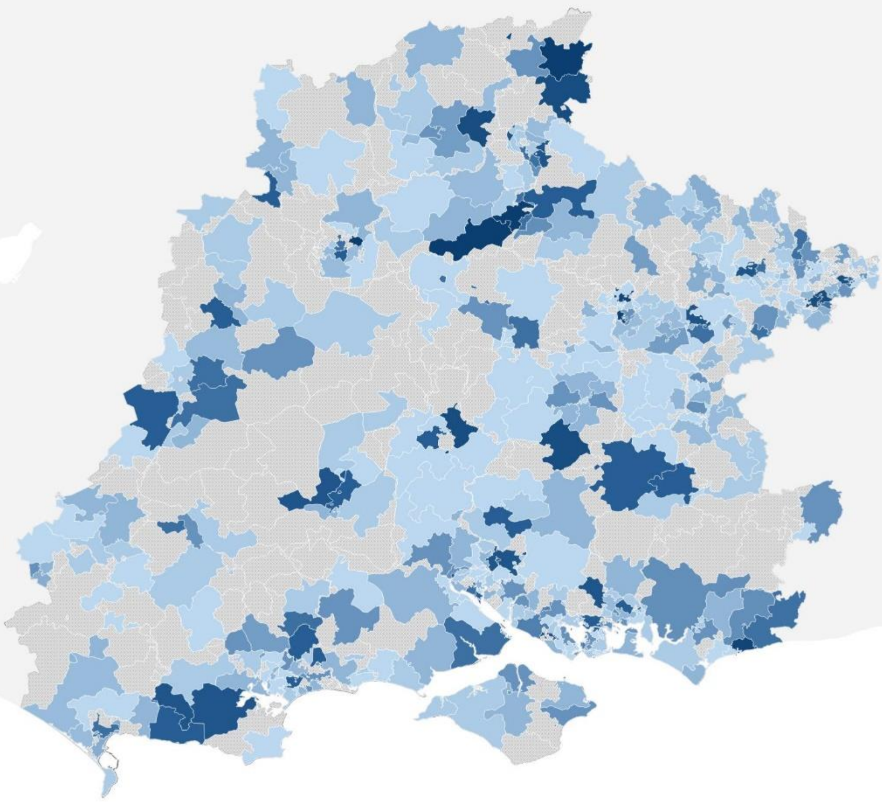
Distribution Future Energy Scenarios 2020 Southern England licence area

Results and methodology report

Produced: December 2020

Version: Final



regen transforming energy

Scottish & Southern Electricity Networks

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Foreword

Scottish and Southern Electricity Networks (SSEN) is responsible for the safe supply of electricity to over 8 million people in 3.8 million homes in the north of Scotland and central southern England.

As part of SSE Group, SSEN is a principle partner of the UK Government's hosting of COP26 the international climate change summit scheduled to take place in 2021, that will have a key role in focusing and driving international decarbonisation efforts.

Climate change is an international problem that requires local solutions. The transition to net zero will tangibly change how our customers experience and engage with the energy system that serves them. The UK and Scottish Governments have demonstrated the leadership that this challenge demands with respective 2050 and 2045 net zero targets. SSEN is committed to supporting these ambitions and enabling the action that is required.

According to the Climate Change Committee's 6th Carbon Budget, electricity demand could treble by 2050. The work REGEN has undertaken in this and previous reports for SSEN has been invaluable in supporting informed decision making and targeting investment. The data gathered and set out here highlights the action that the net zero ambition requires and the pace of change we can expect.

The ban of the sale of new diesel and petrol vehicles by 2030 and the target of installing 600,000 heat pumps a year by 2028 will make a significant impact in reducing the carbon impact of two of the UK's largest emitting sectors.

The next regulatory price control period for distribution networks (RIIO-ED2 2023-28) will have a crucial role in enabling the changes this report sets out. We are constructively engaging with Ofgem to support a settlement that empowers local communities, enables strategic investment and supports a cost-effective transition to net zero.

The sharing of data will be critical on this journey. Open data can be a catalyst to securing change, empowering customers and service providers that enables informed decision making across the energy ecosystem. We will be seeking to use this report to direct and inform conversations with our customers and key stakeholders.

SSEN is working with local communities and local authorities in understanding their net zero ambitions and how we can support and enable the realisation of their goals. This report has a key role in informing and directing those conversations. It sets the path that we, and the communities we serve, need to take to play our role in meeting the UK's net zero ambitions.

For SSEN net zero means: accommodating substantial numbers of electric vehicles, heat pumps and a range of other smart and low-carbon technologies; supporting the development of new markets that provide flexibility solutions that enables a cost-effective transition; and working collaboratively with our customers to ensure their needs are accounted for and met to deliver an equitable net zero future.

I'd like to thank Regen for their work on this illuminating and timely report, and to thank all our stakeholders, including local and regional authorities, who have contributed to the research. We hope it will add to the body of knowledge and evidence needed to turn net zero ambitions into action.

Andrew Roper, DSO Director, SSEN

Introduction

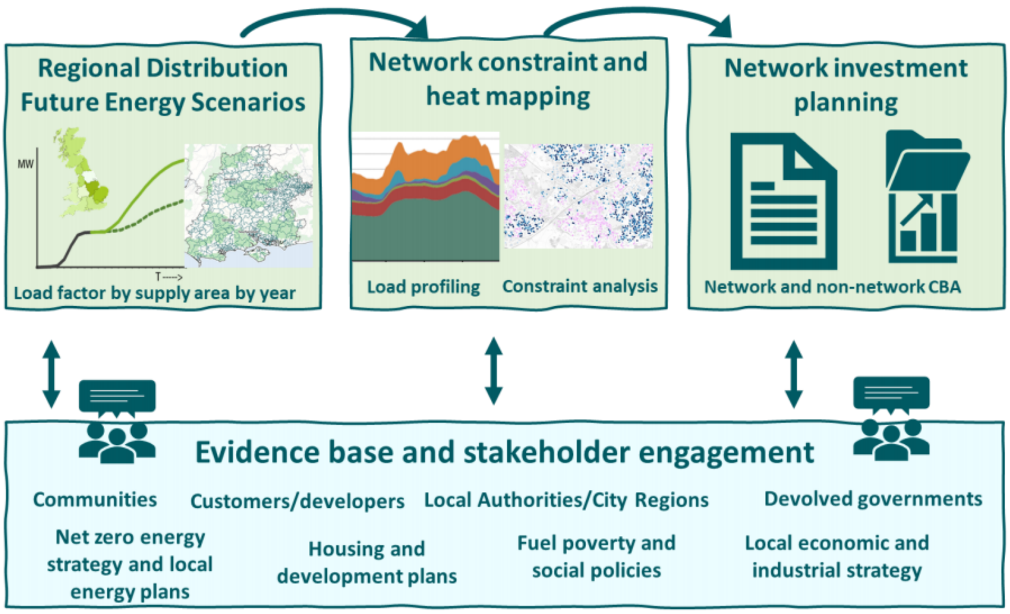
This report provides a summary of the methodology and results of the 2020 edition of the Distribution Future Energy Scenarios (DFES) for the Southern England electricity distribution network licence area[1], operated by Scottish and Southern Electricity Networks (SSEN).

DFES analysis produces granular scenario projections for the increase (or reduction) of the electricity distribution network connected capacity of electricity generation, storage and low carbon demand technologies. The SSEN DFES 2020 analysis also includes projections for new housing growth and new commercial and industrial developments.

As its framework, the DFES uses a set of four national energy scenarios based on the National Grid ESO Future Energy Scenarios (ESO FES) 2020 publication. The DFES projections are however heavily influenced by input by local and regional stakeholders, including local authorities, regional growth factors and a detailed analysis of the pipeline of projects and developments within SSEN's Southern England licence area. The DFES therefore provides a more granular and "bottom-up" assessment of the impact of changes to the energy system and the transition to net zero.

For SSEN, the DFES analysis supports network development planning[2], network constraint analysis and future investment appraisal. DFES data sets allow network planners to model and analyse a range of potential future load scenarios. They also provide an evidence base to enable network strategy teams to appraise different investment options, including the use of flexibility services. The 2020 DFES analysis is being used to provide an evidence base and set of scenarios to engage with local authorities, key stakeholders and customers in the development of SSEN's RIIO[3] ED2 business plan submission to Ofgem.

DFES scenario projections represent a range of potential outcomes which, subject to a number of uncertainties, can be expected to change over time. However by completing annual reviews of the DFES, and through extensive stakeholder engagement, energy networks can build up a picture of how energy consumption, generation, and the uptake of new low carbon technologies is changing as the UK transitions to a net zero energy system.



1 Also referred to as the Scottish Hydro Electricity Power Distribution (SHEPD) licence area
2 Network Development Planning is a statutory responsibility for the networks under EU Electricity Directive 2019/944.
3 RIIO "Revenue = Incentives+Innovation+Outputs" regulatory review process that determines energy network expenditure and investment in GB. The next RII0 ED2 period runs from 2023-2028

Reflecting uncertainty in the DFES analysis

During the stakeholder engagement process that has supported the development of the SSEN 2020 DFES analysis, several questions were raised regarding the degree of uncertainty and risk that accompanies the DFES projections. The question of projection uncertainty has become particularly pertinent in relation to how the DFES scenario projections might feed into the development of SSEN's business case for the RIIO-ED2 business plan submission and the use of budget uncertainty mechanisms.

Over the near term the DFES projections are heavily influenced by the pipeline of projects and new developments that can be identified in; the planning system, SSEN's connection database and by direct discussion with developers and stakeholders. Over the medium and longer term the projections will tend to reflect the underlying scenario assumptions and degrees of certainty supported by regional and national policies.

At a high level DFES projections are subject to a number of areas of uncertainty, including:

1. National Grid ESO FES scenario range of outcomes
2. National and devolved government policy uncertainty
3. Regional policy and local factors
4. Commercial uncertainty
5. Technology development uncertainty
6. Consumer adoption and behaviour uncertainty
7. Local distribution factors
8. Transmission vs distribution network connection uncertainty

Whilst it is important to highlight these areas of uncertainty, it is also important to recognise the counterfactor, that the future of energy in the UK is becoming more certain with the adoption of legally binding decarbonisation targets and the emergence of a more coherent energy strategy. For example, during the course of the SSEN DFES analysis the UK government has firmed up its commitment to ban the sale of petrol and diesel engine vehicles by 2030. This has greatly increased the certainty of a higher growth projection for electric vehicles. Recent UK policy announcements backed by regional decarbonisation programmes, are helping to set a clearer pathway for the energy industry.

When assessing the uncertainty of future energy scenarios, some key underlying assumptions have been made:

- Renewable energy generation capacity is very likely to significantly increase
- Unabated fossil fuel electricity generation is very likely to continue to decline
- The shift to more decentralised energy assets will continue to some degree
- The electrification of transport is already in progress and will accelerate
- Hydrogen has a key role to play for industrial processes and some forms of transport
- Further energy efficiency deployment is vitally needed in both homes and businesses
- The electrification of heat will increase although there remains a key uncertainty over the role that hydrogen boilers could play

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 assumptions that have been made, are identified within each of the technology summary sheets. A summary uncertainty rating of the main generation, storage and demand technologies in the scope of the modelling is shown in Figure 1.

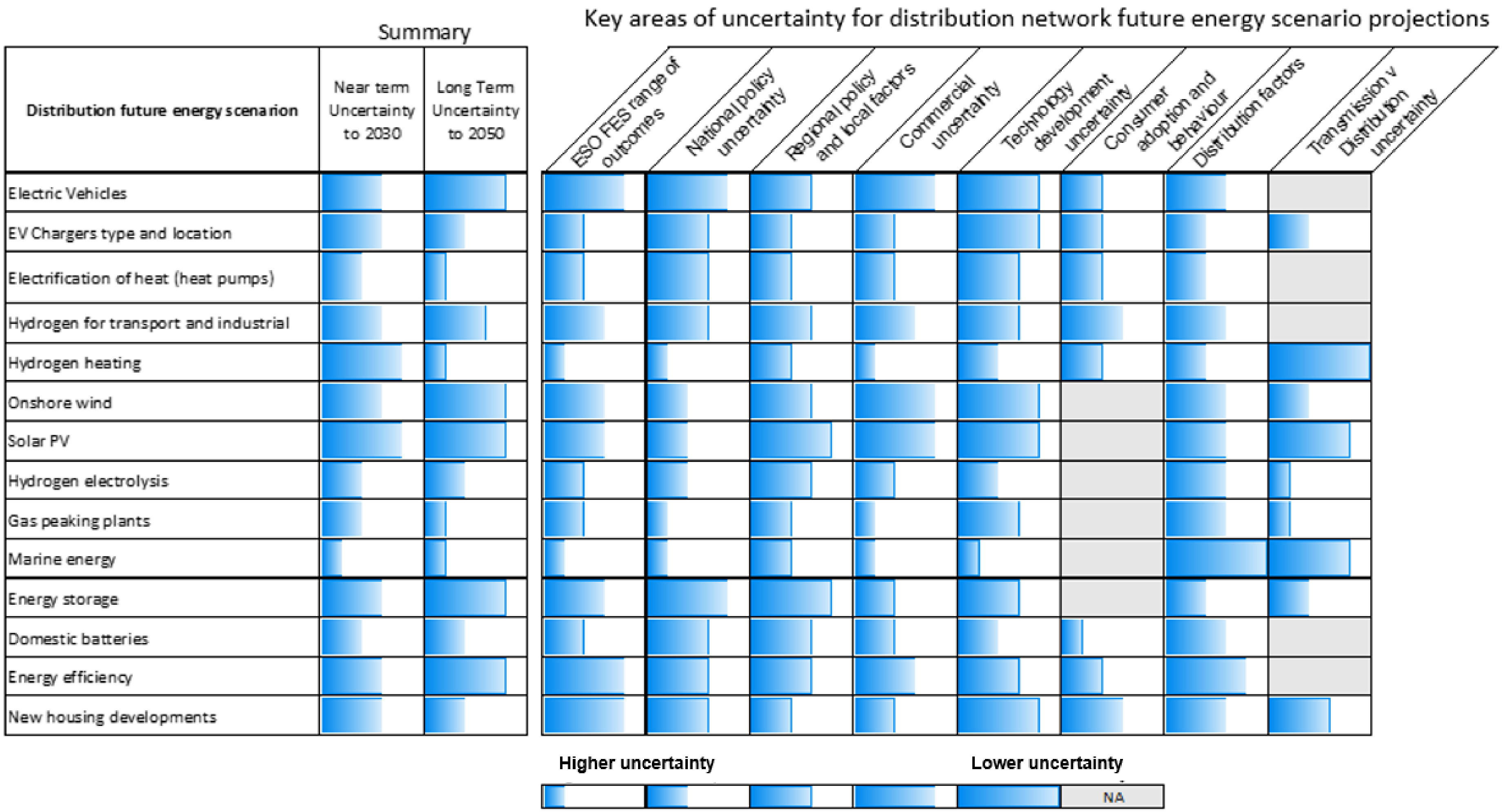


Figure 1: SSEN DFES 2020 technology uncertainty matrix

Distribution Future Energy Scenarios (DFES) methodology

The overall DFES methodology can be summarised under four key headings:

- The **technologies** that are in the scope of the future scenario analysis
- The **scenario framework** that is being used to frame the societal, technological and economic 'worlds' that the projections sit within
- The **analysis stages** that are applied to each technology when modelling scenarios
- The **geographical distribution** of the projections down to sub-regional or local levels

Technologies in-scope

The technology scope of the SSEN DFES includes those technologies and load sources that directly connect to SSEN's electricity distribution network in Southern England, as summarised in Table 1. The DFES scope does not include projections for technologies connected to the Scottish transmission networks.

Table 1 DFES Technologies and demand sources

Electricity generation technology classes	Electricity storage technology classes	Key new sources of electricity demand
Renewable energy generation technologies: solar PV, onshore wind, hydropower and marine. **Waste and bio-resource electricity generation** technologies: biomass, sewage gas and anaerobic digestion from other feedstocks. **Fossil-fuel electricity generation** technologies: diesel and natural gas.	**Battery Storage** Commercial and domestic scale battery storage technologies	**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 technologies:** air source and ground source heat pumps, hybrid heating and direct electric heaters. **Hydrogen electrolysis** **Data centres** **New property developments:** strategic housing developments and commercial and industrial developments.

The National Grid FES 2020 framework

The SSEN DFES 2020 has used the National Grid ESO Future Energy Scenarios 2020[4] (FES 2020) as the overarching framework to base the analysis upon. As well as providing a scenario framework the FES 2020 has been used to provide a basis for national level assumptions and growth projections, and for the technology definitions using the industry standard "Building Block" definitions.

Where available FES 2020 regional, grid supply point (GSP), projections have been used to inform the SSEN DFES, and provide a SSEN DFES to FES 2020 reconciliation for each of the technology building blocks.

The FES 2020 scenario framework is based on two key axis; the speed of decarbonisation and the level of societal change as outlined in Figure 2 and Table 2.

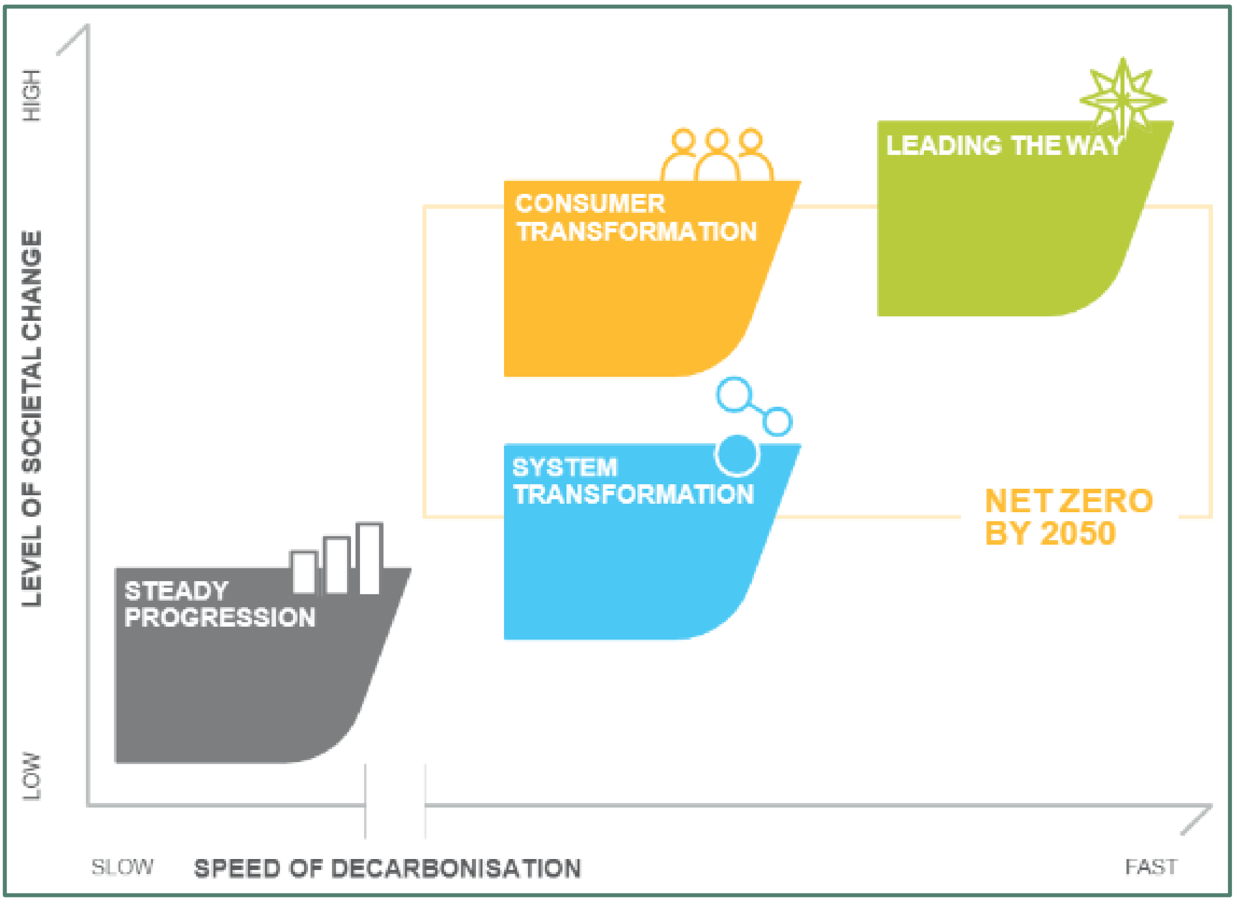


Figure 2 National Grid ESO Future Energy Scenarios 2020 scenario framework

[4] FES 2020 https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2020-documents

Table 2 National Grid ESO FES 2020 high level scenario descriptions

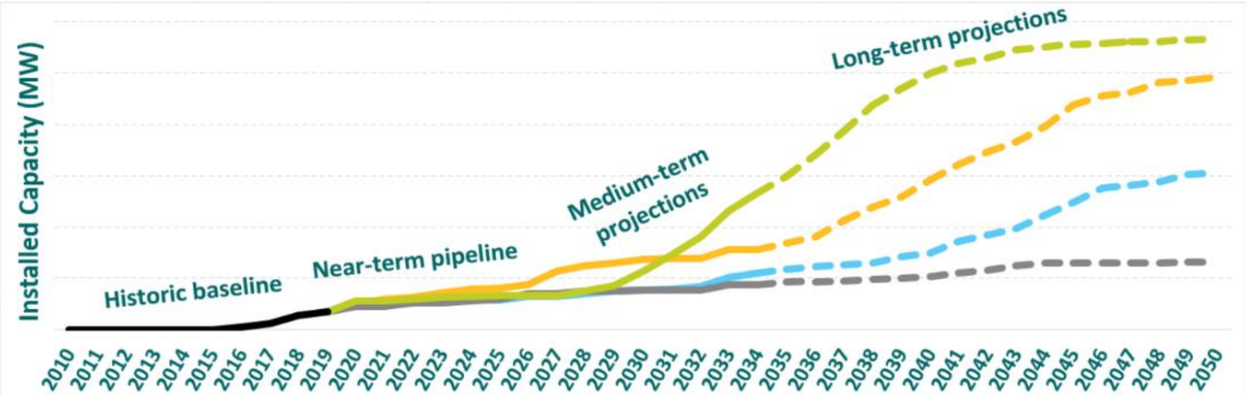
National Grid ESO FES 2020 Scenario	High level scenario description
Steady Progression Does not meets GB net zero targets by 2050	Overall low levels of decarbonisation and societal change. • Uptake of low carbon/renewable generation along current trends • Slower uptake of EVs and heat pumps • Some continued use of unabated fossil fuels • A lower uptake of electricity storage
System Transformation Meets GB net zero targets by 2050	High level of decarbonisation with lower societal change. Larger, more centralised solutions are developed. • Highest levels of hydrogen deployment for heating as well as transport and industrial use • Most hydrogen is produced via Steam Methane Reformation (SMR) with Carbon Capture Utilisation and Storage (CCUS) • Focus on transmission-scale low carbon generation such as offshore wind and nuclear • Practically no uptake of domestic batteries
Consumer Transformation Meets GB net zero targets by 2050	High levels of decarbonisation and societal change. Consumers adopt new technologies rapidly, and more decentralised solutions are developed. • Rapid uptake of EVs, low carbon technologies and energy efficiency • Significant electrification of domestic heat and commercial heat • Low carbon electricity generation more distributed, with high amounts of onshore wind and solar PV
Leading the Way Meets GB net zero targets by 2048	Very high levels of decarbonisation and societal change. Consumers adopt new technologies rapidly, and a mix of solutions is developed. This scenario aims for the "fastest credible" decarbonisation pathway. • Combines some of the features of both Consumer Transformation and System Transformation for low carbon generation and electric vehicles • Large volumes of hydrogen produced purely through electrolysis • Ambitious energy outcomes such as the widespread uptake of autonomous vehicles, hybrid heat pumps and also domestic energy storage

DFES analysis stages

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

1. Determines the **historic deployment** and establishes the **existing baseline** of operational or connected projects
2. Assesses the **near-term development pipeline**, recording and reviewing projects with connection offers or planning applications. For technologies with a high degree of pipeline evidence the range of outcomes between the scenarios may be quite narrow
3. Develops **medium and long term projections** out to 2050, with depending on the technology a much higher level of variation across the four scenario results.
4. **Geographically distributes** these annual, scenario-specific projections across the licence areas.

There is a potentially notable level of scenario variation, which increases as time moves on, again depending on the technology. This results in a widening of total projected outcomes (in MW or number) across the four scenario results.



Granularity and geographical distribution of the DFES

Larger scale generation and storage technologies have been distributed down to Electricity Supply Areas (ESAs) which have in the main been defined at the 11 kV primary substation level.

In the Southern England licence area this has led to a distribution to approximately 933 individual ESAs, which in urban areas such as Swindon or Southampton would equate to a group of post codes or small borough, while in rural areas could equate to a wider area covering part of a county. ESA level data can then be aggregated up to support network analysis at higher voltage levels, or to provide data aggregated to local authorities or other regional boundaries. See Figure 3.

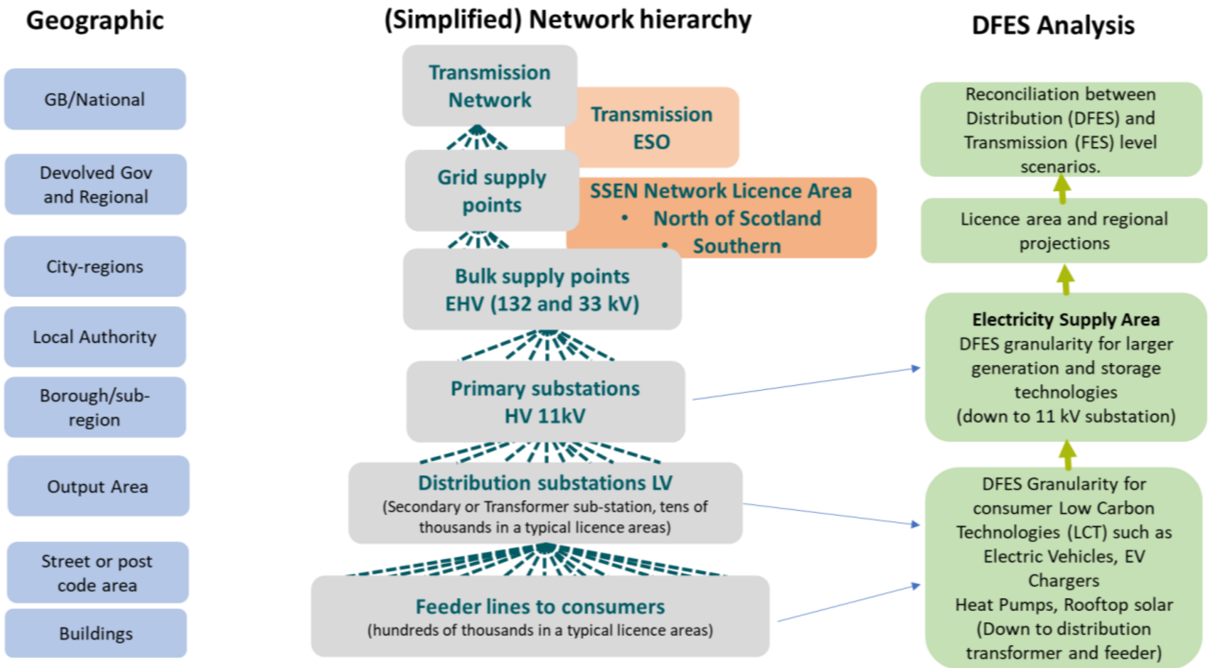


Figure 3 DFES granularity at different network hierarchy levels and corresponding regional & geographic areas

Low carbon technologies at the low voltage distribution sub-station and feeder level

For SSEN DFES 2020, the scenario projections for a number of Low Carbon Technologies (LCTs) have been distributed with much more granularity down to the level of secondary distribution "transformer" sub-station, or to individual LV feeder lines which serve individual or small groups of consumers. This level of granularity corresponds roughly to a post code or street level analysis.

The SSEN DFES LCTs have been distributed to secondary sub-station and feeder line level. The distribution of scenario forecasts, with annualised projections to 2050, to this low level of granularity required the handling of data files with hundreds of millions of individual records. Scenario projections at this low level of detail have also been aggregated within the ESA level datasets.

The apparent preciseness of this very granular analysis should be treated with caution, especially looking out to 2050. The distribution of technology deployments are still based on some high level scenario assumptions and distribution factors. The detailed SSEN DFES datasets do however allow SSEN network planners to begin 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 needed.

The distribution factors that underpin the spatial analysis, which are described in more detail within each of the technology summary sheets, were based on data gathered from a wide range of datasets including Ordnance Survey Addressbase, DfT road traffic flow data, Census Output Area data including affluence and demographic data, postcode statistical data, and individual property EPC data.

Use of affluence as a key distribution factor and implications for the equitable access to low carbon technology

The distribution analysis uses affluence as one of the key factors driving the uptake of low carbon technologies. This is based on previous new technology deployment trends and empirical evidence that the uptake of low carbon technology has, to date, tended towards more affluent areas. For EVs, it is also based on the very practical consideration that, in the near term at least, the availability of off-road parking is a key driver for EV adoption.

The assumption that affluence will be a key driver for LCT adoption does, however, need to be applied with caution, especially in relation to network investment. There is a risk that, if affluence is given too much significance, network investment will be channelled to more affluent areas which would then create inequitable access to LCTs for the future. There is also a risk that networks may underestimate the impacts of other factors which may actively counter balance affluence, for example the actions of local authorities and social housing providers to encourage LCT uptake in less affluent areas, as is already seen in relation to public charge point provision in Scotland. In the case of EVs, there is also a strong argument that the initial cost barrier will be superseded as EV capital costs reduce and EV driving (with lower running costs) becomes the cheaper transport solution.

To provide a degree of balance in the analysis the following approach has been taken.

- Affluence is considered a key distribution factor in the short term for **Consumer Transformation** and **Leading the Way**. For the **Steady Progression** and **System Transformation** scenarios, which have lower social interventions, affluence remains a stronger driver in the medium term.
- Over the medium and longer term, for the higher ambition scenarios, the impact of the affluence distribution factor is reduced and an assumption is made that the deployment of LCT technologies will become more ubiquitous and will follow the underlying factors.
- For solar PV and heat pumps, the scenarios specifically include a social housing weighting factor to counter purely affluent areas. This social housing impact has previously been documented in Regen's DFES studies.
- For the more ambitious scenarios, from mid to late 2020s, the underlying assumption is that EVs will become ubiquitous. Therefore, the growth in demand for EVs in both on-street and off-street areas begins to increase at equivalent rates.

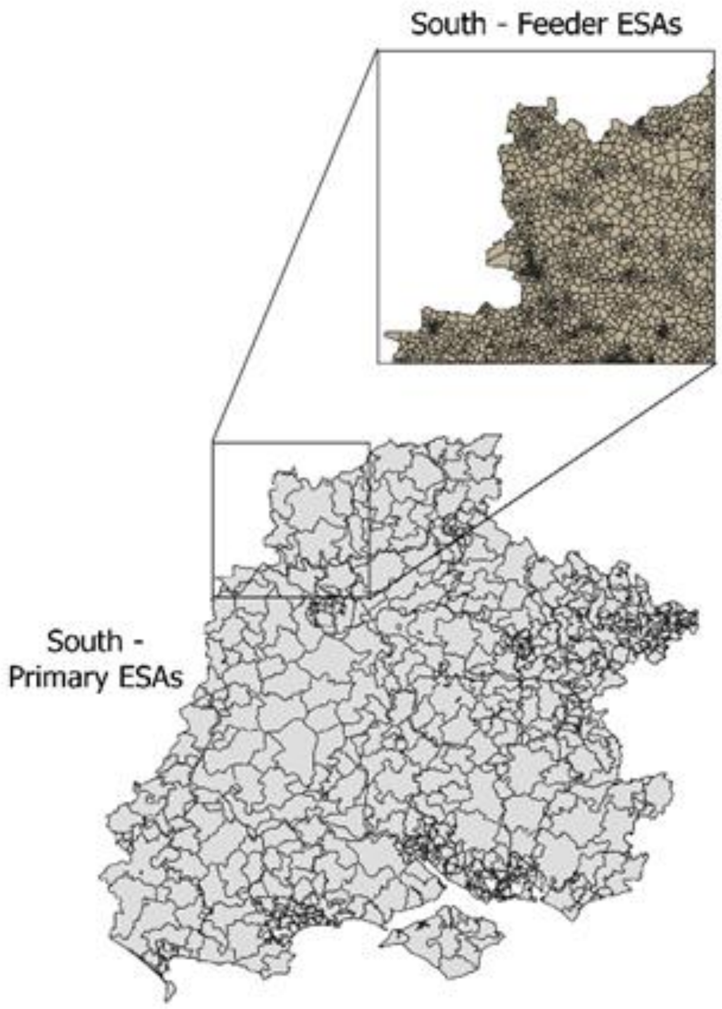
The impact of affluence on LCT uptake, and how the networks respond through network investment to ensure equitable access to new technology, is a key area for further research and should be considered as part of each network's stakeholder engagement, local area plans and RIIO-ED2 business planning. There may be a case for higher levels of network provision in less affluent areas, which is outside the scope of this study.

Table 3 SSEN DFES building blocks granularity of distribution

Level of DFES granularity and distribution	North of Scotland	Southern	DFES building blocks technologies
Electricity Supply Areas (ESAs) **(Primary 11kv sub-station)**	505	933	• Electricity generation except rooftop PV • All battery storage • Hydrogen electrolysis • Air conditioning • New housing and commercial property developments • EVs – HGVs, buses, motorcycles.
Low Voltage secondary substation 'Transformers'	48,789	55,062	• Commercial EV chargers (Car park; Destination; En-route local; En-route national; 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 7kW chargers • Heat pumps (hybrid and non-hybrid) • Small scale Rooftop Solar < 10 kw • Direct electric heating

Technologies that are projected to 11kV ESAs

- Onshore wind
- Offshore wind
- Large-scale solar PV
- Hydropower
- Biomass generation
- Anaerobic digestion
- Sewage gas
- Landfill gas
- Energy from Waste
- ACT
- Gas generation
- Diesel generation
- Hydrogen generation
- Battery storage
- Hydrogen electrolysis
- Data centres
- Air conditioning



Technologies that are projected to LV ESAs

- Electric vehicles
- Electric vehicle chargers
- Heat pumps
- Direct electric heaters
- Rooftop solar PV

The Southern England licence area

The Southern England electricity distribution licence area covers the area served by the low voltage, 11kV, 33kV and 132kV 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 in the East, Chipping North and areas of the Cotswolds in the North, down to the coastal towns of Weymouth, Bournemouth, Southampton and Portsmouth and the Isle of Wight in the South.

The licence area includes both a number of notable urbanised areas such as Oxford, Swindon and Southampton, as well as a number of national parks and rural areas, such as the South Downs, New Forest, Chiltern Hills and parts of the Cotswolds.

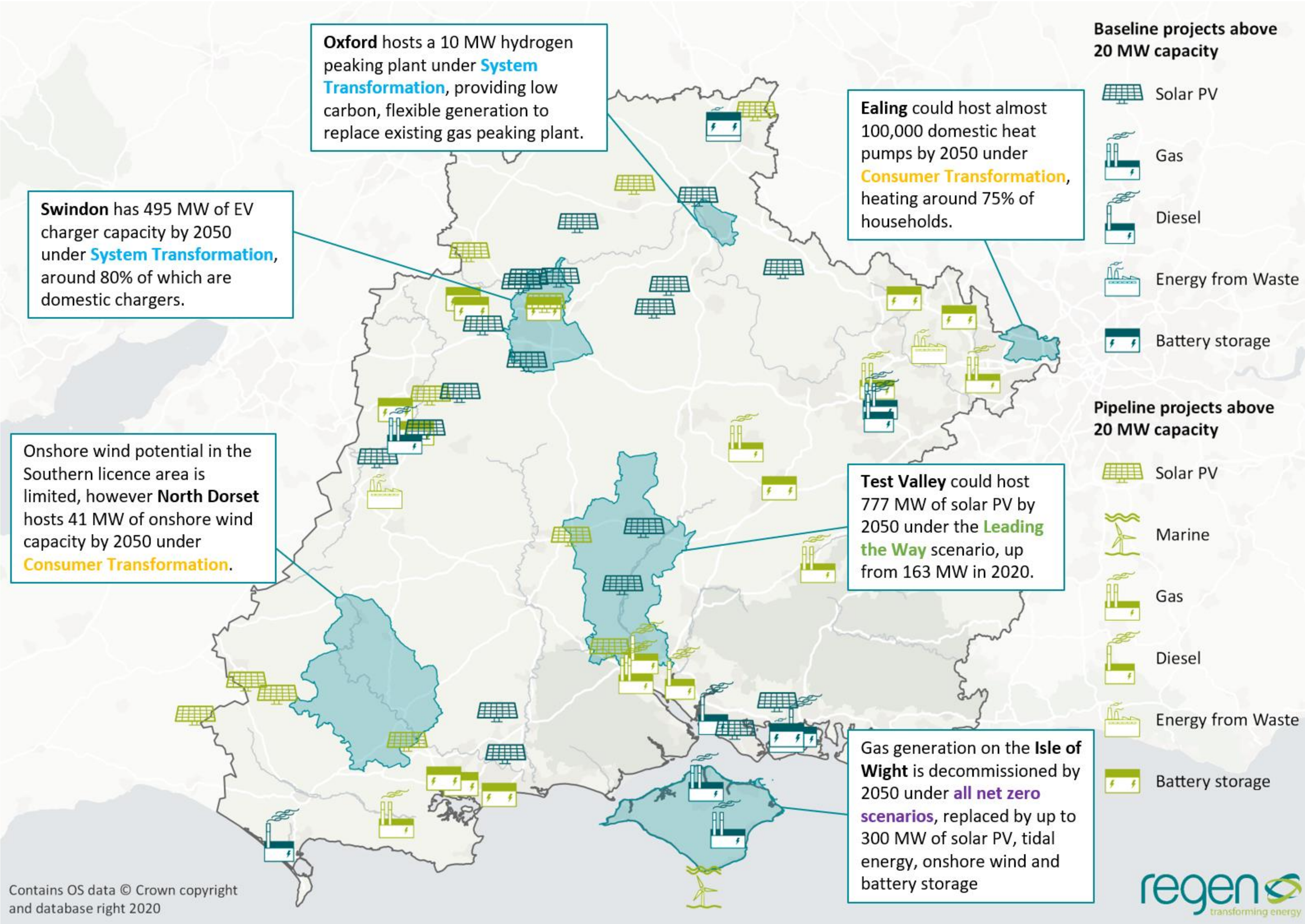
The licence area includes 53 local authority areas.

The total capacity of distributed electricity generation has steadily increased in the past 5-10 years. This growth has been led by large-scale solar PV, breaching 2 GW of total capacity in 2017.

The licence area also hosts 481 MW of natural gas generation, 178 MW of waste-driven generation and 169 MW of diesel generation.

The largest generation site in the licence area is the natural gas-fired 140 MW Cowes OCGT plant on the Isle of Wight.

The licence area is beginning to reflect some of the potential energy transitions and low carbon technology adoptions, with just under 60,000 battery electric vehicles and plug-in hybrids registered in the licence area and c.24,000 homes and businesses with a type of heat pump installed.


Oxford hosts a 10 MW hydrogen peaking plant under **System Transformation**, providing low carbon, flexible generation to replace existing gas peaking plant.
Swindon has 495 MW of EV charger capacity by 2050 under **System Transformation**, around 80% of which are domestic chargers.
Onshore wind potential in the Southern licence area is limited, however **North Dorset** hosts 41 MW of onshore wind capacity by 2050 under **Consumer Transformation**.
Ealing could host almost 100,000 domestic heat pumps by 2050 under **Consumer Transformation**, heating around 75% of households.
Test Valley could host 777 MW of solar PV by 2050 under the **Leading the Way** scenario, up from 163 MW in 2020.
Gas generation on the **Isle of Wight** is decommissioned by 2050 under **all net zero scenarios**, replaced by up to 300 MW of solar PV, tidal energy, onshore wind and battery storage
Baseline projects above 20 MW capacity
Solar PV
Gas
Diesel
Energy from Waste
Battery storage
Pipeline projects above 20 MW capacity
Solar PV
Marine
Gas
Diesel
Energy from Waste
Battery storage
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The Southern England DFES - 2050 projection headlines

By 2050, the scale and variety of technologies connected to the distribution network is significant different than today:

Collectively, distribution network connected solar, wind, hydro and marine generation capacity in the licence area increases by over 390% from c.2.4 GW in 2019 to **c.9 GW** in 2050 in **Consumer Transformation**.
The capacity of distribution network waste-driven electricity generation in Southern England evolves significantly by 2050. With a lot of landfill gas generation sites decommissioning and **c.150 MW** of anaerobic digestion (from various feedstocks) is in operation by 2050 under the **Leading the Way** scenario.
The **650 MW** of unabated diesel and natural gas generation and is removed from the distribution network in all scenarios by 2050, except in **Steady Progression**. Where **c.670 MW** of gas CHPs, reciprocating engines and OCGTs continue to operate. Some **21 MW** of hydrogen fuelled generation is also operating by 2050 in the licence area, under the **System Transformation** scenario.
The total capacity of battery storage projects connecting to the distribution network significantly increases in all scenarios by 2050, reaching just under **2 GW** in the **Leading the Way** scenario, from a small baseline of 3.2 MW.
A huge number of electric vehicles will be on the road in the Southern England licence area, reaching between **4.3-4.8 million** in all scenarios within the 2040s. In the **Leading the Way** scenario, this equates to **c.3.3 GW** of electric vehicle charging capacity by 2050.
A huge number of domestic properties switch their heating technologies to low carbon alternatives by 2050, with **c.1.5million domestic properties** and **c.166,000 non-domestic properties** operating a type of heat pump under the **Consumer Transformation** scenario.
Under the **System Transformation** scenario, the capacity of hydrogen electrolysers connected to the distribution network in the Southern England licence area reaches **911 MW**.
A little over **660 MW** of known new data centre sites come online in all scenarios by the mid 2020s.
c.610,000 new houses could be built and **8.6 million m^2** of non-domestic floorspace could be developed by 2050 in all scenarios.

Three examples of low carbon technology projections at a local level:

1) Electric Vehicles in Southampton

Southampton shows a good example of the potential distribution of domestic electric cars in a city and urban area. Low voltage feeder lines in inner city areas have a lower number of EV cars per household, reflecting a greater use of public transport and lower car ownership found in inner city areas. The proportion of electric cars per household is projected to increase as we move out to more residential and commuter areas with a higher proportion of homes with off-street parking. The **Steady Progression** scenario shown in Figure 4 actually has the slowest electric vehicle uptake, but even under this scenario, by 2050 virtually all vehicles are zero carbon.

