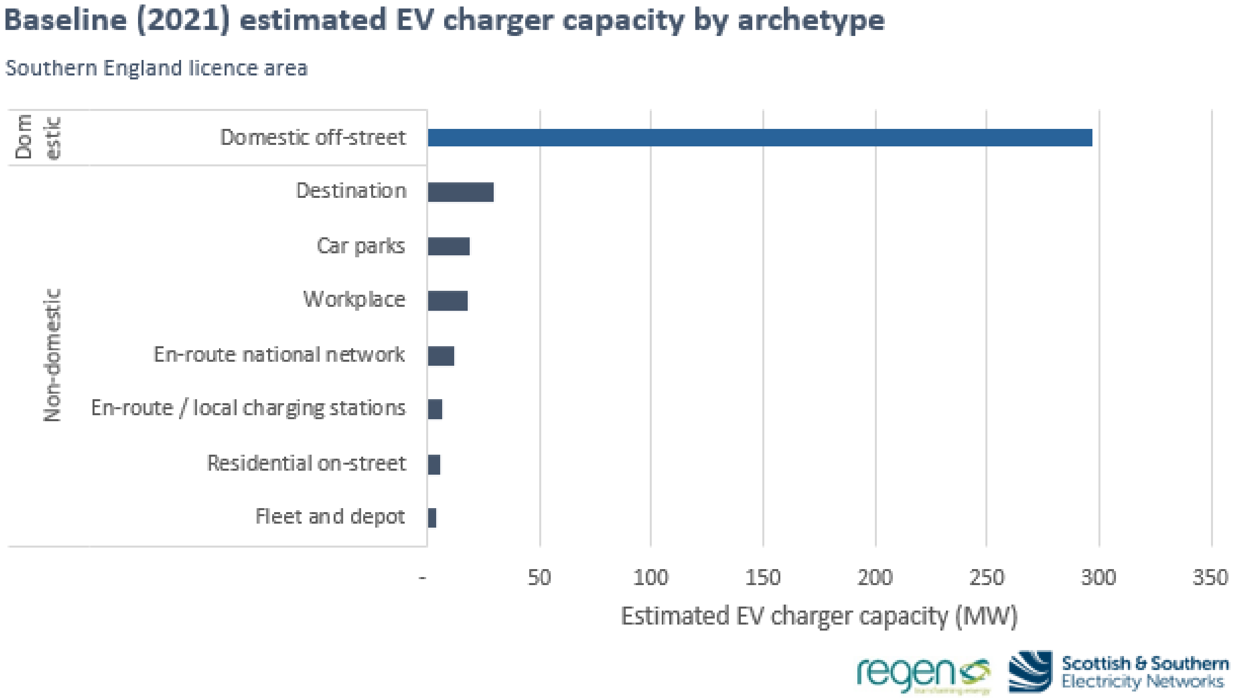
Figure 33: Over 260,000 EV car sales in the UK in 2022, up 40% in 2021. However, these sales are not as high as the uptake in most net zero FES 2021 scenarios.



Modelling and assumptions

<table>
<tr><th colspan="3">Electric Vehicle Baseline (2021)</th></tr>
<tr><th>Archetype</th><th>Thousands of vehicles</th><th>Description</th></tr>
<tr><td>Pure electric car</td><td>83</td><td rowspan="5">EV uptake in the Southern England licence area is currently ahead of the national average. EV uptake has also steadily increased across GB, particularly for battery EVs in recent years. This has been due to several factors, including:
• Favourable tax benefits and grants 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 vehicles, such as light goods vehicles (LGVs) and buses, are beginning to see uptake.
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.</td></tr>
<tr><td>Plug-in hybrid car</td><td>60</td></tr>
<tr><td>Pure electric LGV</td><td>7</td></tr>
<tr><td>Plug-in hybrid LGV</td><td>0</td></tr>
<tr><td>Other electric vehicles</td><td>1</td></tr>
<tr><th colspan="3">EV Charger Baseline (2021)</th></tr>
<tr><th>Archetype</th><th>Capacity or numbers</th><th>Description</th></tr>
<tr><td>Non-domestic EV chargers</td><td>95 MW</td><td rowspan="2">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[ii], non-domestic chargers in car park chargers, workplace charging and rapid en-route chargers on forecourts have seen an increasing rollout in recent years.</td></tr>
<tr><td>Domestic EV chargers</td><td>42,448 chargers</td></tr>
</table>

Figure 34: Domestic and non-domestic EV charger baseline



EV Scenario Projections

Under the three net zero scenarios, EV adoption approaches saturation and purchasing new EVs slows in most areas in the early 2040s. However, harder-to-electrify vehicles that saw lower uptake in the near term, such as HGVs, are projected to see a higher uptake out to 2050.

EV uptake slows and then reduces in all net zero scenarios but most prominently in **Leading the Way** in the long term, reflecting a lower level of car ownership and higher use of public transport. While it is assumed that while EV numbers may reduce in the 2040s under all net zero scenarios, installed EV chargers will remain in place, but may see different use trends as the overall number of vehicles on the road decreases and behaviours change.

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 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. While by 2050, most vehicles are still electrified, a high proportion of this electrification occurs in the 2040s. Under this scenario, there are still petrol and diesel vehicles on the road in 2050.	1,499	4,923
System Transformation	The electrification of vehicles is slightly slower under this scenario, with the ban on sales of new petrol and diesel cars being pushed back until 2032. Nevertheless, the licence area reaches 1 million registered EVs just two years later than the most ambitious scenarios, in 2030.	2,285	4,547

<table>
<tr><td></td><td>Plug-in hybrid vehicles see moderate uptake, but battery electric vehicles are the dominant EV technology across all vehicle classes.

The higher availability of low-carbon hydrogen in this scenario results in fewer passenger and non-passenger vehicles converting to hydrogen. 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></td><td></td></tr>
<tr><td>Consumer Transformation</td><td rowspan="2">Passenger vehicles such as cars and LGVs are rapidly electrified, bolstered by a ban on sales of new petrol and diesel vehicles from 2030. Non-passenger vehicles, such as HGVs and buses, follow suit over a longer timeframe. By 2050, almost all road vehicles are electrified in these scenarios. In Leading the Way, there is a substantial reduction in the total number of EVs between the early 2040s and 2050, facilitated by increased use of active travel, public transport and shared vehicles. In addition, EV uptake is facilitated by a widespread rollout of domestic and non-domestic charging.</td><td>3,572</td><td>4,578</td></tr>
<tr><td>Leading the Way</td><td>3,789</td><td>3,719</td></tr>
</table>

EV Charger Scenario Projections

For non-domestic EV chargers, Regen's EV charger DFES model determines the EV charger capacity required to charge the number of vehicles projected under each of the four DFES scenarios. This capacity is converted to a subsequent number of EV chargers, split across 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 in the projections and assumptions around how EVs may be charged under each FES scenario and mileage driven. Where possible, the National Grid ESO FES data drives these charging behaviour assumptions.

Domestic EV charger uptake is modelled based on EV uptake in households with off-street parking. It is assumed most households with an EV install an 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. By this point, almost all road vehicles are electrified. EV charger uptake is relatively rapid in en-route locations, facilitated by government and local authority leadership; however, uptake across all EV charger archetypes is the slowest compared to other scenarios.	909	1,836	1,170 MW	3,876 MW
System Transformation	Both EV adoption and associated EV charger capacity peak in the late 2040s. 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 scenario.	1,311	1,836	2,006 MW	3,789 MW

<table>
<tr><td>Consumer Transformation</td><td rowspan="2">Both EV adoption and associated EV charger capacity peak in the early 2040s. By this point, almost all road transport is electrified. In Leading the Way, the uptake of EV cars slows and then reduces significantly as consumers adopt new transport methods, including public transport, shared vehicles and autonomous vehicles (AVs). However, while the number of EV cars may reduce, utilisation and milage per AV increases significantly. The reduction in overall energy demand is, therefore, less significant. Consequently, there is not a corresponding decrease in EV charger capacity.</td><td>1,850</td><td>1,913</td><td>2,743 MW</td><td>3,639 MW</td></tr>
<tr><td>Leading the Way</td><td>1,850</td><td>1,904</td><td>2,968 MW</td><td>3,884 MW</td></tr>
</table>

EVs reconciliation with National Grid FES 2022

Modelling Stage	Reconciliation
Baseline	Baseline EV numbers in the DFES 2022 are sourced from DfT vehicle licencing data and are slightly different to the FES 2022 baseline figures, most likely due to the time of data extraction.
Projections	The SSEN DFES 2022 projections align with the FES 2022 projections for this licence area, as reported for the Building Block ID numbers Lct_BB001, Lct_BB002, Lct_BB003 and Lct_BB004. It is assumed the small variations in projections between SSEN DFES 2022 and FES 2022 projections are due to similar variations found in the baseline, associated with varying accounting of the total number of vehicles in the licence area.

