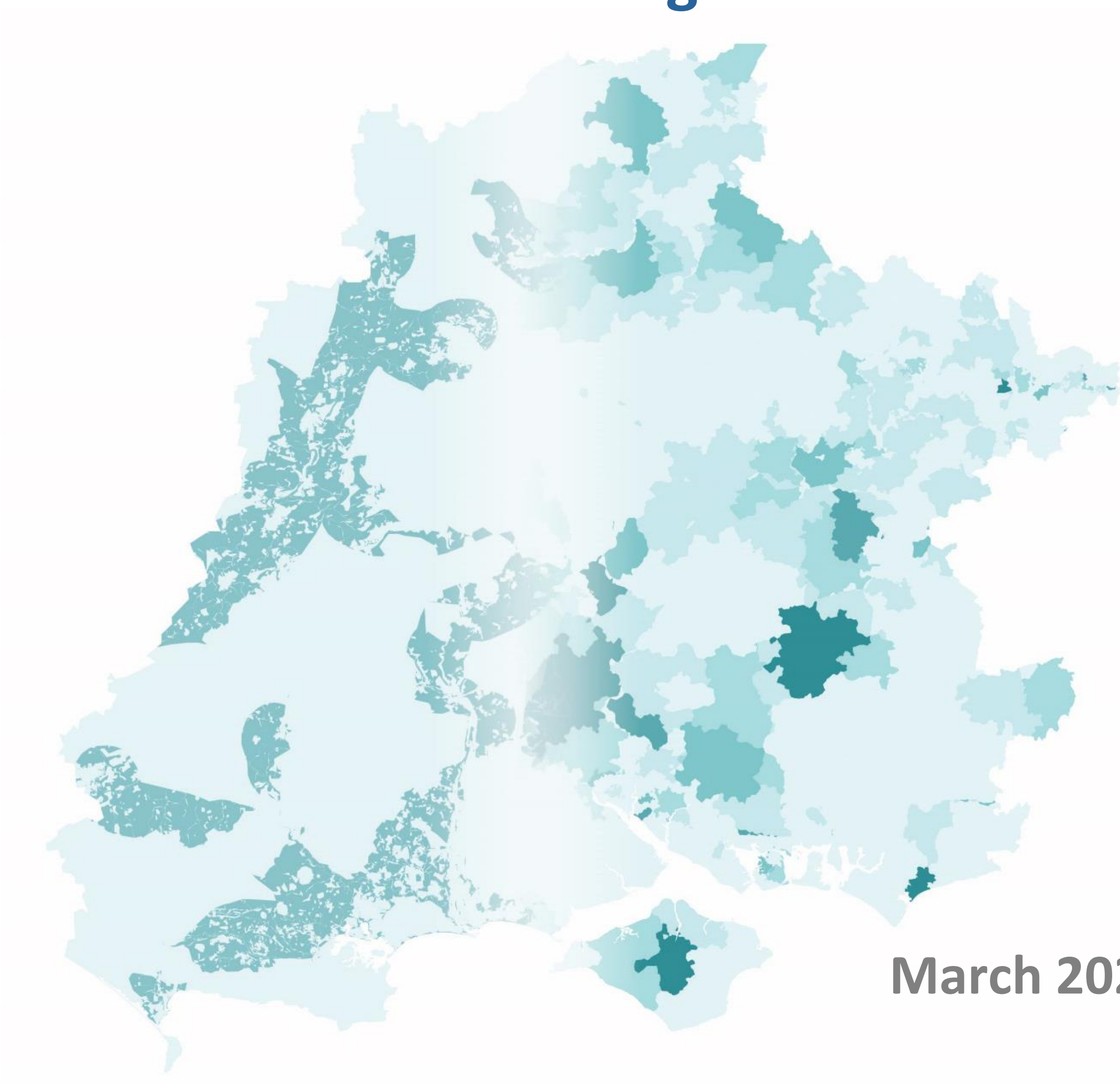
Distribution Future Energy Scenarios 2021

Results and methodology report

Southern England licence area



March 2022

This report was produced for	Scottish and Southern Electricity Networks (SSEN)
Issue date	4th March 2022
Version	Final version for publication
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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 and to ban the technologies that are now most responsible for the UK's contribution to climate change, namely petrol and diesel vehicles and boilers powered by fossil fuels. These targets improve clarity to the market and consumers and allow SSEN to plan for the anticipated three-fold increase in electricity demand that these 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, published in December 2021, draws on these DFES figures to inform our commitments over the next regulatory price control period, during which the building blocks must be put in place for net zero by 2050. We will invest nearly £4bn in our network without increasing our costs on customers' bills, 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 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

DSO Director, Scottish and Southern Electricity Networks

Introduction

This report provides a summary of the methodology and results of the 2021 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 scenario projections for the growth (or reduction) of energy generation (low carbon and conventional), demand and storage technologies which are expected to connect to the distribution network. This analysis helps SSEN to understand how the demands on their networks are likely to change over the next decade and beyond.

The DFES forms part of wider, integrated network planning and investment appraisal process (see Figure 1). The projection datasets allow SSEN's network planning teams to model and analyse different 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 forward looking Network Development Plans. The DFES process has also directly supported the development and evidence base that has underpinned SSEN's RIIO-ED2 business plan[2] and draft determination.

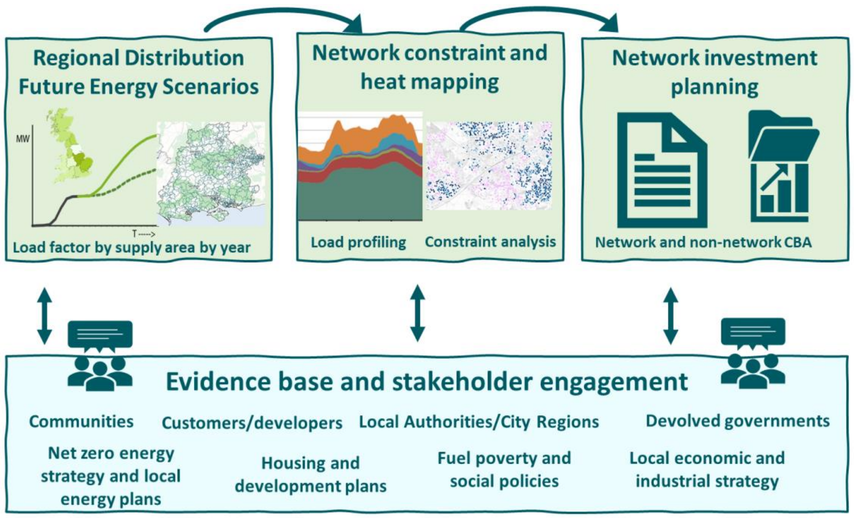


Figure 1: Wider network and investment planning process that DFES analysis feeds into

As its framework, the DFES uses four national energy scenarios, based on the National Grid ESO Future Energy Scenarios 2021 publication[3]. The DFES projections are however heavily influenced by input from local and regional stakeholders, including local authorities and representatives from the Isle of Wight. Regional growth factors and a detailed analysis of the pipeline of known projects within SSEN's Southern England licence area, underpins the near-to-medium term analysis and resultant scenario projections. The DFES seeks to provide a granular and bottom-up assessment of the impact of the net zero energy transition in specific regions.

As an annual publication, the analysis has also built on the DFES 2020 publication[4], reconciling many of the individual technology projections against last year's results. This report provides an overview of Regen's DFES methodology, a summary of the stakeholder engagement input and some of the headline 2050 scenario projections produced for the Southern England licence area. The report also includes an index of individual technology summaries, showing detailed results, evidence 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] See FES 2021: https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2021

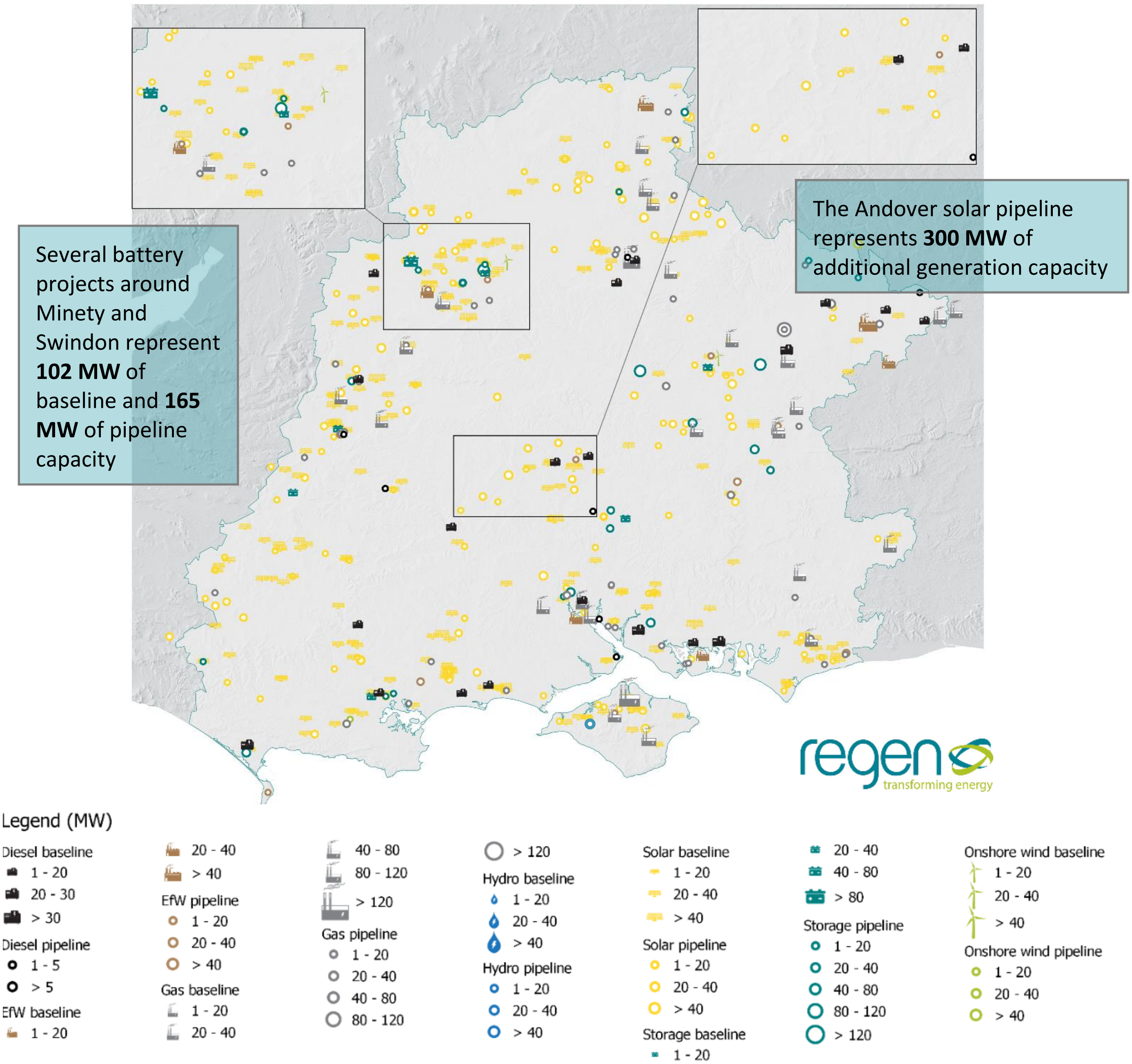
[4] See SSEN DFES 2020: https://www.ssen.co.uk/WorkArea/DownloadAsset.aspx?id=20282

The SSEN Southern England Licence Area

The Southern England electricity distribution licence area covers the area served by the low voltage, 11 kV, 33 kV and 132 kV network in the central southern area of England.

This area spans the borders of south Somerset and west Dorset to the West, Five Oaks Ealing and Chiswick to the East, Chipping North and areas of the Cotswolds in the North and a string of 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 both a number of urban areas such as Oxford, Swindon, Reading and Southampton, as well as a number of 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 smaller city region councils, such as Oxford City, and large district/borough councils, such as Wiltshire.

The total capacity of distribution network connected generation in the licence area stands at 3.2 GW as of the end of 2020. With the licence area having some of the best solar irradiance levels in the UK, over 60% of this connected capacity is solar PV. Solar capacity of all project types (i.e. domestic, commercial and grid scale) currently totals just under 2.5 GW.

The licence area also hosts a notable amount of fossil fuel generation, with natural gas, gas oil and diesel sites totalling a little under 600 MW.

The remaining mix of generation capacity includes:

- A range of waste-drive generation technology assets (230 MW).
- One of the largest operational battery storage projects in Europe (100 MW), which was brought online towards the end of 2020[5] and is aiming to extend its capacity to 150 MW in 2021. It is managed by Independent Distribution Network Operator Eclipse Power.
- A low deployment of onshore wind (11 MW) and hydropower (2 MW).

The largest generation site connected to the distribution network in the licence area is Cowes Power Station, a 140 MW OCGT plant fuelled by gas oil, located on the Isle of Wight[6].

Electricity demand in the licence area can be considered fairly typical, with an average proportion of homes heated via the gas network[7] 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 licence area is beginning to reflect some of the low carbon technology adoption that will be required to deliver the UK target of net zero emissions by 2050.

Adoption of low carbon technologies includes just under 52,000 battery electric cars currently registered in the licence area, around 340 MW of operational electric vehicle charging capacity and over 22,000 homes and businesses with a type of heat pump installed to date.

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

Wider context for SSEN DFES 2021

2021 has been another transformative year for the UK energy system, the broader energy sector and for the UK in general. This includes overarching global concerns such the Covid-19 pandemic, the UK's hosting of the COP26 climate conference, as well as a number of recent UK policy commitments. UK energy consumers have also felt the impact of events in the wider energy market, such as gas price spikes and the collapse of several small-scale energy suppliers.

Covid-19

The UK has been managing the twists and turns of the Covid-19 pandemic, responding to the omicron variant and the move towards restrictions and measures being eased at the end of 2021 and into 2022. The pandemic has continued to impact the everyday life of individuals, households, businesses and developers alike, as well as impacting organisations like SSEN, who are responsible for maintaining a stable electricity supply to end consumers. This unprecedented public health emergency affected the building of energy projects, new housing and commercial developments in 2020 and whilst the impact of Covid-19 restrictions begins to lessen, the pandemic continues to impact the progress of some energy projects and the DFES scenario modelling reflects this.

COP26

2021 also saw the UK host the United Nations Climate Change Conference (COP26) in Glasgow in November[8], leading to the Glasgow Climate Pact.[9] The goals agreed at the conference that are relevant to the energy sector included:

- A commitment to the significant phasing-down of the use of coal internationally.
- A commitment to reduce methane emissions globally, with 100 countries signing up to the *Global Methane Pledge* to reduce methane emissions by 30% by 2030.
- An increased commitment to investment in renewable energy.
- An acceleration of the uptake of electric vehicles, including:
    - Many of the major global vehicle manufacturers committing to 100% zero emission vehicle production by 2035
    - 110 major international companies signing up to the *EV100 Pledge* to operate fully zero-emission vehicle fleets by 2030.

These far-reaching commitments may feel distanced from specific project developments or technology adoption rates in the licence area. However, UK government has continued to enact a package of policies designed to increase ambition and action on decarbonisation. In a different sense, the hype surrounding the build up to and outcomes of COP26 has resulted in an increased awareness of climate change, the energy crisis and the pressure on world leaders to act[10].

[8] See UK COP26 website: https://ukcop26.org/cop26-goals/

[9] See COP26 Glasgow Climate Pact: https://ukcop26.org/wp-content/uploads/2021/11/COP26-Presidency-Outcomes-The-Climate-Pact.pdf

[10] See YouGov statistics summary, *What impact did COP26 have on public opinion?*, Nov 2021: https://yougov.co.uk/topics/politics/articles-reports/2021/11/22/what-impact-did-cop26-have-public-opinion

UK government strategy

Building on the UK government's 'ten point plan' published towards the end of 2020, across the latter half of 2021, BEIS published a suite of other strategy documents defining more specific policy ambitions and targets related to net zero emissions, power, hydrogen and heat (see Figure 2).

Figure 2: UK government energy strategies published mid/late 2021

Within the **Net Zero Strategy** were a number of specific sector pathways, reducing UK emissions from c.450 $MtCO_2e$ in 2020/21 to c.150 $MtCO_2e$ by 2037. For the power sector, the strategy set a target to fully decarbonise the electricity system by 2035, a specific offshore wind capacity target of 40 GW by 2030 and more support to deploy storage and other forms of flexibility. Although the Southern England licence area has very minimal deployment of onshore wind to date, with the right planning policy support, there is the potential for additional capacity to connect to the distribution network in the longer term. In addition to this, as one of the regions of the UK with amongst the highest solar irradiance levels, there is significant potential for additional solar PV capacity connecting in the region.

The Net Zero Strategy also set a target for hydrogen production, aiming for 5 GW of production capacity by 2030. This was supported by the publication of an accompanying **Hydrogen Strategy**, outlining an interim aspirational target of 1 GW of production capacity by 2025, as well as a £240m Net Zero Hydrogen Fund and a £60m Low Carbon Hydrogen Supply Competition. The introduction of such a capacity target and supporting innovation funds could be the trigger point to encourage the development of hydrogen electrolysis capacity across the UK, including in SSEN's licence areas. Although larger hydrogen plants may be connected to the transmission network, the distribution network could also provide the input electricity to these projects, especially in hydrogen hub areas.

The much-delayed **UK Heat and Buildings Strategy**[11], published in October 2021, sets out the government's ambition to decarbonise homes and workplaces, while at the same time creating 240,000 new green jobs. In terms of specific measures, the strategy restates the target to deploy 600,000 heat pumps per year by 2028, starting with a with £5,000 Boiler Upgrade grant scheme.

These measures will help the developing heat pump market which has shown some recent signs of growth from a very low base. There is still however a lot of doubt around the UK overall progress towards heat

[11] Heat and Building Strategy https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1036227/E02666137_CP_388_Heat_and_Buildings_Elay.pdf

decarbonisation and ability to reach the targets that have been set[12].

In other policy areas, the DFES has been produced at a time when the industry is awaiting the outcome of Ofgem's **Network Access and Charging Significant Code Review (SCR)**. This policy could have a significant impact on both generation and demand projects wishing to connect to the distribution network. The impact of the SCR is not clear cut as different provisions could work both for, and against, new connections. Reducing up front connection costs, with "shallower" connection charges, could increase the rate of deployment of low carbon projects. However, this could be offset by higher on-going network charges and by a requirement for distribution network connected generators to pay additional transmission network costs. These factors are discussed in more detail as they pertain to each technology in the different scenarios.

The most recent "minded-to" announcement from Ofgem[13] however, suggests that the impacts of the SCR may be less dramatic than previously thought. Upfront network charges will be reduced but a "High Cost Cap" threshold will be in place to dissuade the highest cost connections. The future of ongoing network charges is delayed, as is the decision to wider the payment of transmission network charges.

Activity in the wider energy sector

Alongside COP26 and net zero policy changes, the big news in the energy sector has been the spike in gas[14] and electricity wholesale prices, and the impact this has had on both consumers and electricity supply companies[15].

Modelling short term market volatility into long term growth projections for individual technologies is extremely difficult. In the case of the recent gas prices rises 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 including energy storage and green hydrogen.

As a more direct consequence of the gas price rise, electricity wholesale prices have also increased which has created a market where subsidy free wind and solar projects are far more likely to be commissioned. There should also be an increase in the deployment of energy efficiency measures and low carbon heating, although this may take some time to materialise.

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[12] See for Example BEIS Select Committee Report and Enquiry https://committees.parliament.uk/committee/365/business-energy-and-industrial-strategy-committee/news/160772/net-zero-decarbonising-heat-in-homes-governments-approach-lacks-strategic-direction-says-business-committee/ February 2022

[13] Ofgem SCR Minded to consultation January 2022 https://www.ofgem.gov.uk/publications/access-and-forward-looking-charges-significant-code-review-updates-our-minded-positions

[14] See BBC News article, *Why are gas prices so high and what is happening to fuel bills,* January 2021: https://www.bbc.co.uk/news/business-58090533

[15] See The Guardian article, *Zog Energy becomes 25th UK supplier to go busy in three months,* Dec 2021: https://www.theguardian.com/business/2021/dec/01/zog-energy-becomes-25th-uk-supplier-to-go-bust-in-three-months

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** that is used to define the overarching societal, technological and economic 'worlds' that DFES scenario projections sit within.
	The **stakeholder engagement evidence and input** used as a direct input to the scenario modelling.
	The **analysis stages** that 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 technology scope of the SSEN DFES includes technologies and load sources that directly connect to SSEN's electricity distribution network assets in the Southern England – see Table 1. DFES analysis does not include projections for any 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 fueled 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 2021 framework

As with previous DFES assessments, the SSEN DFES 2021 has used the National Grid ESO Future Energy Scenarios 2021[16] (FES 2021) as the overarching framework to base the analysis upon. As well as providing a scenario framework, the FES 2021 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 2021 scenario framework is based on two key axes; **the speed of decarbonisation** and **the level of societal change**, as summarised in Figure 3. Whilst some scenarios see similar or aligned projections in the near, medium or even long-term for some technologies, there are other aspects of the energy system that have very different outcomes, depending on the scenario. A general description of each of the scenarios can be found in Table 2. The various technology summary sections within this report also outline specific scenario variances seen under each technology and how the DFES applies them.

Where available, FES 2021 grid supply point (GSP) projection data has been used to provide a SSEN DFES 2021 to FES 2021 reconciliation, for each of the technology building blocks. In some instances, regional building blocks were not available or not directly comparable, due to sub-technology division. In these cases, national FES 2021 projections have been used to complete a more general reconciliation.

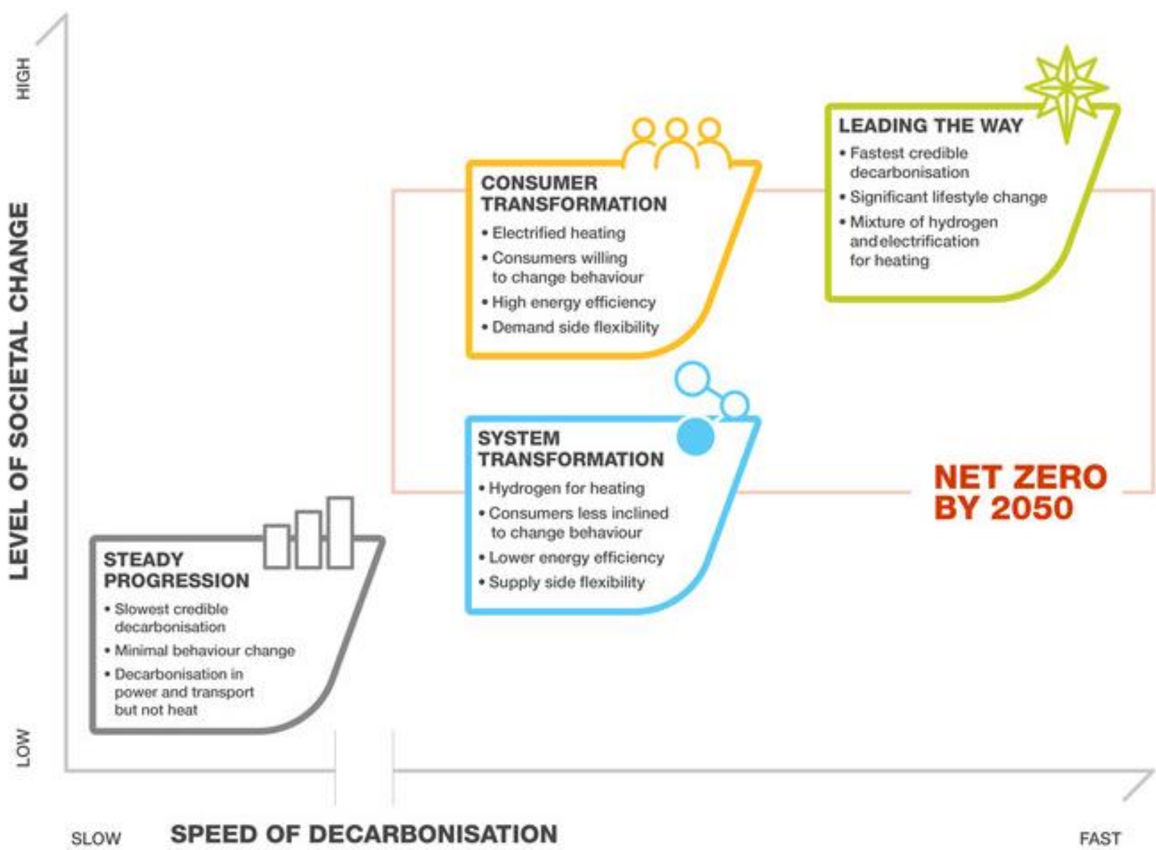


Figure 3: Future Energy Scenarios 2021 framework, National Grid ESO

[16] See National Grid ESO *Future Energy Scenarios 2021*: https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2021

Table 2: FES 2021 scenario descriptions. Source, credit and description wording: National Grid ESO FES 2021, https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2021/scenarios-net-zero

National Grid ESO FES 2021 scenario	High level description *Wording sourced from National Grid ESO FES 2021 publication
Leading the Way *Meets GB net zero targets by 2048*	Assumes that Great Britain decarbonises rapidly with high levels of investment in world-leading decarbonisation technologies. FES 2021 assumptions in different areas of decarbonisation are pushed to the earliest credible dates. Consumers are highly engaged in reducing and managing their own energy consumption. This scenario includes more energy efficiency improvements to drive down energy demand, with homes retrofitted with 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.
Steady Progression *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.

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. For this assessment, the baseline year is defined as the end of 2020.
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 level of 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.

There is some scenario variation which 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 4).

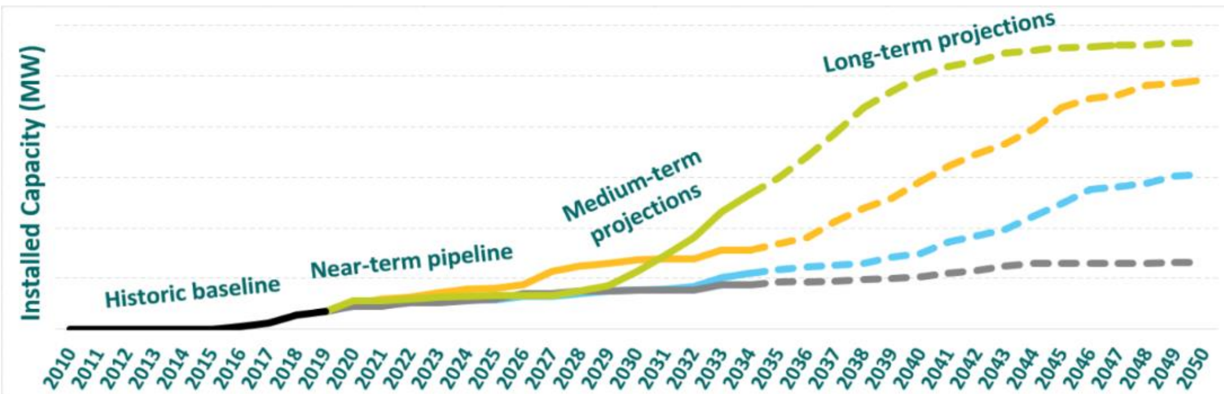


Figure 4: Illustrative stages of DFES scenario analysis

Technology and scenario uncertainty

When developing scenario projections for a broad range of technologies and sources of demand, a number of uncertainties inevitably influence the assumptions that are made and the projection outcomes that are determined. This uncertainty can range by technology and over time.

In the near-term, DFES projections are heavily based upon the analysis of 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 tend to reflect the underlying scenario assumptions defined for each technology. This is also augmented by levels of certainty provided by e.g. regional and national policies. Some of the uncertainties in the DFES analysis include:

1. The range of different outcomes assumed across the FES 2021 scenarios themselves.
2. 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.

Whilst important to highlight areas of uncertainty, the future of energy in the UK is becoming more focused, with the adoption of legally binding net zero emissions targets and the emergence of strategies and government consultations. This includes policy commitments around heat pumps, internal combustion vehicles, renewable energy and hydrogen – to name a few. Therefore, when assessing scenario uncertainty in the DFES, some key underlying assumptions can be made:

- Distributed renewable energy generation capacity is very likely to significantly increase
- Unabated fossil fuel electricity generation is very likely to 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
- Hydrogen has a key role to play for industrial processes and some forms of transport
- The production of low-carbon hydrogen is inevitable, but its scale and location is unclear
- Further energy efficiency deployment is vitally needed 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.

At an individual technology level, uncertainty is considered as a key part of the analysis and is reflected in the range of scenario outcomes presented. Specific uncertainties, and an overview of the technology-specific assumptions that have been made, is summarised in each of the technology summaries.

Granularity and geographical distribution of the DFES

A key stage of the DFES analysis, is to provide an estimation of the geographic spread of the modelled 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 uses a method to geographically distribute licence area projections down to so-called **Electricity Supply Areas** (or ESAs). An ESA is a geographical zone representing a block of demand or generation, as visible from the distribution network and sharing upstream network infrastructure.

The DFES uses two levels of ESA distribution modelling, depending on the technology (see Figure 5).

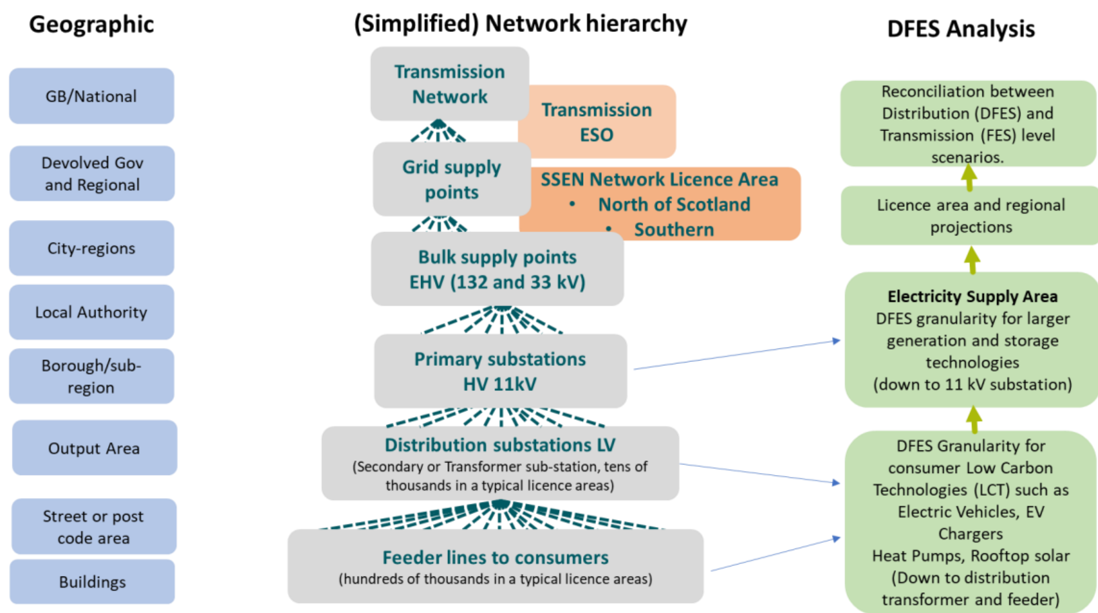


Figure 5: Network hierarchy that informs DFES geographic distribution to ESA

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 post codes or a small borough. In rural areas, this could equate to a wider area covering part of a county. The accompanying DFES projection dataset has been designed so that it can be aggregated up to support network analysis at higher voltage levels, or to provide data aggregated to local authorities or other regional boundaries.

For smaller low carbon technologies (specifically EVs, EV charger capacity, domestic heat pumps, rooftop PV and domestic battery storage), scenario projections have been distributed down to the lower voltage levels. This equates to either secondary distribution substation or individual LV feeder lines serving small groups of customers. This level of granularity corresponds to roughly a post code or street level analysis. The precision of this very granular distribution analysis should be treated with caution, especially looking out to 2050. The distribution of technology deployments is still based on a series of high-level assumptions and weighted distribution factors. The analysis does, however, enable SSEN network planners to model the potential impact of demand and technology changes on the low voltage network and to understand the scale and range of network reinforcement that might be required.

The spatial distribution factors that underpin this ESA modelling are described in more detail within each of the individual technology summaries. These factors are based on data gathered from 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 Isle of Wight stakeholders has also specifically influenced the spatial distribution factors for the SSEN DFES 2021. A summary of the spatial distribution granularity by technology is shown in Table 3 and Figure 6.

Table 3: Summary of the granularity of SSEN DFES spatial distribution, by technology building block

Level of DFES granularity and distribution	Southern England	Southern	DFES building blocks technologies
Electricity Supply Areas (ESAs) (Primary 11kv substation)	505	933	• Electricity generation except rooftop PV • Grid and commercial scale battery storage • Liquid air energy storage • Hydrogen electrolysis • Air conditioning • New housing • New commercial property developments • Data centres • EVs – HGVs, buses, motorcycles.
Low Voltage secondary substation 'transformers'	48,789	55,062	• Commercial EV chargers (Car park; Destination; En-route; Fleet; Workplace) • Non-domestic heat pumps
Feeder lines to consumers	114,891	349,097	• Electric Vehicles - Cars • Electric Vehicles - LGVs • Domestic off-street chargers • Residential on-street 7 kW chargers • Heat pumps (hybrid and non-hybrid) • Small scale Rooftop Solar < 10 kW • Direct electric heating • Domestic battery storage

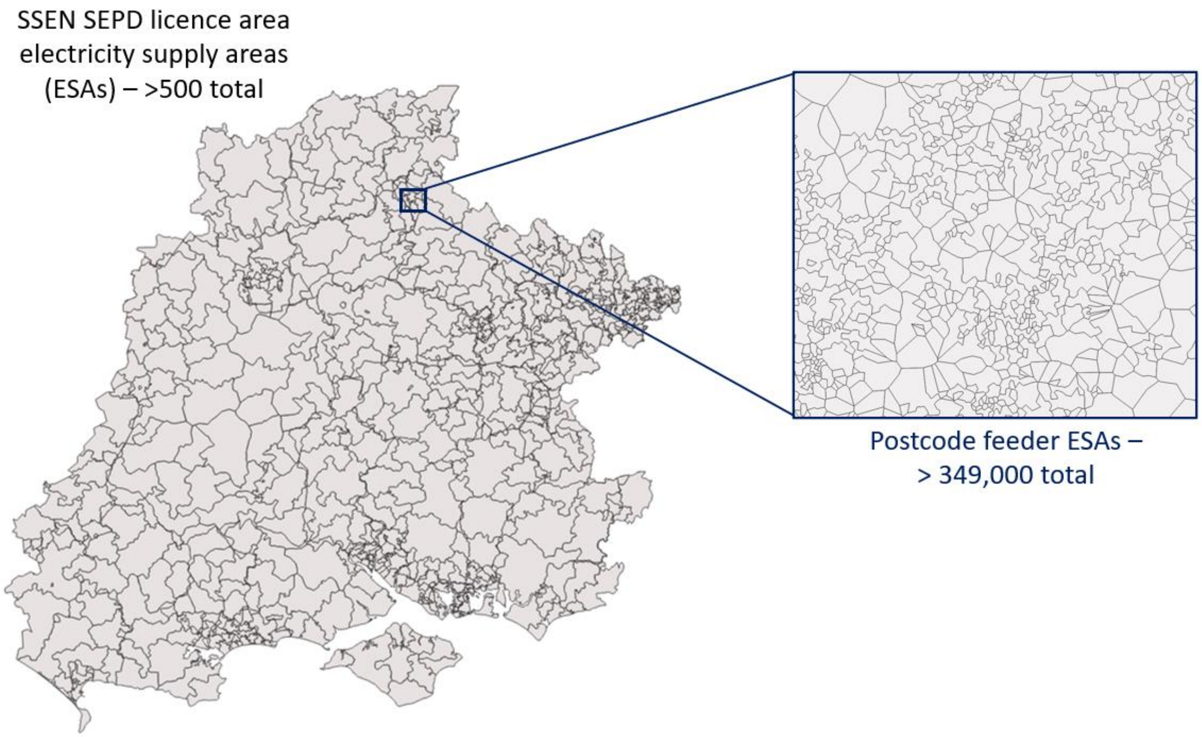


Figure 6: Map of 11 kV and feeder ESAs in the Southern England licence area

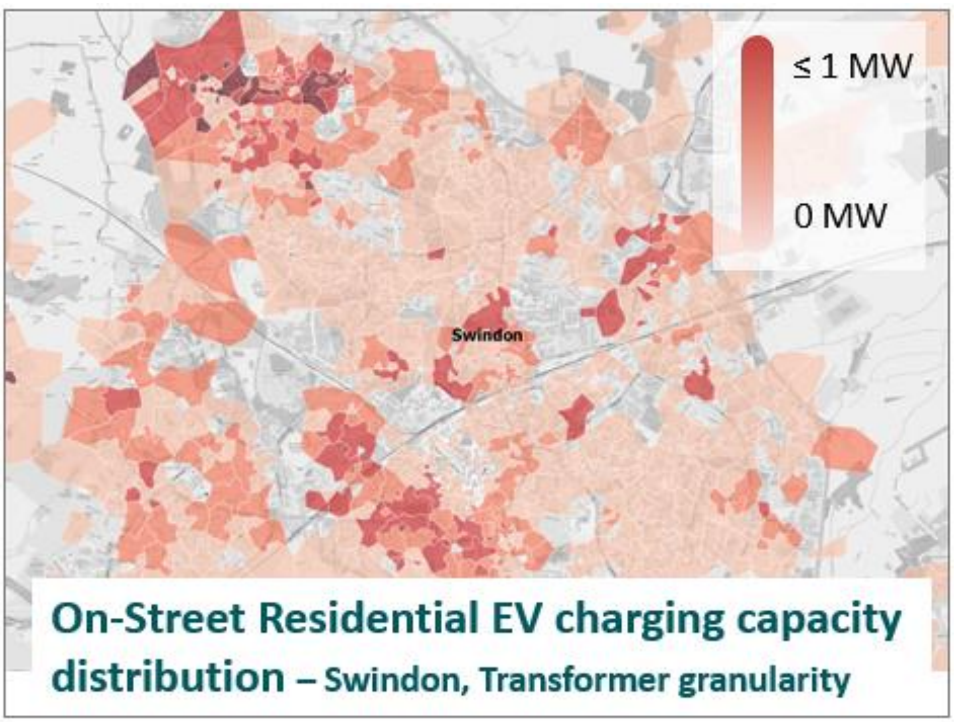


Figure 7: Transformer level geographic distribution of on-street residential EV charger capacity (MW) in Swindon in 2050, under the Consumer Transformation scenario

Stakeholder engagement

DFES analysis is informed by a wide range of inputs, evidence and data. Whilst based on a set of four national energy scenarios, the DFES is intended to be an assessment of future energy scenario outcomes 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. However, in addition to this, consultation and engagement with stakeholders is critically important to inform the modelling of individual technologies. To support the SSEN DFES 2021 analysis the project team has engaged with a wide range of stakeholders through a number of different approaches. These include:

	An **interactive online webinar** held in October 2021[17] with a broad range of regional and energy sector stakeholders and members of the SSEN team. *SSEN summarised how the DFES outputs are used to inform longer-term network planning. This session also made use of an online polling platform to capture specific views and statistical data about the future of a number of energy technologies.*
	A dedicated **Isle of Wight - future energy workshop** held in October 2021, with representatives from the Isle of Wight and SSEN. *Bringing together the Isle of Wight Council, residents and project developers from the islands. Attendees shared views on the severely constrained network on the island, Isle of Wight Council's net zero targets and views on individual technologies such as solar, batteries, EVs and hydrogen.*
	A **new developments online data exchange**, liaising with the planning departments of all of the local authorities within SSEN's licence areas. *Hosted on a Sharepoint site, this data exchange enabled Regen to directly engage with planning and housing teams within the relevant regional councils. This data exchange provided the project team with detailed information on specific new strategic domestic property developments (of 100 houses or more) and non-domestic developments, such as new supermarkets, offices or airports.*
	A **local energy strategy questionnaire** 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.*
	A number of **targeted technology and sector-specific interviews** with project developers, technology companies and other sector representatives. *These interviews were used to inform the modelling of specific pipeline projects, as well as testing assumptions made about specific sectors or technologies. Interviews included large solar PV and battery storage project developers, ITM Power and representatives from the European Marine Energy Centre.*

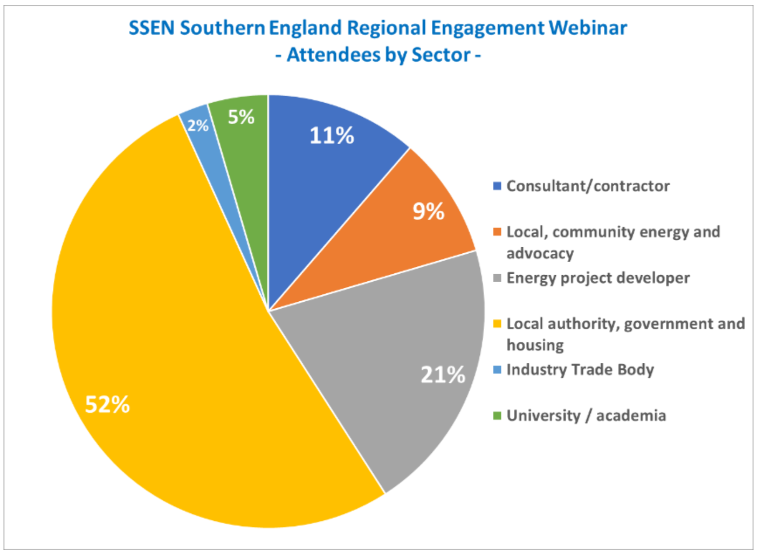
[17] See *SSEN Distribution Future Energy Scenarios – Southern England*, recording and slides: https://www.regen.co.uk/wp-content/uploads/SSEN-DFES-2020-Methodology-and-Results-Companion-Report-for-Southern-England-Licence-Area.pdf

Regional and island engagement webinars

Across October 2021, Regen worked with members of the SSEN team to host four interactive stakeholder engagement webinars centred around the DFES. These collaborative sessions sought to:

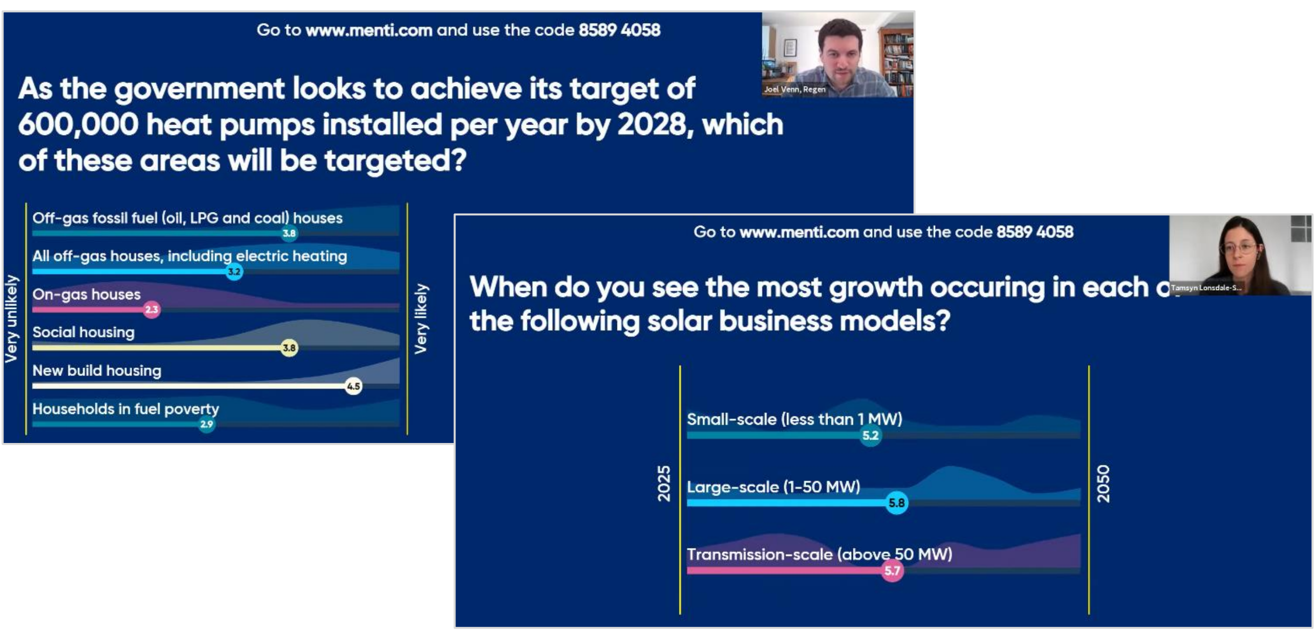
- Provide a summary of the background, method and purpose of undertaking DFES analysis.
- Road-test many of the key assumptions being made around technology capacity growth/ shrinkage and locational distribution factors, that determine the scenario projections.
- Tap in to local and sector knowledge, insights and ambitions relevant to the licence area.
- Discuss views and insights around 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 **main regional webinar** brought together representatives from local authorities, community energy groups, project and technology developers and other sector-specific representatives.



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, via the use of the online voting and live visualisation platform ***Mentimeter***[18].



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

The **Isle of Wight DFES workshop** brought together 10 residents from the Isle of Wight, including members of the teams at Isle of Wight Council, Future Isle of Wight, Wight Community Energy, Minus7, GE Renewable Energy, ReGen Energy Ltd, the University of Portsmouth and the NHS Trust.

As well as summarising the methodology and assumptions used to inform this year's analysis, the project team presented some technology projections from the SSEN DFES 2020. For some generation technologies, an overview of the current baseline and known pipeline on the Island was also outlined, providing a basis for discussing the potential for further deployment and future project development. An example of the type of island-specific data presented to the island attendees is shown in Figure 8.

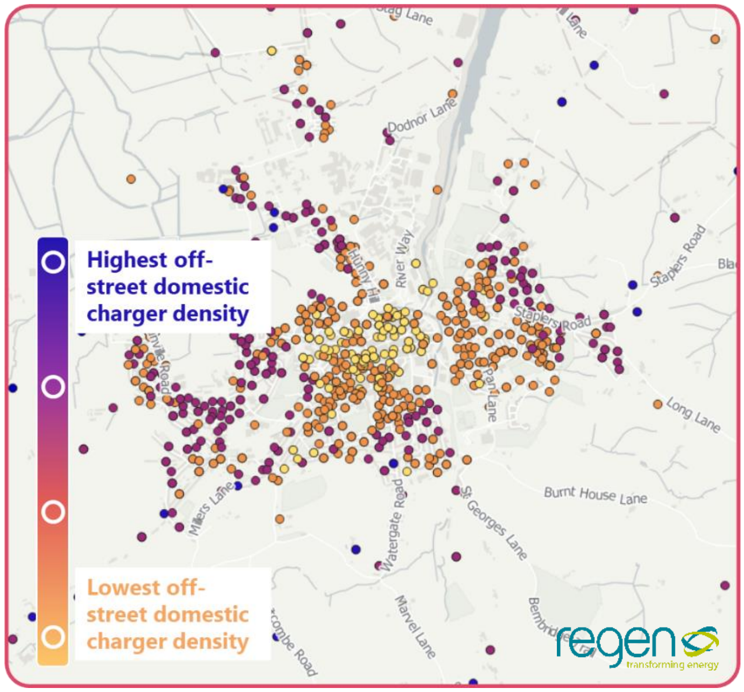


Figure 8: Projections for EV charging in the Newport area on the Isle of Wight, SSEN DFES 2020

The 2020 projections and known project developments were discussed and contextualised alongside a number of island specific issues, ambitions and other considerations raised by the attendees. These factors influenced the projections and the spatial distribution of capacity on for the islands, including:

- A number of expired connection offers for new specific solar PV and battery storage projects on the island, that did not proceed due to network capacity constraints and high connection costs
- The Isle of Wight's climate change emergency declaration and supporting targets to be a net zero island community by 2040[19].
- Feedback highlighting that the DFES 2020 projections for the Isle of Wight supply areas, did not directly reflect the targets and appetite to develop renewable energy capacity on the island.
- Individual projects and initiatives and being developed on the island, including wind, solar repowering and a 30 MW tidal energy generation project on the southern coast of the island[20].

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[19] See Isle of Wight Council Climate Change initiative: https://www.iow.gov.uk/Residents/environment-planning-and-waste/Future-Energy-Initiatives/Climate-Change/Climate-Change-and-the-IWC

[20] See Perpetuus Tidal Energy Centre 30 MW tidal stream project: https://perpetuustidal.com/

Isle of Wight - Net Zero Island Study

Building on the DFES workshop held in October, members of the SSEN Team, Regen and island representatives have established a new Net Zero working group.