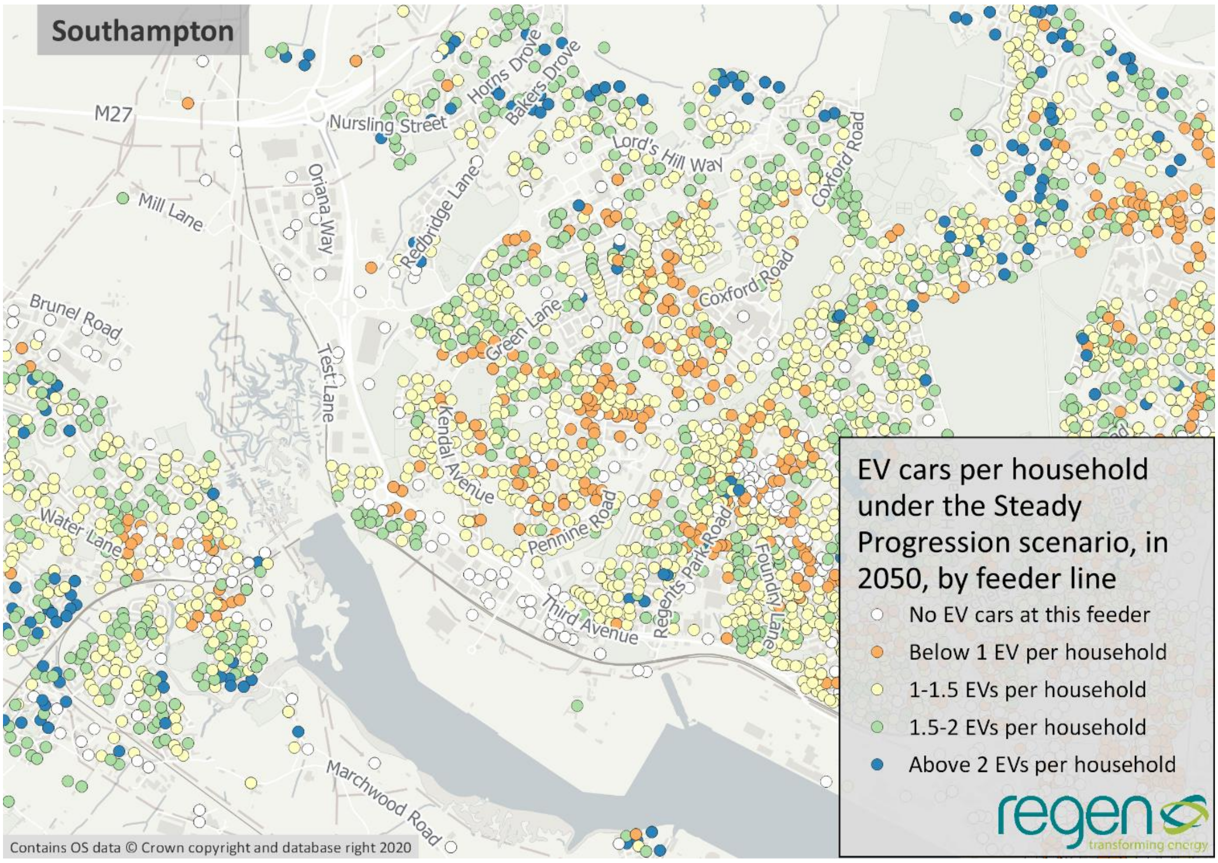


Figure 4 Electric Car distribution at feeder level in Southampton under a Steady Progression scenario

2) Heat pumps on the Isle of Wight

The **System Transformation** scenario assumes that a large number of existing on-gas consumers will switch to hydrogen as a main heating fuel, and that there will also be a higher number of hybrid heat pumps (using hydrogen as a back-up fuel).

This is reflected in the SSEN DFES distribution analysis which shows, for example on the Isle of Wight, a higher rate of heat pump uptake in areas which are off-gas grid. Within more built up areas, such as Cowes and Newport, which are typically on the gas grid, the uptake of heat pumps is less as hydrogen becomes available.

Even in urban areas there may be opportunities for heat pumps. For example, in multi-occupancy properties, which are off-gas and may be reliant on electric heating. Also social housing properties that could be suitable for "shared loop" heat pump systems. Across the island there are also some hotspot areas which are off-gas grid and also feature larger detached properties, which are currently heated by expensive oil boilers, and so would be considered ideal for heat pump installations.

This level of high granularity projection analysis should be treated as illustrative and is subject to some uncertainty. Without doing a very detailed building stock analysis, and also a heat plan for the island, it would be wrong to say with complete certainty which areas are likely to be decarbonised by heat pumps or hydrogen in 2050. The SSEN DFES analysis does however give network planners an initial dataset to begin to model the potential impacts of heat electrification across the low voltage network, and to quantify the likely scale of investment that would be needed.

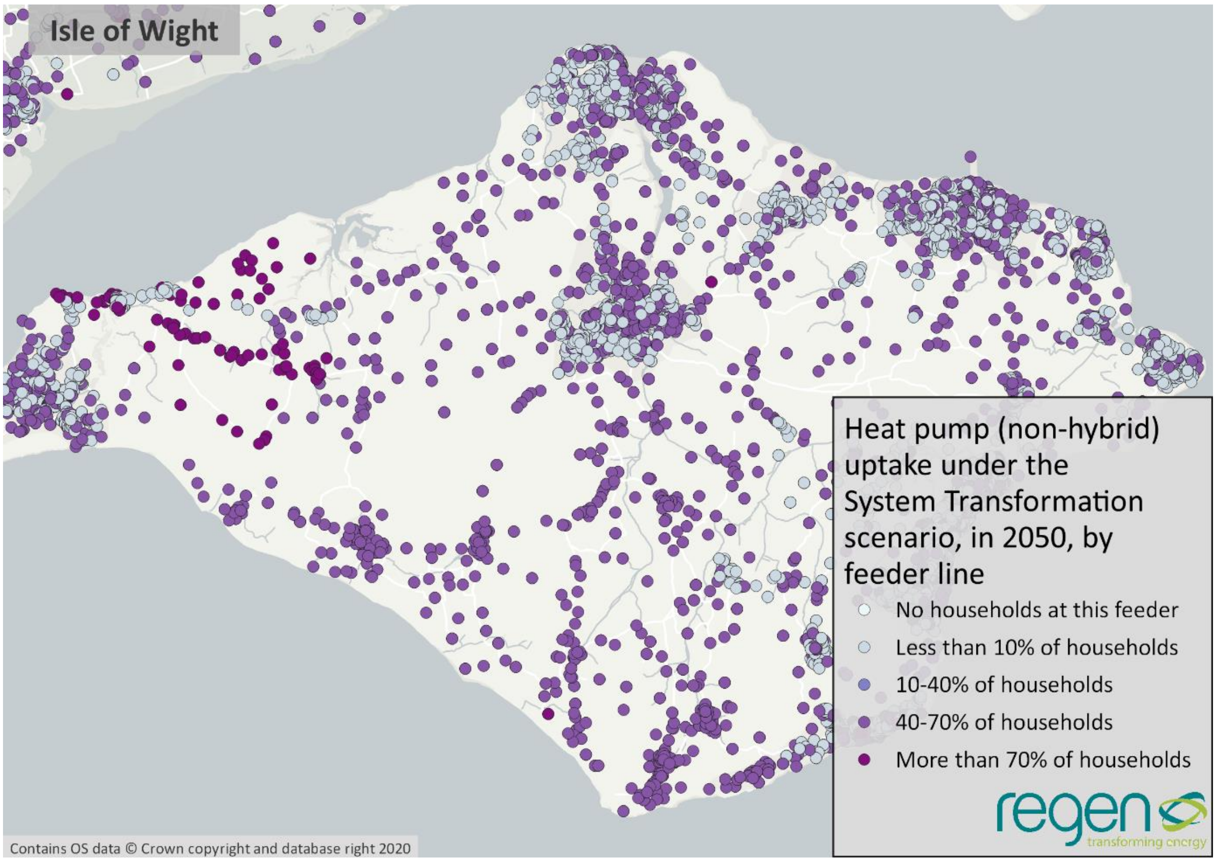


Figure 5 Heat Pump (non-hybrid) distribution on the Isle of Wight in 2050 under a System Transformation Scenario

3) Solar PV in Swindon

The **Consumer Transformation** scenario assumes a very high degree of decentralised and local energy generation. This includes a high level of deployment of rooftop solar, driven in part by falling solar prices as well as by a consumer led transformation towards self generation and smarter local energy systems.

The SSEN DFES projected distribution of rooftop solar in Swindon follows a similar pattern to the distribution of electric vehicles, and there is a likely correlation between the two technologies as EV adopters are more likely to also look for opportunities to self generate electricity. Domestic rooftop solar adoption will also trend towards larger properties, with greater roof area, in more affluent areas. An important counterfactor however is the potential for local authorities, communities and social housing providers to promote solar PV in less affluent areas and through local community energy projects.

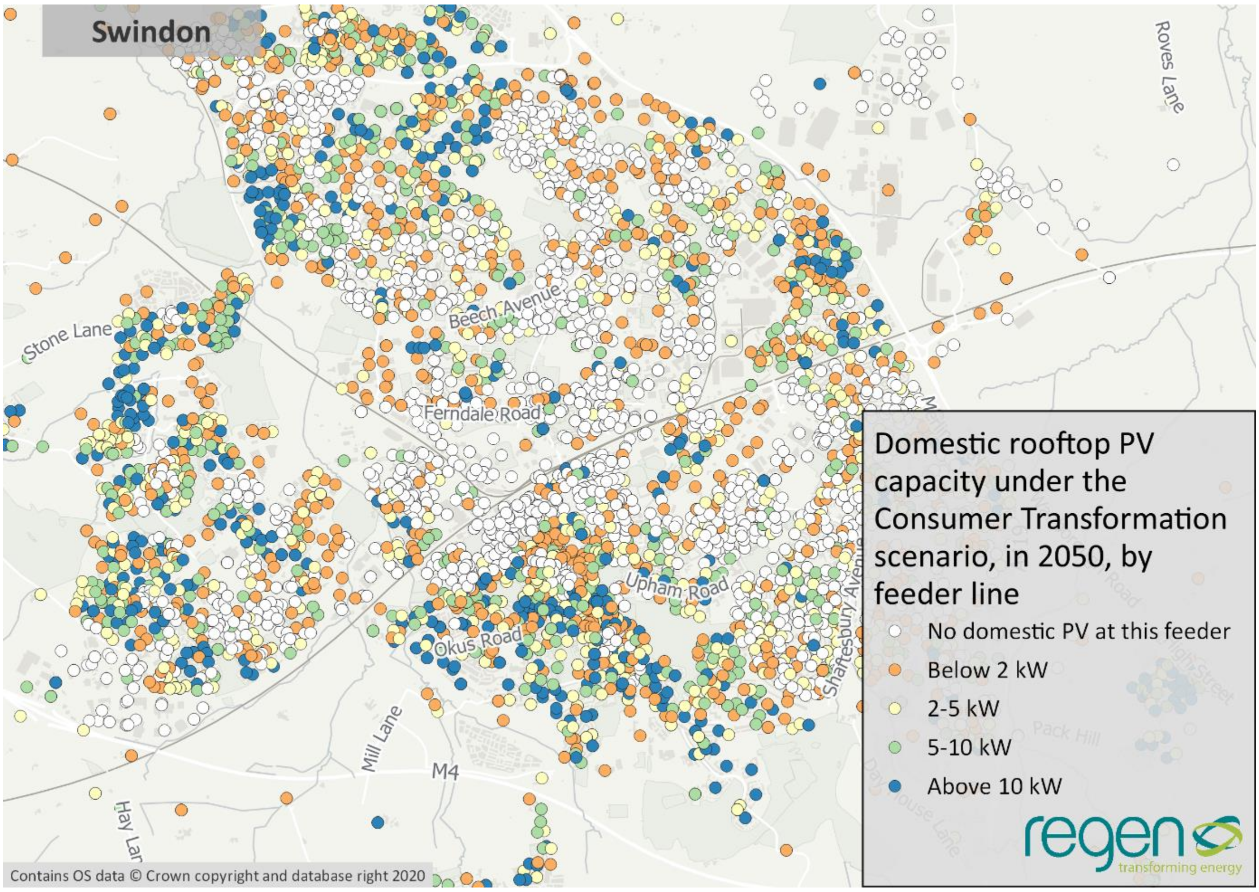


Figure 6 The potential for solar PV in Swindon in 2050 under a Consumer Transformation scenario

Stakeholder engagement

Although based on national energy scenarios, the DFES assessment is intended to be a locally-driven and evidenced-based analysis of the future energy scenario outcomes for a specific region. Stakeholder engagement and consultation is therefore critically important to inform the scenario modelling and test the future assumptions that have been made for the various building block technologies.

To inform the SSEN DFES 2020 analysis the project team has engaged stakeholders through a number of different approaches. These included:

A series of **interactive stakeholder webinars** delivered in August and September, working in collaboration with the SSEN team and the Energy Systems Catapult.

A **data exchange with all of the local authorities** in SSEN's two licence areas, via a SharePoint site, around new strategic housing and commercial developments.

A **local energy strategy survey**, completed by wider environmental teams within a number of the same local authorities.

A number of **technology-specific interviews** and calls with project developers, technology companies, energy sector experts and industry representatives.

Through engaging and consulting with a wide range of organisations and representatives the technology analysis leads were able to seek views and evidence around:

- Individual project development plans and timescales.
- Regional considerations for the potential uptake of specific technologies
- The viability of use cases and business models that would align with assumptions made around increased uptake or reduction of technologies connecting to the network.
- Specific regional policy, regulation and other decision making that could affect both the near-term and long-term trajectories for specific technologies, such as wind planning policy, electric vehicle charger deployment or heat pump uptake

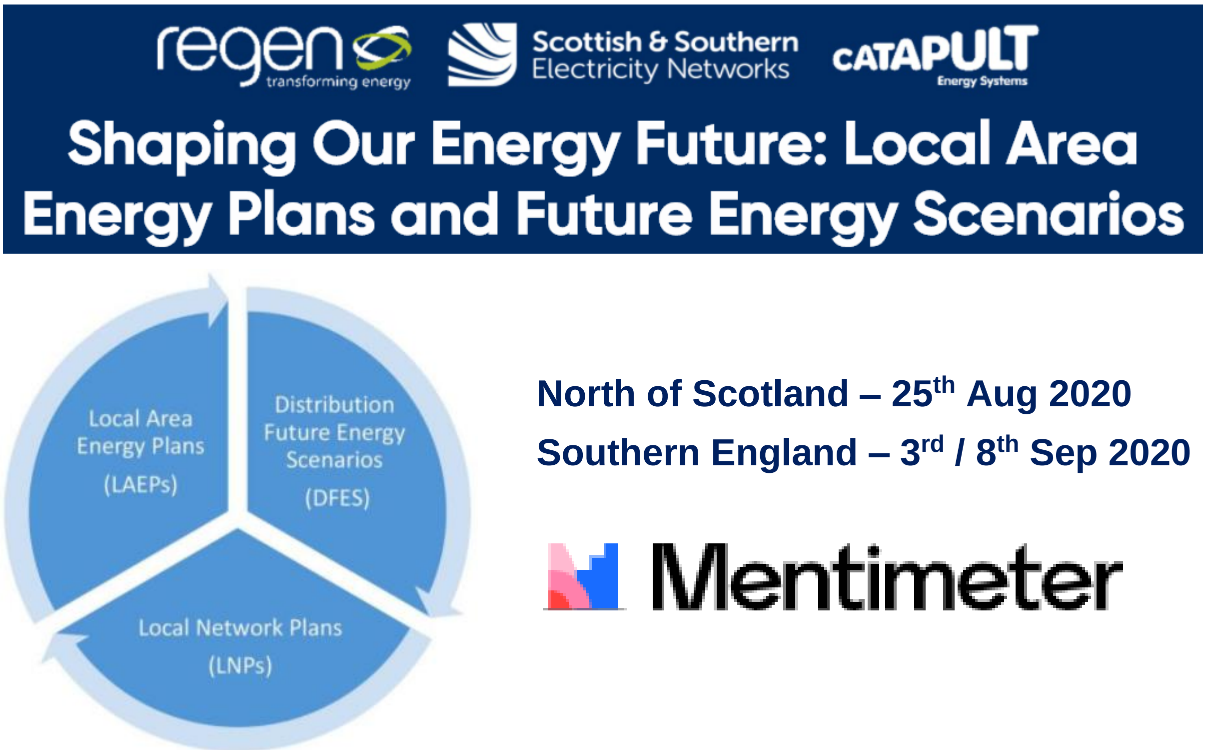
Regional engagement webinars

Regen, SSEN and the Energy Systems Catapult (ESC) delivered three regional engagement webinars across August and September 2020. These interactive and collaborative sessions sought to:

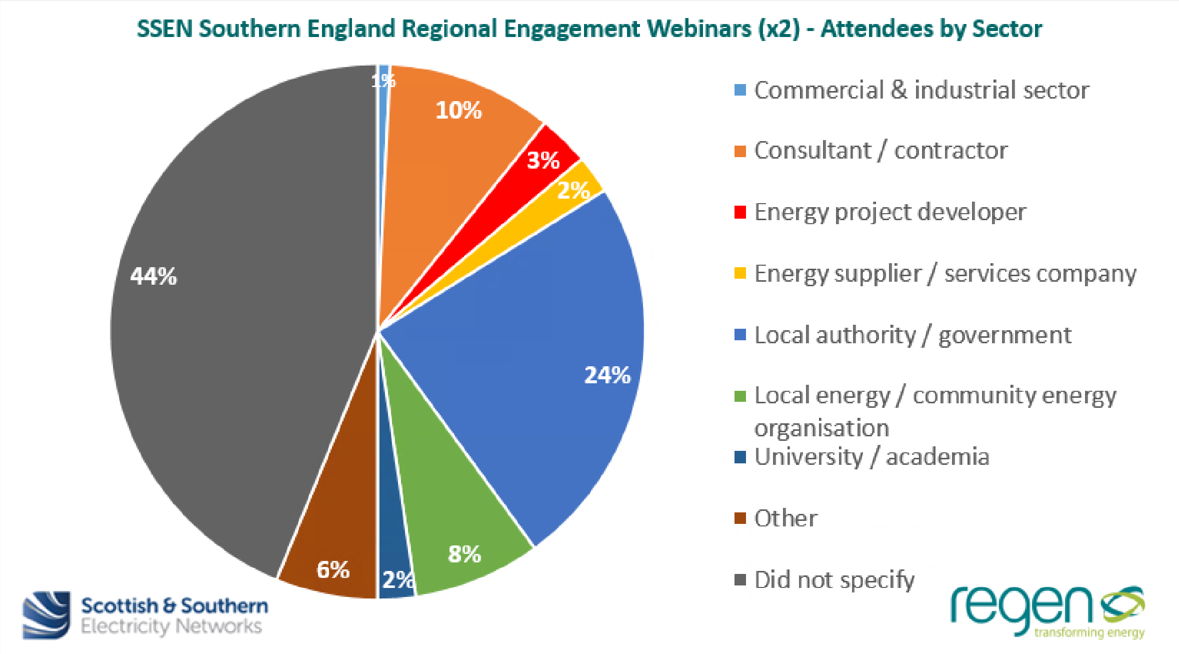
- Tap into stakeholders' local and domain knowledge and insights.
- Increase the understanding of local investment needs for the electricity system, future energy technologies and developments which will influence SSEN's plans for future network developments (including specifically for RIIO-ED2).
- Discuss the potential growth in connected capacity and location of future energy technologies and developments.
- Gauge views on the uptake of new or disruptive technologies, such as hydrogen electrolysis, EVs and heat pumps in the licence areas.

The event brought together a mixture of presentations from the SSEN team around the RIIO-ED2 and local energy plans, the LAEP approach from the ESC team and from Regen, seeking specific views around the key technologies for the 2020 regional DFES and LCT assessments.

As well as an overview of the high level methodology and building blocks that form the scope of the SSEN 2020 DFES and LCT, these events included a number of technology-specific polling sessions, via the online platform Mentimeter.



The Southern England webinars were attended by 150 stakeholders, representing a mixture of sectors across the energy industry:



The webinar attendees were asked a series of polling questions, seeking views (for the licence area in question) on:

- The regional development of distribution network onshore wind generation
- Future battery storage project business models and locational deployment factors
- Future use cases for hydrogen, including hydrogen for heating, industry, electricity generation and hydrogen electrolysers
- The uptake of electric vehicles
- The ownership models for on-street EV charging infrastructure
- The viability of various low-carbon heating technologies for the licence area (e.g. heat pumps, hydrogen heating, hybrid heating systems, bio-fuels, biomethane and district heat networks)

The polling data obtained from Mentimeter, combined with commentary in the online chat function, enabled the analysis team to justify, refine or adjust many of the assumptions that underpinned the individual DFES technology modelling.

Polling results have been included within each technology summary sheet.

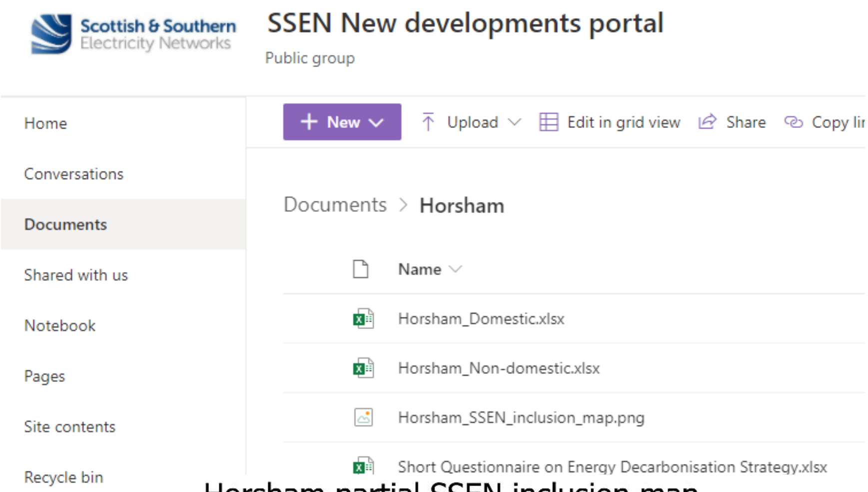
Local authority data exchange and survey

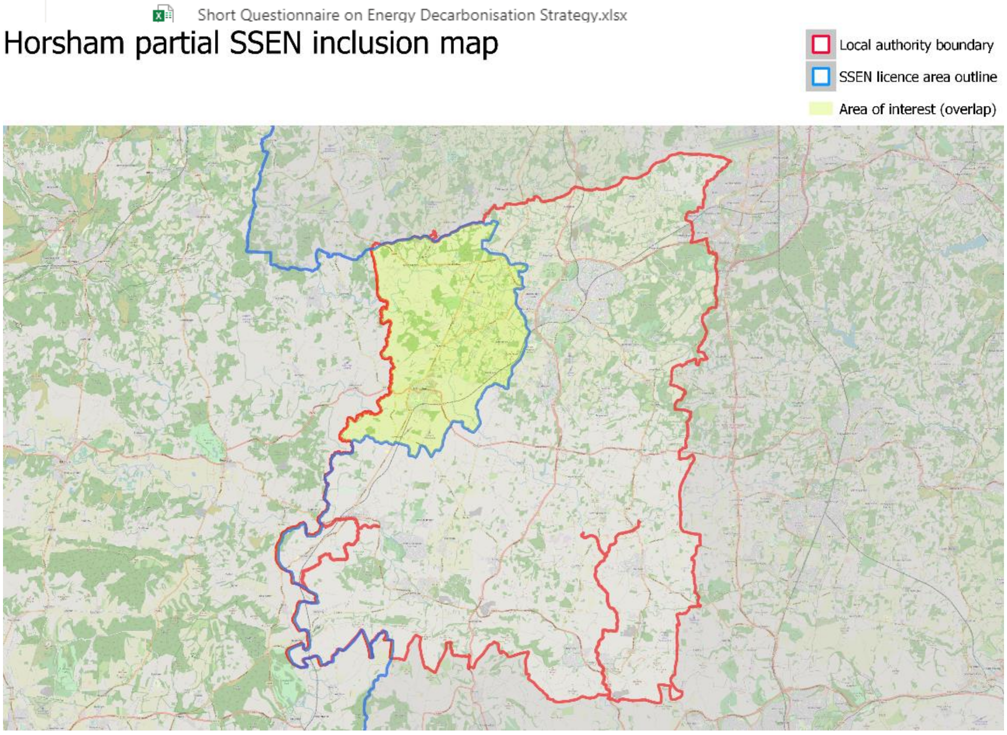
As part of the data gathering process for the 2020 DFES for SSEN, an online portal was established to exchange data related to new housing and commercial developments with all of the local authorities within the Southern England licence area.

The portal greatly improved the gathering and validation of local authority plan data and provided localised, granular evidence to support the scenario projections for:

- The number of new houses (based on strategic housing development threshold of 50 homes or more).
- New commercial and industrial developments (measured in m^2 floorspace of development land), categorised into 8 archetypes: Factory and warehouse, Hospital, Hotel, Medical, Office, Restaurant, Retail, School and College, Sport and Leisure, University and Other.

The use of an online exchange site enabled mutual access and updating of the data for new developments in each local authority area between Regen and the local authority planning departments. For the local authorities with borders across the licence area, a map was also provided outlining the geographic area where new development data was specifically required. In addition to directly updating the datasets held on exchange portal, many local authorities provided information through Housing Land Audit reports and other supplementary documents.





As part of the evolution of this data exchange process with the local authorities, a short questionnaire was issued to explore the development of local energy and decarbonisation strategies and to inform the distribution of key technologies.

The local authority survey sought specific 'yes/no' answers to a set of seven key questions, around local strategies for:

1. **Declaration of a climate emergency**
2. **A transport or low-carbon transport strategy**
3. **A heat or low-carbon heat strategy**
4. **Renewable energy strategy**
5. **Food waste collection strategy**
6. **Net zero strategy**
7. **Net zero target year**

In addition to these questions, open fields for more specific information, notes and links to relevant supporting documents was included.

Although not all local authorities participated the questionnaire provided useful local information for the SSEN DFES, and for the subsequent bilateral engagement that SSEN is undertaking as part of its ED2 business plan development.

The summary results for the councils within the Southern England licence area are below:

Southern England LAs(SEPD)	1	2	3	4	5	6	
Arun	Y	N	N	N	Y	Y	2030
Basingstoke and Deane	Y	Y	N	N	N	Y	2030
BCP (Bournemouth)	Y	Y	Y	Y	Y	Y	2050
BCP (Christchurch)	Y	Y	Y	Y	Y	Y	2050
BCP (Poole)	Y	Y	Y	Y	Y	Y	2050
Bracknell Forest							
Cherwell							
Chichester							
Chiltern	Y						
Cotswold							
Dorset (East Dorset)							
Dorset (North Dorset)							
Dorset (Purbeck)							
Dorset (West Dorset)							
Dorset (Weymouth & Portland)							
Ealing							
East Hampshire	Y						
Eastleigh							
Fareham							
Gosport	N	Y	Y	Y	N	N	
Guildford	Y	N	Y		Y	Y	2030
Hart							
Havant							
Hillingdon							
Horsham							
Hounslow	Y	Y	N	N	Y	Y	2030
Isle of Wight	Y	Y	N	N	Y	Y	2030
Mendip	Y	N	N	N	Y	N	2030
New Forest	N	N	N	N	N	N	
Oxford							
Portsmouth	Y	Y		N	Y	Y	2030
Reading							
Runnymede							
Rushmoor	Y	N	N	N	Y	N	
Slough	N	Y	N	N	Y	Y	2030
South Bucks							
South Oxfordshire	Y	Y	Y	Y	Y	Y	2030
South Somerset	Y	Y	N	N	Y	Y	
Southampton							
Spelthorne	N	Y	N	N	N	N	
Surrey Heath	Y	N	Y	Y	N	Y	
Swindon							
Test Valley	Y	N	N	N	N	N	
Vale of White Horse	Y	Y	Y	N	Y	Y	2045
Waverley	Y	Y	Y	Y	Y	Y	2030
West Berkshire							
West Oxfordshire							
Wiltshire							
Winchester	Y	Y	N	N	N	Y	
Windsor and Maidenhead							
Wokingham							
Wycombe							

Feeding local ambition into the SSEN DFES

The information gained from conducting this local energy strategy survey, and from direct discussions with regional stakeholders, was used to inform the scenario projections. For example:

- Near-term weighting was placed to the Electricity Supply Area (ESA) distribution of future projections for EVs and heat pumps, where local authority areas have low carbon heat or transport strategies in place.
- Some specific local factors (e.g. low emission zones stated in strategy documents) were also used to augment some ESA factors or uptake rates in the 2020s/30s.
- High levels of ambition, through climate emergency declarations or other strategy was considered when modelling some renewable energy generation projects currently in the planning pipeline.

Sector-specific stakeholder consultations

In addition to the stakeholder engagement webinars Regen engaged some other companies and industry representatives, in relation to some of the specific DFES building block technologies. These were more 1-to-1 calls or interviews with technology companies, project developers, industry/utility companies or even representatives of the wider team at SSEN. An overview of the sector-specific consultations that were held to inform the DFES modelling is summarised below.

DFES building block technology	Organisation(s)	Feedback received and how it was reflected in the modelling
Solar **Onshore wind** **Hydro**	Gray Associates RWE	Confirmation of the development status and future timeline plan of various renewable generation projects. The DFES pipeline projections (mainly in the 2020s) were updated based on feedback received about these individual projects
Hydro **Sewage gas AD**	Wessex Water Bournemouth Water	Wessex Water Enterprise was consulted in regards to their future strategy and plans for sewage gas generation and biomethane production. Similarly Bournemouth Water was also consulted in regard to potential future hydro projects. The consultation clarified the assumptions made around these technology projections, due to no development plans being fed back by either water company for the parts of their operational areas that fell within the Southern England licence area.
Hydrogen electrolysis	ITM Power	Clarified the business model of electrolysers supplying hydrogen to fuelling stations. Also confirmed typical electrolyser capacity (MW) scale and use cases we prioritised.

Technology summary sheets for the Southern England licence area

The remaining section of this document is a compendium of the individual summary sheets covering all of the technology building blocks that form the basis of the SSEN DFES 2020 analysis.

These summary sheets provide:

- A definition and scope of the technology
- A summary of scenario projection results at each projection stage (near, medium and long term)
- An overview of the key assumptions, methodology and logic that has been applied to determine the scenario projections
- An overview of the local and stakeholder evidence obtained and fed into the analysis for that technology/sector
- A reconciliation analysis between the SSEN DFES 2020 and the National Grid ESO FES 2020 (either comparing the DFES results to the ESO's GB level FES projections or the regional grid supply point (GSP) datasets)
- A list of the references and data sources used

This report splits the various technology sheets into three sections, as outlined below:

<table>
<tr><th>Technology Category</th><th>Technology / sector</th></tr>
<tr><td rowspan="10">Section 1 - Distributed electricity generation</td><td>1. Onshore wind</td></tr>
<tr><td>2. Large-scale solar PV</td></tr>
<tr><td>3. Hydropower</td></tr>
<tr><td>4. Marine</td></tr>
<tr><td>5. Biomass</td></tr>
<tr><td>6. Waste incineration</td></tr>
<tr><td>7. Renewable engines (AD, sewage gas and biogas)</td></tr>
<tr><td>8. Gas fired generation</td></tr>
<tr><td>9. Diesel generation</td></tr>
<tr><td>10. Other generation</td></tr>
<tr><td>Section 2 - Electricity storage</td><td>11. Battery storage</td></tr>
<tr><td rowspan="8">Section 3 - Low carbon technologies and new sources of electricity demand</td><td>12. Electric vehicles</td></tr>
<tr><td>13. Electric vehicle chargers</td></tr>
<tr><td>14. Heat pumps and direct electric heating</td></tr>
<tr><td>15. Small-scale solar PV</td></tr>
<tr><td>16. Hydrogen electrolysis</td></tr>
<tr><td>17. New property developments</td></tr>
<tr><td>18. Data centres</td></tr>
<tr><td>19. Air conditioning</td></tr>
</table>

Section 1 – Distributed generation

Renewable energy generation technologies

Fossil fuel generation technologies

Waste-driven energy generation technologies

regen transforming energy

Scottish & Southern Electricity Networks

1. Onshore wind in the Southern England licence area

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:

Installed capacity (MW)		Baseline	2020	2025	2030	2035	2040	2045	2050
Large-scale (≥1 MW)	Steady Progression	9	9	9	11	14	17	19	20
	System Transformation		9	9	12	23	31	44	57
	Consumer Transformation		9	11	30	73	124	178	229
	Leading the Way		9	11	27	61	109	159	208
Small-scale (<1 MW)	Steady Progression	1	1	1	1	2	2	2	2
	System Transformation		1	1	1	2	2	3	3
	Consumer Transformation		1	1	3	9	23	39	58
	Leading the Way		1	1	3	6	11	16	22

Overview of technology projections in the licence area:

- The Southern England licence area has a minimal baseline of onshore wind deployment, due to a combination of poor wind resource and difficulties in achieving planning permission for projects. Similarly, there is very little potential near-term development with a very small pipeline.
- The licence area does have some areas of good wind resource, such as parts of the Isle of Wight. Projections to 2050 are dictated by the ability of wind projects to obtain planning permission in these areas under each scenario.

- There is however some uncertainty around the commercial viability of onshore wind and the choice developers may make whether to connect to the transmission or distribution network. The Access and Forward-Looking Charges Significant Code Review has potential to significantly impact the business models of distributed generation in the Southern England
- Under the most ambitious scenario, **Consumer Transformation**, the licence area could host over 200 MW of onshore wind by 2050. This would require a significant change in current planning practices and far greater stakeholder acceptance of onshore wind in the region, potentially supported by greater local and community ownership of windfarms assets.

Scenario projection results:

Baseline (up to end of 2019)

- The large-scale onshore wind baseline, totalling 8.5 MW, is composed of two projects, including the 6.5 MW Westmill Windfarm near Swindon, commissioned in 2008.
- The small-scale baseline of 1.2 MW comprises four projects with an average capacity of 0.3 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 capacity connected between 2011 and 2015.
- Onshore wind projects in the licence area have historically struggled to attain planning permission.

Near term (2020 – 2025)

- There is only 0.6 MW of onshore wind capacity with an accepted connection offer, this consists of one site on the Isle of Wight which failed to attain planning permission and therefore does not go ahead in any scenario.
- The lack of pipeline projects reflects the effective moratorium of onshore wind development in England for the last few years. Recent changes to this policy, including the inclusion of onshore wind in upcoming Contracts for Difference auctions[i], means that project development is expected to restart in areas with good wind resource.
- In the higher growth scenarios planning processes and public acceptance supports onshore wind encouraging developers to bring forward new projects.
- As there are no pipeline projects that go forward under any scenario, COVID-19 does not have an impact on the near-term projections.

Medium term (2025 – 2035)

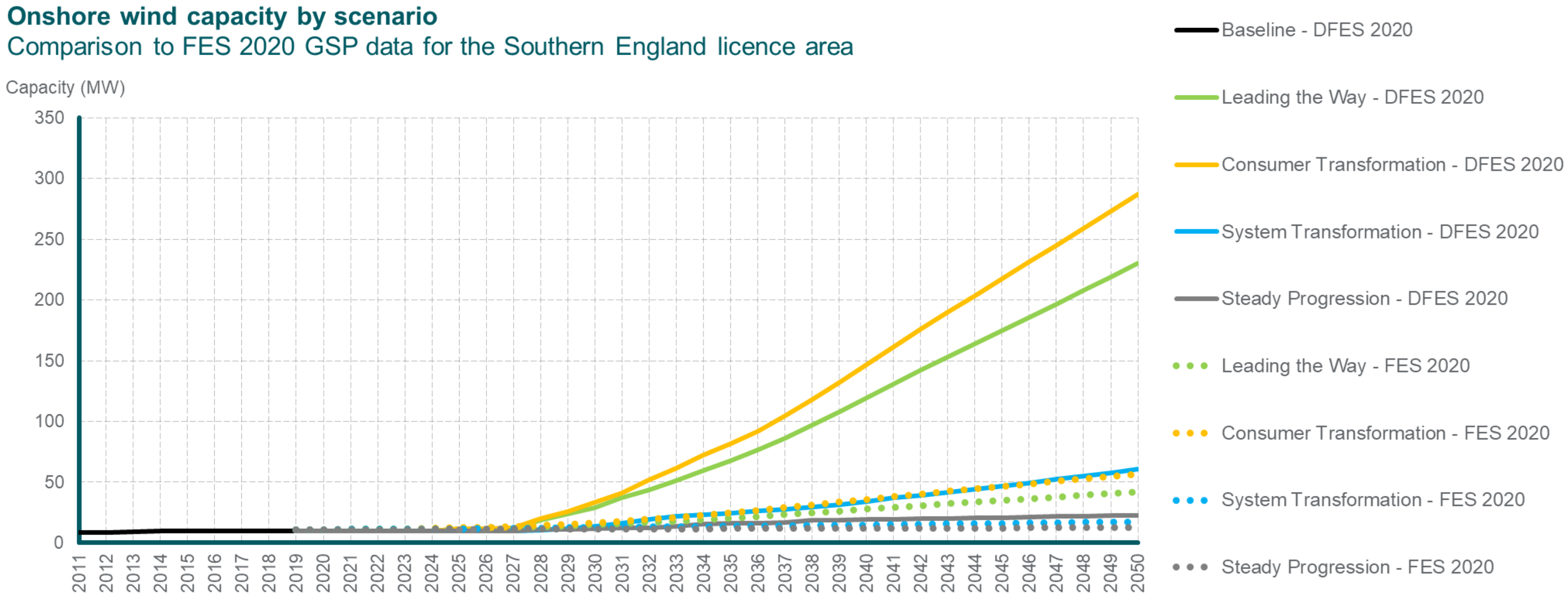
- The medium-term projections hinge strongly on which scenarios have the highest levels of societal change. While the Southern England licence area does not have the greatest wind resource, there are areas with feasible windspeeds that have seen project development in the past, only for the projects to fail in the planning application stage.
- According to the Renewable Energy Planning Database, failed planning applications for onshore wind in the licence area submitted between 1998 and 2014 totals some 253 MW (though this does include a small number of resubmitted projects). It is clear 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 the Pot 1 Contracts for Difference auctions containing onshore wind and solar PV, only the sites with the highest wind speeds are projected to be built out before 2035 under any scenario.
- The low levels of societal change that occur under **Steady Progression** and **System Transformation** mean that projects continue to struggle to attain planning permission in the licence area, and new connected capacity is limited to only the least impactful, optimal sites.
- The Access and Forward-Looking Charges Significant Code Review has potential to significantly impact the business models of distributed generation in the Southern England licence area. As a demand-dominated region, onshore wind projects in the licence area could be supported through the proposed revised charging structure, depending on the code review decision, which is expected imminently. This is a key uncertainty for the development of onshore wind in the region.

Long term (2035 – 2050)

- The long-term projections for distribution network connected onshore wind see a continuation of the trend seen in the medium term, where ability to achieve planning permission strongly dictates the deployment potential of onshore wind in the licence area across the scenarios.
- As technology progresses and costs reduce, more of the 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 development activity. The **Steady Progression** and **System Transformation** scenarios 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.
- By 2050, onshore wind capacity in the licence area under the **Leading the Way** and **Consumer Transformation** scenarios is dictated by the onshore wind resource, rather than historical factors such as the existing baseline or planning considerations. The onshore wind resource assessment does account for protected areas and proximity to homes, as well as availability of suitable wind speeds and network access.
- Despite the large increase in capacity from the negligible baseline under **Consumer Transformation** and **Leading the Way**, capacity in the Southern England licence area only represents around 1% of the total GB onshore wind capacity in these scenarios.

Figure 7: Onshore wind projections for the Southern licence area, compared to National Grid FES 2020 regional projections



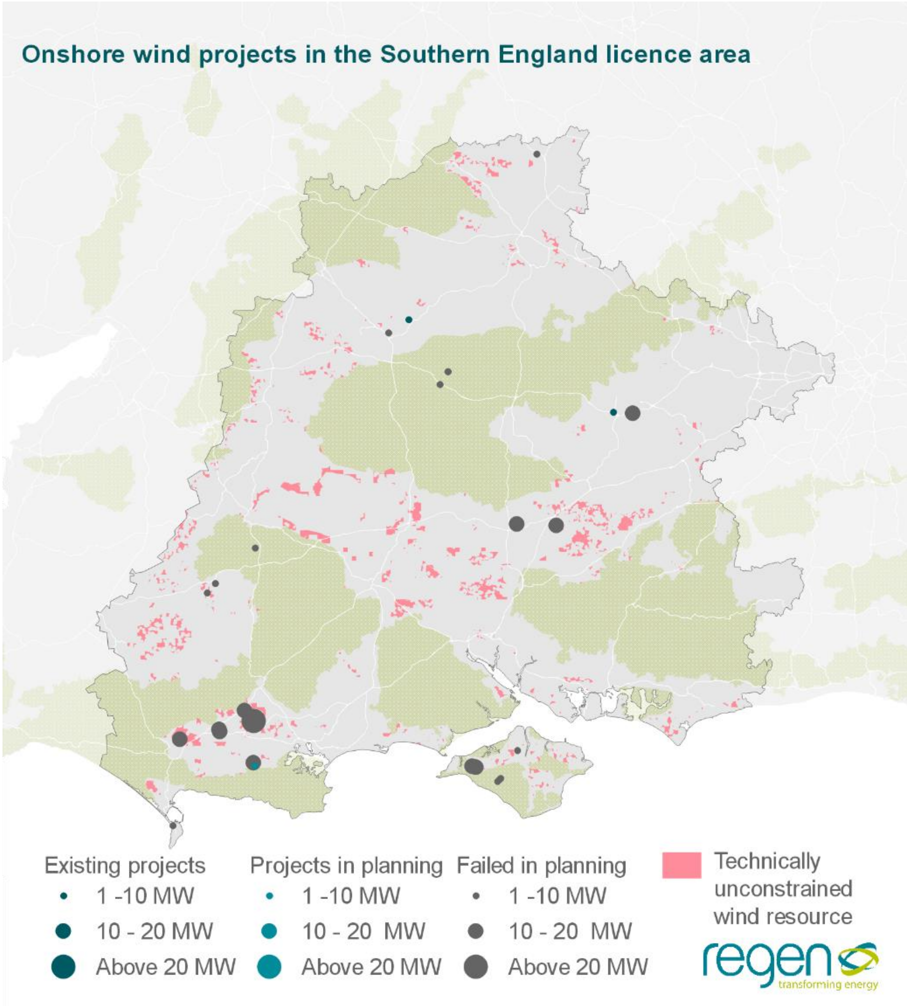
Reconciliation with National Grid FES 2020:

- The baseline and near-term projections are aligned in both the National Grid FES 2020 regional data and the DFES analysis.
- Beyond the pipeline the DFES projections diverge from the FES 2020 regional projections under all scenarios 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 on Regen's onshore wind resource assessment, stakeholder engagement and an analysis of previously attempted projects. These factors all point towards higher levels of deployment in scenarios where planning considerations do not block so much development.