EV charger reconciliation with National Grid FES 2022

Modelling Stage	Reconciliation
Baseline and projections	The ESO FES 2022 data does not provide sufficient regional or GSP-level information to reconcile DFES EV charger projections. However, factors that will affect EV charging infrastructure which are available in the FES 2022 assumptions and data workbooks, are used where it is possible to do so, including: • Projections of vehicle numbers • Projections of EV average annual mileage trends • Projections of EV and EV charger efficiencies. FES assumptions related to EV chargers can be seen in FES 2022 assumption tables below.
Other assumptions	Although there have been several trial projects and new data becoming available, there is still a lack of evidence of future consumer charging behaviour, charger utilisation rates and vehicle ownership trends. This results in some uncertainty in the assumptions that must be made to project future EV charging requirements. Assumptions made include: • What proportion of annual EV energy requirements will be delivered at different locations (and thus by which EV charger archetypes) • EV charger utilisation rates at different locations. These assumptions have been made using industry input and Regen analysis. As more behavioural data and other evidence become available, these assumptions will be further refined for future DFES analysis. Some assumptions have been made as to the behaviour of AV cars, including:

	• The proportion of AVs that are private or shared in the absence of further information. • AV charging behaviour is similar to EV cars, the key difference being increased fleet/depot charging.

Geographical Factors affecting deployment at a local level

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

Relevant assumptions from National Grid FES 2022

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 Transformation	Consumers' demand for public transport increases as attitudes change. Some two-car households shifting to one-car leads to further growth.
Leading the Way	Consumers' demand for public transport increases as attitudes change. Therefore, growth is limited by the growth in Robotaxis for urban transport in this scenario.

3.3.2 - Autonomy	
Falling Short	Uptake is 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 further 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 due to being 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 limit 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's a lack of solutions to residential charging, for those without off-street parking, which consumers are willing to adopt. These consumers charge at destinations such as work
System Transformation	There's a lack of solutions to residential charging, for those without off-street parking, 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 & 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

Stakeholder feedback provided	How this has influenced our analysis
When 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), stakeholder was split but leant towards (44%) more widely dispersed EV charging, compared to 39% neighbourhood charging and 18% a shift towards centralised charging infrastructure.	Stakeholder feedback highlighted the uncertainty of the shape and size of a future EV charger network and future consumer behaviour. Therefore, to reflect this feedback, the scenarios model variability in the proportion of EV charging undertaken at dispersed locations and more centralised locations, as well as the proportion near and far away from home.
The Uptake of EVs in the Southern England licence area is ahead of the national average. However, when asked when uptake across GB could catch up with the Southern England licence area or when uptake in the Southern England licence rea would drop back to the GB average, stakeholders considered that the licence area would remain ahead of the national average until the mid-2030s.	This stakeholder feedback influenced the rate at which the licence area's EV uptake was modelled, with projections ensuring uptake in the licence area would remain ahead of the national average until the 2030s.

References

Department for Transport data, Climate Emergency declaration data, Regen consultation with local stakeholders, Census 2011, SSEN connection data, National Chargepoint Registry, Department for Transport data, Climate Emergency declaration data, Regen consultation with local stakeholders, Census 2011 data.

[i] Department for Transport 2020, *Government takes historic step towards net-zero with end of sale of new petrol and diesel cars by 2030.* https://www.gov.uk/government/news/government-takes-historic-step-towards-net-zero-with-end-of-sale-of-new-petrol-and-diesel-cars-by-2030
[ii] 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 fuelled heating technologies within the scope of the SSEN DFES 2022. 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

		Number of homes (thousands)	Baseline	2025	2030	2035	2040	2045	2050
Domestic	Non-hybrid heat pumps	Falling Short	26	59	168	339	614	923	1,287
		System Transformation		71	159	237	330	474	768
		Consumer Transformation		97	465	1,129	1,803	2,219	2,410
		Leading the Way		228	719	1,269	1,685	1,858	1,904
	Hybrid heat pumps	Falling Short	--	--	3	8	15	21	26
		System Transformation		2	8	22	257	497	671
		Consumer Transformation		1	9	19	29	39	52
		Leading the Way		2	13	79	171	255	283
		Number of properties (thousands)	**Baseline**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Non-domestic	Non-hybrid heat pumps	Falling Short	3	7	12	18	24	30	34
		System Transformation		10	24	38	49	56	60
		Consumer Transformation		14	36	52	70	78	84
		Leading the Way		12	32	47	60	65	66
	Hybrid heat pumps	Falling Short	--	1	1	1	2	4	7
		System Transformation		3	8	17	26	34	38
		Consumer Transformation		4	11	17	20	20	21
		Leading the Way		4	11	19	26	29	32

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	372	355	316	272	233	210	205
	System Transformation		348	304	260	182	121	88
	Consumer Transformation		363	322	271	253	237	208
	Leading the Way		344	308	264	238	216	216

Figure 35: Domestic heat pumps (non-hybrid and hybrid[29]) projections for the Southern England licence area, compared to National Grid FES 2022 regional projections

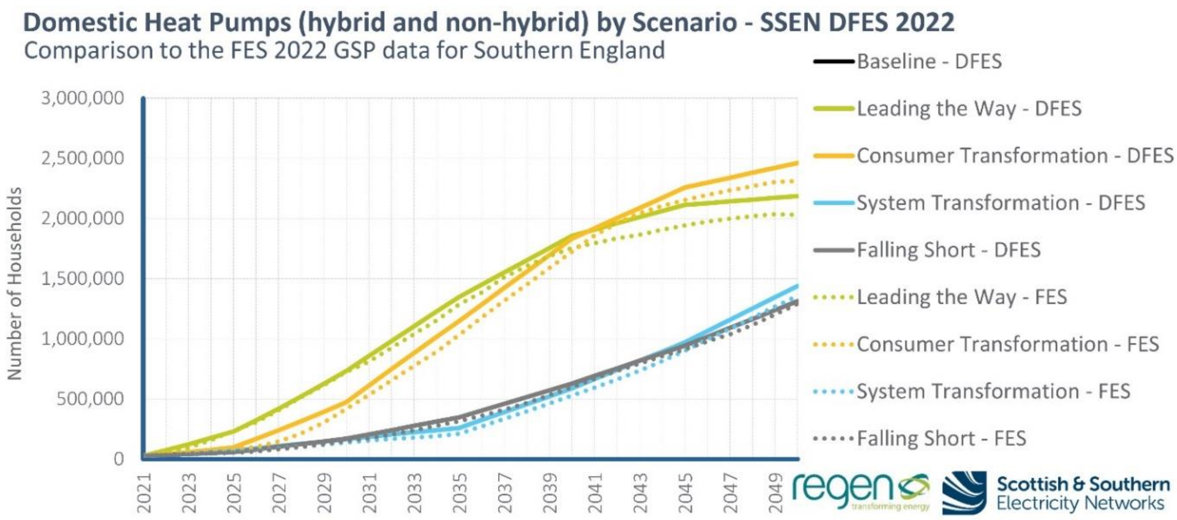
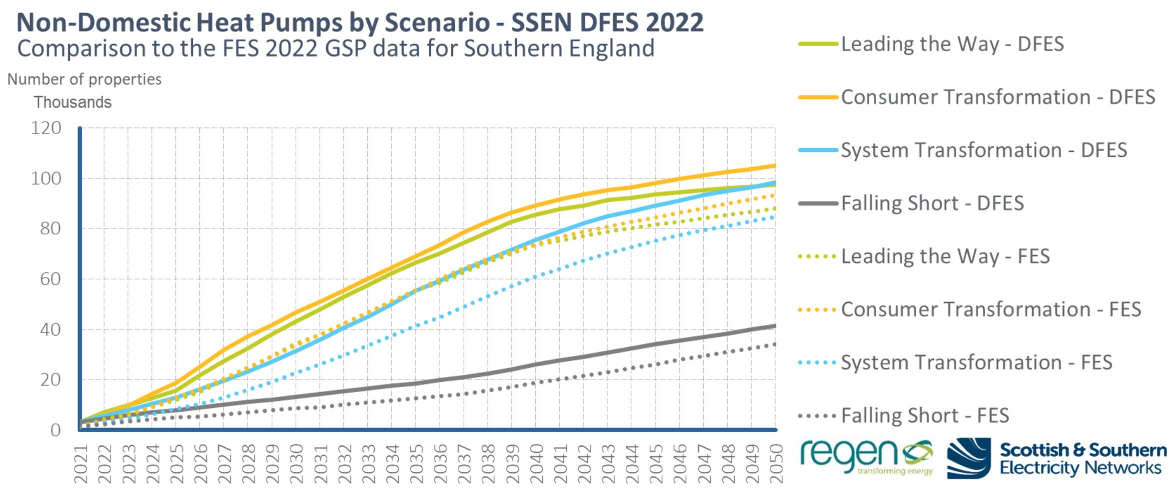
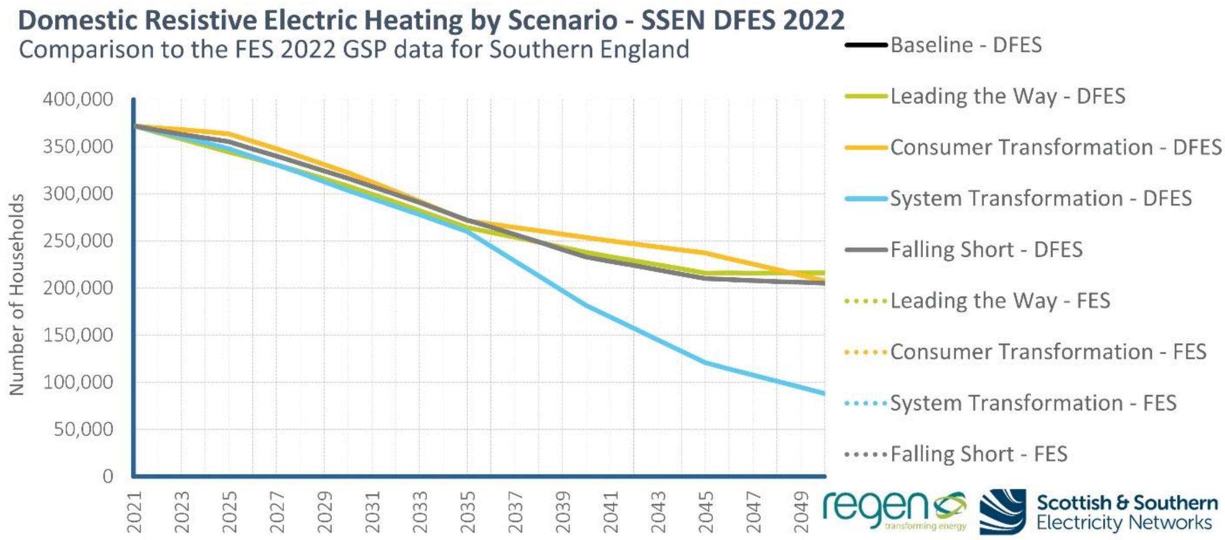