The core aim of this working group is to support SSEN to build an evidence base to submit to Ofgem, that can unlock the constrained network on the island and enable the Isle of Wight Council and wider island community to achieve its net zero goals (see Figure 9).

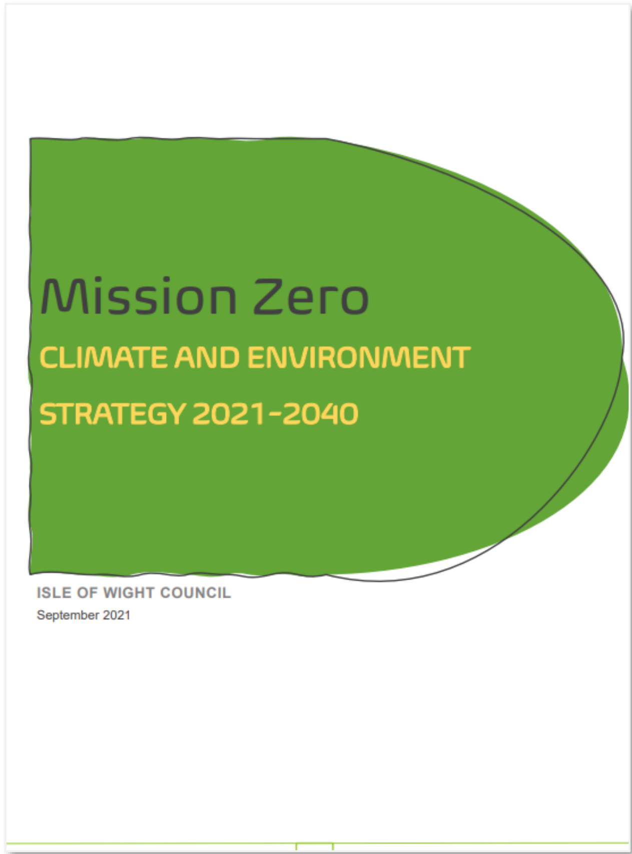


Figure 9: Isle of Wight Council's Climate and Environment Strategy 2021-2040, September 2021
https://www.iow.gov.uk/azservices/documents/2570-Mission-Zero-Climate-and-Environment-Strategy-2021-2040-final.pdf

This working group will meet semi-regularly across 2022, capturing a breadth of 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

The outcome of this working group, targeted to culminate in Q1 2023, will be an SSEN report to Ofgem, seeking approval of additional investment, above that which SSEN has had approved under their ED2 business plan determination, for a range of possible solutions to unlock network capacity on the island.

The outputs of the DFES 2021 analysis summarised in this report will be a key source of input data and information to contribute to the body of evidence developed by this net zero island study.

Engagement with local authorities

Building on engagement undertaken in both the 2019 and 2020 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. Hosted on an external Sharepoint site (see Figure 10), 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, 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 Houslow area.

Through follow-up discussions with relevant local authorities, a bespoke modelling approach was applied to these developments, translating the full development land space to a reduced operational development area that could associate more directly to future energy demand.

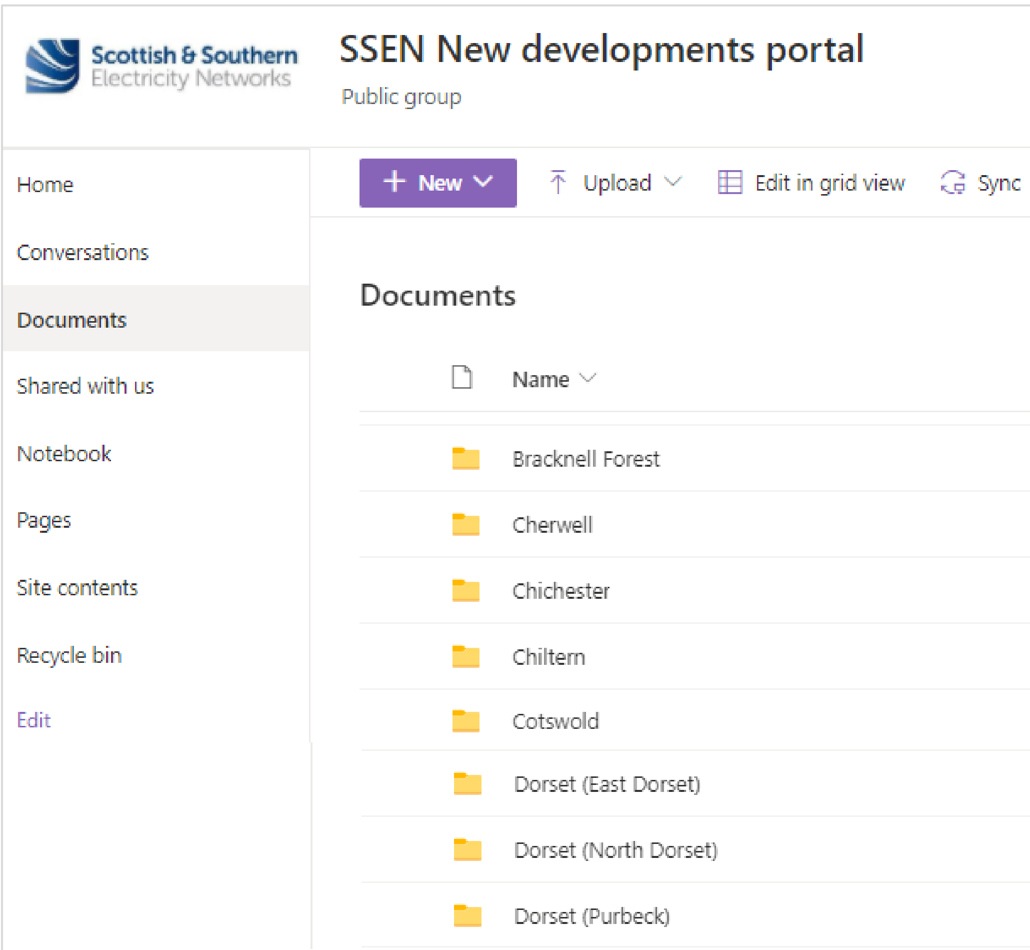
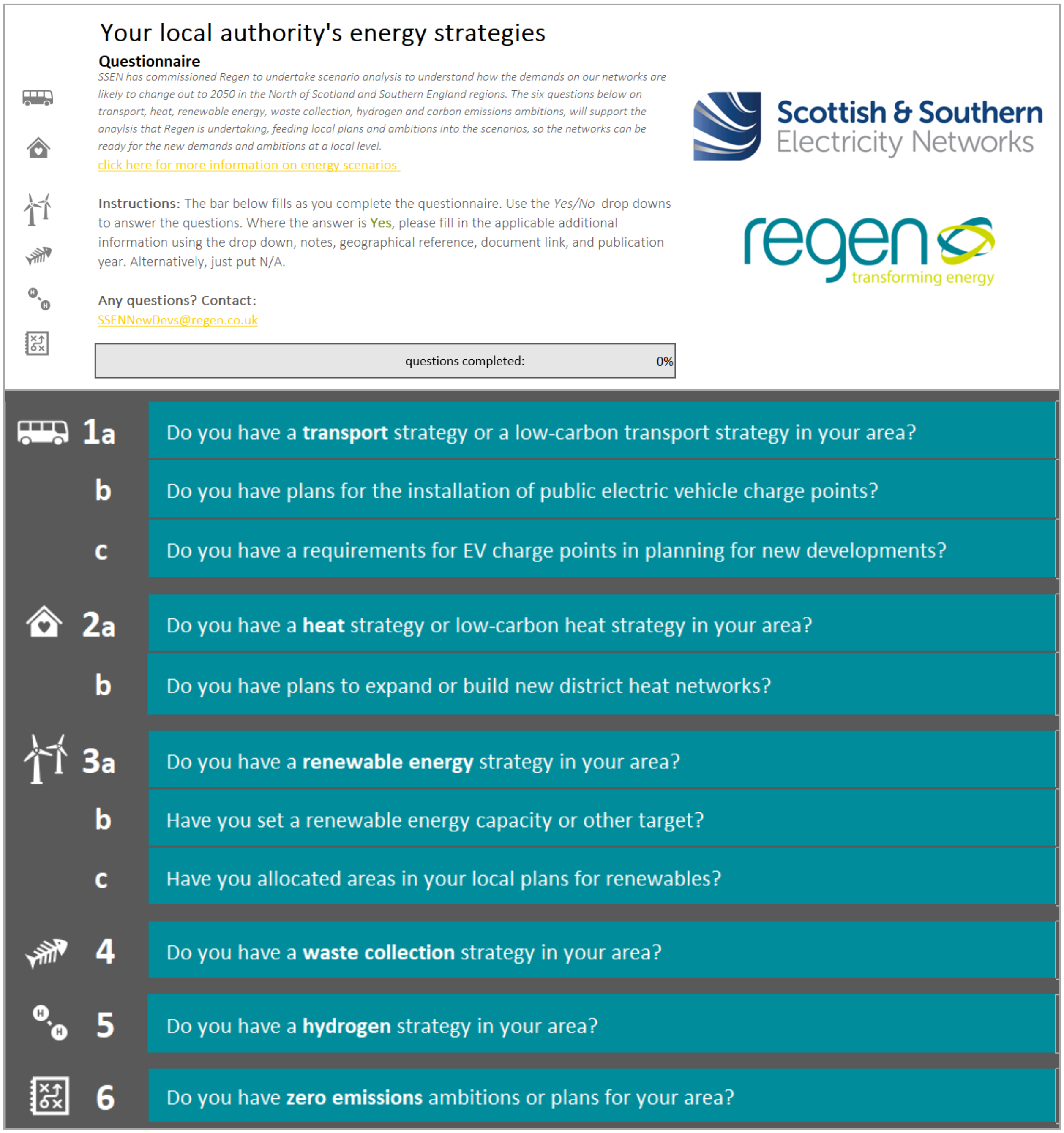


Figure 10: SSEN local authority new developments data exchange, hosted by Regen on Sharepoint

In addition to engaging around new developments, the project team also issued a **local energy strategy survey** to broader environmental and climate change project teams within the local authorities.

This survey (see Figure 11) asked a series of targeted questions about local strategies and action plans around zero emissions and climate change, low carbon transport, low carbon heat, renewable energy development, waste collection and hydrogen. The statistical (Yes/No) response data from this survey was used to influence the spatial distribution of individual technology projections. In addition to this, open text fields and web links to downloadable strategy documents and plans provided additional detail and insight into energy planning in individual council areas.



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%

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?

Figure 11: SSEN local energy strategy survey, developed by Regen for DFES 2021 analysis

The results, shown at a summary level, can be seen in Figure 12. Some councils were unable to respond to the survey within the timeframe of the engagement. However, both the number of councils who responded and the number of sector strategies that have been published, or are in development, has increased since an equivalent survey was completed to support the 2020 DFES analysis.

	Low carbon transport			Low carbon heat		Renewable energy			Waste	Hydrogen	Net zero
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
Basingstoke and Deane											
Bournemouth			Y				Y	N			
Bracknell Forest	Y	Y	Y	N	N	Y	Y	Y		N	Y
Cherwell											
Chichester											
Chiltern											
Christchurch)			Y				Y	N			
Cotswold	ID										
Ealing											
East Dorset	ID	ID	ID	ID	N	ID	ID	ID	Y	N	ID
East Hampshire											
Eastleigh											
Fareham											
Gosport	ID	Y	Y	N	N	N	N	N	N	N	Y
Guildford	Y	Y	Y	N	Y	N	N	N	Y	Y	Y
Hart											
Havant	N	N	Y	N	N	N	N	N	N	N	N
Hillingdon											
Horsham	N	Y	ID	N	N	N	N	N	ID	N	ID
Hounslow	Y	Y	Y	N	Y	Y	N	N	Y	N	Y
Isle of Wight	Y	Y	Y	Y	N	N	Y	Y	Y	ID	Y
Mendip											
New Forest	N	Y	ID	N	N	N	N	N	N	N	N
North Dorset	ID	ID	ID	ID	N	ID	ID	ID	Y	N	ID
Oxford											
Poole			Y				Y	N			
Portsmouth	Y	Y	Y	Y	Y	N	N	N	Y	N	Y
Purbeck	ID	ID	ID	ID	N	ID	ID	ID	Y	N	ID
Reading											
Runnymede	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y
Rushmoor	N	Y		N	N	ID	N				
Slough											
South Bucks	Y	ID	Y	N	N	ID	N	N	Y	N	Y
South Oxfordshire											
South Somerset	Y	Y	N	ID	N	ID	N	ID	Y	N	Y
Southampton	Y	ID	ID	ID	ID	ID	ID	N	Y	N	Y
Spelthorne											
Surrey Heath	N	ID	N	Y	ID	ID	ID	ID		N	ID
Swindon											
Test Valley	N	ID	ID	N	N	ID	N	ID	N	N	ID
Vale of White Horse											
Waverley	Y	Y	Y	N	N	N		N	Y	N	Y
West Berkshire	Y	Y	Y	ID	ID	ID	ID	N	Y	N	Y
West Dorset	ID	ID	ID	ID	N	ID	ID	ID	Y	N	ID
West Oxfordshire											
Weymouth & Portland	ID	ID	ID	ID	N	ID	ID	ID	Y	N	ID
Wiltshire											
Winchester											
Windsor and Maidenhead											
Wokingham											
Wycombe	Y	ID	Y	N	N	ID	N	N	Y	N	Y

Figure 12: High level responses to the 2021 local energy questionnaire, submitted by local authorities in the Southern England

Targeted sector and development engagement

In addition to the broader workshops and online surveys, the project team also engaged a number of individual companies and sector representatives to inform the analysis. These consultations included:

- A series of email exchanges with project developers that hold contracted connection offers for individual generation or storage projects, to determine plans to build out their projects.
- 1:1 video or phone 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 as well as market intelligence around individual technologies, such as data centres and battery storage assets.

An overview of some of the sector-specific consultations is shown below in Table 4.

Table 4: Summary of sector-specific stakeholder engagement undertaken to inform DFES 2021 analysis

DFES building block technology	Organisation(s)	Summary of the feedback received and how it was applied to the DFES analysis
Large-scale (>1 MW) solar PV	Wessex Solar Energy Hive Energy	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, which takes into account a number of spatial factors and land classification constraints.
Hydropower	Raasay Renewables Low Carbon Hub and Project LEO	Discussion around small hydropower as a business model and the barriers facing it. Feedback provided highlighted a lack of subsidy support after the closure of the Feed in Tariff programme. This is a consensus amongst hydro 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.
Energy from Waste	Lakeside EfW	The project developer provided information on plans to develop further waste incineration facilities, including information about some delays in planning. The developer also highlighted a broader industry stance to continue developing unabated waste incineration projects until more rigid policy comes into force. This insight influenced how waste incineration was treated under the **Steady Progression** scenario.
Battery storage	Battery storage project developer companies,	Provided information about the timeline and broader intention to progress individual large-scale (>40 MW)

	including: JBM Solar, RE Projects Development and Bluestone Energy.	battery storage projects that have recently accepted connection offers with SSEN. The feedback provided guided the pipeline analysis and the spatial distribution of the significant battery storage pipeline across the licence area.
Liquid Air Energy Storage (LAES)	Highview Power	Information about broad interest to connect 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[21] and the potential to co-locate LAES projects data centres, as a potential offtaker of cooling load. This insight drove the inclusion of LAES as a separate technology projection, as well as the scale of capacity projected and the spatial location of future LAES sites across both of SSEN's licence areas.
Hydrogen electrolysis	ITM Power	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 a number of areas.

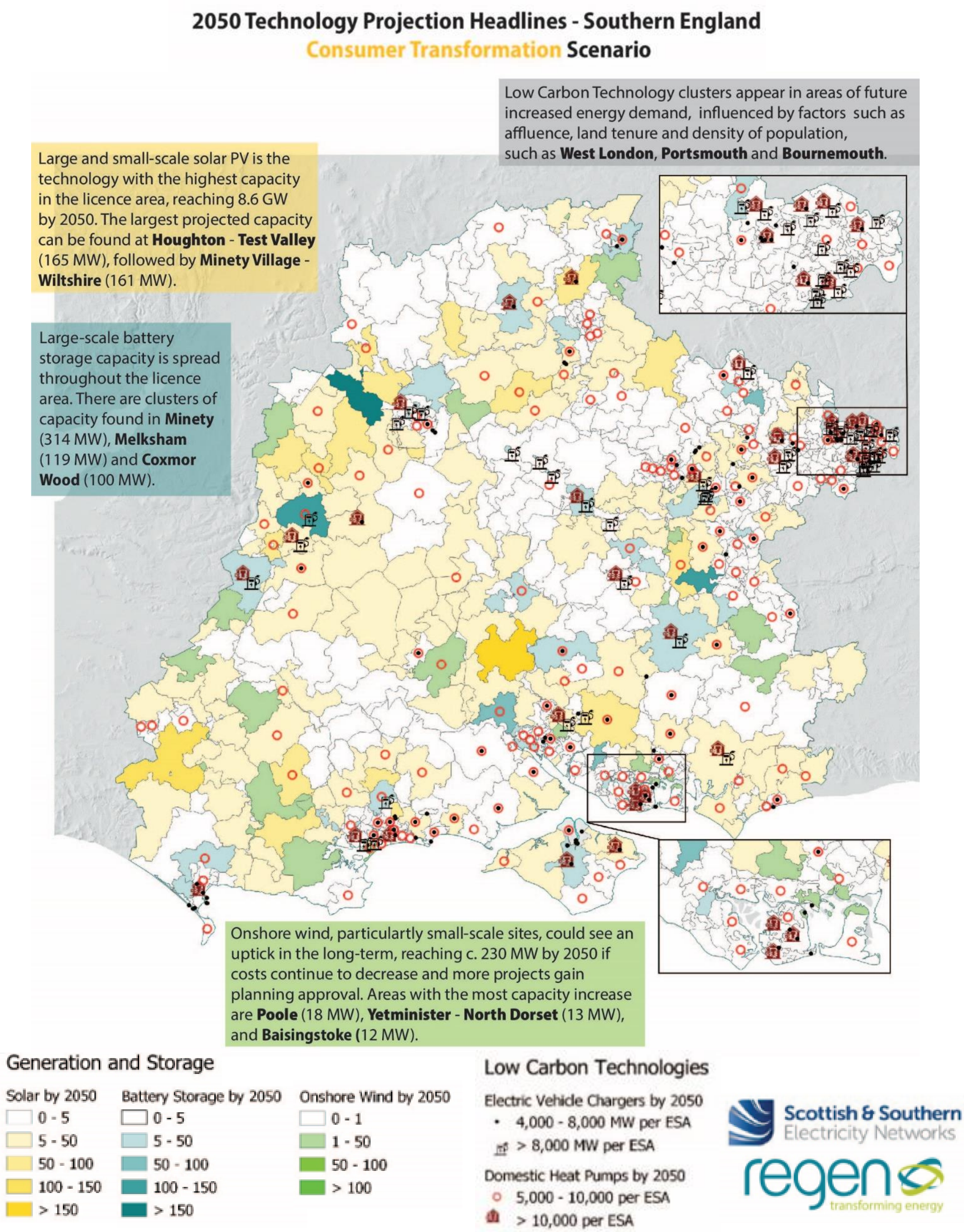
[21] See National Grid ESO NOA Stability Pathfinder – Phase 3 updates: https://www.nationalgrideso.com/future-energy/projects/pathfinders/stability/Phase-3

Projection headlines

In the medium and long term, the scale and range of technologies connecting to the distribution network in the Southern England licence area will be significantly different to today, under all scenarios.

The distribution network in the Southern England in 2030…
Collectively, distribution network connected **solar**, **wind**, **hydro** and **marine** generation capacity in the licence area doubles from c.2.4 GW in 2020 to **c.4.6 GW** in 2030 under the **Consumer Transformation** scenario. This is dominated by large-scale solar PV deployment, which accounts for most of the increase in connected capacity, with just under **4.5 GW** operating in 2030, across all scales.
Waste-driven generation capacity in Southern England evolves by 2030, increasing from 230 MW in 2020 to **364 MW** in 2030 under the **Leading the Way** scenario. This is driven by a notable deployment of advanced conversion technology and anaerobic digestion sites.
A significant proportion of the **95 MW** of existing unabated **diesel generation** decommissions in all scenarios, most so under **Leading the Way**, with only **16 MW** remaining online by 2030. **Fossil gas generation** significantly increases from c.500 MW in 2020 to **c.1.1 GW** in 2030 under **Steady Progression**, driven by the connection of new gas OCGT plants and reciprocating engines. In addition to this, low carbon **hydrogen fuelled generation** begins to connect to the distribution network in the licence area, with **45 MW** modelled to come online by 2030 under **Leading the Way**.
From a 100 MW 2020 baseline, **battery storage** capacity (of varying asset classes / business models) significantly increases in all scenarios by 2030, reaching **c.1.3 GW** under **Leading the Way**.
The number of **electric vehicles** registered in the Southern England licence area also increases significantly in all scenarios by 2030. This ranges from **c.750,000** under **Steady Progression** to just under **2 million** under **Leading the Way**. This equates to a range of **3.2 GW to 9.2 GW** of **electric vehicle charging** capacity by 2030 across these two scenarios.
In line with national targets, a significant number of properties switch their heating technologies to low carbon alternatives by 2030, under **Consumer Transformation**. This translates to **c.350,000 homes** and **c.54,000 non-domestic properties** operating a type of **heat pump** by 2030.
Under the **Leading the Way** scenario, the capacity of distributed **hydrogen electrolysis** in the licence area reaches **c.250 MW**.
A small number of very energy intensive **data centres** with are modelled to come online in the next decade in the licence area. The import demand capacity of these sites totals **c.1.2 GW** by 2030.
c.250,000 new houses could be built and just under **c.6,200,000 sqm** of **non-domestic floorspace** could be developed by 2030 in all scenarios.

The distribution network in the Southern England in 2050…	
	Solar, **wind**, **hydro** and **marine** generation capacity in the licence area further increases to **c.10.7 GW** in 2050 under the **Leading the Way** scenario. Large-scale solar PV continues to be the dominant technology in the licence area, with over 7 GW online by 2050. Onshore wind also sees some support under this scenario, with 200 MW online by 2050.
	Waste-driven generation continues to evolve by 2050, with landfill gas, waste incineration and biomass capacity all decommissioning from the network under **Leading the Way**. In contrast to this, generation capacity from the anaerobic digestion of waste feedstocks (i.e. food, agricultural or sewage gas) increases to **109 MW** by 2050 under this scenario.
	No unabated **diesel generation** is operating on the system by 2050 under any scenario, with generators being replaced with a range of alternative technologies including biomass, biomethane, electricity storage and/or hydrogen fuelled generation. Unbated **fossil gas generation** disappears from the distribution network under the three net zero scenarios by 2050. Under **Steady Progression** **820 MW** remains online, a mixture of gas OCGT, peaking plants (400 MW) and CHPs. In addition to this, low carbon **hydrogen fuelled generation** capacity increases significantly by 2050 in the licence area, reaching c.**600 MW** under **System Transformation** and just under **1 GW** under **Leading the Way**.
	Electricity storage capacity continues to see massive deployment in all scenarios out to 2050. Domestic, commercial and grid scale **battery storage** assets total **c.2.6 GW** under **Leading the Way** and **40 MW** of **liquid air energy storage** capacity is also modelled to connect to the distribution network by 2050.
	The number of registered **EVs** in the licence area accelerates further out to 2050. However, a general reduction in vehicle numbers is seen by 2050 in the net zero scenarios, driven by an increase in public transport use, in average mileage and the introduction of autonomous vehicles. EV numbers resultantly range from **c.5 million** in **Steady Progression** to **c.3.6 million** in **Leading the Way**. **EV charger** capacity reaches **14-15 GW** by 2050 across all scenarios.
	The number of homes and businesses with a type of **heat pump** installed significantly accelerates out to 2050 under all scenarios. This is highest under **Consumer Transformation**, with **c.2.3million homes** and **c.133,000 non-domestic properties** operating a type of **heat pump** by 2050.
	With an increase in the use cases and overall demand for hydrogen in some scenarios, the capacity of **hydrogen electrolysis** in the licence area massively increases. Deployment by 2050 is highest in **Consumer Transformation** with just under **3 GW** operating on the distribution network.
	A number of high energy consuming **data centres** are modelled to connect in the 2030s. The capacity of these sites totals **c.1.3 GW** by 2030, though in reality there could be more sites and an overall higher capacity.
	Under all scenarios, up to **c.618,000 new houses** and just under **c.8.3 million sqm** of **non-domestic floorspace** could be developed by 2050.



regen transforming energy

Scottish & Southern Electricity Networks

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.

This technology is divided into two sub-categories:

- Large-scale (≥1 MW) onshore wind – **DFES technology building block Gen_BB015**
- Small-scale (<1 MW) onshore wind – **DFES technology building block Gen_BB016**

Data summary for onshore wind in the Southern England licence area:

Technology	Installed power capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Large-scale (≥1 MW)	Steady Progression	9	18	23	32	36	37	38
	System Transformation		18	32	54	62	71	79
	Consumer Transformation		18	46	97	139	174	208
	Leading the Way		18	44	98	127	158	195
Small-scale (<1 MW)	Steady Progression	3	3	3	3	3	3	3
	System Transformation		3	3	3	4	4	5
	Consumer Transformation		3	4	5	12	18	25
	Leading the Way		4	6	7	11	13	15

Overview of technology projections in the licence area:

- The Southern England licence area has a minimal baseline of onshore wind deployment and there is little new project development in the pipeline.
- Low deployment has been due to a combination of relatively low wind resource, spatial constraints and historic challenges achieving planning permission for projects.
- The licence area does have some areas of good wind resource, such as parts of the Isle of Wight. However, many areas are limited by constraints such as national parks and AONBs. As a result, the Southern England licence area represents just 2% of the total unconstrained wind resource in Great Britain, see Figure 13.
- Projections to 2050 are therefore much lower than in Scotland, or other regions in the UK, and are dictated by the ability of wind projects to obtain planning permission in these areas under each scenario, as well as resource availability and, to a much smaller extent, local government wind targets and strategies.
- Under the most ambitious scenario, **Consumer Transformation**, the licence area could host over 400 MW of onshore wind by 2050.

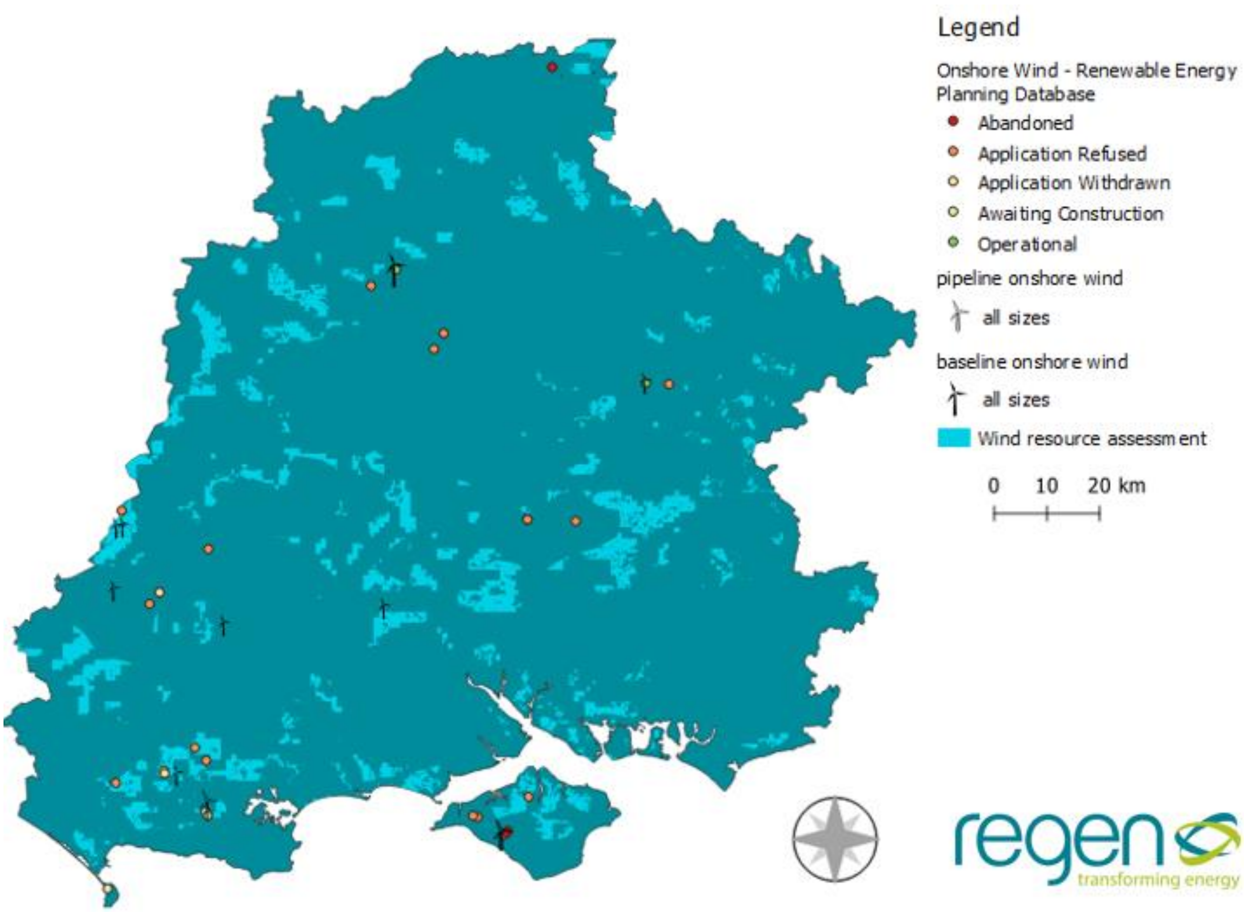


Figure 13: Unconstrained wind resource and onshore wind projects listed in the Renewable Energy Planning Database (REPD)

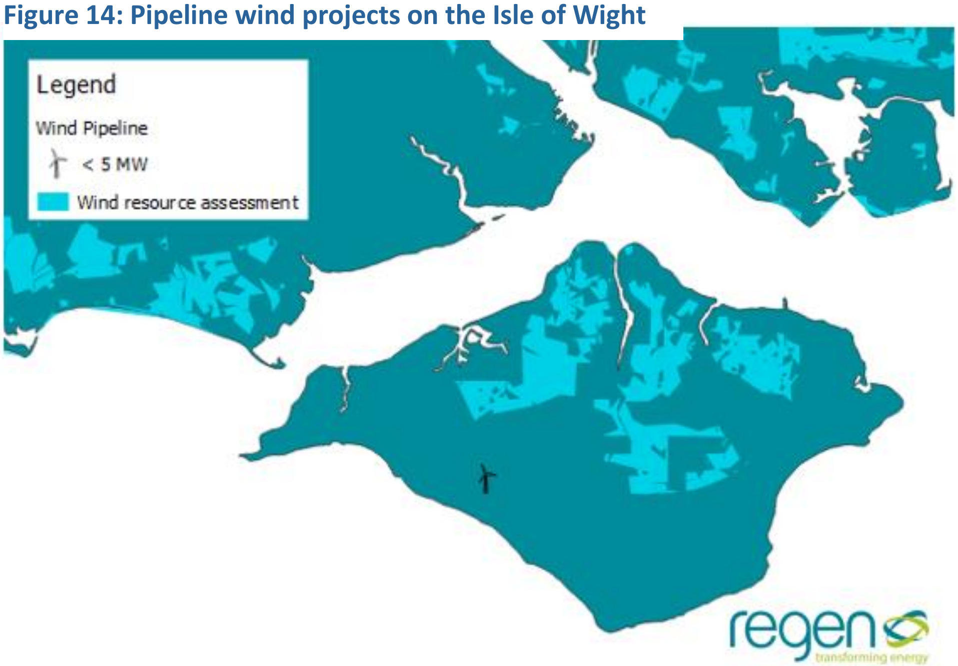
Scenario projection analysis and assumptions:

Baseline (up to end of 2020)

- Onshore wind projects in the licence area have historically struggled to attain planning permission and have suffered from a four-year moratorium on onshore wind subsidies in England. These factors account for the low historic baseline.
- The large-scale onshore wind baseline, totalling 8.5 MW, is composed of two projects, the largest of which being the 6.5 MW Westmill Windfarm near Swindon, commissioned in 2008. This large-scale baseline remains unchanged since DFES 2020.
- The small-scale baseline has increased since DFES 2020 due to the inclusion of two small wind turbine sites as a result of improved connections data quality and screening, increasing the baseline from 4 (1.2 MW) to 6 projects (2.5 MW).
- The majority of small-scale onshore wind development occurred as a result of the higher early rates of the Feed-in Tariff, with all 1.2 MW connecting between 2011 and 2015.

Near term (2020 – 2025)

Figure 14: Pipeline wind projects on the Isle of Wight



- There is only 0.6 MW of accepted onshore wind connection capacity in the pipeline, consisting of one site on the Isle of Wight which has however failed to attain planning permission. The Alaska wind project, which has been stalled for years is now showing signs of progress, and as a result has been included in the near-term pipeline[i].
- The 4th round of Contract for Difference (CfD) allocations includes a budget allocation for "Pot 1" established technologies including onshore wind. This opens the potential for onshore wind to quality for CfD revenue support which should improve the business case for distributed onshore wind In England, albeit with several years of delay as new projects begin the development process.[ii] It is expected that future CfD rounds will also support onshore wind.
- This renewed policy support, leading to an increase in developer interest in England, has been reflected in the **System Transformation** and **Leading the Way** scenarios.
- However, the current lack of pipeline projects means that, despite these policy changes, there will be a significant time lag before projects can deploy in Southern England.
- The Access and Forward-Looking Charges Significant Code Review, and changes to

transmission network (TNUoS) charges for embedded generators, has the potential to impact the business models of distributed generation in Southern England. Depending on the outcome of the code review, the impact for projects in the south could be positive. Upfront connection charges may decrease, however it is uncertain whether ongoing network charges will increase. This is a key uncertainty for the future development of subsidy-free onshore wind in the region, which is also reflected in the range of pipeline connection between scenarios.

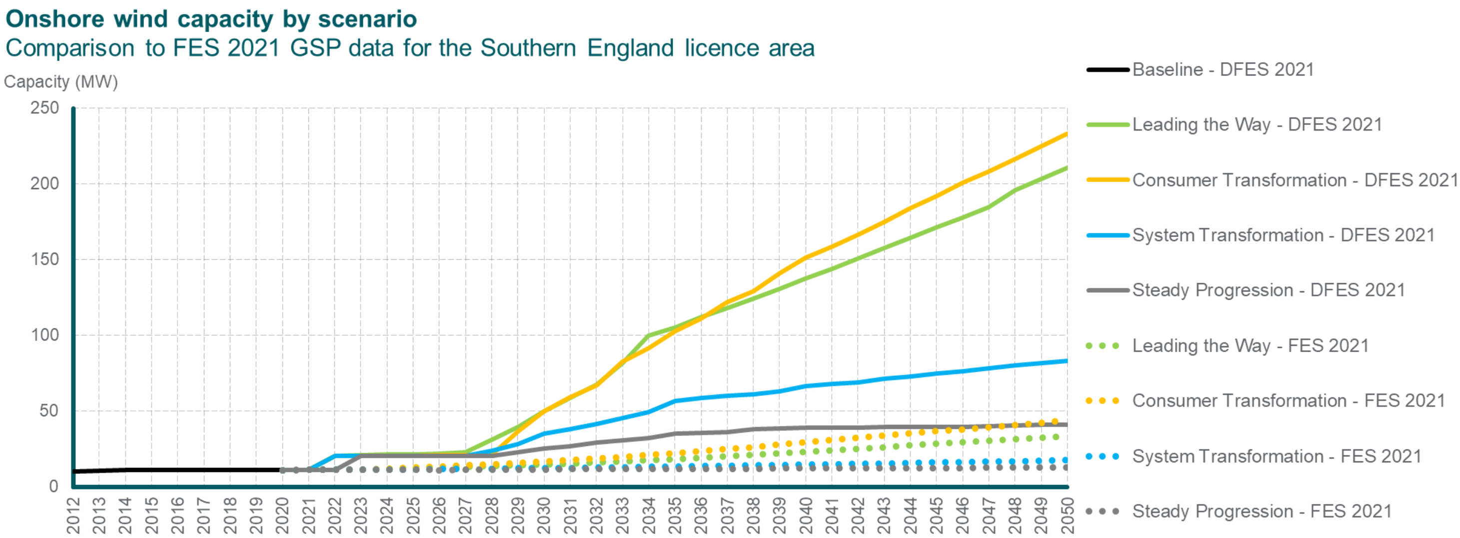
Medium term (2025 – 2035)

- The medium-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 the greatest 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 (although this does include a small number of resubmitted projects), submitted between 1998 and 2014. 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.
- The low level of societal change that occurs under **Steady Progression** and **System Transformation** means that projects continue to struggle to attain planning permission in the licence area, and capacity growth is restricted to only the least impactful optimal sites. **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, and primarily on the transmission network.

Long term (2035 – 2050)

- The long-term projections see a continuation of the medium term trend, where ability to achieve planning permission strongly dictates the deployment of onshore wind in the licence area.
- Average project sizes are expected to remain smaller than those seen in Scotland.
- As technology progresses and costs reduce, more previously failed sites are revived under the **Consumer Transformation** and **Leading the Way** scenarios, as well as areas of wind resource that previously did not see developer interest. **Steady Progression** and **System Transformation** remain hindered by resource and planning restrictions throughout the timeframe to 2050, as policy and support is focused on large-scale transmission-connected generation such as offshore wind and nuclear power.
- By 2050, the onshore wind capacity in the licence area is dictated by the onshore wind resource under the **Leading the Way** and **Consumer Transformation** scenarios, rather than historical factors such as the baseline and planning considerations. The onshore wind resource assessment accounts for protected areas and proximity to homes, as well as availability of suitable wind speeds and network.

Figure 15: Onshore wind projections for the Southern England licence area, compared to National Grid FES 2021 regional projections



Reconciliation with National Grid FES 2021:

- The National Grid FES 2021 baseline and near-term projections concur with the DFES figures up until 2027, when the mid-term projections increase compared to the FES.
- The DFES 2021 projections under **Leading the Way** and **Consumer Transformation** are less ambitious than those projected in DFES 2020. This reflects the relative decrease from FES 2020 to FES 2021 under these two scenarios.
- The long-term DFES projections are higher than the FES regional projections under every scenario except **Steady Progression**. It is understood that the FES regional projections are weighted heavily towards the existing baseline, which is particularly low in the Southern England licence area. In contrast, the DFES projections hinge upon Regen's onshore wind resource assessment, stakeholder engagement and previously attempted projects, all of which point towards higher levels of deployment in scenarios where planning considerations do not block so much development. Recent pipeline evidence also indicates a resurgence of wind in this licence area.

Factors that will affect deployment at a local level:

- New projected onshore wind capacity is based on Regen's onshore wind resource assessment (see Figure 13). This assessment takes into account relevant factors such as wind speed, landscape designations, dwelling proximity and others.
- Capacity increase due to repowering is located directly at existing baseline sites.
- Sites that were previously in development but failed to achieve planning permission are used as indicators of technically developable wind sites and are used to inform the resource assessment.

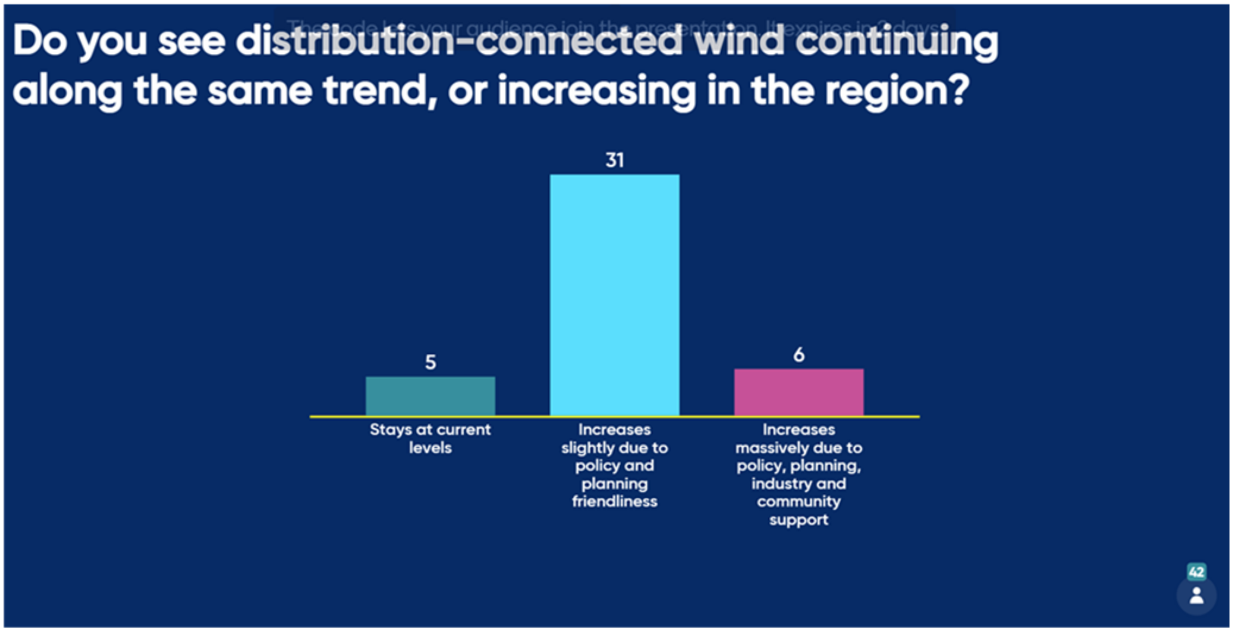
Relevant assumptions from National Grid FES 2021:

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

Stakeholder feedback overview:

Onshore wind	
Stakeholder feedback provided	How this has influenced our analysis
A range of stakeholders were engaged through a dedicated Southern England DFES workshop in October 2021. Stakeholders largely agreed that onshore wind would increase slightly over time due to policy and planning friendliness. This was a cautiously optimistic view. Roughly a quarter of the respondents deviated from this reserved growth pathway, either choosing extensive growth or no growth (see Figure 16).	This uncertainty is reflected in the scenarios, with **Consumer Transformation** and **Leading the Way** seeing Southern England develop more onshore wind capacity than seen in the baseline, while under **System Transformation** and **Steady Progression** onshore wind capacity remains limited out to 2050.
As part of Regen's engagement with local authorities, data was collected on whether local authorities had declared a climate emergency or had specific renewable targets or strategies.	Where these existed, a small positive weighting was given to these local authorities in the near term. 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.
An engagement workshop was held with representatives from the Isle of Wight.	Whilst a technology with less opportunity than e.g. solar PV, a wind project that has stalled on multiple occasions was discussed with the stakeholders. This site was highlighted as being located within an AONB, which may have featured in the difficulty for the project to gain traction despite multiple attempts. The project was acknowledged by the stakeholders, who agreed that it does not have a grid export agreement, and thus has been excluded from the analysis.

Figure 16: Mentimeter results for onshore wind development in Southern England



References:

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

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[i] Infinergy 2021, *Turbines secured for 8MW Alaska Wind Farm in Dorset.* https://www.infinergy.co.uk/2021/11/26/turbines-secured-for-8mw-alaska-wind-farm-in-dorset/

[ii] The Guardian 2020, *UK government lifts block on new onshore windfarm subsidies*: https://www.theguardian.com/business/2020/mar/02/uk-government-lifts-block-on-new-onshore-windfarm-subsidies

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.

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

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

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	1991	2464	2831	3259	3527	3727	3844
System Transformation		3074	3453	4222	4892	5356	5736
Consumer Transformation		3074	3458	4227	4898	5362	5742
Leading the Way		3195	4125	5209	6564	7261	7315

Overview of technology projections in the licence area:

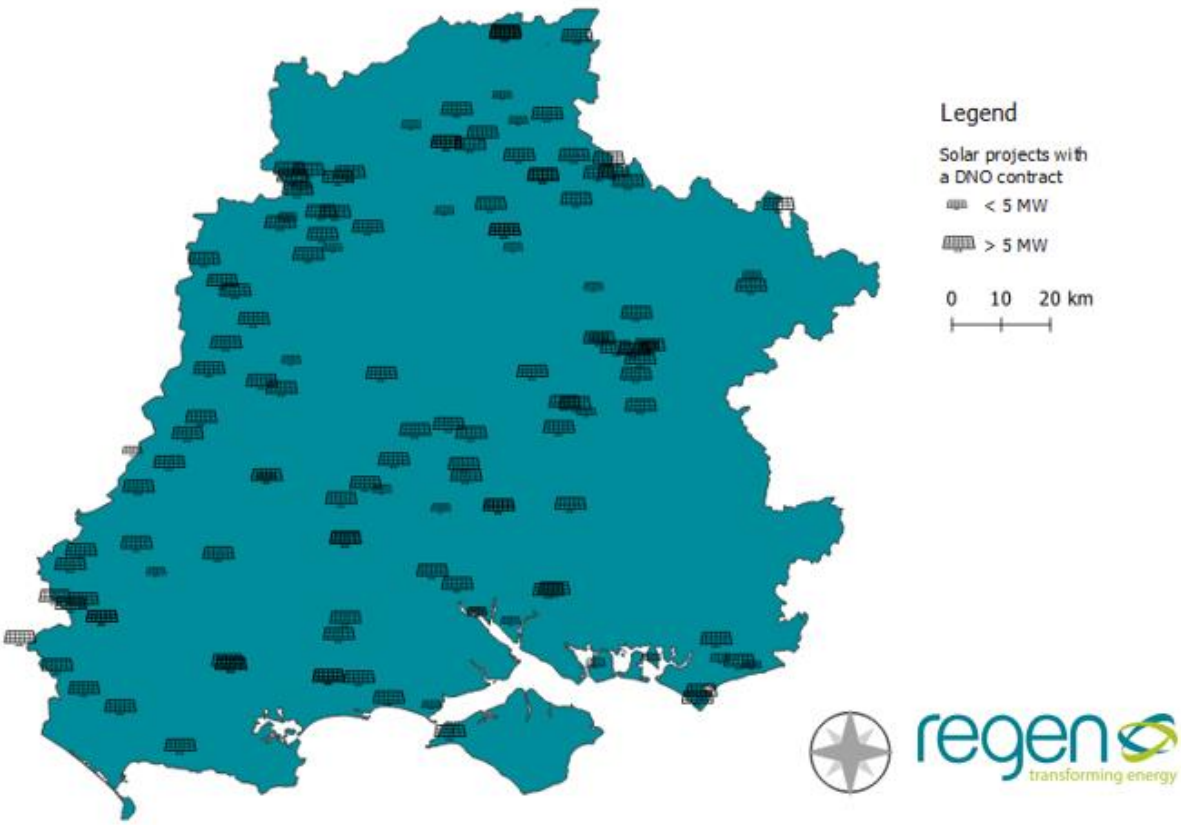
- The Southern England licence area has some of the highest solar irradiance levels in the UK. This has resultantly enabled some of the highest levels of large-scale solar PV deployment in the country – totalling c.2 GW by 2020.
- Beyond this baseline there is also a very large pipeline of sites with accepted connection offers (c.2.3 GW) and quotes that have been issued but not yet accepted (c.884 MW).
- Ongoing reductions in capital costs[iii], improvements in yield efficiencies[iv] and the development of more dynamic and lucrative power purchase agreements[v] is driving new interest to deploy potentially significantly more capacity of large-scale solar PV nationally. With the high irradiance levels and strong history of positive planning applications, the Southern England licence area could continue to be one of the hubs of large-scale solar PV development in the UK.
- With increased solar PV panel efficiencies, there is also the potential for the repowering of baseline sites to drive an additional increase in overall solar PV capacity, as older projects reach the end of their operational life.
- Very high electricity prices seen over the winter of 2021/22, and forward price forecasts, may encourage stalled projects to now move forward.
- Solar developers contacted in relation to the pipeline expressed some confidence that their projects would go ahead.
- Including solar in the CfD Allocation Round 4 auction could further stimulate deployment.
- Stakeholder feedback also suggested that solar deployment in the region in increasingly being linked with battery storage and to high energy users such as new data centres. It is significant therefore that the pipeline for solar, battery storage and new data centres have all increased in the past two years.
- As a result of these factors the ambition and uptake of large-scale solar in the licence area is highest under the **Leading the Way** scenario, reaching 7.3GW by 2050.
- However, even under the least ambitious scenario **Steady Progression**, large-scale solar capacity still sees a notable increase in capacity to 3.8 GW by 2050.

Scenario projection analysis and assumptions:

Baseline (up to end of 2020)

- There are 210 large scale (>1MW) solar PV sites connected to the distribution network in the Southern England licence area, totalling just under 2 GW.
- These sites are between 1 MW and 52 MW in capacity and were connected between 2010 and 2020.