Factors that will affect deployment at a local level:

- New projected onshore wind capacity is based on Regen's onshore wind resource assessment (Figure 8). This assessment takes into account relevant factors such as wind speed, landscape designations, dwelling proximity and others.
- The increase in onshore wind capacity related to repowering existing sites, is located directly at these baseline site locations.
- Sites that were previously in development but failed to achieve planning permission are used as indicators of technically developable onshore wind sites and are thus used to inform the resource assessment.

Figure 8: Onshore wind baseline and pipeline sites, projects that failed in the planning process, and onshore wind resource area in the Southern England licence area

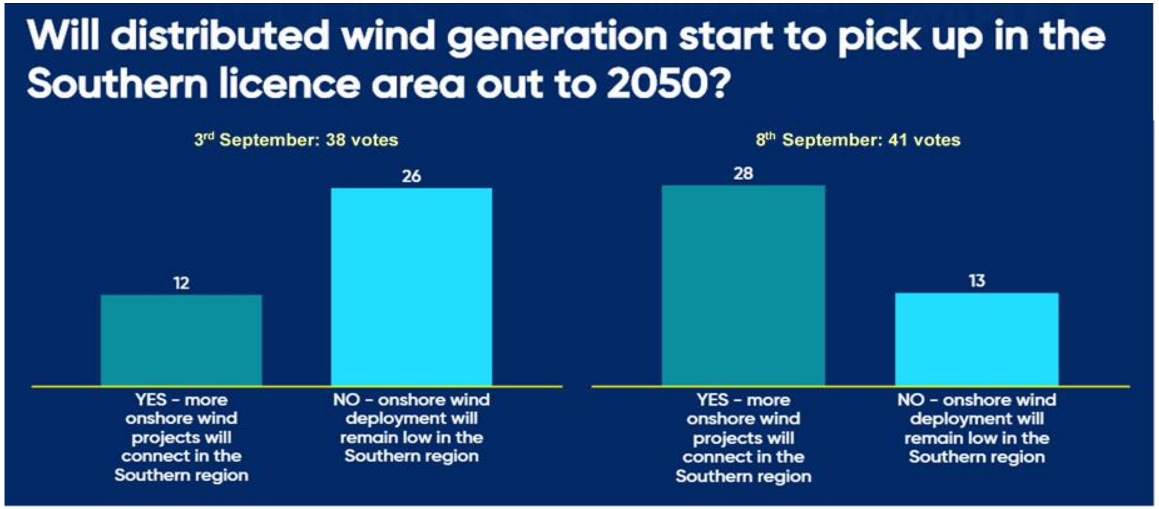


Relevant assumptions from National Grid FES 2020:

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:

Stakeholders in the Southern England licence area were split on whether onshore wind capacity would remain restricted in the south of England in the future, with each webinar delivering a mix of results. 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, the projections in the medium and long term the level of ambition reflects more the ESO FES scenarios themselves.

References:

SSEN connection data, System Wide Resource Registers (GB), the TEC register, the Renewable Energy Planning Database, Climate Emergency declaration data, Feed-in Tariff data, Renewables Obligation data, Contracts for Difference data, Regen resource assessments, Regen consultation with local stakeholders and local authorities.

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[i] Article on recent changes to onshore wind policy in England: https://www.rechargenews.com/wind/uk-government-lifts-support-ban-that-brought-onshore-wind-to-its-knees/2-1-765484

2. Large-scale solar PV in the Southern England licence area

Summary of modelling assumptions and results.

Technology specification:

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

DFES Building block Gen_BB012.

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

Installed capacity (MW)	Baseline	2020	2025	2030	2035	2040	2045	2050
Steady Progression	2,004	2,004	2,135	2,303	2,740	2,937	3,437	3,667
System Transformation		2,004	2,394	2,830	3,675	4,879	5,535	6,024
Consumer Transformation		2,004	2,431	2,867	3,712	4,916	5,572	6,060
Leading the Way		2,004	2,558	3,226	4,377	6,733	7,905	8,719

Overview of technology projections in the licence area:

- Due to the high levels of irradiance relative to the rest of the UK, the Southern England licence area has some of the highest levels of large-scale solar PV deployment in the country.
- This level of development interest is expected to continue throughout the timeframe of the scenarios out to 2050, due to the attractive levels of solar irradiance, though not to the same extent as in the baseline years. This is due to solar PV costs continuing to fall, resulting in ground-mounted solar PV projects being built out across all of GB rather than only in the south of the country.
- With solar PV panel efficiencies also increasing continuously, there is the potential for the repowering of baseline sites to drive a large increase in overall solar PV capacity as projects reach the end of their operational life.

Scenario projection results:

Baseline (up to end of 2019)

- There is currently c. 2 GW of ground-mounted solar PV capacity, from 211 projects, averaging 9.5 MW in capacity. This includes seven sites above 40 MW in size.
- 97% of this baseline capacity was developed between 2011 and 2017, when the Feed-In Tariff programme was available.
- 632 MW of capacity came online in 2015 alone, at the peak of Feed-in Tariff deployment. In contrast, since 2017, only 22 MW of capacity has been installed. This slowing of deployment is largely due to a reduction in Feed-in Tariff rates and the ending of the Feed-in Tariff.

Near term (2020 – 2025)

- There is a pipeline of 563 MW of ground-mounted solar PV projects with accepted connection offers.
- This pipeline comprises 32 projects, giving an average capacity of 17.6 MW – almost twice the average site size of the baseline.
- Notably, six of the pipeline projects are over 40 MW in size, representing 57% of the total pipeline capacity.
- 156 MW of capacity was found to be either under construction or with planning permission. Most of this capacity goes ahead within the next couple of years in the three DFES scenarios that achieve net zero by 2050 (**Leading the Way**, **Consumer Transformation** and **System Transformation**). This relates to new business models and routes to market becoming viable for strong prospective projects, particularly in the Southern England licence area where the levelised cost of electricity from large-scale solar is amongst the lowest in the country.
- Under **Steady Progression**, a small delay is assumed before new solar PV business models are viable.
- While Contracts for Difference auctions are open to solar PV projects from 2021, the highly competitive nature of these contracts means that pipeline projects are not assumed to win a contract.

Medium term (2025 – 2035)

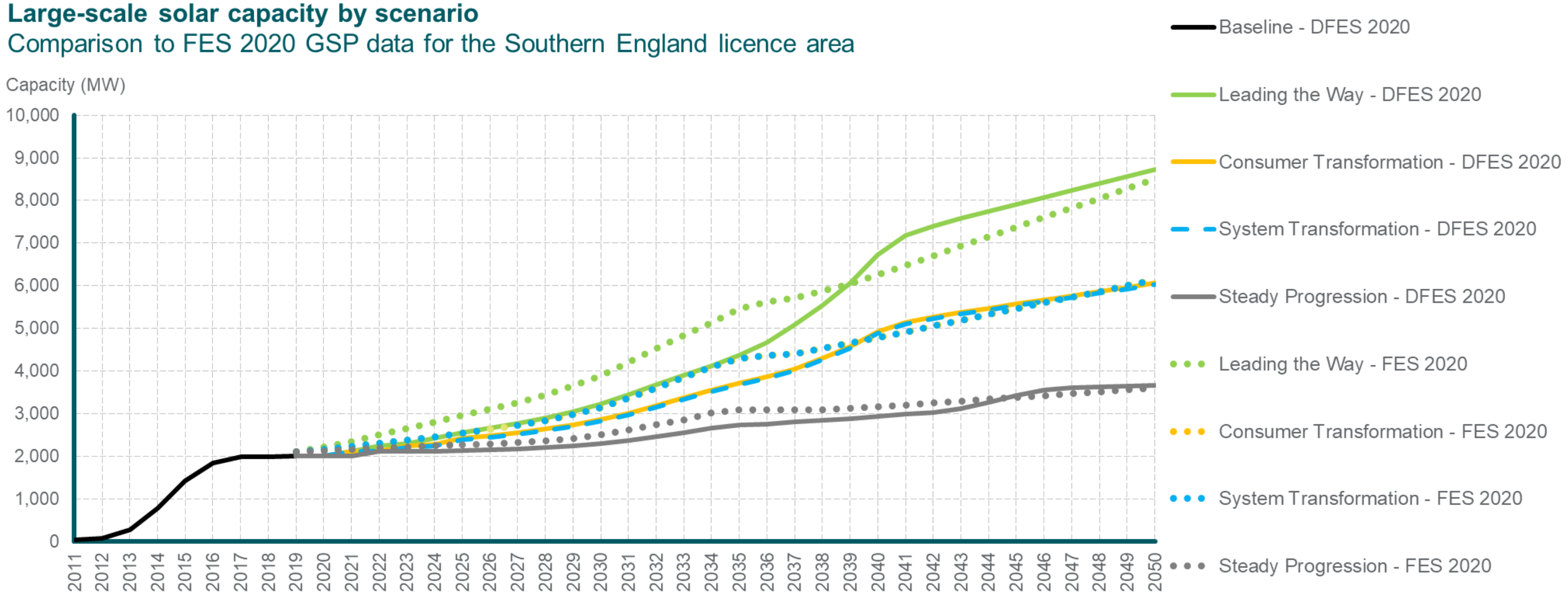
- The medium-term trajectory for solar PV deployment accelerates in the three scenarios that meet net zero, as continued support from government through the Contracts for Difference mechanism, combined with the emergence of other business models utilising co-located storage or Power Purchase Agreements, allows new solar PV capacity to develop strongly after the recent slowdown.
- The level of capacity increase in each scenario is dictated by national trends, whilst also dependent on the solar resource available in the Southern England licence area. As a region with some of the highest levels of irradiance in the country, the licence area is likely to host some of the first solar farms in the UK without subsidy support.
- The 2030-2035 period sees the highest levels of solar PV deployment since the early years of the Feed-in Tariff, as solar PV module costs continue to fall, new business models become commercially viable, and developers exploit strong irradiance levels in the region.
- Deployment is particularly strong under **Leading the Way**, as a result of the highest levels of green ambition, combined with emerging revenue streams from hydrogen electrolysis, which buffers power prices during periods of high solar output.
- The Access and Forward-Looking Charges Significant Code Review has potential to impact the business models of distributed generation in the Southern England licence area. This could benefit solar projects through lower (shallower) network connection changes but may also increase ongoing distribution network charges DUoS, depending on the project location.

- As a demand-dominated region, projects in Southern England could see shallower network charges or even credits, depending on the code review decision expected imminently. This is a key uncertainty for the future development of large-scale solar PV in the region.

Long term (2035 – 2050)

- The long-term projections continue similarly to the preceding years, with steady deployment in the net zero scenarios as solar farms with new routes to market become the norm. These projections are based predominantly on the level of solar PV resource in the licence area, and national trends.
- Wholesale price cannibalisation during peak solar periods has potential to concern investors at high levels of solar deployment. However, solutions such as co-location with storage, production of hydrogen through electrolysis, and wholesale power floor prices bolstered through interconnectors are expected to sustain solar PV business models in the net zero scenarios.
- Repowering of existing projects contributes significantly to capacity growth in the later years of the scenarios, as sites developed during the baseline years reach the end of their planned operational life. Efficiency, and therefore the wattage of each solar panel, has improved significantly since the early 2010s and is expected to continue improving over the coming decades. Existing sites could therefore be repowered to higher capacities, and higher capacity factors, without changing the site layout or number of panels, simply through replacement with higher efficiency modules.
- By 2050, distribution network connected large-scale solar PV capacity is highest in **Leading the Way** at c.8.7 GW and lowest in **Steady Progression** at c.3.7 GW.

Figure 9: Large-scale solar PV projections for the Southern England licence area, compared to National Grid FES 2020 regional projections



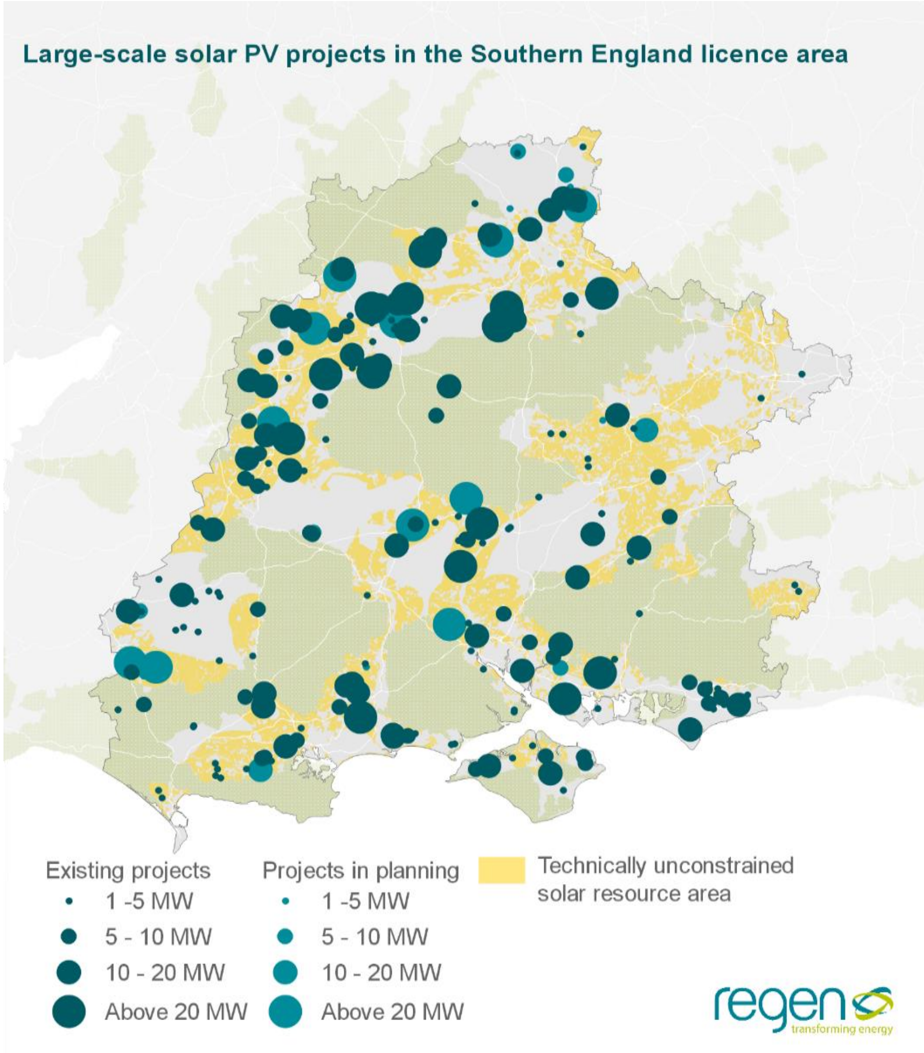
Reconciliation with National Grid FES 2020:

- The DFES and FES 2020 regional baseline for large-scale solar PV in the Southern England licence area are in alignment.
- The FES 2020 regional projections are higher than the DFES in the near-term, as research of the pipeline of accepted connections for the DFES analysis did not justify such a high level of deployment over the next few years. This trend continues in the medium term, with the DFES projections lagging the FES 2020 projections, while following a similar shape.
- The DFES sees a strong uplift in projections beyond the medium term, especially under the three net zero scenarios, where baseline sites are expected to repower in the late 2030s and early 2040s. This is not as apparent in the FES 2020 projections.
- Out to 2050, the scenarios are strongly aligned, as the solar resource in the licence area is reflected in the projections. The long-term DFES projections hinge strongly on the national trajectory for distributed solar PV, so the alignment with the FES 2020 data is expected.

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 (see Figure 10). This considers irradiance, designated land areas, physical constraints, network proximity, ground slope and aspect and proximal buildings.
- Due to the influence of repowering, much of the future large-scale scale PV capacity will be located at existing sites.

Figure 10: Large-scale solar PV baseline and pipeline sites, and solar resource area, in the Southern England licence area



Relevant assumptions from National Grid FES 2020:

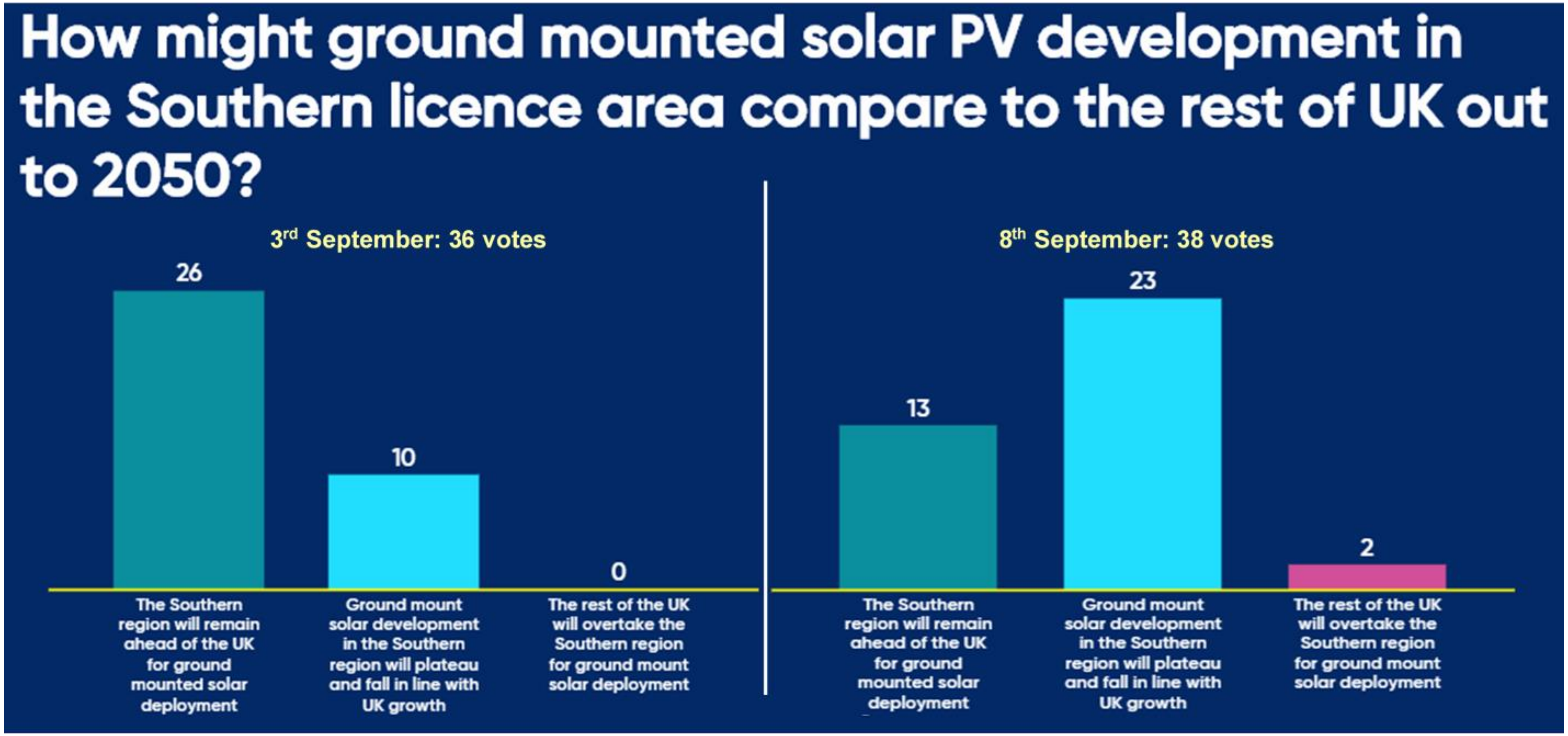
Assumption number	4.2.15
Steady Progression	Slower pace of decarbonisation.
System Transformation	Transition to net zero results in strong deployment of large solar.
Consumer Transformation	Transition to net zero results in strong deployment of large solar.
Leading the Way	Very high ambition to decarbonise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

Stakeholder feedback overview:

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 in the near term. However, the projections in the medium and long term the level of ambition reflects more the ESO FES scenarios themselves.

Stakeholders at two engagement events were asked questions on how the future deployment of large-scale solar PV in the Southern England licence area might compare to the rest of the UK. Results were mixed with some stakeholders suggesting the licence area may remain ahead of the rest of the UK, and others suggesting it may fall in line with national trends. Notably, only two responses expected the licence area to fall behind the UK trajectory. To reflect this mix of opinions, the licence area projections remain ahead of the UK trajectory in the near and medium term, before falling in line with national trends in the long term.

Developers with projects in the pipeline were contacted on an ad-hoc basis to discuss the likely commissioning dates of their projects, which is directly reflected in the near-term projections. These phone calls also covered the likely trajectory for large-scale solar PV in the medium-term, and the impact of coronavirus on projects currently in development.



References:

SSEN connection data, System Wide Resource Registers (GB), the TEC register, the Renewable Energy Planning Database, Climate Emergency declaration data, Feed-in Tariff data, Renewables Obligation data, Contracts for Difference data, Regen resource assessments, Regen consultation with local stakeholders and local authorities.

3. Hydropower in the Southern England licence area

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

DFES building block Gen_BB018

Data summary for hydropower in the Southern England licence area:

Installed capacity (MW)	Baseline	2020	2025	2030	2035	2040	2045	2050
Steady Progression	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
System Transformation		1.6	1.6	1.6	1.6	1.6	1.6	1.6
Consumer Transformation		1.6	1.6	1.9	2.1	2.3	2.3	2.4
Leading the Way		1.6	1.6	1.9	2.1	2.3	2.3	2.4

Overview of technology projections in the licence area:

- The Southern England licence area has very little hydropower resource, limited to a small number of small-scale projects.
- Some small baseline projects were developed in the early 2010s due to higher Feed-in Tariff rates for small-scale renewable generation.
- Any future additional hydro capacity is likely to be kilowatt scale, as per the baseline.
- Therefore, scenario projections for distributed hydro in the licence area are highest in **Consumer Transformation** and **Leading the Way**, where small-scale renewables play a vital role in achieving net zero. Under **System Transformation** and **Steady Progression**, hydropower development is very limited.

Scenario projection results:

Baseline (up to end of 2019)

- There is currently 1.6 MW of hydropower capacity connected to the Southern England distribution network, across 48 sites.
- Development has slowed in recent years with the reduction in Feed-in Tariff rates and the removal of the Feed-in Tariff programme altogether. This has seen only 0.01 MW commissioned in the licence area since 2016.

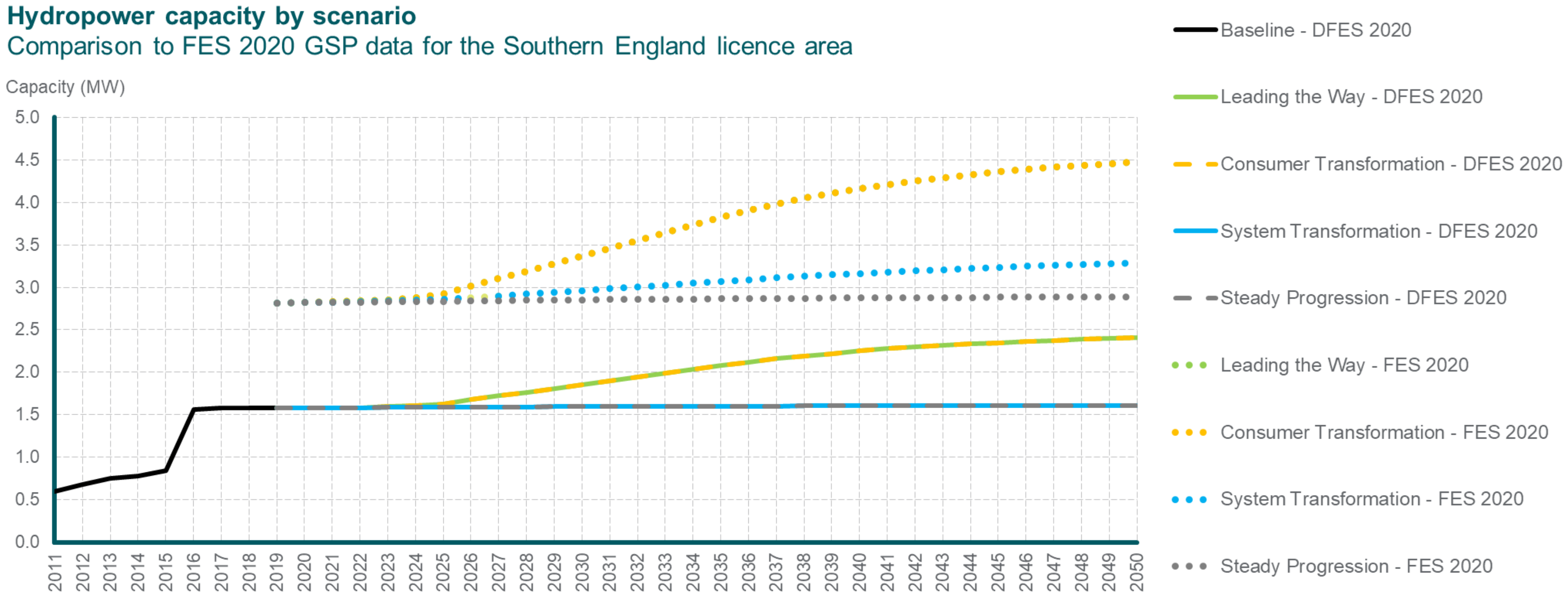
Near term (2020 – 2025)

- Despite the lack of commissioned projects over the last four years, the pipeline of accepted connections totals 0.7 MW, across two sites.
- However, both these 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 revealed a small amount of potential hydro generation repowering in the near-to-medium term, which have been reflected in the near-term scenario projections.

Medium and long term (2025 – 2050)

- Beyond the pipeline, the **Consumer Transformation** and **Leading the Way** scenarios see a very small amount of additional hydro capacity coming online. The lack of hydropower development since 2016 shows that in the Southern England licence area, the potential is extremely limited without significant subsidy support.
- Some 0.8 MW, representing half the baseline capacity, is developed by 2050 across several very small, kilowatt-scale sites, including the rejected pipeline sites, which the DFES has represented as unexploited resource, and minor repowering at existing sites.
- Under **System Transformation** and **Steady Progression**, the trend seen since 2016 continues, with effectively no additional hydropower developed out to 2050.
- Despite many projects being quite old by this point, as a mature technology there is not expected to be significant increase in hydropower output cause by turbines being repowered in existing projects.

Figure 11: Hydropower projections for the Southern England licence area, compared to National Grid FES 2020 regional projections



Reconciliation with National Grid FES 2020:

- The FES 2020 regional baseline of 2.8 MW is around 1.3 MW higher than the DFES baseline for the licence area. While proportionally this is a significant difference, at an absolute level it is negligible, and likely comes down to classification of Feed-in Tariff data.
- With such small capacities, the DFES scenarios have only two outcomes (with two pairs of scenarios tethered) – one outcome where no further hydro is supported (**System Transformation** and **Steady Progression**), and another outcome where the small amount of available resource indicated by two pipeline sites is exploited (**Leading the Way** and **Consumer Transformation**). The FES 2020 regional data has a third scenario (**System Transformation**) that is somewhat in the middle of these outcomes.

Factors that will affect deployment at a local level:

- The distribution of the projections is based purely on the two pipeline sites, which, while not going ahead in the near term represent potential exploitable hydropower resource locations, and existing sites that could repower with marginally more efficient turbines.

Relevant assumptions from National Grid FES 2020:

Assumption number	4.1.1 Hydro generation
Steady Progression	High costs associated with large scale projects. Little ambition or support
System Transformation	High costs associated with large scale projects. Some support is forthcoming for large scale projects, limited societal change from large scale remote generation
Consumer Transformation	Potential for a lot of small scale projects that will have larger societal impact
Leading the Way	Potential for rapid deployment of large and small scale projects; society is more in favour of disruptive projects. Limited by the reduction in energy demand

Stakeholder feedback overview:

Given the minimal baseline and projections, stakeholders in the Southern England licence area were not consulted on hydropower, with the exception of the water companies in the area, who were consulted around potential new sites, or existing sites repowering at higher capacities.

References:

SSEN connection data, System Wide Resource Registers (GB), the TEC register, the Renewable Energy Planning Database, Climate Emergency declaration data, Feed-in Tariff data, Renewables Obligation data, Contracts for Difference data, Regen resource assessments, Regen consultation with local water companies.

4. Marine generation in the Southern England licence area

Summary of modelling assumptions and results.

Technology specification:

DFES technology building block: Marine - tidal stream and wave energy [Gen_BB017]

The analysis covers any marine generation projects (tidal or wave) that connect to the distribution network in the Southern England licence area. The DFES analysis has focussed predominantly on known small scale project developments, plus insight from Regen's marine energy lead (Kerry Hayes) and engagement with the Marine Energy Council around viable pipeline projects that are likely to connect to the distribution network out to 2050. The sub technologies included in the marine energy analysis are:

- **Wave energy** – typically small array and demonstration projects
- **Tidal stream energy –** harnessing kinetic tidal flows around headlands and in channels

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

Installed capacity (MW)	Baseline	2020	2025	2030	2035	2040	2045	2050
Steady Progression	0	0	0	0	0	0	0	0
System Transformation		0	0	0	0	0	0	0
Consumer Transformation		0	0	0	0	0	0	0
Leading the Way		0	0	10	30	30	30	30

Overview of technology projections in the licence area:

- The marine energy generation sector is largely at an early stage of technology development and commercialisation and while there a number of small scale projects around the UK the amount of deployment to date has been limited.
- Marine energy projects will be very location specific based on the availability of wave/tidal resources, physical site characteristics and environmental conditions.
- The withdrawal of subsidy support for wave and tidal energy in 2016[ii] has affected industry confidence and has led to the withdrawal and delay of many pre-commercial projects.
- UK government is now consulting on a new Contracts for Difference round to support marine energy, this could potentially unlock some marine generation project development.[iii]
- If large scale projects do proceed, they are likely to connect to the transmission network. Distribution network projects may therefore be limited to smaller commercial projects, demonstration projects, trial sites and testing facilities.
- The Southern England licence area has no operational marine generation sites connected to the distribution network to date.
- There is a 30 MW project with an accepted connection offer, proposed to be located on the south coast of the Isle of Wight. This has been projected to connect in **Leading the Way** only, as the most ambitious of the net zero compliant scenarios. Given the degree of uncertainty around this project, it has been modelled in the DFES with a staggered deployment of 10 MW installed by 2030, rising to 30 MW by 2035.
- Further marine energy projects off the south coast are possible, including a development area for tidal generation off Portland, however owing to the level of uncertainty no additional marine generation capacity has been modelled to connect to the distribution network in the licence area out to 2050.

Scenario projection results:

Baseline (up to end of 2019)

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

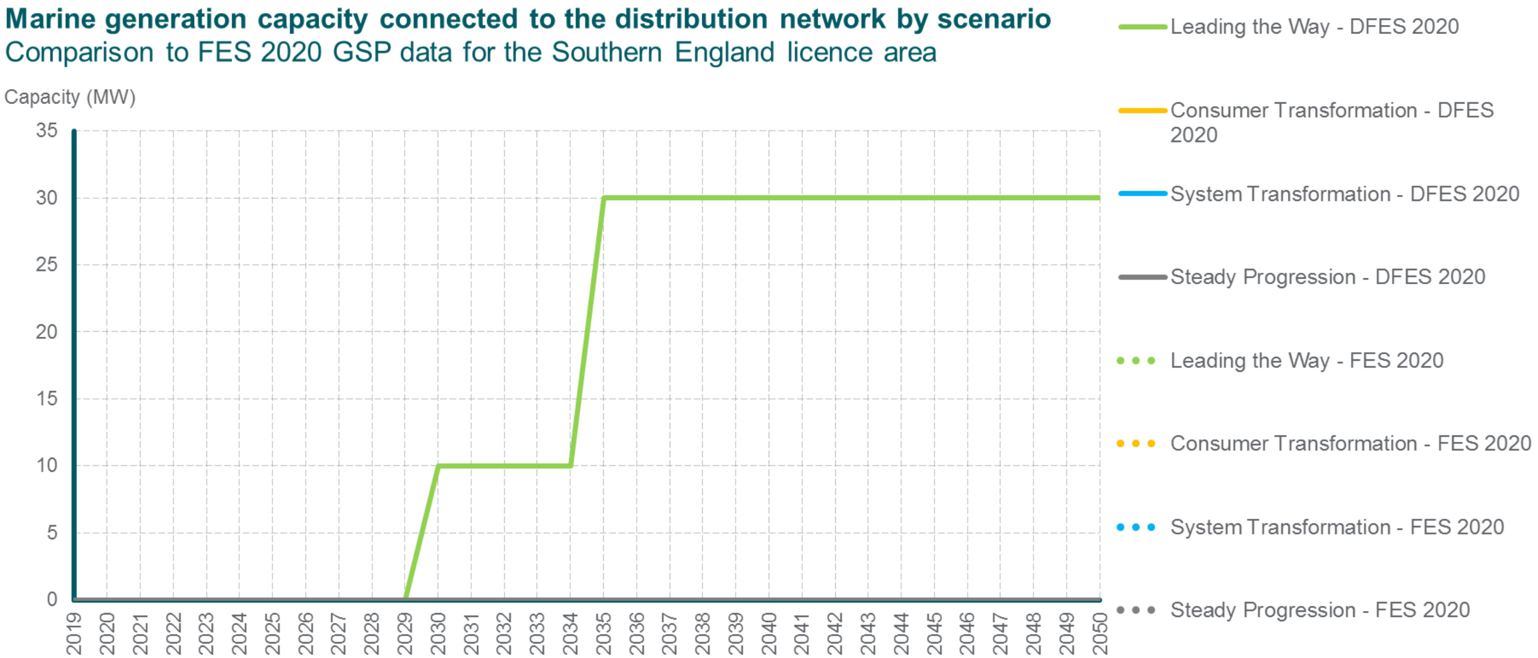
Near/medium term (2020 – 2035)

- There is a 30 MW tidal energy project that has an accepted connection offer in the licence area, located at Ventnor on the south coast of the Isle of Wight. This project, being developed by Perpetuus Tidal Energy Centre (PTEC) received planning approval in 2015[iv], had an accepted connection offer for the full 30 MW generation capacity in April 2014 and announced a development partnership with the European Marine Energy Centre (EMEC) in October 2020[v].
- However, this potential project has also had to both manage funding challenges[vi] and has suffered development delays due to COVID-19[vii].
- The DFES has therefore modelled a staggered connection of capacity at this site location in the **Leading the Way** scenario only. This reflects both the lack of any distribution network marine capacity modelled in the FES for the Southern England licence area and the known challenges for marine generation demonstration projects in general.
- This results in 10 MW initially coming online by 2030, increasing to the full accepted capacity of 30 MW in 2035 in **Leading the Way**.

Long term (2035 – 2050)

- With the lack of any baseline, no projections in the licence area in the FES GSP and the identified challenges, no additional marine generation capacity has been modelled to connect to the distribution network in the licence area between 2035 and 2050 in any scenario.

Figure 12 Comparison of marine generation projections in the Southern England licence DFES analysis to the FES 2020



Reconciliation with National Grid FES 2020:

- The FES 2020 regional dataset has no projections for distribution connected marine generation in the Southern England licence area.
- The DFES has opted to diverge from this assumption of no capacity in the licence area, due to the potential 30 MW tidal pipeline project on the Isle of Wight. This capacity has been modelled to connect in two stages, 10 MW in 2030 and 30 MW in 2035 in **Leading the Way** only.
- The 30 MW modelled to connect in **Leading the Way** in the licence area, equates to c.9% of the total GB marine generation capacity (345 MW) modelled to connect across all distribution network licence areas in 2050 in the FES.

Factors that will affect deployment at a local level:

- The future of wave and tidal energy is uncertain, and it should be recognised that the industry is in a period of technology development.
- Known technical challenges facing wave and tidal projects, combined with the removal of subsidy support to marine projects, means that the potential for future deployment of demonstration projects, let alone fully operational generation assets, is highly uncertain.
- The DFES has, however, acknowledged the presence of the known 30 MW PTEC pipeline project in **Leading the Way**.
- The geographical distribution factor applied for this capacity is the actual location of the site, located on the Ventnor region on the south coast of the Isle of Wight.
- Further tidal energy projects could be developed off Portland, however this has not been included in the DFES modelling.

Relevant assumptions from National Grid FES 2020:

Assumption number	4.1.2 (Other renewables including marine generation)
Steady Progression	Low support where other renewables (e.g. tidal) cannot complete solar and wind generation.
System Transformation	Support for large scale renewable technologies (i.e. tidal).
Consumer Transformation	Small scale generation connected to local supply chains. May be community owned.
Leading the Way	Focus on low carbon technologies promote a wide range of renewable technologies including marine sources at all scales.

References and data sources:

SSEN connection data, Isle of Wight council website, Development news on PTEC website, Marine Energy Council reports and presentations, Marine Energy Wales "State of the Sector" report: https://www.marineenergywales.co.uk/wp-content/uploads/2020/07/MEW-State-Of-The-Sector-2020.pdf

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[ii] Marine energy had a minima CfD for 100 MW at £305 per MWh to be installed by 2019, but this was withdrawn owing to budget limitations placed on the Levy Control Framework introduced in early 2016.
[iii] UK Government Consultation on support for wave and tidal energy using Contracts for Difference (2020) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/913042/marine-energy-projects-call-for-evidence.pdf
[iv] See notification of planning approval (Sep 2015): https://perpetuustidal.com/tidal-energy-onshore-plans-for-a-ventnor-site-have-been-given-planning-permission-by-the-isle-of-wight-council/
[v] See announcement of PTEC and EMEC partnership on Ventnor 30 MW tidal demonstration project (Oct 2020): https://renews.biz/64021/
[vi] See BBC News article reflecting the unclear future of the Ventnor project (Sep 2020): https://www.bbc.co.uk/news/uk-england-hampshire-54331391
[vii] See Isle of Wight Island Echo news article, describing financial uncertainties caused by COVI9-19: https://www.islandecho.co.uk/tidal-energy-centre-delayed-again-due-to-financial-uncertainties/

5. Biomass electricity generation in the Southern England licence area

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, it does include biomass used solely for heat, or bioenergy with carbon capture and storage (CCS). **DFES building block ID Gen_BB010**.

Data summary for biomass in the Southern England licence area:

Installed capacity (MW)	Baseline	2020	2025	2030	2035	2040	2045	2050
Steady Progression	0.1	0.1	1	1	1	1	1	1
System Transformation		0.1	61	61	61	61	61	61
Consumer Transformation		0.1	31	31	31	31	40	49
Leading the Way		0.1	31	31	31	34	43	43

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 issuesviii. There is a great deal of uncertainty regarding the future of biomass generation projects, the DFES analysis has, however, modelled that the Southampton project or a similar equivalent may connect in 2025 in **Leading the Way**, **Consumer Transformation** and **System Transformation**, albeit with reduced capacity. It is not modelled to connect in the **Steady Progression** scenario, reflecting an assumption that the financial challenges that are currently being experienced by the project cannot be resolved in the longer term under this scenario.

Scenario projection results:

Baseline (up to end of 2019)

- There is one farm-scale biomass boiler in the SSEN connection database totalling 0.05 MW.

Near term (2020 – 2025)

- There is one biomass generation site with an accepted connection offer, a 0.6 MW biomass boiler located at a cheese production facility.
- This project is modelled to connect by 2024 in all scenarios.
- Almost all of the near-term additional biomass capacity stems from the known, but stalled, 100 MW Southampton biomass CHP plant.
- This project to connect in 2025 under the three scenarios that meet 2050 net zero targets, but with a reduced capacity:
  - 60 MW in **System Transformation**
  - 30 MW in **Leading the Way** and **Consumer Transformation**
- No additional near-term biomass generation is modelled in **Steady Progression**.

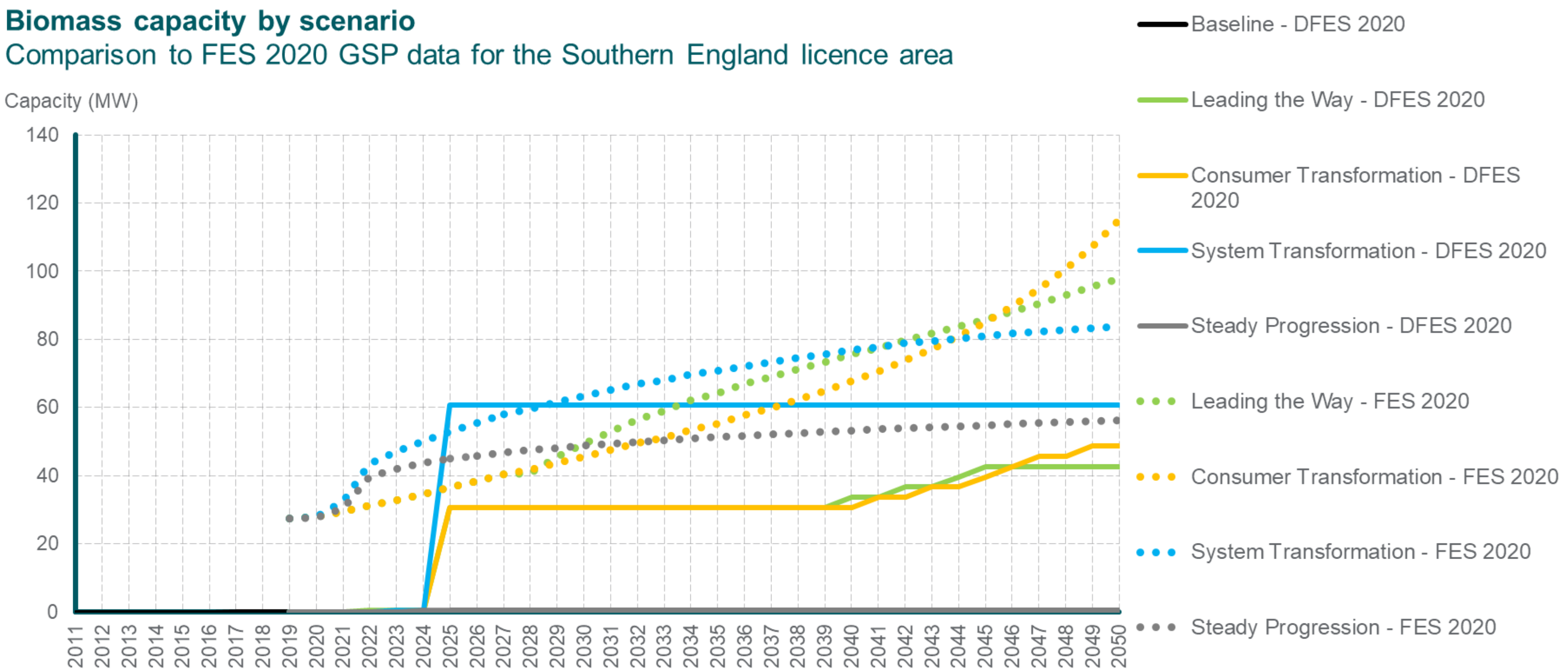
Medium term (2025 – 2035)

- The medium and long-term projections for biomass are based on an assessment of the age of existing operational sites, reflecting assumptions around their operational lifespan and future competing uses for biomass feedstocks.
- The DFES considers that biomass with CCS could see deployment from the medium term onwards, however this has been assumed to connect only at transmission level as the high costs of CCS technology is unlikely to be commercially viable for smaller scale biomass generation plants that are developed without subsidy support.