Figure 36: Non-domestic heat pumps (non-hybrid and hybrid) projections for the Southern England licence area, compared to National Grid FES 2022 regional projections



[29] The Building Block data provided in the FES 2022 classifies an 'ASHP with a resistive heating element' as a hybrid heat pump, whereas the DFES analysis considers this to be a variation of a non-hybrid heat pump. Accordingly, the reconciliation between FES and DFES 2022 results has been undertaken using combined figures for both non-hybrid and hybrid heat pumps together.

Figure 37: 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 carbon reduction targets.
- Under **Consumer Transformation** and **Leading the Way**, heat pumps are the primary driver in the decarbonisation of heat in the Southern England licence area and at a national level. The initial adoption of heat pumps is projected to occur mostly in off-gas, well-insulated buildings, with a subsequent wider-scale rollout of heat pumps across the majority of buildings modelled out to 2050. For the Southern England licence area, this results in c. 2.5 million homes and c. 105,000 non-domestic buildings operating a heat pump by 2050 under **Consumer Transformation**.
- Under **System Transformation**, , the primary driver for the decarbonisation of heat is low-carbon hydrogen, which is utilised through a mixture of standalone hydrogen boilers and hybrid heat pumps. Due to a high proportion of on-gas buildings, the majority of buildings in the Southern England licence area are expected to transition to hydrogen boilers or hydrogen hybrid heat pumps by 2050 under this scenario. However, it is projected that approximately 768,000 homes and 60,000 non-domestic buildings will still operate non-hybrid heat pumps in 2050.
- In all scenarios, there is a decline in the number of buildings using resistive electric heating, including direct electric heating and night storage heaters, which is replaced by heat pumps and district heating. Direct electric heating, being the most expensive heating method, serves as a financial incentive for consumers to transition to alternative technologies in all four scenarios. Additionally, there is a shift from direct electric heating to next-generation storage heating in homes where a boiler or heat pump is less suitable, such as in properties with very low energy efficiency levels.
- 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.

Modelling and assumptions

<table>
<tr><th colspan="4">Baseline (2021)</th></tr>
<tr><th colspan="4">Domestic heat pumps</th></tr>
<tr><th>Sub-technology</th><th>Number of homes (thousands)</th><th>Proportion of homes</th><th>Description</th></tr>
<tr><td>Non-hybrid ASHP</td><td>22</td><td>0.8%</td><td rowspan="3">The Renewable Heat Incentive (RHI) scheme, which operated from 2014 to 2022, provided significant support for the installation of heat pumps in existing homes. The RHI has been succeeded by the Boiler Upgrade Scheme[i], which moves support to an upfront grant payment to reduce the capital costs of installing a heat pump.

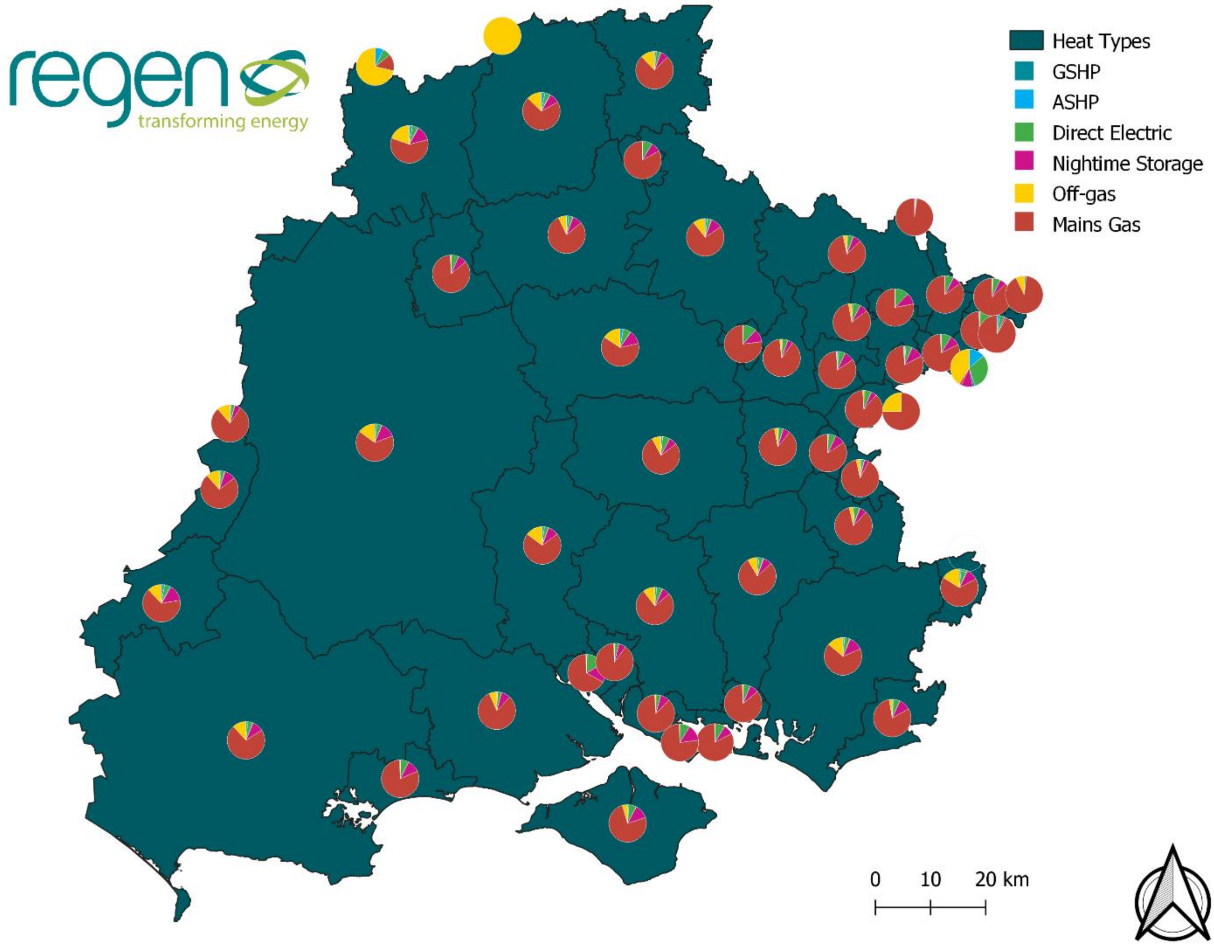
The RHI was particularly popular in the South of England, with around 21% of all heat pumps accredited by the RHI being in the Southern England licence area. 1% of homes in the licence area now have a heat pump, aligning with the national average.

As of the end of 2021, an estimated 26,000 homes were heated by domestic heat pumps, compared to c.19,000 in 2020. This vast increase in baseline data is partly due to far greater availability of EPC data, giving more confidence in the characterisation of the area compared to the more probabilistic assessment of key parameters used for DFES 2021 at a more granular low-voltage, feeder level.</td></tr>
<tr><td>Non-hybrid GSHP</td><td>4</td><td>0.2%</td></tr>
<tr><td>Hybrid heat pump</td><td>-</td><td>-</td></tr>
<tr><th colspan="4">Domestic resistive electric heating</th></tr>
<tr><td>Night storage heaters</td><td>236</td><td>8.6%</td><td rowspan="2">Resistive electric heating is more common in the Southern England licence area compared to the national average, heating almost 13% of homes, compared to 8% nationally, according to FES 2022. As of the end of 2021, approximately 372,000 homes were heated by resistive electric heating, compared to c. 358,000 in 2020. This change in the baseline figure is due to the updated EPC dataset, which holds greater data availability and gives more confidence in this year's baseline figures.