Figure 17: Contracted solar projects



Near term (2020 – 2025)

- There is a very large potential pipeline of 119 sites totalling a little over 2.3 GW with accepted network connection offers in the licence area,.
- In addition, there are a further 40 sites, totalling 885 MW, which have been issued connection offer quotes by SSEN.
- The average site capacity of this pipeline is 20 MW, more than double the average capacity of the existing connected baseline. The top 15 sites in the pipeline are >40 MW, and collectively account for 700 MW (22%) of the total pipeline capacity.
- Of the total development pipeline:
    - 44 sites totalling 1.1 GW are either under construction or have planning approval
    - Five sites (100 MW) have withdrawn planning applications or approval has expired
    - The remaining 89 sites (1.8 GW) have been issued or accepted recent connection offers, but no further development evidence has been found
- Engagement with regional stakeholders and solar developers unanimously highlighted that solar deployment in the Southern England licence area could increase significantly in the long-term. The majority of stakeholders also believed that solar deployment will

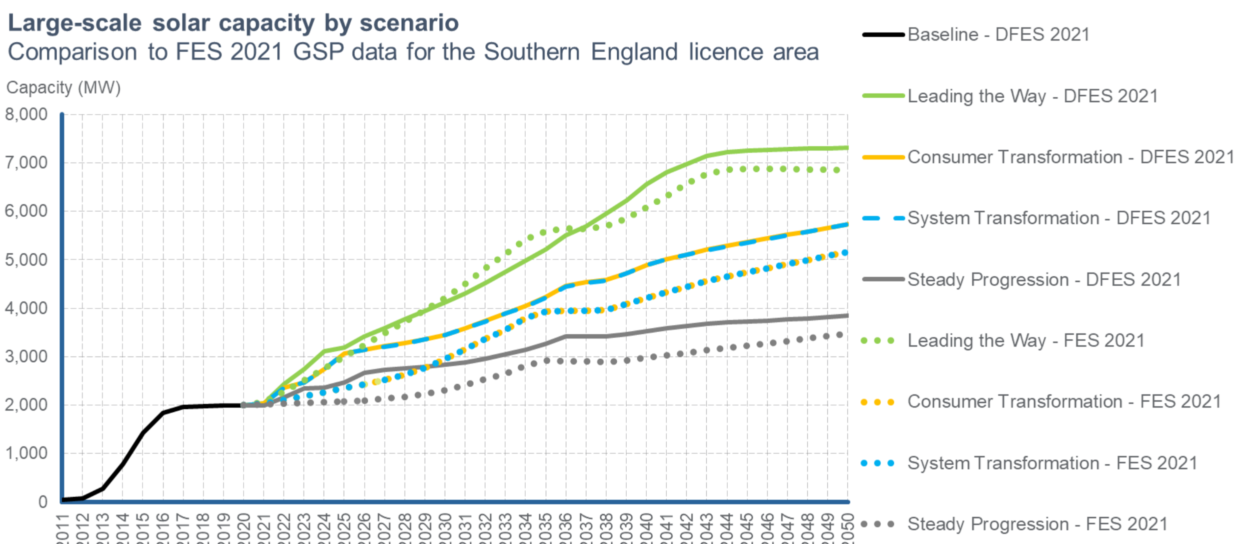
pick-up again with potentially significant growth in connected capacity in the near-term.

- As a result of the large known pipeline and stakeholder engagement views, an increase in solar capacity in the next five years has been modelled under all scenarios, with total capacity ranging from 2.4 GW in **Steady Progression**, to 3.2 GW in **Leading the Way** by the end of 2025.

Medium/long term (2025 – 2050)

- Solar PV capacity deployment continues across the period out to 2050 under all scenarios in the licence area.
- Under **Leading the Way**, a significant proportion of known pipeline projects move through to development across the 2020s and 2030s.
- Reflecting feedback from stakeholders that large-scale solar connecting to the distribution network (1-50 MW) would see the most growth in the mid 2030s and 2040s, this scenario also sees the most ambitious deployment of large-scale solar PV. This scenario maximises the repowering of older operational sites with higher performance solar technologies and the exploitation of potential new business models, such as co-location with electricity storage and hydrogen electrolysis.
- Total large-scale solar PV capacity in the Southern England licence area reaches 5.2 GW by 2035 and 7.3 GW by 2050 under **Leading the Way**.
- Under **Consumer Transformation** and **System Transformation**, there is also strong growth allowing total large-scale solar capacity to reach c.4.2 GW by 2035 and 5.7 GW by 2050 under both of these scenarios. This growth reflects significant repowering, a high proportion of the known pipeline going through to connection and a moderate uptake of battery storage co-location.
- Under **Steady Progression**, total large-scale solar capacity reaches only c.3.3 GW by 2035 and c.3.8 GW by 2050. Whilst still representing an increase from the 2 GW baseline, this scenario reflects a slower conversion of pipeline projects, less dynamic solar business models and fewer opportunities for co-location, leading to less financial investment in new solar projects overall.

Figure 18: Large scale (>1MW) solar PV projections for the Southern England licence area, compared to National Grid FES 2021 regional projections



Reconciliation with National Grid FES 2021:

DFES 2021 projections have been reconciled to the FES 2021 data for the relevant GSPs within the Southern England licence area for building block Gen_BB012.

- Overall the DFES 2021 and FES 2021 projections are closely aligned See Figure 18.
- The SSEN DFES 2021 has c.10 MW less capacity in the 2020 baseline than the FES 2021 GSP data. The reason for this small variance (in a baseline of 2 GW) is unclear but could be related to a handful of technology classification differences.
- Projections in the near-term are more ambitious in the DFES than modelled in the FES 2021. This reflects the significant known pipeline with grid connection agreements in place and positive planning evidence, that are likely go through to construction in the 2020s.
- Beyond this near-term variance 2025, the trend of the DFES and FES 2021 projections align well. By 2050, the DFES has modelled c.400-600 MW more overall capacity (depending on the scenario) than the FES 2021 projections. This is likely based on the more ambitious near-term uptake of new solar capacity in the 2020s and the repowering of sites in later years modelled in the DFES.

Factors that will affect deployment at a local level:

- New large-scale solar PV capacity is distributed to developable land area based on Regen's large-scale solar PV resource assessment. This considers irradiance, designated land areas, physical constraints, network proximity, ground slope/aspect and proximal buildings.
- Due to the influence of repowering, some of the future large-scale scale PV capacity will be located at existing sites.
- In addition to this, the location of sites with connection offers that have recently expired has also been used to influence the distribution of medium and long-term capacity.

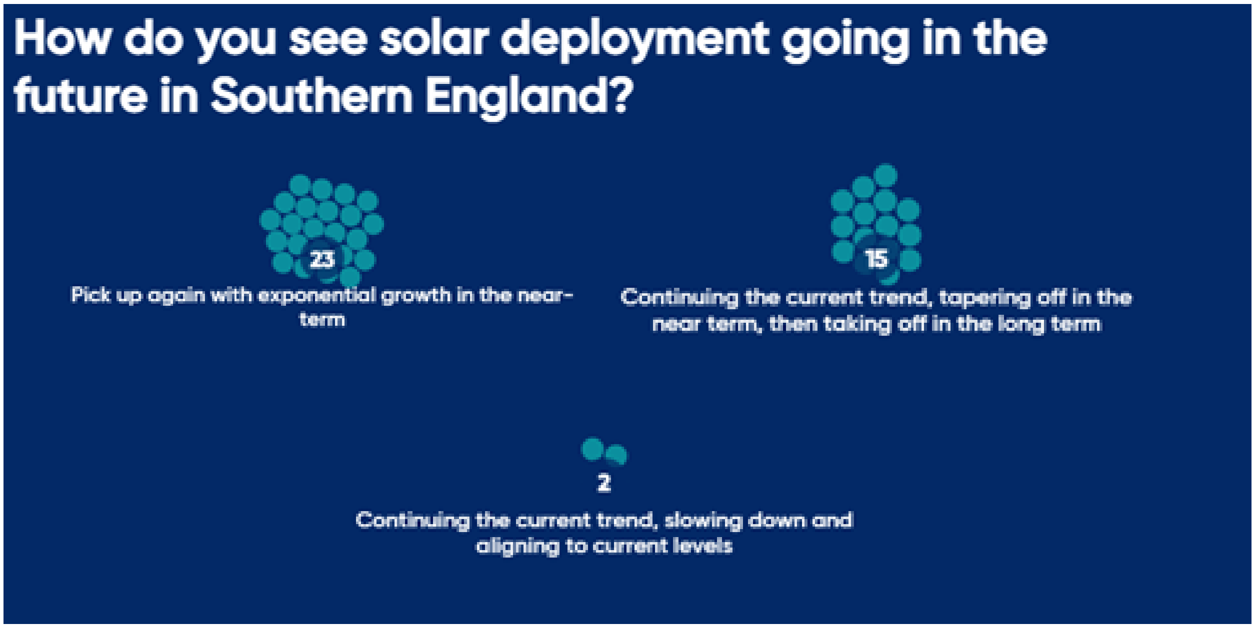
Relevant assumptions from National Grid FES 2021:

Assumption number	4.2.15 – Large-scale solar PV
Steady Progression	Slower pace of decarbonisation.
System Transformation	Transition to net zero results in strong growth in large solar.
Consumer Transformation	Transition to net zero results in strong growth in large solar.
Leading the Way	Very high ambition to decarbonise drives a focus on technologies that are low carbon. Supports production of hydrogen by electrolysis.

Stakeholder feedback overview:

Large-scale solar PV	
Stakeholder feedback provided	How this has influenced our analysis
A range of stakeholders were engaged through a dedicated Southern England DFES workshop in October 2021. There was a range of views around future solar PV deployment in the Southern England, with 58% of stakeholders suggesting there could be exponential growth in new solar PV capacity in the near term and 38% suggesting the current trend would continue and uptake of new solar could accelerate in the longer term. Planning friendliness, solar irradiance and local solar deployment targets were voted as the top 3 factors determining the location of new solar capacity in the licence area. Solar developers contacted in relation to the pipeline projects expressed a high degree of confidence that their development projects would go ahead. Stakeholder feedback suggests that solar deployment in the region in increasingly being linked with battery storage, and to high energy users such as new data centres. It is significant therefore that the pipeline for solar, battery storage and new data centres have all increased in the past two years.	All DFES scenario reflect significant growth in Solar PV. The range in views around the scale of uptake of new large scale solar capacity has been reflected across the four scenarios. **Steady Progression** sees a less ambitious and slower deployment, whilst **Leading the Way** reflects almost all known pipeline sites with positive planning evidence, some recently lapsed projects moving forward to development and additional future capacity being deployed in strong solar resource areas. Regen's solar resource assessment and geographical distribution model applies solar irradiance, other geographical factors and planning friendliness to distribute solar capacity across the licence area.
Engagement with the Isle of Wight (one of the highest solar irradiance areas in the UK) highlighted that there was significant interest to develop new solar projects, but the network constraints present on the island are creating prohibitively expensive connection quotes and thus projects are being shelved. This stalled solar capacity currently totals c.156 MW with recent connection quotes that have expired. For the Isle of Wight to achieve its 2030 net zero target[vi], a significant amount of new solar capacity will need to be brought online in the 2020s. SSEN is working with the Isle of Wight across 2022 to build the evidence case for an uncertainty mechanism investment case, amending their ED2 plan determination for SSEN to submit to Ofgem for consideration.	The DFES 2021 analysis has considered those "latent" demand from projects whose connection quotes where not accepted. Scenario projections of solar deployment on the Isle of Wight has increased in DFES 2021 compared to DFES 2020. Under **Leading the Way**, c.150 MW of expired connection offer capacity at locations on the Isle of Wight have been modelled to connect across the late 2020s.

Figure 19: Stakeholder responses to solar PV question in the online engagement webinar



References:

SSEN connection offer data, DNO Embedded Capacity Registers, the Renewable Energy Planning Database, Regen consultation with local stakeholders, representatives from the Isle of Wight and discussion with solar project developers.

[iii] See IRENA study showing cost of utility scale solar could fall by a further 55% by 2030: https://www.powerengineeringint.com/renewables/irena-wind-and-solar-costs-will-continue-to-fall/

[iv] See NREL solar cell efficiency tracker: https://www.nrel.gov/pv/cell-efficiency.html

[v] See EY solar PPA agreement, Dec 2020: https://www.ey.com/en_uk/news/2020/12/ey-agrees-its-first-zero-carbon-power-purchase-agreement-in-uk-with-solar-energy-farm

[vi] See Isle of Wight climate emergency declaration and commitment to net zero emissions by 2030: https://www.iow.gov.uk/Residents/environment-planning-and-waste/Future-Energy-Initiatives/Climate-Change/Climate-Change-and-the-IWC

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.

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

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

Installed power capacity (MW)		Baseline	2025	2030	2035	2040	2045	2050
<10 kW	Steady Progression	273	305	392	497	606	716	826
	System Transformation		371	609	877	1146	1406	1658
	Consumer Transformation		439	797	1186	1581	1981	2374
	Leading the Way		439	797	1186	1581	1981	2374
10 kW – 1 MW	Steady Progression	92	133	149	169	188	206	223
	System Transformation		153	203	257	309	361	412
	Consumer Transformation		176	252	332	411	491	571
	Leading the Way		176	252	332	411	491	571

Overview of technology projections in the licence area:

- Domestic-scale solar PV in the Southern England licence area has historically seen levels of uptake area in line with the national average, despite having higher levels of irradiance compared to the rest of the country. This deployment has historically been driven by Feed-in Tariff support in the 2010s.
- While domestic-scale solar PV is a more attractive investment in sunnier regions, levels of irradiance are less influential on uptake, compared to utility-scale ground-mounted solar PV. As a result, the capacity of domestic-scale solar PV in the licence area is expected to broadly align with national trends in each of the four scenarios.
- This is driven largely by consumer engagement, the uptake of other domestic technologies (such as electric vehicles and domestic batteries), and reduction in the costs of domestic solar array installations. In **Leading the Way** (the scenario reflecting the highest decarbonisation ambition), around one in five domestic properties host rooftop PV by 2050.
- Small-scale commercial-scale solar PV is typically impacted by a blend of the drivers of

domestic-scale and utility-scale solar PV. Consequently, commercial-scale solar PV deployment has a similar trajectory to these other solar asset classes, with a strong increase in connected capacity under **Consumer Transformation** in particular.

- The DFES 2021 projections are broadly the same as those projected in DFES 2020. The exception is **Leading the Way**, which now matches the ambition and support seen under **Consumer Transformation**, reflecting broader FES 2021 scenario assumptions.
- In the **Consumer Transformation** and **Leading the Way** scenarios, around one in six domestic properties hosts rooftop solar PV by 2050.
- Total small-scale solar PV capacity reaches c.3 GW under these scenarios by 2050.

Scenario projection analysis and assumptions:

Baseline (up to end of 2020)

- There is 273 MW of domestic-scale solar PV connected in the Southern England licence area, equivalent to rooftop arrays on 2.9% of domestic buildings, slightly below the GB-wide average figure of 3.0%.
- Around 85% of these installations occurred between 2010 and 2015, supported by the Feed-in Tariff. The installation rate peaked at around 80 MW installed in 2012.
- Deployment slowed notably as the Feed-in Tariff rates reduced and the eventual end of the Feed-in Tariff programme, with only 36 MW installed since 2016.
- The commercial-scale solar PV baseline totals 92 MW. As per domestic-scale installations, the Feed-in Tariff supported this deployment, and development has equivalently tailed off since 2016.

Near term (2020 – 2025)

- There are 222 solar PV sites of 1 MW or lower with an accepted connection offer in the licence area. This contracted capacity totals 39 MW.
- In addition to this, there are 44 sites totalling 9 MW with a quote issued for a network connection, that have not yet been accepted.
- It is assumed that all sites with an accepted connection offer will go ahead in all scenarios. This is modelled to happen within two years under **Leading the Way** and **Consumer Transformation** and within four years for **Steady Progression** and **System Transformation**.
- Sites with a quote issued are modelled to connect within the 2020s in **Leading the Way** and **Consumer Transformation**.
- None go ahead in **Steady Progression**, while only sites with a quote issued within the last three years go through to connection in **System Transformation**.
- The trajectory for small-scale solar in the near term may depend strongly on the uptake of the Smart Export Guarantee[vii], and attractiveness of rooftop solar for homeowners in terms of installation costs, and savings from reduced wholesale electricity consumption.
- However, despite the Smart Export Guarantee having been in place for two years, it has not increased small-scale solar PV deployment, as deployment rates nationwide remain at similar levels to those in the years after the Feed-in Tariff closed in 2015. Therefore, the cost of installation and return on investment (discounting the Smart Export Guarantee) may be the more significant factors.
- The **Leading the Way** and **Consumer Transformation** scenarios, with high levels of green ambition from the public and a high near-term uptake of electrified transport, sees a corresponding uptake in solar PV due to both ambition and financial benefits. Capacity reaches c.600 MW by 2025 in these scenarios.

Medium term (2025 – 2035)

- Beyond the near term, small-scale solar uptake depends strongly on national trajectories rather than licence area factors. While the Southern England licence area has higher levels of irradiance than the rest of 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 in the medium term.
- In addition to solar irradiance, factors such as social housing, affluence and available roof area were considered to inform the projections.
- Rooftop solar PV on new build housing accounts for 10-20% of the uptake seen in all scenarios, owing to lower installation costs compared to retrofit panels.
- **Leading the Way** and **Consumer Transformation** see high levels of growth as a result of high consumer ambition and engagement, and high levels of electrification in transport, heat and cooling. **System Transformation** has strong uptake as panel costs fall, but to a lower extent than **Leading the Way** and **Consumer Transformation** as decarbonisation of electricity is achieved through larger-scale projects.
- By 2035, total small-scale solar PV capacity in the licence area ranges from c.1.5 GW in **Leading the Way** and **Consumer Transformation**, to c.650 MW in **Steady Progression**.

Long term (2035 – 2050)

- In line with the FES 2021, the overall trends established for each scenario in the medium term continue out to 2050, with deployment rates remaining relatively constant between 2026 and 2050.
- Figure 21 illustrates how the scenario's annual deployment rate of small-scale solar PV capacity varies relative to the baseline's annual deployment rate.

Figure 20: Small-scale solar PV projections for the Southern England licence area, compared to National Grid FES 2021 regional projections

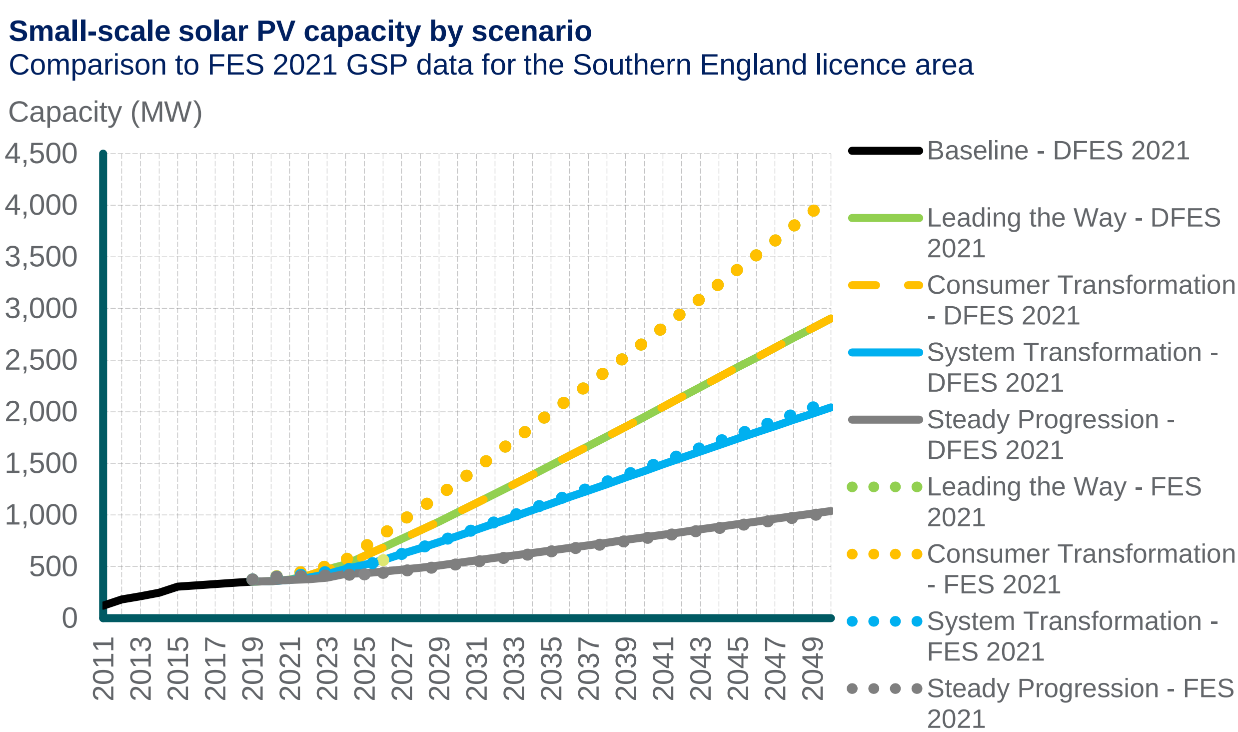
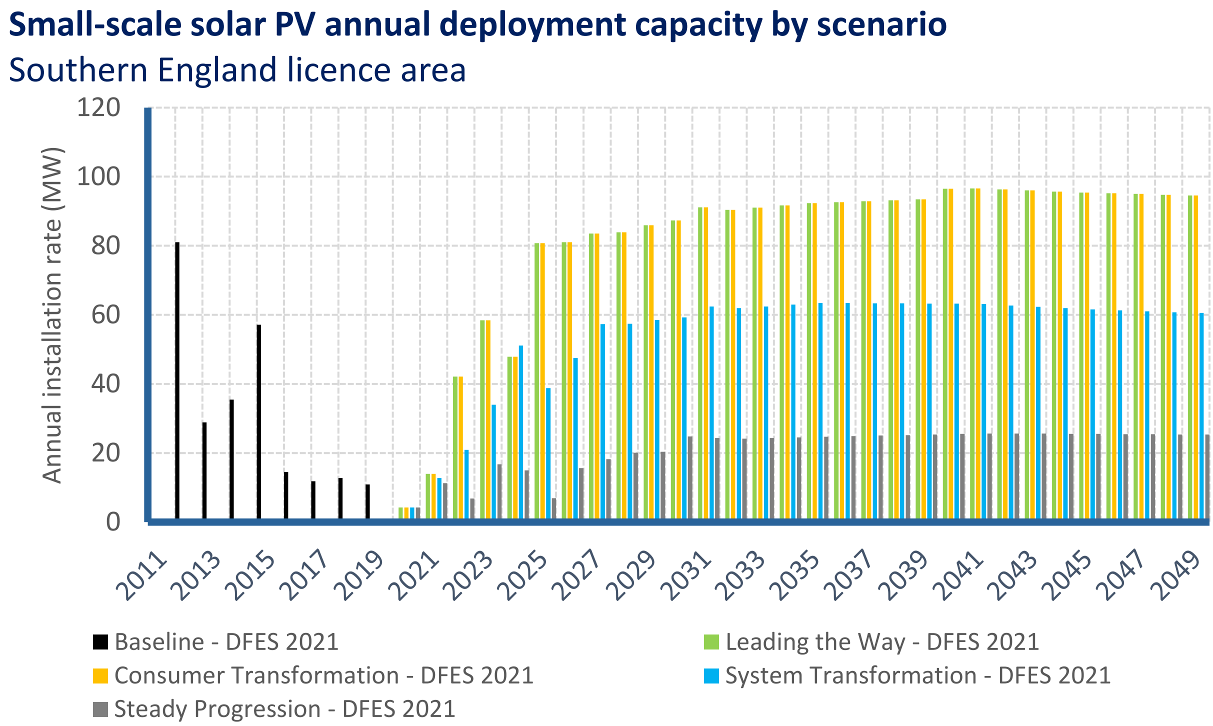


Figure 21: Annual small-scale solar PV projections for the Southern England licence area scenarios relative to the baseline annual deployment rate



Reconciliation with National Grid FES 2021:

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

- The DFES 2021 **Steady Progression** and **System Transformation** scenarios align strongly with FES 2021 GSP projections throughout the projection period.
- Under **Leading the Way** and **Consumer Transformation** the DFES 2021 projections are lower than those in the FES 2021. 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[viii].
- Even with decreasing installation costs for rooftop PV, increased electrification of transport, heat and cooling, and increased consumer engagement and ambition under these scenarios, it is difficult to envisage a scenario where installation rates exceed the levels seen in 2010, when Feed-in Tariff rates exceeded 50 p/kWh for domestic retrofit solar PV installations.

Factors that will affect deployment at a local level:

- The spatial distribution of new small scale solar PV in the licence area has been divided into domestic scale solar PV (<10 kW) and commercial scale (10 kW – 1 MW).
- Domestic uptake is mainly influenced by factors such as affluence, home ownership and social housing. In the near-term, 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 solar PV becomes increasingly ubiquitous.

- Almost 600,000 new homes are projected to be built in the licence area between now and 2050. In **Consumer Transformation** (the highest deployment scenario), 45% of the new build homes have a total of 661 MW of rooftop solar capacity installed by 2050, a fifth of the total domestic projection.

Relevant assumptions from National Grid FES 2021:

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

Stakeholder feedback overview:

Small-scale solar PV was not discussed directly at the engagement events, with priority given to technologies that had more regional considerations, such as large-scale ground mounted solar. However, Regen's existing market insight and knowledge from undertaking previous and ongoing DFES projects, was used to inform these scenario projections.

As part of Regen's engagement with local authorities, data was collected on whether each local authority had declared a climate emergency or had specific renewable targets or strategies. Where these existed, a small positive weighting of new small-scale solar capacity was applied in the near term to these locations. However, the projections in the medium and long term reflect the broader level of ambition for each scenario outlined in the FES 2021.

References:

SSEN connection data, Climate Emergency declaration data, Feed-in Tariff data, Regen resource assessments, Regen consultation with local stakeholders and local authorities.

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

[viii] See historic Feed-in Tariff rates from Ofgem: https://www.ofgem.gov.uk/environmental-programmes/fit/fit-tariff-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, but excludes pumped hydropower, which is considered an energy storage technology.

Technology building block: **Gen_BB018 – Non-pumped hydro**

Data summary for hydropower in the Southern England licence area:

Installed power capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	1.6	1.6	1.6	1.6	1.6	1.6	1.6
System Transformation		1.7	2.0	2.2	2.3	2.4	2.5
Consumer Transformation		1.7	2.2	2.6	3.0	3.4	3.6
Leading the Way		1.7	2.2	2.6	3.0	3.4	3.6

Overview of technology projections in the licence area:

- The Southern England licence area has very little hydropower resource and only a handful of very small-scale projects, with a total capacity of 1.6 MW.
- Some small baseline projects were developed in the early 2010s, encouraged by higher Feed-in Tariff rates for small-scale renewable generation.
- Although an absolute theoretical potential of approximately 70 MW was identified in the licence area, according to the BEIS UK Potential Sites of Hydropower Opportunity[ix], this analysis is based on data that is now dated and did not take into account precipitation, runoff attenuation or water flow accumulation. The true economic potential of hydropower in the licence area is therefore expected to be significantly lower.
- The DFES analysis of baseline and pipeline evidence suggests that additional hydropower capacity will continue to be made up of very small, kilowatt-scale projects.
- Scenario projections for distributed hydropower in the licence area are highest (3.6 MW) in **Consumer Transformation** and **Leading the Way**, where small-scale renewables play a vital role in achieving net zero.
- Under **System Transformation**, hydropower development in the licence area remains limited out to 2050, only increasing to 2.5 MW.
- Under **Steady Progression**, no additional capacity is modelled to connect by 2050.

Scenario projection analysis and assumptions:

Baseline (up to end of 2020)

- There is currently 1.6 MW of hydropower capacity connected to the distribution network in the Southern England licence area. This comprises 49 sites, five of which were included in the SSEN connections data.
- Development has slowed in recent years with the reduction in Feed-in Tariff rates and the removal of the Feed-in Tariff programme altogether. There has only been 0.01 MW of hydropower capacity commissioned in the licence area since 2016.

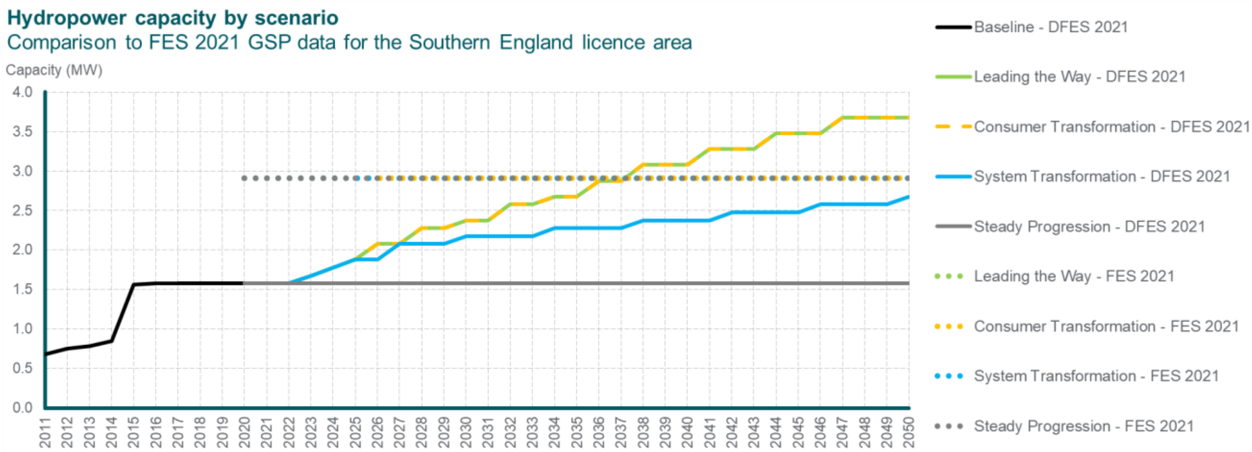
Near term (2020 – 2025)

- Despite the lack of commissioned projects over the last four years, there are three sites totalling 1 MW with accepted connection offers. The newest addition to the pipeline is a temporary capacity increase at Sandford Hydropower, under the Project LEO pilot[x], which, according to engagement with the developer, is a temporary increase in capacity that will be removed at the end of the trial period.
- The remaining two projects have held a connection agreement for over five years without seeing any further evidence of development. As such, the projects are not expected to proceed in their current state under any scenario.
- Consultation with water utility companies in the Southern England licence area in 2020 revealed a small amount of potential hydro generation repowering in the near-to-medium term, which has been reflected in the near-term scenario projections.
- The Access and Forward-Looking Charges Significant Code Review, and changes to transmission network (TNUoS) charges for embedded generators, has the potential to impact the business case for distributed generation in Southern England. Depending on the outcome of the code review, the impact for projects in the Southern England licence area could be positive. Upfront connection charges may decrease, however it is uncertain whether ongoing network charges will increase.

Medium and long term (2025 – 2050)

- Beyond the pipeline, the **Consumer Transformation** and **Leading the Way** scenarios see continued deployment of c.200 kW every two-to-three years, allowing for an uptick in hydropower development and the addition of small capacities at specific sites.
- The potential is extremely limited without subsidy support. These projects are supported primarily by the Smart Export Guarantee[xi] with potential value from power purchase agreements or direct co-location with electricity demand, for example at industrial sites.
- Under **System Transformation** hydropower development is lower as preference is given to larger-scale generation. This results in more hydropower projects failing to develop, resulting in additional capacity by 2050 totalling half that seen in the other two net zero scenarios.
- To reflect limited growth seen in recent years, **Steady Progression** has no increase in capacity, remaining at 1.6 MW of capacity out to 2050.
- Despite many projects being quite old by this point, as a mature technology there is not expected to be a significant increase in hydropower output caused by turbines being repowered in existing projects.

Figure 22: Hydropower projections for the Southern England licence area, compared to National Grid FES 2021 regional projections



Reconciliation with National Grid FES 2021:

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

- The FES 2021 has 2.8 MW of hydropower capacity as a baseline, double the size of the DFES 2021 baseline. While, proportionally, this is a significant difference, at an absolute level it is negligible, and likely comes down to the classification of Feed-in Tariff data.
- The FES 2021 has not projected any growth in hydropower in this licence area, which is a deviation away from the FES 2020 results, which saw a 1.5 MW increase under the most ambitious scenarios. The DFES 2021 has opted to align more closely with the FES 2020 trajectories to better reflect the limited, but still existent, hydropower potential in the licence area.
- The staged c.100-300 kW increases modelled in the DFES 2021 projections represent a realistic set of projections, modelling the commissioning of individual projects.

Factors that will affect deployment at a local level:

- The near term distribution of hydropower capacity is based on the location of known pipeline sites. Additional small-scale, medium- and long-term projections will be distributed geographically based on areas of theoretical hydropower potential.
- The hydropower assessment from BEIS[ix] was not used, considering that it is old and highly theoretical. Regen is developing an in-house hydropower resource assessment that may be used in future iterations of the DFES.

Relevant assumptions from National Grid FES 2021:

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

Stakeholder feedback overview:

Onshore wind	
Stakeholder feedback provided	How this has influenced our analysis
As part of the engagement process, the DFES team contacted a hydropower developer in the Southern England licence area, whose project is being developed under a pilot project focused on grid flexibility services in Oxfordshire.	This engagement led to the decision to remove this site from the analysis, as the connection offer is temporary.

References:

SSEN connection offer data, DNO Embedded Capacity Registers, National Grid ESO TEC register, the Renewable Energy Planning Database, Regen consultation with local stakeholders and discussion with developers.

[ix] BEIS 2010, *England and Wales Hydropower Potential Sites of Opportunity*: https://data.gov.uk/dataset/cda61957-f48b-4b75-b855-a18060302ed1/potential-sites-of-hydropower-opportunity

[x] See Sandford Hydro Trials, as part of Project LEO: https://project-leo.co.uk/case-studies/sandford-hydro-trials/

[xi] See Ofgem summary of Smart Export Guarantee: 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 covers any marine generation projects (tidal or wave) 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 Marine Energy Council and representatives from the Isle of Wight. This has helped to identify any other potential pipeline projects that are likely to connect to the distribution network out to 2050.

The DFES projections specifically focus on marine generation projects connecting to the distribution network. However, it is recognised that if the technology proves successful at a commercial scale, additional marine energy 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, and these would, in any case, 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 power capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	0	0	0	0	0	0	0
System Transformation		0	0	0	0	0	0
Consumer Transformation		0	25	25	25	25	25
Leading the Way		20	25	40	50	50	50

Overview of technology projections in the licence area:

- The location of marine energy projects is dependent on a number of specific factors:
    - Available energy resources
    - Seabed depths and conditions
    - Marine environmental designations
    - Port availability.
- Whilst there is the potential for marine generation projects off the south coast of England, including a previously explored development area for tidal generation off Portland, most of the focus for tidal generation has been on sites in high tidal resource areas off the coast of the Isle of Wight.
- The Southern England licence area currently has no operational marine energy generation sites connected to the distribution network.
- The marine energy sector has faced a number of challenges in recent years and has struggled to expand beyond a small number of trial sites and the first Meygen pilot project in the Pentland Firth.

- A core issue was the withdrawal of specific Contracts for Difference (CfD) subsidy support for wave and tidal energy in 2016, which affected industry confidence and led to the withdrawal and delay of many pre-commercial projects[xii].
- The marine sector (specifically the Marine Energy Council) has lobbied BEIS to reform the CfD Allocation Round 4 (AR4) framework to include specific ring-fenced support for marine energy technologies. In late November 2021, BEIS announced that tidal stream would be awarded a £20m ring-fenced minima within AR4, at an administrative strike price of £211/MWh[xiii]. This amendment has been welcomed by the industry[xiv] and could re-ignite investment and development of new tidal projects.
- Wave energy development and deployment has been slower than tidal energy and, in the near term, is still limited to testing and demonstration sites.
- There are two identified pipeline tidal energy projects in the licence area, totalling 25 MW. This includes the 20 MW PTEC project on the Isle of Wight.
- These two pipeline sites are modelled to come online across the 2020s and early 2030s under **Leading the Way** and **Consumer Transformation** only.
- Even under scenarios that are highly supportive of developing renewable technologies, it is recognised that marine energy faces a challenging development environment and the viability of this technology to deliver significant generation capacity is dependent on cost reduction, access to seabed areas and continued policy support.
- As a result of this uncertainty, additional capacity beyond the known pipeline has been modelled under **Leading the Way** only, with connected capacity reaching 50 MW by 2040 under this scenario.

Scenario projection analysis and assumptions:

Baseline (up to end of 2020)

- There are no operational marine energy generation projects connected to the distribution network in the Southern England licence area.

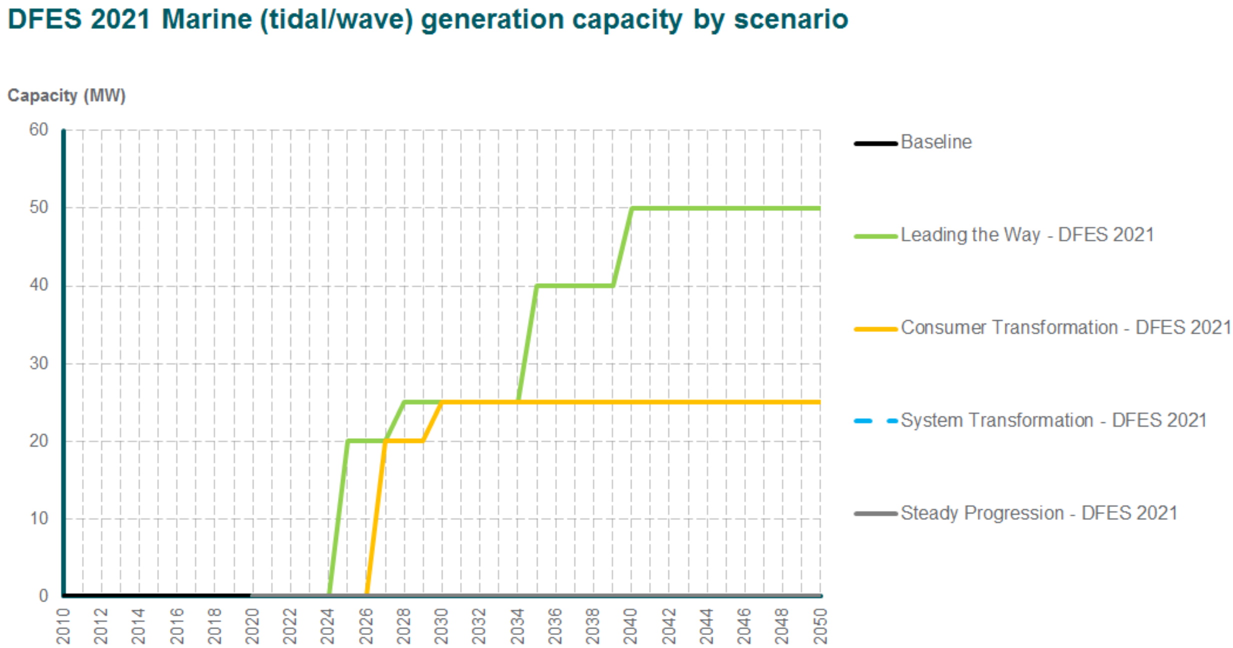
Near and medium term (2020 – 2035)

- There are two known pipeline marine energy projects in the licence area:
- The Perpetuus Tidal Energy Centre (PTEC), located at Ventnor on the south coast of the Isle of Wight.
  - There have been a number of export capacity applications to SSEN for this site; but engagement with the developer has confirmed the site is targeting 20 MW.
  - The PTEC site originally secured planning approval in 2015 and more recently secured planning to site the substation, control room and cabling on land at Ventnor, near to Southern Water's pumping station[xv].
  - PTEC has also announced a new partnership with the European Marine Energy Centre (EMEC)[xvi] and is expected to bid into the CfD Allocation Round 4 auction.
- In addition to this is a 5 MW application to test tidal devices off the coast of Yarmouth[xvii].
- These projects have been modelled to come online across the 2020s and 2030s under the **Consumer Transformation** and **Leading the Way** scenarios. Capacity reaches 25 MW by 2028 in **Leading the Way** and by 2030 in **Consumer Transformation**.

Long term (2035 – 2050)

- Larger-scale marine projects are likely to connect to the transmission network. This limits the potential for any further capacity connecting to the distribution network in the Southern England licence area.
- However, under **Leading the Way** an additional 25 MW of additional demonstration projects has been modelled to come online beyond 2035, with capacity reaching 50 MW under this scenario.

Figure 23: Marine generation projections for the Southern England licence area



Reconciliation with National Grid FES 2021:

- The FES 2021 has no marine generation capacity connecting to the distribution network in the Southern England licence area out to 2050, under any scenario.
- The DFES 2021 has modelled both known pipeline projects to connect in more ambitious scenarios across the late 2020s and 2030s, with an additional 25 MW of development capacity connecting under **Leading the Way** across the 2030s and 2040s.

Factors that will affect deployment at a local level:

- The DFES analysis for marine generation focuses on the location of known pipeline project developments, in waters and coastal land at Yarmouth and the Isle of Wight.

Relevant assumptions from National Grid FES 2021:

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

Stakeholder feedback overview:

Marine generation (tidal and wave)	
Stakeholder feedback provided	**How this has influenced our analysis**
Representatives from the Isle of Wight, Marine Energy Council and the marine energy development sector were engaged to inform this year's analysis. Stakeholders highlighted a partnership between PTEC and EMEC as positive support for the development of the PTEC project on the Isle of Wight[xviii]. Feedback suggested that more ambitious deployment could be modelled, compared to the 2020 edition of the SSEN DFES.	The 2021 DFES analysis has sought to bring forward known pipeline projects under both **Leading the Way** and **Consumer Transformation** than in the 2020 DFES. An additional 25 MW of non-pipeline capacity has also been included in the long-term under **Leading the Way**.

References:

SSEN connection offer data, Regen consultation with Isle of Wight stakeholders and discussion with marine energy sector and project developers.

[xii] See Guardian article from 2018 about the loss of UK development: https://www.theguardian.com/environment/2018/jun/19/huge-mistake-britain-throwing-away-lead-in-tidal-energy-say-developers

[xiii] See BEIS announcement, 24 Nov 2021: https://www.gov.uk/government/news/uk-government-announces-biggest-investment-into-britains-tidal-power

[xiv] See Regen https://www.regen.co.uk/eleventh-hour-opportunity-as-tidal-energy-gets-20m-reserve-allocation-in-latest-cfd-round/

[xv] See update on PTEC development, 15 December 2021: https://www.countypress.co.uk/news/19784817.isle-wights-ptec-tidal-energy-project-gets-final-green-light/

[xvi] See partnership between PTEC and EMEC, accounted Oct 2020: https://www.emec.org.uk/press-release-emec-enters-partnership-with-ptec-to-grow-uk-tidal-energy-market/

[xvii] See notice to The Crown Estate, 10 December 2021: https://www.thecrownestate.co.uk/en-gb/media-and-insights/seabed-and-coastal-notices/wave-and-tidal/

[xviii] See partnership between PTEC and EMEC, announced October 2020: https://www.emec.org.uk/press-release-emec-enters-partnership-with-ptec-to-grow-uk-tidal-energy-market/

Biomass

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 with carbon capture and storage (BECCS).

Technology building block ID: Gen_BB010

Data summary for biomass generation in the Southern England licence area:

Installed power capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	0.05	1.1	1.1	1.1	1.1	1.1	1.1
System Transformation		1.1	41.1	41.1	41.1	41.1	41.1
Consumer Transformation		0.7	0.7	0.7	0.7	0.6	0.0
Leading the Way		0.7	0.7	0.7	0.7	0.6	0.0

Overview of technology projections in the licence area:

- Historically, the Southern England licence area has had virtually no biomass-fuelled electricity generation connected to the distribution network, due to a lack of available resource in the area (e.g. no large scale forestry or biomass crop production). Some schemes have been suggested in locations such as Southampton, where a 100 MW plant could potentially be built to support the heat network development in the city.
- This 100 MW Southampton biomass plant was first proposed in 2015 and has since been shelved due to financial issues[xix]. In DFES 2020, this site was included in the analysis under several scenarios, to represent the possibility of this site being reignited or replaced by similar projects. However, due to significant levels of uncertainty and a continued lack of pipeline evidence regarding the future of biomass generation projects in the licence area, the 2021 DFES analysis has modelled this site to connect at a reduced capacity in **System Transformation**, after the ED2 investment period.
- When analysing planning permission friendliness towards biomass projects in the Southern England licence area, it has been shown that even when projects are seen as viable despite the lack of local feedstock, they have largely not been successful in attaining planning permission. This is evidenced by recent pushback from local councils[xx] and organisations such as Biofuels Watch[xxi] in the area, due to sustainability concerns effectively delaying projects even if they have gained planning permission.
- The National Grid ESO FES 2021 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 2021 has adopted this assumption for the Southern England licence area in the relevant scenarios.

- Finally, it should be noted that there is a call for evidence[xxii] to remove the 300 MW minimum threshold for Carbon Capture Readiness requirements, which would mean that small-scale generators "*must demonstrate that it will be technically and economically feasible to retrofit carbon capture technology within the lifetime of the plant.*" The call for evidence is also seeking views on the inclusion of biomass (along with other combustion technologies) under the scope of Carbon Capture Readiness requirements. If this policy revision goes through, then small-scale distributed biomass as a business model will become increasingly challenging without further subsidy support.
- As a result of these regional and national factors, very little capacity comes online across the period to 2050 under **Leading the Way**, **Consumer Transformation** and **Steady Progression**. Under **System Transformation**, only the known pipeline development in Southampton has been modelled to connect, which remains online beyond 2050.

Scenario projection analysis and assumptions:

Baseline (up to end of 2021)

- Biomass capacity in Southern England is extremely limited, with only one farm-scale biomass boiler in the SSEN connection data, with a capacity of 0.05 MW.

Near term (2021 – 2025)

- There are two biomass sites with an accepted connection offer, totalling 1 MW. Both sites are modelled to connect in **System Transformation** and **Steady Progression**.
- Under **Leading the Way** and **Consumer Transformation**, only one of the contracted sites is modelled to connect due to a lack of sufficient planning information.

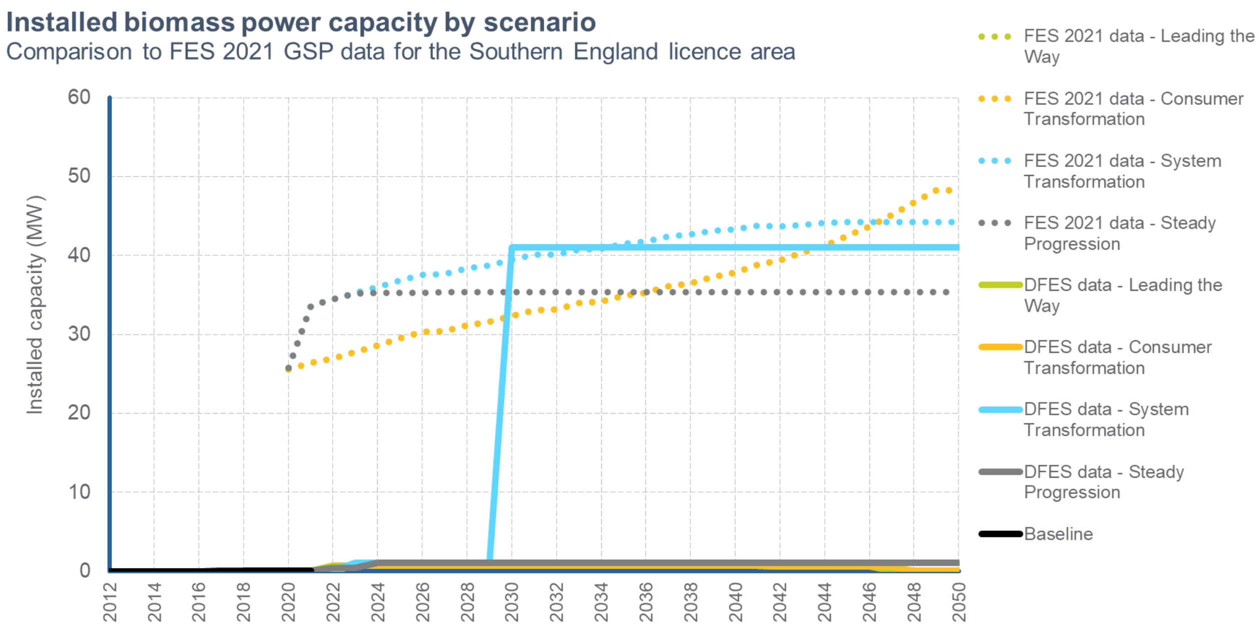
Medium term (2025 – 2035)

- The stalled 100 MW biomass site in Southampton which has been in development since 2015 is modelled to connect in 2030 under **System Transformation**, at a reduced capacity of 40 MW. This is based on an assumption that this scenario is more supportive of large-scale biomass projects. This project makes up nearly all of the projected near-term capacity increase under this scenario.
- The DFES considers that BECCS could see deployment from the medium term onwards; however, it has been assumed to connect at transmission level, as the high costs of CCS technology are unlikely to be commercially viable for smaller-scale biomass generation plants that are developed without subsidy support.