Long term (2035 – 2050)

- From the 2030s onwards, the DFES has assumed that sustainable sources of biomass feedstock is prioritised for large scale biomass with CCS, heat or other non-energy uses. This leads to a very limited increase in distribution network connected biomass generation capacity.
- In addition to this, a projected reduction in capacity of the Southampton biomass CHP pipeline project is modelled in **System Transformation**.
- Some smaller-scale dispatchable biomass power generation is assumed to continue generating throughout the projection period. There is some potential for additional biomass generation under **Leading the Way** and **Consumer Transformation** around areas with district heating.

Figure 13 Summarising scenario projection graph for biomass, with comparison to FES regional



Reconciliation with National Grid FES 2020:

- The assumptions underpinning this work are in line with the FES 2020 results, however the results differ due to local spatial factors.
- SSEN connections data suggest a baseline capacity which is lower than the FES 2020 baseline for the Southern England licence area which means the projections are lower than the FES projections.
- Near term deployment is significant in the net zero scenarios due to the large Southampton biomass CHP plant.
- The limited number of sites mean that there are larger ‘step’ changes in the SSEN DFES projections as single sites connect or reach the end of their operational life, than compared to the FES 2020 projection.

Factors that will affect deployment at a local level:

- Other than the proposed large scale biomass scheme in Southampton to be used as part of a city heat network, a few new biomass plants have been projected to connect in the long term in the **Leading the Way** and **Consumer Transformation** scenarios. The spatial distribution of these new sites is based on the location of existing sites either currently connected or identified by developers through planning applications.
- According to the FES assumptions, the long term projections refer to biomass plants used as part of city heat networks. Therefore, the geographical distribution of new sites are predominantly around urban areas where heat networks are likely to be developed, such as Oxford, Swindon and Reading.

Relevant assumptions from National Grid FES 2020:

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

References:

SSEN connection data, System Wide Resource Registers (GB), the TEC register, the Renewable Energy Planning Database, Climate Emergency declaration data, Regen consultation with local stakeholders and discussion with technology developers.

[viii] See BBC News article about the shelving of Southampton biomass plant: https://www.bbc.co.uk/news/uk-england-32016109

6. Waste (incineration) electricity generation in the Southern England licence area

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. **DFES Building block ID number Gen_BB011.**

Data summary for energy from waste in the Southern England licence area:

Installed capacity (MW)	Baseline	2020	2025	2030	2035	2040	2045	2050
Steady Progression	77	77	233	233	233	233	233	233
System Transformation		77	137	117	100	100	60	60
Consumer Transformation		77	137	137	137	137	117	100
Leading the Way		77	137	117	100	100	60	60

Overview of technology projections in the licence area:

The carbon emissions from older unabated waste incineration plants are not consistent with a net zero emissions targets. As a result, it is assumed in the scenarios that meet net zero targets that connected incineration plant capacity reduces after 2028 as these older facilities reach the end of their lifetime and the capacity is not replaced.

ACT gasification plants, of which there is 70 MW in the pipeline in the licence area, are expected to have lower associated carbon emissions and are a compatible technology with net zero 2050 targets, assuming that the residual emissions are abated. The DFES analysis assumes that all ACT facilities with planning permission (60 MW) go ahead in all scenarios however, there have been cases in the past where ACT projects have failed even after receiving planning permission, and therefore there is uncertainty associated with near term projections for this technology in the licence area. ACT facilities are also not projected to decommission in the analysis period, in any scenario.

Under a **Steady Progression** scenario, it is assumed that both the pipeline of new incineration plants and ACT plants connect in the near term and do not decommission out to 2050.

Scenario projection results:

Baseline (up to end of 2019)

- There is a total of 77 MW of energy from waste connected in the Southern England licence area.
- There are four baseline sites in total, the largest being a 40 MW incineration plant in Bicester which connected in 2014.

Near term (2020 – 2025)

- There is a large pipeline of eight new incineration sites totalling 200 MW. The connection date of each pipeline site is determined by the SSEN connection status, the planning status, and whether the plant is an incinerator or an ACT plant.
  - Incineration plants only connect in **Steady Progression** if they have either a connection offer, or planning permission
  - ACT plants connect in all scenarios if they have either a connection offer or planning permission
- Several sites have been in development for some time and there is some degree of uncertainty over which sites will proceed. The DFES scenarios have therefore modelled different site combinations and timings. See overview of this logic applied to the pipeline sites in Table 1.

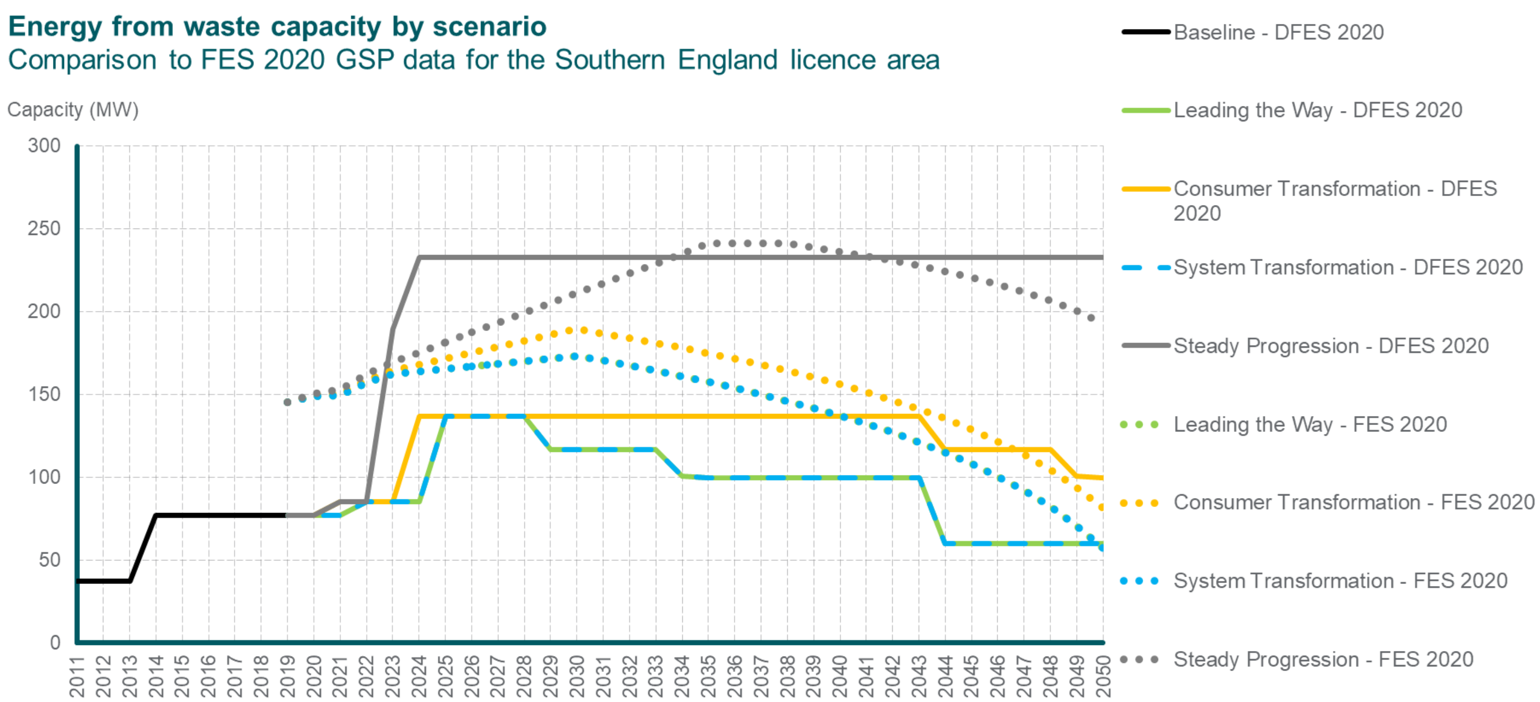
Table 14 Summarising scenario pipeline connection year for energy from waste in the Southern England licence area

ESA	Capacity (MW)	SSEN connection offer	Planning permission	Technology	Connection year by scenario			
					Leading the Way	Consumer Transformation	System Transformation	Steady Progression
SUTTON LANE_South Bucks	43.4	Yes	No	Incineration	-	-	-	2024
ALTON LOCAL_East Hampshire	33.0	No	No	Incineration	-	-	-	-
ANDOVER EAST_Test Valley	10.0	No	No	ACT	-	-	-	-
STANTON FITZWARREN_Swindon	14.5	No	Yes	ACT	2025	2024	2025	2023
MINETY VILLAGE_Wiltshire	5.7	Yes	Yes	ACT	2022	2021	2022	2021
HAWKERIDGE_Wiltshire	37.3	Yes	Yes	ACT	2025	2024	2025	2023
FARNHAM ROYAL_Slough	52.6	Yes	Yes	Incineration	-	-	-	2023
SHALFLEET_Isle of Wight	2.2	Yes	Yes	ACT	2022	2021	2022	2021

Medium and long term (2025 – 2050)

- No additional capacity has been projected beyond the pipeline; this aligns with the FES 2020 regional projections for the licence area.
- The medium and long term waste generation projections were determined by decommissioning the baseline and pipeline sites, based on a defined asset lifetime, which varies according to the scenario:
    - In **Consumer Transformation**, incinerators have a lifetime of 45 years
    - In **Leading the Way** and **System Transformation**, incinerators have a shorter lifetime of 30 years, due to decreasing waste resource availability, as a result of higher societal change and less waste produced overall, in these scenarios.
- No ACT capacity is modelled to decommission by 2050, based on an assumption that they are compliant with a net zero emissions target.
- All waste generation sites remain connected up to and beyond 2050 in **Steady Progression**.
- In addition, it is assumed that the municipal waste produced per person will decrease towards 2050 meaning there may be less available and thus the generation site load factors may change also.

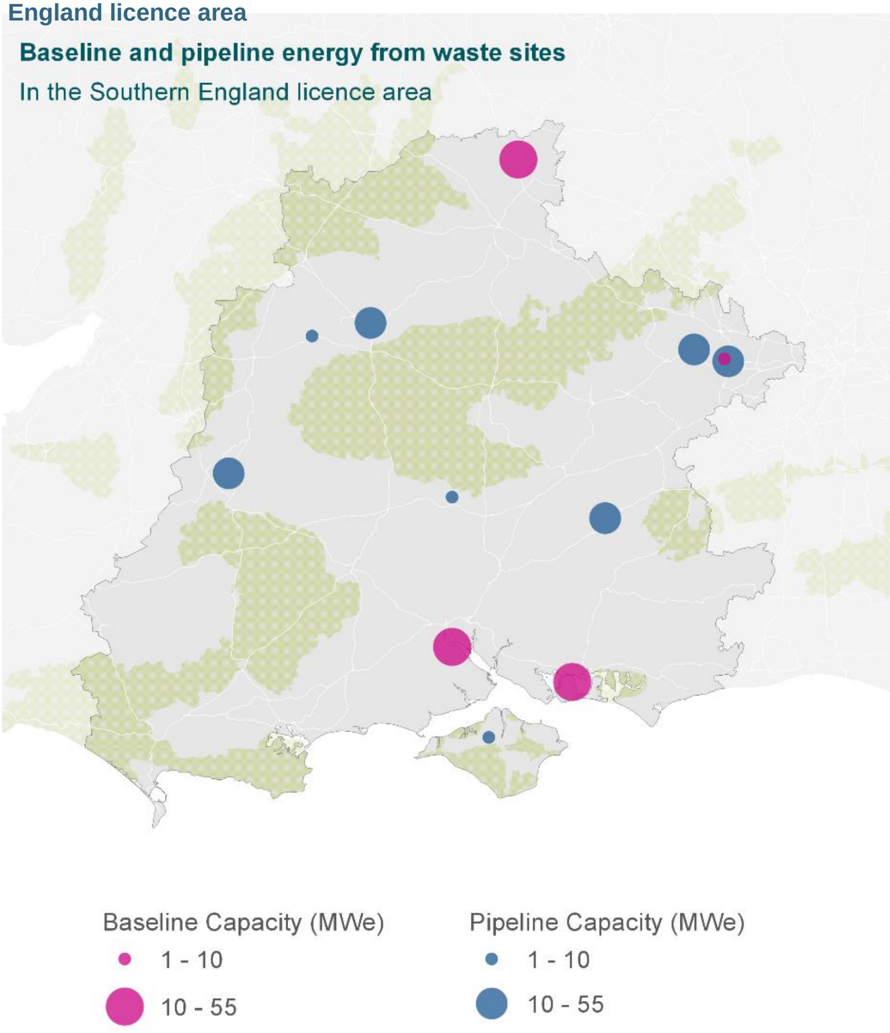
Figure 15 Summarising scenario projection graph for energy from waste, with comparison to FES regional



Reconciliation with National Grid FES 2020:

- The assumptions underpinning the DFES analysis are largely in-line with the FES 2020 regional projections, however the results differ due to local factors and spatial distribution.
- SSEN connections data suggest a baseline capacity which is c.70 MW lower than the FES 2020 baseline for the Southern England licence area. However the baseline in the regional FES 2020 aligns with the previous DFES baseline for energy from waste. This is because a few of the sites in the previous study's baseline have since decommissioned. These include the 52 MW facility at Lakeside (which has recently been decommissioned and is set to be replaced with a new incineration facility by 2024 under the **Steady Progression**) and two 12 MW plants in Slough and Basingstoke.
- Near term deployment is significant due to the size of the pipeline with planning permission.
- Where the FES 2020 regional projection data shows a smooth decline, the DFES analysis of connected and contracted energy from waste generation sites results in a decommissioning of actual sites, thus the capacity projection is much more stepped down.

Figure 16 – Energy from waste baseline and pipeline sites in the Southern England licence area



Relevant assumptions from National Grid FES 2020:

Assumption number	4.1.11 (Waste generation)
Steady Progression	No great change in waste management from society; leaving waste available as a fuel source.
System Transformation	Less waste to burn in general due to a highly conscious society adapting to low waste living.
Consumer Transformation	Limited societal change in waste management; less waste than current produced, limiting waste to burn generation.
Leading the Way	Less waste to burn in general due to a highly conscious society adapting to low waste living.

References:

SSEN connection data, System Wide Resource Registers (GB), the TEC register, the Renewable Energy Planning Database, Climate Emergency declaration data, Regen consultation with local stakeholders and discussion with technology developers.

7. Renewable engines (landfill, sewage, biogas) in the Southern England licence area

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. **DFES Building Block ID number Gen_BB004.**

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

Technology	Installed capacity (MW)	Baseline	2020	2025	2030	2035	2040	2045	2050
Anaerobic digestion	Steady Progression	36	36	39	42	47	50	52	54
	System Transformation		36	50	60	70	76	77	70
	Consumer Transformation		36	54	72	92	101	103	97
	Leading the Way		36	56	74	92	103	109	119
Landfill gas	Steady Progression	33	33	45	45	45	45	45	45
	System Transformation		33	45	45	45	45	23	17
	Consumer Transformation		33	45	45	45	45	23	17
	Leading the Way		33	45	45	45	23	17	17
Sewage gas	Steady Progression	32	32	32	32	32	32	32	32
	System Transformation		32	32	32	32	32	32	32
	Consumer Transformation		32	32	32	32	32	32	32
	Leading the Way		32	32	32	32	32	32	32

Overview of anaerobic digestion projections in the licence area:

Feedstock from waste is a critical factor in the potential to develop new/additional AD capacity. The licence area has good potential for AD as a result of both high agricultural production, as well as dense population areas where food waste is not yet collected, for example across both Hampshire and Wiltshire.

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. There is also the potential opportunity, which has been highlighted by the Committee on Climate Change[ix], to use biomethane in larger generation plants with carbon capture and storage to create negative emissions. It is likely therefore that AD produced biomethane for small scale electricity generation will be limited.

The FES 2020 assumes that there is a bigger push for biomethane in **Consumer Transformation** and **System Transformation**, this has been reflected in the DFES analysis.

Overview of landfill gas projections in the licence area:

Landfill gas capacity is expected to decline over time in the three scenarios that meet net zero targets, as residual waste is either gasified or directly burned, as opposed to buried. Baseline landfill gas sites connected to the distribution network are assumed to have a lifetime of 30 to 40 years in these three net zero scenarios. Under **Steady Progression** however, these sites do not decommission and are instead repowered.

Overview of sewage gas projections in the licence area:

From consultation with Wessex Water Enterprise, there are currently no plans to increase generation of biogas or biomethane in the Southern Licence area and therefore, we have not projected any change in sewage gas used for electricity generation. There is uncertainty over whether sites in the long term might convert to biomethane as demand for green gas increases. However, the DFES has aligned more with the FES 2020 projections in the longer term, and therefore this uncertainty has not been directly reflected.

Scenario projection results:

Baseline (up to end of 2019)

Anaerobic digestion:

- The Southern England licence area currently has 36 MW of AD used for electricity generation. This accounts for around 4.6% of the baseline capacity in GB.
- There are 28 sites in this baseline, ranging from 0.2 MW to 5 MW, which correlates with the upper capacity limit of the Feed-in Tariff.

Landfill gas:

- There are 10 landfill gas generation sites connected to the distribution network in the Southern England licence area totalling 33 MW.
- There has been no new landfill generation capacity added to the distribution network in the licence area since 2011.

Sewage gas:

- There are 12 sewage gas generation sites connected in the Southern England licence area, totalling 32 MW. This is based on both SSEN connection data and the AD Biogas Map.

Near term (2020 – 2025)

Anaerobic digestion:

- There are two AD sites with an accepted connection offer in the licence area, and one site in the Renewable Energy Planning Database.
- This pipeline capacity totals 7 MW.
- Two of these sites connect by 2023 in the three scenarios that achieve net zero targets
- The third site connects in all scenarios in the 2020s, as it has both planning permission and a connection offer.

Landfill gas:

- There are three landfill gas sites with an accepted connection offer in the licence area, totalling 12 MW.
- The two larger sites (that are 5 MW and 6 MW respectively) both have planning permission and therefore are modelled to connect in all scenarios by 2023. The remaining 1 MW site without planning approval does not connect under any scenario.

Sewage gas:

- There are two sewage gas sites with an accepted connection offer, totalling 0.7 MW.
- Both sites are projected to connect by 2024 in all scenarios.

Medium term (2025 – 2035)

Anaerobic digestion:

- In the medium term, the potential for additional AD capacity is assumed to be driven by local authorities requiring additional food waste processing facilities in the mid-2020s, as indicated in the latest Environment Bill[x].

Landfill gas and sewage gas:

- There is no change projected in the existing or new connected capacity for either landfill gas or sewage gas between 2025 and 2035.

Long term (2035 – 2050)

Anaerobic digestion:

- Further increases in connected AD generation will be driven by technology cost reductions, potentially through modularisation, and the high revenues that could be captured from AD plants providing more flexibility and balancing services to networks.
- However, an increase in connected generation capacity is expected to slow in the longer term due to competing demands for biomethane as a fuel option for zero carbon heat, green gas injection or transport, and as the government incentivises a switch to larger plants that can achieve negative emissions (e.g. through Bio Energy Carbon Capture and Storage, BECCS).

- In addition to this, it is assumed that food waste produced per person will likely decrease towards 2050, meaning there may be less feedstock available for AD processing.

Landfill gas:

- Older landfill gas sites in the Southern England licence area are expected to decommission as a result of declining waste resource availability and competition with other waste processing technologies such as energy from waste.
- Landfill gas sites in the licence area are assumed to have a lifetime of 40 to 45 years in the scenarios that meet net zero targets by 2050 and therefore sites begin to decommission from 2037.
- Under **Steady Progression**, a scenario has been considered where all existing distribution network connected landfill gas sites with connection agreements, remain online out to 2050.

Sewage gas:

- In the long term, the scale of use of sewage gas for electricity generation is unclear.
- Whilst there might the potential for Wessex Water to increase use of sewage gas for power generation, discussions did not indicate this was currently a priority. The DFES has therefore not modelled any increase in sewage gas electricity generation or conversion to biomethane injection under any scenario, these assumptions align well with the FES 2020 assumptions and projections.

Figure 17 Summarising scenario projection graph for anaerobic digestion

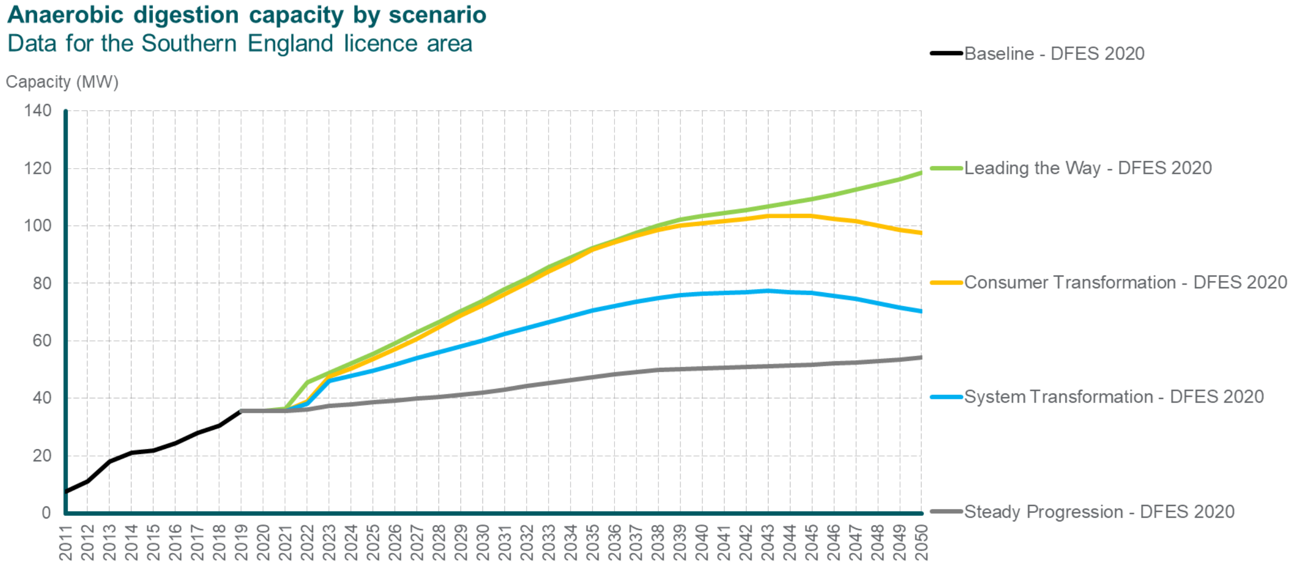


Figure 18 Summarising scenario projection graph for landfill gas

Figure 19 Summarising scenario projection graph for sewage gas

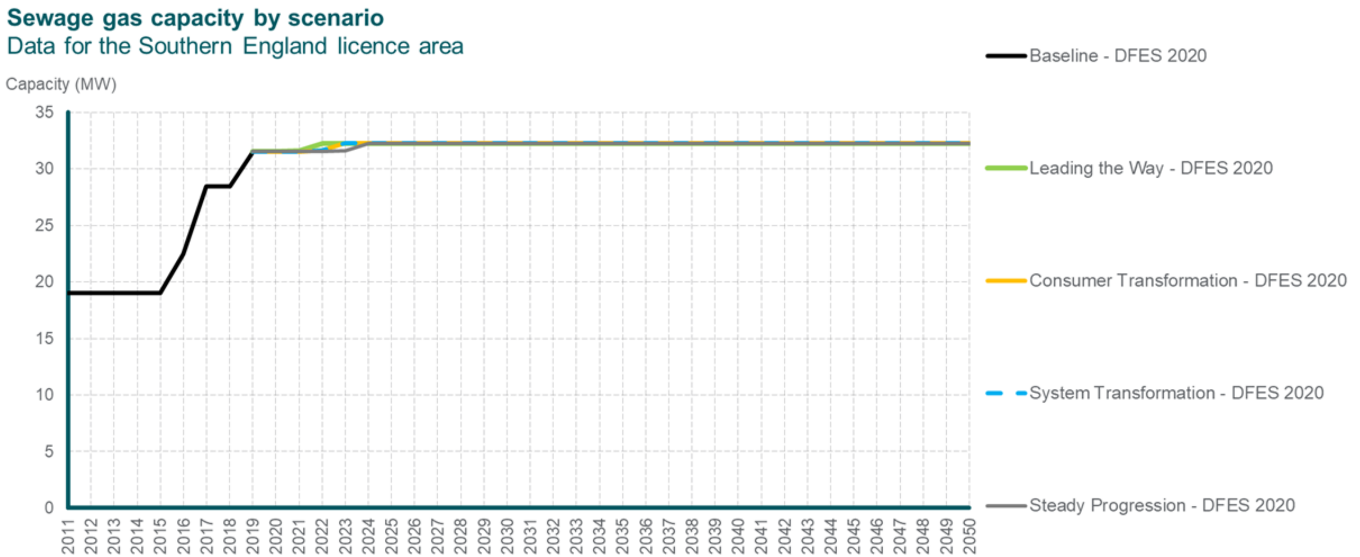
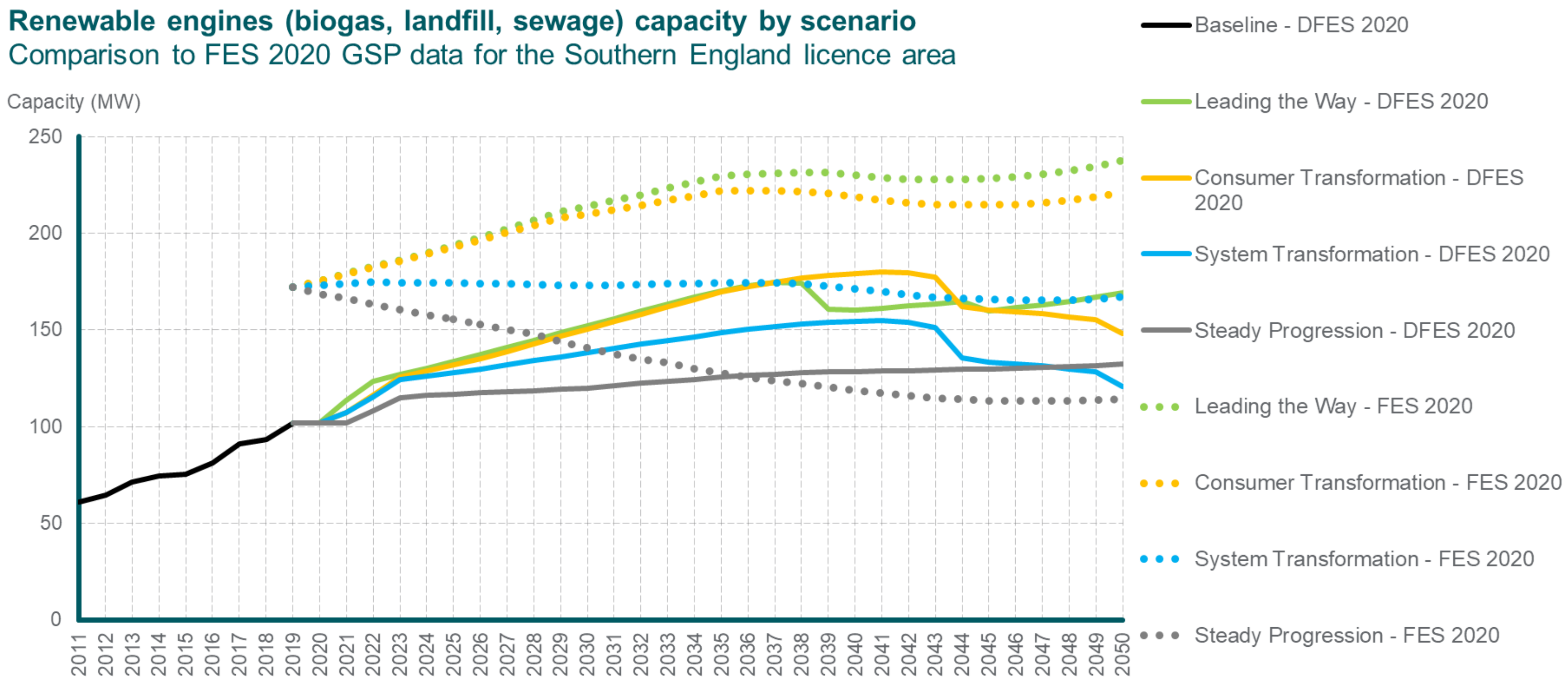


Figure 20 Summarising scenario projection graph for renewable engines, with comparison to FES regional projections



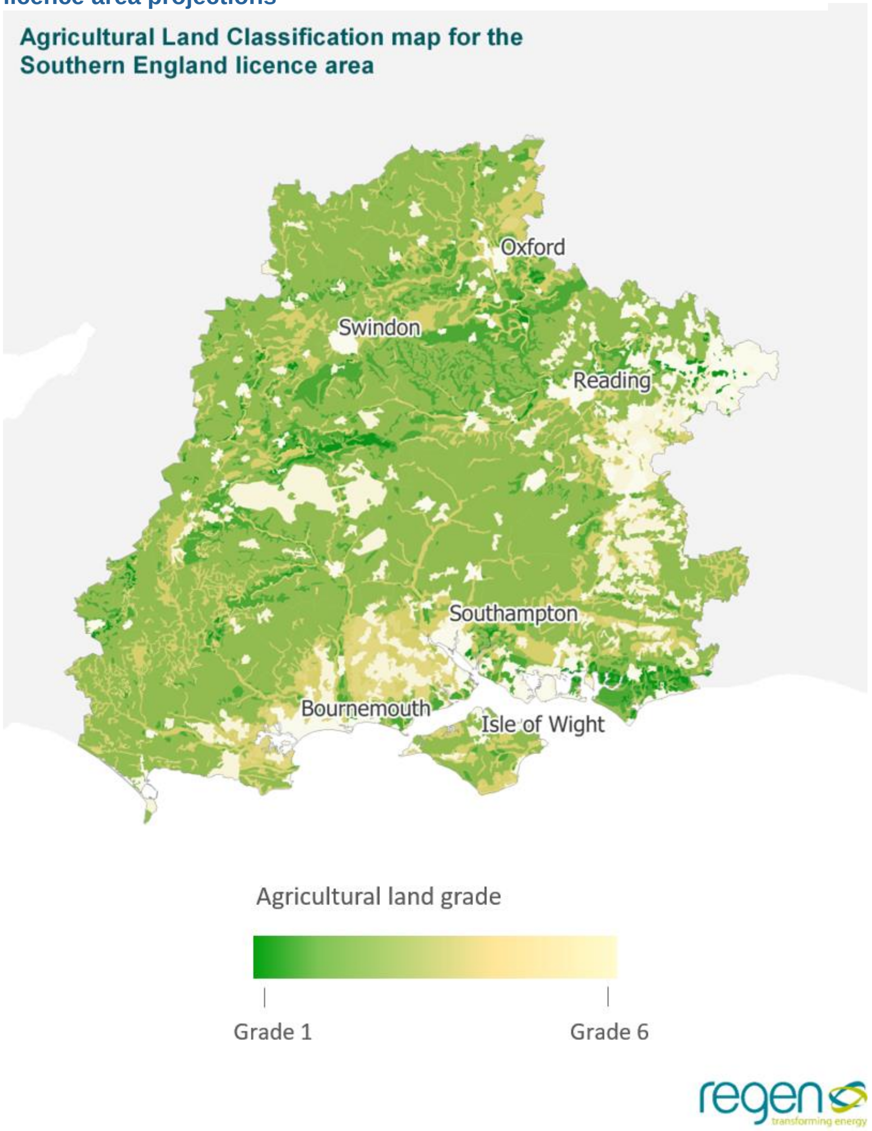
Reconciliation to the National Grid FES 2020

- The assumptions underpinning the DFES analysis are in line with the FES 2020 results, however the results differ in some areas, due to local factors or spatial distribution.
    - The DFES overall renewable engine generation capacity baseline capacity is lower than the FES 2020 baseline for the Southern England licence area.
    - The increase in connected generating capacity comes primarily from AD, with the pipeline of landfill gas sites also contributing 11 MW to the near term increase in capacity.
    - It has been assumed in the DFES for the Southern England licence area, that landfill gas sites connected to the distribution network are decommissioned after an operational life of 40 to 45 years, due to a reduction in available waste resources. This results in significant drops in renewable engine capacity in the longer term.
    - The decommissioning method for sites in the medium and long term means that the decline in total capacity is more stepped.
- The FES 2020 projects an overall decrease in capacity in the **Steady Progression** scenario. This has not been reflected in the DFES due to the fact that all existing sites with connection agreements stay online in **Steady Progression** out to 2050.

Factors that will affect deployment at a local level:

- The spatial distribution of future AD sites that connect to the distribution network is weighted towards areas with sufficient agricultural land grade (grade 1 and 2 (Figure 21) and also towards local authorities that do not yet collect food waste as potential new feedstocks can arise in these areas.
- In the SEPD licence area, 46% of local authorities do not collect food waste and 17% have indicated they have plans to start collecting food waste in the next three years. This data was collected as part of an annual survey Regen send to local authorities as part of the new developments study.

Figure 21 Agricultural land classification map for the Southern England licence area projections



Relevant assumptions from National Grid FES 2020:

Assumption number	1.1.5 (Incentive regime for biomethane)
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:

Wessex Water Enterprise was consulted in regard to future strategy and plans for sewage gas generation and biomethane production. Feedback was provided that there are currently plans to increase existing biomethane production and therefore, the DFES has not modelled any decline 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 long term.

References:

SSEN connection data, System Wide Resource Registers (GB), the TEC register, the Renewable Energy Planning Database, Climate Emergency declaration data, Regen consultation with local stakeholders and discussion with technology developers.

[ix] Committee on Climate Change - https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf
[x] See Environment Bill 2019-21: https://services.parliament.uk/bills/2019-21/environment.html

8. Gas fired generation in the Southern England licence area

Summary of modelling assumptions and results.

Technology specification:

DFES technology building blocks:

- **Non-renewable Engines (Combined Heat and Power (CHP)) - Gas [Gen_BB001], [Gen_BB002] and [Gen_BB003]**
- **Non-renewable Engines (non CHP) – Gas Reciprocating Engines [Gen_BB006]**
- **Gas Open Cycle Gas Turbines (OCGTs) (non CHP) – [Gen_BB008]**

This analysis covers any natural gas fuelled electricity generation in the Southern England licence area, connecting to the distribution network. This includes sub technologies of OCGTs, gas CHPs and gas reciprocating engines. Distribution network CCGTs are not included in the DFES, with no baseline projects or projections out to 2050 in any scenario. The analysis also includes hydrogen fuelled electricity generation, which has been modelled to connect to the distribution network in areas of where there is the potential for hydrogen gas network conversion by or before 2050, in the **System Transformation**, **Leading the Way** and **Consumer Transformation** scenarios only.

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

Gas sub-technology	Installed capacity (MW)	Baseline	2020	2025	2030	2035	2040	2045	2050
Gas OCGTs	Steady Progression	246	246	378	378	378	238	232	232
	System Transformation		246	240	100	100	0	0	0
	Consumer Transformation		246	246	106	100	0	0	0
	Leading the Way		246	106	100	0	0	0	0
Gas reciprocating engines	Steady Progression	88	135	281	281	281	281	281	234
	System Transformation		98	108	108	108	93	0	0
	Consumer Transformation		98	108	108	108	93	0	0
	Leading the Way		98	108	108	108	93	0	0
Gas CHPs	Steady Progression	147	148	215	215	215	215	215	207
	System Transformation		147	155	148	148	148	101	0
	Consumer Transformation		147	155	148	148	142	3	0
	Leading the Way		147	148	148	148	109	0	0
Hydrogen peaking plants	Steady Progression	0	0	0	0	0	0	0	0
	System Transformation		0	0	0	7	7	21	21
	Consumer Transformation		0	0	0	0	0	9	10
	Leading the Way		0	0	0	7	7	16	17

Overview of technology projections in the licence area:

The connected capacity of decentralised natural gas fired generation in the Southern England licence area is above average when compared to some other parts of the UK (e.g. the baseline in other DFES analyses Regen has recently completed for WPD's licence areas). This c.550 MW baseline reflects a strong gas network coverage in the licence area, as well as notable industrial regions such as Swindon, Portsmouth and West London. As well as three sizeable OCGT sites, there are a number of gas CHPs and reciprocating engine projects of varying capacities connected across the licence area. There is also a significant pipeline of c.419 MW of potential new natural gas generation sites in the licence area, which is a mixture of all three natural gas sub-technologies.

The DFES analysis for gas generation in the Southern Licence area has therefore focussed on three distinct areas:

1. Modelling the potential future pathways for each of the natural gas sub-technology sites in the baseline. This modelling specifically looks at the potential for many of these baseline sites to decommission across the 2030s and 2040s, in line with the **Leading the Way**, **Consumer Transformation** and **System Transformation** scenarios meeting net zero emissions by 2050.
2. Assessing the development potential for the significant pipeline, as new/additional fossil fuel generators, within the scenarios and the equivalent future decommissioning of these sites, likely to mostly be within the 2040s.
3. The longer term DFES analysis also considers the potential for some of the known baseline/pipeline projects that may operate more commercially, to convert their generator assets to be able to run on hydrogen instead of natural gas. This has been determined to mostly likely be in city or local authority regions within the licence area that have been identified as hydrogen supply zones.

For the three scenarios that are compliant with the target to achieve net zero emissions by 2050 in England, all natural gas generation is decommissioned before 2045 and a small amount of hydrogen fuelled generation capacity is modelled to come online between 2035 and 2050. In the **Steady Progression** scenario, the total connected capacity of natural gas generation is higher in the licence area in 2050 than in 2019, though this connected capacity peaks across the 2030s and sees a small decline across the 2040s.

At a high level, the long term role of natural gas and hydrogen fuelled generation is uncertain. Gas generation is an inherently flexible and responsive technology, that can potentially support the operability of the electricity system in the near-term. However, with natural gas being a carbon intensive fuel and with exhaust emission abatement technologies potentially being prohibitively costly to fit to smaller scale generators, the running of unabated natural gas generation in the long-term is at odds with net zero emission targets. Add to this the significant level of uncertainty around the likely strategy for hydrogen production, hydrogen supply infrastructure and the locational or national scale of hydrogen demand, the potential scale of hydrogen fuelled generation is equally uncertain. This uncertainty is reflected through a notable spread of capacity trajectories across the scenarios.

Scenario projection results:

Baseline (up to end of 2019)

- In the Southern England licence area, there are 45 natural gas generation sites connected to the distribution network, totalling c.481 MW.
- The breakdown of these sites is as follows:
    - 3 OCGT sites totalling 246 MW, two of which are greater than 100 MW
    - 33 gas CHP sites totalling 147 MW, 30 of which are onsite generators at hospitals, leisure centres and dairies etc. that are <10MW
    - 9 gas reciprocating engine sites totalling 88 MW, many of which appear to be more commercially driven assets.

Near term (2020 – 2025)

- There are 49 natural gas generation projects with accepted connection offers in the licence area, totalling c.428 MW. This pipeline includes:
    - A 132 MW OCGT project located in Maidenhead
    - 19 gas reciprocating engine projects, totalling c.224 MW
    - 29 gas CHPs, totalling c.72 MW (many of which are <1 MW plants onsite at schools, leisure centres, hotels, and garden centres)
- From reviewing local planning portals:
    - The 132 MW OCGT project in Maidenhead submitted a planning application in March 2020 and is currently awaiting a decision
    - 5 gas reciprocating engine sites (totalling 28 MW) and 2 gas CHP sites (totalling 9 MW) have received planning approval
    - 2 gas reciprocating engine sites (totalling 31 MW) have been refused in planning
    - The remaining 36 sites (207 MW) were either too small or were unable to be found in planning.
- From reviewing Capacity Market auctions 8 sites (totalling 100 MW) either successfully pre-qualified for, or were awarded a Capacity Market Agreement in recent T-4 or T-1 auctions. These were almost all large reciprocating engines in Hampshire, Berkshire, Wiltshire, Swindon or Oxford.
- No development information could be found for the remaining pipeline capacity.
- From this analysis, the DFES has therefore modelled 384 MW of additional gas fired generation to connect to the network in the early 2020s in the **Steady Progression** scenario, this includes the 132 MW OCGT plant in Maidenhead, as well as:
    - 191 MW of reciprocating engine capacity with accepted offers
    - 61 MW of gas CHP capacity with accepted offers
- In **Leading the Way**, **Consumer Transformation** and **System Transformation**, only 19 MW goes through to connection in the early 2020s, as many of these sites are deemed speculative. With the carbon emissions of operating flexibility markets being reviewed by BEIS and Ofgem, the business model for distribution network connected fossil fuel generation could potentially become highly uncertain.

Medium term (2025 – 2035)

- Reflecting a general need to reduce unabated fossil fuel generation to achieve net zero emission targets in England, the DFES has sought to decommission some of the 481 MW of baseline sites across the late 2020s-2030s in **Consumer Transformation** and **System Transformation**.
- A more accelerated decommissioning of this baseline was modelled in **Leading the Way**, reflecting even more ambitious decarbonisation.
- In **Steady Progression**, the 481 MW baseline is modelled to continue operating across the 2020s and out to the late 2030s, reflecting a much slower decommissioning of these operational CHP and reciprocating engine sites. The additional pipeline sites that were modelled to come online also continue operating into the 2030s and 2040s, seeing overall gas generation capacity rising to 874 MW by 2035.

Long term (2035 – 2050)

- No additional natural gas generation has been modelled to connect in any scenario between 2035 and 2050. This reflects longer term ambitions to reduce emissions from electricity generation in line with UK Government targets to achieve net zero by 2050 and recent announcements from UK Government around introducing a carbon threshold in the UK Capacity Market[xi].
- The decommissioning of existing baseline and pipeline sites is also modelled to continue in the scenarios, based on a categorisation of connection year, capacity and gas generation sub-technology. This culminates in no unabated natural gas generation operating on the distribution network in the licence area by 2042 in **Leading the Way**, by 2044 in **Consumer Transformation** and by 2047 in **System Transformation**. **Steady Progression** sees a moderate reduction in capacity in the late 2040s, with 663 MW operating in the licence area in this scenario in 2050.

Hydrogen and hydrogen fuelled electricity generation

A lot of work is being progressed by UK government, industry and commercial sectors to explore the potential of hydrogen as a future low carbon fuel for industry, transport and heating. Technology research, trials and demonstration projects to supply and consume hydrogen are being progressed in various parts of the country[xii]. In addition to this, the future market structures for hydrogen to be supplied to a range of end users is also being explored by National Grid[xiii]. Alongside thermal industrial processes, fuel for heavy transport and heating, gas fired electricity generation is category of gas consumer that could potentially make use of hydrogen in the future, given the right business model, incentives and commodity pricing.