The licence area has a slightly higher-than-average proportion of off-gas homes (see Figure 38) 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.</td></tr>
<tr><td>Direct electric heaters</td><td>136</td><td>5.0%</td></tr>
</table>

<table>
<tr><th colspan="4">Non-domestic heat pumps</th></tr>
<tr><td>Non-hybrid heat pump</td><td>3</td><td>--</td><td>An estimated 3,200 non-domestic properties are currently heated by a non-hybrid heat pump. As with domestic properties, there are no hybrid heat pumps in the baseline.</td></tr>
</table>

Figure 38: Heat Type by Local Authority for the SSEN Southern England Licence Area



<table>
<tr><th colspan="4">Near-term projections (2022-2025)</th></tr>
<tr><td colspan="4">The future uptake of different types of electric heating in the licence area is modelled based on several key factors, such as housing 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 LPG. Conversely, the number of homes heated by resistive electric heating is projected to slowly decrease under every scenario in the near term.</td></tr>
<tr><th colspan="4">Domestic heat pumps</th></tr>
<tr><th rowspan="2">Scenario</th><th rowspan="2">Description</th><th colspan="2">Proportion of homes with a heat pump in 2025</th></tr>
<tr><th>Southern England</th><th>GB (FES)</th></tr>
<tr><td>Falling Short</td><td rowspan="2">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. 59,000-73,000 homes (and c. 7,000-10,000 non-domestic buildings) 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.</td><td>2%</td><td>2%</td></tr>
<tr><td>System Transformation</td><td>3%</td><td>2%</td></tr>
<tr><td>Consumer Transformation</td><td rowspan="2">As a licence area with numerous heavily populated areas, the Southern England licence area has a strong potential to contribute to national heat pump targets. Under the Consumer Transformation and Leading the Way scenarios, the uptake of both ASHP and GSHP heat pumps is highest 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)[ii].

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, some on-gas houses and flats also convert to heat pumps due to the regional adoption of the Boiler Upgrade Scheme[i].

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.</td><td>3%</td><td>3%</td></tr>
<tr><td>Leading the Way</td><td>8%</td><td>7%</td></tr>
</table>

Domestic resistive electric heating

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, whilst current gas prices remain high, with the licence area hosting a notable 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.	13%	8%
System Transformation		12%	8%
Consumer Transformation	Under these two scenarios, 5% 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.	13%	8%
Leading the Way		12%	8%

Non-domestic heat pumps

Scenario	Description	Installations in 2025	
		non-hybrid	**hybrid**
Falling Short	Non-domestic heat pump varies slightly by scenario in the near-term, with the most uptake occurring under **Consumer Transformation**, where small-scale businesses are expected to accelerate uptake to decarbonise heating at a faster rate as conscious commercial consumers.	7,442	623
System Transformation		10,091	2,998
Consumer Transformation		14,500	4,423
Leading the Way		11,683	4,097

Medium and Long-term projections (2025-2050)

Heat decarbonisation accelerates in the Southern England licence area in the medium term, especially under 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. Under every scenario, this includes both heat pumps and connections to district heat networks. There are 470,000-560,000 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[iii].

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.	11%	11%	41%	41%
System Transformation	Under **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.	8%	7%	44%	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 (38-44%); a national shift in heating technologies drives this. By 2050, almost all properties are heated by standalone heat pumps, district heating or resistive electric heating under 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. 2.2-2.5 million properties are operating a type of heat pump by 2050 under these scenarios.	38%	35%	76%	73%
Leading the Way		44%	42%	66%	64%

Domestic resistive electric heating					
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 boilers and hybrid heat pumps.	9%	6%	6%	5%
System Transformation		9%	6%	3%	2%
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. 208-216 thousand homes are operating a resistive electric heater by 2050 under these scenarios.	9%	7%	6%	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 except System Transformation, which also sees more ambitious uptake than with domestic heat pumps by 2050. Under Consumer Transformation, c.105,000 non-domestic premises install a type of heat pump by 2050, reflecting more businesses focusing on electrification to meet their net zero plans in the region.	17,763	869	34,070	7,305
System Transformation		37,956	16,697	60,372	37,916
Consumer Transformation		52,244	16,850	83,702	21,325
Leading the Way		47,172	19,395	65,813	31,837

Reconciliation with National Grid FES 2022

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 larger number of non-domestic heat pumps than the FES, likely due to a difference in the modelled number of non-domestic properties in the licence area (evidenced by EPC and DEC data for the DFES).
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:** The DFES shows more non-domestic heat pumps than the FES.
Overarching trend	The DFES outcomes for total heat pumps under each scenario are broadly aligned with the FES 2022 data, albeit with slightly higher overall outcomes under every scenario by 2050. This could be due to differences in the total housing stock modelled in the FES and DFES. In all scenarios, the DFES non-domestic heat pump projections are higher than the FES 2022. This is likely due to small differences in the total number of heated non-domestic buildings considered in each analysis. The DFES building stock is modelled based on BEIS NEED data, Ordnance Survey Addressbase data, Non-Domestic EPC, and Display Energy Certificate 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[iv], ONS Census[v]
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 levels of energy efficiency is categorised into well-insulated homes (EPC B and above) and less well-insulated homes	EPC data

Relevant assumptions from National Grid FES 2022

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 focussed 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.

[i] 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
[ii] UK Government 2021, *Heat and Buildings Strategy.* https://www.gov.uk/government/publications/heat-and-buildings-strategy
[iii] 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
[iv] Open Data Communities 2022, *Energy Performance of Buildings Data England and Wales.* https://opendatacommunities.org/home
[v] Nomis 2021, *2021 Census.* https://www.nomisweb.co.uk/sources/census_2021

Domestic air conditioning

Summary of modelling assumptions and results

Technology specification

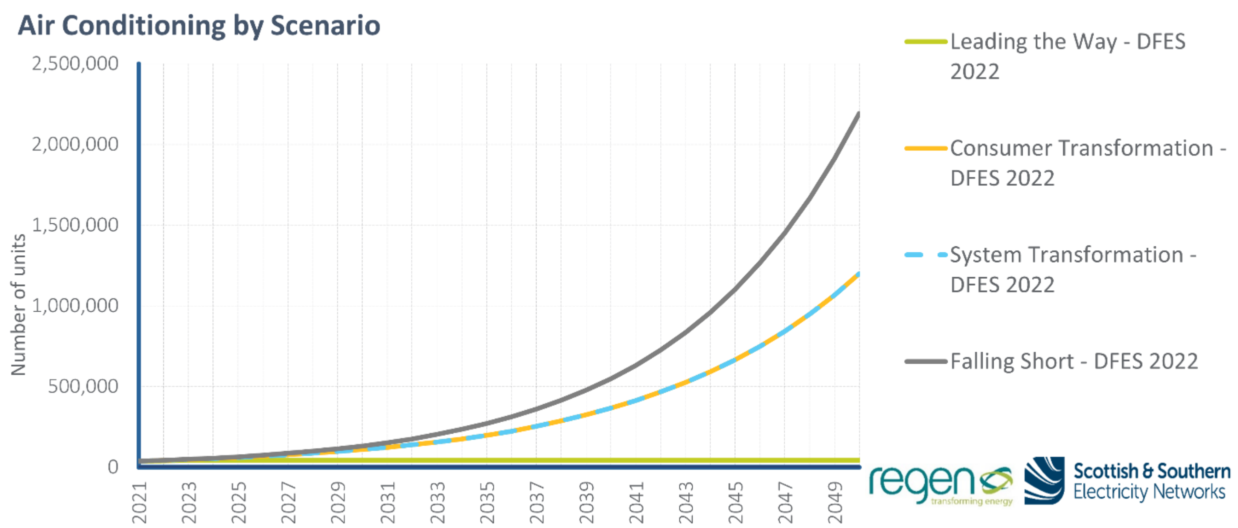
This analysis covers domestic air conditioning units, based on a typical portable or window-mounted unit in the Southern England licence area.

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	38	65	130	271	547	1,102	2,192
System Transformation		61	110	197	366	665	1,199
Consumer Transformation		61	110	197	366	665	1,199
Leading the Way		42	43	43	43	43	43

Figure 39: Air conditioning projections for the Southern England licence area



Summary

- The baseline for air conditioning (AC) units in the Southern England licence area, ~38,000 units, represents 1.45% of homes in the licence area. This is higher than the national baseline of c. 1% of UK homes currently containing AC units[i].
- The number of cooling degree days[ii] at 18.5 °C in the Southern England licence area was the second highest in the UK.
- Based on assumptions in relevant Building Regulations[iii] it has been assumed that domestic AC units will not be added to new developments in the licence area.
- The small baseline numbers and high uncertainty around the future of domestic cooling have resulted in a broad range of scenario outcomes for the licence area. **Leading the Way** sees the lowest uptake of AC units (c.43,448) by 2050. **Falling Short** models domestic AC becoming much more common, with a projection of c. 2.2 million new units.

Modelling and assumptions

Baseline (2021)	
Number of domestic units	**The proportion of homes with AC unit**
38,170	1.45%

Baseline modelling assumptions

We have aligned with the National Grid FES 2022[i] data, which provides a national baseline of around 296,000 domestic air conditions, equivalent to around 1.1% of homes in the UK.

In addition, a 2016 report by Tyndall Manchester[iv] reviews AC installations in the UK, stating that 1-3% of households reported some form of AC.

The national figure was distributed based on regional temperate data and housing density to estimate the licence area baseline. The Southern England licence area was found to be the UK licence area with the second-highest days at or above 18.5 °C and the fifth-highest population density[v]. As a result, a baseline that is slightly higher than the national average (1.45%) was modelled, equating to c.38,000 AC units.

Near-term (2023-2025)

Scenario	Description
Falling Short System Transformation Consumer Transformation	Under these scenarios, uptake in domestic AC units increases 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". The uptake of AC units is expected to be between c. 61-65 thousand units in homes by 2025 in these scenarios.
Leading the Way	The uptake of domestic AC is minimal, with households opting for passive cooling methods such as shading, ventilation, and insulation. As a result, very few new AC units are installed by 2025 under this scenario.