Long term (2035 – 2050)

- From the 2030s, the DFES has assumed that sustainable sources of biomass feedstock are prioritised for large-scale biomass with CCS connecting to the transmission network, heat or other non-energy uses. This leads to no further increase in distribution network connected biomass generation capacity in the long term, under any scenario.
- The Southampton biomass CHP pipeline project is modelled to remain online under **System Transformation**, assuming that by this time, CCUS technologies are fitted and proven at this smaller scale.
- Projections differ from DFES 2020, following the assumption that small-scale biomass sites will not be able to connect under most circumstances, as abated biomass will only be financially viable at transmission scale. This assumption reflects the UK Biomass Policy Statement[xxiii], published by BEIS in late 2021, that most off-gas biomass sites will be used for heating purposes. Stakeholder feedback and local authority input also suggested that biomass in urban areas may be more suited to dedicated heat networks.

Figure 24: Biomass projections for the Southern England licence area, compared to National Grid FES 2021 regional projections



Reconciliation with National Grid FES 2021:

Results in this section relate to the FES 2021 data for the relevant GSPs within the Southern England licence area for **technology building block ID: Gen_BB010**.

- The assumptions underpinning this work are in line with the FES 2021; however, the results differ due to local spatial factors and regional expertise.
- SSEN connections data suggest a very low (0.05 MW) baseline, which is significantly lower than the c.25 MW baseline shown in the FES 2021 GSP data for the licence area.
- The baseline discrepancy has been investigated by comparing FES building block data by GSP to known entries in the Embedded Capacity Register and SSEN connections data. After an analysis of these sites, insufficient evidence was found to justify an increase in baseline capacity in DFES 2021 for the licence area. The reason for the variance is unclear but could be a difference in methodology surrounding technology classification between FES and DFES, leading to some FES 2021 biomass sites being considered as waste technology sites in DFES 2021, for example.
- The FES 2021 has a gradual increase in distributed biomass capacity under **Consumer Transformation**, and a stable trajectory from the baseline under **Steady Progression** and **System Transformation.** However, the DFES 2021 models a large step increase to reflect the commissioning of a 40 MW Southampton CHP plant under **System Transformation**. This is due to a consideration that large-scale biomass projects are more likely to incorporate the CCUS technology required to make biomass compliant with net zero ambitions and thus seek to connect at transmission network level.

Relevant assumptions from National Grid FES 2021:

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

References:

SSEN connection offer data, DNO Embedded Capacity Registers, National Grid ESO TEC register, the Renewable Energy Planning Database, Contracts for Difference auction data, Regen consultation with local stakeholders, Regen questionnaire and consultation with local authorities.

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

[xx] Electricity Forum 2021, *Bristol rejects 50-MW biomass plant.* https://www.electricityforum.com/news-archive/mar10/Bristolrejectsbiomassplant

[xxi] Biofuels Watch n.d., Shoreham EGP Objection. https://www.biofuelwatch.org.uk/wp-content/uploads/Shorheam-EGP-objection.pdf

[xxii] Department for Business, Energy & Industrial Strategy and Welsh Government 2021, Decarbonisation readiness: call for evidence on the expansion of the 2009 Carbon Capture Readiness requirements. https://www.gov.uk/government/consultations/decarbonisation-readiness-call-for-evidence-on-the-expansion-of-the-2009-carbon-capture-readiness-requirements

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

Renewable engines

Summary of modelling assumptions and results

Technology specification:

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

Building block: **Gen_BB004 - Renewable Engines (Landfill Gas, Sewage Gas, Biogas)**

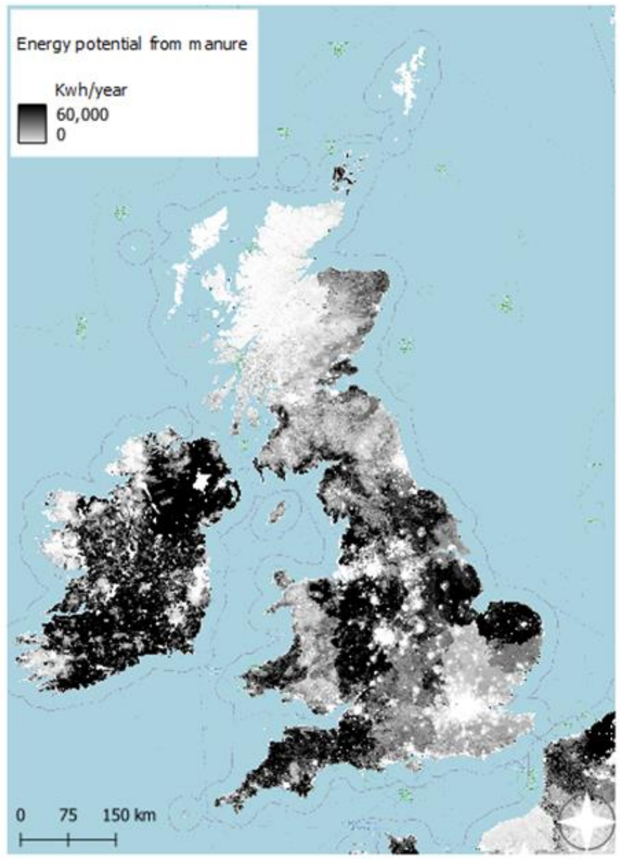
Data summary for renewable engines in the Southern England licence area:

Technology	Installed power capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Anaerobic digestion	Steady Progression	34	48	48	48	48	48	49
	System Transformation		50	51	52	52	53	53
	Consumer Transformation		51	53	55	57	58	58
	Leading the Way		52	54	56	59	60	61
Landfill gas	Steady Progression	31	38	21	14	14	8	8
	System Transformation		21	14	8	8	8	0
	Consumer Transformation		19	14	8	8	8	0
	Leading the Way		6	6	0	0	0	0
Sewage gas	Steady Progression	26	26	19	19	19	1	0
	System Transformation		26	26	26	19	19	19
	Consumer Transformation		26	26	26	26	26	26
	Leading the Way		26	26	26	26	26	26

Overview of anaerobic digestion projections in the licence area:

- There are 34 MW of AD capacity operational in the licence area.
- Feedstock from waste is a critical factor in the potential to develop new/additional AD capacity. The Southern England licence area has some potential for AD, representing approximately 17% of the local authorities in GB that do not yet have separate food waste collection. This indicates that there is potential in the near term to valorise food waste in the licence area.
- Agricultural land grade in the Southern England licence area is moderate, representing 7% of all viable land in GB. Approximately 11% of the licence area sits on high-quality agricultural land. According to manure resource assessment analysis (see Figure 25), around 7% of total theoretical feedstock potential in GB from manure is located in the Southern England licence area. However, more analysis would be needed to discover how much of this potential is technically and economically recoverable.
- In the medium and long term, demand for 'green gas' is expected to increase for a variety of applications including transport, gas grid injection and heat networks. This is incentivised by the Green Gas Support Scheme[xxiv], which is expected to limit the interest in electricity grid connections. For this reason, DFES 2021 projections for AD have been notably reduced, compared to the results seen in the 2020 DFES analysis.
- As highlighted by the Committee on Climate Change[xxv], there is also the potential opportunity to use biomethane in larger generation plants with carbon capture and storage (CCS) to create negative emissions, with half of the available generation set aside for industry and heat in buildings.

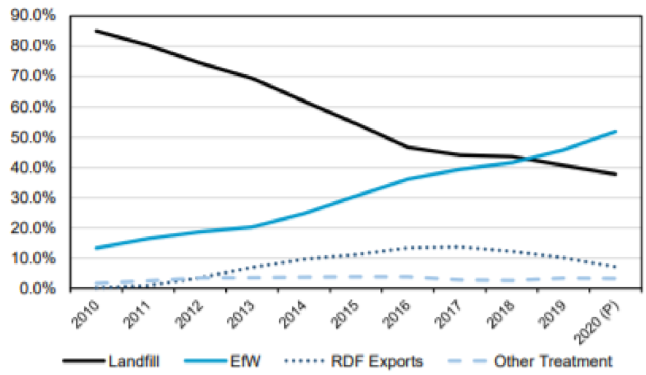
Figure 25: Results of Regen's anaerobic digestion resource assessment from manure feedstocks



Overview of landfill gas projections in the licence area:

- In the Southern England licence area, landfill gas generation currently totals 31 MW.
- Operational and pipeline landfill gas sites are expected to decommission in all net zero scenarios by 2050, due to the limited (c.20 year) lifetime of such plants[xxvi].
- In addition to this, there is an overall declining trend in waste-to-landfill as Energy from Waste (EfW)technologies take prominence. The amount of waste being sent to landfill has declined in recent years, from capturing over 80% of the residual waste market in 2010 to under 40% in 2020. This trend is expected to continue[xxvii].

Figure 26: UK Residual Waste Market



Source: [UK Energy from Waste Statistics, Tolvik Consulting]

- For this reason, the DFES 2021 has modelled decommissioning from as early as 2025 in **Leading the Way** and **Consumer Transformation**. All capacity is decommissioned by the mid-2030s under **Leading the Way** and the early 2040s in **Consumer Transformation** and **System Transformation**.
- 8 MW remains online by 2050 under **Steady Progression**.
- Many existing landfill sites will be slowly restored, i.e. undergo natural restoration. To exemplify this trend, waste management giants like Viridor are reducing operational landfill sites from 18 to just three remaining sites[xxviii].

Overview of sewage gas projections in the licence area:

- There is 26 MW of sewage gas generation currently operational in the licence area. The operation of this technology is largely restricted to regulated water utility companies.
- Consultation with Wessex Water to support the DFES 2020 analysis, highlighted that there were currently no plans to increase electricity generation, but biomethane production is being explored.
- Therefore, the DFES has not projected any change in sewage gas used for electricity generation across the timeframe under **Leading the Way** and **Consumer Transformation** out to 2050.
- A partial conversion to gas-to-grid injection is modelled under **System Transformation**, with sewage gas generation capacity reducing to 19 MW in 2050.
- Full conversion is modelled under **Steady Progression**, with all generation capacity decommissioning in the late 2040s.

Scenario projection analysis and assumptions:

Baseline (up to end of 2021)

Anaerobic digestion:

- There is a limited baseline of distribution network connected AD facilities in the Southern England licence area, with only 34 MW from 26 sites connected as of the end of 2021.
- This represents a 2 MW decrease from DFES 2020, largely due to the reclassification of several small baseline sites.

Landfill gas:

- There are 10 sites, totalling 31 MW, of landfill gas generation connected to the distribution network in the Southern England licence area.
- Only three sites (6 MW) have connected to the distribution network in the licence area since 2010.
- The largest site at Calne, representing 4.7 MW of capacity, accepted its last load of waste in 2016 and has already entered the restoration phase[xxix].

Sewage gas:

- The baseline for sewage gas is 25.8 MW from 13 sites. This is a decrease compared to

DFES 2020, due to the improved quality of baseline connection data. Specifically, an 11.4 MW site was reclassified as natural gas, while three small sites totalling 5.7 MW were reclassified as sewage sites, some of which were previously classified as AD. These corrections represent a net decrease of c.6 MW.

Near term (2021 – 2025)

Anaerobic digestion:

- In the Southern England licence area, there are two pipeline AD sites totalling 7 MW, of which a 580 kW site has an accepted connection offer.
- As food waste collection becomes mandatory in 2023 in England[xxx], an immediate increase in AD capacity is expected to accommodate for the increase in feedstocks. There is uncertainty as to how much of this will be diverted to electricity generation versus gas-to-grid injection. As a result, 52 MW has been modelled to connect by 2025 in **Leading the Way** and only 48 MW connected by 2025 in **Steady Progression**.

Landfill gas:

- There is an 8 MW landfill gas site with an accepted connection offer in the licence area. The developer was contacted and confirmed that planning has been secured. They were confident that the site will move forward to build in 2022/2023. Therefore, this site has been modelled to connect under all scenarios in the early 2020s.
- No further increase in landfill gas generation capacity has been projected in the licence area under any scenario, reflecting the lack of pipeline and age of existing sites.
- To reflect national carbon reduction targets, landfill gas generation capacity begins to decline from 2022 in **Leading the Way**, modelled to decommission c. 20 years after being put into operation. This results in significant capacity coming offline between 2022 and 2025. Under this scenario, only 6 MW remains connected by 2025.
- Under **Consumer Transformation** and **System Transformation**, baseline sites take longer to decommission, with remaining capacity decreasing to 19 MW in **Consumer Transformation** and 21 MW in **System Transformation** by 2025.
- Under **Steady Progression,** the existing capacity (and 8 MW pipeline site) remain online.

Sewage gas:

- There are two sewage gas pipeline sites with a connection offer. One 100 kW site in Wokingham is assumed to be abandoned due to the age of the connection offer and lack of planning data. The other site in Bracknell Forest (630 kW) has secured planning; thus, the site has been modelled to connect in 2022 under all scenarios.
- Installed capacity remains at 26 MW out to 2025 under all scenarios. This assumes that any potential additional near-term sewage gas sites will be incentivized away from electricity generation and target gas grid injection, supported by the green gas levy. This consideration was supported through engagement with Wessex Water in 2020.

Medium term (2025 – 2035)

Anaerobic digestion:

- In the medium term, AD generation capacity is assumed to be primarily driven by increased valorisation of manure, agricultural and industrial waste from the mid-2020s, followed by a much smaller proportion of remaining food waste that has not yet been collected and used as a commercial feedstock.
- Due to higher density in population and availability of feedstocks, there is a greater possibility for an increase in capacity compared to the North of Scotland licence area.
- A moderate increase in connected capacity is seen in all scenarios in the medium term,

with **Leading the Way** and **Consumer Transformation** reaching 56 and 55 MW respectively by 2035.

- **System Transformation** and **Steady Progression** see slightly less uptake, with 52 MW and 48 MW connected to the network by 2035, respectively. This reflects scenarios in which feedstocks are used for larger-scale EfW facilities under **System Transformation**, whereas waste feedstocks are largely left under-managed in **Steady Progression**.

Landfill gas:

- Decommissioning of landfill generation sites continues in all scenarios, as EfW facilities continue to take precedence. In addition to this, consumers become increasingly conscious of zero waste practices under the three net zero scenarios, further reducing un-recycled and re-valorised waste streams.
- By 2035, only 14 MW remains connected in **Steady Progression**, 8 MW in **Consumer Transformation** and **System Transformation**, and 0.2 MW in **Leading the Way**.
- **Steady Progression** also reflects decommissioning in the later years, with many baseline sites being modelled to disconnect after 30 years of operational life. By 2035, 14 MW remains connected to the distribution network under this scenario.

Sewage gas:

- Some sewage gas sites already begin to disconnect under **Steady Progression,** from 2029 onwards. This is due to support for green gas production and injection under the green gas levy, resulting in a steady decline in electricity generation under both **Steady Progression** and **System Transformation**.
- By 2035, **Steady Progression** decreases to 19 MW of installed capacity, whereas no change is seen in **System Transformation** yet due to longer decommissioning timeframes.
- Installed capacity remains at 26 MW under **Leading the Way** and **Consumer Transformation** out to 2050, reflecting more value in onsite power generation from existing sites, superseding the commercial opportunities of green gas production.

Long term (2035 – 2050)

Anaerobic digestion:

- By 2050, AD capacity in the licence area reaches 61 MW in **Leading the Way** and 58 MW in **Consumer Transformation**. Although waste feedstocks have depleted drastically by this time, due to a conscious consumer society, there is a significant amount of resource for waste products in the licence area to support feedstocks from manure, food waste and agricultural and commercial residue.
- The **System Transformation** trajectory remains limited, reaching 53 MW by 2050.
- Under **Steady Progression**, the trajectory continues a slight upwards trend, reflecting historic trends, with installed capacity reaching a conservative 49 MW.

Landfill gas:

- Due to the small pipeline for landfill gas generation in the licence area and the decommissioning of existing sites across all scenarios, all landfill gas capacity is decommissioned under the three net zero scenarios by 2050.
- Only the 8 MW pipeline site remains operational by 2050 under **Steady Progression**.

Sewage gas:

- **Steady Progression** and **System Transformation** continue to decommission existing sites out to 2050, as limited subsidy support from CfDs and interest in the green gas levy will see more water treatment facilities looking to convert existing infrastructure to heat and transport fuels and away from electricity production. All capacity is modelled to decommission under **Steady Progression** and only 19 MW remains under **System Transformation** by 2050.

Figure 27: Anaerobic digestion projections for the Southern England licence area

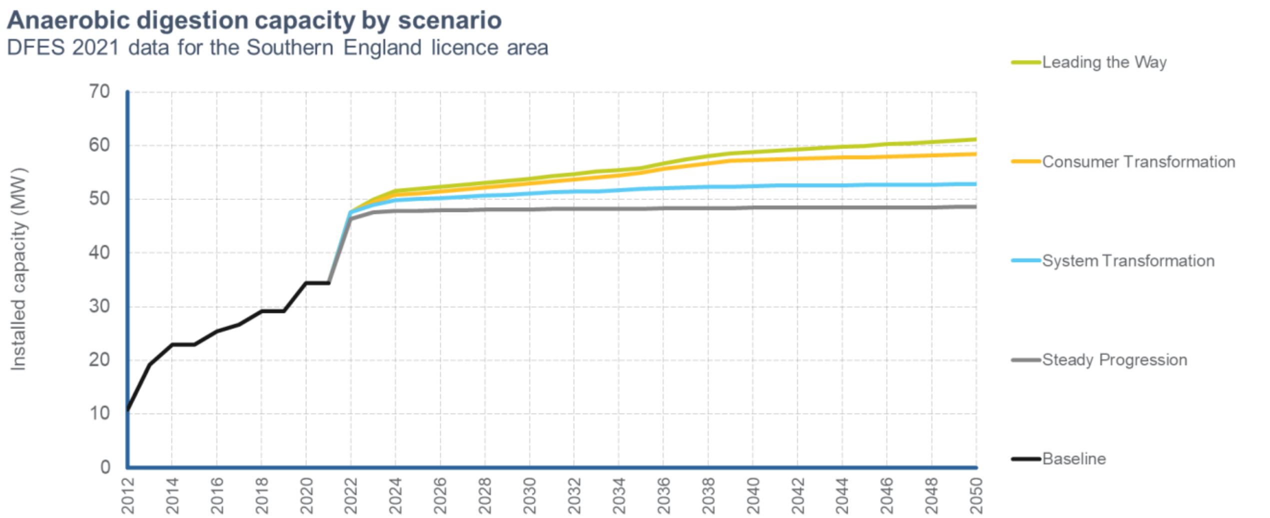


Figure 28: Landfill gas projections for the Southern England licence area

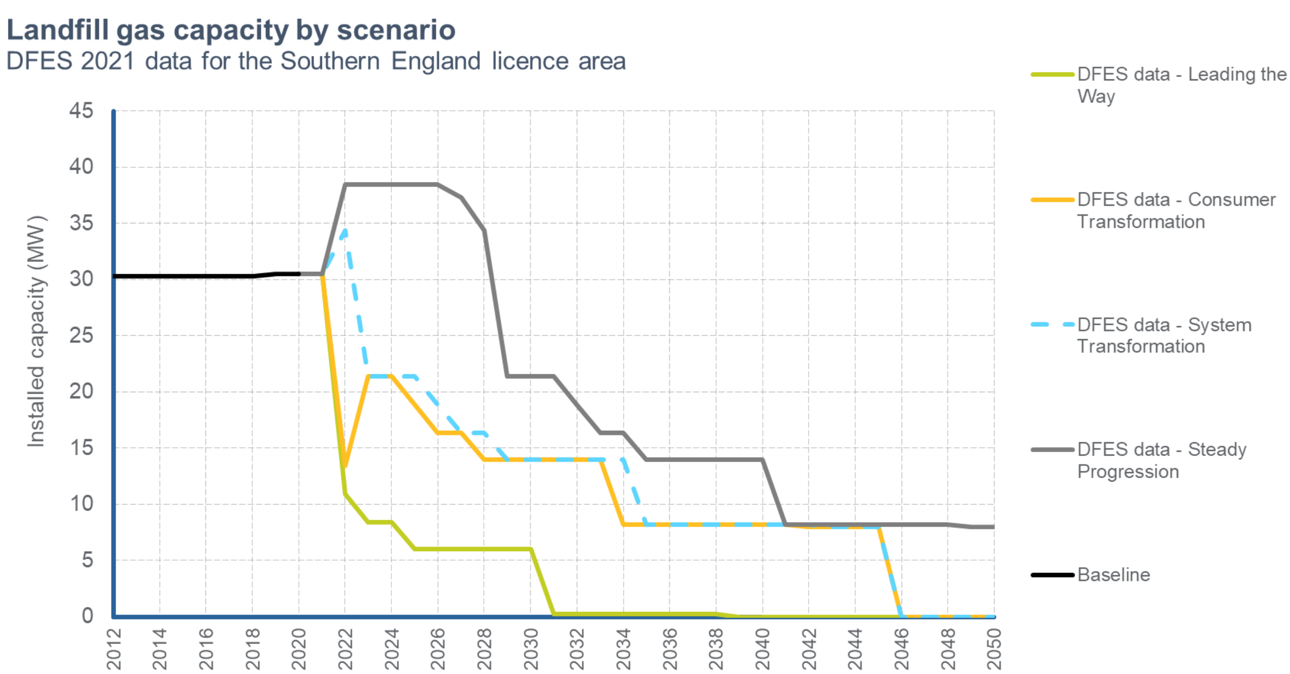


Figure 29: Sewage gas projections for the Southern England licence area

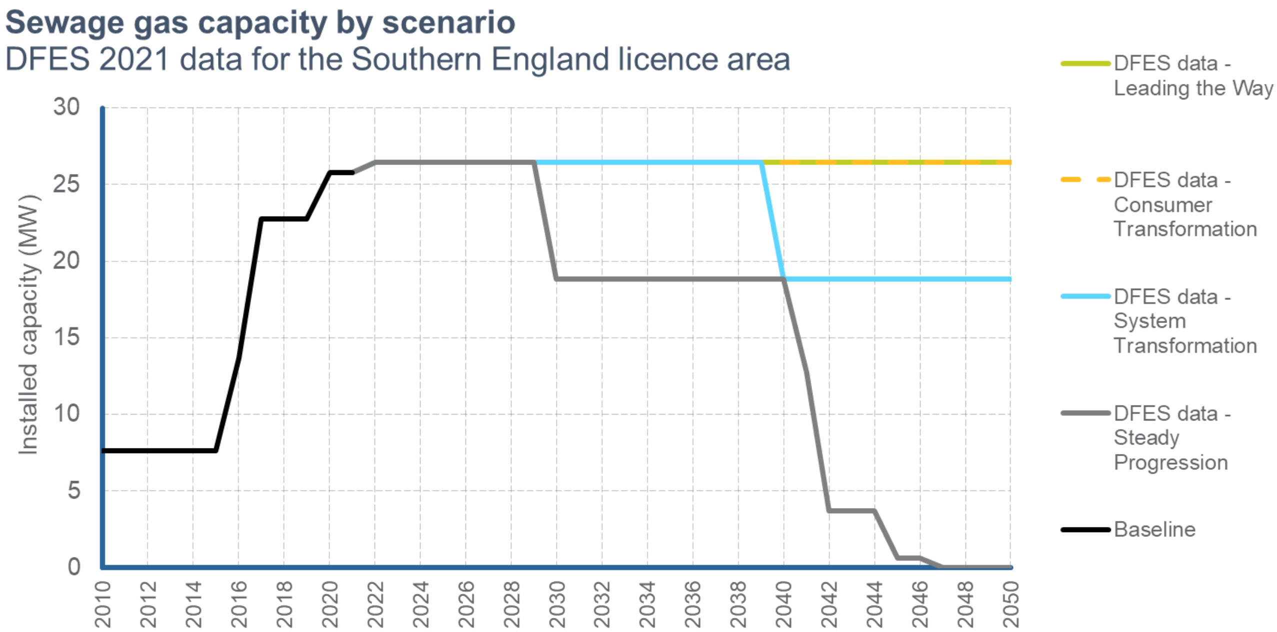
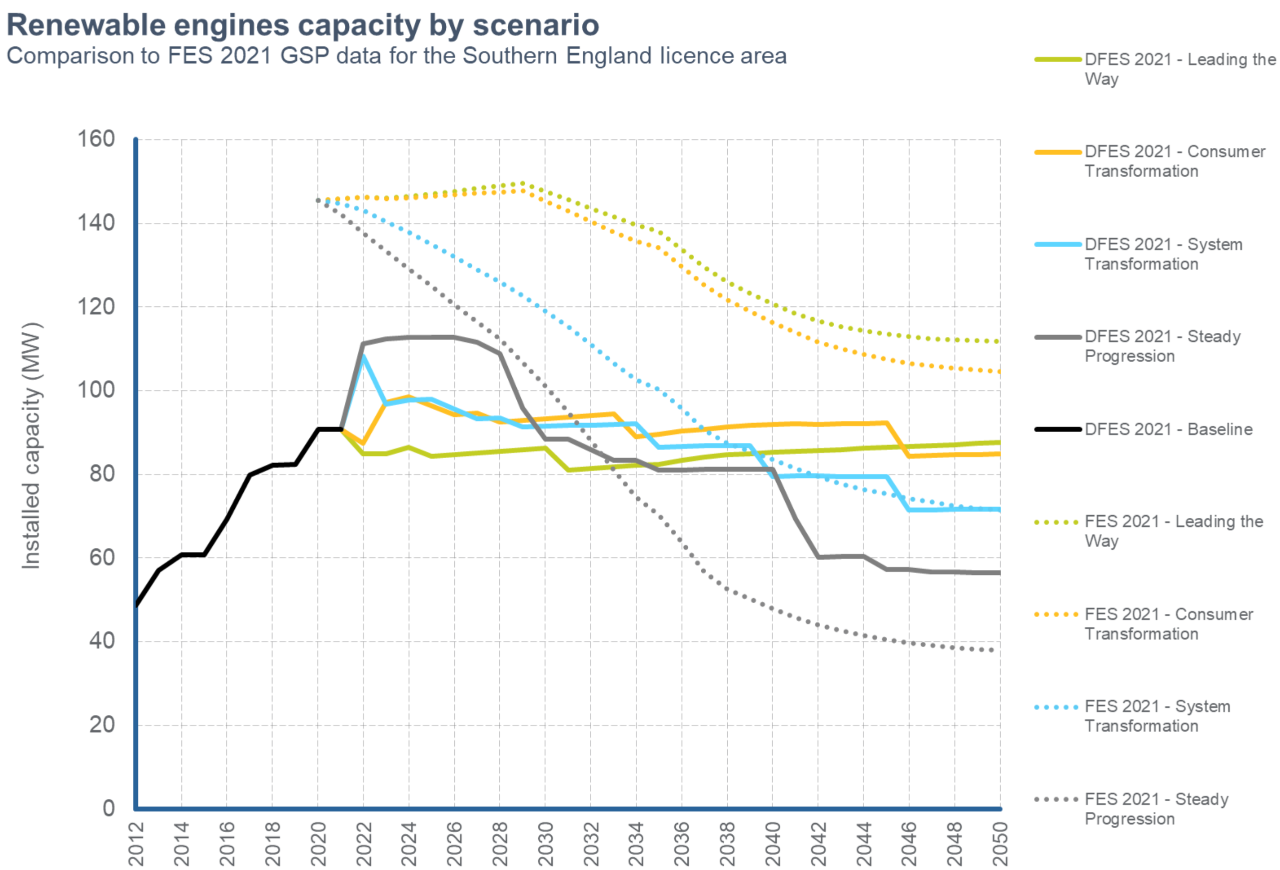


Figure 30: Renewable engines (biogas, landfill, sewage) projections for the Southern England licence area, compared to National Grid FES 2021 regional projections



Reconciliation with National Grid FES 2021:

- The FES 2021 data for renewable engines was not split out by sub-technology. In order to reconcile the DFES 2021 sub-technology projections, data from the FES 2019 renewable engines sub-technologies was used to create a viable reconciliation in the DFES 2021.
- The decommissioning logic used by Regen for sewage and landfill gas represents the majority of the deviation from the FES 2021 projections in the Southern England Licence Area. This is partially a reflection of the sub-technology approach to the analysis undertaken in the DFES 2021, making use of stakeholder input and analysis of individual sites, as well as historic and planned waste industry trends.
- Landfill gas is decommissioned across the 2020s, representing most of the deviation from FES 2021 in this timeframe. Beyond this, the DFES 2021 projections deviate further from the FES 2021, with a net increase in all scenarios out to 2050. The reason for this deviation and variations in projections between licence areas is unclear.
- Landfill gas was modelled to decommission earlier than both FES 2019 and 2020, and DFES 2020 projections. This is based on new insights from the Regen sector leads, identifying a decreasing trend in waste to landfill and poor levels of energy capture from operational sites, after 20 years of operation.
- The growth trajectory for FES 2019 sewage gas saw an increase and subsequent levelling out in all scenarios. To reflect real-world variation and the possibility of conversion to gas-to-grid, DFES 2021 modelled a decrease in two scenarios.

Factors that will affect deployment at a local level:

- Manure and slurry is a predominant feedstock in anaerobic digestion, followed by crop residues, energy crops and food waste. Thus, these were the three key feedstocks that were used to determine the spatial distribution of new plants.
- The spatial distribution of future AD sites that connect to the distribution network is weighted towards areas with sufficient agricultural land grade (grades 1 and 2) and also towards local authorities that do not yet collect food waste, as potential new feedstocks can arise in these areas. Additionally, DFES 2021 includes an in-house resource assessment based on gridded livestock density, including bovine, poultry and pigs[xxxi], to estimate the total theoretical potential of biogas from each livestock category, using a manure to biogas energy yield factor[xxxii] (see Figure 25).
- As part of the stakeholder engagement process, a survey was sent to all local authorities within the licence area. Included in the survey was a question on mandatory food waste collection. Responses from local authorities, augmented by further desk-based research was used to determine a geographic distribution factor for food waste collection. This factor was then scaled to population density to determine locations in the near term that are likely to have an abundance of new food waste feedstock. Many of these local authorities in England will race to comply with the 2023 mandate on compulsory food waste collection.
- The spatial distribution of landfill gas and sewage gas capacity is based on the location of existing baseline and pipeline sites connecting to the distribution network in the licence area.

Relevant assumptions from National Grid FES 2021:

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

Stakeholder feedback overview:

Biomass	
Stakeholder feedback provided	How this has influenced our analysis
Local authorities were surveyed about their food waste collection policy.	Responses were directly used to inform the geographic distribution of AD capacity.
Wessex Water was consulted in 2020 in regard to their future strategy and plans for sewage gas generation and biomethane production. Feedback included plans to increase existing biomethane production in the licence area. Engagement was also made with wastewater treatment companies for the WPD DFES 2021. This revealed an increased interest from water companies in gas-to-grid conversions.	The SSEN DFES 2021 has not modelled any increase in sewage gas capacity on the electricity network. However, sewage gas sites converting to potentially produce (or inject) biomethane, remains an uncertainty factor in the longer term, which is reflected in the scenario variation.

References:

SSEN connection offer data, DNO Embedded Capacity Registers, Gridded Livestock of the World database (GLW 3), National Grid ESO TEC register, the Renewable Energy Planning Database, Contracts for Difference Auction Outcomes data, Capacity Market Register, Regen consultation with local stakeholders and discussion with developers, Regen questionnaire and consultation with local authorities.

[xxiv] 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-

[xxv] Committee on Climate Change 2019, *Net Zero The UK's contribution to stopping global warming:* https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf

[xxvi] Agency for Toxic Substances and Disease Registry 2001, *Chapter 2: Landfill Gas Basics* https://www.atsdr.cdc.gov/hac/landfill/html/ch2.html

[xxvii] Tolvik Consulting 2020, *EfW Statistics 2020 Report* https://www.tolvik.com/wp-content/uploads/2021/05/Tolvik-UK-EfW-Statistics-2020-Report_Published-May-2021.pdf

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

[xxix] Viridor 2016, *Moving into restoration Calne landfill finishes with waste.* https://www.viridor.co.uk/who-we-are/latest-news/2016-news/moving-into-restoration-calne-landfill-finishes-with-waste/

[xxx] DEFRA 2020, *Household food waste to be collected separately by 2023 and 50,000 city trees to be planted in Urban Tree Challenge Fund.* https://deframedia.blog.gov.uk/2020/02/10/household-food-waste-to-be-collected-separately-by-2023-and-50000-city-trees-to-be-planted-in-urban-tree-challenge-fund/

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

[xxxii] 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 (ACT) that are connected to the distribution network in the Southern England licence area.

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

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

Technology	Installed power capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Incineration	Steady Progression	126	191	219	203	153	113	113
	System Transformation		145	104	64	64	64	30
	Consumer Transformation		138	67	27	27	27	0
	Leading the Way		126	0	0	0	0	0
Advanced Conversion Technologies (ACT)	Steady Progression	13	68	68	84	134	134	134
	System Transformation		98	164	164	164	164	171
	Consumer Transformation		76	162	162	162	162	162
	Leading the Way		130	196	196	196	196	196

Overview of technology projections in the licence area:

- Overall the SSEN DFES scenario analysis follows the FES framework assumption that, over time, older waste incineration technologies will be replaced by newer, lower-carbon ACT technology. By 2050 ACT sites are assumed to be dominant in these scenarios.
- However, in the Southern England licence area, the analysis is complicated by the fact that there is a significant pipeline of both waste incineration and ACT projects which could be built in the near term. This pipeline is partly in response to increased waste in the region, as landfill sites are closed and the amount of waste exported is reduced.
- There is some uncertainty about whether the full pipeline of either technology will be built. This will partly be driven by planning, environmental regulations, waste availability (versus recycling, etc.), financial viability and competition for available waste resources.
    - ACT is a relatively new technology and is still more expensive than other waste

technologies. Previous projects have been withdrawn, but there does not appear to be an increased likelihood that projects will go ahead, supported in part by the availability of CfD subsidies.
    - Waste incineration projects have typically struggled in planning; however, there are a number of projects in the pipeline that have already secured planning.
- Therefore, the DFES analysis has made a number of scenario-specific assumptions regarding pipeline build-out rates. For the purpose of network planning, it is assumed that projects with a network connection and planning permission will go ahead; this may have inflated the build-out forecast.
- In the near term, capacity grows; however, from 2030 there is an overall reduction in waste generation technology capacity as the volume of waste processing is reduced and older, higher carbon emission sites are replaced by lower-carbon ACT gasification plants. The transition is most pronounced in the three net zero scenarios
- ACT gasification plants are expected to have lower associated carbon emissions and, assuming that the residual emissions are abated, could be considered a compatible technology with net zero 2050 targets. Therefore, the DFES 2021 analysis assumes that all ACT facilities with planning permission go ahead in all scenarios in the near term.
- The baseline of incineration and ACT plants has increased significantly since DFES 2020, from 77 MW in 2020 to 139 MW in this year's analysis.
- ACT technology will begin to replace existing waste incineration plants as they decommission. The growth of ACT technology is highest under **System Transformation**. Under **Leading the Way** overall waste generation capacity is lower as there is less overall waste produced in this more environmentally conscious scenario.
- Under **Steady Progression**, it is assumed that waste incinerator use continues beyond 2050 and that unabated incineration remains a key solution for waste treatment.

Scenario projection analysis and assumptions:

Baseline (up to end of 2021)

- The baseline of waste incineration plants has increased significantly since DFES 2020, amounting to a total of 139 MW. This is due to improved quality of connection data which has allowed for the identification of three new sites with a combined capacity of 63 MW; 13 MW of ACT capacity and the 50 MW Lakeside Energy from Waste (EfW) plant, which was previously flagged to have been decommissioned.
- The baseline includes a 40 MW waste incineration site located in Bicester, as well as a 20 MW incinerator in Portsmouth and a 16 MW incinerator in Hampshire.

Near term (2021 – 2025)

- As of 2021, the confirmed waste technology pipeline equates to 263 MW from 16 sites, of which 191 MW (11 sites) have been granted planning permission. Of those that have attained planning permission, 123 MW (six sites) have also secured a connection agreement with SSEN.
- A number of ACT sites totalling 39 MW, of which two have planning permission, have been issued a connection quote by SSEN, that has not yet been accepted.
- 113 MW of the confirmed pipeline comes from nine ACT sites, all but one of which have been granted planning permission.

Medium term (2025 – 2035)

- Under all scenarios, some pipeline projects continue to connect out to the medium term, and capacity is at its highest in 2030 under all scenarios with:
  - **Leading the Way** reaching 196 MW (of which 0 MW is incineration)
  - **Consumer Transformation** reaching 229 MW (of which 67 MW is incineration)
  - **System Transformation** reaching 268 MW (of which 104 MW is incineration)
  - **Steady Progression** reaching 287 MW (of which 219 MW is incineration).
- ACT increases significantly in all scenarios, with capacity by 2030 at:
  - 196 MW in **Leading the Way**
  - 162 MW in **Consumer Transformation**
  - 164 MW in **System Transformation**
  - 68 MW in **Steady Progression**.
- By the mid-2030s, net capacity has decreased in all scenarios, with more incineration plants coming offline than ACT plants replacing them, which follows the assumption of a more waste-conscious society. As of 2035, overall capacity from both sub-technologies decreases to:
  - 196 MW in **Leading the Way**
  - 189 MW in **Consumer Transformation**
  - 228 MW in **System Transformation**
  - 287 MW in **Steady Progression**.

Long term (2035 – 2050)

- As decommissioning continues, more waste generation comes offline in the 2030s and 2040s:
  - In **Steady Progression**, incineration facilities surpass the average operational lifetime of 25 years[xxxiii] and are modelled to decommission after 30 years.
  - In **Leading the Way**, unabated incinerators have a lifetime of 15 to 20 years, generally decommissioning before the end of their operational lifetime to be in line with net zero ambitions and tighter environmental regulations.
  - In **Consumer Transformation** and **System Transformation**, incinerators have a lifetime of between 20 and 25 years.
- By 2050, 113 MW of incineration capacity remains operational under **Steady Progression**, reflecting a scenario in which EfW is the main waste treatment technology, and thus much of the pipeline remains online.
- **System Transformation** allows some small incineration capacities to continue to operate beyond 2050, provided that they are coupled with highly efficienct abatement technologies. Other facilities may also migrate to the transmission network with higher capacities and CCUS integration. By 2050, all incineration plants have come offline in **Leading the Way** and **Consumer Transformation**.
- Across the three net zero scenarios it is assumed that ACT technologies continue to replace older incineration plants. The ACT capacity development varies by scenario and will depend in-part on environmental regulations and the extent to which societal change and consumer behaviour reduces the amount of unrecycled waste being processed.
  - In **Leading the Way**, 196 MW of ACT capacity has come online by 2050 compared to 162 MW in **Consumer Transformation**.
  - In **System Transformation**, 171 MW of ACT capacity comes online by 2050. The decrease since the 2020s is in part due to the assumption that large transmission scale EfW facilities fitted with CCUS will make up a larger portion of waste treatment.

Figure 31: Waste incineration projections for the Southern England licence area

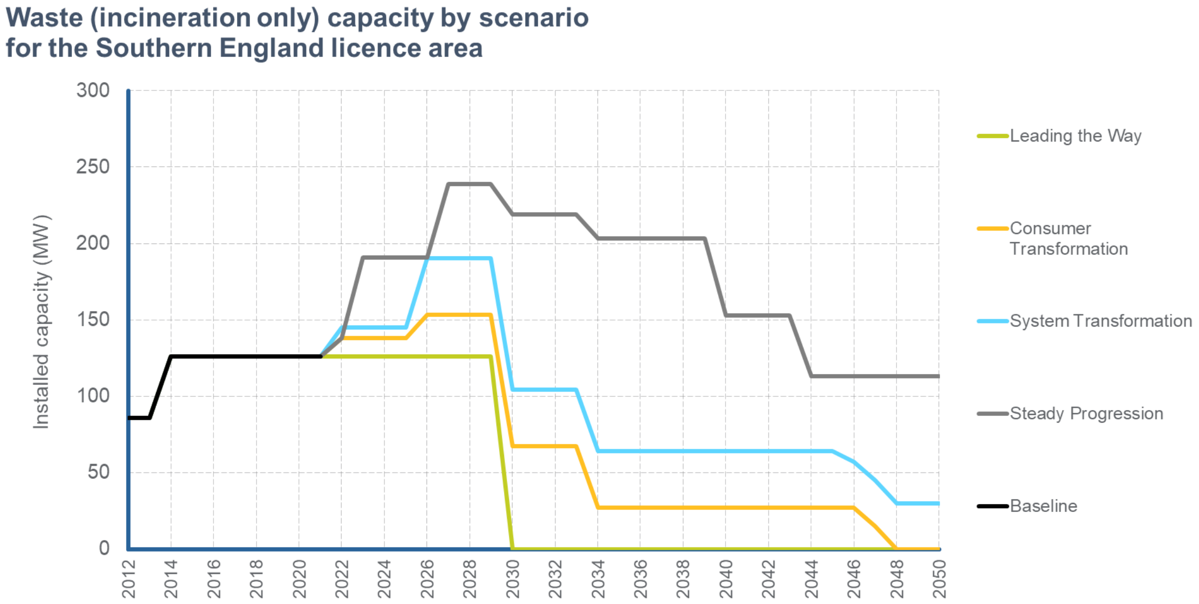


Figure 32: ACT projections for the Southern England licence area

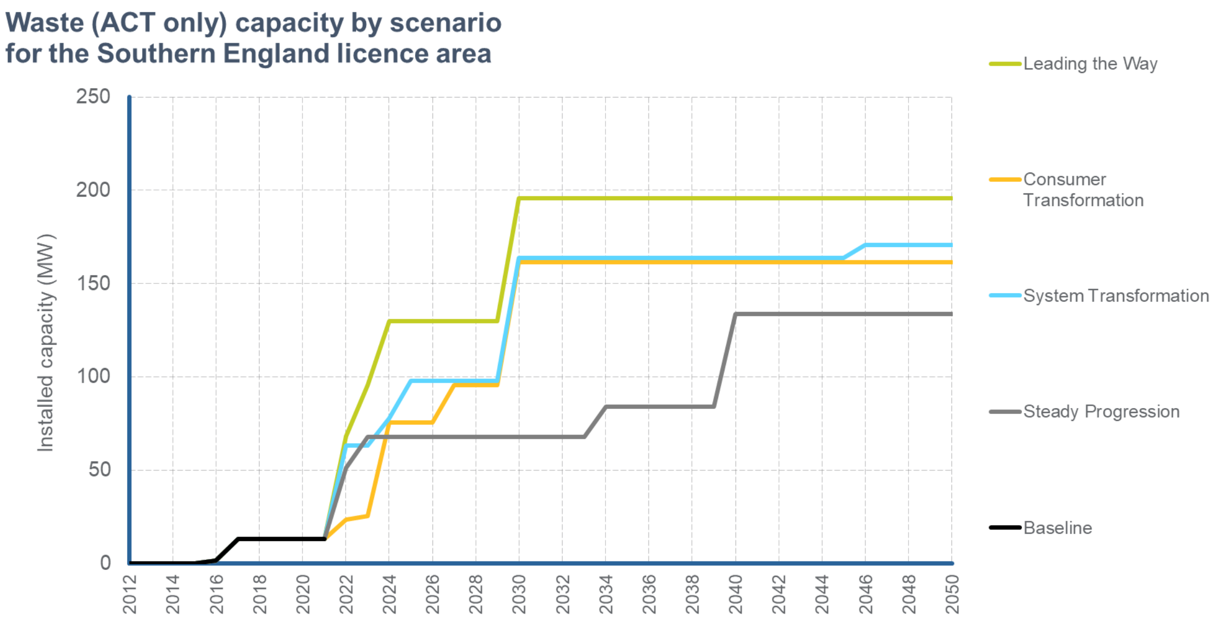
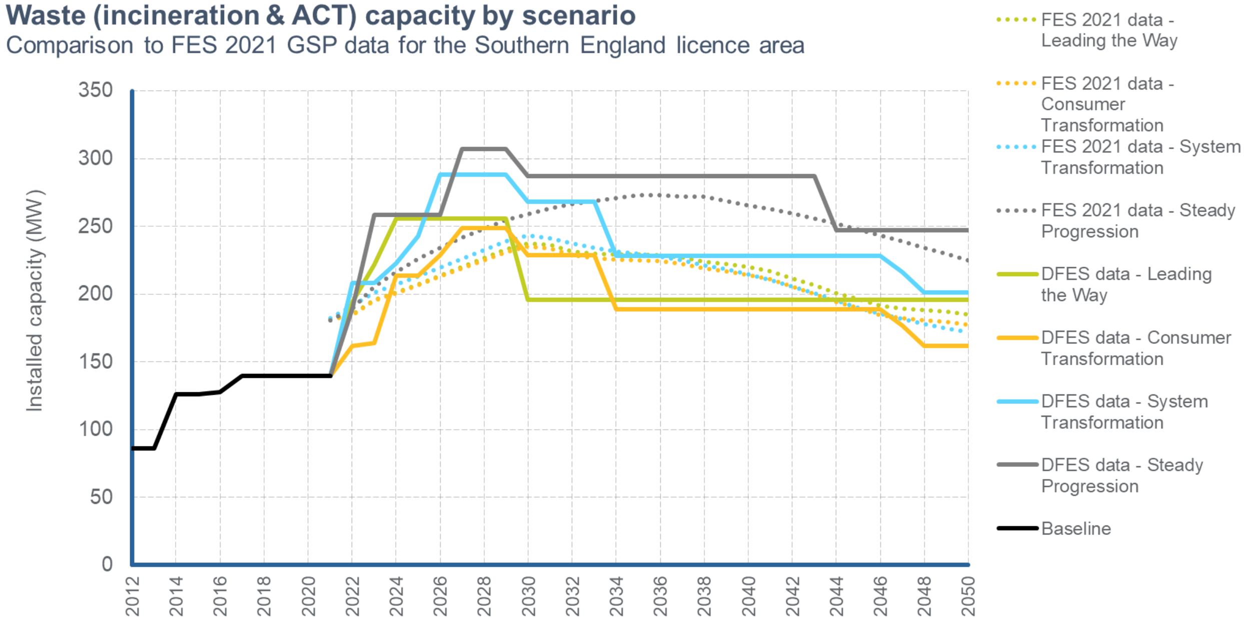


Figure 33: Energy from Waste projections for the Southern England licence area, compared to National Grid FES 2021 regional projections



Reconciliation with National Grid FES 2021:

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

- Assumptions underpinning the DFES analysis are closely aligned with the FES 2021 regional projections, though results differ due to local factors and spatial distribution.
- The DFES 2021 analysis follows the underlying FES 2021 assumption that ACT technologies will replace legacy waste incinerators over time. There is no breakdown by technology type in the published FES datasets and so a sub-technology reconciliation has not been undertaken.
- The baseline in DFES 2021 aligns more closely to that of FES 2020 than FES 2021, with FES 2021 showing 180 MW of baseline capacity, compared to 139 MW in DFES 2021. Compared to 2020, the 2021 DFES and FES assessments have increased the estimated baseline capacity by c.62 MW and c.30 MW respectively.
- The reason for baseline discrepancy is based on multiple factors including different interpretations of data in the Renewable Energy Planning Database (REPD) and different technology classifications of projects in both FES and DFES connection datasets. Historically, there has been some mislabelling of the various waste, landfill gas, sewage, fossil generation, AD and bioenergy generation projects. Developer and planning data is itself sometimes incorrect or ambiguous.
- As a recommendation, it would be good for the DFES and FES teams to collaborate to agree and maintain a common baseline. See Figure 33.
- Near-term projections in the DFES 2021 are slightly higher and more rapid than that modelled in the FES 2021. This is due to the near-term pipeline analysis in the DFES, which accounts for known sites with planning permission and connection agreements.
- Near-term deployment is significant due to the size of the pipeline, especially ACT sites that have secured planning permission.
- Where the FES 2021 regional projections data shows a smooth decline, the DFES 2021 analysis of connected and contracted waste generation sites seeks to decommission actual sites, thus the capacity projections are more stepped down.