The DFES analysis has therefore sought to identify ESAs in the Southern England licence area that could fall within potential future hydrogen supply zones and a proportion of the baseline natural gas sites (and thus their MW capacities) were modelled to essentially 're-power' as hydrogen fuelled generation sites in the late 2030s and 2040s. The geographic scope of hydrogen supply zones is most widespread in **System Transformation**, as the scenario with the highest abundance of network supplied hydrogen. The scope of hydrogen ESAs was second highest in **Leading the Way** and a limited number of hydrogen ESAs have been modelled in **Consumer Transformation**. These ESAs have been identified using known hydrogen trial projects or hydrogen technology deployments within the Southern England licence area, combined with areas that could see more demand for hydrogen in the future, such as more industrial areas where distributed gas generation currently operates, and city regions with urban heat demand. Swindon has been proposed to be a hydrogen development hub[xiv] within the Southern England licence area. The methodology employed in the DFES to re-power existing natural gas generation sites (due to existing site infrastructure, electricity export connection capacity and a gas network connection already in-place), negates any hydrogen fuelled electricity generation sites in Swindon from coming online. This is due to there being no natural gas generation sites exporting to the electricity distribution network in Swindon. This does not necessarily mean that there will definitively be no hydrogen fuelled generation within the Swindon city region in the future, but just that the scenario methodology applied in the DFES limits the potential uptake of this future generation technology to other specific areas. This scenario-specific modelling of hydrogen zones has therefore created a range of hydrogen electricity generation capacity connecting to the distribution network by 2050 in the scenarios. At a summary level, by 2050:

- In **System Transformation**, seven hydrogen generation sites, totalling 21 MW, connect by 2050, across the Oxford and Southampton city regions as well as areas around Hounslow, Hillingdon and Ealing.
- In **Leading the Way**, three sites, totalling 16.5 MW, connect by 2050, across the Oxford and Southampton city regions.
- In **Consumer Transformation**, two sites, totalling 9.5 MW, connect by 2050, in the Oxford city region only.
- In **Steady Progression**, no hydrogen generation sites are modelled to connect by 2050.

As a general consideration, the business case for hydrogen fuelled electricity generation is likely to be challenging, with hydrogen as the future input fuel almost certainly set to be more expensive than natural gas is today. This creates a notable level of uncertainty around distribution network connected hydrogen fuelled electricity generation out to 2050 in the Southern England licence area, which is reflected in the range of scenario outcomes in the DFES.

Figure 22 Comparison of gas OCGT projections in the Southern England licence DFES analysis to the FES 2020

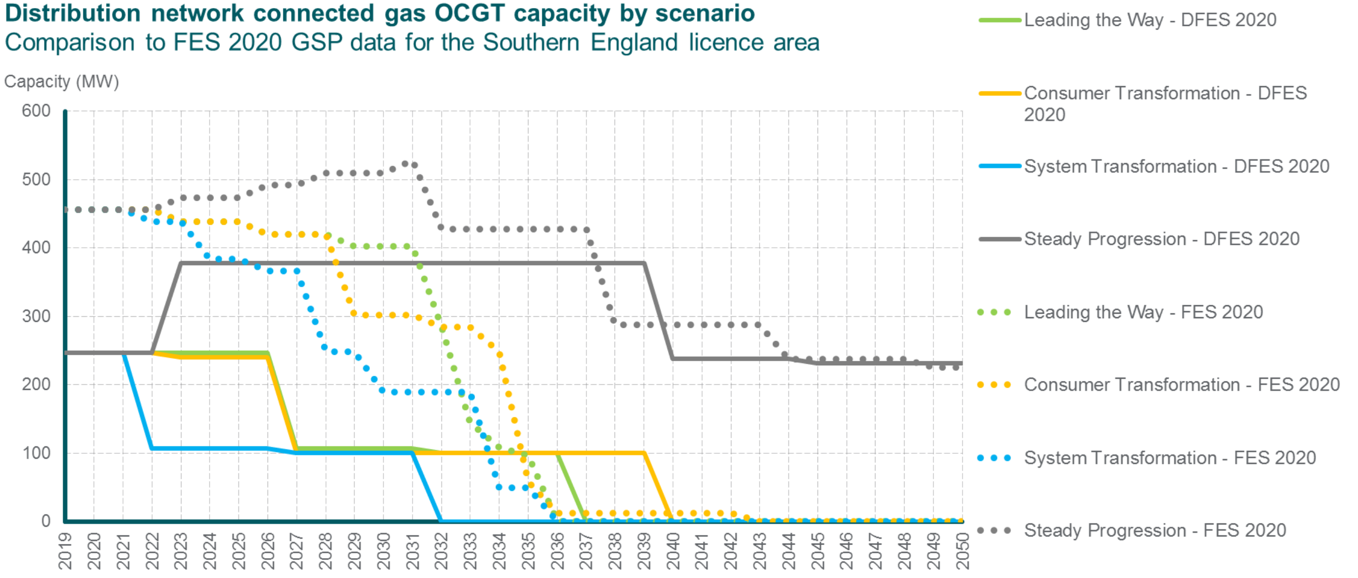


Figure 23 Gas reciprocating engine projections in the Southern England licence from DFES analysis

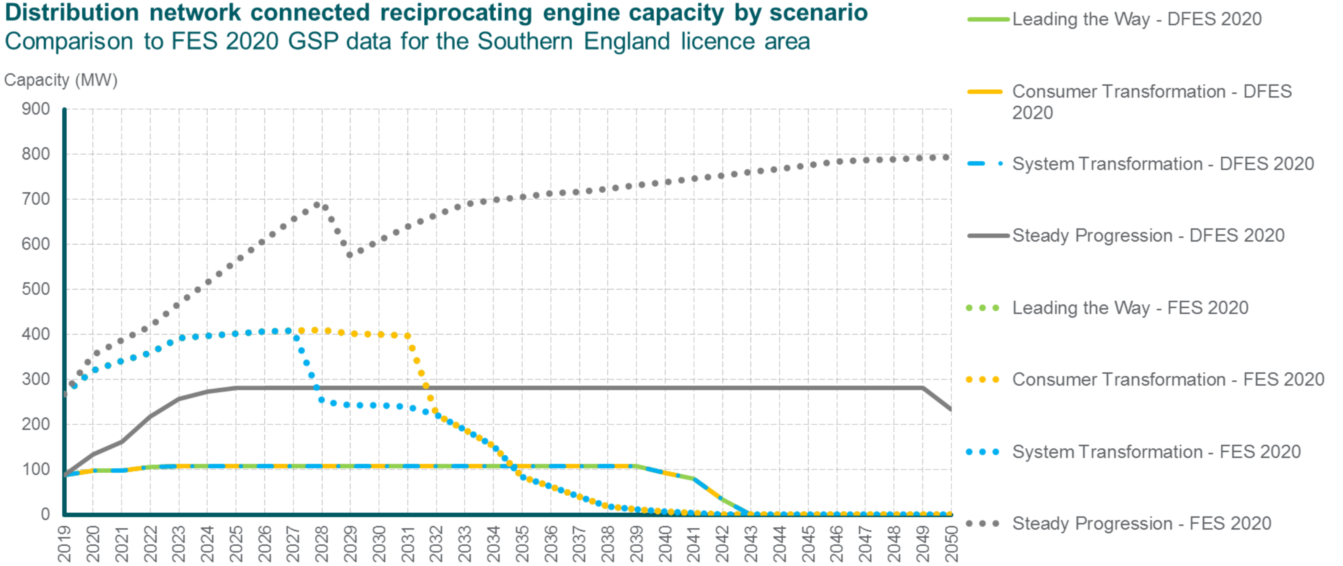


Figure 24 Comparison of gas CHP projections in the Southern England licence DFES analysis to the FES 2020

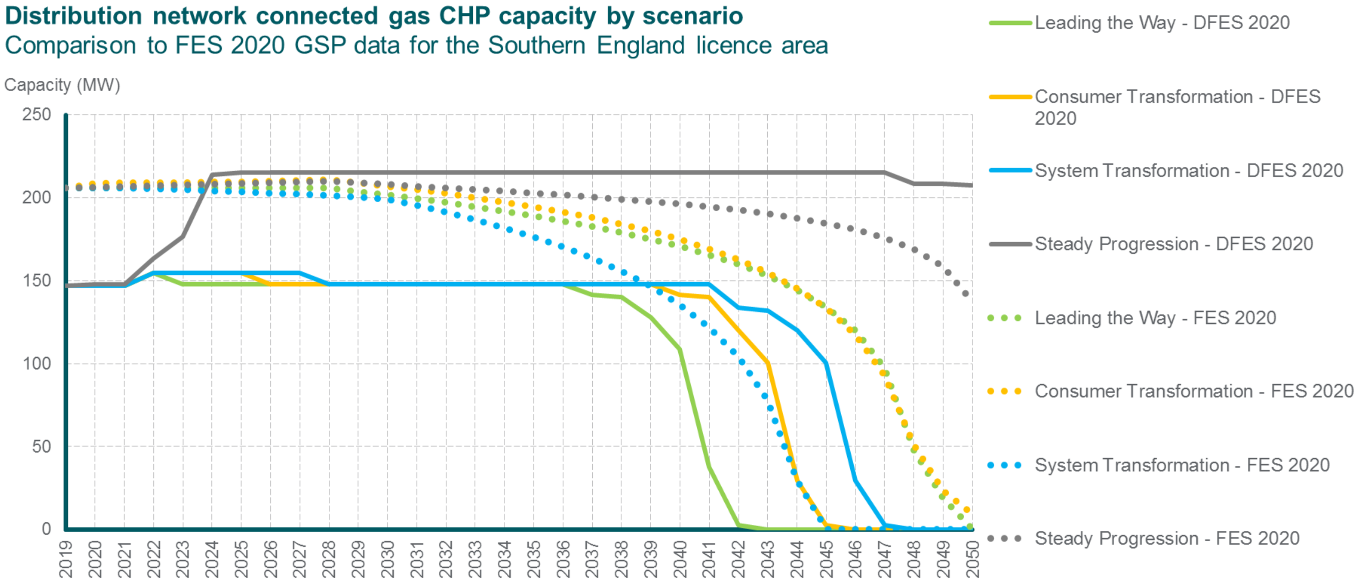
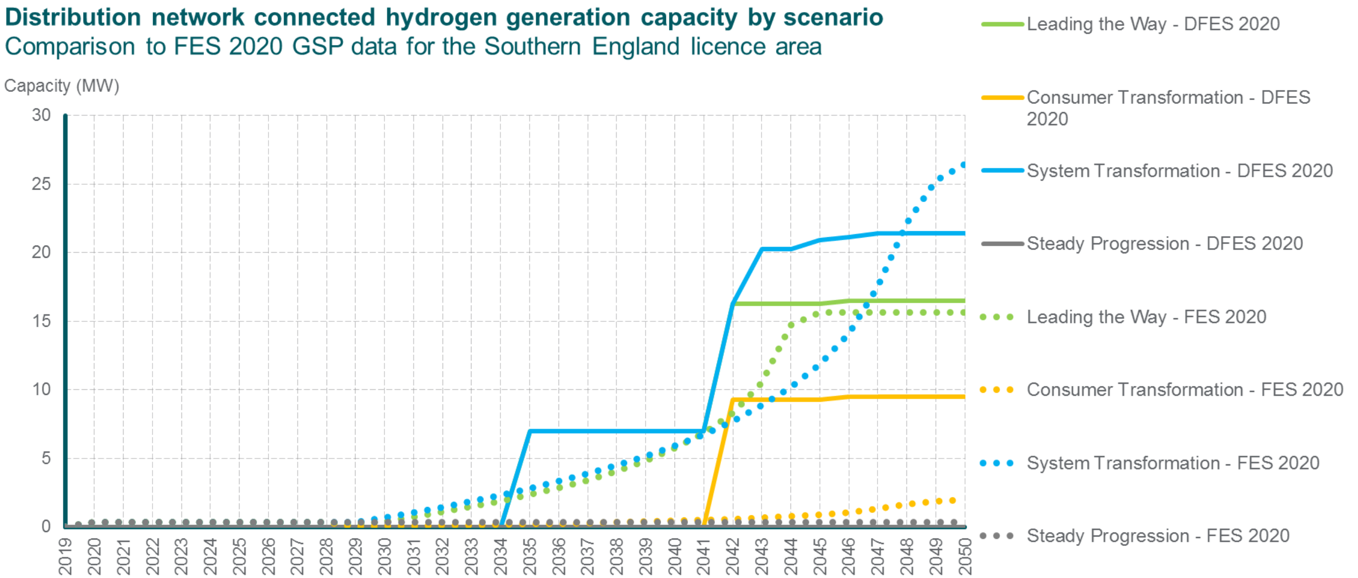


Figure 25 Hydrogen fuelled electricity generation projections in the Southern England licence from DFES analysis



Reconciliation with National Grid FES 2020:

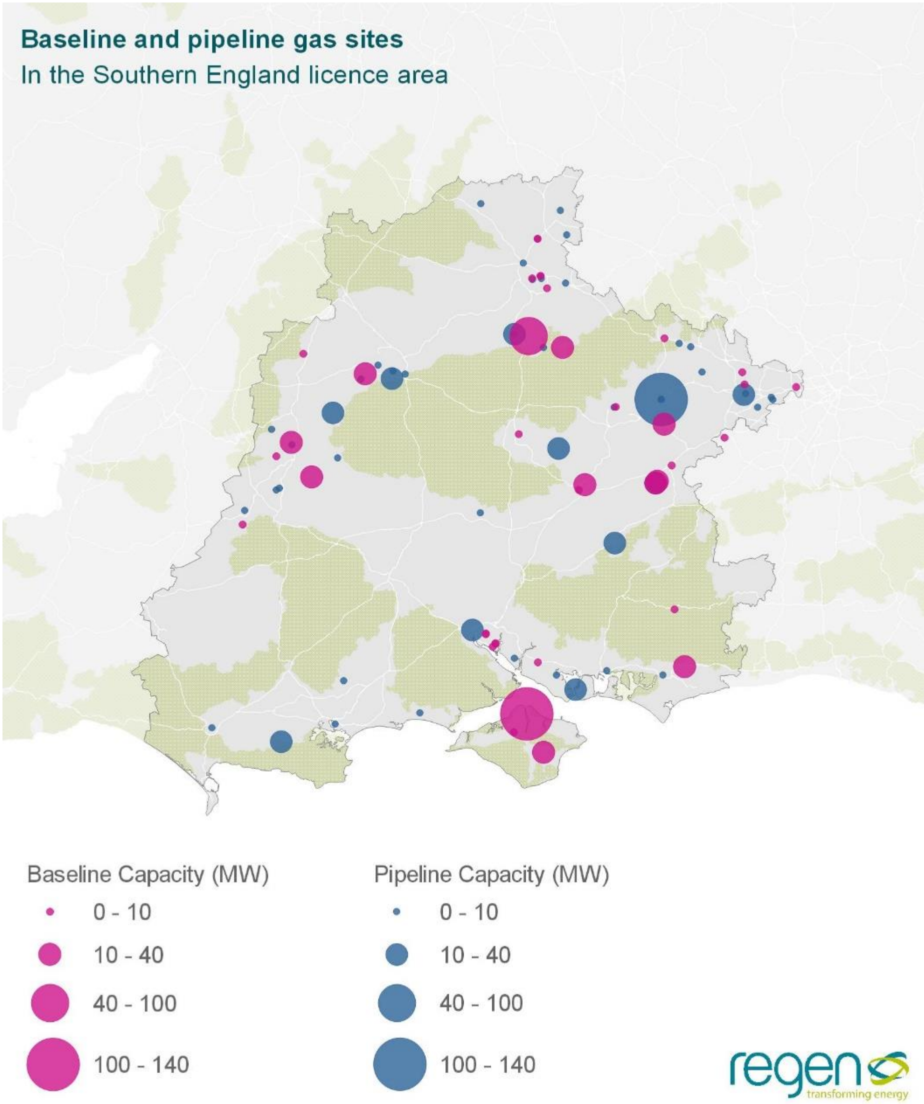
- The DFES and FES concur on there being no existing or future **CCGT** projects in the Southern England licence in any scenario.
- With regards to **gas OCGT** sites in the licence area (see Figure 22):
  - The FES GSP level data has a higher baseline than the DFES (456 MW compared to 246 MW). The reason for this notable variance is unclear but could be related to either a misclassification of technologies when determining the SEPD connection data or potentially different data or metrics that the FES analysis used to determine GSP level figures.
  - Beyond this variance, the FES GSP level data shows a similar stepped level of decommissioning of gas OCGT sites in the Southern England licence area in all scenarios. This reflects a lower number of larger capacity sites that is typical of OCGT project scale.
  - The DFES models no OCGT capacity operating in the licence area by 2032, whereas the FES reaches zero megawatts by 2036.
  - OCGT decommissioning trends align closely in **Consumer Transformation** and **System Transformation**, in both the DFES and the FES, with no OCGT capacity operating in the late 2030s/early 2040s in all cases.
  - The DFES and FES align closely in **Steady Progression** in the 2040s, both modelling in the region of 225 MW of OCGT capacity still operating on the network by 2050 in the licence area.
- With regards to **gas reciprocating engines** in the licence area (see Figure 23):
  - The FES GSP level data has a higher baseline than the DFES (267 MW compared to 88 MW). This could be down to a misclassification of technologies or sub-technologies in the data. However, being that there is a notable pipeline of reciprocating engine capacity in the licence area, there may be a misinterpretation of connection status.
  - The medium and long term scenario projections in the DFES diverge somewhat from the FES GSP data, which shows both a 90 MW increase in the near-term and a more rapid decline in the late 2020s and early 2030s in the **Leading the Way**, **Consumer Transformation** and **System Transformation** scenarios. However, from the development evidence found on the pipeline projects, only 22 MW of additional capacity is modelled to connect in the 2020s in these scenarios and the removal of capacity does not start until the late 2030s, reflecting a more realistic project life of the relatively recent baseline sites and new pipeline sites.
  - The capacity in **Steady Progression** in the DFES remains flat at 279 MW out to the 2040s.
- With regards to **gas CHPs** in the licence area (see Figure 24):
  - The FES GSP level data has a higher baseline than the DFES (206 MW compared to 147 MW). This could be down to a misclassification of technologies or gas sub-technologies in the data.
  - The gas CHP trends across the scenarios align fairly well between the FES, essentially reflecting earliest decommissioning of all natural gas CHPs in **Leading the Way** by 2041, with **Consumer Transformation** and **System Transformation** decommissioning by 2045 and 2047 respectively. **Steady Progression** has 199 MW continuing to operate in the licence area beyond 2050.
- With regards to **hydrogen fuelled generation** in the licence area (see Figure 25)
  - The FES GSP projections align to the DFES projections across most scenarios by 2050.

- However, the FES has modelled a much smoother, more gradual increase in connected hydrogen generation capacity between 2030 and 2050 in **System Transformation** (the scenario with the highest connected capacity). Whereas the DFES has sought to model specific baseline or pipeline project capacities within identified potential future hydrogen supply ESAs, resulting in a much more stepped increase in capacity in this scenario across the 2030s and 2040s.
- The method by which the DFES allocates project capacity in other scenarios (see "Hydrogen and hydrogen fuelled electricity generation" section above), sees a slightly higher overall capacity connecting in **Leading the Way** and **Consumer Transformation** in the DFES by 2050, compared to the FES GSP projections. Though with these variances being less than 10 MW across the licence area in each case, the impact on the network can be considered low to moderate, when compared to the future projections for other generation technologies in the Southern England licence area.

Factors that will affect deployment at a local level:

- Gas network coverage is strong in the Southern England licence area[xv], this highlights a moderately above-average potential for gas fired generation capacity to connect in the licence area compared to other areas of the UK. This is evidenced by 419 MW of known pipeline projects with accepted connection offers.
- For modelling the decommissioning of existing natural gas generation sites in the DFES, the actual location of known baseline and pipeline sites have been used. Similarly, the distribution of the pipeline sites that have been modelled to connect in the 2020s (mostly in **Steady Progression**) also use their respective known site locations.
- For modelling the connection of hydrogen fuelled generation in the 2030s and 2040s, a spatial analysis of hydrogen technology trials, hydrogen electrolyser deployments and potential gas network conversion areas was completed and compared to baseline and pipeline natural gas site locations.

Figure 26 Map of distribution network baseline and pipleine natural gas generation sites in the Southern England licence area



- The sites that both fell within these nominated potential hydrogen supply ESAs and those classified as being a potentially viable site to switch fuels (e.g. industrial premises or commercial operators that aren't currently running a gas CHP purely for self-use), were modelled to connect in **System Transformation** between 2035 and 2050. A lower number of these hydrogen supply ESAs were nominated in **Leading the Way** and a shortlist of ESAs in Oxford city region only were nominated in **Consumer Transformation**.

Relevant assumptions from National Grid FES 2020:

Assumption number	4.1.31 (Unabated small scale thermal generation)
Steady Progression	Less focus on decarbonisation compared to other scenarios. Diesel plant retired later than other scenarios.
System Transformation	Initial growth in gas peaking plant as renewables grow (instead of high growth in storage technologies), later switching to Hydrogen.
Consumer Transformation	Initial growth in gas peaking plant as renewables grow (instead of high growth in storage technologies), later switching to alternate sources of flexibility such as storage and V2G.
Leading the Way	Low use as scenario sees greater use of other technologies (e.g. storage). Earliest closure of diesel reciprocating engines.

Stakeholder feedback overview:

Regen engaged many of the local authorities within the Southern England licence area, seeking information around new housing and commercial developments and asking a series of high level questions around local energy strategy for transport, heat, renewable energy, food waste and net zero/climate change objectives. Of the 24 local authorities that responded to this survey:

- 20 of them (83%) stated they have declared a climate emergency
- 19 of them (80%) stated they published or are working on a net zero strategy for their area, and of these:
  - 10 stated a net zero target year of 2030
  - 1 stated a net zero target year of 2045
  - 3 stated a net zero target year of 2050

This provides strong support to the DFES modelling for natural gas generation across all scenarios, as potentially one of the more active fossil fuel generation technologies in the planning jurisdiction for local authorities.

References:

SSEN connection data, EMR Delivery Body Capacity Market registers, non-gas map, online planning portals.

[xi] See Edie article on Capacity Market carbon threshold: https://www.edie.net/news/11/Government-to-introduce--carbon-threshold--for-Capacity-Market/
[xii] See H100 project in Fife (https://www.sgn.co.uk/about-us/future-of-gas/hydrogen/hydrogen-100) and H21 in Leeds (https://www.h21.green/)
[xiii] See Hydrogen Gas Markets plan as part of the Future of Gas Steering Group: https://www.nationalgrid.com/uk/gas-transmission/future-of-gas/hydrogen
[xiv] See article around Swindon hydrogen fuelling station development: https://www.businessbiscuit.com/8-news/5208-new-hydrogen-station
[xv] See Non Gas Map: https://www.nongasmap.org.uk/

9. Diesel generation in the Southern England licence area

Summary of modelling assumptions and results.

Technology specification:

DFES technology building block: Non-renewable Engines (non CHP) – Diesel [Gen_BB005]

The analysis covers any commercially operating diesel generation plants that are able to 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.

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

Installed capacity (MW)	Baseline	2020	2025	2030	2035	2040	2045	2050
Steady Progression	169	191	197	72	39	0	0	0
System Transformation		171	110	21	0	0	0	0
Consumer Transformation		171	110	21	0	0	0	0
Leading the Way		171	32	21	0	0	0	0

Overview of technology projections in the licence area:

For the Southern England licence area, the DFES analysis has focussed primarily on the future of the existing operational sites (e.g. baseline), as well as an assessment of the very near-term known sites with an accepted connection offer in the licence area. Unabated diesel generators are unlikely to have a long term operational role in the scenarios that achieve net zero emissions by 2050.

The stringent environmental permitting regulations and air quality requirements under the Medium Combustion Plant Directive (MCPD) that have been passed into UK law[xvi], has caused the DFES modelling to limit the uptake of distribution network connected diesel within the 2020s. Within the three scenarios that are compliant with the target to achieve net zero emissions by 2050, the analysis has removed all distribution network connected diesel generation capacity by the early to mid 2030s.This is similarly the case in **Steady Progression**, but some capacity remains connected until the late 2030s. The long term outcome of no distribution network connected diesel generation in all scenarios within the 2030s/40s shows a higher degree of certainty compared to some other distributed generation technologies in the DFES. This reflects the stringent environmental permitting regulations and ambitious emission reduction targets.

Scenario projection results:

Baseline (up to end of 2019)

- There are 25 operational diesel engines totalling 169 MW in the Southern England licence area. These are a mixture of various capacities (some less than 1 MW, others >20 MW) and likely a mixture of standalone/commercial plants and others that operate as standby as well.

Near term (2020 – 2025)

- There are 17 diesel projects with accepted connection offers in the licence area totalling c.82 MW.
    - 14 are small generators of c.5 MW or less and are likely onsite standby generators (that may or may not export to the network)
    - There are three standalone diesel pipeline projects that are 20MW or greater.
- Many of the smaller pipeline projects have been identified as being sited at supermarkets, water treatment works, research laboratories, leisure centres or DIY superstores, so could feasibly be classified as standby generators that could also export to the network. Many of these have been modelled to go through to connection in the 2020s, as feasibly these companies will want back-up generation installed and there is no reason why they would not connect and register under the MCPD, but be exempt from permitting requirements if they operate these generators less than 500 hours per year.
- Of the three larger standalone diesel plants:
    - Botley Road (27 MW) has been identified as using particulate emission filter technology (specifically Particle Oxidation Catalyst). This suggests it could feasibly operate under an environmental permit and thus meet the MCPD requirements. It has therefore been modelled to go through to connection in the **Steady Progression** scenario only in the mid 2020s.
    - Rownhams (20 MW) secured planning approval in 2015 and was active in both the 2015 (for 2020) T-4 and Early Auction in 2017. This has also, therefore, been modelled to go through to connection in the **Steady Progression** scenario in the early 2020s.
    - The PeakGen Itchen (21 MW) project presented no development information from planning or the Capacity Market and thus has not been modelled to go through to connection in any scenario.

Medium term (2025 – 2035)

- As discussed above, the MCPD prevents unabated fossil fuel generators with a capacity greater than 1 MW, and installed after 20 December 2018, from operating in commercial markets. For these relevant generators:
    - Plants between 5 MW and 50 MW will have to register for an environmental permit by 1 Jan 2024 and comply with emission limit values by 1 Jan 2025.
    - Plants between 1 MW and 5 MW will have to register for an environmental permit by 1 Jan 2029 and comply with emission limit values by 1 Jan 2030.
- The DFES has therefore determined a 'disconnection year' for all baseline and pipeline projects within the Southern England licence area. These disconnection timeframes vary by scenario and whether they are legacy sites or new/pipeline projects. See Table 4.

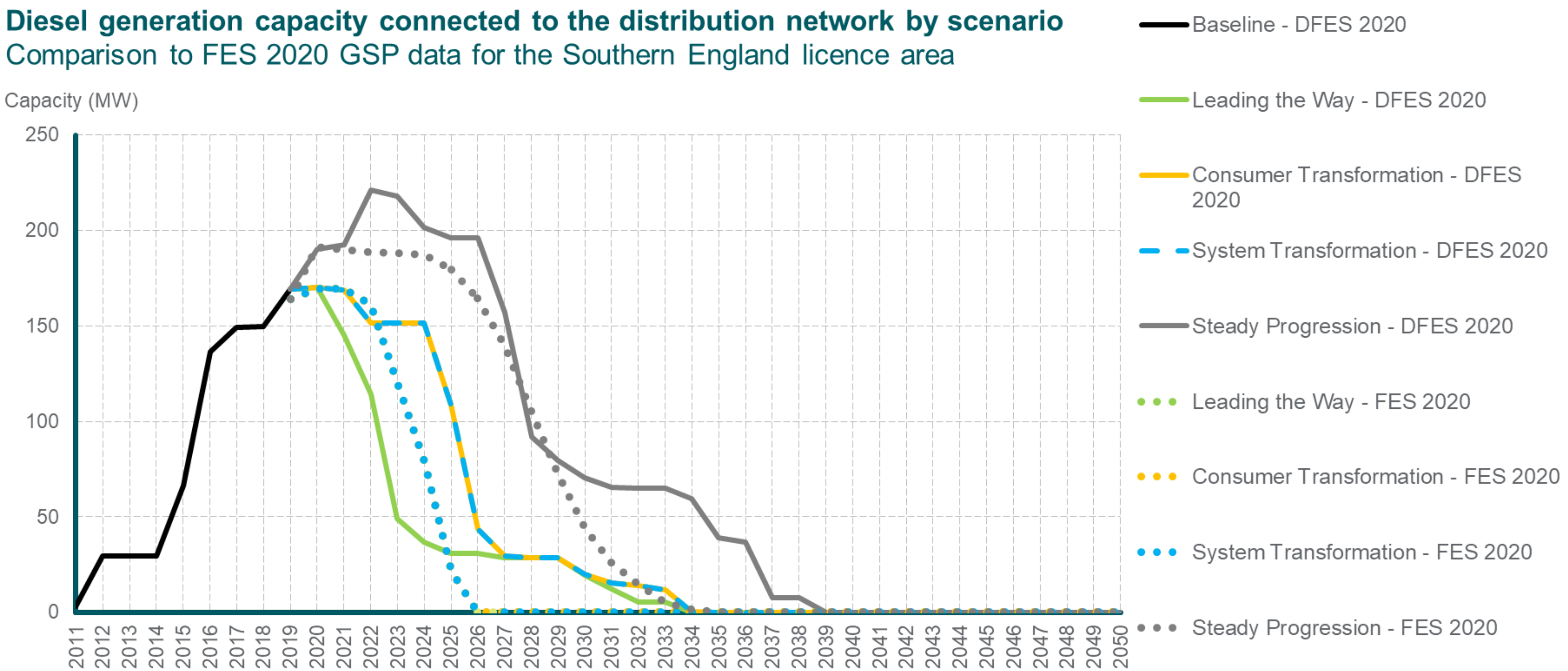
Table 4 Number of years after connection that classes of diesel engine disconnect under each scenario in the DFES 2020

Scenario	Baseline site disconnection		Pipeline site disconnection	
	Standalone	Back-up	Standalone	Back-up
Steady Progression	+12 years	+15 years	+15 years	+15 years
System Transformation	+10 years	+15 years	+12 years	+12 years
Consumer Transformation	+10 years	+15 years	+12 years	+12 years
Leading the Way	+7 years	+15 years	+10 years	+10 years

Long term (2035 – 2050)

- No additional diesel generation has been modelled to connect in any scenario between 2035 and 2050. This reflects the embedding of the MCPD into UK law.
- No diesel capacity is operating in the licence area in **Leading the Way**, **Consumer Transformation** or **System Transformation** by 2035.
- The only diesel generation that is operating on the network by 2030 will likely be standby generators supporting critical sites (e.g. hospitals) during outages or mains failures on site. Therefore, the hours of operation will be very low for these residual generators in the early 2030s.
- No diesel capacity is operating in the licence area in the **Steady Progression** scenario by 2040.

Figure 27 Comparison of diesel generation projections in the Southern England licence DFES analysis to the FES 2020



Reconciliation with National Grid FES 2020:

- The FES scenario logic aligns very well to the DFES, with regards to:
    - The same connected capacity in the baseline in 2019
    - **Steady Progression** being the only scenario with any increase in distribution network connected diesel capacity in the licence area
    - The other three scenarios decommissioning all unabated diesel generation c.5-10 years earlier than **Steady Progression**
    - No diesel generation being connected to the distribution network in the Southern England licence area at all, well before 2050
- The DFES analysis has opted to put some separation between **Leading the Way** and the other two scenarios that meet net zero targets. This better reflects the FES assumption (4.1.31) that states **Leading the Way** sees the "*Earliest closure of diesel reciprocating engines*".

Factors that will affect deployment at a local level:

- With Southern England having some commercial and industrial areas in and around cities such as Oxford, Swindon and West London, or port areas such as Bournemouth and Portsmouth, there is likely to be a notable amount of diesel engines across the licence area (including those listed in the baseline). However, many local authorities and businesses in the licence area are seeking to tackle carbon emissions and climate change in their localities[xvii] [xviii], which will inevitably place some focus on unabated fossil fuel generation such as diesel.
- However, through a combination of many of these engines being for back-up use only, combined with the environmental permitting laws under the MCPD, the decline of diesel engines operating commercially can already be seen.
- The only geographical distribution factor applied for modelling diesel generation capacity across the licence area, is the actual location of the existing baseline projects being modelled disconnect across the 2020s and 2030s, and the location of known pipeline developments.

Relevant assumptions from National Grid FES 2020:

Assumption number	4.1.31 (Unabated small scale thermal generation)
Steady Progression	Less focus on decarbonisation compared to other scenarios. **Diesel plant retired later than other scenarios.**
System Transformation	Initial growth in gas peaking plant as renewables grow (instead of high growth in storage technologies), later switching to Hydrogen.
Consumer Transformation	Initial growth in gas peaking plant as renewables grow (instead of high growth in storage technologies), later switching to alternate sources of flexibility such as storage and V2G.
Leading the Way	Low use as scenario sees greater use of other technologies (e.g. storage). **Earliest closure of diesel reciprocating engines.**

References and data sources:

- SSEN connection data
- EMR Delivery Body Capacity Market Registers
- Online local authority planning portals (various)

[xvi] See DEFRA and EA guidance on the MCPD: https://www.gov.uk/guidance/medium-combustion-plant-and-specified-generators-environmental-permits
[xvii] See *Fossil Free Oxford* campaign: https://mycouncil.oxford.gov.uk/documents/s17307/Fossil%20Free%20Oxon%20-%20summary%20fo
[xviii] See list of local authorities that have declared a climate emergency: https://www.climateemergency.uk/blog/list-of-councils/

10. Other generation in the Southern England licence area

Summary of modelling assumptions and results.

Technology specification:

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

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

Installed capacity (MW)	Baseline	2020	2025	2030	2035	2040	2045	2050
All scenarios	15.4	18	25	25	25	25	25	25

Overview of technology projections in the licence area:

- The baseline consists of 22 projects, totalling 15.4 MW in capacity.
- At an average capacity of 0.7 MW, these sites are predominantly CHP plants within buildings, where the fuel type is uncertain.
- The pipeline consists of 26 projects, totalling 9.3 MW in capacity.
- All pipeline projects connect according to their anticipated connection date, which is across the 2020s.
- Other generation is not projected beyond the baseline and pipeline. There is no difference between the scenarios for this technology.

Reconciliation with National Grid FES 2020:

- There is not ‘other generation’ technology in the National Grid FES 2020

References:

SSEN connection data.

Section 2 – Electricity storage

Battery storage

11. Electricity storage in the Southern England licence area

Summary of modelling assumptions and results.

Technology specification:

DFES technology building blocks:

- **Batteries (Srg_BB001)**
- **Domestic batteries (G98) (Srg_BB002)**

The analysis covers any electricity storage projects[xix] that directly connect to the distribution network in the Southern England licence area.

The DFES analysis for energy storage has been categorised into four storage business models:

- **Standalone network services –** typically multiple MW scale, that provide balancing, flexibility, and support services to the network. Future uptake is based upon a scenario-specific inflation of the baseline and pipeline that is reconciled more closely with the FES GSP projections. For Southern England, this considers both the accessibility to the distribution network and the network charging reforms that are being proposed that could adversely affect the already challenging business case for new standalone battery projects connecting at distribution network voltages[xx].
- **Generation co-location** – typically multiple MW scale projects, sited alongside renewable energy (or possibly other) generation projects. Future uptake is based upon the corresponding DFES scenario modelling for distribution network onshore wind and ground mount solar PV within the licence area. With a strong baseline and proposed future deployment of distribution network onshore wind capacity in the licence area, batteries connecting under this business model could see a significant increase.
- **Behind-the-meter high energy user** – single MW or 'hundreds of kW' scale projects, sited at large energy user operational sites, to support onsite energy management or to avoid high electricity cost periods. Future uptake is based on modelling a scenario-specific proportion of known commercial and industrial properties in the licence area, that are suited to co-locating batteries behind the meter.
- **Domestic batteries** – typically 10-20 kW scale batteries that households buy to operate alongside domestic rooftop PV, to exploit domestic time-of-use-tariffs, or to provide mains back-up support to the home. Future uptake is based upon the DFES scenario modelling for domestic rooftop solar PV in the licence area.

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

Installed power capacity (MW)		Baseline	2020	2025	2030	2035	2040	2045	2050
Standalone network services Srg_BB001	Steady Progression	0.1	0.1	378	381	401	421	442	446
	System Transformation		0.1	218	221	232	243	255	260
	Consumer Transformation		0.1	428	449	561	673	707	721
	Leading the Way		0.1	378	397	436	654	667	667
Generation co-location Srg_BB001	Steady Progression	1.7	2	57	74	78	93	98	137
	System Transformation		2	54	61	63	68	71	73
	Consumer Transformation		2	63	100	109	162	181	234
	Leading the Way		2	61	118	138	252	309	336
Behind the meter high energy user Srg_BB001	Steady Progression	1.4	10	18	35	65	71	121	121
	System Transformation		7	13	24	37	40	87	87
	Consumer Transformation		12	22	44	116	156	214	214
	Leading the Way		12	38	124	133	145	185	185
Domestic batteries Srg_BB002	Steady Progression	0	1	3	13	15	26	54	113
	System Transformation		1	2	4	5	6	11	12
	Consumer Transformation		1	4	64	126	205	321	624
	Leading the Way		1	31	129	379	641	740	790

Overview of technology projections in the licence area:

In the Southern England licence area, a significant amount of distribution network connected battery storage capacity (MW) is seen in all scenarios by 2050, compared to a relatively small 3.2 MW baseline. This reflects a significant near-term known pipeline of 736 MW, including two projects that are greater than 100 MW and several others that are in the c.30-50 MW range.

The highest connected capacity is in the **Leading the Way** scenario, with c.2 GW modelled to connect to the distribution network by 2050. This is c.12% of the FES 2020 total GB projected capacity on the distribution network in this scenario by 2050. This reflects a significant proportion of the pipeline going through to connection, as well as additional standalone, co-location and high energy user projects connecting in the medium term and a notable uptake of domestic batteries by 2050 in this scenario.

The lowest connected capacity is seen in the **System Transformation** scenario, with c.0.4 GW connected by 2050. This reflects a more general scenario assumption of a lesser need for distribution network connected flexibility and overall lower levels of electrification and renewable electricity generation deployment. It also reflects a significantly lower uptake of domestic batteries.

Whilst a notable increase in connected capacity is seen in all scenarios by 2050, beyond the sizeable pipeline there is a degree of uncertainty around the development of battery storage projects under any business model. This uncertainty relates to high levels of competition in national and local flexibility markets and network charging reforms that could impact the long term business case of distribution network storage assets. The degree of uncertainty impacting deployment under each storage business model has been reflected through the four scenarios.

Scenario projection results:

Baseline (up to end of 2019)

- There is only 3.2 MW of distribution network connected battery storage capacity in the licence area, of this:
    - 0.1 MW are standalone battery projects
    - 1.7 MW is co-located with renewable energy generation
    - 1.4 MW is installed behind the meter at high energy user commercial and industrial sites
    - There may also be a small number of domestic battery installations however these are not apparent in the connection data that forms the baseline.

Near term (2020 – 2025)

- There is a sizeable pipeline of distribution network battery storage projects with an accepted connection offer in the licence area. This 31 project pipeline totals c.736 MW and can be categorised as follows:
    - 18 sites, totalling 659 MW, are standalone battery projects
    - 2 sites, totalling 60 MW, are generation co-location projects
    - 10 sites, totalling 17 MW, are commercial and industrial high energy user projects installed
    - A single 5 kW domestic battery in Portsmouth.
- When assessing the development activity of these pipeline projects:
    - 11 sites, totalling 398 MW have received planning approval. These are almost entirely standalone battery projects
    - 11 sites, totalling 272 MW have either secured a Capacity Agreement or successfully pre-qualified in various T-4 or T-1 Capacity Market auctions. These are also almost entirely standalone projects.
    - 8 sites, totalling 1.2 MW, were individually too small for either planning or direct entry into Capacity Market auction registers
    - A 7.2 MW project in Marlow was withdrawn from planning in February 2020 and has not been modelled to connect in any scenario.
- As a result of this analysis:
    - The 272 MW with positive development activity in the Capacity Market is modelled to connect in all scenarios in the early/mid 2020s in all scenarios. In each case, the connection year is based upon either modelling five years after planning approval was received or the Capacity Market delivery year that was identified from T-4 or T-1 auction register data
    - In **Consumer Transformation** and **Leading the Way**, the 8 sites (1.2 MW) that were below planning or Capacity Market thresholds, and those sites with planning approval only, are also modelled to connect five years after receiving accepted connection offers
    - The sites with no development information at all are modelled to connect ten years after receiving accepted connection offers in the **Consumer Transformation** scenario only. This culminates in some 540 MW connecting by 2025 in this scenario.

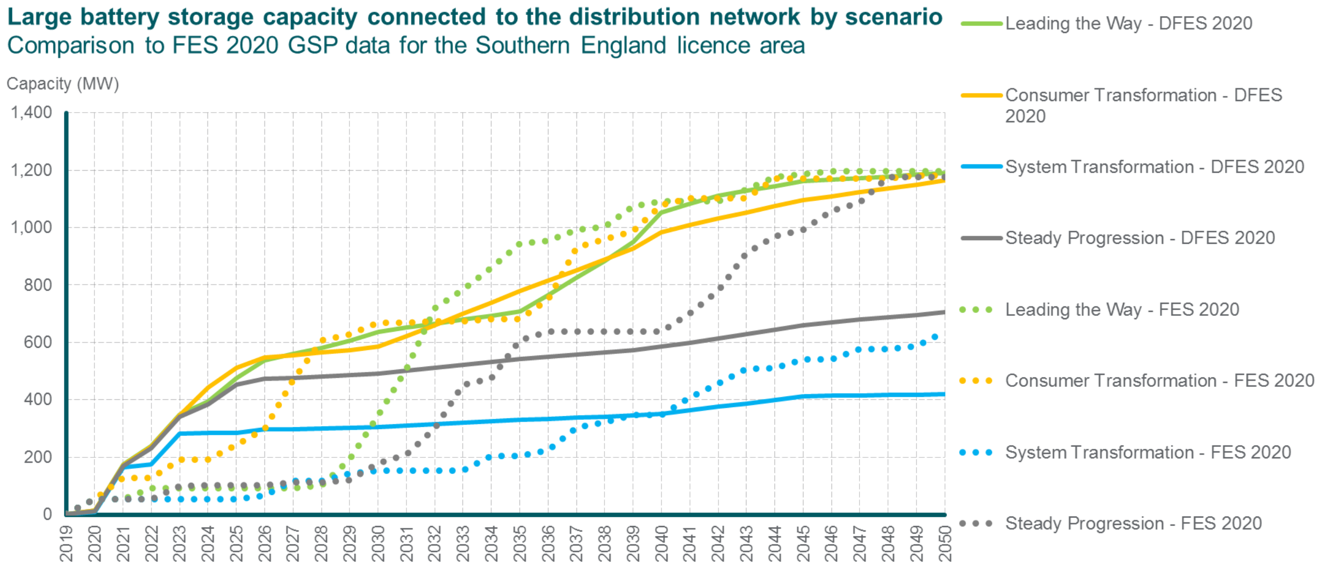
Medium term (2025 – 2035)

- Across late 2020s and early 2030s a proportion of the pipeline projects which currently have limited development evidence are assumed to connect in the **Consumer Transformation** and **Leading the Way** scenarios.
- The characteristics of the Southern England licence area and the resultant scenario outcomes can be summarised as follows:
    - A significant capacity of large scale solar generation is projected to connect to the distribution network in all scenarios, but this is most significant in **Leading the Way**, with just over 4 GW of solar capacity connected by 2035. Contrarily, a minor amount of distribution network connected onshore wind is modelled to come online in the licence area, reflecting below average wind resources and a very challenging planning environment. The scenario with the most generation co-located battery storage capacity in 2035 is **Leading the Way** with 138 MW. The scenario with the lowest capacity is **System Transformation** with 63 MW by 2035.
    - A notable number of commercial and industrial properties (c.107,000) in the licence area in areas such as Oxford, Swindon, Portsmouth, Southampton and West London, is a firm basis for the uptake for smaller scale batteries installed behind-the-meter at high energy user sites. This business model sees 133 MW in **Leading the Way** and 63 MW in **System Transformation** by 2035.
    - With over 1.6 million homes in the Southern England licence area and a potentially significant uptake of rooftop solar in the **Leading the Way** and **Consumer Transformation** scenarios, there is also notable potential for domestic battery installations in the medium term. This business model sees the most significant range of scenario outcomes by 2035, with c.379 MW being modelled to connect in **Leading the Way** (equivalent of c.75,000 homes), but only 5 MW (equivalent of 1,000 homes) in **System Transformation** by 2035.