Medium-term and long-term (2025-2050)

Scenario	Description	Homes with AC units (1000s) In 2035	% Of housing stock In 2035	Homes with AC units (1000s) In 2050	% Of housing stock In 2050
Falling Short	The increasing frequency of heat waves and societal reluctance to engage in passive cooling leads to a more significant uptake of domestic AC as the 'easiest' route to comfortable internal temperatures. This is an increase from the DFES 2021 projections reflecting both an increase from the FES 2021 and also the amount of 18.5 °C cooling days occurring per year.	271	10.3%	2,192	83.5%

System Transformation Consumer Transformation	Uptake of domestic AC accelerates in urban areas due to heat island effects and the prevalence of smaller dwellings such as flats.	197	7.5%	1,199	45.7%
Leading the Way	This scenario aims to limit carbon emissions and electricity consumption using passive cooling measures. As a result, additional AC uptake is resultantly minimal in the licence area by 2050.	43	1.6%	43	1.7%

Modelling assumptions	
Criteria	**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. Population density (person 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 is located in very densely populated areas, including areas just outside of London, within Bournemouth and sections 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.

Cooling degrees days	Cooling degree days at 18.5 °C in Southern England are the second highest in the UK, with c. 163 recorded days in the licence area. This metric was used in all scenarios.
Future Homes Standard	The Future Homes Standard Document O[vi] stipulates high energy efficiency for air conditioning and limits oversizing cooling systems in new homes. As a result, the DFES 2022 modelling assumes that the vast majority of domestic air conditioning uptake is retrofitted in existing homes under every scenario.

Reconciliation with National Grid FES 2022:

- The FES 2022 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 2022 national average in every scenario.

Geographical Factors affecting deployment at a local level

Geographical Factors	Description
Population Density	Early uptake is focused in denser urban areas. Later uptake expands to areas of lower housing density in scenarios where domestic AC becomes more prevalent.
Affluence	The near-term distribution of domestic AC is influenced by net annual income after housing costs due to the relatively high upfront costs and running of domestic AC units.

Relevant assumptions from National Grid FES 2022

Scenario		3.1.2 - Uptake of Residential Air Conditioning
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)

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[i] National Grid 2020. *FES 2020 Data workbook, ED2 worksheet Data Item for Residential Air Conditioning.* https://www.nationalgrideso.com/future-energy/future-energy-scenarios/archive
[ii] Stark 2022, *Degree Days for Free.* https://www.stark.co.uk/degree-days-for-free/
[iii]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
[iv] Tyndall Manchester 2016, *Air conditioning demand assessment*. https://www.enwl.co.uk/globalassets/innovation/enwl001-demand-scenarios--atlas/enwl001-closedown-report/appendix-3---tyndall-uom---air-conditioning-demand-report-may2016.pdf
[v] ONS 2011. Census2011: *Usual Resident Population*. https://www.nomisweb.co.uk/census/2011/ks101uk
[vi] UK 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

Hydrogen electrolysis

Summary of modelling assumptions and results

Technology specification

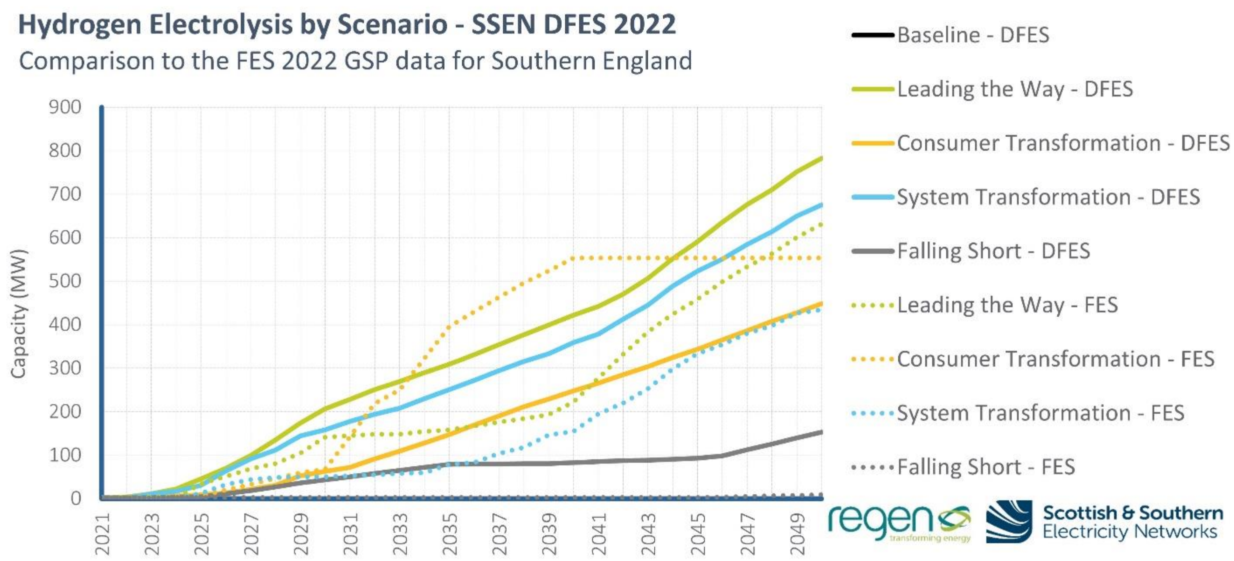
The analysis covers the capacity of hydrogen electrolysers connected to the distribution network in the Southern England licence area. The analysis does not include electrolysers that are directly powered by renewable energy without a dedicated grid connection ('off-grid') or large-scale electrolysers connected to the transmission network. Nor does it include 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	2	4	43	78	83	93	153
System Transformation		31	159	229	359	523	675
Consumer Transformation		9	63	136	248	343	448
Leading the Way		46	206	285	422	590	782

Figure 40: Hydrogen electrolysis projections for the Southern England licence area, compared to National Grid FES 2022 regional projections



Summary

- There is a degree of uncertainty around the direction of travel for hydrogen electrolysis as an emerging technology.
- This uncertainty results in a wide range of future capacity projections under the three net zero scenarios and limited growth under **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.
- Southern England is a transport hub comprising road and rail networks, Heathrow Airport, and multiple ports along the southern 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 several hydrogen hubs.
- The British Energy Security Strategy[i] outlines 10 GW of low carbon hydrogen, of which 5 GW is to be from electrolysis, by 2030. The Regional Transport Strategy of England's Economic Heartland subnational transport body highlights the future role of electric hydrogen in road and rail transport[ii].
- The UK government's electrolytic allocation round[iii] will provide government subsidy support from 2023 onwards for both CAPEX, via capital grants, and OPEX, via ongoing revenue payments. Projects over 5 MW are eligible for support, with successful applicants announced in early 2023.
- Of all DNO licence areas, Southern England is modelled to host between 7-11% of distribution-connected hydrogen electrolysis across GB by 2050, depending on the scenario and regional considerations.
- The largest capacity of distribution-connected hydrogen electrolysers in 2050 is modelled under **Leading the Way** (782 MW) and **System Transformation** (675 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 (2021)		
Number of Sites	**Total Capacity**	**Description**
3	2.4 MW	As of the end of 2021, there were three known electricity networked hydrogen electrolysis sites, all of which are hydrogen refuelling stations. Two stations in Swindon and Beaconsfield, owned by ITM power, were recently upgraded from 0.1 MW to 0.7 MW electrolysers. A third station, operated by BOC and Honda, was recently obtained by Panattoni, which plans to expand the site as a hydrogen plant[iv].

Pipeline (2022-2029)	
Number of pipeline sites	**Total capacity**
2	8.3 MW
Description	
Two prospective hydrogen electrolysis projects are identified in the pipeline where the capacity is known. The decommissioning of the Swindon ITM refuelling station was announced and thus modelled to come offline in all scenarios in 2022[v].	

A further seven sites have been identified with unknown capacity and are thus reflected in the near-term pipeline projections. In cases where sites are non-networked or operating under existing import connections, they have been modelled as 0 kW capacity but recorded for completeness. Networked sites with unknown capacities are reflected through the near-term projections for new electrolysis capacity, co-located alongside areas with hydrogen hubs, boosting near-term projections. These near-term projected 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 obtained by Panattoni

There is a growing number of hydrogen demonstrator and pilot projects across Southern England. However, many of these sites could fall out-of-scope of the analysis due to deriving hydrogen from off-network sources. The extent to which these sites may have backup electricity import agreements to complement on-site generation is unknown, thereby minimising costs[30].

There is an additional 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 projects and full demonstrations are fulfilled.

Networked Pipeline Projects

Pipeline Project	Description	Scenario	Connection Year
Science Museum Group's Science and Innovation Park[vi], 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. Given its pre-feasibility study stage, it is modelled to connect under the three net zero scenarios. The additional 2.5 MW connect under a 2-year delay in **Leading the Way** and **System Transformation**.	**Falling Short**	--
		System Transformation	2027
		Consumer Transformation	2029
		Leading the Way	2025
Dorset Green H2[vii], 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	2022

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.

[30] 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 likely seek backup network import agreements.

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, provides some impetus for the sector[iii]. Successful projects, which must be 5 MW minimum to be eligible to apply, are due to be announced in early 2023.

While Southern England hosts many regional hydrogen innovation hubs, many known projects are destined for transmission or gas grid connection as standalone hubs. For example, sites like the Southampton Hydrogen Superhub could be entirely transmission-connected or off the electricity grid.