Relevant assumptions from National Grid FES 2021:

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

Stakeholder feedback overview:

Waste (incineration & ACT)	
Stakeholder feedback provided	How this has influenced our analysis
The Operations Manager at the 50 MW Lakeside Energy from Waste facility was engaged to inform this year's analysis. Feedback suggested that medium-scale facilities like these are not necessarily planning to install CCUS technologies anytime in the near future, and are generally not planning to install CCUS technology until something scalable or economically feasible becomes available on the market. Furthermore, the developer's application for an expansion at the Ford Circular Energy Park was met with planning roadblocks and is no longer likely to continue.	These insights have underpinned the assumptions taken in the analysis for the licence area. Under current technology readiness assumptions, the DFES 2021 has assumed that any existing EfW plants are decommissioned over time, as the scale of these operations is unlikely to be coupled with CCUS technology to remain compliant with a truly net zero trajectory. Furthermore, new facilities have not been considered to come online in the net zero scenarios, reflecting difficult planning environments.
Part of the stakeholder engagement informing this year's analysis was an online survey with all of the local authorities in the Southern England licence area. 18 local authorities, out of the 23 that responded to the questionnaire, had a waste development strategy. Two did not yet have a strategy in place, while a further three had a strategy in development.	This information suggests that many councils will be planning for a more efficient waste management system and pushing for a waste-conscious society, further evidencing the FES and DFES assumptions.

References:

SSEN connection offer data, Dedicated Stakeholder Engagement, DNO Embedded Capacity Registers, National Grid ESO TEC register, the Renewable Energy Planning Database, Contracts for Difference Auction Outcomes data, Capacity Market Register, Regen consultation with local stakeholders and discussion with developers, Regen questionnaire and consultation with local authorities.

[xxxiii] 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

Diesel generation

Summary of modelling assumptions and results

Technology specification:

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

The analysis does not include dedicated back-up 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 power capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	166	184	157	2	0	0	0
System Transformation		135	0	0	0	0	0
Consumer Transformation		135	0	0	0	0	0
Leading the Way		0	0	0	0	0	0

Overview of technology projections in the licence area:

- The Southern England licence area has a number of existing operational diesel engines. This is a mixture of both standalone commercial scale diesel generation sites and behind-the-meter back-up generators, co-located with large energy users.
- There are also a number of potential new diesel sites with accepted connection offers in the licence area, 25 MW of which has secured planning approval.
- As a result, all diesel capacity disconnects from the network in all scenarios by 2030 under the three net zero scenarios. Some capacity remains online until the 2040s under the **Steady Progression** scenario.
- **Leading the Way** has the most rapid disconnection of diesel capacity in the licence area, with all sites decommissioning within the early 2020s.

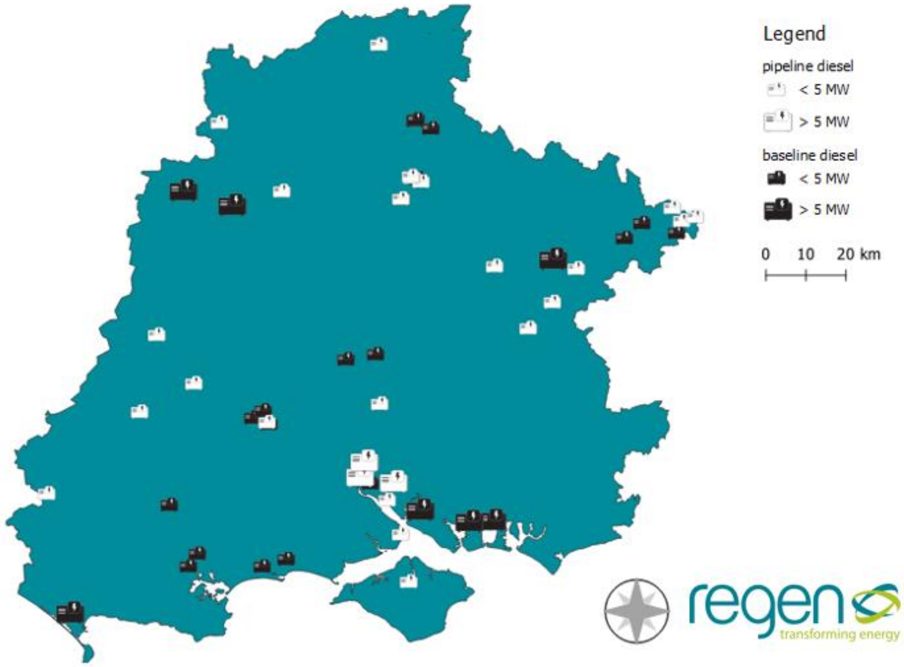
Scenario projection analysis and assumptions:

Baseline (up to end of 2020)

- There are 26 operational diesel generation sites in the Southern England licence area totalling 166 MW of generation capacity.
- These are a mixture of large standalone commercial-scale diesel plants (7 sites, 130 MW) and small back-up generators (19 sites, 36 MW).
- The standalone plants have historically targeted commercial network reserve services such as Short Term Operating Reserve (STOR) and Capacity Market auctions.
- The smaller back-up generators are co-located onsite at a number of high energy user premises, such as hospitals, retail buildings, warehouses and banks.

Near term (2020 – 2025)

Figure 34: baseline and pipeline diesel projects

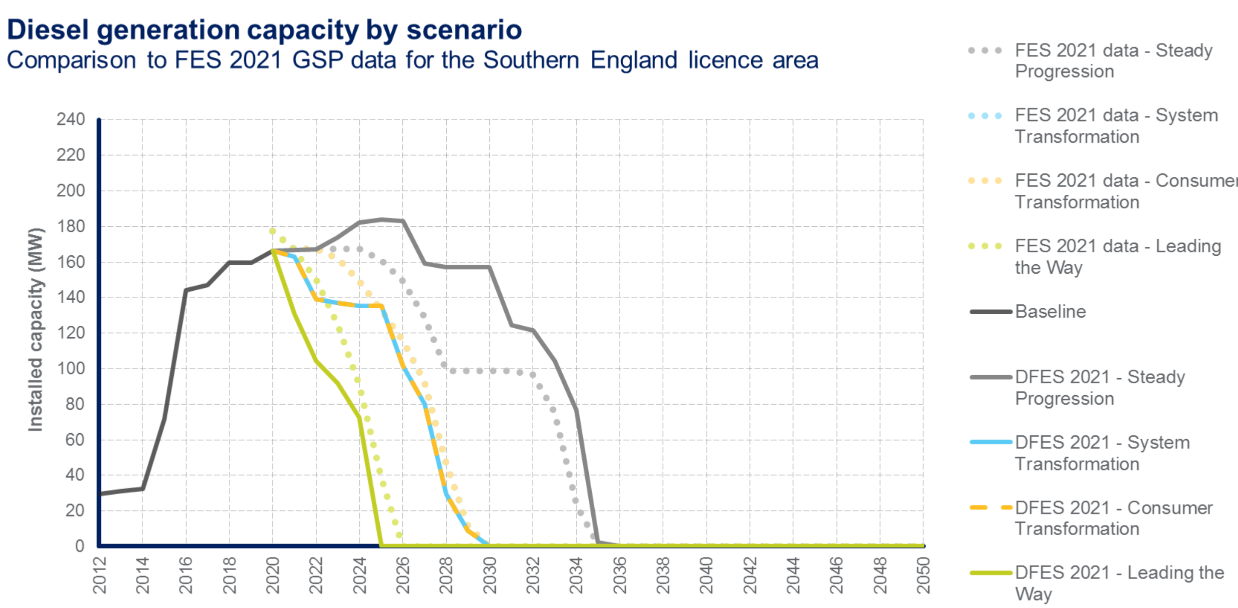


- There are 26 potential new diesel sites (89 MW) with an accepted connection offer.
- These are a mixture of four larger standalone diesel plants (69 MW) and 22 smaller new diesel back-up generators (20 MW). These smaller back-up sites are proposed to be located at various commercial premises, including water treatment works, leisure centres, supermarkets, hospitals and rail depots.
- Of these 26 sites, only four (24 MW) have secured planning approval. There is some doubt whether the remaining sites will apply for, or receive, planning.
- Diesel generators have a higher carbon intensity compared to other forms of peaking plant. They also emit higher levels of particulate emissions that impact local air quality. There is therefore a general assumption that continued use and development of diesel plants is inconsistent with the UK net zero and clean air targets.
- Regulation restricting the use of diesel generators such as the Medium Combustion Plant Directive (MCPD)[xxxiv] have already been implemented. This requires combustion plants to adhere to stringent air quality limits through securing environmental permits, unless a plant only operates for a few hours per year (i.e. back-up generators only).
- Unabated commercial diesel generation connected to the distribution network falls within this regulation and will therefore no longer be allowed to operate from 2025[xxxv] without exhaust abatement technologies (such as catalytic reduction technology). This type of companion technology is unlikely to be financially viable in the near term.
- Under the three net zero scenarios diesel generation begins to decommission across the early 2020s. No diesel capacity remains operational in the licence area by 2025 under **Leading the Way** and a reduced capacity (135 MW) remains operational under **Consumer Transformation** and **System Transformation**.
- Under **Steady Progression**, there is some short-term capacity increase. This consists of behind-the-meter diesel sites with accepted connection offers (22 sites, totalling 20 MW).

Medium and long term (2025 – 2050)

- In the medium to long term, the DFES analysis continues to model the decommissioning of diesel generators within the licence area.
- Between now and the mid-2030s, depending on the scenario, the model's decommissioning logic considers the following factors:
  - The type of diesel site (standalone or back-up)
  - The year it was installed
  - How each scenario reflects environmental permitting requirements under the MCPD and progress towards net zero targets
  - The potential for low-carbon diesel or biodiesel to enable back-up generators to operate for longer under some scenarios
- As a result of these factors, the remaining 135 MW of diesel capacity still online in 2025 under **Consumer Transformation** and **System Transformation** is modelled to disconnect from the network by 2030.
- Under **Steady Progression**, both operational baseline sites (166 MW) and new sites modelled to come online in the early 2020s (20 MW) continue to operate for longer. All capacity is modelled to disconnect from the network by 2035 under this scenario.
- Feedback from energy sector stakeholders suggested that back-up diesel generation could move to lower carbon alternatives, including long-duration battery storage and hydrogen fuel cells. This view was particularly prevalent amongst local authority and Government representatives.

Figure 35: Diesel generation projections for the Southern England licence area, compared to National Grid FES 2021 regional projections



Reconciliation with National Grid FES 2021:

The DFES projections have been reconciled (See Figure 35) with the FES 2021 data for the relevant GSPs within the Southern England licence area for building block technology Gen_BB005 (Non-renewable engines (diesel) (non CHP).

- The current installed capacity of diesel generation in the Southern England Licence area is c.11 MW lower in the SSEN DFES 2021 than in the FES 2021 GSP data. The reason for this is unclear, but could be related to the fuel classification of thermal generators.
- The DFES projections broadly align with the FES assumptions for diesel generation across the four scenarios, with all diesel capacity decommissioned by:
  - 2025 in **Leading the Way**
  - 2030 in **Consumer Transformation** and **System Transformation**
  - 2035 in **Steady Progression**

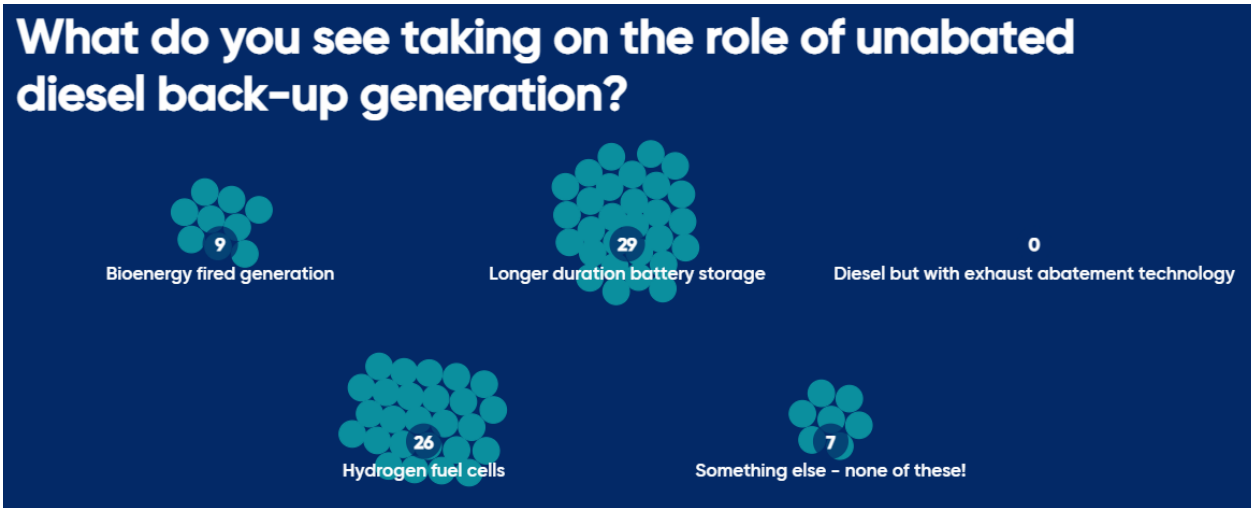
Factors that will affect deployment at a local level:

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.

Stakeholder feedback overview:

Diesel fuelled generation	
Stakeholder feedback provided	How this has influenced our analysis
A range of stakeholders were engaged through a dedicated Southern England DFES workshop in October 2021. Stakeholders were in agreement that unabated diesel fuelled generation would decommission from the distribution network. There were a range of views as to which technologies would take on the role of unabated diesel back-up generation. The alternative technologies that most stakeholders considered were long duration battery storage and hydrogen fuel cells.	The net zero scenarios have modelled rapid decommissioning of the existing baseline of diesel generation in the licence area. This results in no diesel capacity operating on the distribution network by 2025 in **Leading the Way** and by 2030 in **Consumer Transformation** and **System Transformation**. The location of existing diesel generators have been used to inform the geographical distribution modelling for the uptake of battery storage and hydrogen generation.

Figure 36: Stakeholder responses to diesel question in the online engagement webinar



References:

SSEN connection offer data, DNO Embedded Capacity Registers, Regen consultation with local stakeholders in the Southern Licence area and workshop with Isle of Wight stakeholders.

[xxxiv] European Commission, *The Medium Combustion Plant Directive.* https://ec.europa.eu/environment/industry/stationary/mcp.htm
[xxxv] See BEIS 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:

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

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

As well as natural gas, the analysis includes generators fuelled by gas oil.

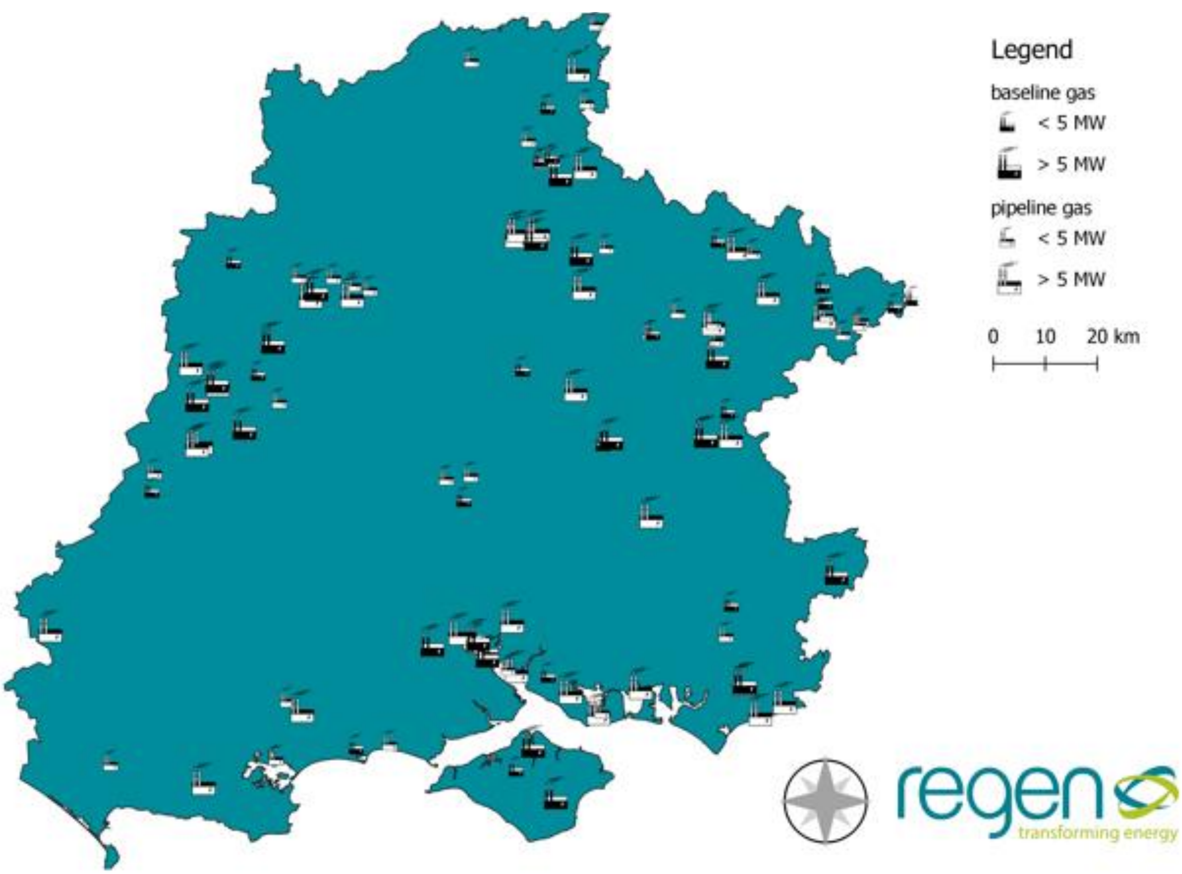
Data summary for gas fired generation in the Southern England licence area:

Installed power capacity (MW)		Baseline	2025	2030	2035	2040	2045	2050
CCGT	Steady Progression	--	--	--	--	--	--	--
	System Transformation		--	--	--	--	--	--
	Consumer Transformation		--	--	--	--	--	--
	Leading the Way		--	--	--	--	--	--
OCGT	Steady Progression	240	428	428	428	288	288	288
	System Transformation		240	100	0	0	0	0
	Consumer Transformation		240	100	0	0	0	0
	Leading the Way		240	100	0	0	0	0
Reciprocating engines	Steady Progression	135	322	484	534	534	528	399
	System Transformation		204	204	122	122	122	0
	Consumer Transformation		204	204	122	122	122	0
	Leading the Way		174	129	0	0	0	0
Gas CHPs	Steady Progression	99	204	231	224	224	186	133
	System Transformation		147	145	89	89	54	0
	Consumer Transformation		147	145	89	89	54	0
	Leading the Way		102	89	0	0	0	0

Overview of technology projections in the licence area:

- There is a significant baseline (474 MW) of operational fossil gas-fired generation connected to the distribution network in the Southern England licence area.
- This baseline ranges in scale, age and generation technology type, from large 30-year-old gas oil fuelled power stations, to smaller gas peaking plants and onsite gas CHPs brought online in 2020.
- In addition, there is a significant pipeline of potential new fossil gas generation sites in the licence area, made up of 62 sites totalling 589 MW. This pipeline includes:
  - A 132 MW OCGT plant in Maidenhead and a 56 MW OCGT plant in Slough
  - 33 reciprocating engine sites totalling 248 MW
  - 27 gas CHPs totalling 151 MW
- Those sites that have secured planning approval, and/or been active in the recent Capacity Market auctions, have been modelled to come online in the near-term.
- Under the three net zero scenarios, all technology types of fossil gas generation see a large decrease in capacity in the medium term and are fully decommissioned by 2050.
- Under **Steady Progression**, all technology types see a moderate increase in connected capacity in the medium-term and have capacity still in operation in 2050.
- The primary role of distribution-scale gas-fired generation is to provide flexibility and back-up services to the electricity system. While capacity may be seen to remain constant or increase some scenarios, the annual operating hours and energy output decreases significantly by 2050 in all scenarios as the electricity system is decarbonised.

Figure 37: baseline and pipeline gas sites in Southern England



- In practice gas generation capacity may be transferred to new low carbon generation technologies such as hydrogen, battery storage or biomethane generation, or enabled with carbon capture.
- At a national level, some scenarios include hydrogen generation becoming a potentially viable source of supply-side flexibility after 2030. This results in some existing fossil gas generation sites 'repowering' to become hydrogen fuelled generation sites out to 2050.
- Hydrogen fuelled generation scenario analysis and results are outlined in a separate technology summary sheet.

Scenario projection analysis and assumptions:

Baseline (up to end of 2020)

- There are 42 operational fossil gas generation sites in the Southern England licence area, totalling 474 MW.
- This is broken down into the following fossil gas technologies:
    - 2 OCGT sites totalling 240 MW.
    - 13 gas reciprocating engine sites totalling 135 MW.
    - 27 gas CHPs totalling 99 MW.
- There are no operational CCGT sites connected to the distribution network in the Southern England licence area.

Near term (2020 – 2025)

OCGT:

- The existing OCGT sites are modelled to decommission in the late 2020s or early-to-mid 2030s under the three net zero scenarios. This reflects a rapid move away from fossil-fuel generation technologies that have historically provided baseload generation.
- Under **Steady Progression** these sites remain online, reflecting a longer-term use of fossil fuel generation and minimal action to address the carbon intensity of grid electricity. In addition to this, the two pipeline OCGT sites (totalling 188 MW) are modelled to connect in the mid-2020s under **Steady Progression**.
- Under **Steady Progression**, OCGT capacity therefore grows to 428 MW.
- By 2025 under the **Leading the Way**, **Consumer Transformation** and **System Transformation** scenarios, the existing OCGT baseline capacity remains online.

Gas reciprocating engines and gas CHPs:

- There are 34 **gas reciprocating engine** sites and 26 **gas CHPs** with an accepted connection offer in the Southern England licence area, collectively totalling 402 MW.
- Of this pipeline:
    - 14 sites (78 MW) have received planning approval in the last 3-5 years.
    - 7 sites (59 MW) have secured Capacity Agreements in recent Capacity Market auctions – for a range of delivery years (2021 – 2024).
    - 3 sites (59 MW) prequalified for recent T-4 Capacity Market auctions but did not go on to secure a Capacity Agreement.
    - A planning application for a 16 MW reciprocating engine site in Yeovil was withdrawn in 2018. Another planning application for a 7.5 MW gas CHP site in Swindon was rejected in June 2019.
    - 7 sites (70 MW) were either rejected or did not prequalify for recent T-4 Capacity Market auctions.
    - The remaining 38 sites (207 MW) are either too small to apply for planning or the Capacity Market, or no development information could be found.

- Gas reciprocating engines are a source of flexible, dispatchable generation that can provide a range of services to the network. As a fossil fuel however, the carbon intensity of this technology will require a longer-term reduction in capacity, or replacement by alternative low carbon technologies, in a net zero energy system.
- It is unlikely that exhaust abatement technology[xxxvi] would be a cost-effective measure for distribution network scale assets and therefore the DFES modelling has focused on the decommissioning (or repowering as another technology) of fossil gas generation sites.
- As a result, in both the near and medium-term, the speed of switching to lower carbon sources of flexibility has been applied as a variable factor across the four scenarios.
- Similarly, gas CHPs are a source of dispatchable onsite power and heat for occupied or industrial buildings. Whilst a fossil fuel, they are nominally lower carbon than, for example, onsite diesel generators or other combustible solid fuels. Therefore, a number of gas CHPs may continue to connect and remain operational in the near-term.
- The individual project development evidence of pipeline sites under both technologies was used to determine the near-term connected capacity across the four scenarios. By 2025 fossil gas generation capacity in the Southern England licence area increases in all scenarios, to a varying degree.
- Under **Leading the Way**, only sites with both positive planning and Capacity Market development evidence are modelled to connect, based on Capacity Market delivery years. By 2025 under this scenario, reciprocating engine capacity reaches 174 MW and gas CHP capacity reaches 102 MW.
- Under **Consumer Transformation** and **System Transformation**, sites with either positive planning or Capacity Market development evidence are modelled to connect. By 2025 under these scenarios, reciprocating engine capacity reaches 204 MW and gas CHP capacity reaches 147 MW.
- Under **Steady Progression**, only sites that have been withdrawn/rejected in planning or rejected/not prequalified in Capacity Market auctions are not modelled to connect. Any remaining site capacity is modelled to come online, based on a short delay from the year that the developer accepted their connection offers. By 2025 under this scenario:
    - Reciprocating engine capacity reaches 322 MW
    - Gas CHP capacity reaches 204 MW.

Medium term (2025 – 2035)

OCGT:

- In the medium-term, gas-turbine technology is assumed to be unable to compete in flexibility markets with faster-responding technologies, such as battery storage and gas engines. Therefore, under the **Leading the Way**, **Consumer Transformation** and **System Transformation** scenarios, all OCGT capacity is assumed to be decommissioned by 2035.
- Under **Steady Progression**, OCGT continues to play a significant role in supporting the wider energy system. Connected OCGT capacity therefore remains at 428 MW in the licence area in 2035.

Gas reciprocating engines:

- Under **Leading the Way**, a more rapid transition to low-carbon sources of flexibility is reflected. Therefore, all gas reciprocating engine capacity is modelled to disconnect from the distribution network in the licence area by 2035.
- Under **Consumer Transformation** and **System Transformation**, a moderately slower transition to low-carbon flexibility is reflected. Therefore, reciprocating engine capacity

reduces from 204 MW to 122 MW by 2035.

- Under **Steady Progression**, the value of gas peaking plants as a source of flexibility remains high in the medium term. Capacity, therefore, grows to 534 MW by 2035.

Gas CHPs:

- Under **Leading the Way**, a transition to low-carbon sources of smaller-scale onsite power and heat is reflected. Therefore, all gas CHP capacity is modelled to disconnect from the distribution network in licence area by 2035.
- Under **Consumer Transformation** and **System Transformation**, gas CHPs continue to provide heat and power to buildings in the medium term. Therefore, only older gas CHPs are modelled to disconnect, and overall capacity moderately reduces to 89 MW by 2035.

Long term (2035 – 2050)

Gas reciprocating engines:

- The transition to low-carbon sources of flexibility sees all gas reciprocating engine capacity disconnect from the distribution network in the licence area by 2050 under both **Consumer Transformation** and **System Transformation**.
- Under **Steady Progression**, older baseline reciprocating engine sites are assumed to not be repowered and resultantly connected capacity reduces to 399 MW by 2050.

Gas CHPs:

- Similarly, a transition away from high-carbon sources of small-scale onsite power and heat sees a significant reduction in gas CHP generation connected to the distribution network, with all capacity disconnecting by 2048 under both **Consumer Transformation** and **System Transformation**.
- Under **Steady Progression**, older gas CHP sites are modelled to not be replaced and resultantly, connected capacity reduces to 133 MW by 2050.

Figure 38: Open Cycle Gas Turbine (OCGT) projections for the Southern England licence area, compared to National Grid FES 2021 regional projections

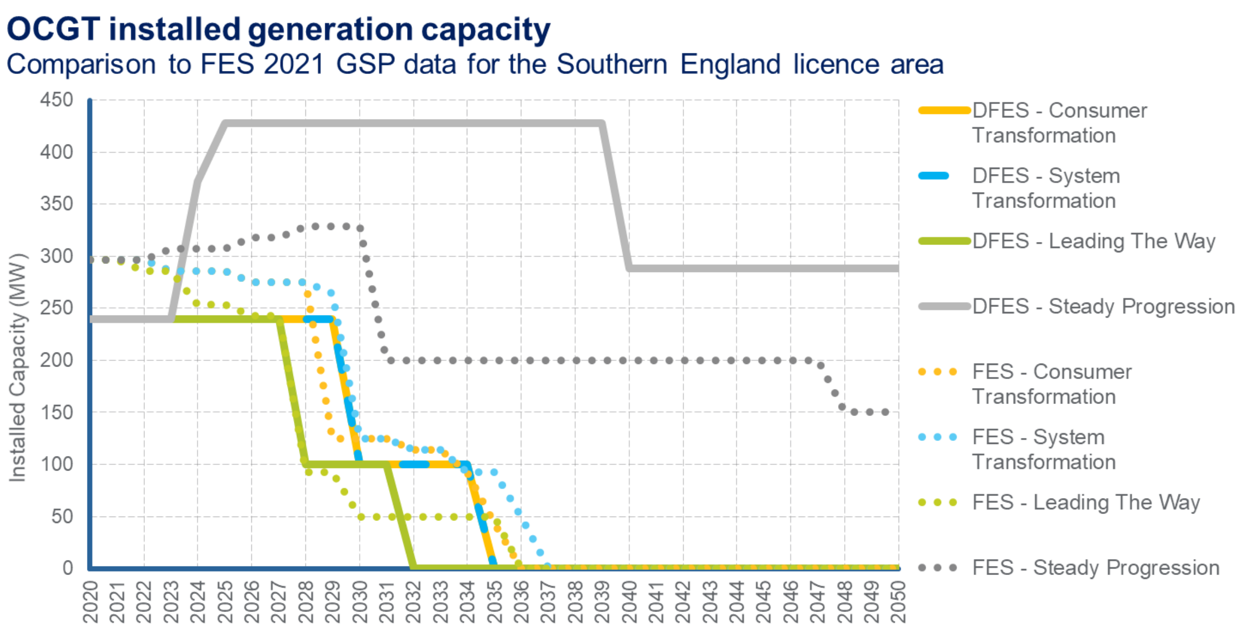


Figure 39: Fossil gas reciprocating engine projections for the Southern England licence area, compared to National Grid FES 2021 regional projections

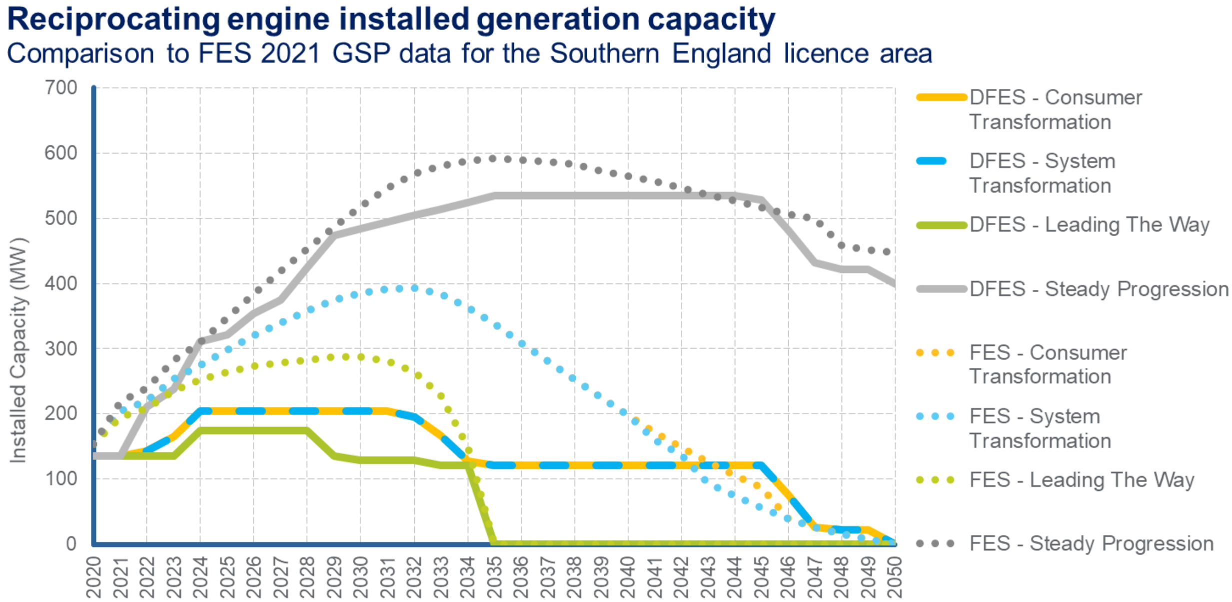
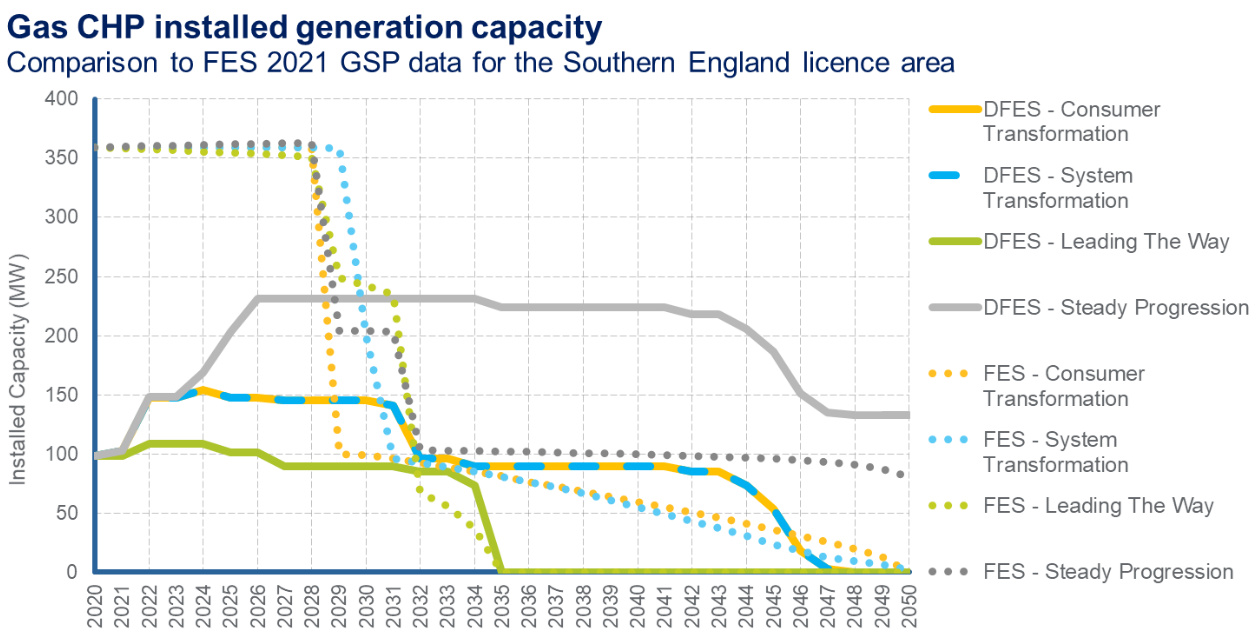


Figure 40: Fossil gas CHP projections for the Southern England licence area, compared to National Grid FES 2021 regional projections



Reconciliation with National Grid FES 2021:

DFES 21 projections have been reconciled to the FES 2021 data for the relevant GSPs within the Southern England licence area for the equivalent fossil gas FES building block technologies.

OCGT – [Building block Gen_BB008]

- The current baseline of OCGT capacity in the Southern England Licence area is 57 MW lower in the SSEN DFES 2021 than in the FES 2021 GSP data. The reason for this variance is unclear but may relate to fossil fuel sub-technologies and fuel types.
- The DFES projections broadly align with the FES 2021 projections across the four scenarios. However, under **Steady Progression**, two large-scale pipeline OCGT sites have been modelled to connect, taking the DFES projected capacity c.150MW above the FES 2021 regional projections across the 2020s and 2030s.
- All OCGT capacity is modelled to disconnect from the distribution network a few years earlier in the DFES under **Leading the Way**, due to the decommissioning of older OCGT baseline sites sooner than is reflected in the FES 2021.
- Under **Consumer Transformation** and **System Transformation**, all OCGT capacity is modelled to disconnect from the network by the mid-2030s.
- Under **Steady Progression**, the DFES has 138 MW additional OCGT capacity assumed to remain online by 2050 than in the FES 2021. This is due to large pipeline OCGT sites that the DFES has modelled to come online under this scenario, remaining operational.

Gas reciprocating engines – [Building block Gen_BB006]

- The current installed capacity of gas reciprocating engines in the licence area is only 2 MW higher in the DFES than in the FES 2021 GSP data. This very small variance is likely due to the classification of an individual site or handful of smaller sites.
- Under **Steady Progression**, the DFES projections align well with the FES 2021 GSP data, showing a near-term increase in connected capacity, levelling off in the 2030s and a moderate reduction in capacity between 2035 and 2050.
- Under **Leading the Way**, **Consumer Transformation** and **System Transformation** the DFES projections see fewer new reciprocating engine sites connecting in the 2020s than seen in the FES 2021 GSP data. This lower near-term increase in connected capacity in these scenarios is based on only a few known pipeline sites securing planning approval and/or capacity agreements under the Capacity Market.
- Beyond the pipeline, under these scenarios the DFES and FES 2021 align well in the medium-term and long-term, with all reciprocating engine capacity disconnecting from the network by 2035 under **Leading the Way** and by 2050 in **Consumer Transformation** and **System Transformation**.

Factors that will affect deployment at a local level:

- The DFES analysis for fossil gas generation focuses predominantly on known baseline and pipeline sites to identify where capacity could increase in the near-term, and where capacity will reduce in the medium and long term.
- Therefore, the spatial distribution entirely references known site locations.

Stakeholder feedback overview:

Fossil gas fuelled generation	
Stakeholder feedback provided	How this has influenced our analysis
A range of stakeholders were engaged through a dedicated Southern England DFES workshop in October 2021. Stakeholders felt that gas-fired generation will continue to see deployment in the licence area until the mid-2030s. Some energy project developers that were engaged were more aligned to there being a surge of interest to connect new gas generation projects in the 2020s, followed by a steady decline from 2030-2040. Cowes OCGT power station on the Isle of Wight was discussed with representatives from the island. Stakeholders advised that the has a very low capacity factor and Future operation of the site is unclear. Though it was identified that the operators (RWE) are diversifying their operation behind the meter with battery storage, a shunt reactor for Black Start services and a diesel generator.	The net zero scenarios have modelled a range of decommissioning of the existing baseline of gas generation capacity. This results in no gas generation capacity operating on the distribution network by 2025 in **Leading the Way** and by 2030/40 (depending on the gas sub-technology) in **Consumer Transformation** and **System Transformation**. The uncertainty around the future operation of Cowes OCGT site (140 MW) was reflected in a range of decommissioning years in the scenarios. This site was modelled to disconnected in 2028 in **Leading the Way**, by 2030 in **Consumer Transformation** and **System Transformation**, and by 2040 in **Steady Progression**.

Figure 41: Stakeholder responses to fossil gas question in the online engagement webinar

References:

SSEN connection offer data, DNO Embedded Capacity Registers, Regen consultation with local stakeholders in the Southern Licence area and workshop with Isle of Wight stakeholders.

[xxxvi] See summary of exhaust abatement systems: https://www.ebara.co.jp/en/precision/index/gas-abatement.html

Hydrogen fuelled electricity generation

Summary of modelling assumptions and results

Technology specification:

This analysis covers Hydrogen fuelled electricity generation, which has been modelled to connect to the distribution network in areas where there is the potential for hydrogen supply. The focus of the analysis has been to consider the conversion of existing fossil fuel peaking plants to low carbon hydrogen[xxxvii]. This analysis is therefore closely linked to the DFES analysis undertaken for fossil fuel generation, including the use of gas and diesel generators.

Larger scale, new, hydrogen turbines could also be developed. However, in the absence of a firm pipeline, it is assumed that these generation plants will connect mainly to the transmission network. This assumption will be reviewed in future DFES studies.

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

Note: hydrogen production, via electrolysis, has been modelled separately.

Data summary for Hydrogen fuelled generation in the Southern England licence area:

Installed capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	0	0	0	0	0	0	0
System Transformation		0	9	25	290	565	577
Consumer Transformation		0	9	46	165	169	208
Leading the Way		0	45	298	606	708	921

Overview of technology projections in the licence area:

- The analysis of this technology considers the potential for existing fossil fuel generation sites (fossil gas and diesel) to repower their thermal generation assets to run on low carbon hydrogen.
- The conversion of these sites has been modelled in the DFES to occur in areas of the Southern England licence area where hydrogen supply zones could be developed.
- Hydrogen supply zones have been identified, in phases, through consideration of:
    - The conversion of existing gas network infrastructure
    - Hydrogen development hubs around heavy transport areas or industrial clusters such as West London, Swindon, Oxford, East Bristol and Reading
    - Ports/marine engineering areas such as Southampton or Portsmouth
    - Existing fossil fuel generation on the Isle of Wight.
- Already a number of turbine manufacturers, including Siemens and GE, are offering hybrid hydrogen/methane turbines, and have committed to providing 100% hydrogen plants in the near future[xxxviii].
- A key advantage of Hydrogen fuelled electricity generation is the potential to manufacture hydrogen during periods of high renewable generation (when electricity

prices may be very low) and then store and use that hydrogen to generate electricity during periods when electricity prices are very high. This model could be applied, at a local and national level, to provide a source of system balancing and energy security.
- However, while the UK government has announced a target to reach 5 GW of hydrogen production capacity by 2030, it is not yet clear if, and when, hydrogen may begin to displace fossil fuel generation.
- Apart from demonstration and trial projects, the industry consensus, which is reflected in the FES 2021 scenarios, is that hydrogen for electricity peaking plant generation is unlikely to feature as a significant technology until the late 2020s and 2030s. The key considerations behind this assumption include the supply and cost of hydrogen, competing (higher value) uses for hydrogen supply, the availability of compatible turbines, the need for regulatory changes, the underlying carbon price and the availability of subsidy support. Fossil fuel generators may also choose an alternative decarbonisation route such as carbon capture and storage, or biomethane.
- Given this uncertainty, the scale and timing of conversion to Hydrogen fuelled generation in the DFES 2021 analysis varies widely by scenario. This approach also mirrors the wide range of projections for Hydrogen fuelled generation in the FES 2021.
- In terms of conversion potential, the Southern England licence area has 651 MW of existing operational fossil fuel generation capacity (495 MW fossil gas and 156 MW diesel).
- In addition to existing sites, the licence area has a fossil fuel generation pipeline of 689 MW (589 MW fossil gas and 89 MW diesel). This presents a strong potential for the growth in connected capacity of Hydrogen fuelled generation across the 2030s and 2040s.
- By 2050, Hydrogen fuelled generation capacity ranges from zero under **Steady Progression** to c.1 GW under the **Leading the Way** scenario.

Scenario projection analysis and assumptions:

Baseline (up to end of 2020)

- There is no Hydrogen fuelled generation currently operating in the UK.

Near term (2020 – 2025)

- It is expected that low carbon hydrogen production will increase in response to the UK government's target of 5 GW production capacity by 2030.
- There is; however, no visible pipeline of distribution connected Hydrogen fuelled electricity generation projects. Note: pipeline projects may exist but not have applied for a network connection if their plans are to use existing network connection capacity.
- Apart from demonstration and trial projects, it is unlikely that fossil fuel plants will convert to hydrogen in the near term. This is due to a variety of factors including hydrogen turbine supply, hydrogen fuel supply and the regulatory changes that would be required. The cost of hydrogen fuel, absence of a subsidy framework and competing uses of available hydrogen for other, higher-value, applications are also important factors.
- In line with the FES 2021, no Hydrogen fuelled generation has been modelled to connect to the distribution network in any scenario by 2025. This will be reviewed in future DFES studies.

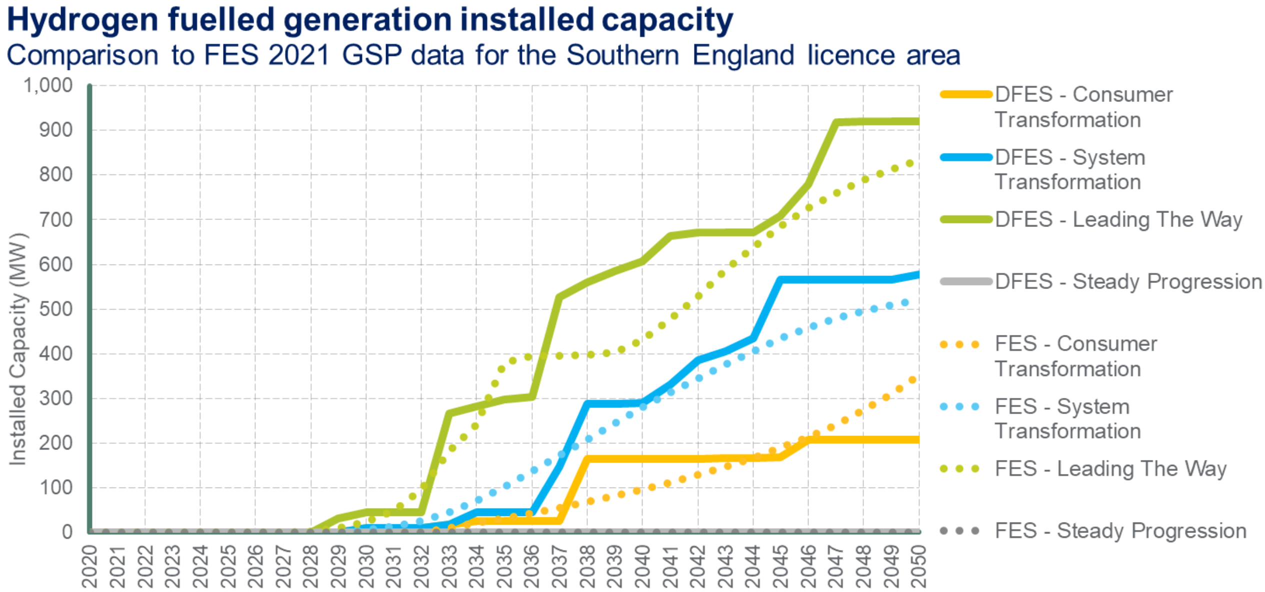
Medium term (2025 – 2035)

- With the growth of hydrogen production it is likely that a proportion of fossil fuel generators will convert to low carbon solutions including hydrogen.
- Conversion will likely begin for generation assets within industrial clusters and in areas with high renewables and potential for hydrogen electrolysis.
- Areas that have high levels of renewable generation to meet ambitious net zero targets, but may be grid constrained, such as the Isle of Wight, could also be amongst the first to deploy hydrogen electrolysis and convert to Hydrogen fuelled generation technology.
- From 2030, further growth in low carbon hydrogen production capacity, and rising carbon prices, could incentivise more site operators to convert their assets to run on hydrogen in the medium term.
- In the Southern England licence area, some of the key areas that could see hydrogen development might include Swindon[xxxix], Portsmouth[xl], Oxford[xli] and the Isle of Wight.
- The SSEN DFES has modelled the conversion of a range of existing and pipeline fossil fuel generation sites located in identified hydrogen supply zones.
- The highest development of Hydrogen fuelled generation is seen under the **Leading the Way**, with connected capacity reaching 298 MW by 2035.
- Fewer fossil fuel generation sites are modelled to convert under **Consumer Transformation** and **System Transformation**, with capacity reaching 46 MW and 26 MW respectively by 2035.
- Due to the slow decarbonisation of electricity supply and integration of flexibility systems in **Steady Progression**, fossil fuel generation continues to operate in the medium and long term. Therefore, no Hydrogen fuelled generation capacity has been modelled to connect in this scenario.

Long term (2035 – 2050)

- Under the three net zero scenarios, and assuming hydrogen becomes a significant net zero fuel, it is likely that hydrogen will play a role in electricity generation.
- Depending on the ultimate cost of hydrogen and the future carbon price, Hydrogen fuelled generation is likely to be limited to backup and peaking plant functions, for security of supply and to balance variable renewable generation during periods of very high electricity prices.
- In DFES 2021, this has been modelled by including additional areas for hydrogen conversion under the **Leading the Way** and **System Transformation** scenarios out to 2050.
- Under **Leading the Way**, medium-scale fossil fuel generation sites (< 50 MW) in these supply zones were modelled to repower as Hydrogen fuelled generators with 50% more capacity. This represents the most ambitious scenario for Hydrogen fuelled generation on the distribution network.
- Under **System Transformation**, it is assumed that a proportion of sites currently on the distribution network repower at the same capacity. A significant amount of Hydrogen fuelled generation capacity is also expected on the transmission network in this scenario.
- By 2050, Hydrogen fuelled generation capacity on the distribution network reaches:
  - 921 MW under **Leading the Way**
  - 577 MW under **System Transformation**
  - 208 MW under **Consumer Transformation**
  - No hydrogen generation has been modelled under **Steady Progression**.

Figure 42: Hydrogen fuelled generation projections for the Southern England licence area, compared to National Grid FES 2021 regional projections



Reconciliation with National Grid FES 2021:

The DFES 2021 has been reconciled to the FES 2021 data for the relevant GSPs within the Southern England licence area for technology building block Gen_BB023.

- There is no baseline of Hydrogen fuelled generation in either the DFES 2021 or FES 2021
- Both DFES and FES do not model any Hydrogen fuelled generation deployment until the late 2020s. This will be reviewed in future DFES studies.
- The SSEN DFES 2021 projections broadly align with the FES 2021 GSP projections across the four scenarios in the near term, with Hydrogen fuelled generation capacity only beginning to connect to the distribution network from the late 2020s/early 2030s.
- There is no capacity modelled to connect under **Steady Progression** in either the DFES or FES 2021.
- Under the three net zero scenarios, the DFES and FES 2021 projections are aligned between 2030 and 2045.
- From 2045 to 2050, the DFES has modelled more capacity connecting than the FES 2021 GSP data. This reflects the conversion of known fossil fuel generation sites under **Leading the Way** and **System Transformation**.
- It should be noted that, for both DFES and FES projections, there is a high degree of uncertainty regarding the potential role that Hydrogen fuelled generation will play.