Long term (2035 – 2050)

- The spread of total connected battery storage capacity in the licence area continues across the scenarios between 2035 and 2050.
- The accelerated uptake of battery storage in all business models in **Leading the Way** plateaus in the 2040s, whereas the trends in the other scenarios continues out to 2050. The limited uptake of domestic batteries continues in **System Transformation**.
- In the licence area by 2050, the total amount of distribution connected battery storage in **Leading the Way** reaches just under 2 GW. Most of this capacity is either standalone battery projects providing network services or domestic batteries supporting some 150,000 households to optimise their help manage domestic energy bills and increase the self-consumption of domestic solar generation
- The total amount of capacity in **System Transformation** reaches a much lower 432 MW. Most of this capacity is standalone battery projects, with a moderate amount of storage co-located with renewable generation and installed behind-the-meter at a c.260 high energy user sites. There is are only c.2,000 homes with a domestic battery in this scenario by 2050.

Figure 28 Comparison of large battery storage projections in the Southern England licence DFES analysis to the FES 2020

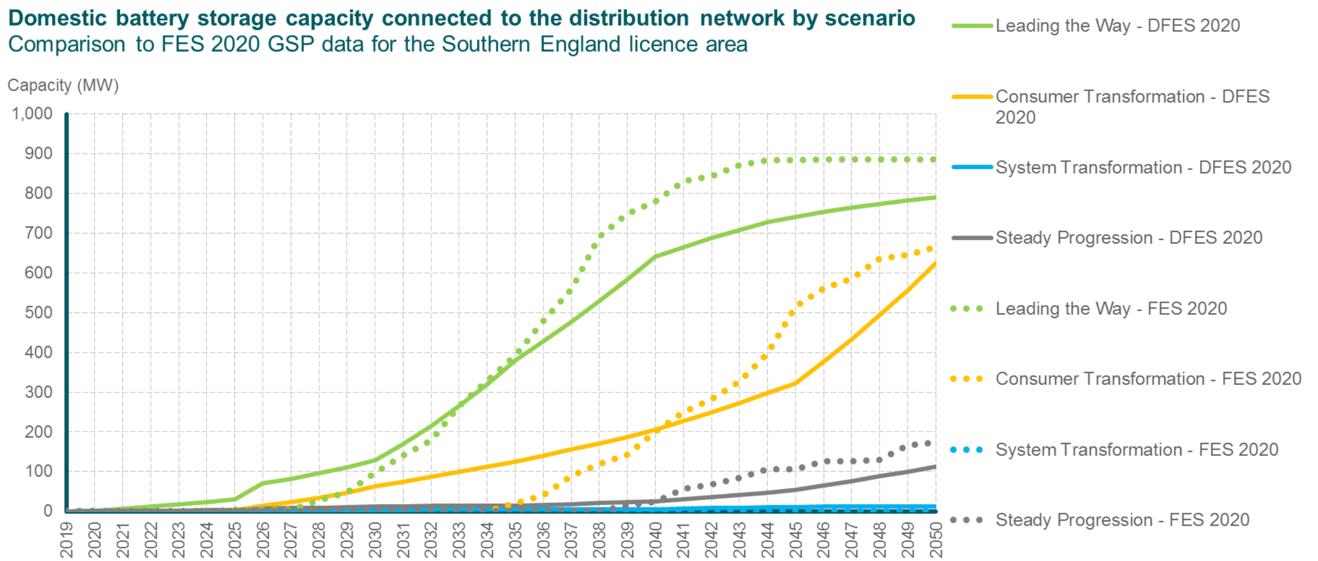


Total capacity of large scale storage business models:

- Standalone network services
- Generation co-location
- Behind the meter high energy user.

Equivalent to FES building block:
Batteries (Srg_BB001)

Figure 29 Comparison of domestic battery storage projections in the Southern England licence DFES analysis to the FES 2020



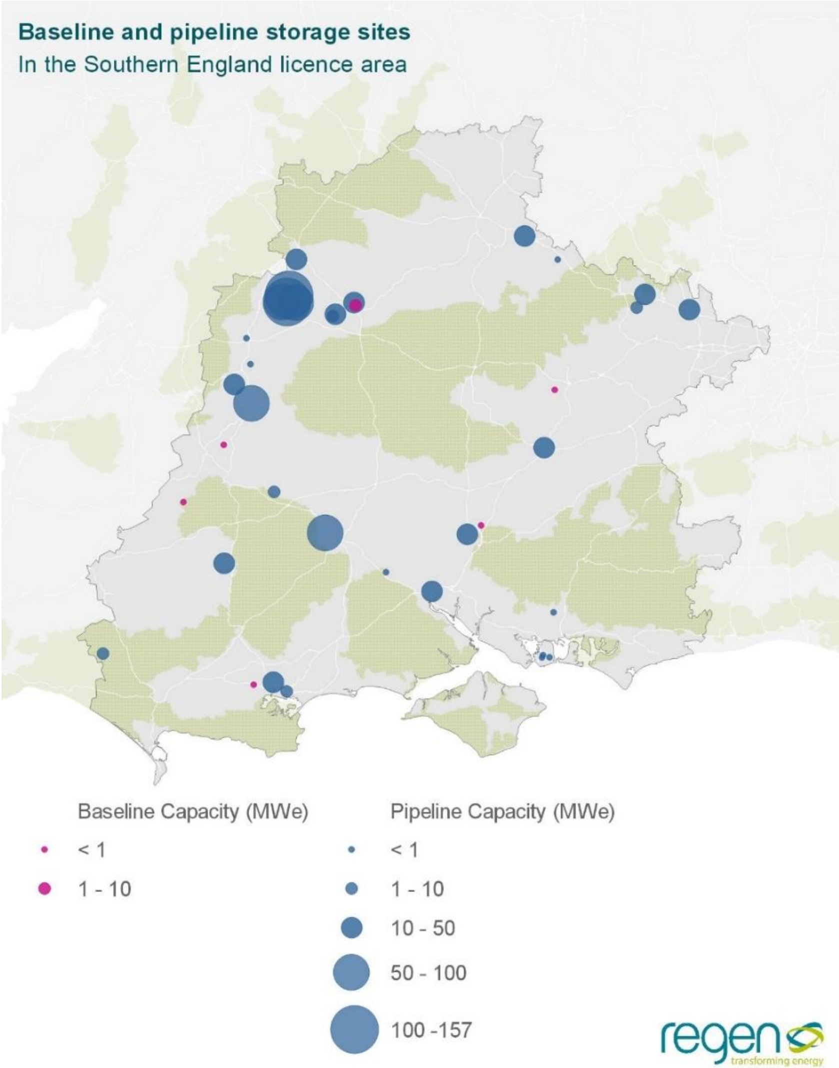
Total capacity of domestic storage.

Equivalent to FES building block:
Domestic Batteries (G98) (Srg_BB002)

Reconciliation with National Grid FES 2020:

- With regards to **large batteries**, (see Figure 28) the summation of the three large-scale storage business model DFES projections align in some scenarios in the longer term. There are however several areas where the DFES projections have diverged from the FES GSP projections for the Southern England licence area:
    - Between 2020 and 2030, the DFES has projected a significantly more rapid connection of new battery storage capacity in all scenarios than the FES. This reflects both a sizable pipeline of battery storage projects (and capacity) with an accepted connection offer and a notable amount of this pipeline that has clear development evidence, in the form of recent planning approval or positive Capacity Market auction activity.
    - Beyond this pipeline and out to 2050, the DFES projections align much closer to the FES GSP projections, except for the **Steady Progression** scenario, where the FES projections culminate in the same total as the other scenarios. The DFES analysis modelled a much lesser uptake of battery storage in **Steady Progression** across all business models than **Leading the Way** and **Consumer Transformation**, but more than **System Transformation**. This reflects the FES assumption: "*Moderate levels of flexibility requirements encourage new storage. Not as much deployed compared to other scenarios*".
    - The DFES and FES **System Transformation** projections for large scale batteries are aligned in the sense of **System Transformation** being the lowest overall scenario, but the DFES has projected a higher connected capacity in the 2020s and 2030s, reflecting the significant pipeline with development evidence. Contrarily, DFES has also projected c.200 MW less overall capacity by 2050 in this scenario, reflecting lower levels of renewable electricity generation for co-location, fewer commercial and industrial properties locating batteries behind the meter and less standalone battery storage capacity providing network services in the licence area.

Figure 30 Map of baseline and pipeline battery storage projects in the Southern England licence area



- With regards to **domestic batteries**, (see Figure 29), the DFES projections align fairly well to the FES GSP projections for the licence area.
- The main areas where the DFES has diverged from the FES are:
    - Fewer domestic batteries have been modelled to connect in the DFES by 2050 in all scenarios except for **System Transformation**. This reflects a consideration that the future role, use cases and value of domestic batteries to households is uncertain, so a proportion of the level of capacity assumed in **Leading the Way** in the FES in 2050 was resultantly reduced in the DFES.
    - Contrarily, the FES GSP projections have practically no domestic batteries connecting in **System Transformation** between 2020 and 2050, with connected capacity in the licence area increasing from c.0.9 MW to c.1.1 MW. The DFES analysis considered this to be a disproportionately small increase in domestic battery capacity, even in this as a hydrogen heavy and very centralised technology scenario. The DFES has therefore modelled a moderate amount (12 MW) of domestic storage connecting by 2050.
- In general, the potential of widespread domestic battery uptake in the future is uncertain. Whilst potential use cases exist such as time-shifting exported domestic solar output to be self-consumed, participation in aggregated domestic flexibility services[xxi] or exploiting domestic time-of-use-tariffs[xxii], the sustainability of these as sources of guaranteed savings/income for homeowners in the long run is unclear. This explains in part the range of domestic storage capacity scenario projections seen in both the FES and the DFES out to 2050.

Factors that will affect deployment at a local level:

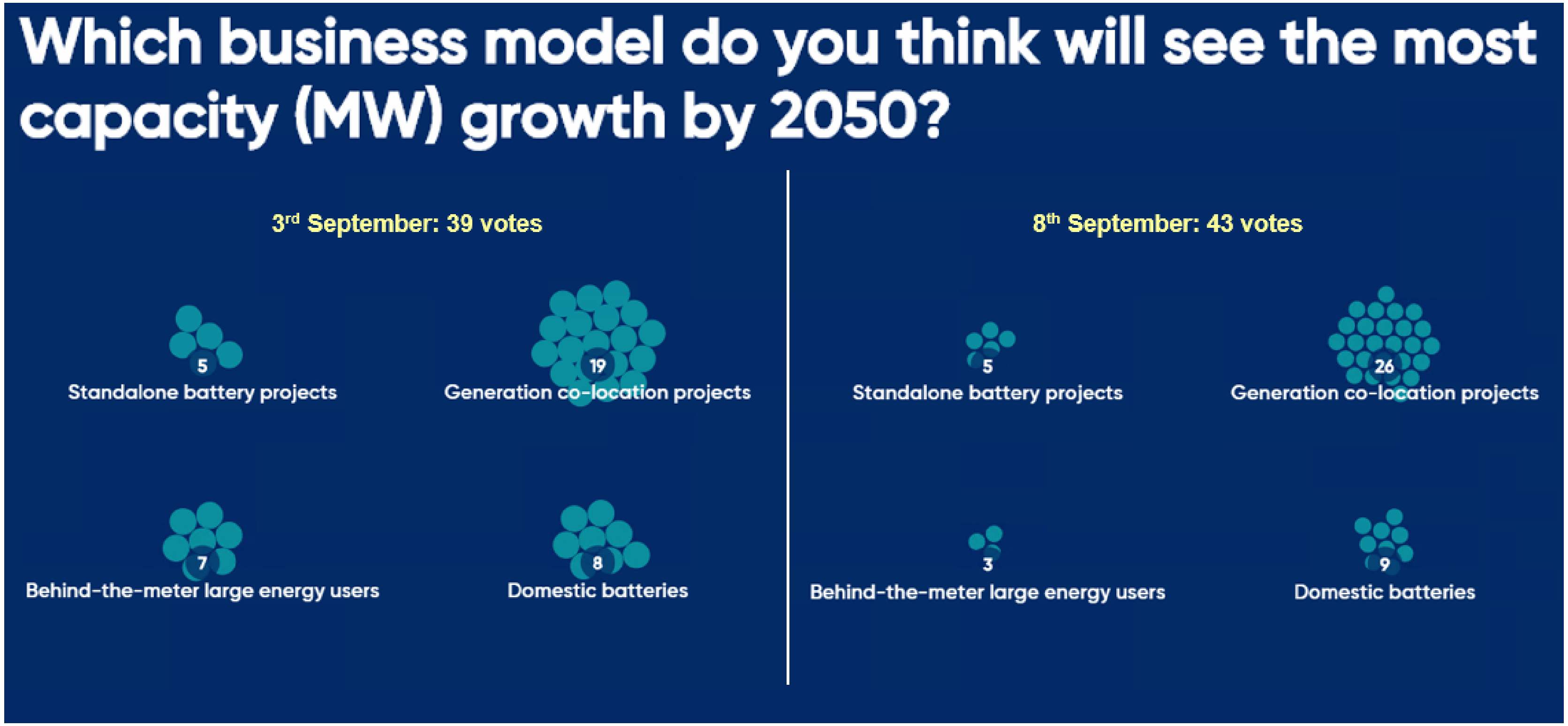
- The spatial distribution of new battery storage projects in the near term is based on the location of the identified pipeline sites.
- In the longer term, spatial distribution varies according to the four battery storage business models used in the modelling.
- The factors applied to distribute storage capacity into 11kV ESAs across the Southern England licence area, can be summarised as:
    - **Standalone network services:** Proximity to 33kV and 132kV electricity network.
    - **Generation co-location:** Proximity to ground mounted solar PV and onshore wind generation within the licence area
    - **Behind-the-meter high energy user:** Proximity to industrial areas and commercial buildings in city/urban areas
    - **Domestic batteries:** Domestic dwellings with rooftop PV.

Relevant assumptions from National Grid FES 2020:

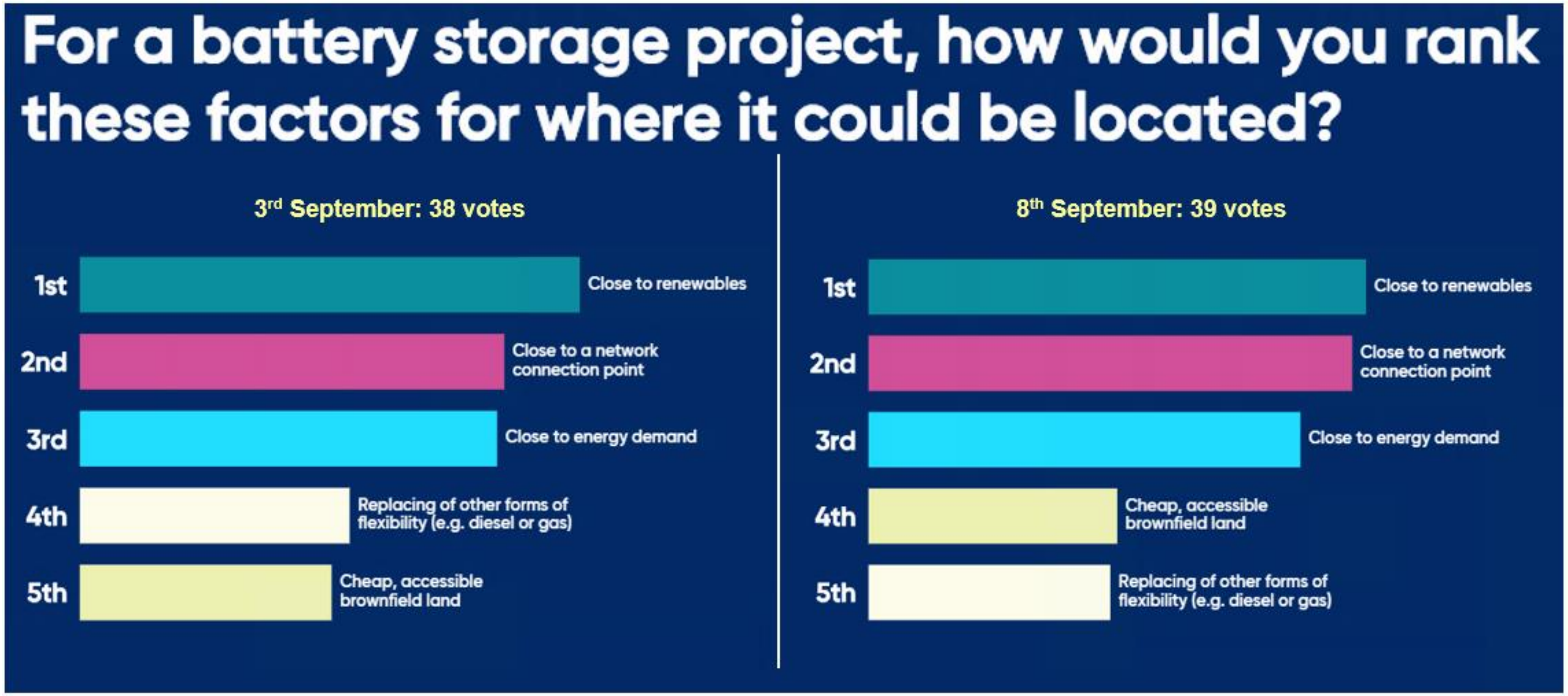
Assumption number	4.2.24 (Electricity storage of duration of 2 hrs or less) e.g. Domestic batteries and larger short-duration batteries	4.2.25 (Electricity storage of duration between 2 and 4 hrs) e.g. Medium batteries, compressed or liquid air storage)	4.2.26 (Electricity storage of duration longer than 4 hrs) e.g. Large batteries, compressed air and pumped hydro storage)
Steady Progression	Moderate levels of flexibility requirements encourage new storage. Not as much deployed compared to other scenarios.	Lower flexibility requirements means that this technology does not come forward at the volumes seen in the other scenarios.	
System Transformation	Not as much deployed compared to other scenarios due to high use of Hydrogen within this scenario.	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.	Presence of high volumes of Hydrogen limit the need for long duration storage.
Consumer Transformation	High levels of variable clean generation and flexibility requirements encourage new storage technologies to emerge.	Flexibility requirements encourage new storage.	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.	High levels of flexibility requirements encourage new storage.	Even higher levels of flexibility requirements encourage new storage technologies to emerge at distributed and transmission levels.

Overview of stakeholder and regional input:

On the 3 and 8 September Regen, SSEN and the Energy Systems Catapult ran interactive webinars with online polling platform Mentimeter. These webinars engaged regional stakeholders with regards to future energy scenarios and local energy planning for the Southern England licence area. This included specific engagement around some of the key technologies in the scope of the DFES analysis, one of which was battery storage. Stakeholders were informed about the baseline and pipeline position in the licence area and asked questions regarding storage business models and locational factors. The results are summarised below:



This feedback reinforced the need to reflect a notable amount of battery storage capacity being co-located with renewable energy generation across the scenarios out to 2050. In the Southern England licence area, this is most notable an opportunity for large scale solar generation.



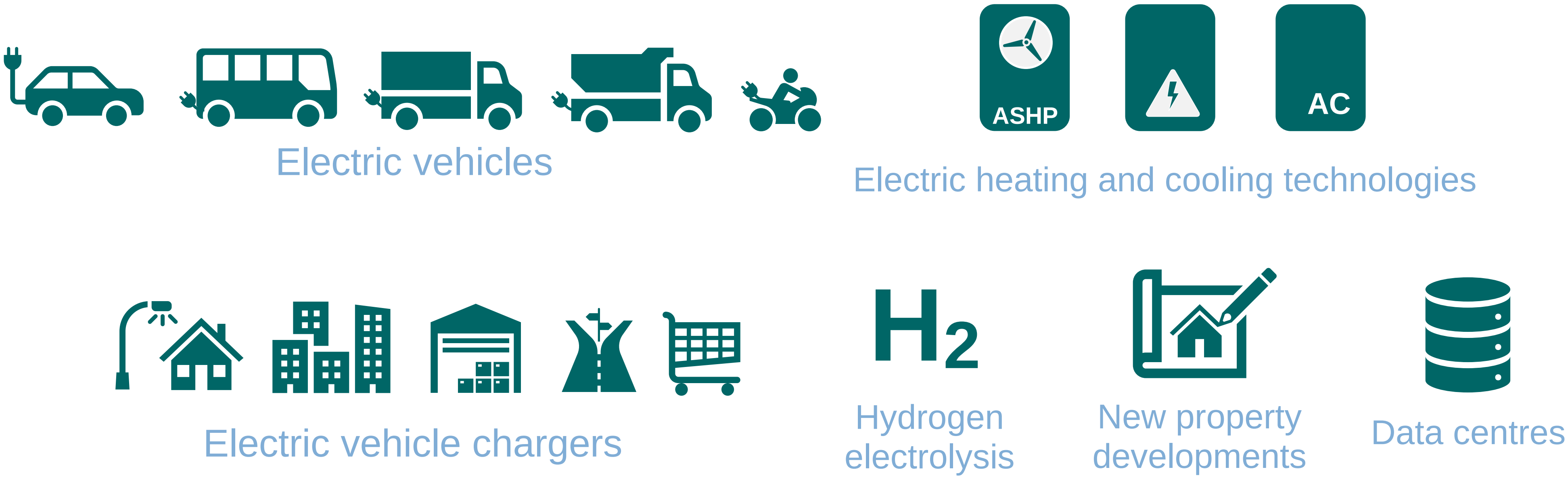
The feedback around locational factors also aligned well with the DFES assumptions made around geographic distribution factors, where more weighting is put towards proximity to the distribution network and renewables than land designations in the modelling.

References:

SSEN connection data, EMR Delivery Body Capacity Market Registers, online planning portals.

[xix] Whilst the DFES sought to also analyse the potential for pumped hydro, no development evidence or FES scenario projections were found for pumped hydro connecting to the distribution network in the licence area. Therefore the analysis has entirely focused on battery storage.
[xx] See Regen's webinar event discussing the proposed network charging reforms, that could incur potentially notable costs in 'generation dominated' primary substations in the licence area: https://www.regen.co.uk/event/the-significant-code-review-a-step-forward-for-decarbonisation/
[xxi] See SSEN innovation project Social Constraint Management Zone: https://www.smarternetworks.org/project/nia_ssen_0036
[xxii] See Octopus and Tesla time of use tariff around Powerwall home batteries: https://octopus.energy/tesla-energy-plan-faq/

Section 3 – Low carbon technologies and new sources of electricity demand



12. Electric Vehicles in the Southern licence area

Summary of modelling assumptions and results.

Technology specification:

The analysis covers Electric Vehicles (EVs) operated within the Southern England licence area. This includes non-autonomous cars, autonomous cars, buses and coaches, HGVs, LGVs and Motorcycles, including battery EVs and plug-in hybrid EVs.

DFES Building Block ID numbers Lct_BB001, Lct_BB002, Lct_BB003, Lct_BB004

Data summary for electric vehicles in the Southern licence area:

Number of EVs (total, 1000s)		Baseline	2025	2030	2035	2040	2045	2050
Battery EVs (thousands)	Steady Progression	27	186	533	1,407	2,868	4,371	4,806
	System Transformation	27	188	779	2,139	4,049	4,750	4,555
	Consumer Transformation	27	493	1,647	3,489	4,674	4,797	4,501
	Leading the Way	27	499	1,676	3,770	4,593	4,310	3,442
Plug-in hybrid EVs (thousands)	Steady Progression	31	118	267	473	629	425	145
	System Transformation	31	103	223	335	243	90	16
	Consumer Transformation	31	77	139	171	113	44	19
	Leading the Way	31	96	170	134	66	14	14

Overview of technology projections in the licence area:

- A more detailed overview of the specific assumptions used in Regen's Transport Model is available in the Electric Vehicle and Charger Assumptions Workbook, which accompanies the DFES dataset. This workbook includes assumptions related to vehicle milage, vehicle efficiency, charging behaviour, charger utilisation etc.
- At present, EVs represent approximately 1.1% of all vehicles in the Southern licence area, which is above the GB average of nearly 1%. The EV uptake rate in the Southern licence area is expected to remain ahead of the GB average until the late 2020s in most scenarios, when EV uptake becomes increasingly ubiquitous.
- Electrification is the key route to decarbonising transport in the ESO FES 2020 scenarios, with hydrogen contributing to the decarbonisation of HGVs and buses.
- All scenarios in ESO FES 2020 show a more rapid EV uptake compared to the ESO FES 2019. Even the slower growth scenarios of **Steady Progression** and **System Transformation** have faster growth rates than in previous FES 2019 scenarios.
- A significant difference between the ESO FES 2020 and ESO FES 2019 scenarios is the introduction of Autonomous Vehicles (AVs) and a more significant reduction in overall vehicle numbers. This is particularly true for **Leading the Way**, which has a third fewer vehicles than **Steady Progression**.
- The reduction in vehicle numbers in the ESO FES 2020 is facilitated by an increase in active and public transport use, an increase in average vehicle mileage, and the introduction of AVs which have high average annual mileage.
- Hydrogen vehicles numbers increase significantly throughout the 2030s, and are concentrated in HGVs, buses and LGVs in all scenarios except **Steady Progression**, which prioritises natural gas as a fuel in those vehicle archetypes.
- Analysis of AVs was introduced in ESO FES 2020. FES estimates these vehicles will represent between 9% and 23% of all cars by 2050 depending on the scenario. This is, therefore, the first SSEN DFES to include a preliminary analysis of AVs.

Scenario projection results:

Baseline (up to end of 2019)

- 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, Oxford, Swindon, Southampton, Portsmouth and Reading.
- There are an estimated 27,485 battery EV cars in the licence area, representing 0.5% of all vehicles in the licence area.
- There are an estimated 30,536 plug-in hybrid EV cars in the licence area, representing 0.6% of all vehicles in the licence area.
- While the number of plug-in hybrid EVs is currently higher than battery EVs, across all scenarios battery EVs are projected to become the most prevalent low carbon vehicle in the near term and quickly eclipse plug-in hybrids. The most ambitious scenarios have zero plug-in hybrids by the 2040s.

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 186,000 battery EVs in **Steady Progression** and 499,000 in **Consumer Transformation**. Therefore, by 2025 EVs are projected to account for up to 9% of all cars.
- Autonomous vehicle uptake starts at the earliest in 2023 in all scenarios, however, uptake is assumed to be very slow in the near term.
- Local initiatives to lower air quality or expand access to charging are expected to increase local uptake. ‘Clean Air Zones’ have been proposed in both Reading and Oxford and are assumed to go ahead in all net zero compliant scenarios in the near-term.

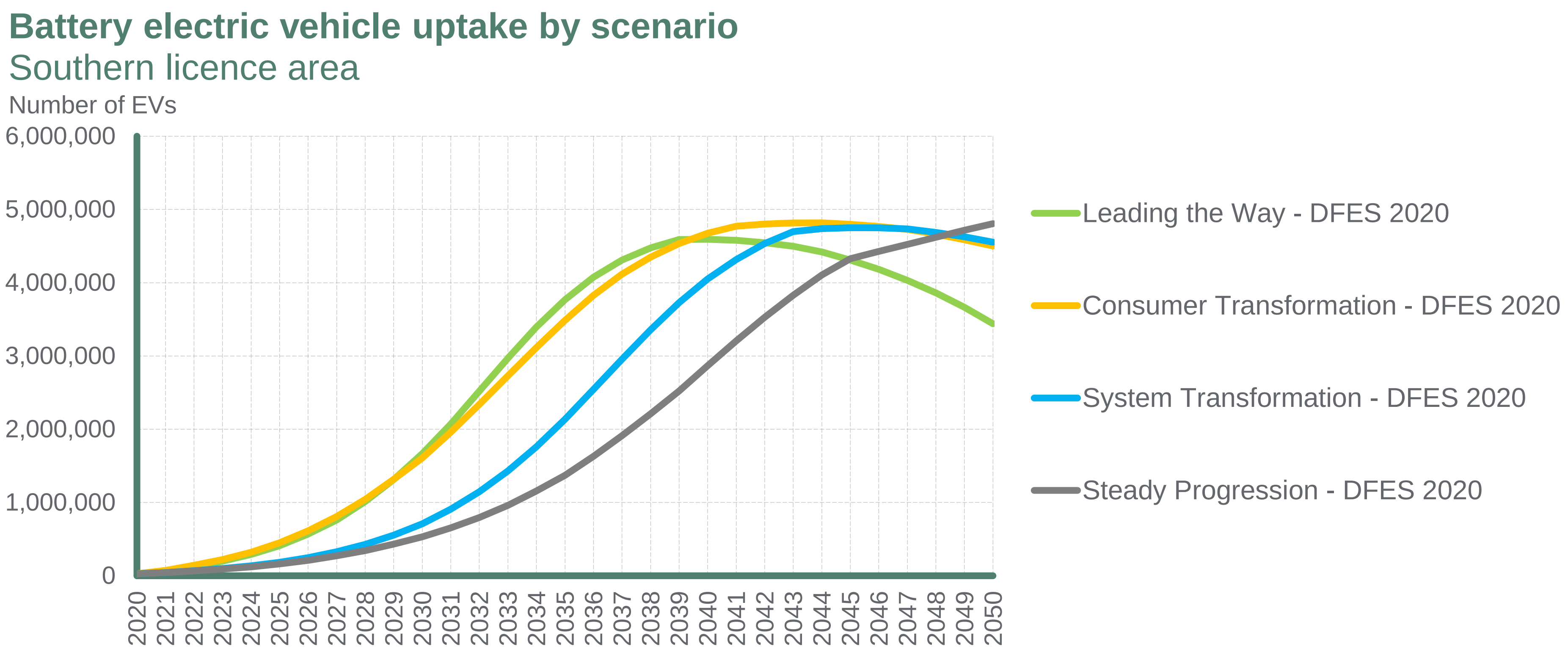
Medium term (2025 – 2035)

- The uptake of EVs is expected to continue increasing between 2025 and 2035 across all scenarios.
- **Steady Progression** has the fewest estimated battery EVs in 2035, with around 1.4 million. **Leading the Way** has the most, with over 3.7 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 being fuelled by petrol or diesel. Other factors also contribute to uptake slowing, including the total number of vehicles reducing, increased use of AVs, and increased use of 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 from 2032.

Long term (2035 – 2050)

- The uptake of EVs continues to increase in **Steady Progression**, right up until 2050 when battery EVs total nearly 4.8 million. In **System Transformation**, the uptake of battery EVs approximately flattens from the mid-2040s at around 4.7 million.
- 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 real term 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 31 Summarising scenario projection graph for the technology, with comparison to FES regional



Reconciliation with National Grid ESA FES 2020:

The 2020 SSEN DFES uses the ESO FES 2020 Building Block ID numbers Lct_BB001, Lct_BB002, Lct_BB003, Lct_BB004' as the framework for future projections. EV uptake in the licence area is expected to remain ahead of the national average in the near-term, before aligning with national ESO FES 2020 projections in the medium and long term.

Interim assumptions have been made as to the uptake and distribution of AVs in the absence of other information including:

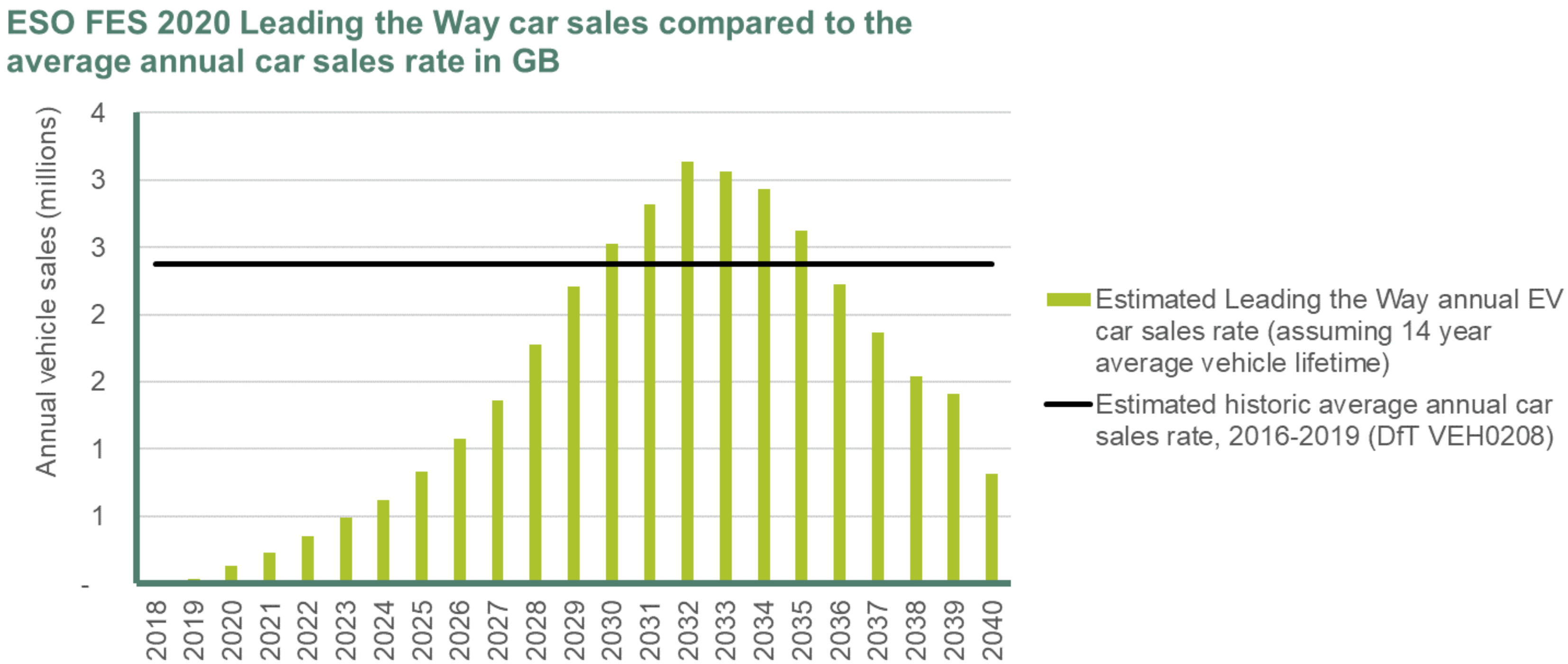
- Their spatial distribution is treated the same as non-autonomous EVs due to a lack of information about their future uptake.
- It is assumed that the uptake of EVs in on and off-street settings is the same as for non-autonomous EVs
- The uptake and distribution of AVs is an area that needs to be considered for future analysis when more evidence is available.

The UK Government has announced plans to ban the sale of new petrol and diesel cars in 2030, and plug-in hybrid cars from 2035. The National Grid ESO FES 2020 projections were produced before this was announced and therefore included an assumption that the ban on petrol and diesel cars would be between 2032 and 2040, for both battery EVs and plug-in hybrids. The inclusion of the government's new 2030 target into the DFES 2020 analysis for EV uptake was considered and discussed with the SSEN team, and it was decided that reflecting this accelerated ambition could be achieved in the DFES without altering the existing projections, specifically:

- For the more ambitious scenarios (**Leading the Way** and **Consumer Transformation**), it was identified that the rate of sales of new electric cars goes beyond the historic car sales rate in 2030 already, this is illustrated in Figure 32.
- For the less ambitious scenarios, particularly **Steady Progression**, it was considered unnecessary to model fewer scenarios or augment **Steady Progression**'s uptake to match a more ambitious scenario. Or more specifically, discussions with the SSEN team concluded that the impact of EVs on the distribution network could essentially be modelled either without Steady Progression, or this scenario could be used to represent an outcome for EV manufacturing rates where the government's petrol and diesel limitation is not achieved.

The full impact of the Government plan will be considered in more detail in future DFES analysis and when new evidence becomes available.

Figure 32: Sales rate of vehicles historically and in Leading the Way



The ESO FES 2020 and this DFES study assumes plug-in hybrids will form part of the government's proposed ban and that the ban is implemented as follows:

- **Leading the Way** in 2032
- **Consumer Transformation** and **System Transformation** in 2035
- **Steady Progression** in 2040

Factors that will affect deployment at a local level:

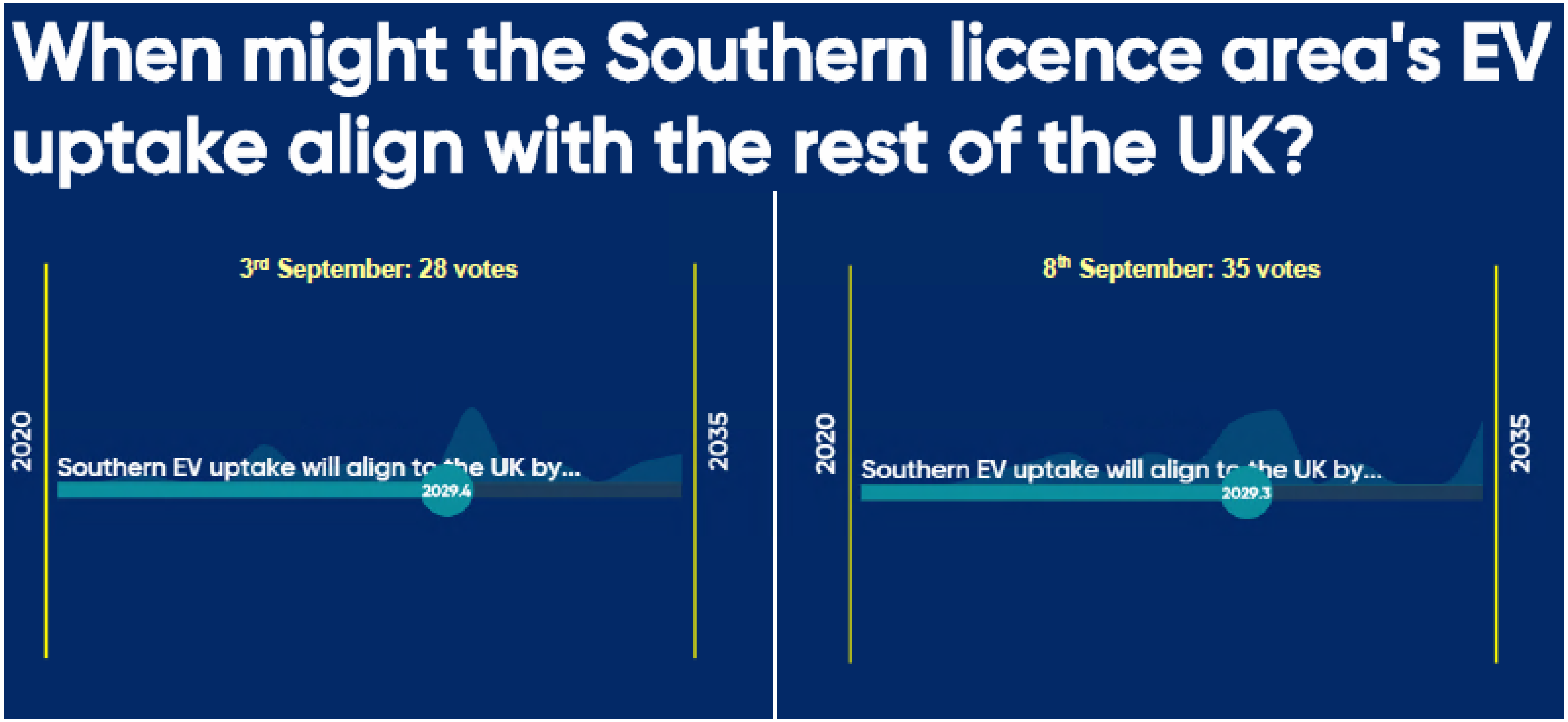
- The uptake of EVs was evaluated to a much higher granularity than ESAs. The uptake of EVs was evaluated to SSEN's 400,000 individual feeders, equivalent to street-level forecasts
- A wide variety of datasets were used to analyse specific regional and feeder specific demographic and technical attributes and geographical characteristics. For example, in order to evaluate the distribution of houses with on and off street parking and their associated vehicles, SSEN connectivity data was used to identify the number of houses associated with a feeder, which were then classified by type of housing and vehicles with a combination of DfT, EPC, Census and Ordnance Survey data. While not perfect, owing to data limitations, this allowed a much more granular assessment of commercial and industrial activity connected to the network.
- In the SSEN DFES 2020 consultation events, stakeholders raised local plans and policies which could increase uptake and are included as positive weightings in the near and medium term.
- The spatial distribution of EV cars in the near term is based on affluence, rurality, existing vehicle baselines and the distribution of on and off-street parking. However, the more ambitious scenarios see the impact of these factors on the uptake of EVs diminishing in the mid-2020s, and by the late 2020s EV uptake is assumed to be ubiquitous. This means that almost all consumers are assumed to have the same likelihood of adopting an electric vehicle. In order to evaluate the distribution of EVs to a feeder level, the above factors were interpolated down to individual feeders from the highest granularity of publicly available datasets.