Hydrogen electrolysis capacity will likely 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 addition, wider transport decarbonisation policy measures, such as the ban on the sale of new petrol and diesel cars by 2030, will further incentivise this transition to low-carbon heavy vehicles. However, it is understood that most smaller road vehicles will likely be battery-electric vehicles.

In the longer term, hydrogen electrolysers are expected to scale their capacity by increasing the number of modules connecting to a compressor. The total capacity of distribution-connected electrolysers rapidly increases out to 2050 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 2035	Capacity by 2050
Falling Short	All the GB (very limited) electrolysis development remains distribution network-connected out to 2030 and 85% by 2050. Industrial and transport demand see some small hydrogen growth in Southern England.	78 MW	153 MW
System Transformation	Moderate growth is mainly driven by the presence of renewable generation in the licence area and, to some degree, by demand for marine transport. Decent industrial and heavy transport demand in Southern England supports growth. The establishment of a national hydrogen network boosts electrolysis uptake.	229 MW	675 MW
Consumer Transformation	Factors determining the uptake of hydrogen electrolysis are diversified, with industrial customers and clusters being the strongest factor, followed closely 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.	136 MW	448 MW
Leading the Way	GB-wide hydrogen targets are met, and cost parity with hydrogen reformation is reached early on. By 2045, hydrogen is further expanded to support export capabilities. The establishment of a national hydrogen network boosts electrolysis projections.	285 MW	782 MW

Network-connected electrolysis projections – methodology overview

To determine licence-area projections beyond known projects, FES 2022 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 (see table below).

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.

Hydrogen Distribution Factors

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

Below is a brief description of how the licence area weighting factors are applied to the DFES scenarios. The presence of known hydrogen innovation projects is a strong near-term determining factor across all scenarios until at least 2030. Hydrogen produced via electrolysis will be used for transport across all scenarios, favoured over CCUS-enabled hydrogen due to its increased quality/purity.

Scenario	Description
Falling Short	Known hydrogen innovation projects are more important than other regional factors until 2040. Industrial customers and clusters are given strong importance, followed by heavy transport with medium importance. Existing grey hydrogen locations are relatively high compared to other scenarios from 2026 onwards. Storage facilities, marine demand gar network proximity, renewable generation and potential for hydrogen trains are not considered.
System Transformation	Importance is weighted towards heavy transport demand in the early projection years from 2023 onwards. In contrast, industrial customers and clusters take over as the strongest pull factor in later projection years out to 2050. Renewable generation plays a stronger role than other regional factors.

Consumer Transformation	Factors determining the uptake of hydrogen electrolysis are diversified, with industrial customers and clusters being the strongest pull factor, followed closely by heavy transport and marine transport demand. Weighted less strongly are proximity to storage sites and renewable generation. Smaller importance is given to the potential for hydrogen trains and existing grey hydrogen sites.
Leading the Way	Areas with a high density of renewable generation projects and high industrial demand areas are highly important from 2023 onwards, followed by heavy transport demand. Southern England has a decent amount of renewables, heavy transport and industrial demand compared to other licence areas, which furthers its high uptake levels.

Comparison to DFES 2021

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

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

The proportion of GB electrolysis capacity assumed to be distribution network connected by 2050

Scenario	DFES 2021	Capacity by 2050 (MW)	DFES & FES 2022	Capacity by 2050 (MW)
Falling Short	100%	88	85%	9
System Transformation	22%	821	17%	434
Consumer Transformation	74%	2,996	17%	554
Leading the Way	31%	1,944	20%	631

Reconciliation with National Grid FES 2022

Modelling Stage	Reconciliation
Baseline	The DFES and FES 2022 are aligned
Pipeline	Early pipeline years have a slightly higher uptake in Southern England than in the FES. The presence of known projects and hydrogen hub locations in the licence area likely drives this. The DFES analysis method considers licence area proportions of the FES GB level projections. Early-year growth in Southern England is supported by heavy transport, industrial demand, and existing renewable generation in the 2020s.
Projections	Medium and long-term growth is linear across the two leading scenarios in DFES 2022. In contrast, the FES 2022 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 assumptions.
Overarching Trend	FES **Consumer Transformation** projections seem to perform much more highly in Southern England compared to the North of Scotland, where **Leading the Way** and **System Transformation** perform better for distributed electrolysis. However, the reason for this is unable to be determined.

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 bubs and road traffic count for light commercial vehicles, heavy goods vehicles, coaches and buses.
Renewable resource	Based on the in-house Regen large-scale solar and wind resource assessments
Pseudo-pipeline	This factor is used to direct near-term projections into ESAs where known pipeline projects are to connect, but the capacity size of these projects is unknown.
Hydrogen ESAs and Regional Hub locations	As part of the analysis, Regen hand-picks 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 and pseudo-pipeline projects.

Relevant assumptions from National Grid FES 2022

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 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 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	Webinar participants with expertise in hydrogen answered that the best use of hydrogen would be for decarbonising industrial processes first and foremost, followed by heavy transport, shipping and rail. All participants thought decarbonising shipping and industrial processes were the most preferred uses of hydrogen. 15 Respondents identified the area around Portsmouth as the first future hydrogen hub in Southern England, while seven selected Southampton and three selected Oxford.

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

[ii] 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

[iii] 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

[iv] Hydrogen plant and robots form part of Honda redevelopment masterplan 2022, https://www.swindonadvertiser.co.uk/news/19952606.hydrogen-plant-robots-form-part-honda-redevelopment-masterplan/

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

[vi] 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

[vii] 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

Demand growth from new data centres 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 2022 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	72	661	1,304	1,663	1,738	1,771	1,782
System Transformation		661	1,328	1,675	1,789	1,837	1,854
Consumer Transformation		661	1,370	1,704	1,860	1,905	1,928
Leading the Way		661	1,382	1,747	1,966	2,029	2,062

Figure 41: Data Centre demand growth projections for the Southern England licence area

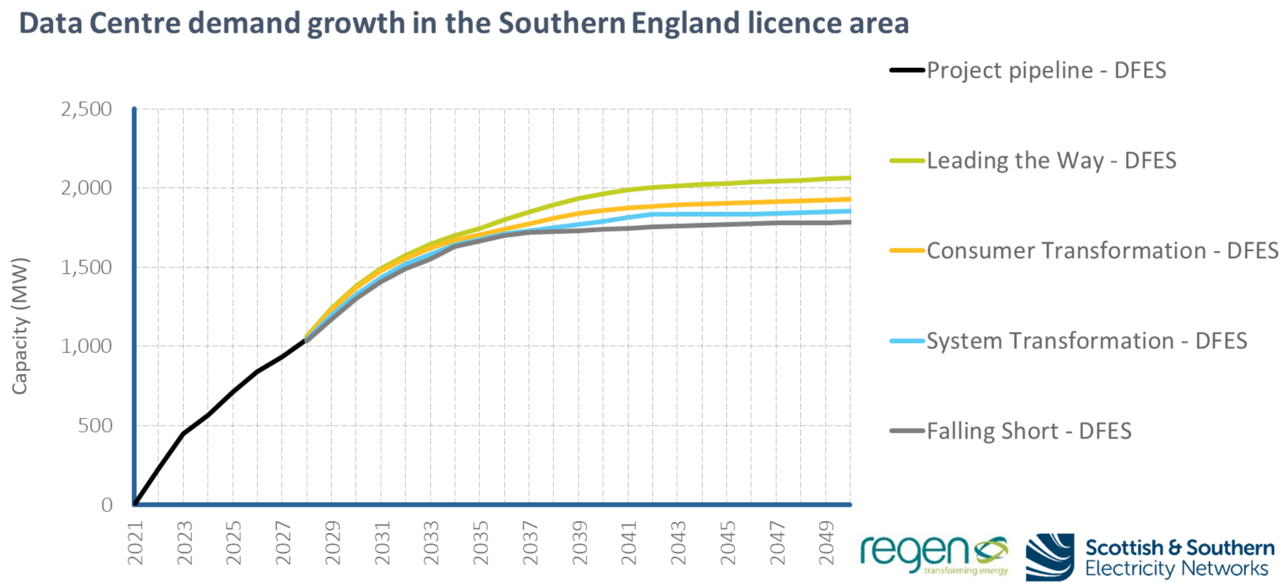
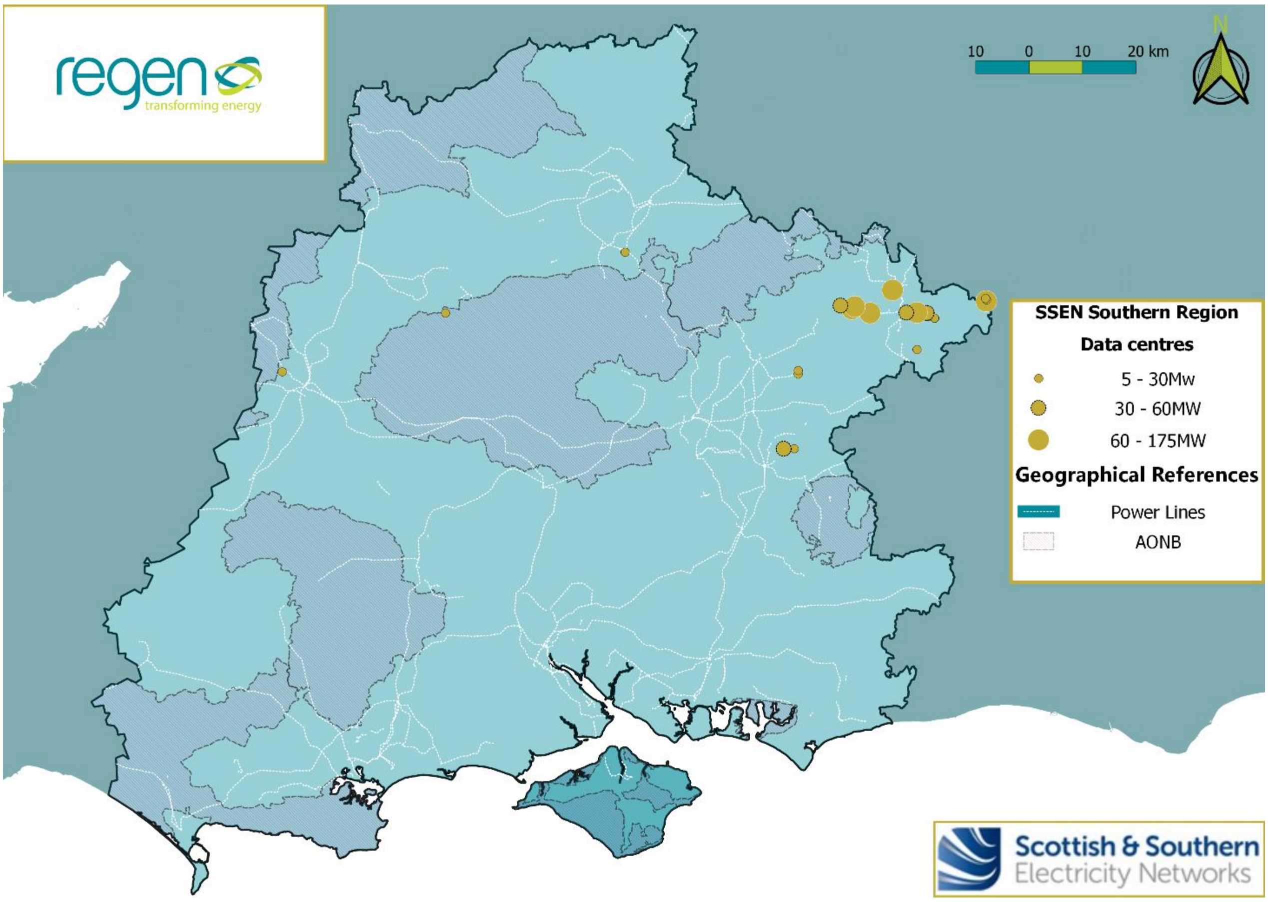