Factors that will affect deployment at a local level:

- To model the connection of Hydrogen fuelled generation in the 2030s and 2040s, a spatial analysis of potential hydrogen supply areas was completed and compared to commercial baseline and pipeline fossil fuel generation sites.
- The identification of these hydrogen supply areas considered the location of:
    - existing hydrogen trials
    - large industrial clusters
    - proximity to the gas network
    - proximity to major roads and motorways
    - potential hydrogen storage facilities.
- The location of projected Hydrogen fuelled generation sites is based on the location of existing and fossil fuel generation sites.
- Engagement with National Grid ESO identified that most of the dedicated hydrogen generation will be new build, albeit located at existing sites.

References:

SSEN connection offer data, Regen consultation with local stakeholders in the Southern England licence area, including Isle of Wight stakeholders.

[xxxvii] The standards for low carbon hydrogen are the subject of consultation but are assumed to include hydrogen that is manufactured via electrolysis (using renewable electricity as the input electricity) and via methane reformation (using an efficient CCUS process).

[xxxviii] GE Hydrogen Turbines and Siemens Hydrogen Turbines

[xxxix] See *Swindon Hydrogen Hub*: https://www.hydrogenhub.org/locally/

[xl] See green hydrogen energy maritime competition win for Portsmouth International Port: https://www.port.ac.uk/news-events-and-blogs/news/portsmouth-project-among-winners-of-the-uks-biggest-clean-maritime-competition

[xli] See *Oxfordshire Hydrogen Hub*: https://www.hydrogenhub.org/2018/03/16/launch-oxfordshire-hydrogen-hub/

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 other generation in the South of England licence area:

Installed power capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
All Scenarios	1.0	10.9	10.9	10.9	10.9	10.9	10.9

Overview of technology projections in the licence area:

- There are eight sites of unidentified generation technology in the South of England Licence area totalling c. 1 MW of installed capacity. This is a significant decrease since DFES 2020 (15.4 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 120 kW, these sites are predominantly micro CHP plants within hotels, small businesses and recreational centres; however, the fuel type is uncertain, hence these sites cannot be allocated a technology. The largest site is 211 kW.
- Three sites have been assumed to have connected in 2021, as per their anticipated date of connection, and have been included in the baseline.
- A further 9.9 MW is expected to connect by 2023, the largest of which is a 7 MW CHP plant of unknown fuel type, located near Chichester.
- Other generation is not projected beyond the baseline and pipeline, and there is no variance between the scenarios for this technology.

Factors that will affect deployment at a local level:

- Distribution is entirely based on the location of baseline and pipeline sites as referenced in the SSEN connections database.

References:

SSEN connection offer data, developer outreach, various news articles and project pages, Grid Reference Finder, Renewable Energy Planning Database

Battery storage

Summary of modelling assumptions and results

Technology specification:

Battery-based storage projects (solid-state and flow-state) connected to the distribution network in the Southern England licence area, covering four business models:

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

These 3 business models or asset classes combine to align to technology building block: **Batteries Srg_BB001**

4. **Domestic batteries –** typically 5-20 kW scale batteries that households buy to operate alongside domestic-scale rooftop PV or to provide backup services to the home.

This business model aligns to technology building block: **Domestic Batteries(G98) Srg_BB002**

Data summary for battery storage in the Southern England licence area:

Installed power capacity (MW)		Baseline	2025	2030	2035	2040	2045	2050
Standalone network services	Steady Progression	100	396	778	855	941	988	998
	System Transformation		671	777	933	1026	1077	1099
	Consumer Transformation		967	991	1015	1066	1120	1142
	Leading the Way		1129	1157	1185	1244	1307	1333
Generation co-location	Steady Progression	12	12	40	54	59	70	83
	System Transformation		12	56	77	86	115	124
	Consumer Transformation		38	73	81	129	138	146
	Leading the Way		98	161	178	219	231	234
Behind-the-meter high energy user	Steady Progression	1.4	21	39	41	43	44	47
	System Transformation		37	58	64	68	71	75
	Consumer Transformation		67	83	90	147	153	166
	Leading the Way		99	126	137	147	153	166
Domestic batteries	Steady Progression	0	2	7	13	15	38	84
	System Transformation		1	33	47	62	150	177
	Consumer Transformation		6	94	161	263	433	771
	Leading the Way		16	128	216	348	570	1012

Overview of technology projections in the licence area:

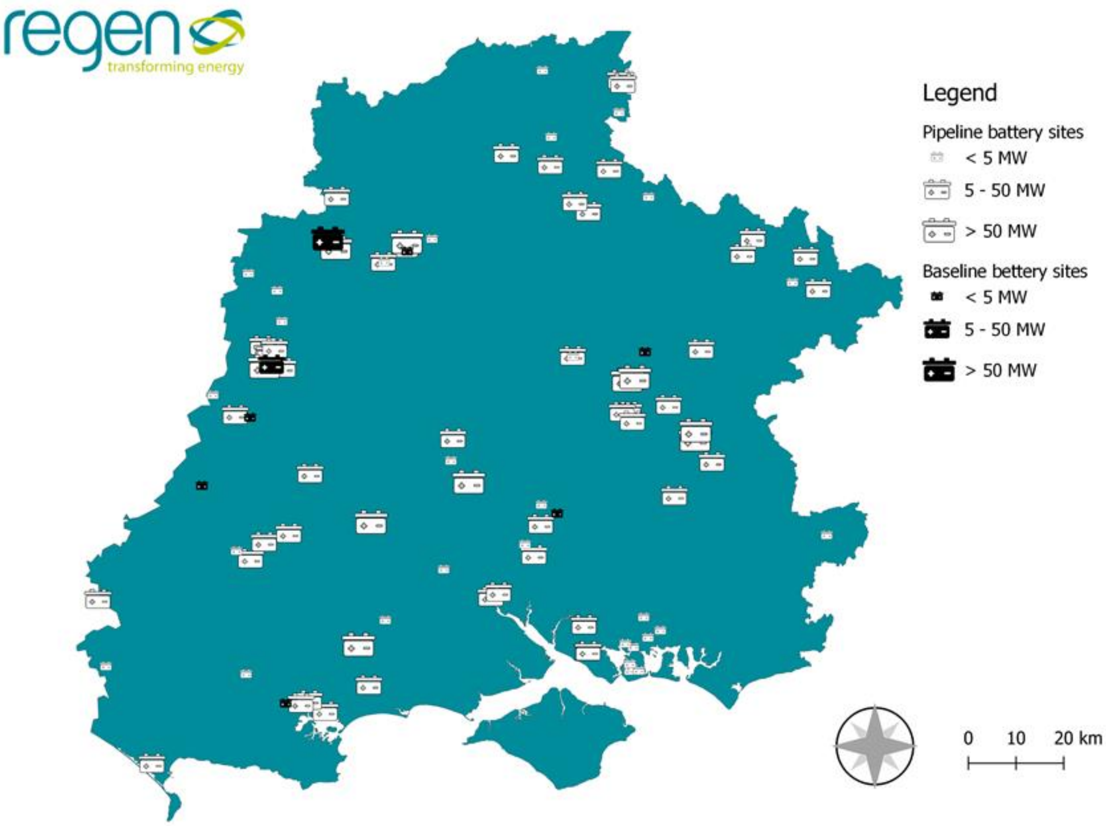
- The Southern England licence area has very strong potential for long term growth in connected storage capacity. This is due to:
  - Amongst the best solar irradiance in the UK and thus strong potential for significant battery storage co-location
  - A significant number of properties and solar resource for domestic rooftop PV could see a high number of domestic battery installations under some scenarios
  - A high number of commercial and industrial premises with the potential for behind-the-meter batteries (including industrial areas such Oxford, Reading and Swindon, and ports areas such as Southampton, Bournemouth and Portsmouth).
  - There are also a high number of data centres in development in the region which will likely be associated with 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.
- There is 113 MW of battery storage connected to the distribution network in the Southern England licence area (to the end of 2020). This includes the first phase (100 MW) of a 150 MW Stonehill battery project being developed at Minety in Wiltshire. This is currently one of the largest battery projects in Europe.
- Across 2021 a further 140 MW of standalone battery capacity (3 projects) are under construction in 2021. This includes a 50 MW extension to the Stonehill Minety battery.
- Looking ahead, there is very large pipeline (amongst the highest in the UK) of potential new battery projects, 98 sites totalling a little over 2.4 GW.
- Of this significant known pipeline, a number have secured planning approval, others have positive bid activity in recent Capacity Market auctions.
- Through engagement with project developers, a number of projects have also been confirmed as very likely to progress to construction in the early-to-mid 2020s.
- As a result, a high number of battery projects have been modelled to come online in the near-term in **Leading the Way** and **Consumer Transformation**.
- Overall battery storage across the four business models in 2050 in the Southern England licence area ranges from 1.2 GW in **Steady Progression** to 2.8 GW in **Leading the Way**.

Scenario projection analysis and assumptions:

Baseline (up to end of 2020)

- There are 8 operational batteries connected to the distribution network in the Southern England licence area, totalling 113 MW, this includes:
  - Phase 1 (100 MW) of a large standalone battery storage asset (150 MW) being developed in Minety in Wiltshire. This is operated by IDNO Eclipse Power
  - A 112 kW standalone battery located just outside Winchester
  - A 10 MW battery co-located with a diesel generator in Melksham
  - 4 batteries co-located with solar farms totalling 1.7 MW, located in in Slepe[xlii], Grazeley Green, Hawkeridge and Frome
  - A 1.4 MW battery located at retail store in Swindon.

Figure 43: Battery baseline and pipeline sites



Near term (2020 – 2025)

- The licence area has a very large pipeline of potential new battery storage projects:
  - 79 sites (totalling 1.6 GW) have an accepted connection offer
  - 20 sites (totalling 740 MW) have connection quotes issued but not yet accepted
  - This includes 8 sites that are individually 100 MW or greater in power capacity.
- This pipeline is a mixture of battery storage business models:
  - Most are large-scale standalone battery projects, 60 sites totalling 2.2 GW
  - A moderate amount of batteries co-locating with solar, 26 sites totalling 198 MW
  - A few smaller-scale batteries located onsite at high energy user premises such as farms, a cricket club, a prison and an airfield – 8 sites totalling 21 MW
  - A few domestic batteries – 5 sites totalling 50 kW (the full domestic pipeline is not fully captured in current connection data).
- The remaining 50 MW capacity of the Stonehill Minety Battery[xliii] is targeted to commission in 2021 (current operational capacity stands at 100 MW). This has therefore been modelled to connect in all scenarios in 2021.
- A further 248 MW of standalone battery capacity (3 projects) were found to be under construction in Southampton (50 MW) and High Wycombe (40 MW).
- Through engagement with developers and analysis of each of the remaining pipeline projects in planning and Capacity Market registers suggests:
  - Developers have advised that 8 projects (totalling 591 MW) will be progressed and operational by 2023-2024
  - 25 projects (632 MW) have recently secured planning approval
  - 4 projects (60 MW) have secured Capacity Agreements in recent Capacity Market auctions

- A further 12 projects (344 MW) successfully pre-qualified in recent Capacity Market auctions
    - 4 projects (71 MW) had their planning applications rejected and a further 2 projects (73 MW) were unsuccessful in recent Capacity Market auctions
    - The remaining 58 sites (1.3 GW) were either too small to require planning approval, or no development information could be found.
- The recent planning evidence and Capacity Market activity of the pipeline sites are key weighting factors that determine when battery storage capacity is modelled to connect under the four scenarios.
- By 2025, battery storage capacity connected to the distribution network in the Southern England licence area is highest (1.1 GW) under **Leading the Way** and lowest (396 MW) under **Steady Progression**. The range of capacity that is seen across the scenarios reflects the level of uncertainty of potentially speculative battery storage capacity that may or may not be progressed to construction.

Medium term (2025 – 2035)

- Across the late 2020s and early 2030s a proportion of the pipeline projects that have limited development evidence are assumed to connect under both **Leading the Way** and **Consumer Transformation**.
- The characteristics of the licence area influences the development of new battery projects in a different way for each of the four business models:

Standalone network services	The very large pipeline of large-scale (>50 MW) standalone projects, targeting land enabling easily accessible, cost-effective network connection points. This includes, notably, land adjacent to the 400 kV transmission network substation in Minety, northwest of Swindon, where a number of large-scale batteries are seeking to connect. By 2035 standalone battery capacity resultantly reaches 1 GW under **Consumer Transformation** and c.1.2 GW under **Leading the Way**.
Generation co-location	Significant capacity of large-scale solar generation is projected to connect to the distribution network in all scenarios. This is most significant in **Leading the Way** with 5.2 GW modelled to connect by 2035. The potential for co-located battery storage under this scenario is notable, reaching 178 MW by 2035.
Behind-the-meter high energy user	There are over 100,000 commercial and industrial properties that could potentially host behind-the-meter battery storage assets in the licence area. This includes a number of retail, military, port/marine and logistic premises. As a result, by 2035 high energy user battery capacity ranges from 41 MW under **Steady Progression** to 137 MW under **Leading the Way**.
Domestic batteries	The licence area also has over 1.6 million domestic properties, and with strong potential for domestic rooftop PV there is a potentially significant opportunity for domestic battery storage under **Consumer Transformation** and **Leading the Way**. By 2035, total domestic battery storage capacity reaches 227 MW (equivalent to 45,000 homes) under **Leading the Way** and 13 MW (equivalent to c.2,600 homes) under **Steady Progression**.

Long term (2035 – 2050)

- Although there is a range of projections, the total connected capacity of battery storage increases across all four scenarios out to 2050.
- The highest increase in overall connected capacity is seen under **Leading the Way** with all four business models seeing notable further deployment out to 2050. Total battery storage capacity reaches 2.8 GW by 2050 in this scenario.
- The lowest increase and overall connected capacity is seen under **Steady Progression**. With a moderate increase in standalone and generation co-location projects and a minimal adoption of domestic and high energy user batteries, with other methods of flexibility in homes and businesses favoured under this scenario. Total battery storage capacity reaches just under 1.2 GW by 2050 in this scenario.

Figure 44: Large-scale battery storage projections for the Southern England licence area, compared to National Grid FES 2021 regional projections

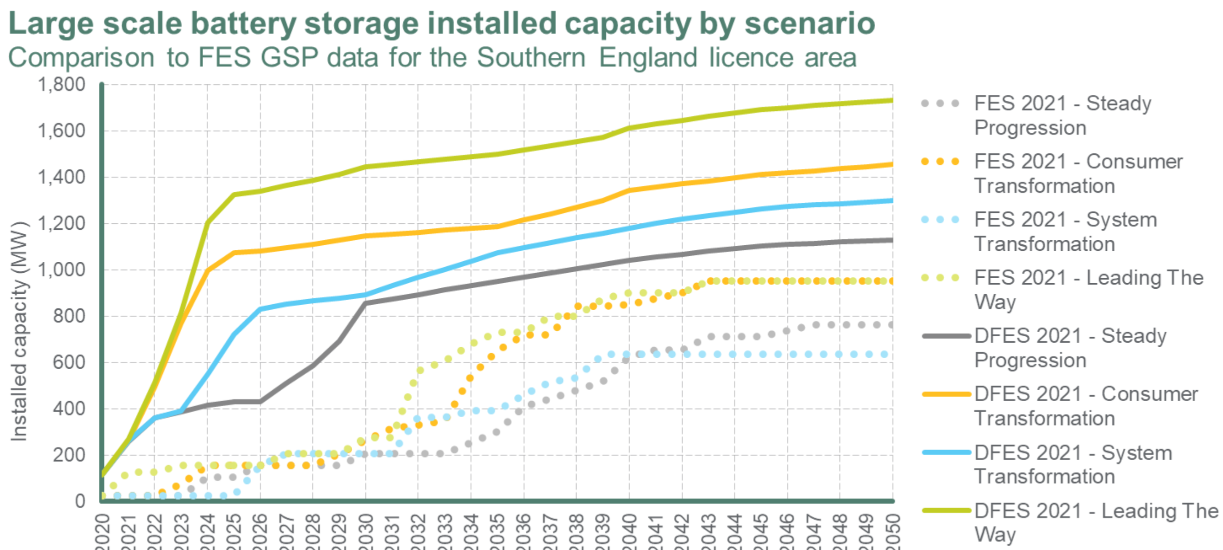
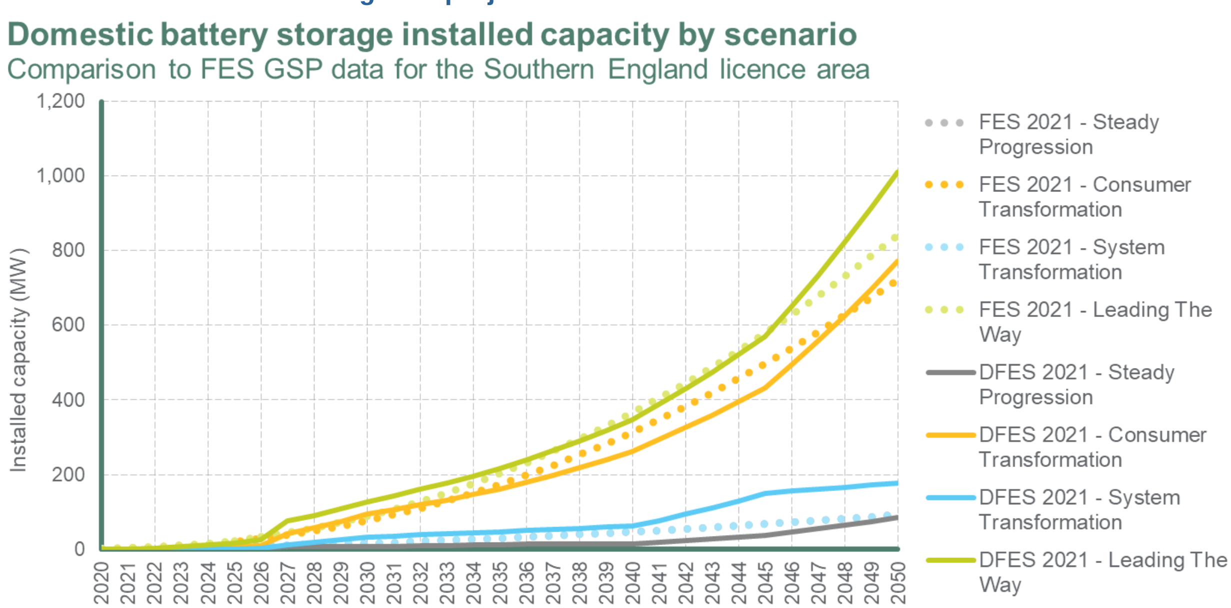


Figure 45: Domestic battery storage projections for the Southern England licence area, compared to National Grid FES 2021 regional projections



Reconciliation with National Grid FES 2021:

Results in this section relate to the FES 2021 data for the relevant regional GSPs within the Southern England licence area for the battery storage building block technologies.

Batteries - [Srg_BB001]

- The DFES 2021 has a much higher baseline than the FES 2021 GSP data. This suggests that the first 100 MW phase of the 150 MW Stonehill Minety Battery project development, that came online towards the end of 2020, has not been included in the FES 2021 baseline.
- Under all scenarios, the DFES 2021 shows a significantly higher increase in connected capacity in the near and medium term. This is based on the site-specific development analysis and direct engagement with project developers in the DFES, showing the potential for a much more accelerated deployment of new battery projects under all scenarios across the 2020s. The variation is most significant under the **Consumer Transformation** and **Leading the Way** scenarios over the next decade.
- By 2050, a variance of c.500-800 MW is seen between the FES 2021 and DFES 2021 under the **Consumer Transformation** and **Leading the Way** scenarios respectively. Beyond the pipeline evidence, the DFES has sought to reflect the potential for additional large-scale standalone batteries, additional solar generation co-location storage capacity and high energy user installations. This results in a further increase in total storage capacity by 2050 in the DFES 2021 and thus a sustained variance to the FES 2021.
- Under **Steady Progression** the variance between the FES 2021 and DFES 2021 is lessened by 2050, reducing from a c.650 MW variance in 2030 to less than 200 MW by 2050. This reflects the notable pipeline project development in near-term in the DFES, reducing over time to align closer to the FES 2021 long-term projections in this scenario.

Domestic batteries - [Srg_BB002]

- The baseline, near and medium-term projections for domestic batteries align well across all four scenarios under the FES 2021 and DFES 2021. Both analyses showing <1 MW currently connected, and a range of c.30 MW-350 MW connected by 2040.
- By 2050, a slightly higher capacity is projected in the DFES 2021 than the FES 2021 under the three net zero scenarios. This reflects the notable future projected capacity of rooftop PV in the licence area under these scenarios in the DFES 2021.

Factors that will affect deployment at a local level:

- The spatial distribution of new battery storage projects in the near and medium term is predominantly based on the location of the significant pipeline of new potential sites.
- In the longer term, spatial distribution varies according to the four battery storage business models used in the DFES 2021 modelling. These local factors are:
  - **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 large-scale ground mounted solar PV 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 2021.

Relevant assumptions from National Grid FES 2021:

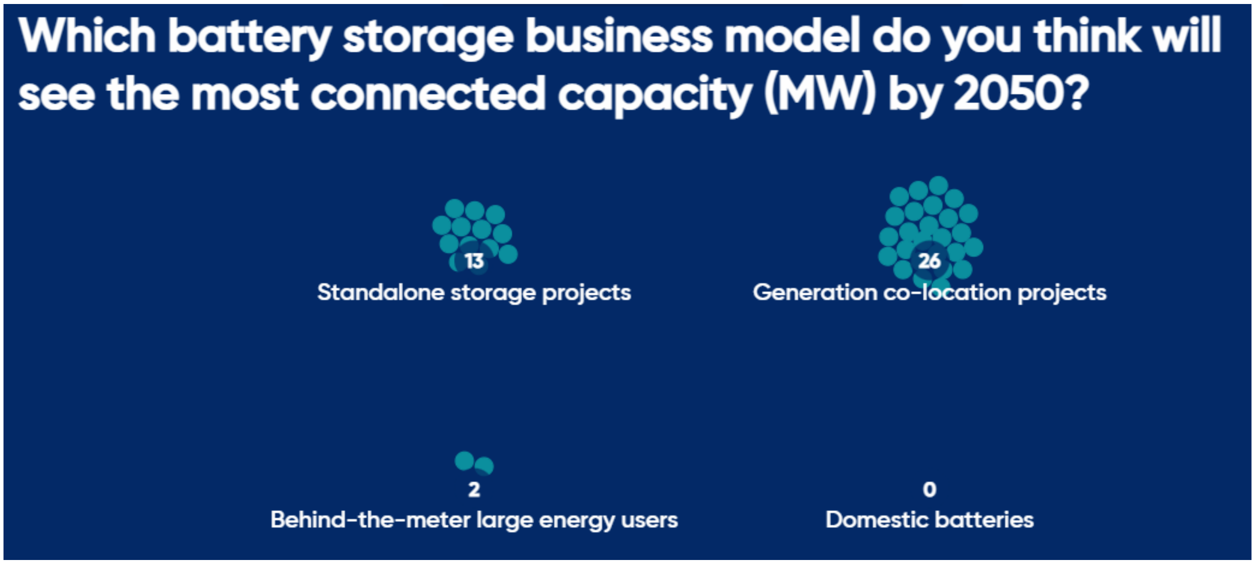
Assumption number	4.2.24 – Short duration electricity storage
Steady Progression	Moderate levels of flexibility requirements encourage new storage. Not as much deployed compared to other scenarios.
System Transformation	Not as much deployed compared to other scenarios due to high use of hydrogen within this scenario.
Consumer Transformation	High levels of variable clean generation and flexibility requirements encourage new storage technologies to emerge.
Leading the Way	Even higher levels of flexibility requirements encourage new storage technologies to emerge at distributed and transmission levels.

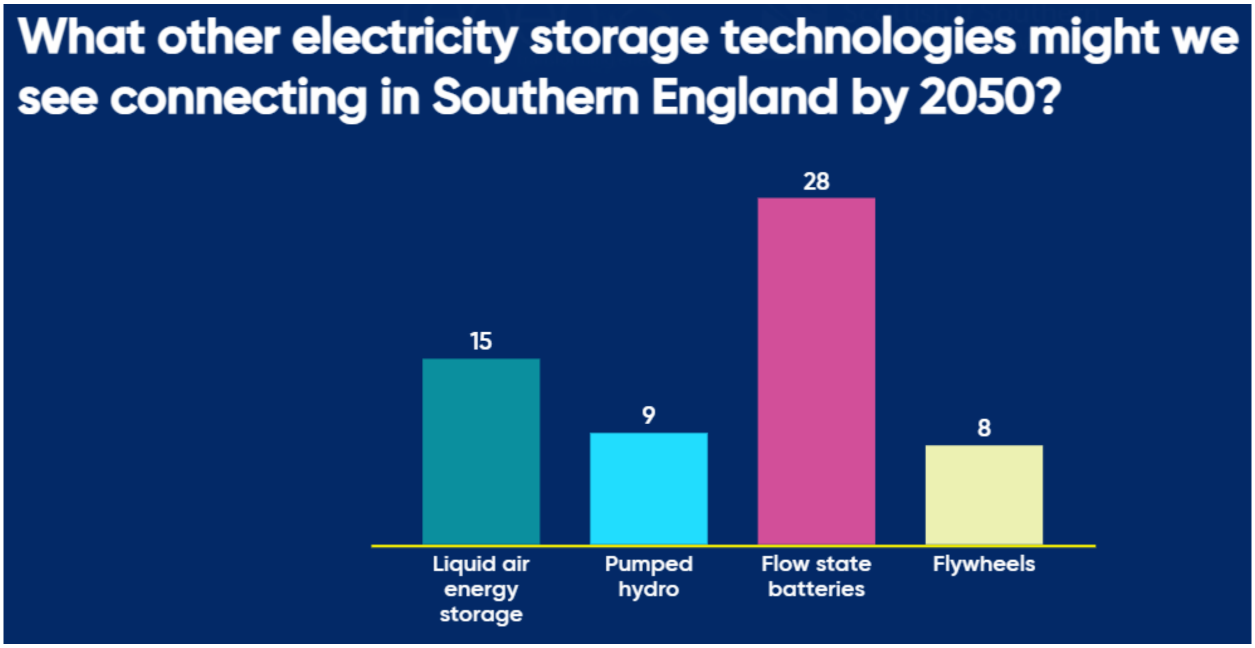
Assumption number	4.2.25 – Medium duration electricity storage
Steady Progression	Lower flexibility requirements means that this technology does not come forward at the volumes seen in the other scenarios.
System Transformation	Moderate levels of flexibility requirements encourage new storage. Not as much deployed compared to other scenarios due to high use of hydrogen within this scenario.
Consumer Transformation	Flexibility requirements encourage new storage.
Leading the Way	High levels of flexibility requirements encourage new storage.

Stakeholder feedback overview:

Battery storage	
Stakeholder feedback provided	How this has influenced our analysis
A range of stakeholders were engaged through a dedicated Southern England DFES workshop in October 2021. Stakeholders felt that standalone storage (30%) and generation co-location (63%) projects would see the most connected capacity by 2050.	The DFES has modelled these two business models separately, rather than a singular large-scale battery storage projection. Whilst a significant capacity of generation co-location storage has been modelled to connect under **Leading the Way** and **Consumer Transformation**, the majority (c.2.2 GW) of the known pipeline (c.2.4 GW) was identified to be standalone projects. Therefore, this is the business model that has the highest projection overall.
When asked what electricity storage technologies might connect to the distribution network in the licence area by 2050, flow-state batteries and liquid air scored first (78%) and second (41%).	The DFES battery storage analysis includes both solid-state and flow-state batteries. Whilst no flow battery projects have been identified in the SSEN connection data, this technology could see deployment in the longer-term in any of the three non-domestic business models. The DFES 2021 has included a separate analysis and projection of liquid air energy storage (LAES) for the first time and is summarised in a separate technology sheet.
Engagement with representatives from the Isle of Wight identified a historic pipeline of 120 MW of standalone or co-located battery projects with solar PV.	This historic pipeline has been considered alongside the rest of the known live pipeline in the licence area. The Isle of Wight has also been considered in the geographical distribution of DFES 2021 projections.

Figure 46: Stakeholder responses to battery storage questions in the online engagement webinar





References:

SSEN connection offer data, Regen consultation with local stakeholders in the Southern Licence area, workshop with Isle of Wight stakeholders and direct engagement with battery storage project developers.

[xlii] See Anesco Slepe Farm Battery project: https://anesco.co.uk/project/slepe-farm/
[xliii] See Eclipse Power Networks Minety Battery Storage: https://eclipsepower.co.uk/project/minety-battery-storage/

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 analysis could be reconciled in part to building block: **Srg_BB004 – Other energy storage**.

Data summary for LAES in the Southern England licence area:

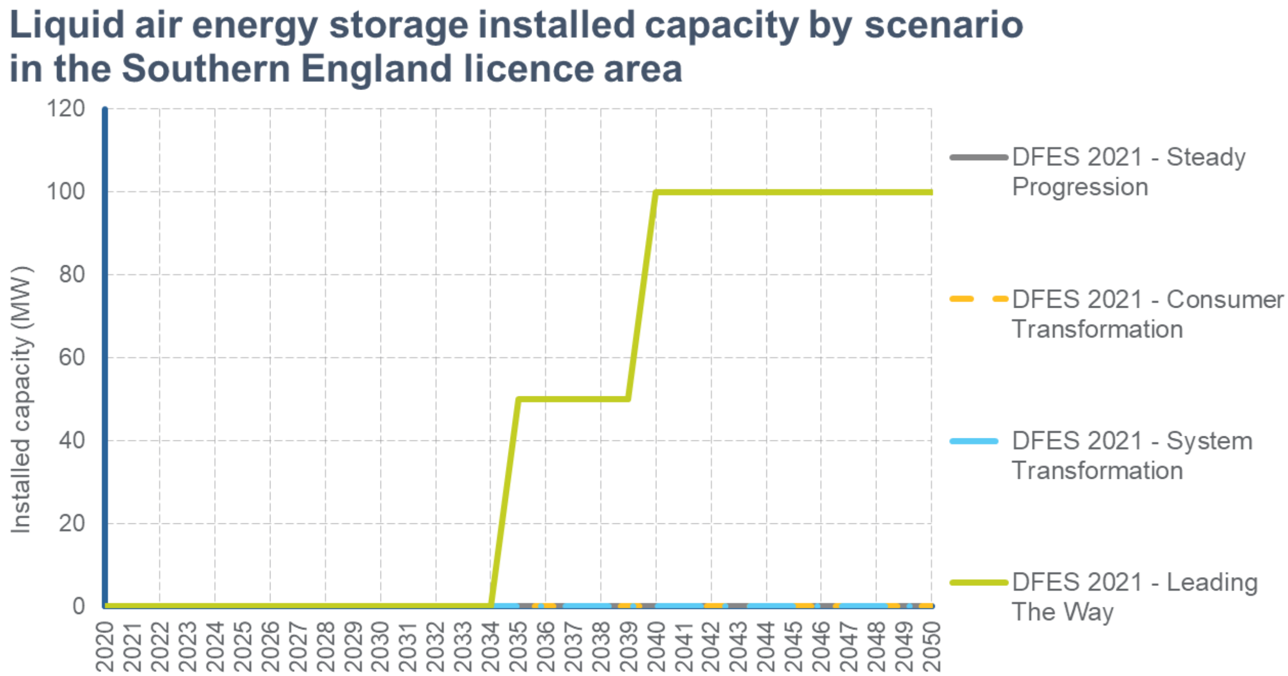
Installed power capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	0	0	0	0	0	0	0
System Transformation		0	0	0	0	0	0
Consumer Transformation		0	0	0	0	0	0
Leading the Way		0	0	50	100	100	100

Overview of technology projections in the licence area:

- 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.
- It is considered as one of the technologies that could provide longer duration storage services to the electricity system, with project developers looking to move from small-scale trials to full commercial-scale plants. This technology could be supported by BEIS' Long Duration Storage Competition grant funding, launched in 2021[xliv].
- Whilst there are a couple of proponents of LAES technology, is a relatively recent technology development. One of the leading developers in the UK is Highview Power, who has developed trial and pre-commercial plants in Greater Manchester[xlv].
- At present 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, some business models they are considering include the potential to:
    - Co-locate with renewable energy generation technology (as a source of low-cost, low-carbon input electricity)
    - Co-locate with large-scale data centres that require a significant cooling load (this aligns with the cryogenic aspect of the LAES storage cycle).
- As a result of this feedback and significant future capacity of large-scale solar PV and data centre demand in the Southern England licence area, the DFES 2021 has modelled 50 MW of new LAES capacity to come online by 2035 and 100 MW by 2050, under **Leading the Way**. There is the potential for additional capacity to connect to the transmission network.

Scenario projection analysis and assumptions:

Figure 47: Liquid air energy storage projections for the Southern England licence area



Reconciliation with National Grid FES 2021:

There are no equivalent projections for LAES capacity in the FES 2021 to reconcile these DFES 2021 projections against.

Factors that will affect 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 is based on the potential to co-locate with renewable energy generation sites and large-scale data centres.

References:

Engagement with LAES technology developers.

[xliv] See BEIS long duration storage competition overview: https://www.gov.uk/government/publications/longer-duration-energy-storage-demonstration
[xlv] See Highview Power operational plants: https://highviewpower.com/plants/

Electric vehicles

Summary of modelling assumptions and results

Technology specification:

Electric vehicles (EVs) – including non-autonomous cars, autonomous cars, buses and coaches, HGVs, LGVs and motorcycles, covering both Battery EVs and Plug-in Hybrid EVs. Technology building blocks: Lct_BB001, Lct_BB002, Lct_BB003, Lct_BB004.

Data summary for electric vehicles in the Southern England licence area:

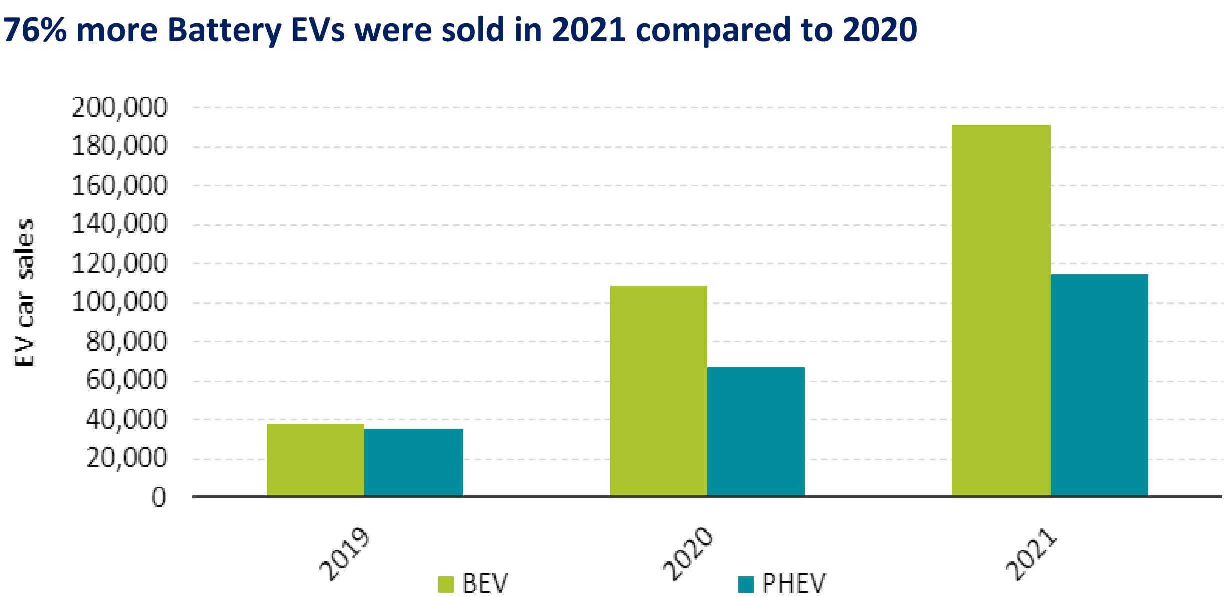
Number of EVs (total, 1000s)		Baseline	2025	2030	2035	2040	2045	2050
Battery EVs	Steady Progression	52	254	752	1,808	3,436	4,644	4,988
	System Transformation		255	927	2,637	4,397	4,745	4,468
	Consumer Transformation		548	1,793	3,875	4,742	4,742	4,458
	Leading the Way		531	1,969	4,154	4,765	4,450	3,588
Hybrid EVs	Steady Progression	43	114	213	339	432	298	125
	System Transformation		93	172	238	173	73	25
	Consumer Transformation		82	125	150	103	45	24
	Leading the Way		105	169	139	81	35	35

Overview of technology projections in the licence area:

- At present, EVs (including Battery EVs and Plug-in Hybrid EVs) represent approximately 1.9% of all vehicles in the Southern England licence area. The GB average is 1.4%; therefore, the area currently has an above-average uptake of EVs. This is predominantly due to the area's large number of commercial vehicles, higher than average affluence and large urban areas.
- EV uptake rate in the Southern England licence area is expected to remain ahead of the GB average until the mid-2020s in most scenarios when EV uptake becomes increasingly ubiquitous.
- Electrification is the key route to decarbonising transport in the FES 2021 scenarios, with hydrogen contributing to the decarbonisation of HGVs and buses.

- The number of Plug-in Hybrid EVs in the licence area is 22% lower than the number of Battery EVs; reflecting a shift in GB wide EV adoption trends between 2020 and 2021 when Battery EVs have become more numerous than Plug-in Hybrid EVs. The proportion of Plug-in Hybrid EVs compared to Battery EVs is projected to reduce further in all scenarios, as Battery EVs remain the dominant form of EV. The number of Plug-in Hybrids peaks in the 2030s in all net zero scenarios, followed by a decline to 2050.
- All scenarios in FES 2021 show a more rapid EV uptake compared to the FES 2020. Even the slower growth scenarios of **Steady Progression** and **System Transformation** have faster growth rates than in previous FES 2020 scenarios.
- The reduction in vehicle numbers in the long term in the ESO FES 2021 is facilitated by an increase in active and public transport use, an increase in average vehicle mileage and the introduction of autonomous vehicles (AVs) which have high average annual mileage.
- Hydrogen vehicle numbers increase throughout the 2030s and are concentrated in HGVs, buses and LGVs in all scenarios. **System Transformation** has significantly more hydrogen vehicles than the other scenarios, with four to five times as many hydrogen vehicles compared to other net zero scenarios and 25 times more than **Steady Progression**.
- Society of Motor Manufacturers and Traders (SMMT) data finds that 76% more Battery EVs were sold in GB in 2021 compared to 2020 and 380% more than in 2019. In addition, Battery EV sales now eclipse those of Plug-in Hybrid EVs.

Figure 48: UK annual EV sales (non-cumulative), source: SMMT, Regen analysis



- 2021 has seen a number of important EV market and policy developments across the UK, whose implications have been considered for this licence area's DFES scenarios.
  - The UK government has pledged that all new HGVs from 2040 will be zero-emission, and potentially sooner for smaller HGVs[xlvi].
  - The UK government has consulted on phasing out of non-zero emission buses from between 2025 and 2032[xlvii].
  - The UK government has announced changes to the EV grant scheme, which will now provide grants of up to £1,500 for electric cars priced under £32,000[xlviii].

Scenario projection analysis and assumptions:

Baseline (up to end of 2020)

- There is currently slower uptake of EVs across many of the rural areas of the licence area, but a more rapid uptake in urban areas, such as West London, including Slough and Maidenhead, Oxford, Swindon, and Portsmouth.
- There are a total of 51,752 Battery EVs in the Southern England licence area, representing a 90% increase in Battery EVs compared to the DFES 2020 study.
- There are a total of 42,590 Plug-in Hybrid EVs in the Southern England licence area, representing a 40% increase in Plug-in Hybrid EVs compared to the DFES 2020 study.
- Around 95% of Battery and Plug-in Hybrid EVs are cars, while HGVs, LGVs, buses, coaches and motorcycles make up the remaining EV numbers.

Near term (2020 – 2025)

- Across all scenarios, the uptake of EVs is expected to accelerate significantly in the mid-2020s. The overwhelming majority of this uptake is from electric cars.
- It is projected that by 2025, there could be between c.254,000 Battery EVs in **Steady Progression** to c.548,000 in **Consumer Transformation** – potentially over a ten-fold increase by 2025.
- Local initiatives to lower air quality or expand access to charging are expected to increase local uptake. Oxford and Portsmouth have started charging drivers of non-compliant vehicles in their Clean Air Zones in August and November 2021 respectively, while Clean Air Zones have also been proposed in nine other towns and cities across the licence area. These are assumed to go ahead in all net zero compliant scenarios in the near term.

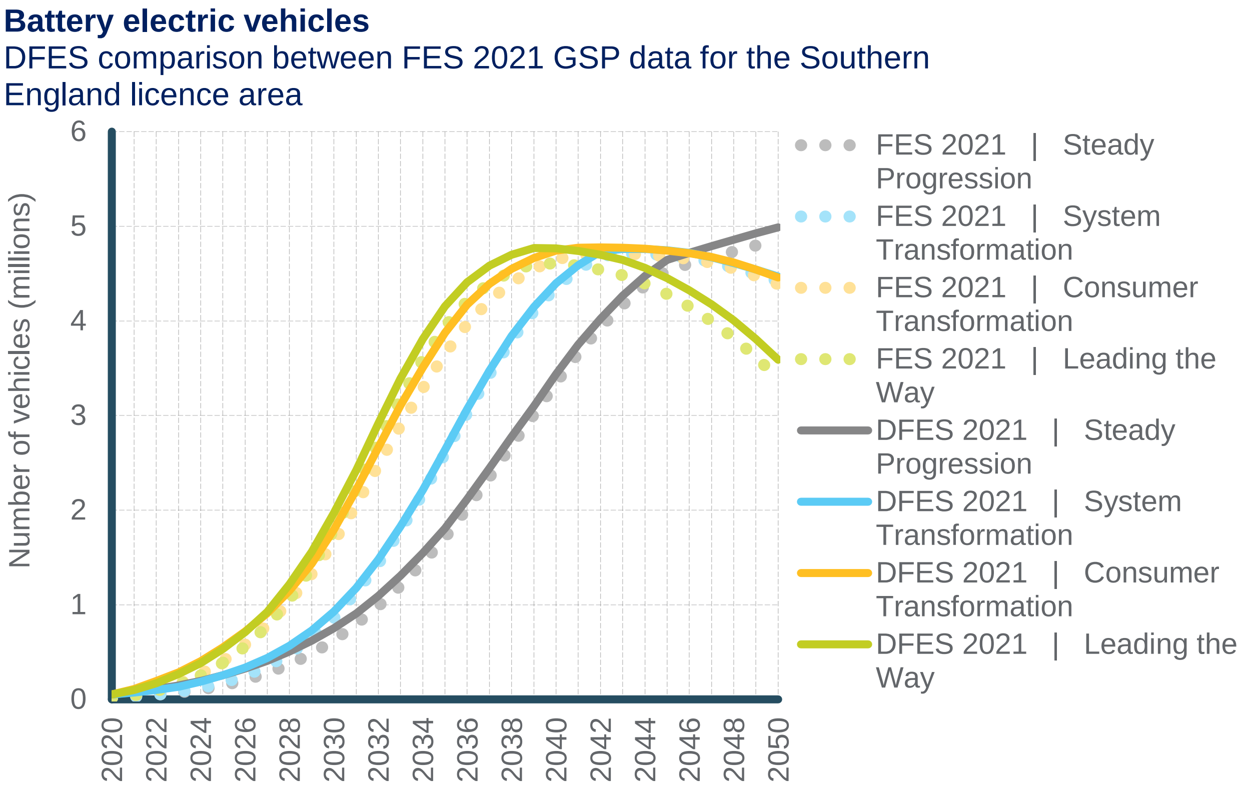
Medium term (2025 – 2035)

- The uptake of EVs is expected to accelerate between 2025 and 2035 in all scenarios.
- **Steady Progression** is the scenario with the fewest estimated Battery EVs in 2035: c. 700,000. **Leading the Way** remains the scenario with the most, with nearly 1.8 million Battery EVs by 2035.
- EV uptake begins to slow in the mid-2030s as EV adoption approaches saturation and only the hardest-to-electrify vehicles, such as HGVs, remain fuelled by petrol or diesel. Other factors also contribute to uptake slowing, including the total number of vehicles reducing, increased use of AVs and an increase in public transport and active travel.
- The uptake of Plug-in Hybrids slows and then reduces in **Leading the Way**, as a result of the assumed restriction on their sale in the early 2030s.

Long term (2035 – 2050)

- The uptake of EVs continues to increase in **Steady Progression**, up until 2050 when Battery EVs total nearly 5 million. In **System Transformation**, the uptake of Battery EVs flattens and then marginally reduces from the mid-2040s as a result of an increase in the number of hydrogen cars.
- In **Leading the Way** and **Consumer Transformation**, the numbers of EVs reduces from the late 2030s and mid-2040s, respectively. This is the result of societal change and technological development such as increased use of public and active travel and the rising number of AVs.
- Many homes opt to have one or no car at all, which results in a decrease in the number of company and private vehicles.
- The number of Battery EVs, and total vehicles, in **Leading the Way** reduces substantially, peaking at 4.6 million before reducing to 3.4 million in 2050.

Figure 49: Electric vehicle projections for the Southern England licence area, compared to National Grid FES 2021 regional projections



Reconciliation with National Grid FES 2021:

- The SSEN DFES 2021 projections are broadly in line with the FES 2021 projections for this licence area, as reported for the Building Block ID numbers Lct_BB001, Lct_BB002, Lct_BB003 and Lct_BB004.
- Baseline EV numbers in the DFES 2021 are sourced from DfT vehicle licencing data (DfT Table VEH0132), which are slightly different to the FES 2021 GSP baseline figures, most likely due to the time of data extract. This variance results in higher EV uptake figures in the short- and medium-term in the DFES 2021 compared to FES 2021.
- Interim assumptions have been made as to the uptake and distribution of AVs in the absence of other information. The spatial distribution of AV uptake is treated the same as non-autonomous EVs due to a lack of information about their future uptake. It is assumed that the uptake of AVs in on and off-street settings is the same as for non-autonomous EVs. The uptake and distribution of AVs is an area that needs to be considered for future analysis when more evidence is available.

Factors that will affect deployment at a local level:

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

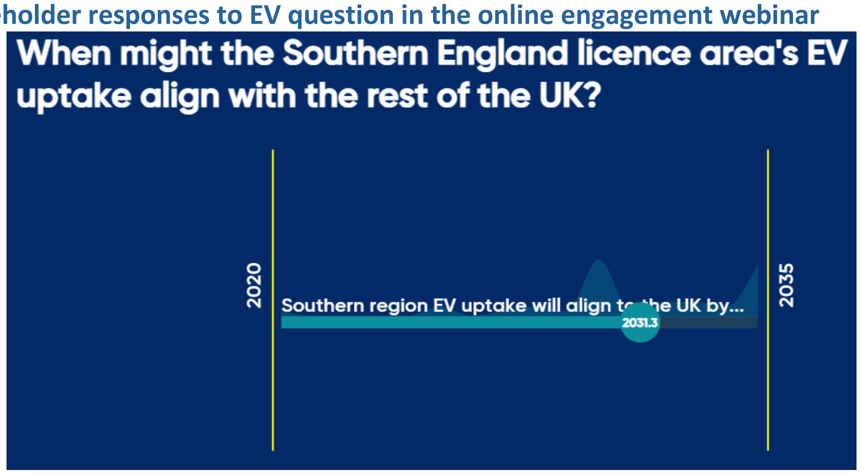
Relevant assumptions from National Grid FES 2021:

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

Stakeholder feedback overview:

Electric Vehicles Stakeholder feedback provided	How this has influenced our analysis
Upon reflecting on the Southern England licence area's high EV uptake in the baseline compared to the GB average, when asked "when might the Southern England licence area's EV uptake align with the rest of the UK" it was stakeholders' view that EV uptake in the licence area will remain above the average until the 2030s. This view was held by all stakeholder groups.	EV uptake rates in the Southern England licence area remain ahead of the national average until the 2030s in all net zero scenarios.
For the uptake of EVs, other feedback was received at a stakeholder workshop focused on the Isle of Wight. This feedback confirmed initial assumptions in the modelling, such as the ambition of the net zero scenarios and distribution models.	Confirmed existing assumptions.
Feedback from industry stakeholders highlighted that the ambitious growth of the net zero scenarios was dependant on the supply of EVs, and that presently supply is not meeting demand as a result of chip shortages, manufacturing limitations and other factors. An additional challenge for the UK is also to secure sufficient imports of EVs against the backdrop of high global demand for EVs.	The deliverability and progress achieved towards the scenarios will be reviewed annually. FES 2021 conducted this analysis and found that EV uptake seen last year fell well within the credible range of scenarios.