Relevant assumptions from National Grid the ESO FES 2020:

Assumptions	3.3.5 (Battery Electric Vehicles), 3.3.2 (Autonomy)
Steady Progression	**Steady Progression** is the scenario with the least ambitious new petrol and diesel sales ban of 2040. **Steady Progression** assumes autonomous vehicles will be privately owned. In this scenario, this increases average miles travelled.
System Transformation	**System Transformation** assumes that in some cases a two-car household becomes a one car household, where shared autonomous vehicles meet some transport needs. However, most households still have two vehicles, which leads to a modest decrease of only 8% in the number of vehicles compared to **Steady Progression**.
Consumer Transformation	In **Consumer Transformation** autonomous vehicles, acting as a taxi service, often replace the need for a second car. They are used by consumers to commute to work or for leisure trips. Combined with greater use of public transport, this results in a 15% decrease in vehicles in this scenario, compared to **Steady Progression**.
Leading the Way	In **Leading the Way**, the high levels of societal change have led us to assume that use of autonomous vehicles and public transport reduces the overall number of cars as many homes opt to have no car at all, relying instead on shared mobility solutions, using AVs, which can accommodate four people. Total number of cars is one third less in 2050 than in **Steady Progression**.

Stakeholder feedback overview:

- At the Southern England stakeholder engagement workshop, stakeholders gave their opinion on the uptake rate of EVs in the Southern licence area. The majority of stakeholders thought that the licence area's EV uptake would continue to remain ahead of the GB average until 2029 on average.
- Stakeholders views on EV uptake has been reflected in all scenarios, however, the Southern licence area's EV uptake approaches the GB average quicker in the more ambitious scenarios as a result of other regions of GB catching up with this licence area's higher uptake rate.
- Local initiatives to lower air quality or expand access to charging are expected to increase local uptake. 'Clean Air Zones' have been proposed in both Reading and Oxford and are assumed to go ahead in all net zero compliant scenarios in the near-term.



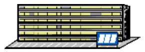
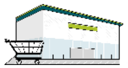
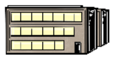
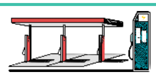
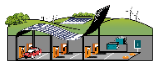
References:

SSEN connection data, Department for Transport Vehicle registration and milage data, Climate Emergency declaration data, Regen consultation with local stakeholders, Census data.

13. Electric vehicle chargers in the Southern licence area

Summary of modelling assumptions and results.

Technology specification:

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, thus 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 which 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

Please note that the projection units of domestic and non-domestic EV chargers are different. To illustrate the scale of EV charger uptake, domestic EV chargers are displayed in numbers while non-domestic EV chargers are displayed in total network 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, numbers of chargers is considered a more useful indicator of the scale of future uptake as it enables comparisons of chargers on a per household and per EV basis.

Data summary for EV chargers in the Southern licence area:

EV chargers		Baseline	2025	2030	2035	2040	2045	2050
Domestic off-street EV chargers (Total, numbers, thousands)	**Steady Progression**	16	136	315	762	1,491	1,657	1,676
	System Transformation	16	131	466	1,245	1,662	1,688	1,688
	Consumer Transformation	16	341	961	1,631	1,692	1,693	1,693
	Leading the Way	16	369	1,053	1,668	1,696	1,696	1,696
Non-domestic EV chargers (Total, MW)	**Steady Progression**	74	327	649	1,215	2,049	2,753	2,848
	System Transformation	74	308	746	1,668	2,740	3,139	3,246
	Consumer Transformation	74	489	1,113	2,226	2,933	3,187	3,285
	Leading the Way	74	549	1,367	2,681	3,294	3,452	3,506

Overview of technology projections in the licence area:

- A more detailed overview of the assumptions used in Regen's Transport Model is available in an assumptions spreadsheet made available to SSEN. This assumptions spreadsheet covers specific assumptions on assumed vehicle mileage, EV efficiencies, consumer charging behaviour, and charger utilisation rates.
- At present, the installation of public EV chargers in the Southern England licence area is approximately the same as the GB average, when as a reflection of the number of EVs in the licence area. This trend is expected to continue as EVs become increasingly ubiquitous in the medium term.
- These projections aim to represent the envelope of the possible spread and rate of deployment of EV chargers. In many modelling areas there is a lack of behavioural evidence and so interim assumptions have been made.
- Compared to the previous 'SSEN High granularity projections for low carbon technology'[i] report, the uptake rate of EV chargers is higher and the envelope of charger capacity in 2050 has narrowed. This is predominalty due to an increased uptake of EVs in the less ambitious scenarios in the ESO FES 2020 compared to the 2019 report, thus narrowing the EV uptake projections.
- Projected public EV charger capacity has increased in this study due to the introduction of AVs. It is assumed that the uptake of AVs will result in less at-home charging, and more charging in public and fleet/workplace locations. However, the number of off-street domestic EV chargers is not necessarily lower, since most AV uptake occurs after the number of EVs peaks, in the 2040s.

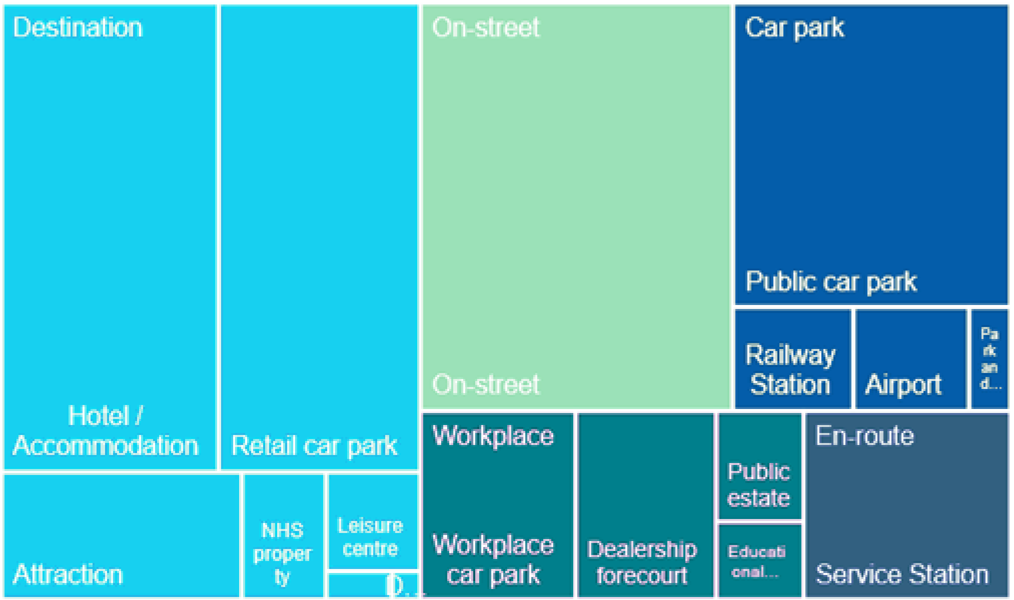
Scenario projection results:

Baseline (up to end of 2019)

- There are a total of 2,713 public EV chargers in the Southern licence area. This is approximately average for the number of vehicles in the licence area and are predominalty privately operated, with approximately three private operators operating 50% of all chargers: Podpoint, Polar and Ubitricity.
- The charging infrastructure in the Southern licence area is relatively decentralised, with approximately 41% of chargers in the licence area in destination locations and 21% in on-street locations
- It is estimated that there are approximately 16,000 domestic EV chargers in the Southern licence area.

Public EV charger baseline

Southern licence area, charger numbers, source: ZapMap



Near term (2020 – 2025)

- In all scenarios, the uptake of EV chargers is expected to increase dramatically in the near term. EV charging investment is expected to be led by the private sector and so it is expected that EV charger capacity will remain more decentralised in the near term. However, this does vary by scenario and in **System Transformation** and **Steady Progression** more centralised chargers in public places are projected.
- It is projected that by 2025, there could be between 327 MW of non-domestic off-street chargers in **Steady Progression** and 549 MW in **Leading the Way**.

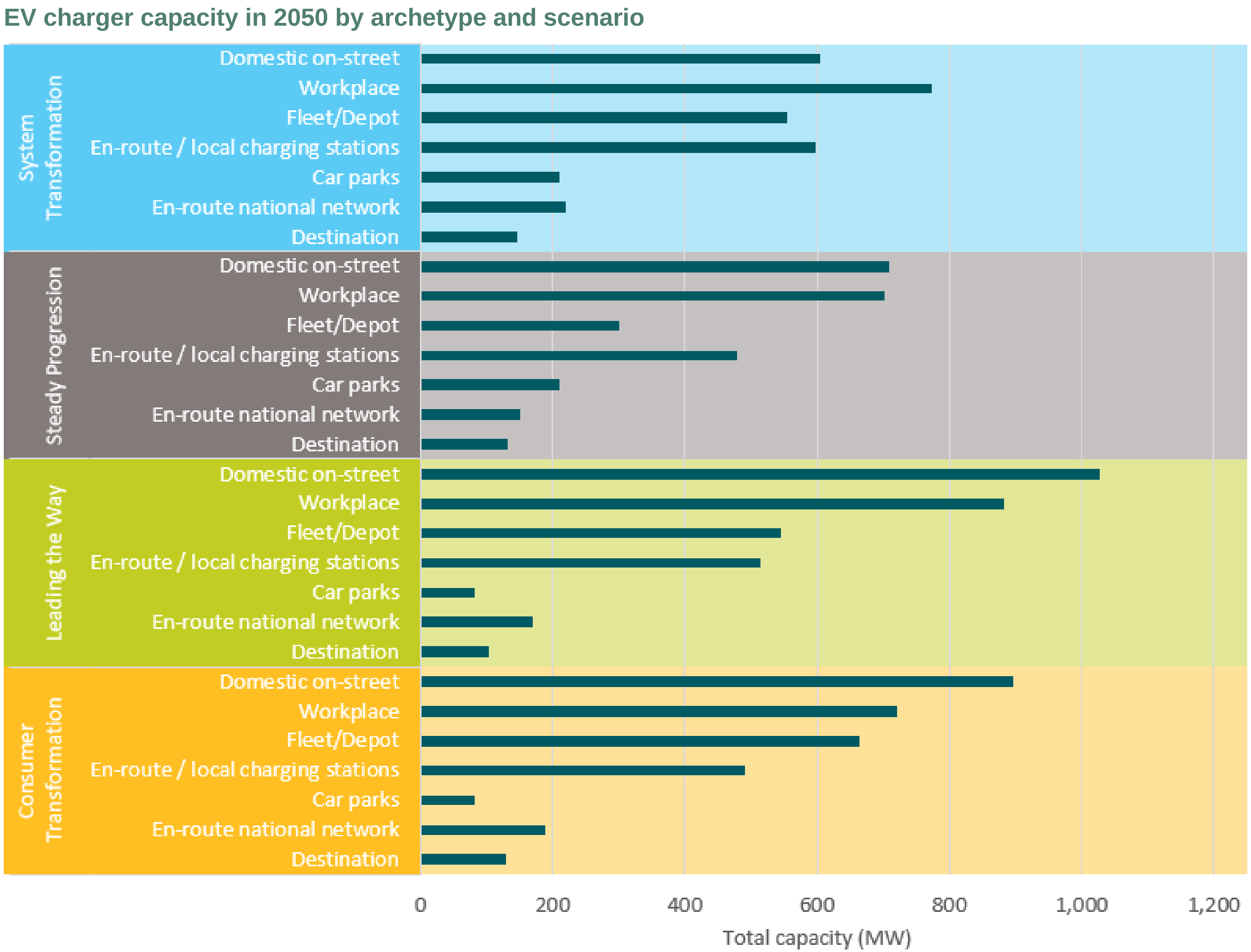
Medium term (2025 – 2035)

- 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, ranges increase and as more households without access to off-street parking adopt EVs.
- **Leading the Way** has the highest capacity, with nearly 1.7 million domestic EV chargers and 2.7 GW of non-domestic capacity. **Steady Progression** has the lowest estimated EV charger capacity in 2035, with nearly 0.8 million domestic EV chargers and 1.2 GW of non-domestic capacity.
- The rate of EV uptake begins to slow in the mid-2030s as EV adoption approaches saturation. Therefore, the installation rate of EV chargers also slows.
- It is likely that the growth in the number of EV charger locations may flatten, although the capacity and utilisation of existing charge stations is likely to increase.

Long term (2035 – 2050)

- In some of the ESO FES 2020 scenarios, notably **Leading the Way**, the uptake of EVs slows and then reduces significantly as consumer adopt new transport methods including public transport, shared vehicles and autonomous vehicles. However, while the number of EV vehicles may reduce their utilisation and mileage per vehicle increases significantly. The reduction in energy demand is therefore significantly less.
- The uptake of EVs and EV chargers continues to increase in **Steady Progression**, right up until 2050 when there are over 1.6 million domestic EV chargers.
- In **Leading the Way** and **Consumer Transformation**, the total capacity of EV chargers is static from the late 2030s.
- The amount of EV charging capacity across the scenarios converges throughout this period as the total amount of energy EVs require converges. However, the scenarios maintain variation in the amount of centralised and decentralised charging capacity.

Figure 33 Summarising scenario projection graph for public EV chargers for the Southern England licence area



Reconciliation with National Grid FES 2020:

- The ESO FES 2020 data publications do not provide sufficient regional or GSP level information to reconcile DFES EV charger projections with national projections.
- Factors that will affect EV charging infrastructure which are available in the FES 2020 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
- At present there is a lack of evidence of future consumer charging behaviour, charger utilisation rates and vehicle ownership trends which results in uncertainty in the assumptions that must be made for the projection of future EV charging requirements. Therefore, assumptions have been made on topics including: (more detail is provided on these in the Regen Transport Model EV and EV Charger Assumption Workbook)
  - What proportion of annual EV energy requirements will be delivered at different locations (which EV charger archetypes)
  - EV charger utilisation rates at different locations.
    - The baseline capacity utilisation rates are where possible benchmarked against existing publications, trials and data sources.
    - In the short and medium term, the capacity utilisation rates trend towards a business model assessment of the utilisation rates required to be profitable, for the individual business models expected at each charger archetype.
    - In the long term, in the absence of other evidence, the capacity utilisation rates trend towards Regen's own assessment of utilisation rates at each charger archetype, based on anecdotal and circumstantial evidence.
  - These assumptions have been made using industry input and Regen analysis. As more behavioural data and other evidence becomes available, these assumptions will be further refined in the future. More detail on the specific assumptions used is provided in the Regen Transport Model assumptions spreadsheet.
- Interim assumptions have been made as to the behaviour of AV cars in the absence of other information, including:
  - The proportion of AVs that are private or shared in the absence of further information.
  - AV charging behaviour is similar to EVs, the key difference being an increase in fleet/depot charging.
  - AVs are associated with on and off-street households and charging at the same rate as EVs.

The uptake and distribution of chargers associated with AVs is an area that needs to be considered for future analysis.

Reconciliation with SSEN's 'High granularity projections for low carbon technology' study (June 2020):

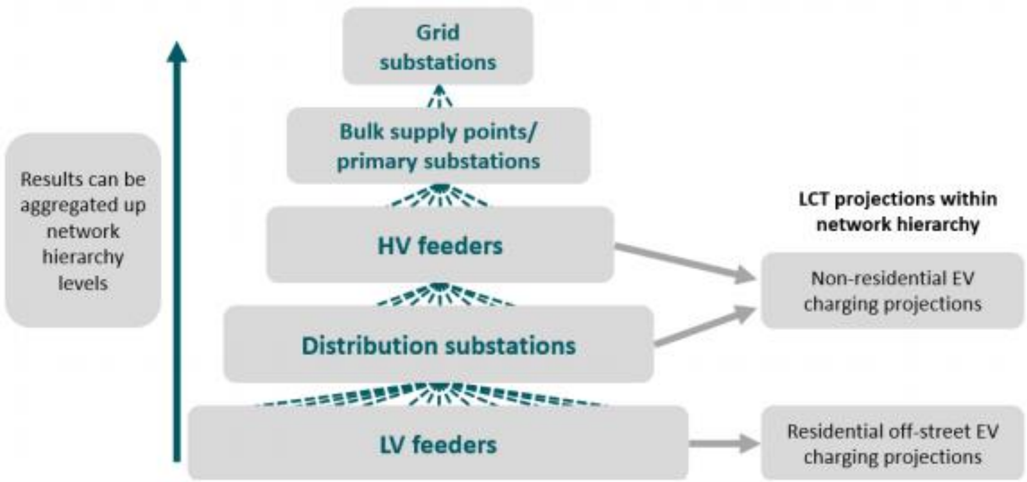
Regen recently delivered similar analysis with SSEN in a study published here[xxiii]. This study used the ESO FES 2019 scenario framework and projections (ESO FES 2020 was not available) and was published in June 2020 after analysis was undertaken in Q4 2019 and Q1 2020. There are, therefore, a number of differences between the study's results due to = market developments and modelling changes between ESO FES 2019 and ESO FES 2020. The changes include:

- Projected total EV charger capacity in the more ambitious scenarios has remained within a few percentage points of the June study. However, the narrowed range of EV projections that increased the uptake of EVs in the less ambitious scenarios has increased the total charger capacity in those less ambitious scenarios by between 25% and 40%.
- Projected public EV charger capacity has increased in this study due to the introduction of AVs. This is since it's assumed that the uptake of AVs will result in less domestic charging, and more charging in public and fleet/workplace locations. However, the number of off-street domestic EV chargers are not necessarily lower, since most AV uptake occurs after the number of EVs peaks, in the 2040s.
- The amount of public EV capacity in the near and medium-term has increases as a result of an accelerated projected EV uptake across the scenarios.

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

1) Scale factor

How many situations are suitable for chargers at each substation? Spatial data including, for example:

- Number of homes (Source: SSEN)
- Number commercial and industrial (Source: SSEN)
- Number of petrol stations (Adddressbase)
- Number of car parks (Adddressbase)

2) Uptake factor

What is the attractiveness of the situation for each technology archetype at each substation? Spatial data including, for example:

- Urban/ rural setting
- Affluence
- Road miles distribution
- Number of jobs
- On/off gas heating
- On/off street parking
- Car park size

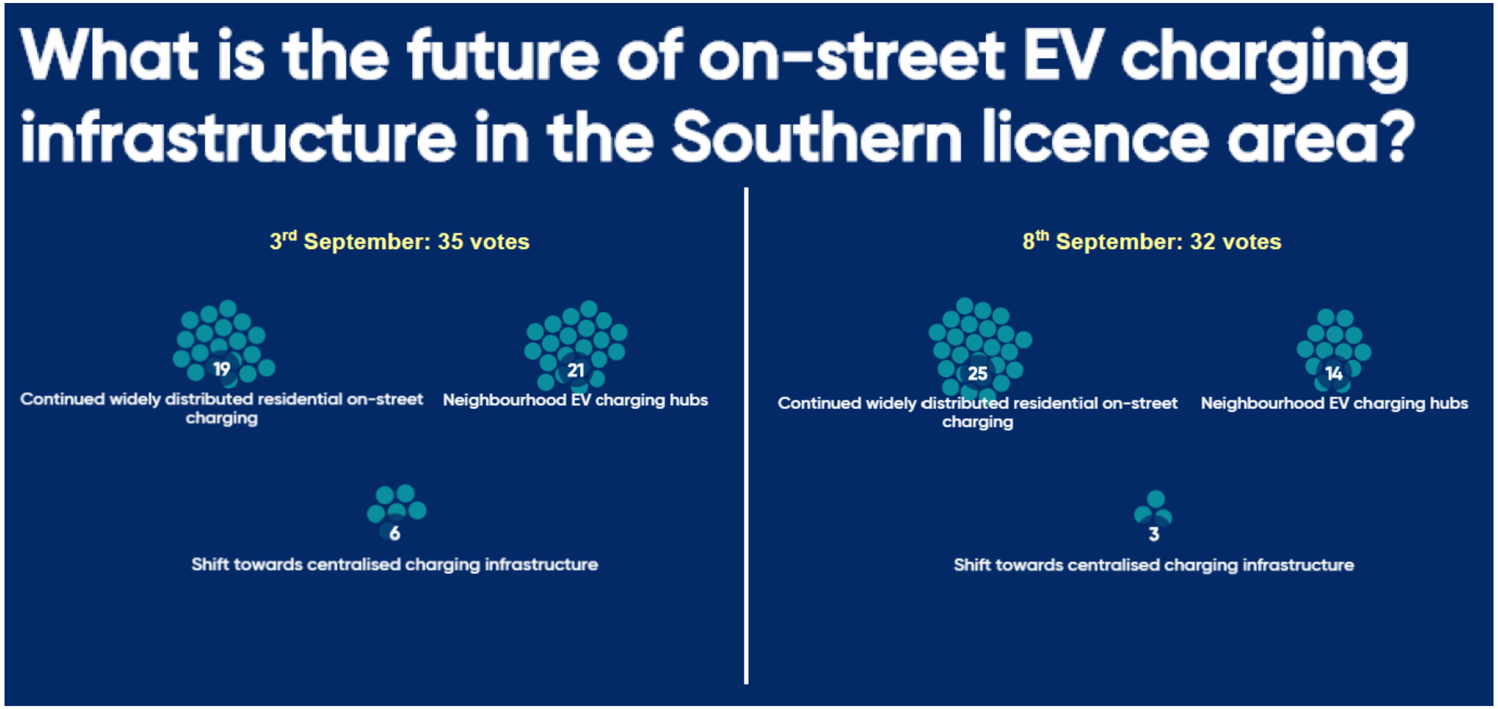
- The take up of home EV chargers is distributed in the near term towards more urban, sub-urban and affluent areas and those where there are high levels of off-street parking.
- The spatial distribution of non-domestic chargers was produced differently for each archetype.
  - En-route local and national 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, workplace 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 EVs will become ubiquitous. Therefore, the growth in demand for EVs in both on street and off-street areas, 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 2020:

Assumption number	
Steady Progression	Charging at home is limited by a lack of viable solution for those without off-street parking. A more centralised approach to EV chargers is adopted.
System Transformation	Emphasis on public rollout of fast chargers to allow rapid charging. More rapid and fast public charging is demanded from consumers due to more limited near home charging opportunities.
Consumer Transformation	Charging predominately happens near 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.

Stakeholder feedback overview:

Regen ran two stakeholder engagement events for the Southern England licence area in August and September. At these events, stakeholders gave their opinion on the future of EV charging infrastructure in SSEN's Southern licence area. There was a reasonably strong view from stakeholders that EV charging infrastructure in the Southern licence area will remain decentralised. This is backed up by the number of private installers actively installing EV chargers in public decentralised locations across the region, particularly in urban areas. This has contributed to the future charging assumptions in this study, which has adopted a more decentralised approach to EV charging infrastructure when compared to assumptions made in SSEN's Southern licence area.



References:

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

[xxiii] See *High granularity projections for low carbon technology uptake*, June 2020: https://www.regen.co.uk/wp-content/uploads/Regen-SSEN-High-granularity-LCT-projections-Final.pdf

14. Heat pumps and direct electric heating in the Southern England licence area

Summary of modelling assumptions and results.

Technology specification:

The analysis covers all variants of electrically fuelled heating technologies within the scope of the DFES, specifically:

Domestic heat pumps – electric heat pump systems providing space heating and hot water to domestic buildings. This technology is divided into two sub-categories:

- Non-hybrid domestic heat pumps - powered purely by electricity **– DFES building block Lct_BB005**
- Hybrid heat domestic pumps - a combination of a gas boiler and electric heat pump. In the net zero scenarios, the gas boiler is supplied by hydrogen in the latter years of the scenario projections **– DFES building block Lct_BB006**

Commercial heat pumps – as per the domestic heat pumps, but supplying commercial buildings:

- Non-hybrid commercial heat pumps **– DFES building block Lct_BB007**
- Hybrid heat commercial pumps **– DFES building block Lct_BB008**

Direct electric heating - a system using electricity to provide primary space heat and hot water to domestic buildings, typically via a night storage or direct radiant electric heater. This does not include heat networks. There is no corresponding **DFES building block ID**.

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

Number of homes		Baseline	2020	2025	2030	2035	2040	2045	2050
Non-hybrid heat pumps	Steady Progression	20,406	21,961	31,303	39,302	83,420	146,228	267,602	370,780
	System Transformation		24,658	60,550	134,684	228,797	326,554	484,056	607,632
	Consumer Transformation		25,803	245,067	651,263	1,124,881	1,520,493	1,888,364	2,240,709
	Leading the Way		26,926	235,890	626,309	926,091	1,264,423	1,646,834	1,700,023
Hybrid heat pumps	Steady Progression	0	0	2,925	24,264	52,197	67,101	104,046	167,138
	System Transformation		0	34,687	76,716	161,636	202,996	295,743	380,016
	Consumer Transformation		0	17,023	56,777	124,505	191,011	238,143	292,887
	Leading the Way		0	62,498	203,079	361,946	554,363	766,003	762,835

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

Number of commercial properties		Baseline	2020	2025	2030	2035	2040	2045	2050
Non-hybrid heat pumps	Steady Progression	2,727	2,827	3,419	3,770	8,290	14,909	28,363	39,435
	System Transformation		3,187	7,385	16,546	28,116	38,209	52,722	63,408
	Consumer Transformation		3,340	24,372	53,350	83,796	107,327	127,929	147,083
	Leading the Way		3,490	24,399	54,065	75,866	97,439	120,101	121,942
Hybrid heat pumps	Steady Progression	0	0	169	1,404	3,021	3,884	6,023	9,675
	System Transformation		0	2,008	4,441	9,356	11,750	17,118	21,997
	Consumer Transformation		0	985	3,287	7,207	11,057	13,785	16,954
	Leading the Way		0	3,618	11,755	20,951	32,090	44,340	44,157

Data summary for direct electric heating in the Southern England licence area:

Number of commercial properties		Baseline	2020	2025	2030	2035	2040	2045	2050
Direct electric heating	Steady Progression	277,339	279,806	292,233	303,892	314,773	324,949	334,405	343,158
	System Transformation		279,806	291,132	297,312	302,822	307,732	312,026	315,721
	Consumer Transformation		279,806	274,128	251,454	253,901	256,608	258,852	260,643
	Leading the Way		279,806	277,308	263,761	267,588	272,067	275,969	279,305

Overview of technology projections in the licence area:

- In line with decarbonisation strategies across the country, the Southern England licence area sees a dramatic shift to low carbon heating in all three of the net zero compliant scenarios.
- In the more electrified **Consumer Transformation** and **Leading the Way** scenarios, there is a significant increase in heat pump deployment during the next decade. This is consistent with the UK government's target to deploy 600,000 heat pumps per year by 2028[xxiv] as well as the legal commitment to meet the 4th and 5th carbon budgets. By 2050 c.70% of homes are heated by a non-hybrid or hybrid heat pump.

- The housing stock in the licence area is broadly similar to the average GB home when considering energy efficiency, size, building form and tenure. However, 23% of houses in the area are not connected to the gas network, significantly above the national average of 15%. This results in heat pump uptake exceeding the national trajectory, particularly in the near and medium term where off-gas homes are more likely to convert to a heat pump. The lower number of on-gas homes also reduces the uptake of hybrid heat pumps.
- Uptake of commercial heat pumps experiences a similar trajectory to domestic heat pumps. However, the penetration of heat pumps is lower than in domestic homes, due to the higher proportion of commercial units expected to use direct electric heating throughout the scenario timeframe. Currently, according to non-domestic EPC records, almost 50% of GB commercial properties are heated by electric heating, compared to 8% of domestic households.
- Under the **Consumer Transformation** and **Leading the Way** scenarios, just over 60% of commercial properties are heated by a form of heat pump in 2050. **Leading the Way** has a significantly higher proportion of hybrid heat pumps.
- Direct electric heating is compliant with net zero emissions targets, and is therefore not explicitly targeted for heat decarbonisation measures. However, as one of the most expensive heating methods, scenarios with high levels of support for low carbon heating solutions such as heat pumps will see a reduction in existing homes with direct electric heating over time.
- Conversely, direct electric heating is currently installed in some new build homes, and this will elicit an increase in directly heating homes in some scenarios, particularly in the near-term.
- In the long-term, all three net zero scenarios see a reduction in direct electric heated homes from today's levels, due to the prevalence of affordable electric heat pumps, hydrogen heating or low carbon district heat networks for the majority of homes in these scenarios.

Scenario projection results:

Baseline (up to end of 2019)

- There are a total of 20,406 heat pumps in the Southern England licence area, all of which are non-hybrid heat pumps. This represents 0.7% of homes, compared to the GB average of 0.6%.
- The majority of heat pump installations have been supported by the Domestic Renewable Heat Incentive (RHI).
- The baseline is constructed from a combination of EPC and RHI data, aiming to capture heat pump installations that were not accredited for the RHI scheme. There are likely to be a minimal number of households with heat pumps that are not captured in the EPC or RHI data.
- There is a total of 277,339 homes heated primarily by direct electric heating in the Southern England licence area, based on analysis of EPC and Census 2011 data.
- This represents 10% of homes, (GB average is 7%), which aligns with the greater proportion of off-gas homes present in the licence area.

Near term (2020 – 2030)

- Heat pump uptake increases under the net zero scenarios in the near term, supported by the Domestic RHI and the new Green Homes Grant[xxv], which is underway as of November 2020 and has been extended to 2022.
- From 2022, there is a step change in installation rates under the more electrified **Consumer Transformation** and **Leading the Way** scenarios, as central and devolved heat strategy lean towards electrification and drives significant change in the heating industry.

- The high level of uptake and support for heat pumps also results in a decrease in the number of homes with direct electric heating.
- The **Consumer Transformation** and **Leading the Way** scenarios reflect a UK government target of 600,000 heat pump installations per year by 2028.
- With central and devolved government policy focusing on decarbonisation of off-gas homes in the near-to-medium term, the Southern England licence area, with a proportion of off-gas homes c.50% higher than the national average, sees strong uptake as homes with oil, LPG, solid fuel and direct electric heating are encouraged to switch to heat pump systems to benefit both fuel bills and carbon emissions.
- Under the **Consumer Transformation** and **Leading the Way** scenarios the proposed ban on gas connections in new build housing in England is implemented, increasing deployments from 2025 onwards as heat pumps become the predominant heating technology in new-build homes.

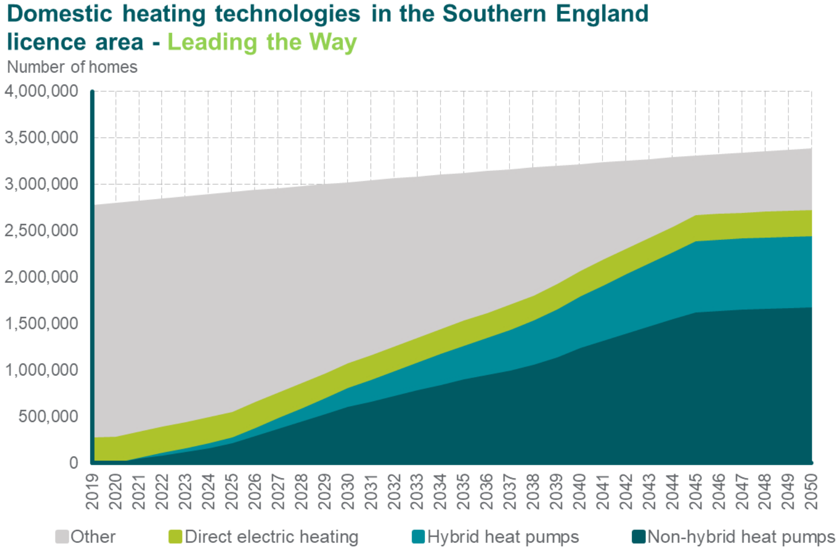
Medium term (2030 – 2040)

- Beyond 2030, the variance in heat pump uptake across the scenarios is driven by national heat decarbonisation strategy, including the potential alternative use of hydrogen for domestic heating in **System Transformation**.
- Under all scenarios, deployment is highest across homes that are more suitable for heat pumps deployment (highly efficient homes, homes with more floorspace, and areas with high levels of home ownership) and those that are targeted for support such as social housing, households in fuel poverty, off-gas homes.
- Under **Consumer Transformation** and **Leading the Way**, heat pump installation rates accelerate in the 2030s to the extent that a heat pump is the typical replacement for an end-of-life heating system by the late 2030s, across the majority of households. A strong focus on energy efficiency in these scenarios means that the efficiency of housing is not a limiting factor to heat pump deployment by the mid-2030s.
- Under **System Transformation** and **Steady Progression** lower energy efficiency measures means that heat pump uptake is slower and restricted primarily to the most suitable homes.
- In new developments, heat pumps are still the most common heating system, however the market share of other low carbon alternatives such as district heat networks increases. Direct electric heating is still installed in some new builds at levels similar to today, around 10%. This encompasses new builds with a low heating demand, such as highly efficient buildings and smaller dwellings, where the expense of direct electric heating is less of a concern compared to the higher capital cost of a heat pump system.

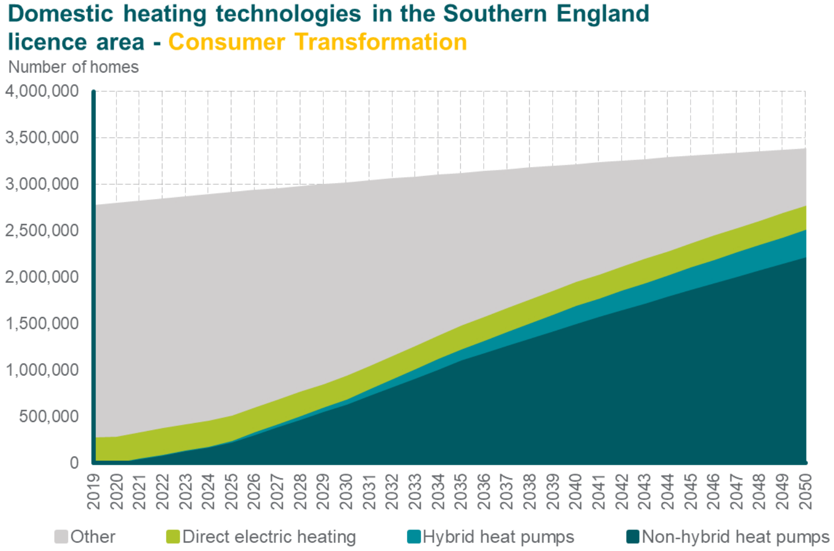
Long term (2040 – 2050)

- Under the **Consumer Transformation** and **Leading the Way** scenarios (Figure 34), the high levels of heat pump uptake seen in the 2030s continues to 2050, as the UK achieves its 2050 Net Zero goal. By 2050, just under 90% of homes are heated by a heat pump or direct electric heating under these scenarios, with the remainder heated via low carbon district heat, biomass or other biofuels.
- Under **System Transformation**, heat pump uptake remains moderate, as on-gas homes are predominantly fuelled by hydrogen. Off-gas homes are fully decarbonised by 2050 as per the other net zero scenarios, primarily through non-hybrid heat pumps. By 2050, 43% of homes in the licence area are heated by a heat pump or direct electric heating, with the vast majority of the remainder heated by hydrogen boilers.
- **Steady Progression** uptake remains low as the UK fails to meet its legally binding net zero target in this scenario, with most homes still heated by natural gas in 2050. 28% of Southern England homes are heated by a heat pump or direct electric heating by 2050, predominantly in currently off-gas homes or hybrid systems in on-gas homes.

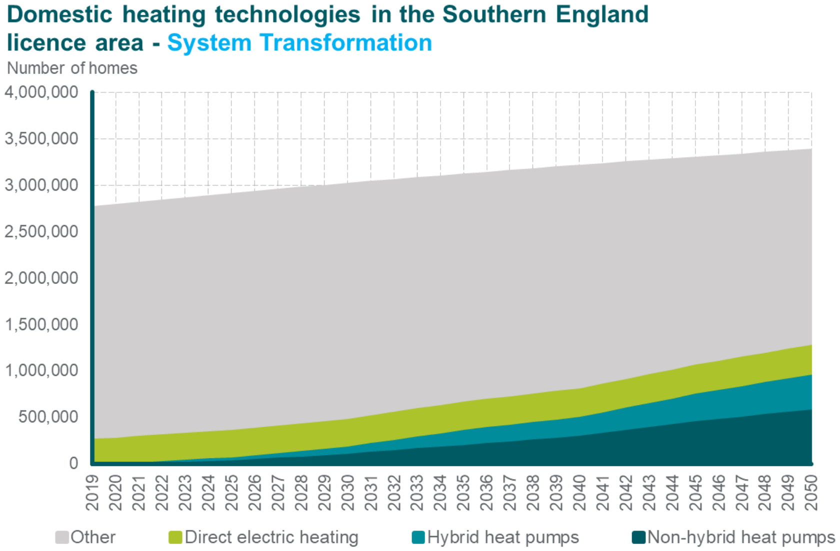
Figure 34: Breakdown of domestic heating projections for the Southern England licence area under the four scenarios



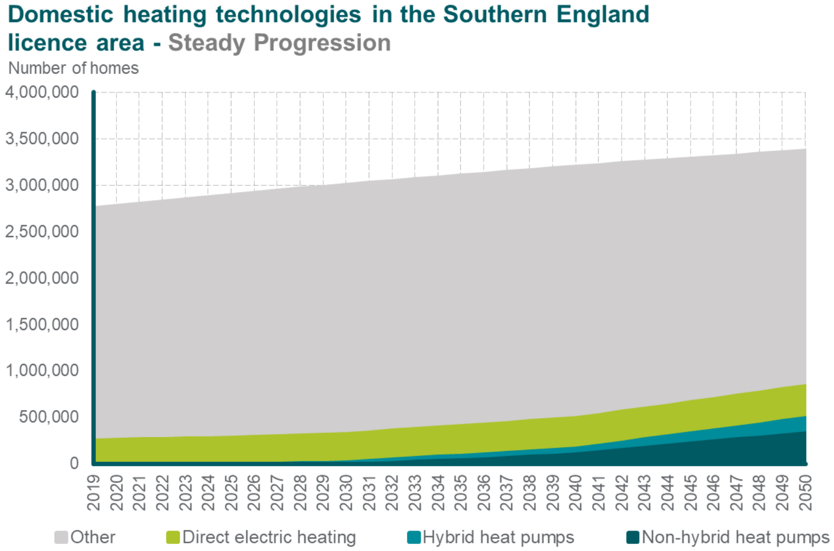
'Other' heating includes fossil fuels, hydrogen, district heating and bioenergy



'Other' heating includes fossil fuels, hydrogen, district heating and bioenergy



- 'Other' heating includes fossil fuels, hydrogen, district heating and bioenergy



'Other' heating includes fossil fuels, hydrogen, district heating and bioenergy

Figure 35: Hybrid heat pump projections for the Southern England licence area, compared to National Grid FES 2020 regional projections

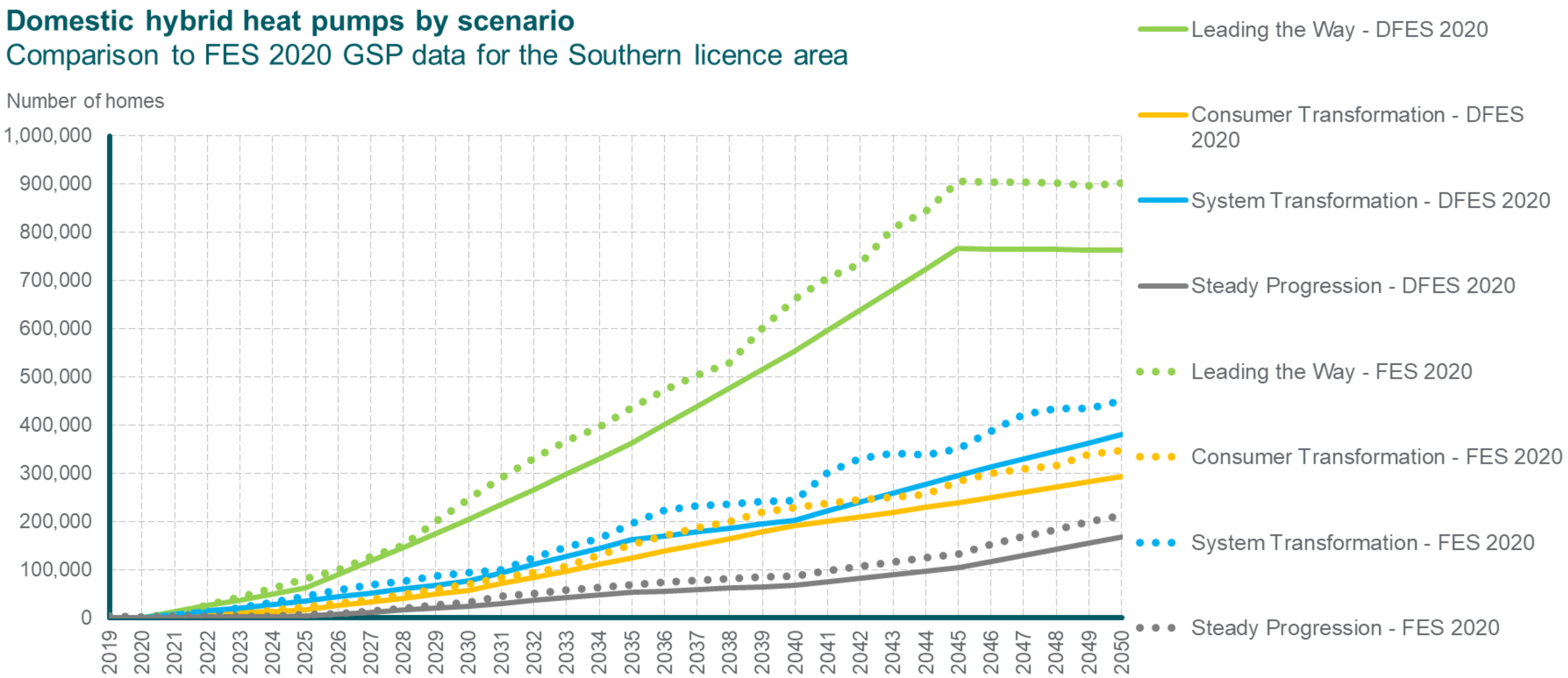


Figure 36: Non-hybrid heat pump projections for the Southern England licence area, compared to National Grid FES 2020 regional projections