Figure 42: Data centres contracted to connect to the SEPD distribution network, with a large concentration in West London



Summary

- Large-scale commercial data centres have only recently featured as specific sources of disruptive demand in the DFES analysis. The first analysis for data centres was conducted in the DFES 2020 due to a significant pipeline of new commercial data centre sites applying for large import connections in the Southern England licence area.
- DFES 2022 has sight of 26 data centre sites, totalling c. 1.34 GW, that have secured connection agreements with SSEN, compared to 27 sites with c. 1.32 GW of demand in DFES 2021. Six of these sites seek import capacities of 100 MW or higher (the largest being 175 MW).
- In the DFES 2020, this demand comprised of just 13 sites that were developed and brought online across the 2020s, culminating in 665 MW of new demand by 2026.
- Many of the larger sites aim to undertake a staged build-out of servers and associated equipment (such as cooling plants), meaning that some pipeline sites could build out and increase their operational demand capacity over 3-5 years. By 2032, all sites in the pipeline will have completed their staged build-out.
- Eight of these data centres (268 MW) have also been identified as having secured planning approval.
- 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, heavily focused 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, as seen in the recent surge of new connection applications. 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 2022 has used the staged development timelines of the 26 known data centre sites to project near-term demand growth.
- For the first time, the DFES has also developed 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 2022 of data centre energy consumption (GWh). By 2050, a maximum of c. 2.1 GW of additional demand is connected under **Leading the Way**, whereas c. 1.8 GW is connected by 2050 under **Falling Short**.

Modelling and assumptions

Baseline (2021)

Several existing data centres of various sizes operate in the licence area, but data on this is incomplete; therefore, the analysis has focused solely on sites from previous analyses that have potentially begun their phased build out, and other prospective new large-scale commercial data centres that have accepted connection offers.

Pipeline (2022-2030)

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. As of mid/late-2022, this increased further to 1,343 MW from 26 sites.

This scale of 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 over 100 MW. Feedback from SSEN's dialogue with the developers suggests that many will stage their deployment over several years, increasing infrastructure and associated import demand 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 2022, 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	Capacity by 2035	Capacity by 2050

This year, the DFES analysis has sought to develop projections for data centre capacity in the licence area beyond the current pipeline of sites. The FES 2022 has referenced the growth of annual data centre energy consumption (in GWh) for the whole of GB in their publication[i] and scenario projections out to 2050[ii]. This data shows that whilst overall there is significant future growth, a notable majority of future data centres could be directly connected to the transmission network under all scenarios.

FES 2022's GB energy consumption projections for data centres connecting at the distribution network level are still significant but vary by scenario, with **Leading the Way** highest at c. 8,000 GWh by 2050; **Falling Short** lowest at c. 5,000 GWh.

The DFES 2022 uses the FES' national data centre energy consumption figures to indicate data centre demand capacity growth 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 represents nationally distributed data centre deployment. This has resulted 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. However, this growth slows by the mid-2030s, after which the scenarios diverge. **Falling Short** sees little additional growth by 2050 (1.7 GW), while in **Leading the Way**, approximately 300 MW is added, leading to 2.1 GW of connected capacity by 2050.

Falling Short	1,663 MW	1,782 MW
System Transformation	1,675 MW	1,854 MW
Consumer Transformation	1,704 MW	1,928 MW
Leading the Way	1,747 MW	2,062 MW

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 ESAs. 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 but in adjacent ESAs. This reflects the likelihood that future data centres will continue to locate close to existing technology companies and 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 2022

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

[i] National Grid ESO 2022, *Data Centres.* https://www.nationalgrideso.com/document/246446/download
[ii] National Grid ESO 2022, *FES 2022 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. Therefore forecasts of new housing and commercial and industrial (C&I) 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.). Relevant FES technology blocks are as follows:

- **Gen_BB001a – number of domestic customers**
- **Gen_BB002b – meters squared of I&C customers**

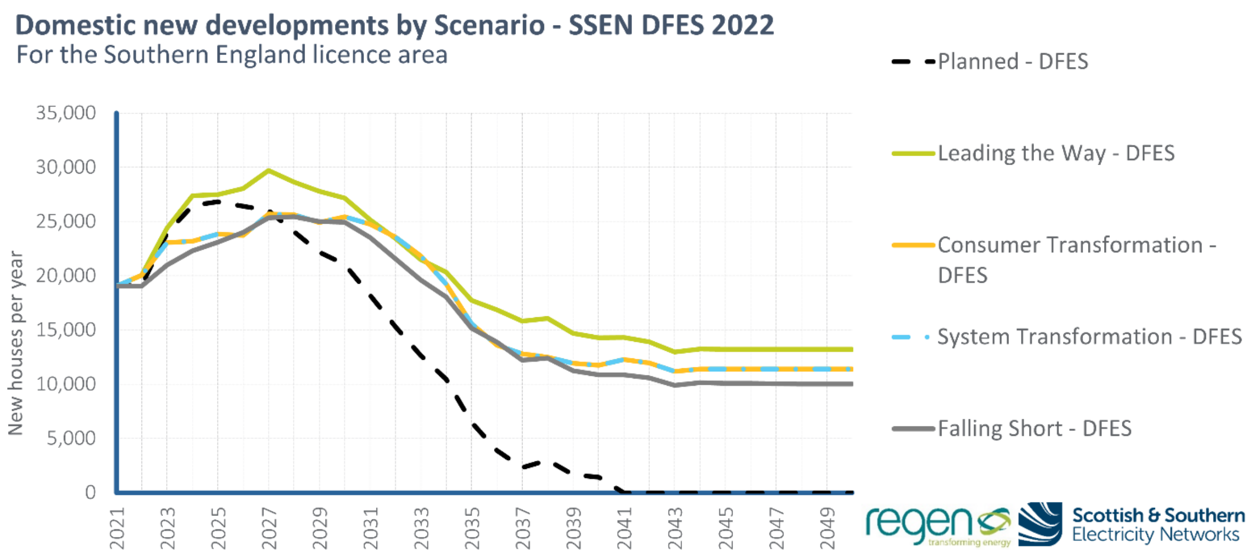
Data on planned domestic and non-domestic developments for the SSEN licence areas have been gathered through data exchange with all local authorities (LAs) in the Southern England licence area. This process used an online data portal and individual engagement with local authority planners and data providers.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

Alongside historic build rates and ONS household projections[i], the data provided by the LAs 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 (thousands)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	--	85	210	308	369	420	470
System Transformation		90	216	320	383	441	498
Consumer Transformation		90	216	320	383	441	498
Leading the Way		99	241	349	426	494	560