Figure 50: Stakeholder responses to EV question in the online engagement webinar



References:

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

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xlvi https://www.gov.uk/government/news/uk-confirms-pledge-for-zero-emission-hgvs-by-2040-and-unveils-new-chargepoint-design

xlvii https://www.gov.uk/government/consultations/ending-the-sale-of-new-diesel-buses

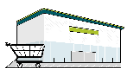
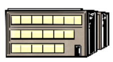
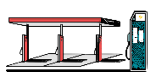
xlviii https://www.gov.uk/government/news/government-funding-targeted-at-more-affordable-zero-emission-vehicles-as-market-charges-ahead-in-shift-towards-an-electric-future

Electric vehicle chargers

Summary of modelling assumptions and results

Technology specification:

The uptake of the following EV charger archetypes are modelled:

Off-street domestic		Homes with somewhere to park a private vehicle off-street
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

FES 2021 does not publish EV charger projections and so the DFES 2021 projections cannot be reconciled against a specific FES technology building block or dataset.

Data summary for electric vehicle chargers in the Southern England licence area:

Note that the projection units for domestic and non-domestic EV chargers in the following table are different. To illustrate the scale of EV charger uptake, domestic off-street EV chargers are displayed in numbers, 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 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 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.

EV chargers		Baseline	2025	2030	2035	2040	2045	2050
Domestic off-street EV chargers (Total, numbers, thousands)	Steady Progression	32	168	428	960	1,757	1,885	1,928
	System Transformation		169	579	1,349	1,805	1,870	1,906
	Consumer Transformation		401	1,069	1,806	1,882	1,928	1,972
	Leading the Way		405	1,226	1,814	1,892	1,942	1,990
Non-domestic EV chargers (Total, MW)	Steady Progression	95	279	550	1,118	2,116	2,990	3,097
	System Transformation		310	721	1,657	2,908	3,360	3,467
	Consumer Transformation		483	1,097	2,299	3,211	3,419	3,518
	Leading the Way		527	1,360	2,808	3,630	3,770	3,823

Overview of technology projections in the licence area:

- At present, the installation of public EV chargers per EV in the Southern England licence area is approximately the same as the GB average. This trend is expected to continue as EVs become increasingly ubiquitous.
- There is significant uncertainty regarding the shape and size of a future EV charger network, as well as future consumer behaviour; in particular the split between off-street home charging versus public charging, as well as the market share between ultra-fast charging hubs versus lower voltage on-street, neighbourhood and municipal charging. The DFES projections, therefore, aim to represent the envelope of the possible spread and rate of deployment of EV chargers in the licence area.
- 2021 has seen a number of important new EV charging market and policy developments across the UK. The implications of these developments have been considered and influenced the scenario projections in the Southern England licence area as follows:
    - The outcome of the UK government's consultation on EV charge points in residential and non-residential buildings has been published, revealing plans for all new buildings in England to have electric car charge points from 2022[xlix].
    - Ofgem has announced which of the projects proposed by DNOs have received funding from the £300 million green recovery scheme. The scheme is designed to support network capacity investment for 'shovel-ready' net zero projects (such as EV charging hubs and solar farms)[l]. Around 40% of the investment proposals support increasing network capacity at Motorway Service Areas, working alongside OZEV's Project RAPID to allow an estimated 1,800 ultra-rapid charge points to be installed (there are 948 installed at present).
    - This year has seen the rise of the EV forecourt, dedicated rapid and ultra-rapid EV charger-only forecourts and am expanded rollout of EV chargers at existing petrol stations.
- Network access and charging reforms[li] may accelerate the deployment of higher voltage chargers by reducing upfront connection charges.

- Compared to the DFES 2020 report and FES 2021, the uptake rate of EV chargers is higher and the scenario envelope of charger capacity in 2050 has narrowed. This is due to increased uptake of EVs in the less ambitious scenarios in the FES 2021 compared to FES 2020, thus narrowing the EV uptake projections. In addition, the FES 2021 assumptions around EV efficiency have changed, resulting in an increase in EV energy requirements and thus EV charger capacity requirements to meet that energy demand.
- By 2050, total EV charger capacity is highest under **Leading the Way**, with c.3.8 GW of non-domestic charger capacity and c.2 million domestic EV chargers in operation.

Scenario projection analysis and assumptions:

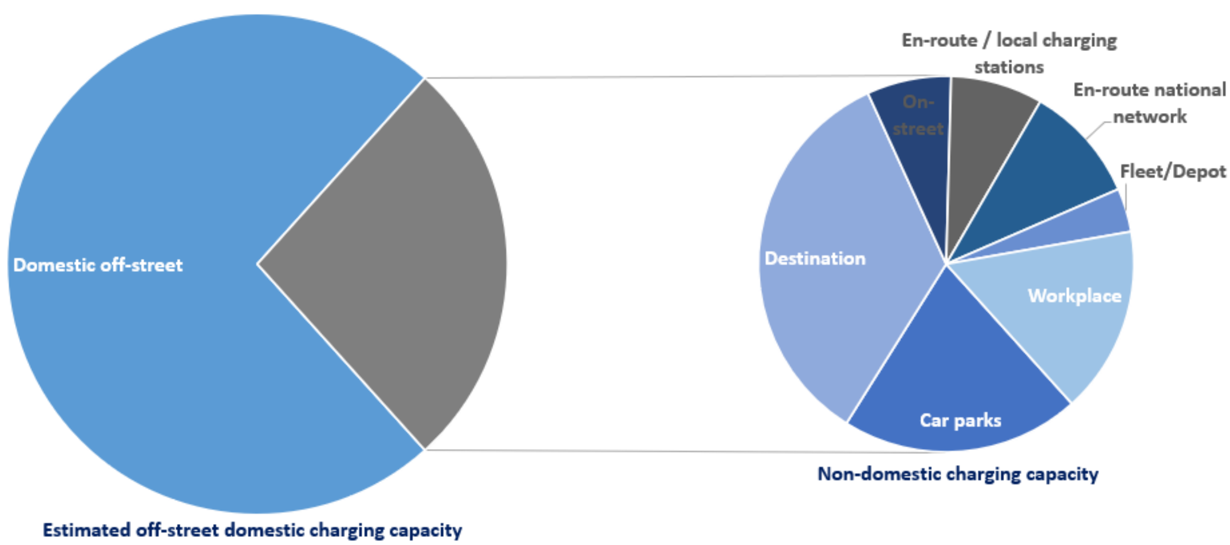
Baseline (up to end of 2020)

- There are a total of 3,134 public EV chargers in the Southern England licence area, totalling an estimated 95 MW of public charger capacity. This capacity is broadly in line with the GB average when compared to the number of vehicles in the licence area.
- This represents a 20% increase in EV charger capacity since DFES 2020. This is a significant increase but is still less than the growth of electric vehicles in the region which has jumped by 90% over the same analysis period.
- It is estimated that there are approximately 32,000 domestic EV chargers in operation in the Southern England licence area.

EV charger baseline

Figure 51: Southern England licence area - charger capacity

Source: National Chargepoint Registry and Regen analysis



Near term (2020 – 2025)

- In all scenarios, the uptake of EV chargers is expected to increase rapidly in the near term. Most EV charging investment is expected to be led by the private sector, hence it is expected that EV charger capacity will continue to be focused on charging hubs, en-route locations and areas of higher EV uptake. However, this does vary by scenario; **Consumer Transformation** has more decentralised local and residential on-street chargers whereas in **System Transformation,** chargers are weighted toward road networks and other hub locations.

- Public funding, such as the Rapid Charging fund[lii] [liii], leads to significant investment at motorway and A-road service stations across England. As a result, en-route charging capacity is assumed to increase rapidly in the near term and may, in fact, continue to be deployed even while electricity network capacity is constrained.
- Network access and charging reforms may encourage rapid deployment of chargers from 2023 onwards.
- The early uptake of EV cars and LGVs by consumers with off-street parking is expected. It is projected that by 2025, there could be between 168,000 domestic off-street chargers in **Steady Progression** and 405,000 in **Leading the Way**.
- In addition, it is projected that by 2025, there could be between 279 MW of non-domestic off-street chargers in **Steady Progression** and 527 MW in **Leading the Way**.

Medium term (2025 – 2035)

- EV charger installation rates are expected to accelerate between 2025 and 2035 across all scenarios.
- Public charging, including on-street charging in residential areas and rapid charging hubs, is expected to increase substantially as EV usage increases, range increases and more households without access to off-street parking begin to adopt EVs.
- **Leading the Way** is the scenario that has the highest EV charger capacity deployed, with around 1.8 million domestic EV chargers and 2.8 GW of non-domestic capacity by 2035. **Steady Progression** has the lowest estimated EV charger capacity by 2035, with c.1 million domestic EV chargers and 1.1 GW of non-domestic capacity.
- The rate of EV uptake begins to slow in the mid-2030s as EV adoption approaches saturation. The installation rate of EV chargers equivalently slows across all scenarios.
- As the market matures, it is likely that the growth in the number of EV charger locations may flatten, and may even fall, although the capacity and utilisation of existing charge stations are likely to increase.

Long term (2035 – 2050)

- In some of the FES 2021 scenarios, notably **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 increase significantly. The reduction in overall energy demand is, therefore, less significant.
- The uptake of EVs and EV chargers continues to increase in **Steady Progression** up until 2050, by which time there are nearly 2 million domestic EV chargers in operation.
- In **Leading the Way** and **Consumer Transformation**, the total capacity of EV chargers remains static from the late 2030s.
- The amount of EV charging capacity across the scenarios converges in the long term, as the total amount of energy that EVs require aligns. However, the scenarios maintain a variation in the amount of centralised and decentralised charging capacity.

Figure 52: Scenario projections for non-domestic EV chargers for the Southern England licence area

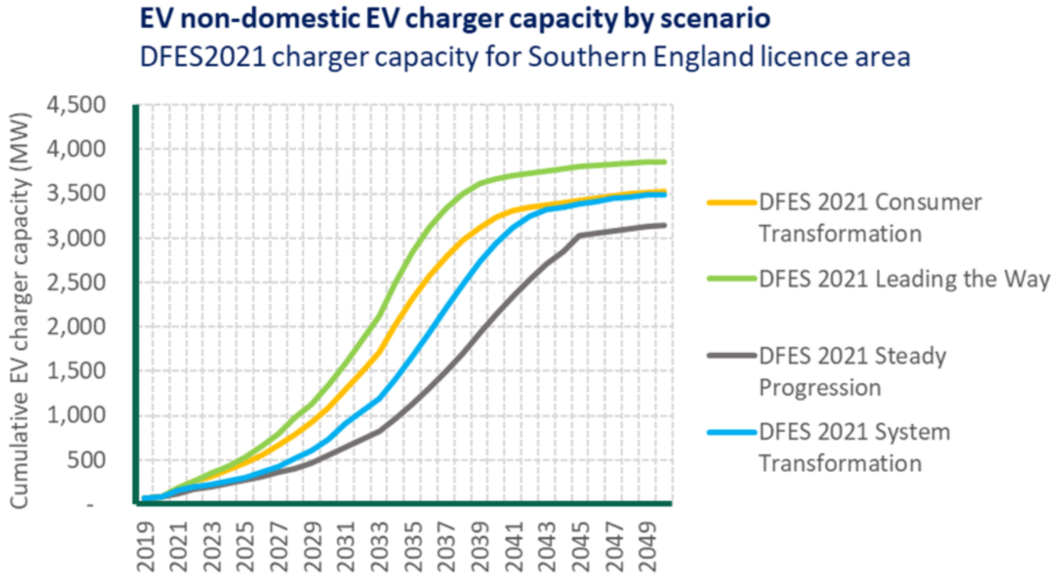


Figure 53: Scenario projection graph for public EV chargers for the Southern England licence area, by scenario

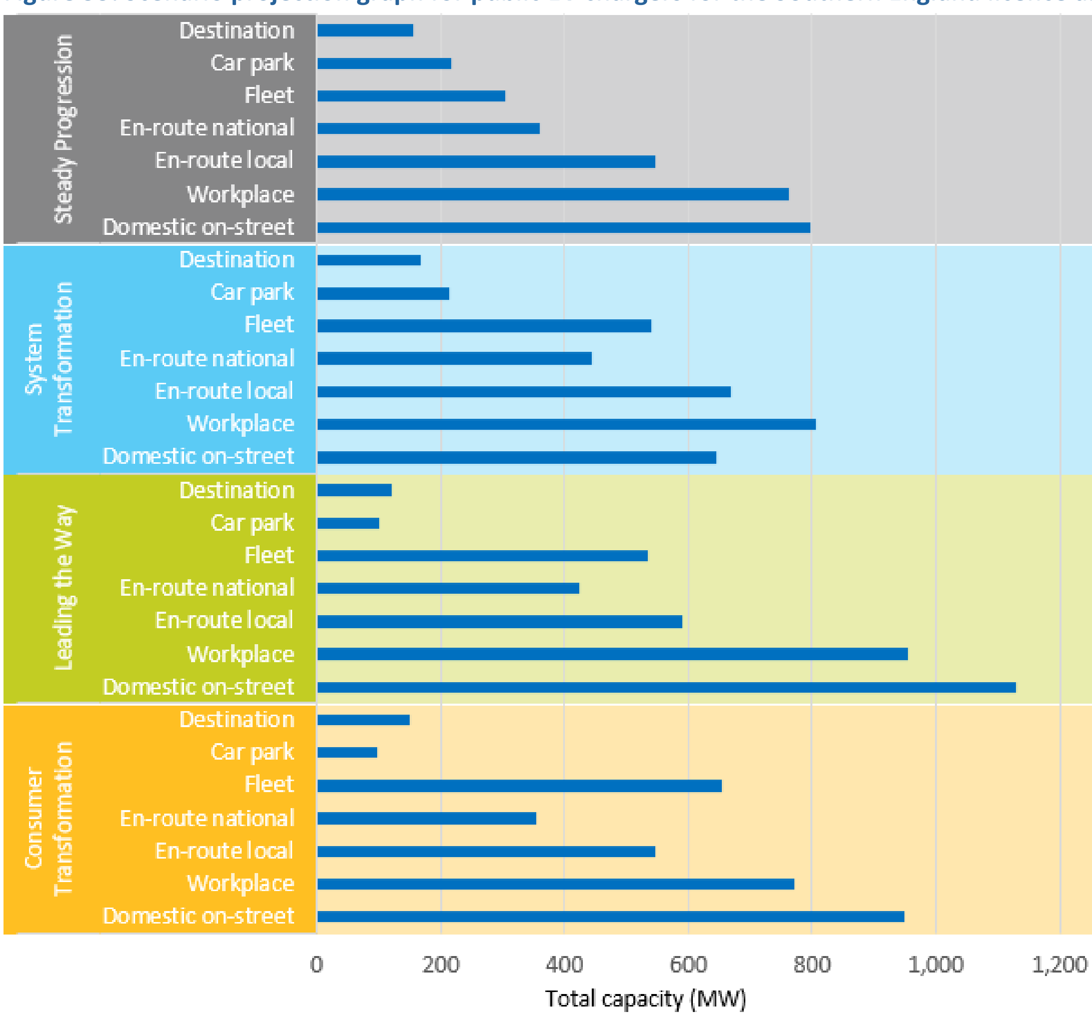
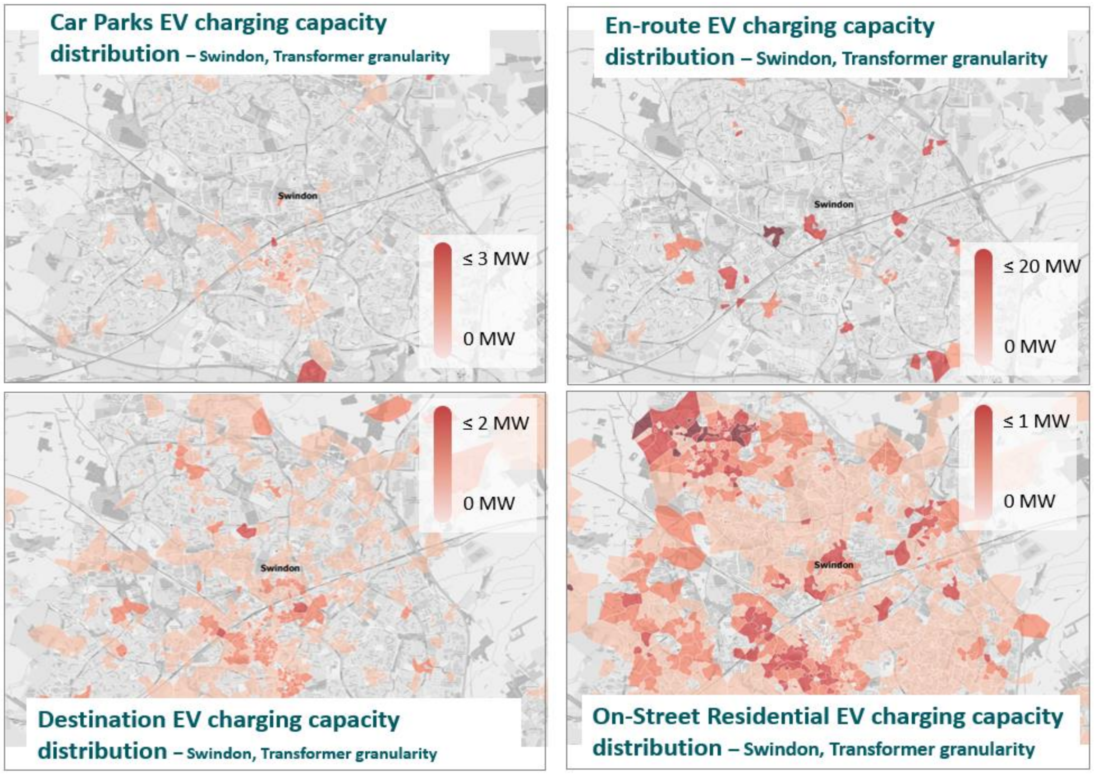


Figure 54: Map of illustrative Dundee EV charger capacity distribution results in 2050, under Consumer Transformation



Reconciliation with National Grid FES 2021:

- The ESO FES 2021 data does not provide sufficient regional or GSP level information to reconcile DFES EV charger projections with.
- Factors that will affect EV charging infrastructure which are available in the FES 2021 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.
- Although there have been a number of 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 for the projection of future EV charging requirements.
- Assumptions that have been 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 an increase in fleet/depot charging.
    - AVs are associated to on and off-street houses and charge at the same rate as EV cars.
- The uptake and distribution of chargers associated with AVs is an area that needs to be considered and developed for future DFES analysis.

Reconciliation with DFES 2020:

- FES 2021 has updated its assumed EV efficiencies (miles driven per kWh consumed) compared to FES 2020. These differences are outlined in the table below, alongside the equivalent DFES 2020 and 2021 assumptions.

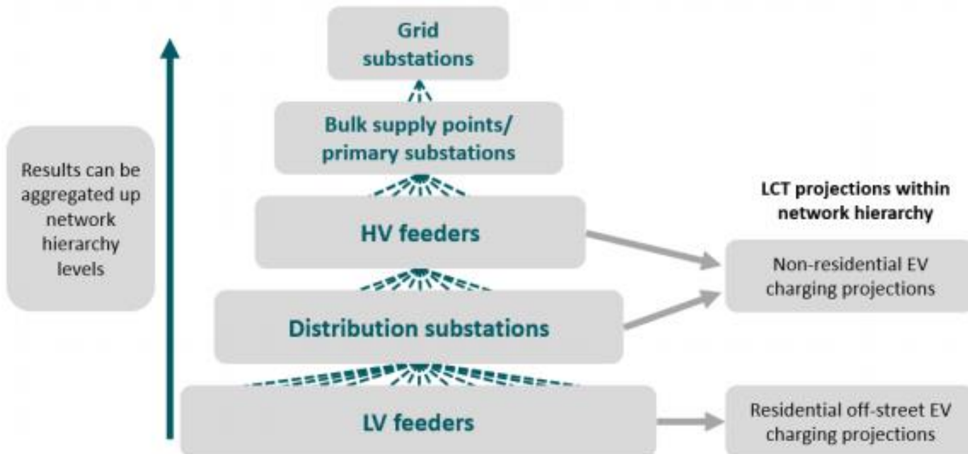
Year	FES EV efficiency (miles/kwh)		DFES EV efficiency (miles/kwh)	
	2020	2021	2020	2021
2020	4.1	3.1	3.1	3.1
2050	5.1	3.9	5.1	3.9

- In summary:
  - FES 2021 EV energy to mileage efficiency assumptions have reduced significantly
  - In the short term, this has brought the FES and DFES into alignment and has not, therefore, had an impact on the overall energy demand
  - In the long term, both the FES and DFES efficiency assumptions have been reduced, increasing the energy required per vehicle mile.
- Impact on charger capacity:
  - In the short term, the impact has been minimal
  - Over the long term, a reduction in vehicle efficiency has led to increased energy demand and, other things being equal, an increase in the EV charger capacity (number and power capacity) required to meet that demand
  - Capacity charger increases, caused by a reduction in EV efficiency assumptions, is mitigated to some extent by an assumption that charger utilisation will also increase.
- The uncertainty regarding EV vehicle energy efficiency is one example of a factor that could significantly change the requirements for EV chargers in the future.
- The FES 2021 EV energy to mileage efficiency assumptions for HGVs, LGVs, motorcycles and buses have also changed, though these changes have less impact on total EV charger capacity than cars.

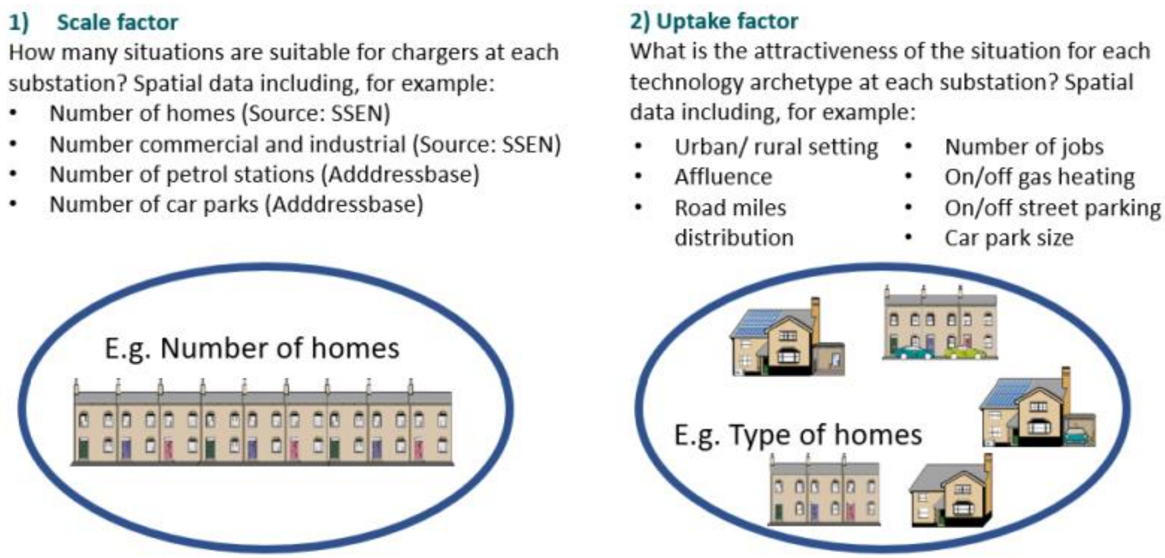
Factors that will affect deployment at a local level:

- The uptake of EV chargers was evaluated to a much higher granularity than ESAs. The uptake of domestic and on-street residential EV chargers were evaluated to SSEN's 400,000 individual feeders, equivalent to street-level forecasts, while non-domestic and public chargers were evaluated to SSEN's 100,000 distribution substations. Where feeders and distribution substations sit in SSEN's network hierarchy is illustrated in the graphic below.
- A wide variety of datasets were used to analyse specific regional and feeder specific demographic and technical attributes, geographical characteristics and local resources. For example, in order to evaluate the number of commercial and industrial sites connected to a feeder, SSEN connectivity data was used to identify individual sites which were then classified by type of commercial and industrial activity using Ordnance Survey Addressbase data. While not perfect, owing to data limitations, this allowed a much more granular assessment of commercial and industrial activity connected to the network.

Simplified electricity network hierachy



Assigning data to individual substations and technology archetypes



- The uptake of home EV chargers is distributed in the near term towards more urban, sub-urban and affluent areas and those where there are high levels of off-street parking.
- The spatial distribution of non-domestic chargers was produced differently for each archetype.
  - En-route local and national charging locations were distributed based on the density of local housing, the volume of local traffic, the distribution of existing petrol stations and the road classification on where the site is located
  - Car parks, workplaces and fleet depot locations were identified from Ordnance Survey data
  - The on-street residential analysis was undertaken in parallel with the off-street parking analysis to identify vehicles associated with on-street parking.
- The distribution analysis uses affluence as one of the key factors driving the uptake of EV chargers in the near term. For the more ambitious scenarios, from mid- to late-2020s, the underlying assumption is that EV cars will become ubiquitous. Therefore, the growth in demand for EV cars in both on-street and off-street areas and lower and higher affluence areas begins to increase at equivalent rates.

- In order to evaluate the distribution of chargers to a feeder level, the above factors were interpolated down to individual feeders from the highest granularity of publicly accessible datasets that are available. In addition, Ordnance Survey Addressbase data has been used to identify the locations at which EV chargers could be located.

Relevant assumptions from National Grid FES 2021:

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

Stakeholder feedback overview:

At the stakeholder event for the Southern England licence area, stakeholders gave their opinion on the future of EV charging infrastructure in SSEN's Southern England licence area.

There was a split view as to whether local charging for households without off-street/home charging would, in the future, be provided by:

a) widely distributed on-street charging, directly outside peoples homes, or in residential parking areas, and very likely connected to the nearest low voltage distribution feeder/substation

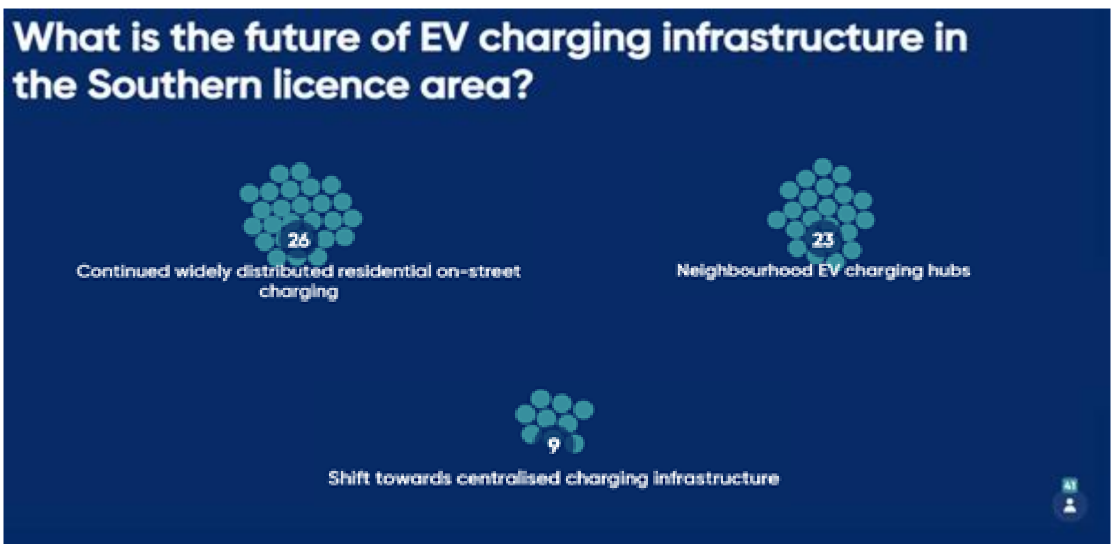
Or

b) larger charging hubs, with more rapid chargers, located in public (or private) spaces such as car parks, school car parks, industrial estates, leisure centres etc. These could connect to primary distribution feeders or even HV networks.

The consensus in the workshop was that both types of charger infrastructure will likely be needed depending on local factors. Privately funded and operated networks in England would probably be focused on deployment of higher voltage chargers at road networks and other hub locations. Publicly funded and operated chargers, may then provide services in more remote and rural locations and for residential on-street chargers

This input has contributed to the future charging scenario assumptions in this study including the definition of the **Consumer Transformation** scenario, which features more localised and residential on-street charging, and **System Transformation** which has fewer, larger and faster chargers which are located at road network and other hub locations.

Figure 55: Stakeholder responses to EV charger question in the online engagement webinar



EV chargers	
Stakeholder feedback provided	How this has influenced our analysis
Stakeholders highlighted the impact of potential upcoming distribution network charging changes.	Regen modelled a moderate pause and then acceleration in the uptake of EV charger capacity before and after April 2023. As the changes to network charges are presently only a minded-to decision, this impact is only modelled in **Leading the Way**.
For the uptake of EVs chargers, other feedback was received by the Isle of Wight stakeholders which confirmed initial assumptions in the modelling such as the types of suitable charging locations and the focus on public vs private charging infrastructure.	This feedback has been directly reflected in the scenario projections for the Isle of Wight supply areas.

References:

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

[xlix] Department for Transport, *Electric vehicle charge points in residential and non-residential buildings:* https://www.gov.uk/government/consultations/electric-vehicle-chargepoints-in-residential-and-non-residential-buildings?utm_source=pocket_mylist

[l] https://www.ofgem.gov.uk/publications/decision-riio-ed1-green-recovery-scheme

[li] See https://www.ofgem.gov.uk/energy-policy-and-regulation/policy-and-regulatory-programmes/network-charging-and-access-reform

[lii] See guidance on the Rapid Charging fund. https://www.gov.uk/guidance/rapid-charging-fund

[liii] See the government policy paper on the Government's vision for the rapid chargepoint network in England https://www.gov.uk/government/publications/government-vision-for-the-rapid-chargepoint-network-in-england/government-vision-for-the-rapid-chargepoint-network-in-england

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 2021. 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 a night storage or direct radiant electric heater.

This technology is divided into five sub-categories:

- Domestic non-hybrid heat pumps – **DFES technology building block Lct_BB005**
- Domestic hybrid heat pumps – **DFES technology building block Lct_BB006**
- Non-domestic non-hybrid heat pumps – **DFES technology building block Lct_BB007**
- Non-domestic hybrid heat pumps – **DFES technology building block Lct_BB008**
- Domestic resistive electric heating - **No corresponding DFES building block ID**.

Data summary for domestic heat pumps in the Southern England licence area:

Number of homes (thousands)		Baseline	2025	2030	2035	2040	2045	2050
Non-hybrid heat pumps	Steady Progression	19	19	54	185	375	605	764
	System Transformation		19	72	174	297	432	544
	Consumer Transformation		19	131	455	1,027	1,777	2,307
	Leading the Way		19	281	840	1,386	1,778	1,932
Hybrid heat pumps	Steady Progression	0	0	9	19	28	29	30
	System Transformation		4	10	54	225	406	578
	Consumer Transformation		5	13	53	105	148	165
	Leading the Way		7	48	120	225	273	299

Data summary for non-domestic heat pumps in the Southern England licence area:

Number of non-domestic properties (thousands)		Baseline	2025	2030	2035	2040	2045	2050
Non-hybrid heat pumps	Steady Progression	3	9	15	23	28	32	35
	System Transformation		15	40	59	70	73	78
	Consumer Transformation		23	53	78	99	110	117
	Leading the Way		19	46	70	88	96	99
Hybrid heat pumps	Steady Progression	0	0	0	1	1	1	1
	System Transformation		1	2	10	20	28	32
	Consumer Transformation		1	2	4	7	9	9
	Leading the Way		1	4	8	12	15	17

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	Steady Progression	358	337	285	238	197	160	138
	System Transformation		347	298	247	169	94	52
	Consumer Transformation		350	294	237	171	106	88
	Leading the Way		309	263	199	168	161	176

Overview of technology projections in the licence area:

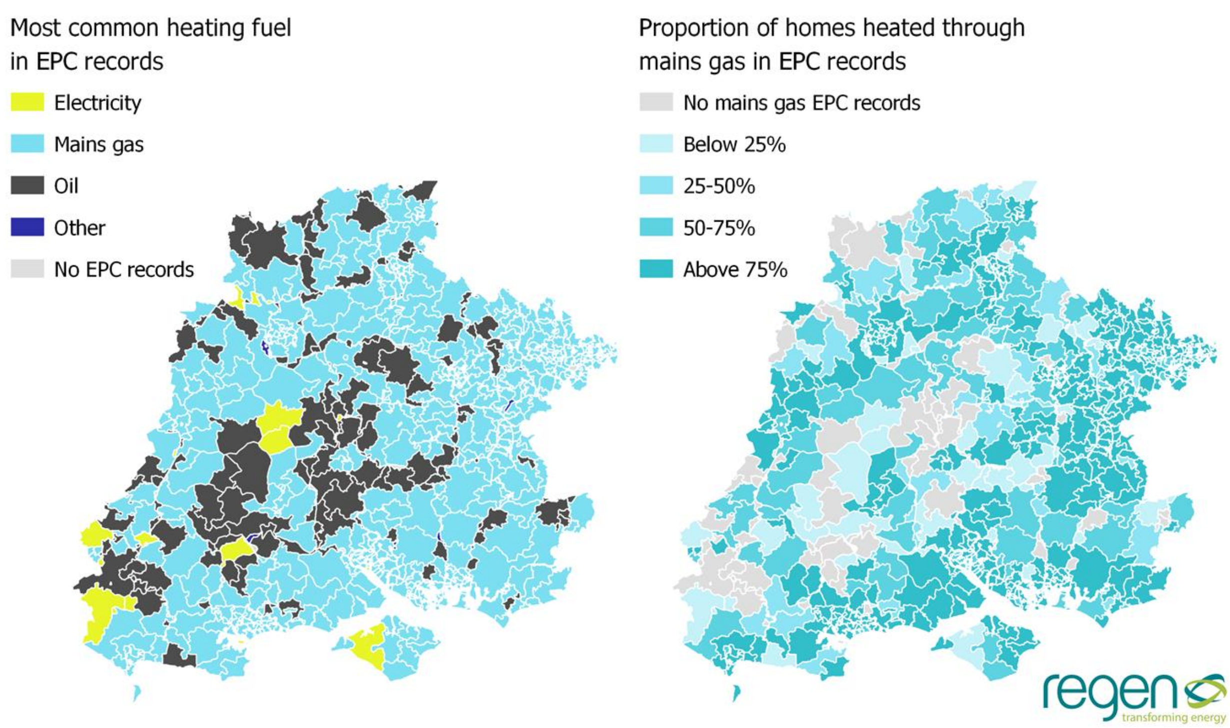
- The majority of homes in the Southern England licence area use fossil gas heating systems, and much of the off-gas homes use heating oil or LPG. These will require conversion to a low carbon form of heating in the next thirty years, if the UK is to meet its carbon reduction targets.
- Several announcements, research papers and strategies were published in towards the end of 2021, setting out how the UK plans to reduce carbon emissions over the coming decades. Consultations regarding the development of specific policy measures discussed in these strategies are underway, but the strategies themselves provide many of the principles for future decarbonisation, including context for future heat decarbonisation:
    - The UK's Net Zero Strategy was published, bringing together all national decarbonisation policy, moving towards identifying and understanding the dependencies between departments and sectors.[liv]
    - The UK's Heat and Buildings Strategy was published, setting out how the UK will look to decarbonise residential, commercial, industrial and public sector buildings.[lv]
    - Consultations on heat network zoning, transparency of carbon content in energy products, phasing out the installation of fossil fuel heating in homes not connected to the gas grid, and the development of a market based mechanism for low carbon heat are underway or awaiting results.
- The findings of these consultations, and subsequent policy measures, will be revealed in the coming months. The envelope of scenarios in the DFES reflects the range of potential upcoming policy measures. As more specific policies, ambitions and actions are unveiled, future DFES studies are likely to see a narrower range of scenario pathways for the decarbonisation of heat.
- In line with potential options for decarbonising heat at a national level, there is a dramatic shift to low carbon heating in the licence area in all three of the net zero scenarios. Under **Consumer Transformation** and **Leading the Way**, this results in heat pumps becoming the predominant domestic heating technology in the UK by 2050.
- Under **System Transformation**, the decarbonisation of heat on a UK level is driven by hydrogen, either through standalone boilers or hybrid heat pumps. Availability of hydrogen from domestic heating is assumed to be in-line with the current availability of fossil gas heating.
- Resistive electric heating, both direct electric and night storage heating, reduces in all scenarios. Despite being a zero emissions heating technology, the high running costs of resistive electric heating means that it is replaced by heat pumps or district heating in many cases.
- Non-domestic properties see a similar uptake of low carbon heating technologies, with heat pumps and hydrogen heating becoming common heating technologies alongside resistive electric heating.

Scenario projection analysis and assumptions:

Baseline (up to end of 2020)

- The Southern England licence area has an estimated 19,400 homes heated by a non-hybrid heat pump, of which 80% are air source and the remaining 20% are ground source. There are no domestic hybrid heat pumps in the baseline.
- The heat pump baseline represents 0.7% of homes, slightly above the GB average of 0.6%. This is likely due to the licence area being slightly more off-gas than the UK average.
- An estimated 2,800 non-domestic properties are heated by a non-hybrid heat pump. As with domestic properties, there are no hybrid heat pumps in the baseline.
- The baseline is composed of RHI data augmented with EPC data, aiming to capture heat pump installations that were not accredited for the RHI scheme. There may be a small number of homes with heat pumps that are not captured by EPC or RHI data.
- 358,000 homes in the licence area are heated primarily by resistive electric heating, based on analysis of EPC and Census 2011 data.
- 14% of homes in the licence area are heated via electricity, compared to the GB average of 11%. The licence area has a slightly higher than average proportion of off-gas homes, but also a higher than average number of flats, especially in urban areas such as Greater London, Swindon, Oxford and Southampton, which are more likely to be electrically heated.

Figure 56: Current primary heating fuels for homes in the Southern England licence area, showing the high level of homes heated by fossil mains gas throughout most of the licence area



Near term (2020 – 2025)

- Heat pump uptake increases in all scenarios in the near term, but remains low in all scenarios except **Leading the Way**. Uptake of heat pumps is supported by the domestic RHI and its upcoming successor, the Boiler Upgrade Scheme.
- Under **Leading the Way**, very high levels of consumer engagement and green ambition results in high levels of heat pump deployment in the near term.

Medium term (2025 – 2035)

- From 2025 onwards, heat pump uptake accelerates in all scenarios, most notably under **Consumer Transformation** and **Leading the Way**. This reflects UK government ambitions to achieve at least 600,000 heat pump installations per annum by 2028.
- Heat pump uptake under **System Transformation** and **Steady Progression** also increase, however UK government heat pump deployment targets are not met in these scenarios.
- Hybrid heat pump uptake is limited in the 2020s and early 2030s. By 2035, hybrids make up less than 10% of all heat pumps installations in every scenario except **System Transformation**, under which 18% of heat pumps are hybrid.
- As a common factor in fuel poverty due to high costs, resistive electric heating reduces in all four scenarios in favour of heat pumps, heat networks, gas network expansion and other more affordable heating systems. However, some installations occur in energy efficient new build properties, especially smaller homes such as flats.
- The anticipated Future Homes Standard may require all new buildings to low carbon heating systems from 2025. This is implemented under **Consumer Transformation** and **Leading the Way**, resulting in an increase in heat pump deployment in new build homes.

Long term (2035 – 2050)

- Under the **Consumer Transformation** and **Leading the Way** scenarios, the high levels of heat pump uptake seen in the 2030s continues to 2050, as the UK achieves its net zero target. By 2050, over 80% of homes are heated directly by electricity under these scenarios, with the remainder heated via low carbon district heat (which could be driven by a heat pump), biofuels or hydrogen. Similarly, the vast majority of non-domestic properties are electrically heated in these scenarios.
- Under **System Transformation**, heat pump uptake is overshadowed by the emergence of hydrogen boilers for domestic heating, which becomes the heating technology for the vast majority of currently on-gas homes. However, with costs of hydrogen for domestic consumption likely to be high relative to fossil gas, hybrid heat pumps with hydrogen boiler back-ups see significant uptake in the longer term under this scenario, totalling 578,000 in the licence area by 2050.
- Under **Steady Progression**, heat pump uptake remains low as the UK fails to meet its decarbonisation targets.
- Resistive electric heating continues to decline under **Consumer Transformation**, **System Transformation** and **Steady Progression** as less costly forms of heating continue to be adopted.

- Under **Leading the Way**, high levels of societal engagement, energy efficiency and technological advances in smart, phase-change storage heating results in next-generation storage heating becoming a more affordable form of domestic heating in the longer term, and a source of demand-side response flexibility through smart heaters and Time Of Use Tariffs. As a result, this scenario sees an uptick in resistive electric heating in the latter years of the scenario timeframe, replacing many of the remaining fossil fuelled heating systems present in the licence area.

Figure 57: Domestic heat pumps (non-hybrid and hybrid) in the Southern England licence area, compared to National Grid FES 2021 regional projections

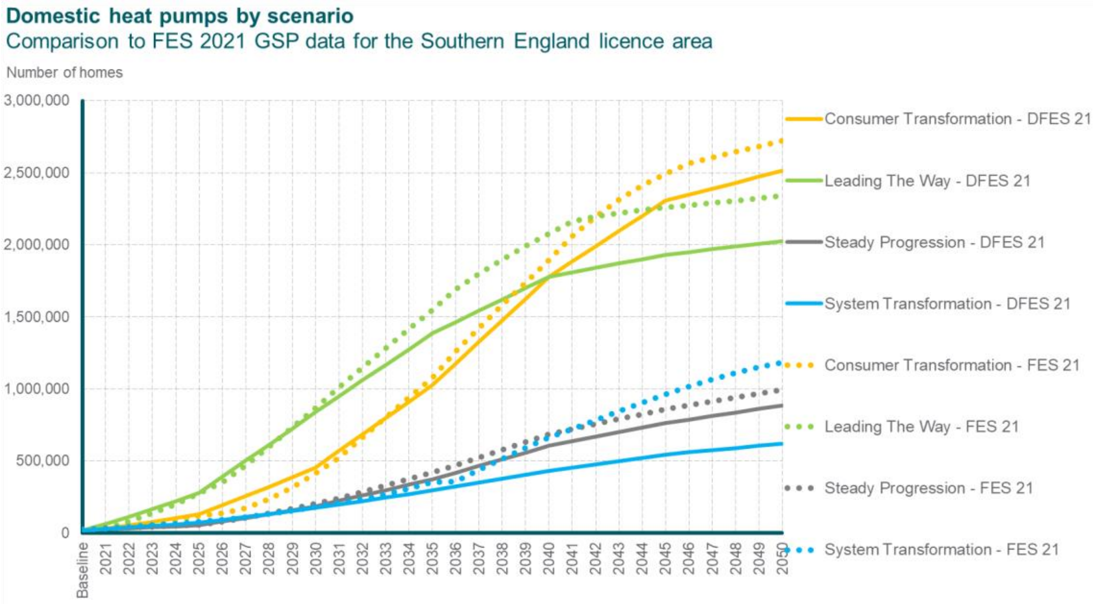


Figure 58: Non-domestic heat pumps (non-hybrid and hybrid) in the Southern England licence area, compared to National Grid FES 2021 regional projections

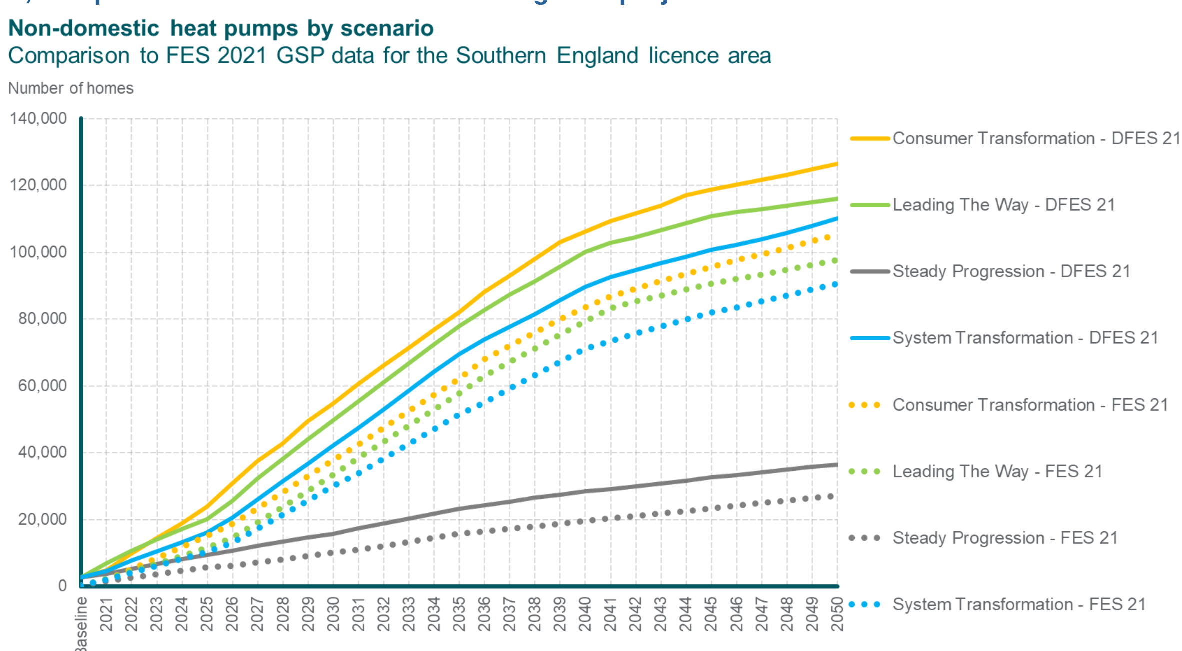
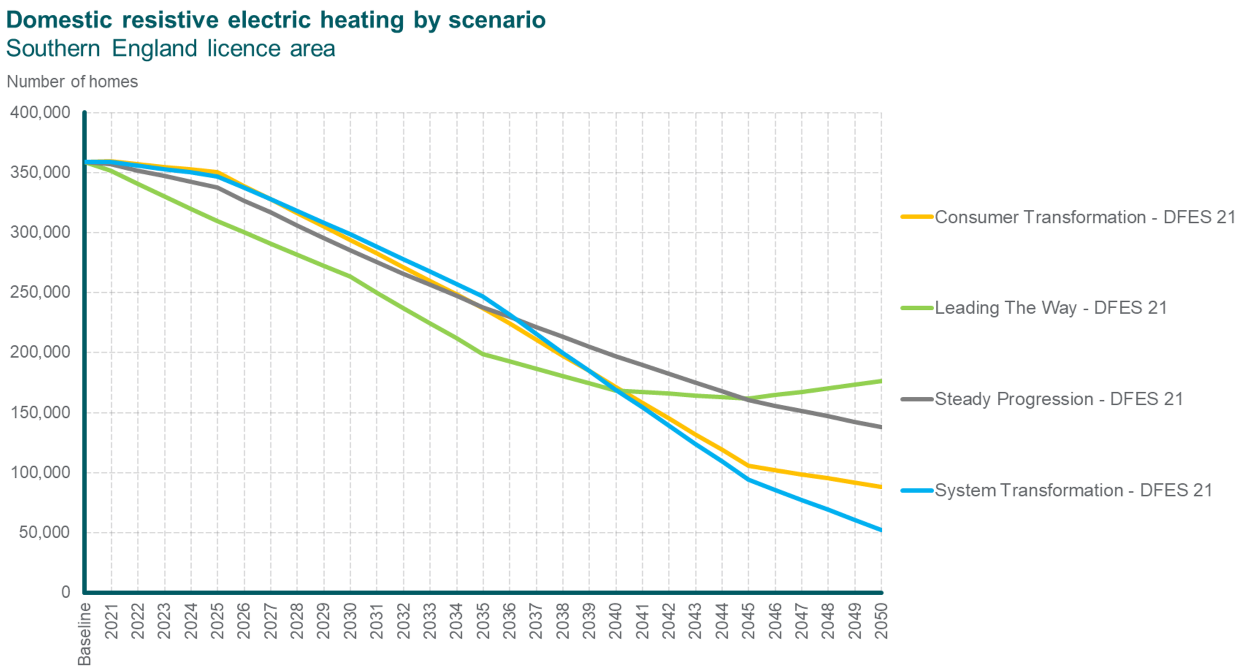


Figure 59: Domestic resistive electric heating in the Southern England licence area



Reconciliation with National Grid FES 2021:

The SSEN DFES 2021 analysis has been reconciled to the FES 2021 data for the relevant GSPs within the Southern England licence area.

The Building Block data provided in the FES 2021 classifies an 'ASHP with a resistive heating element' as a hybrid heat pump (Lct_BB006), whereas the DFES analysis considers this is to be a variation of a non-hybrid heat pump (Lct_BB005). Accordingly, the reconciliation has been undertaken using combined figures for both non-hybrid and hybrid heat pumps, as this specific form of heat pump cannot be accurately disaggregated from the FES data at a GSP level.

- In the near and medium term, domestic heat pump uptake in the Southern England licence area is in line with the FES 2021 regional projections.
- In the longer term, the licence area projections for total domestic heat pumps are below the FES 2021 data especially under **Consumer Transformation** and **Leading the Way**. The modelling assumes a relatively high deployment of district heating in the licence area under these scenarios, particularly in dense urban areas, as opposed to individual heat pumps. This may be the cause of the difference between the two sets of projections.
- Non-domestic heat pump uptake is slightly higher in the DFES outputs compared to FES 2021 in all scenarios. This is assumed to be due to 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 and Non-Domestic EPC and Display Energy Certificate data.
- There is no regional FES 2021 data for resistive electric heating. The scenario projections for the Southern England licence area are based on national FES trends, with consideration for the increased rate of heat pump deployment in the near and medium term in the licence area.

Factors that will affect deployment at a local level:

- The uptake of heat pumps is modelled to a very high level of granularity within the SSEN low voltage network. Domestic heat pump uptake was evaluated across over 400,000 individual feeders across SSEN's licence areas, while non-domestic heat pumps were evaluated across over 100,000 distribution substations.
- Various data were used to model local uptake of heating technologies, such as socio-demographic graphics, building attributes, and geographical characteristics.
- Key factors for the uptake of heat pumps are gas network connectivity, building characteristics such as energy efficiency and building type, and affluence and tenure.
- As levels of heat pump deployment increase, especially under **Consumer Transformation** and **Leading the Way**, uptake is assumed to become more evenly distributed across all types of homes and non-domestic buildings. In the longer term, as heat pumps become the most common heating technology in these scenarios, uptake is inevitably seen in areas that did not see high levels of deployment previously.

Relevant assumptions from National Grid FES 2021:

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

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

Stakeholder feedback overview:

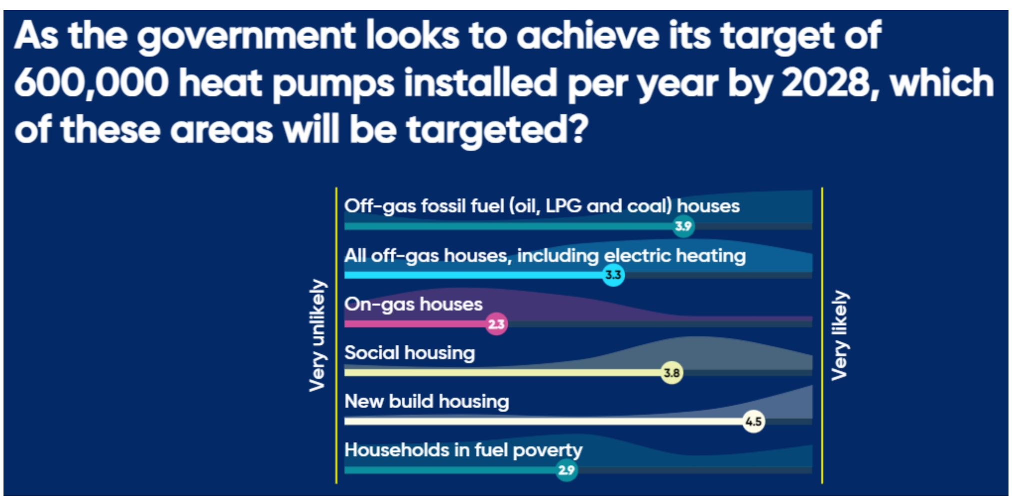
Regional stakeholders were consulted on various aspects of low carbon heat as part of a wider stakeholder engagement webinar. Stakeholders were presented information about the current heating technologies present in the licence area, then canvassed for opinions on where heat pumps may be prioritised in the near term and potential use cases for hydrogen.

A further workshop was held with stakeholders from Isle of Wight, alongside the SSEN and Regen teams. This included discussion around the decarbonisation of heat on the island, including how much heat decarbonisation might be aligned with national trajectories, and the role of different heat technologies on the island, such as hybrid heat pumps.

The table below summaries the key areas where stakeholder feedback has influenced the DFES analysis for electrified heat:

Heat pumps and resistive electric heating	
Stakeholder feedback provided	How this has influenced our analysis
In the context of the UK government's 2030 target for heat pump uptake, stakeholders thought that heat pumps deployment would be focussed in 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 understand which authorities had a low carbon heat strategy established or in development. However, this formed a minority of local authorities.	Heat pump uptake is weighted towards local authorities with low carbon heat strategies in the near term.

Figure 60: Stakeholder responses to heating question in the online engagement webinar



References:

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

[liv] https://www.gov.uk/government/publications/net-zero-strategy
[lv] https://www.gov.uk/government/publications/heat-and-buildings-strategy

Domestic air conditioning

Summary of modelling assumptions and results

Technology specification:

The analysis covers the number of domestic air conditioning (A/C) units, based on a typical portable or window-mounted air conditioner.

Technology building block: **Lct_BB014 (A/C domestic units)**

Data summary for domestic air conditioning in the Southern England licence area:

A/C units (thousands)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	25	44	87	179	351	693	1,340
System Transformation		40	72	124	227	404	707
Consumer Transformation		40	72	124	228	405	708
Leading the Way		25	26	26	26	26	26

Overview of technology projections in the licence area:

- Air conditioning is currently uncommon in UK homes, with just over 1% of homes currently containing an A/C unit.
- While regional data is not available for domestic A/C, the Southern England licence area is modelled to have units in around 0.9% of homes. This is based on analysis of cooling requirements and the building density of homes in the licence area.
- Increasing temperatures and falling costs of A/C units could result in increased uptake over the coming decades.
- With a minimal baseline and high levels of uncertainty around future cooling demand, as well as cooling methods, there is a wide range of scenario outcomes.
- This range results in minimal uptake under **Leading the Way**, compared to A/C becoming commonplace by 2050 under **Steady Progression**.

Scenario projection analysis and assumptions:

Baseline (up to end of 2020)

- There is limited data on domestic A/C in the UK, and no available data at a regional level. A 2016 report by Tyndall Manchester[lvi] suggested that 1-3% of UK households had A/C in some form.
- The analysis is aligned with the National Grid FES 2021 A/C demand data, from which a national baseline of c.300,000 domestic air conditioner units has been derived.
- Using regional temperature data and the characteristics of the licence area's building stock, this national figure was disaggregated to determine a regional baseline.
- This results in a modelled baseline of 25,000 domestic A/C units in the Southern England licence area.

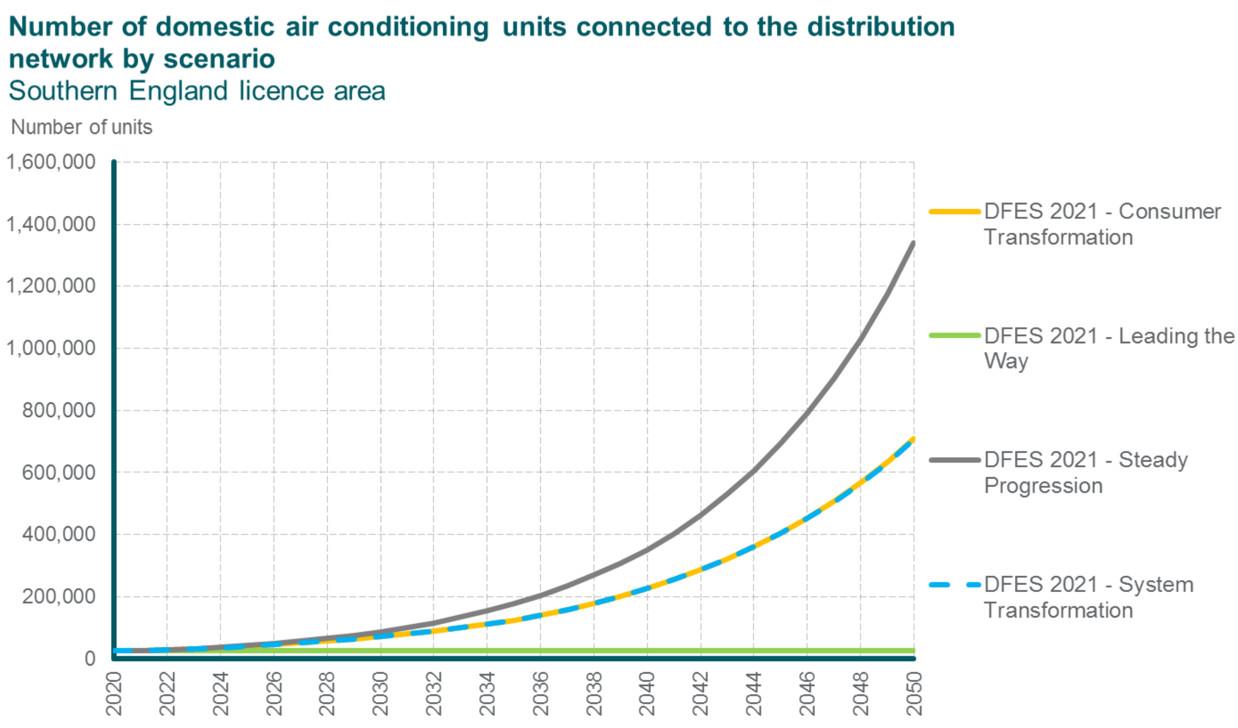
Near term (2020 – 2025)

- Near-term uptake of domestic A/C is limited in all scenarios. Domestic A/C is associated with high upfront and running costs and is not seen as necessary in most homes.

Medium and long term (2025 – 2050)

- The uptake of A/C accelerates in the medium term in all scenarios.
- Under **Steady Progression**, increasing summer temperatures and limited deployment of passive cooling measures lead to rapidly accelerating uptake of domestic A/C. By 2050, 48% of existing homes in the licence area (c.1.3 million) have an A/C unit in this scenario.
- Under **Consumer Transformation** and **System Transformation**, uptake of domestic A/C accelerates, especially in urban 'heat island' areas. However, increased deployment of passive cooling measures limits uptake. In these scenarios, 25% of homes in the Southern England licence area (c.708,000) have an A/C unit by 2050.
- Under **Leading the Way**, domestic A/C remains rare, with cooling requirements met through more sustainable methods such as high levels of passive cooling deployment, coupled with behaviour change. Throughout the scenario timeframe, around 1% of homes in the licence area (c.26,000) have an A/C unit.

Figure 61: Domestic air conditioning projections for the Southern England licence area



Reconciliation with National Grid FES 2021:

- The FES 2021 does not directly detail numbers of domestic A/C units, thus direct comparison is not possible. However, annual electricity demand for domestic A/C is provided at a national level, alongside typical consumption values for domestic A/C units. This allows for reconciliation against national figures, at a high level.

- The Southern England licence area covers one of the warmest regions in the UK. Temperature data shows the licence area has significantly more cooling degree days at 18.5°C than the national average.
- Housing density in the Southern England licence area is similar to the national average. A/C uptake is anticipated to be focussed in dense urban 'heat islands', which feature in the Southern England licence area around Greater London, Southampton, Swindon and Oxford etc.
- As a result, the proportion of homes with an A/C unit in the Southern England licence area is slightly above the FES 2021 national average in every scenario.

Factors that will affect deployment at a local level:

- Affluence is a key factor in the distribution of domestic A/C, given the high upfront and running costs of domestic units. This is weighted most strongly in the near term, where A/C is an uncommon 'luxury' in all scenarios.
- Property tenure is also a significant factor in the near term, due to the greater likelihood of homeowners to invest in relatively expensive home improvements such as A/C, compared to tenants that are renting or landlords.
- Urban 'heat island' areas are seen as drivers in the uptake of domestic A/C in the medium and long term. Urban areas also contain higher proportions of flats, which have a lower ratio of external surface area to floorspace, which prevents heat from escaping effectively at high temperatures.

Relevant assumptions from National Grid FES 2021:

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

References:

National Grid ESO FES 2021 data, UK cooling degree days data, Census 2011.

[lvi] See *Air conditioning demand assessment* report by Tyndall Manchester, May 2016: https://www.enwl.co.uk/globalassets/innovation/enwl001-demand-scenarios--atlas/enwl001-closedown-report/appendix-3---tyndall-uom---air-conditioning-demand-report-may2016.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 ('behind-the-meter') or large-scale electrolysers connected to the transmission network. Nor does it include CCUS-enabled hydrogen produced via the reformation of natural gas or other fossil fuels.

Technology building block: **Dem_BB009 (hydrogen electrolysis)**

Due to a lack of GSP level data for this building block, SSEN DFES 2021 projections have been compared to FES 2021 figures at a national level.

Data summary for hydrogen electrolysis in the Southern England licence area:

Installed power capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
Steady Progression	1.2	1.3	15	88	88	88	88
System Transformation		5	30	137	311	610	821
Consumer Transformation		5	61	789	1,156	2,141	2,996
Leading the Way		19	253	768	1,094	1,598	1,944

Overview of technology projections in the licence area:

- There is significant uncertainty around the development of hydrogen electrolysis as an emerging technology. The main sources of uncertainty are:
    - The split of capacity that may connect to the distribution network or transmission network
    - The contribution of hydrogen electrolysis to national hydrogen aims, compared to CCUS-enabled hydrogen (i.e. blue hydrogen produced via methane reformation)
    - The types of connection arrangements for hydrogen electrolysers, including behind-the-meter co-location with renewable generation
    - The range of end-uses for hydrogen, including transport, industrial processes, aviation and shipping, power generation and heating
    - Major government policy decisions regarding revenue support that are still to be finalised
    - How far and how quickly hydrogen costs will fall.
- Ofgem's announcement of their minded-to decisions related to the Network Access and Charging Significant Code Review could be beneficial for hydrogen electrolysers, if it leads to reduced network connection charges. This is modelled to be a factor under **Leading the Way** and **Consumer Transformation**.

- The Southern England licence area 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, the Southern England licence area has the potential to host a number of hydrogen hubs.
- The largest capacity of distribution-connected hydrogen electrolysers in 2050 in the Southern England licence area is modelled under **Consumer Transformation** (3 GW) and **Leading the Way** (1.9 GW). This reflects a focus on hydrogen as a widespread zero carbon fuel for use in transport, industrial processes, shipping and heating.
- In contrast, the least capacity is modelled under **Steady Progression** (88 MW) reflecting limited government policy support for this technology and the assumption that high construction, production and commodity costs limit the rollout of electrolysis.

Scenario projection analysis and assumptions:

Baseline (up to the end of 2020)

- There is 1.2 MW of hydrogen electrolysers connected to the distribution network in the Southern England licence area.
- This comprises three hydrogen refuelling stations, two in Swindon and one in Beaconsfield.
- ITM Power operates two 0.1 MW electrolysers in Swindon and Beaconsfield. ITM Power plans to upgrade these stations to 0.7 MW in the near future.
- BOC operates an electrolyser located at Honda Manufacturing in Swindon. While this was operational during 2020, it has since been decommissioned with the closure of the Honda factory in July 2021[lvii].

Near term (2020 – 2025)

- In the near term, **Leading the Way** sees the highest increase in connected capacity, reflecting strong government support for hydrogen. This is likely to be focused on transport, including the introduction of hydrogen buses and HGVs.
- Swindon and Oxford have been identified as future hydrogen hubs, particularly for hydrogen-powered transport. Swindon already has two hydrogen refuelling stations, while Oxford hopes to use hydrogen and fuel cell technologies to achieve their net zero target[lviii].
- Hydrogen is set to be a crucial part of the UK's net zero targets, and a number of future projects have been announced or are in discussion.
- Some projects that have been identified, which aim to be operational before 2025, include:
    - Canford Renewable Energy wants to expand its operations at a former landfill site at Canford Resource Park to include a solar park and a hydrogen fuel processing plant. It has been awarded a grant of £1.5m by Low Carbon Dorset and has been granted planning permission in 2021[lix].
    - Hydrogen refuelling stations in both Perivale, Ealing and Fawley, Southampton received planning permission in 2020.
- By the end of 2025 electrolyser capacity in the licence area ranges from 1.3 MW under **Steady Progression** to 19 MW under **Leading the Way**.

Medium term (2025 – 2035)

- Hydrogen produced via electrolysis will be used for transport across all scenarios, favoured over CCUS-enabled hydrogen due to its increased quality/purity.
- As a result, hydrogen electrolysis capacity is likely to increase in the medium term across all scenarios. This is driven by the uptake of hydrogen-fuelled heavy vehicle fleets and the introduction of mainstream hydrogen fuel cell public transport. This transition to low carbon heavy vehicles will be further incentivised by wider transport decarbonisation policy measures, such as the ban on the sale of new petrol and diesel cars by 2030.
- The M4 runs through the middle of the Southern England licence area, hence it is likely to be a prominent area for future hydrogen refuelling stations.
- Location of major ports and marine/shipping activity, such as the Isle of Wight, Portsmouth and Gosport, are also likely to be key hubs for hydrogen electrolysis for marine transport.
- Large thermal industrial, chemical and processing users within the Southern England licence area could also convert to hydrogen instead of using fossil fuels under some scenarios. Whilst there is currently no government mandate that requires industry to decarbonise earlier than 2050, fears over the impact of carbon pricing have encouraged industrial users to seek low carbon alternatives, including the potential use of hydrogen.
- Research has identified some additional opportunities in the Southern England licence area:
    - SGN have launched a comprehensive study of the Southampton region's hydrogen opportunities, exploring the potential of a hydrogen super-hub[lx]. Southampton is one of six major industrial clusters identified by the UK government. It is unclear whether this project is targeting CCUS-enabled hydrogen or hydrogen electrolysis.
    - Wales and West Utilities have been given the go-ahead to inject hydrogen into the gas grid in Swindon. While this only covers up to 1% hydrogen, it could make Swindon a good location to produce hydrogen in the future[lxi].
- Under **Consumer Transformation** and **Leading the Way**, it is expected that hydrogen electrolysis will achieve cost parity with CCUS-enabled hydrogen by the mid-2030s.
- From consultation with electrolyser manufacturers, 5 MW and 10 MW electrolyser units are anticipated to become commercially viable in the medium term. This will allow existing and new sites to scale up their installed capacity.
- **System Transformation** does not see electrolysis reaching cost parity in the same timeframe, so CCUS-enabled hydrogen is the favoured production method, particularly for decarbonising industrial clusters and heating homes.
- Under **Steady Progression**, there is little policy support for hydrogen production in general.
- As a result of these sector developments, **Consumer Transformation** and **Leading the Way** see unprecedented growth in capacity between 2025 and 2035, with 783 MW and 749 MW of additional capacity, respectively. This growth in capacity is in line with the UK government's target of 5 GW clean hydrogen capacity by 2030[lxii].
- In contrast, **System Transformation** and **Steady Progression** see limited growth in capacity in the medium term, with 132 MW and 87 MW of additional capacity, respectively.

Long term (2035 – 2050)

- In the long term, electrolysers are expected to scale their capacity by increasing the number of modules connecting to a compressor. This means that the development of new sites is likely to slow, and instead, existing locations are likely to be expanded to cater for higher demand.
- **Leading the Way** and **Consumer Transformation** continue to experience further increased deployment of hydrogen electrolysers, seeing more than a doubling of capacity in each scenario between 2035 and 2050.
- This is due to a number of factors, including:
  - Wider hydrogen sector developments, i.e., the repurposing of large-scale storage facilities for hydrogen and a decrease in upfront costs, as hydrogen electrolyser capacity increases across the UK
  - Demand for hydrogen from a variety of sectors, including heating, industrial demand, road transport, power, shipping and aviation
  - The coupling of hydrogen electrolysis with renewable generation in high-renewables scenarios.
- In **Consumer Transformation**, electrolysers are located close to demand as a national hydrogen network is not expected. This results in more, small-scale electrolysers connecting to the distribution network, close to demand. In 2050, electrolyser capacity reaches 3 GW, the highest of the four scenarios.
- In **Leading the Way**, a national hydrogen transmission network allows production capacity to increase rapidly. This could favour transmission-scale production, resulting in the growth of hydrogen electrolyser capacity on the distribution network in this scenario tapering in the long term, resulting in 1.9 GW connected by 2050.
- **System Transformation** and **Steady Progression** have significantly lower electrolyser capacity connecting by 2050, due to a focus on CCUS-enabled hydrogen.

Key modelling assumptions:

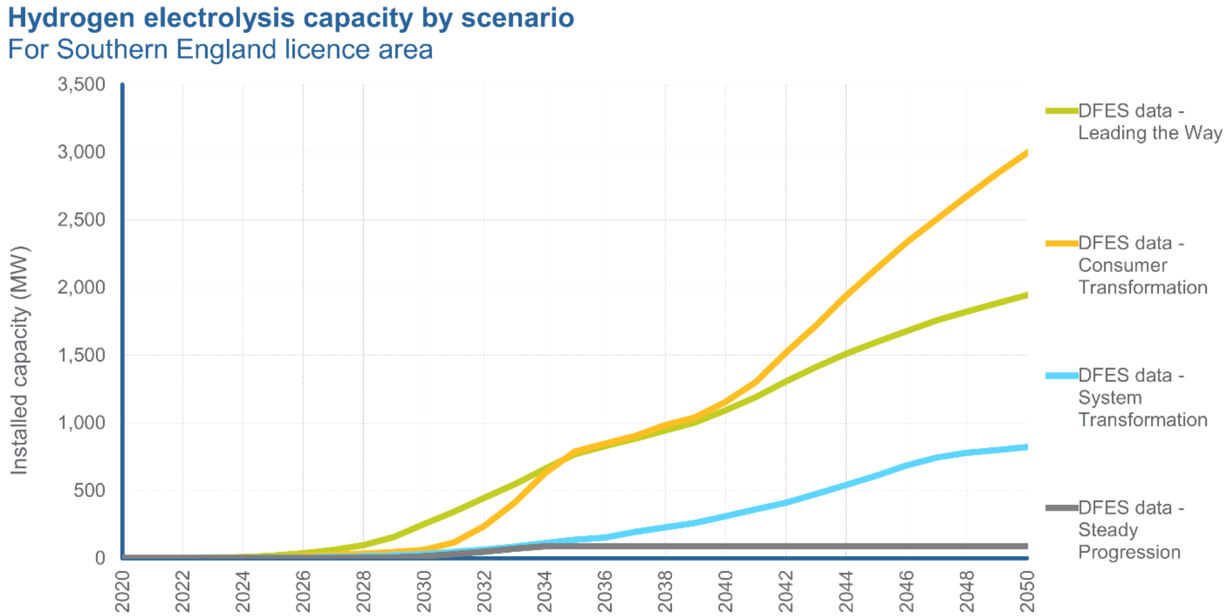
- **Leading the Way**, **Consumer Transformation** and **System Transformation** have been modelled with total GB hydrogen electrolysis capacity split between the transmission and distribution networks. Total distribution connected capacity is modelled to account for 31%, 74% and 22% of the total capacity, respectively.
- **Steady Progression** is the only scenario to have all grid-connected hydrogen electrolysis (100%) modelled on the distribution network.
- All scenarios project electrolytic hydrogen to be used in transport applications. Hydrogen refuelling infrastructure is likely to be co-located with existing petrol stations, particularly ones with high HGV fuelling demand.
- In scenarios where CCUS-enabled hydrogen is also present in the energy mix, it is assumed this is used to decarbonise existing high-carbon hydrogen production and the majority of industrial clusters.
- As a new technology, it is not clear how electrolysers co-located with renewable generation will connect to the grid. It is therefore assumed that hydrogen production co-located with renewable generation, but with its own grid connection, will connect to the same network as the renewable generation site itself.

From engaging electrolyser developers, a number of factors influencing the location of sites were identified, as seen in Table 5. These factors were weighted based on the assumptions underpinning the four FES scenarios and used to create licence area projections.

Table 5 - Locational factors used in the modelling of hydrogen electrolysis capacity, by scenario

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

Figure 62: Hydrogen electrolysis projections for the Southern England licence area, compared to National Grid FES 2021 regional projections



Reconciliation with National Grid FES 2021:

Results in this section pertain to FES 2021 Building Block ID number Dem_BB009; however, due to a lack of GSP level data for this building block, reconciliation is difficult. Instead, the SSEN DFES 2021 projections have been calculated as the distribution network proportion of FES 2021 grid-connected hydrogen electrolysis capacity at a national level. These were calculated based on the locational factors outlined in Table 5, including the location of existing hydrogen production sites, large industrial clusters and heavy transport demand.

- As a result, hydrogen electrolysis capacity in 2050 in the Southern England licence area under **Leading the Way** equates to 3% of the FES 2021 national grid-connected hydrogen electrolysis capacity. **Consumer Transformation** (8%) and **System Transformation** (3%) have assumed there is capacity on both the transmission and distribution networks.
- **Steady Progression** models 7% of FES national capacity to be connected to the distribution network in the Southern England licence area, with all capacity in this scenario assumed to be connected to the distribution network.

Factors that will affect deployment at a local level:

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

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

Relevant assumptions from National Grid FES 2021:

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

Stakeholder feedback overview:

Hydrogen electrolysis	
Stakeholder feedback provided	How this has influenced our analysis
A range of stakeholders were engaged through a dedicated Southern England DFES workshop, where Menti was used to gauge stakeholders' views. There was a range of opinions on Southern England as a producer of green hydrogen.	Stakeholders concluded that the best uses of hydrogen are as a fuel for shipping, ferries and large road vehicles, and for firing industrial processes. This has been included in the methodology as locational factors that influence the distribution of hydrogen electrolysis, as well as the allocation of "hydrogen hubs". The uncertainty in future hydrogen production has been reflected in the range of 2050 projections, from 88 MW to 3 GW.
A workshop was held with representatives from the Isle of Wight. It was noted that the potential for hydrogen electrolysis is very polarised, and that much of it depends on SGN's plans for the island.	The range of future scenarios has been captured in the contrasting scenarios of **System Transformation** (high hydrogen scenario, but mainly CCUS-enabled) and **Consumer Transformation** (high electrification scenario).

References:

IEA hydrogen project database, FES 2021 data workbook, Network Rail Traction Decarbonisation Strategy, the Renewable Energy Planning Database, Regen consultation with ITM Power, UK Hydrogen Strategy, National Atmospheric Emissions Inventory, BEIS energy consumption dataset, Department for Transport local authority vehicle miles data, UK Carbon Capture and Storage Research Centre, 2011 Census data, Regen consultation with local stakeholders and discussion with developers, Regen questionnaire and consultation with local authorities.

[lvii] Honda announces proposal to cease production at its Swindon factory in 2021: https://hondanews.eu/gb/en/cars/media/pressreleases/161911/honda-announces-proposal-to-cease-production-at-its-swindon-factory-in-2021

[lviii] See Oxfordshire Hydrogen Hub: https://www.hydrogenhub.org/2018/03/16/launch-oxfordshire-hydrogen-hub/

[lix] Canford Renewable Energy hydrogen plant: https://www.bbc.co.uk/news/uk-england-dorset-57986600

[lx] Southampton hydrogen super-hub: https://www.sgn.co.uk/news/were-exploring-potential-of-hydrogen-super-hub-port-of-southampton

[lxi] Wales & West Utilities gets go-ahead to inject hydrogen to grid in Swindon: https://www.wwutilities.co.uk/news-and-events/wales-west-utilities-gets-go-ahead-to-inject-hydrogen-to-grid-in-swindon/

[lxii] UK Hydrogen strategy: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011283/UK-Hydrogen-Strategy_web.pdf

Data centres

Summary of modelling assumptions and results

Technology specification:

The analysis covers large data centres connected to the distribution network in the Southern England licence area. No equivalent technology building block currently exists, but engagement with the ESO FES team has suggested data centres will be incorporated into FES 2022.

Data summary for data centres in the Southern England licence area:

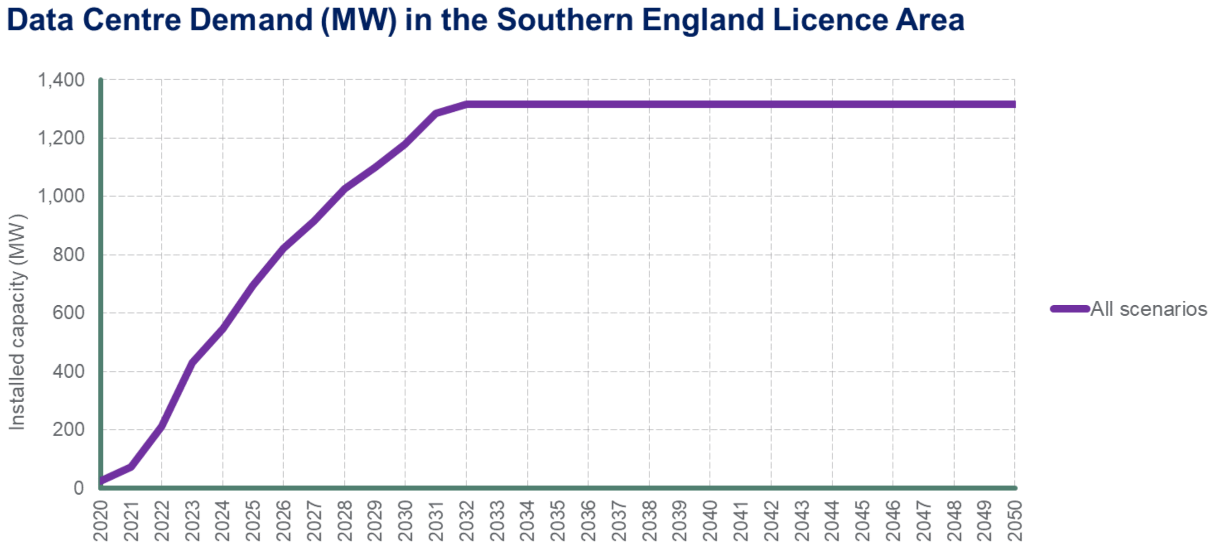
Installed power capacity (MW)	Baseline	2025	2030	2035	2040	2045	2050
All scenarios	--	693	1180	1315	1315	1315	1315

Overview of technology projections in the licence area:

- New large-scale data centres were included as a source of future demand for the first time in DFES 2020. A pipeline of known new sites with accepted connection offers was assessed across the Southern England licence area.
- In the DFES 2020, this demand comprised 13 sites that were developed and brought online across the 2020s, culminating in 665 MW of new demand by 2026.
- SSEN connection data for DFES 2021 has seen this pipeline of new data centres increase significantly to 27 sites, totalling 1.3 GW.
- Six of these data centres have an accepted import capacity of 100 MW or more, totalling 784 MW (the largest individual site being 160 MW).
- Through discussions with SSEN network planners, many of these sites have proposed staged development, where a proportion of the full accepted import connection is modelled to come online over 3-5 years (depending on the capacity).
- Five sites, totalling 207 MW, have also successfully secured planning approval.
- This represents a significant amount of new electricity demand on the distribution network in the Southern England licence during the 2020s.
- The increased interest in data centres can be partially related to a number of businesses looking to move their data server infrastructure offsite, as a positive action against their own scope 1 and 2 carbon emissions.
- Once committed, data centre projects tend to have a high acceptance rate and likelihood of being brought online. The DFES 2021 projections have therefore been modelled to be the same across all four scenarios.
- Beyond these known projects, no additional capacity has been projected. This is due to the lack of future development data, as well as the absence of FES 2021 scenario projections nationally or regionally and minimal long-term forecasts or market information.
- A recent report published by BloombergNEF[lxiii] suggests that under a high-growth scenario, the UK could see c.2 GW of operational data centre capacity by 2030.
- The pipeline seen in the Southern England licence area indicates several hot spots as prime regions for developers, potentially based on access to high-speed internet connectivity and appropriate land on which to develop sites.

Scenario projection analysis and assumptions:

Figure 63: Data centre projections for the Southern England licence area



Reconciliation with National Grid FES 2021:

There are no equivalent projections for new data centres in the FES 2021 to reconcile these DFES 2021 projections against.

Factors that will affect deployment at a local level:

The DFES analysis for data centres focuses entirely on existing known pipeline sites. Therefore, spatial distribution references the site locations of these as known future sites.

References:

SSEN connection offer data, local planning portals.

[lxiii] Bloomberg New Energy Finance, Statkraft and Eaton 2021, *Data Centres and Decarbonisation: Unlocking flexibility in Europe's Data Centres* . Full report available for download at https://content.eaton.com/en-gb-datacentre-bnef-download?percolateContentId=post:1424691567933983940
Executive summary available at https://www.eaton.com/content/dam/eaton/company/news-insights/energy-transition/documents/bnef-data-centers-and-decarbonization-executive-summary.pdf

New property developments

Summary of modelling assumptions and results.

Technology specification:

New property developments can have a significant impact on local electricity demand and therefore forecasts of new housing and commercial and industrial (C&I) builds have been included in 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.). These correspond to the following FES technology building blocks:

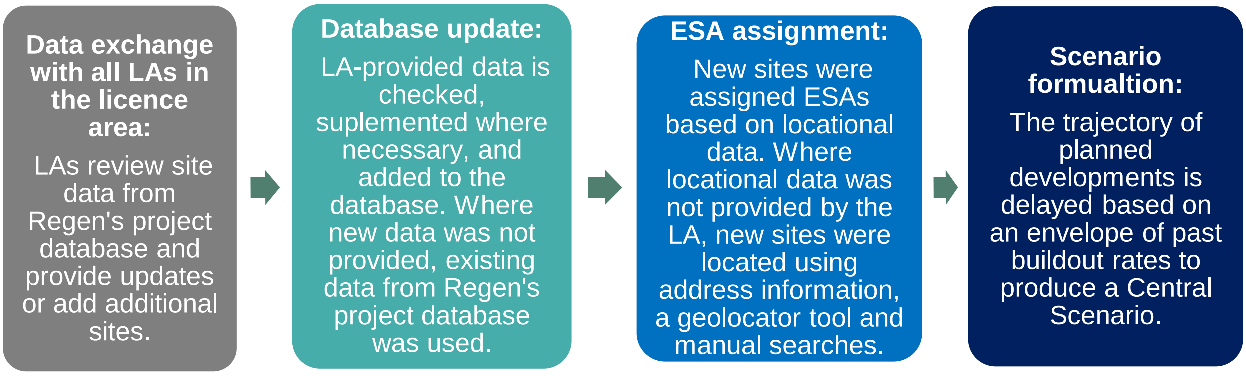
- Number of domestic customers - **DFES technology building block Gen_BB001a**
- Meters squared of I&C customers - **DFES technology building block Gen_BB002b**

Data on planned domestic and non-domestic developments is gathered through a data exchange with all local authorities (LAs) in the Southern England licence area. The process made use of an online data portal, together with individual engagement with local authority planners and data providers. Desk based research and site investigation has helped to validate and augment the data supplied.

Alongside historic build rates, the data provided by the LAs is used to inform licence area projections for future housing numbers and non-domestic floorspace (sqm).

Summary of process and assumptions:

Figure 64: Summary of methodology for new developments analysis



Database update and ESA assignment

- Through engagement with LAs, Regen's database of new developments was updated to inform the DFES 2021 analysis.
- This database contains information on development location, size, likely use (for non-domestic), development stage and planned buildout timescale.
- Every LA within the licence area was contacted and invited to verify or update their datasheets via a SharePoint site. Over half of the LAs in the licence area provided new data through the SharePoint or directly to the project team. For the remaining LAs, Regen's existing new developments data, developed through previous DFES iterations, was used to inform this year's projections.
- All sites are geographically assigned an ESA, via the following method:
  - Most could be carried over from Regen's existing project database.
  - For newly provided developments with locational data, ESAs were assigned using GIS mapping. Large sites near an ESA border were manually checked and split across the neighbouring ESAs as appropriate.
  - The remaining sites are assigned ESAs using a geolocator tool, supplemented by manual searching and investigation of individual sites.

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

Delay factors and historic build rates

- The timeline and build out rate of new developments is a key source of uncertainty. Developer suppled data typically comes with a high degree of "optimism bias" with almost all developments nominally scheduled for completion within a 5 year timeframe.
- Planned developments peak in the medium term; it is likely that a proportion of these developments will be subject to delays. For the purpose of network planning, the model applies delay factors to planned buildout timescales. In this way, the location and scale of development is maintained, but the period over which the sites are built is extended.

Table 6: Domestic delay factors, the percentage of domestic developments which are completed as planned, with the remainder delayed.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030-2040
Central Scenario	100%	80%	80%	80%	80%	80%	80%	75%	65%	90%

- The past ten years of build out data is used to define an annual average housebuilding rate.
- Government projections that forecast a levelling off in the growth of household numbers are also considered.
- These delay factors, the historic housebuilding rates and government projections are then used to define a **Central Scenario** projection for new domestic property developments.
- There is no historic build rate data or future projections available for non-domestic developments. Only delay factors are used to account for project delays and define the non-domestic **Central Scenario**.

Table 7: Non-domestic delay factors, the percentage of non-domestic developments which are completed as planned, with the remainder delayed.

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030-2040
Central Scenario	90%	45%	40%	40%	40%	40%	40%	40%	40%	40%

Residual sites and modelled development

- The domestic analysis seeks to capture all significant developments, constituting 100 homes or more. Analysis of previous new developments studies suggests this cut-off leaves about 15% of homes un-recorded, so an estimation of these residual small-scale sites is modelled and included in the **Central Scenario** projection.
- Given typical development timeframes, there is a natural reduction in the data for planned developments after 2025. Additional domestic developments are modelled post 2025, this modelled development brings the long-term trajectory in-line with the **Central Scenario**.
- There are no residual sites or modelled developments for non-domestic developments.

Scenario projection analysis and assumptions:

- For the SSEN DFES 2021 a **Central Scenario** is used rather than four FES scenarios, as the analysis is based on known property development information provided by LAs.

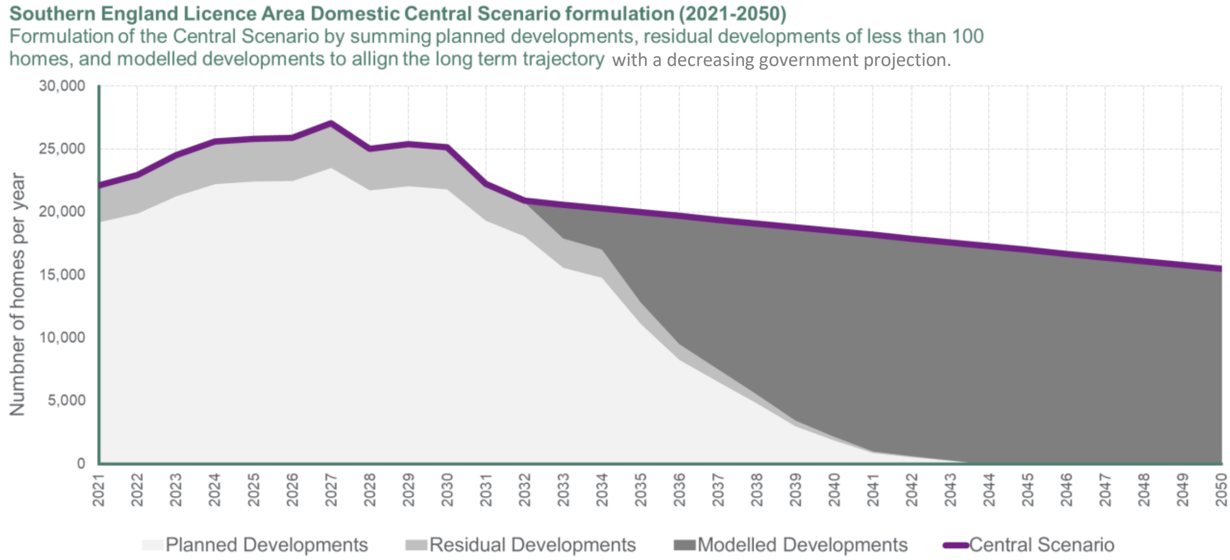
Data summary for cumulative new properties in the Southern England licence area

Classification of new property development	Near-term projections of known developments			Modelled projections of new developments beyond 2030		
	2025	2030	2035	2040	2045	2050
New domestic properties (number of houses)	121,014	249,586	353,616	449,092	537,068	617,545
New non-domestic development floorspace (sqm)	3,584,596	6,281,713	8,043,553	8,293,866	8,332,653	8,349,615

New domestic properties

- For the Southern England licence area, the **Central Scenario** for new domestic property developments decreases from a historic average build rate of 23,000 homes annually in the near term, before declining to be in line with government projections from 2030-2050.
- This equates to a cumulative total of just over 617,000 new domestic properties by 2050.

Figure 65: Domestic Central Scenario and it's formulation

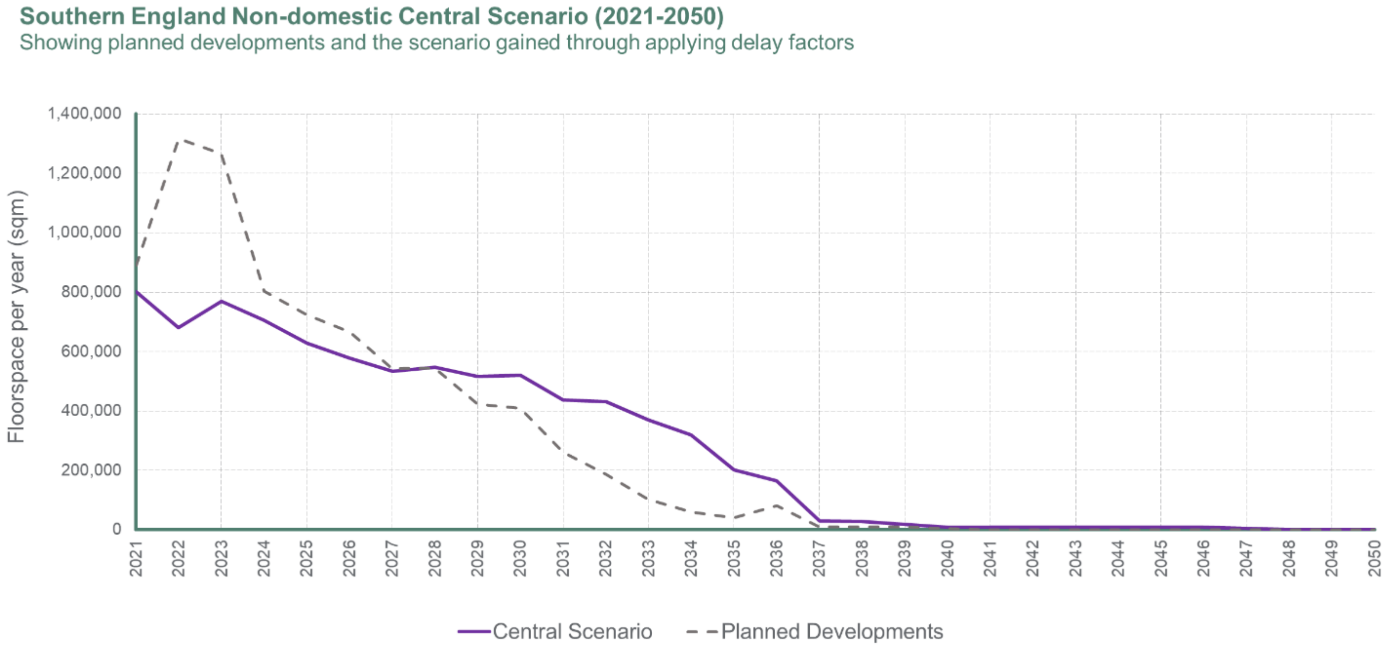


- Berinsfield South Oxfordshire is the ESA with the highest number of domestic developments projected to be built, at over 8,000 homes. This is driven by large mixed-use developments near Culham Science Centre and at Chalgrove Airfield, due to build out from 2025.
- These projections also inform the analysis of domestic technologies such as electric vehicles, heat pumps and rooftop solar PV. The spatial data from the local plans define where on the SSEN distribution network these technologies may be located in the future.

New non-domestic developments

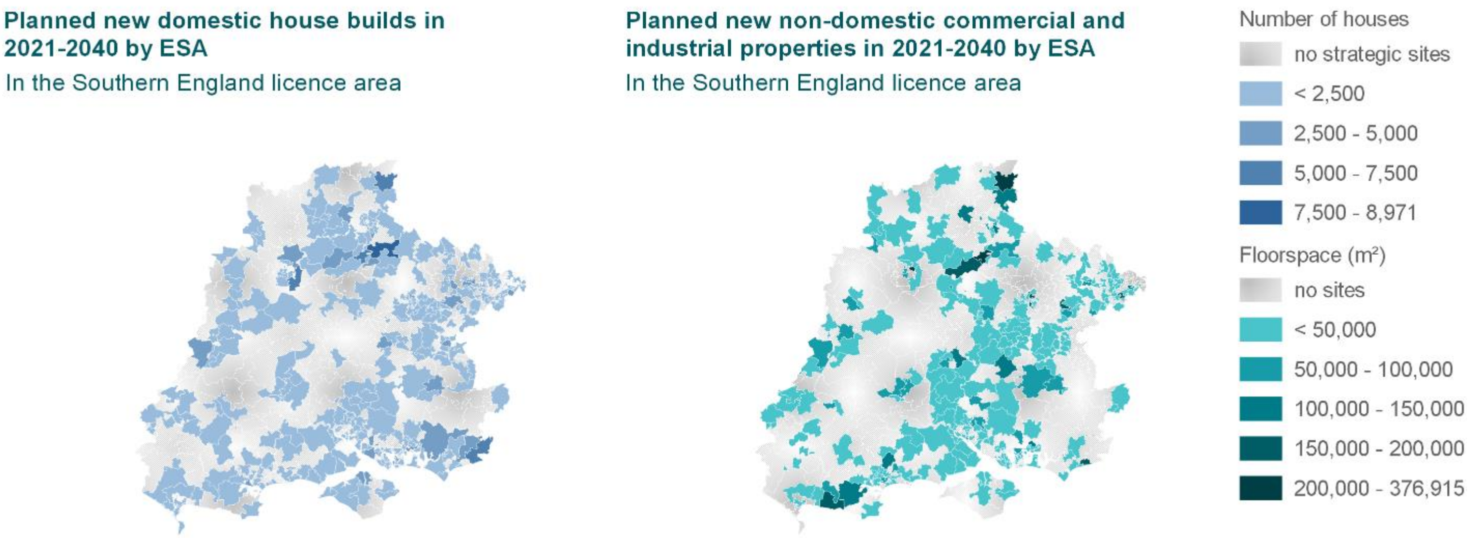
- For the Southern England licence area, the **Central Scenario** for non-domestic developments has modelled a decrease from 800,000 sqm of floorspace added annually in the near term to just under 200,000 sqm by 2035.
- This equates to a cumulative total of just over 8.3 million sqm by 2050.

Figure 66: Non-domestic planned developments and Central Scenario



- Of the planned non-domestic developments, 30% are new factory and warehouse developments and 32% is new office space.
- Milton - Vale of White Horse is the ESA with the greatest amount of non-domestic floorspace due to be developed at around 375,000 sqm. Of this, factory and warehouse accounts for 230,000 sqm. This is driven by developments adjacent to Didcot Power Station which are currently under construction.

Figure 67: Distribution of planned developments over the licence area



Stakeholder engagement:

- The initial stage of this process is reliant on engagement with LAs in the licence area. Over half of the LAs provided new data through a SharePoint site, or directly to the project team. For the remaining LAs, Regen's existing project database was used.
- With many LAs engaging directly with the process, the projections are based on the most accurate and up to date information available.
- Some LAs were not able to provide information within the timeframe of the project, especially due to resourcing pressures as a result of the ongoing COVID-19 pandemic.
- Regen's project database ensured that all LAs were represented with recent high granularity development data wherever possible.
- Large non-domestic developments (over 50,000 sqm floorspace) were subject to additional analysis, due to their impact on future demand. This involved further contact with LAs to confirm developments, their size, and expected buildout.
- More specifically, any site which appeared to have large open areas, including airports, spaceports, and marine parks, were highlighted and brought to the attention of the LAs.
- An additional category was considered to encompass these developments due to their distorted area/floorspace ratio. However, LAs confirmed that only two of these developments were due to build out, and the decision was made to continue using the 'other' classification with an updated floorspace.
- Alongside the new developments data exchange, the LAs were also asked about existing or draft decarbonisation strategies for energy, transport, waste, and heating in their local area. This data was used to inform analysis within the wider SSEN DFES 2021.