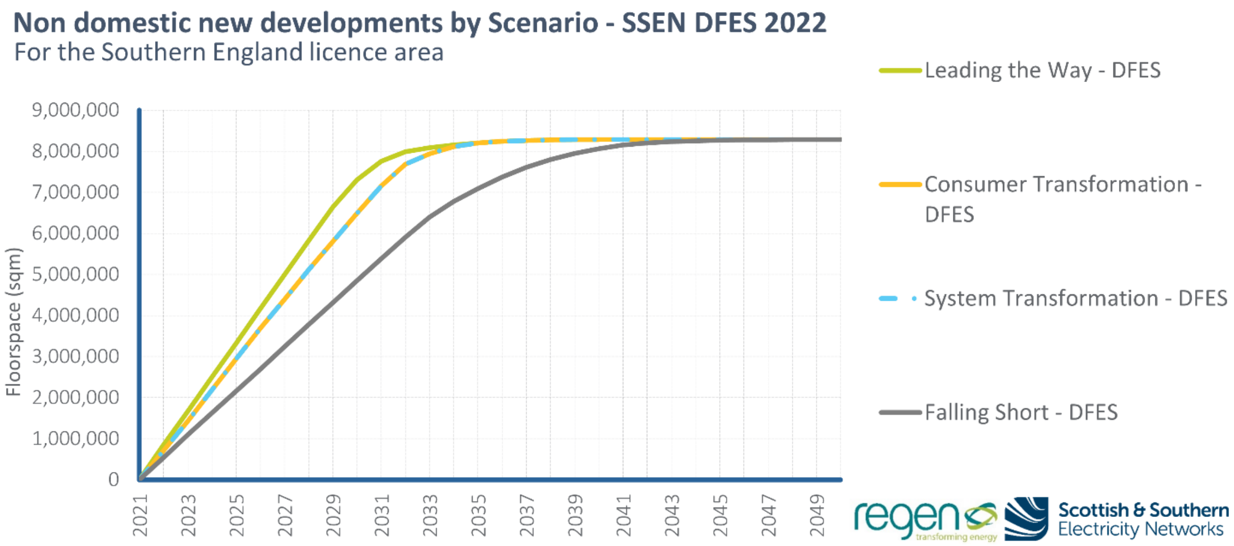
Figure 43: Non-cumulative new domestic development projections by scenario for the Southern England licence area.



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

Floorspace (sqm, 100,000s)	Baseline	2025	2030	2035	2040	2045	2050
Falling Short	--	22	49	71	81	83	83
System Transformation		29	65	82	83	83	83
Consumer Transformation		29	65	82	83	83	83
Leading the Way		33	73	82	83	83	83

Figure 44: Cumulative non-domestic developments by scenario in 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 detail the planning stages of each new development, i.e., 'under construction', 'full planning permission', or allocated lands for future use.
- The local planning documents provided data until 2042, so new long-term housing developments were modelled based on an analysis of ONS household projections[i].
- By 2050, this modelling results in between 470,000 and 560,000 new homes in the Southern England licence area, representing a 16%-19% increase in domestic customers.
- An additional 8.3 million square meters of non-domestic floorspace is also modelled to be in the licence area under each DFES scenario.

Modelling and assumptions

Baseline (2021)
The focus 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

Data exchange with all LAs in the licence area	A SharePoint database hosts individual data sheets for all LAs within the Southern England licence area. Regen engages with the LA planning departments to ensure the datasheets are updated. 65% of Local Authorities within the Southern England licence area have updated their datasheets within the last three years.
Database update	This data provided by the LA 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 • Developments of less than 1000 sqm (non-domestic)
ESA assignment	All sites are assigned an 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**), Medium (**System Transformation** and **Consumer Transformation** paired together) and Low (**Falling Short**). For new domestic developments, this is carried out using ONS projections[i] data. In contrast, non-domestic projections are determined from the 8-year, 10-year, and 15-year averages of planned developments of new non-domestic premises.

Domestic housing pipeline

Number of development sites identified	Total number of houses
707	299,074

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

Local Authority	Number of homes	Number of Sites	Largest development site
Hounslow	20,228	55	West Cross Industrial Estate (1,800 Residential Flats)
South Oxfordshire	19,515	19	Culham Science Village (3,500 houses)
Swindon	15,811	24	New Eastern Villages (6,525 houses)

Hounslow has 55 housing sites planned, averaging 370 homes per site. In addition to the West Cross Industrial Estate, three other large sites of 1,000 homes or greater are planned in the area:

- All sites, including West Cross, are in the allocation phase, with construction estimated to begin in 2025 and be completed by 2034.
- The other sites have 1,370, 1,030 and 1,000 homes planned, respectively.

There are 19 planned sites in **South Oxfordshire,** with an average of 1,027 homes per site.

- Six sites are 1,000 homes or greater.
- A 1,631-home site is currently under construction, averaging 150 homes per year and is set to be completed in 2032.
- The other sites, including Culham Science Village, have yet to be started. Four are estimated to be completed in 2025, and the remaining two, including Culham, are set to begin in 2026.

There are 24 housing sites planned in **Swindon**.

- The New Eastern Village is significantly larger than the other planned sites at 6,525 homes.
- There are two other sites of greater than 1,000 homes.
- Excluding the New Eastern Villages site, developments average 400 homes per site.
- No development buildout data has been provided for this local authority, but all three large sites are estimated to be under construction in 2022.

Outside of these three LAs, the Southern England licence area has 48 other planned housing sites greater than 1,000 homes, accounting for nearly 90,000 new homes in total.

- 14 sites are estimated to be currently under construction, with an additional five sites identified to be under construction.
- Eight additional sites have been allocated, and construction is estimated to begin by 2027.
- 22 sites have no development stage provided.
- Six sites have been estimated to have begun construction in 2022.

Non-domestic development pipeline

Regen category	Non-domestic sites		Non-domestic floorspace (sqm)	
	Number	Proportion	Total per category	Proportion of total
Factory and warehouse	267	31.0%	3,183,456	38.3%
Office	304	35.3%	3,592,643	43.2%
School and College, Universities	91	10.6%	547,442	6.6%
Retail	76	8.8%	324,704	3.9%
Other (e.g., medical, hotel, restaurant, sport & leisure)	124	14.4%	646,062	7.7%

The majority of 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 82% of the planned non-domestic developments. **Hounslow** is the local authority with the most floorspace of planned non-domestic developments, at 777,994 sqm from 77 sites.

The licence area has 23 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 Harwell Campus Science Park in the **Vale of White Horse** and the Oxfordshire Cotswold Garden Village in **West Oxfordshire** have split floorspace of 63,000 and 67,000 sqm, respectively. There is no development stage information provided for these sites, but both are indicated to have started construction this year 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 LA. 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	2022	2023-2025	2026-2028	2029-2031	2023-2031

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 by Regen category, 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 LA. Using current and historical DFES data for sites with both a site area and floorspace, a ratio was calculated for each Regen development category. This ratio was then used to assign a floorspace to any site where this was not directly provided not provided by dividing the given site size (converted to sqm) by the category ratio.

Delay factors: For network planning, the DFES modelling applies scenario-specific delay factors to planned buildout timescales provided by the LA. This method enables the location and scale of the development to be maintained, but the period over which the sites are built out is extended.

For domestic builds, a delay factor is applied differently for the high, low and central trajectories and used for modelling post-planned developments out to 2050.

For non-domestic, this is used to model the three scenarios based on the rate of the development buildout. Each scenario is modelled by applying a delay factor to maintain a buildout based on a yearly average:

- **Leading the Way** reflects an 8-year average buildout rate.
- **System Transformation** and **Consumer Transformation** reflect a 10-year average buildout rate.
- **Falling Short** is delayed reflecting a 15-year average buildout rate.

All scenarios are modelled to keep non-domestic floorspace the same as planned but change the rates at which the projects are completed. This is partly because new developments' timelines and build rates are key sources of uncertainty. By applying three scenarios and associated delay factors, very ambitious development is captured in the **Leading the Way** scenario, and heavy unforeseen delays are captured in the **Falling Short**.

Modelled developments (2022 – 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 2022 and 2050.

Residual developments	These are small-scale developments of less than 100 homes, under the threshold of the data collection with local authorities. Analysis of previous new developments data suggests that these developments could account for approximately 5% of total new-build housing. As a result, a 5% uplift was applied to the planned projections throughout the scenario timeframe to account for these residual developments.
Post-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[i].

Non-domestic

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

Reconciliation DFES 2021

A few methodology changes have been made between the 2021 and 2022 DFES that have resulted in a reduction in projected domestic housing developments.

- **Central Projections:** DFES 2021 utilised a central delay factor (10-year average), and when Local Authority data dropped off, it was infilled with a constant value until 2050. As explained in the methodology section, this was changed for the DFES 2022 projections using three scenarios and government projections data. This methodology change resulted in a change from 617,000 homes in DFES 2021 to 560,000 homes in DFES 2022, by 2050.

For non-domestic developments, a no significant change in floorspace projections between DFES 2021 and DFES 2022. Modification to Regen category ratios were made but the LA data for the Southern England licence had minimal office sites that required a calculated floorspace. Other factors affecting this change were:

- The category ratio for **'Office'** changed this year to 18% of the site area allocated as floorspace. This is a change from DFES 2021, which had an assumed 33% of site area allocated as floorspace. This change occurred as a result of more data collection.

Reconciliation with National Grid FES 2022

- 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	Modelled sites 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. 13 of the local authorities provided updated or new data through a SharePoint site or directly to the project team. For the remaining Local Authorities, Regen's existing project database was used.

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