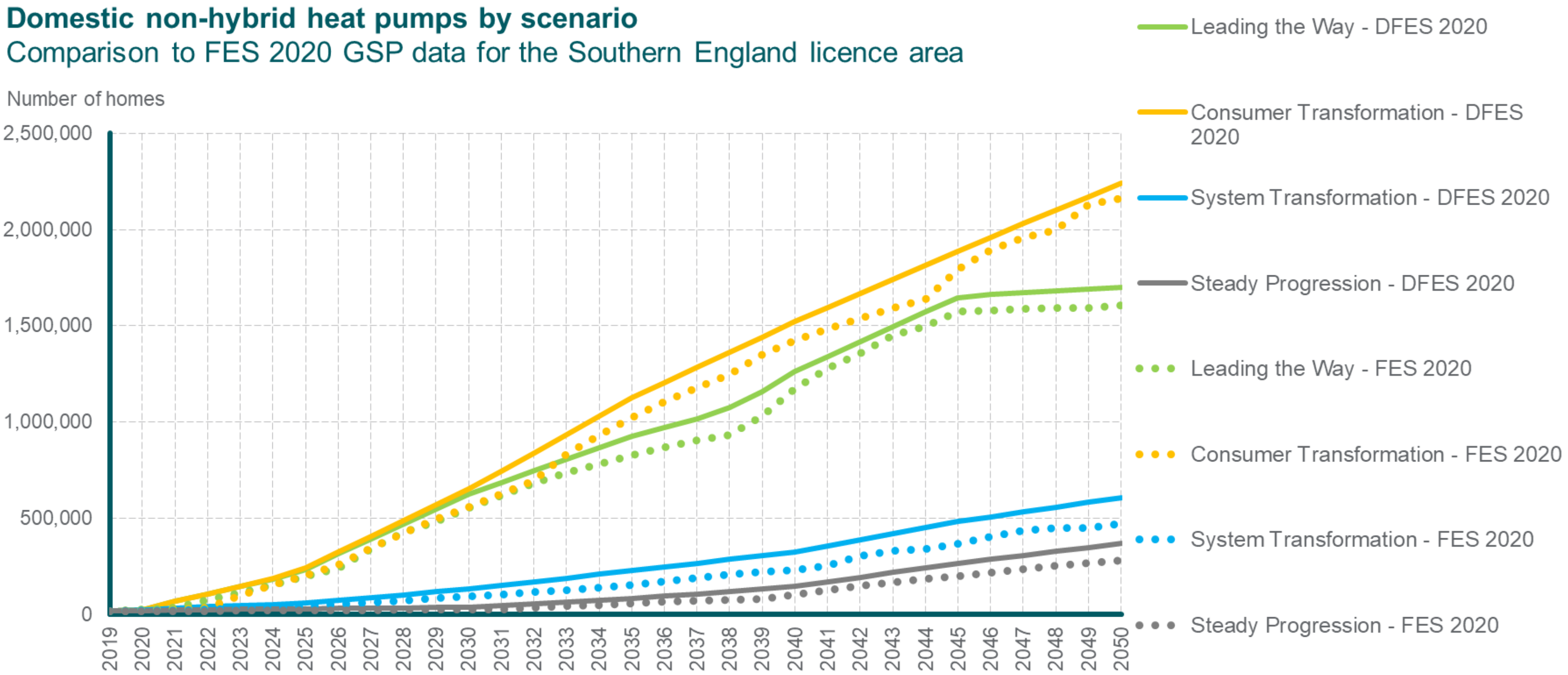


Figure 37: Direct electric heating projections for the Southern England licence area, compared to National Grid FES 2020 national projections scaled pro-rata

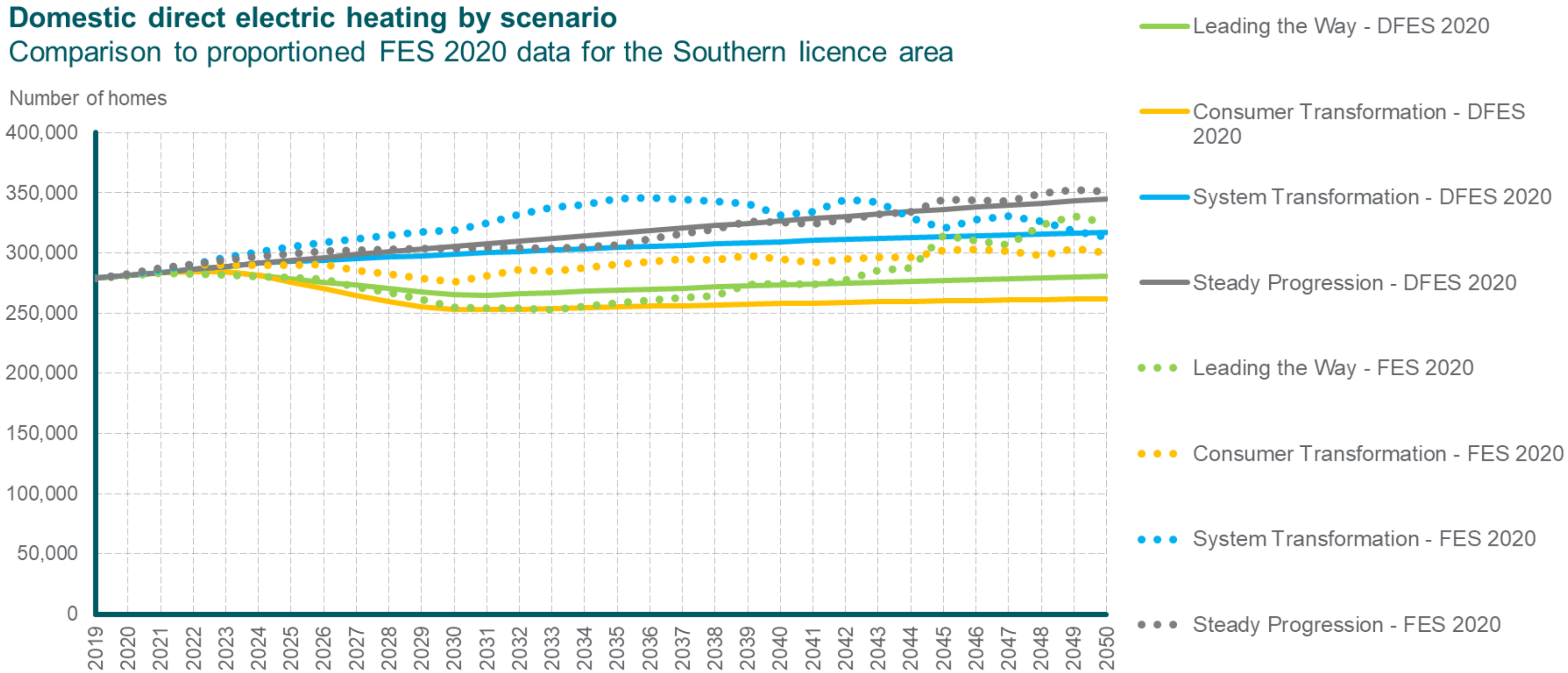
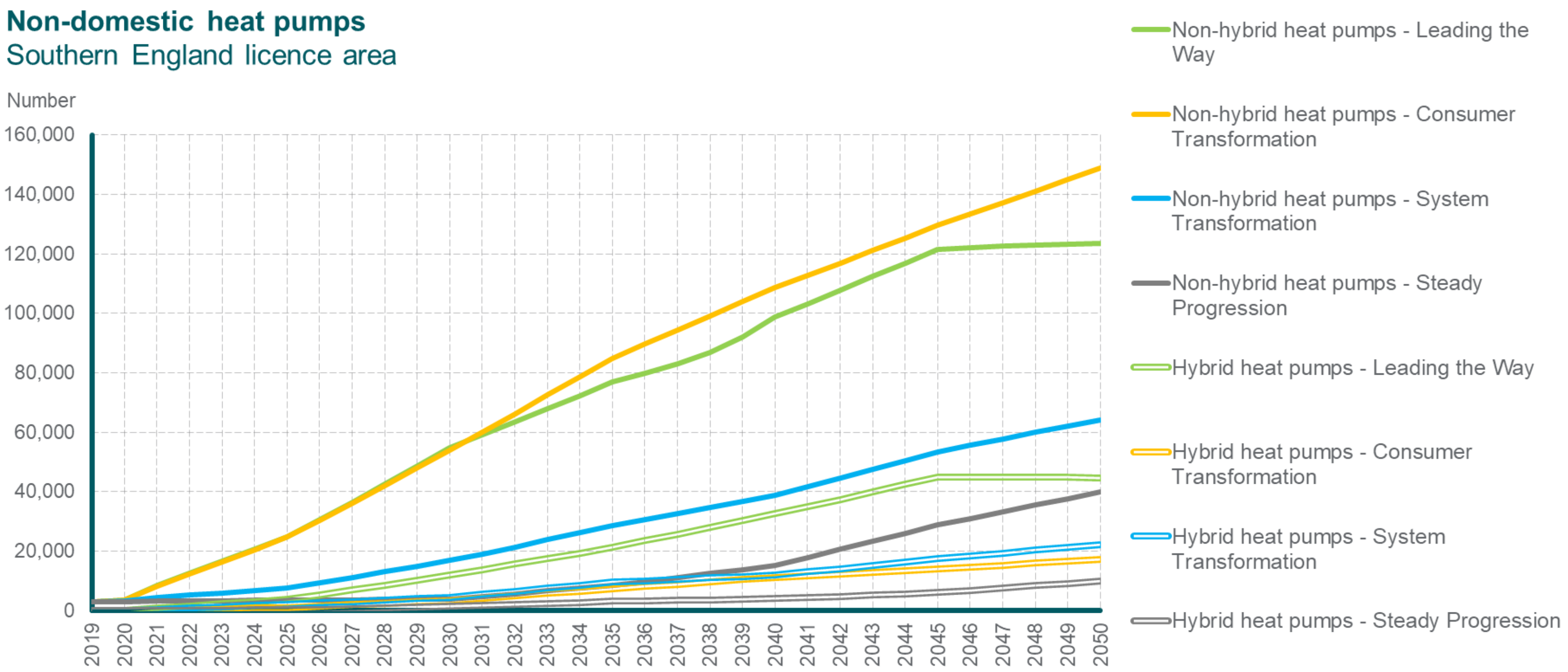


Figure 38: Non-domestic heat pump projections for the Southern England licence area



Reconciliation with National Grid FES 2020:

- The FES 2020 regional projections for non-hybrid heat pumps are lower than the DFES projections across the scenarios, except for the latter years of **Consumer Transformation**, and are higher than the DFES projections for hybrids. This reflects the proportion of homes off and on the gas in the licence area as well as the higher UK government ambition recently announced. Currently, 77% of homes are connected to the gas network, compared to 85% nationally. The higher proportion of off-gas homes results in a faster uptake of non-hybrid heat pumps in the near term under the DFES than under the FES 2020 scenarios.
- However, the Southern England licence area has a greater proportion of flats compared to the GB average, which reduces heat pump uptake as these properties are more likely to be served by communal heating systems and direct electric heating than houses. As a result, the total combined number of non-hybrid and hybrid heat pumps in the DFES is only marginally above the FES 2020 combined total."
- As there is no regional data for direct electric heating in the FES 2020 dataset, comparison is made against national scenario figures pro-rata against the current baseline.
- The number of homes with direct electric heating is similar between the DFES and the FES 2020 scenarios, and hinges mainly on the level of non-hybrid heat pump uptake seen under each scenario. The exception to this is the latter years of **Leading the Way**, where direct electric heating sees strong levels of uptake not reflected in the DFES projections.
- In the FES 2020, electric heating is split into night storage heating and non-storage heating. In every scenario from 2019 to 2050, night storage heating represents 66% of total direct electric heating, and this high-level breakdown can reasonably be applied to the DFES projections also.
- There are no projections for the number of commercial heat pumps in the FES 2020.

Factors that will affect deployment at a local level:

- The uptake of heat pumps, and other consumer based Low Carbon Technologies (LCTs), was projected to a very high level of granularity within the SSEN low voltage network. Domestic heat pump uptake was evaluated to SSEN's over 400,000 individual feeders, equivalent to street-level forecasts, while non-domestic heat pumps were evaluated to SSEN's over 100,000 distribution substations roughly equivalent to a post code level.
- A wide variety of datasets were used to analyse regional and feeder specific demographic, technical attributes and geographical characteristics. For example, the key spatial and household characteristics used in this study for the uptake of heat pumps was information on gas network connectivity, household information evaluated from EPC data, affluence and home ownership. This data is available from MHCLG, Census, BEIS and ONS. While there are data limitations and some of this data needs to be interpolated down to a feeder level granularity, this analysis allows a much more granular assessment of scenario-based heat pump uptake on the network.
- However, as levels of deployment increase, uptake is assumed to become more evenly distributed. In the long term uptake is weighted towards those areas of low uptake in the early period.

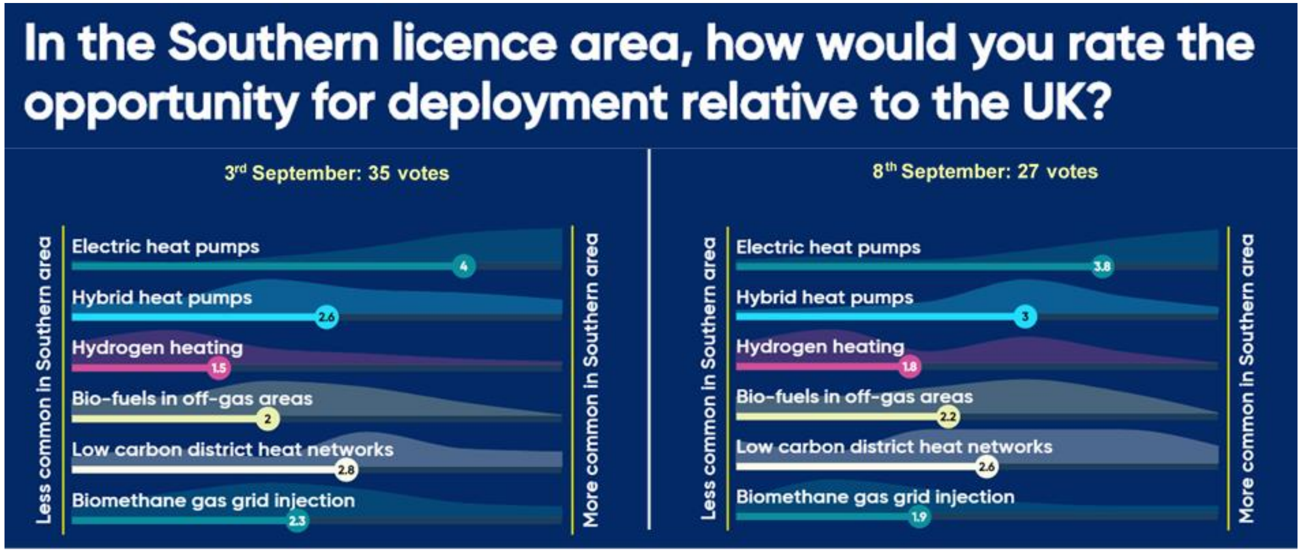
Relevant assumptions from National Grid FES 2020:

Assumption number	3.1.3 Heat pump adoption rates
Steady Progression	Consumers continue to buy similar appliances to today
System Transformation	Low willingness to change lifestyle results in hydrogen being the preferred low carbon heating technology for consumers
Consumer Transformation	High energy prices and consumer willingness to adapt results in high levels of heat pump uptake
Leading the Way	High income, energy prices and consumer green ambition results in high levels of hybrid and non-hybrid uptake

Stakeholder feedback overview:

Local stakeholders were polled across two engagement sessions around the opportunity for various low carbon heating options in the Southern licence area. Across both sessions non-hybrid heat pumps were seen as the heating technology with the most potential, while hydrogen heating was seen as having the least potential. This evidence was used to support the scenario projections, with the licence area seeing levels of non-hybrid heat pump deployment ahead of the national average in all scenarios, with the exception of the latter years of **Consumer Transformation**.

As part of Regen's engagement with local authorities, data was collected on whether local authorities had declared a climate emergency or had specific low carbon heat strategies. Where these existed, a small positive weighting was given in the near term. However, the projections in the medium and long term the level of ambition reflects more the ESO FES scenarios themselves.



References:

Energy Performance Certificates, Census 2011, English Housing Survey, Renewable Heat Incentive data, Climate Emergency declaration data, Regen consultation with local stakeholders and local authorities.

[xxiv] UK Government 10 Point Plan November 2020 https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution
[xxv] Green Homes Grant https://www.gov.uk/guidance/apply-for-the-green-homes-grant-scheme

15. Small-scale solar PV in the Southern England licence area

Summary of modelling assumptions and results.

Technology specification:

The analysis covers small-scale solar PV generation with capacity less than 1 MW connected to the distribution network in the Southern England licence area. This is typically rooftop solar PV, but may also include some small ground-mounted arrays.

This technology is divided into two sub-categories:

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

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

Installed capacity (MW)		Baseline	2020	2025	2030	2035	2040	2045	2050
<10 kW	Steady Progression	264	269	310	377	465	558	647	728
	System Transformation		271	369	621	897	1,155	1,371	1,533
	Consumer Transformation		272	451	811	1,222	1,630	2,010	2,353
	Leading the Way		271	369	620	896	1,152	1,369	1,530
10 kW – 1 MW	Steady Progression	91	92	111	122	137	152	163	172
	System Transformation		96	122	173	227	276	314	338
	Consumer Transformation		97	143	218	302	387	467	538
	Leading the Way		96	122	174	227	276	314	338

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 was 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, 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, uptake of other domestic technologies (such as electric vehicles and domestic batteries), and reduction in the costs of domestic solar array installations.
- In the highly ambitious **Consumer Transformation** scenario, around one in six domestic properties hosts rooftop solar PV by 2050.
- 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 sees a similar trajectory to these technologies, with a strong increase in connected capacity under the **Consumer Transformation** scenario in particular.

Scenario projection results:

Baseline (up to end of 2019)

- There is 264 MW of domestic-scale solar PV in the Southern England licence area, equivalent to rooftop arrays on 2.9% of domestic buildings, which is in line with the GB average.
- Almost all of these installations occurred between 2010 and 2019, supported by the Feed-in Tariff. The installation rate peaked at 53 MW installed in 2012. Deployment slowed notably as support through the Feed-in Tariff reduced, with only 33 MW installed since 2015.
- The commercial-scale solar PV baseline totals 75 MW. As per domestic-scale installations, the Feed-in Tariff supported this deployment, which has tailed off since 2016.

Near term (2020 – 2025)

- At sub-megawatt scale, fewer projects are represented in the connection data-driven pipeline; especially for domestic scale solar PV. The trajectory for small-scale solar in the near term depends strongly on the uptake of the Smart Export Guarantee, and attractiveness of rooftop solar PV for homeowners, in terms of installation costs.
- The **Consumer Transformation** scenario, with high levels of green ambition from the public and high near-term uptake of electrified vehicles, sees a corresponding uptake in solar PV due to both ambition and financial benefits.

Medium term (2025 – 2035)

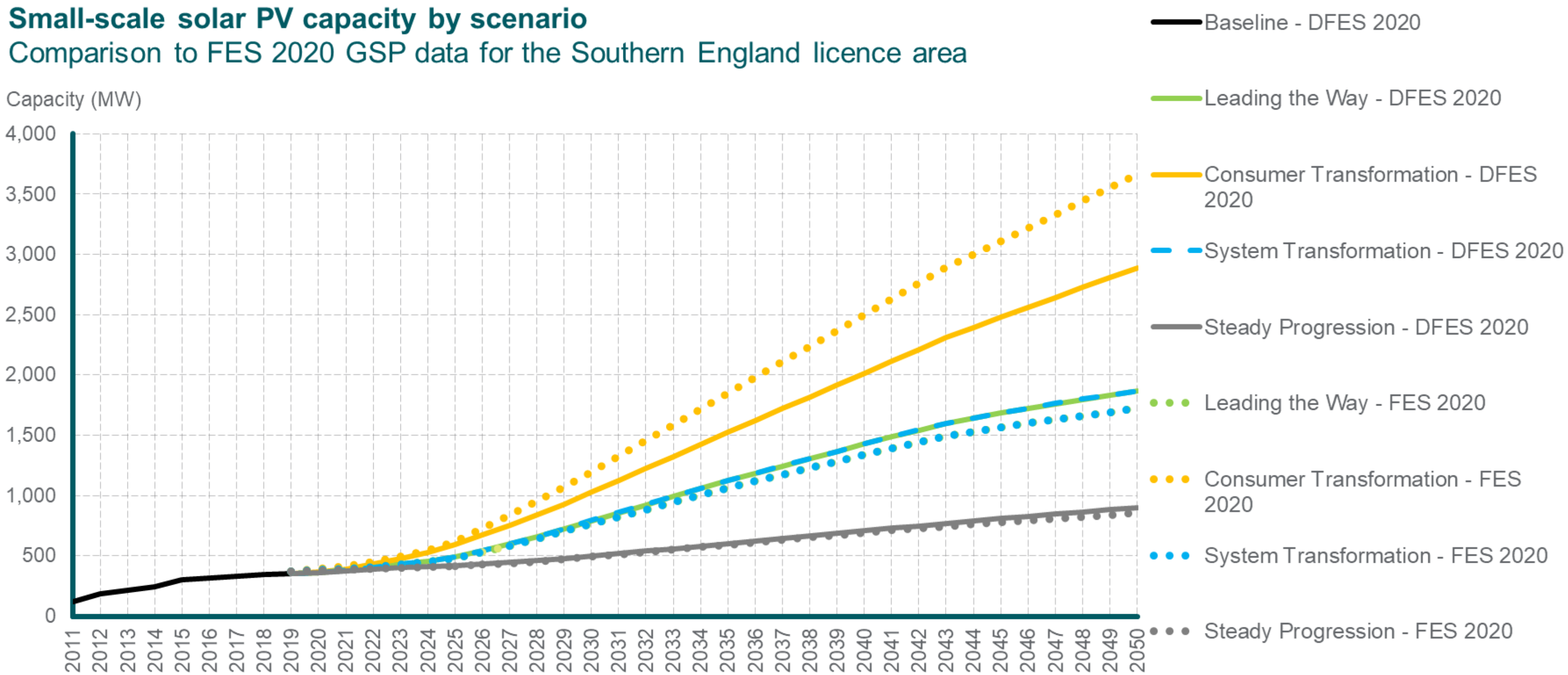
- Beyond the near term, small-scale solar uptake depends strongly on national trajectories rather than licence area factors. While the Southern licence area has higher levels of irradiance than the rest of the UK, the evidence from the baseline, where historic uptake is in line with the overall GB trajectory, suggests the licence area will remain aligned in the medium term. In addition to solar irradiance, factors such as social housing, affluence and available roof area were considered to form the projections.

- Rooftop solar PV on new build housing accounts for 10-20% of uptake in all scenarios, with lower installation costs than retrofit panels.
- As in the medium term, **Consumer Transformation** sees high levels of growth as a result of high consumer ambition and engagement, and high levels of electrification in transport, heat and cooling. The rate of installation under this scenario is similar to a rapid roll-out of rooftop solar seen in the first few years of the Feed-in Tariff (2010 to 2012). The two other net zero scenarios see strong uptake as panel costs fall, but to a lower extent than **Consumer Transformation**, as decarbonisation of electricity is achieved through larger-scale projects.

Long term (2035 – 2050)

- The overall trends established in the medium term continue out to 2050, with some levelling-out of deployment in each scenario. This is due to a combination of a slowing of house building, and the most suitable homes with adequate south-facing roof area having seen solar PV deployment in the preceding years of the scenarios.

Figure 39: Small-scale solar PV projections for the Southern England licence area, compared to National Grid FES 2020 regional projections



Reconciliation with National Grid FES 2020:

- As small-scale solar PV is more strongly driven by national considerations, support, policy and public sentiment, the DFES scenarios align strongly with the FES 2020 regional data throughout the projection period in terms of trajectory between scenarios.
- The exception is the **Consumer Transformation** scenario, where the DFES uptake is significantly lower than the FES 2020 regional figures. The DFES modelling for this scenario results in a consistent deployment rate similar to the early years of the Feed-in Tariff tariff payments were well above the retail price of electricity for domestic customers[xxvi]. Even with decreasing installation costs for rooftop PV, increased electrification of transport, heat and cooling, and increased consumer engagement and ambition under this scenario, 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.
- The near term pipeline for commercial-scale solar, and assumptions around solar PV on new developments, results in **Steady Progression** seeing higher levels of development in the DFES. However, this remains low compared to the three net zero scenarios, in line with the FES 2020 scenario framework.

Factors that will affect deployment at a local level:

- The uptake of domestic small-scale solar PV, and other consumer based Low Carbon Technologies was projected to a very high level of granularity within the SSEN low voltage network. Domestic small-scale solar PV uptake was evaluated to SSEN's over 400,000 individual feeders, equivalent to street-level forecasts, while commercial solar PV was evaluated to SSEN's over 1,400 ESAs.
- A wide variety of datasets were used to analyse regional and feeder specific demographic, technical attributes and geographical characteristics. For example, the key spatial and household characteristics used in this study for the uptake of domestic solar PV were information on affluence, social housing and home ownership. This data is available from MHCLG, Census, and ONS. While there are data limitations and some of this data needs to be interpolated down to a feeder level granularity, this analysis allows a much more granular assessment of scenario-based heat pump uptake on the network.
- However, as levels of deployment increase, uptake is assumed to become more evenly distributed. In the long term uptake is weighted towards those areas of low uptake in the early period.

Relevant assumptions from National Grid FES 2020:

Assumption number	4.1.5
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. Regen's existing market insight and knowledge from undertaking previous and ongoing DFES projects was used to inform the scenario projections.

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 in the near term. However the projections in the medium and long term the level of ambition reflects more the ESO FES scenarios themselves.

References:

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

[xxvi] See historic Feed-in Tariff rates from Ofgem: https://www.ofgem.gov.uk/environmental-programmes/fit/fit-tariff-rates

16. Hydrogen electrolysis in the Southern England licence area

Summary of modelling assumptions and results.

Technology specification:

The analysis covers any hydrogen electrolysers connected to the distribution network in the Southern England licence area. The analysis does not include off-grid electrolysers that are directly powered by renewable energy or large-scale electrolysers connected to the transmission network. Nor does it include hydrogen produced via reformation of natural gas or other fossil fuels.

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

Installed capacity (MW)	Baseline	2020	2025	2030	2035	2040	2045	2050
Steady Progression	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
System Transformation		2.3	7.3	36	48	314	615	723
Consumer Transformation		2.6	7.8	30	391	514	679	911
Leading the Way*		1.4	1.4	1.4	1.4	1.4	1.4	1.4

*Under the FES 2020 projections, Leading the Way has zero distribution connected electrolysers.

Relevant assumptions from National Grid FES 2020:

Assumption number	4.2.19 (Hydrogen electrolysis)
Steady Progression*	High cost limits rollout of electrolysis – used mainly in transport.
System Transformation	Competition from SMR** limits rollout of electrolysis – used mainly in transport. SMR covers heat.
Consumer Transformation	Electrolysis used to decarbonise heat, transport and some I&C.
Leading the Way*	Electrolysis used to decarbonise heat, transport and I&C but rollout starts in the mid-2020s.

* Steady Progression and Leading the Way both have hydrogen electrolysis in their projections, with Leading the Way projecting 72GW of grid-connected electrolysis by 2050 for Great Britain, however these have all been allocated to the transmission network and thus there is no distribution connected electrolysers in either of these scenarios.

** Steam Methane Reformation. A method of producing hydrogen from natural gas, also referred to as “blue hydrogen”.

Overview of technology projections in the licence area:

For the Southern England licence area, the DFES analysis has remained closely aligned to ESO FES 2020 projections. With a limited baseline and no significant concerns with the assumptions made for electrolysis development in the Southern England licence area, the DFES analysis has not deviated too far from the FES 2020 GSP level results. However, there has been some changes made to the speed of uptake of new electrolyser capacity, to more closely align to the proposed uptake of hydrogen vehicles in the DFES. In general, there is a significant level of uncertainty in modelling future hydrogen electrolysis capacity, as this technology sector is still fairly new and there is very little historic data to base projections upon. Similarly, there is a lot of uncertainty in predicting whether hydrogen electrolysis will connect to the distribution network or the transmission network, and the split between hydrogen electrolysis and "blue" hydrogen produced using methane reformation and CCS. The resultant range of projections seen in the DFES across the four scenarios reflects different levels of hydrogen policy support and technological development out to 2050.

The analysis has focussed primarily on the uptake of hydrogen vehicles and fleets (likely heavy vehicle fleets), which is assumed to be the largest driver of electrolysis demand connecting to the distribution network, alongside the use of hydrogen electrolysers in decarbonising hard-to-electrify industries. The role of hydrogen in rail and marine shipping has also been included. Considering the ban on the sale of petrol and diesel vehicles by 2030[xxvii] announced in the government's Ten Point Plan, the modelling has assumed an increased uptake of hydrogen electrolysis for use in transport from 2030 onwards in **System Transformation** and 2025 in **Consumer Transformation**.

In the FES 2020 projections, **Steady Progression** does not see an increase in electrolyser capacity from today's baseline, due to a lack of hydrogen policy and incentives in this as a scenario that does not meet net zero targets.

Under **Leading the Way**, which achieves net zero emissions by 2048, it is envisaged that there will be behind-the-meter electrolysers or regional electrolyser installations close to renewable generation sites. This scenario model commercialisation of electrolysis at scale from the early 2030s. It is also projected that the hydrogen markets will grow such that there is a global trade of imported and exported hydrogen. This would require large scale electrolysers to meet demand, therefore electrolysers are expected to connect to the transmission network only in this scenario.

In the Southern England licence area, the M4 has been identified as a prominent area for future hydrogen refuelling stations, as well as industrial clusters around Southampton and Bournemouth, which has been reflected in the **System Transformation** and **Consumer Transformation** scenarios.

Scenario projection results:

Baseline (up to end of 2019)

- There is a total of 1.4 MW of hydrogen electrolyser capacity connected to the distribution network in the Southern England licence area, comprising two hydrogen refuelling stations, both part of the H2ME[xxviii] project. These sites currently have a daily hydrogen capacity of c.270kg[xxix], which is equivalent to 9,072 kWh/day. These are mainly fuelling hydrogen fuel cell electric vehicles.

Near term (2020 – 2025)

- There are no known electrolysis pipeline projects that are expected to connect to the distribution network in the licence area.
- A small increase in connected capacity is modelled in **System Transformation** (7.3 MW) and **Consumer Transformation** (7.8 MW) by 2025, whilst connected capacity in **Steady Progression** and **Leading the Way** remains at the 1.4 MW baseline position.

Medium term (2025 – 2035)

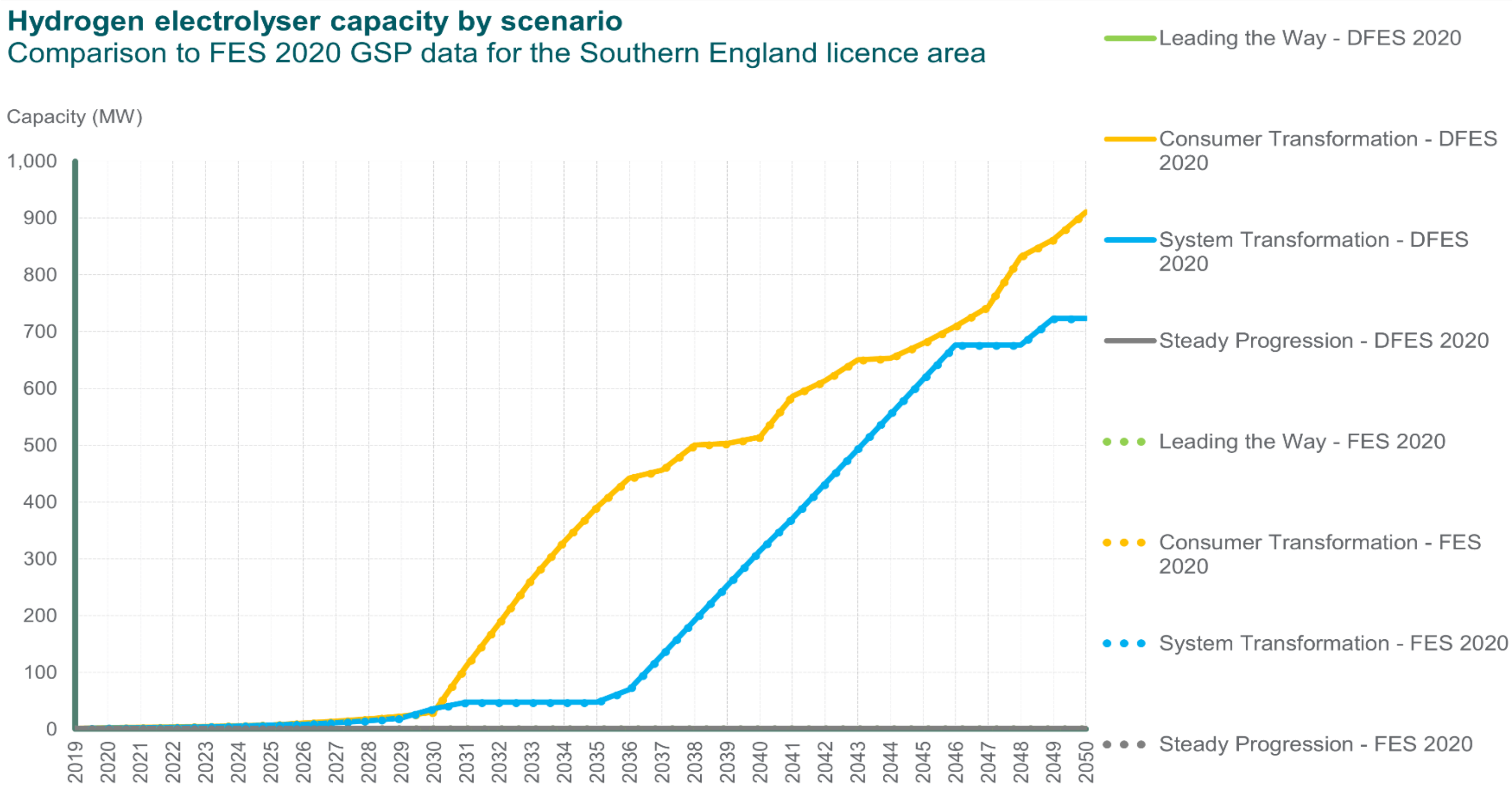
- The demand for hydrogen electrolysers will potentially increase between 2025 and 2035, driven by the uptake of hydrogen fuelled heavy vehicle fleets and the introduction of mainstream hydrogen fuel cell electric vehicles. This vehicle fuel switching will be further incentivised by policy measures such as the ban on the sale of new petrol and diesel cars by 2030. The H2Mobility[xxx] project is aiming for 1,150 hydrogen refuelling stations to be operational across the UK by 2030, with the M4 being a key location.
- Hydrogen electrolyser developers could potentially favour co-locating hydrogen refuelling stations with existing petrol stations, particularly ones with large HGV fuelling demand, so hydrogen electrolysers are likely to be located near motorways and primary roads. An alternative business model involves more centralised hydrogen electrolysers located near highly populated areas, such as Oxford and Swindon. In this case, the hydrogen could be transported to hydrogen demand areas by truck.
- Within the FES 2020 assumptions, the **Consumer Transformation** scenario assumes that green hydrogen will achieve cost parity with blue hydrogen in the mid-2030s, while **System Transformation** does not see electrolysis reaching cost parity in the same timeframe, so blue hydrogen is the favoured production method. However, hydrogen produced via electrolysis, rather than from natural gas, is needed for transport due to its purity.
- This analysis culminates in the total electrolyser capacity reaching 391 MW in **Consumer Transformation** and 47 MW in **System Transformation** by 2035. Capacity remains at 1.4 MW in **Steady Progression** and **Leading the Way**.

Long term (2035 – 2050)

- With the ability to upgrade existing hydrogen refuelling stations to have a greater MW capacity, the development of new sites is likely to slow, and instead, existing locations are likely to be expanded to cater for more vehicles.
- Some smaller scale, more rural stations may be built in line with England's 2050 net zero target[xxxi]. This will be driven by policy changes or incentive mechanisms and reduction in electrolysis costs, which would make hydrogen electrolysis cost competitive with other fuels and production technology variants.

- It is likely that the Southern England licence area could see rapid uptake of hydrogen electrolysers from 2035 in **Consumer Transformation**, due to the demand for hydrogen to decarbonise industry. Large thermal industrial, chemical and processing industries within the Southern England licence area could convert to hydrogen instead of using fossil fuels. Whilst there is no government mandate that requires industry to decarbonise earlier than the 2050 net zero target, there are moves within the industry[xxxii] towards earlier decarbonisation and there may be incentives that come in to force within the next 10-15 years that seek to switch to low carbon fuels.
- Industrial hubs like Southampton and Bournemouth could be key areas in the Southern England licence area for large scale distribution network connected electrolysers. Under **System Transformation**, industries are expected to produce blue hydrogen, made by reforming natural gas, as they are already connected to the gas network.
- Under **Consumer Transformation**, green hydrogen through electrolysis is modelled to supply a range of end users. With this high hydrogen demand under **Consumer Transformation**, the Southern England licence area could see centralised electrolysis plants supply multiple industries and transport, as well as being used for heating homes. However, if this were to be the favoured approach, the electrolyser would likely connect to the transmission network, removing the demand from the distribution network.
- By 2050 the deployment of distribution network connected electrolysis reaches 723 MW in **System Transformation** and 911 MW in **Consumer Transformation**. Only the 1.4 MW of known baseline projects continue to operate in the **Steady Progression** and **Leading the Way** scenarios out to 2050.

Figure 40 - Comparison of DFES analysis to the FES 2020 projections of hydrogen electrolysis capacity in the Southern England licence area



Reconciliation with National Grid FES 2020:

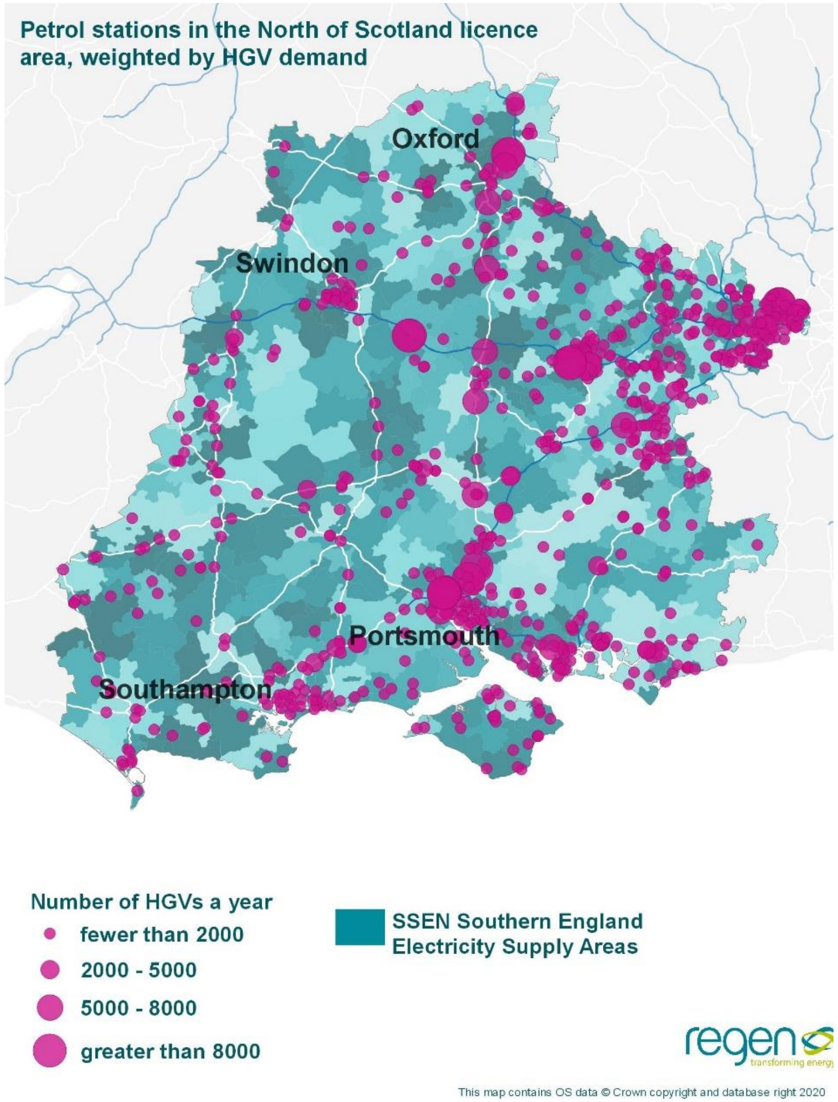
The reconciliation analysis in this section is based on relevant FES 2020 projections [xxxiii] that relate to hydrogen electrolysis.

- The DFES projections largely align with FES 2020 for distribution network electrolyser capacity in the licence area.
- The FES 2020 GB scenario projections for electrolyser capacity did not include the existing projects that were found through online research. The DFES projections have reflected the c.1.4 MW in the baseline under all scenarios.
- In **Steady Progression** and **Leading the Way**, there are no distribution network connected electrolysers in the FES 2020 projections. This has been modelled, by assuming there will be no increase in hydrogen electrolysis capacity from today's levels.
- For **Consumer Transformation**, installed electrolyser capacity increases rapidly from 2030 onwards, while **System Transformation** does not see notable capacity connecting until 2035. This increase in electrolyser capacity is likely to be driven by demand for hydrogen in industry, mainly seen in **Consumer Transformation**, as under **System Transformation**, blue hydrogen is likely to be used in industry.
- In the Southern England licence area, FES 2020 GSP level data shows four main electrolyser plants, in Swindon, South Oxfordshire, South Buckinghamshire and Romsey. Conversations with the ESO FES Analyst Team identified that this is a preliminary assumption to model the capacity, while in reality they know that these larger sites would probably be split up into smaller individual projects or spread more regionally. The DFES has therefore determined that there will be more, smaller scale electrolysers and these will be more localised.
- The DFES has also modelled these electrolysers to be deployed in stages, allowing developers to adapt to growing demand.
- Electrolysers for hydrogen refuelling stations will likely either be smaller on-site installations or located at centralised hub locations, with the hydrogen being transported by trucks. **System Transformation** will see more centralised electrolysers and **Consumer Transformation** favours co-location.

Factors that will affect deployment at a local level:

- From engaging electrolyser technology developers, locational factors of hydrogen fuel cell electric vehicles and access to the gas distribution network were identified as priorities when deciding where to build hydrogen refuelling stations.
- The spatial distribution of hydrogen electrolysers in the Southern England licence area out to 2030 is primarily based on the location of existing hydrogen refuelling stations, as well as key fuelling hub locations identified through conversations with ITM Power.
- Demand will be centred around the M4, which runs the width of the Southern England licence area. Co-location of electrolysers with existing petrol stations that have high HGV demand is a key geographical distribution factor, particularly between 2020 and 2030, where hydrogen vehicle fleets will drive locational demand.
- After 2035, smaller petrol stations will also potentially see hydrogen refuelling stations installed onsite. These smaller scale electrolysers could have a capacity of less than 1 MW[xxxiv], so pockets 1MW of hydrogen electrolysis capacity could be distributed across several Electricity Supply Areas in the Southern England licence area.
- Existing hydrogen refuelling stations could be upgraded to 800kg/day (or 26,880kWh/day), especially if they are used as depots or hub fuelling locations, which would increase their electrical import capacity to between 2 and 5 MW.
- The potential market for electrolysers supplying industry could potentially see several hundred MW of capacity installed per refinery[xxxv]. This will mainly occur under **Consumer Transformation** and could be evident in Southampton, Bournemouth and Portsmouth.
- The other factors that will affect deployment at a local level could include:
    - Location of major ports and marine/shipping activity, such as the Isle of Wight, Portsmouth and Gosport
    - Rail depots that supply rural train networks on the Isle of Wight, which could see an introduction of hydrogen fuelled trains
    - The ambition of the local authorities within the licence area to invest in hydrogen electrolysis as a low carbon technology.

Figure 41 - Petrol stations in the Southern England licence area, weighted by annual HGV demand

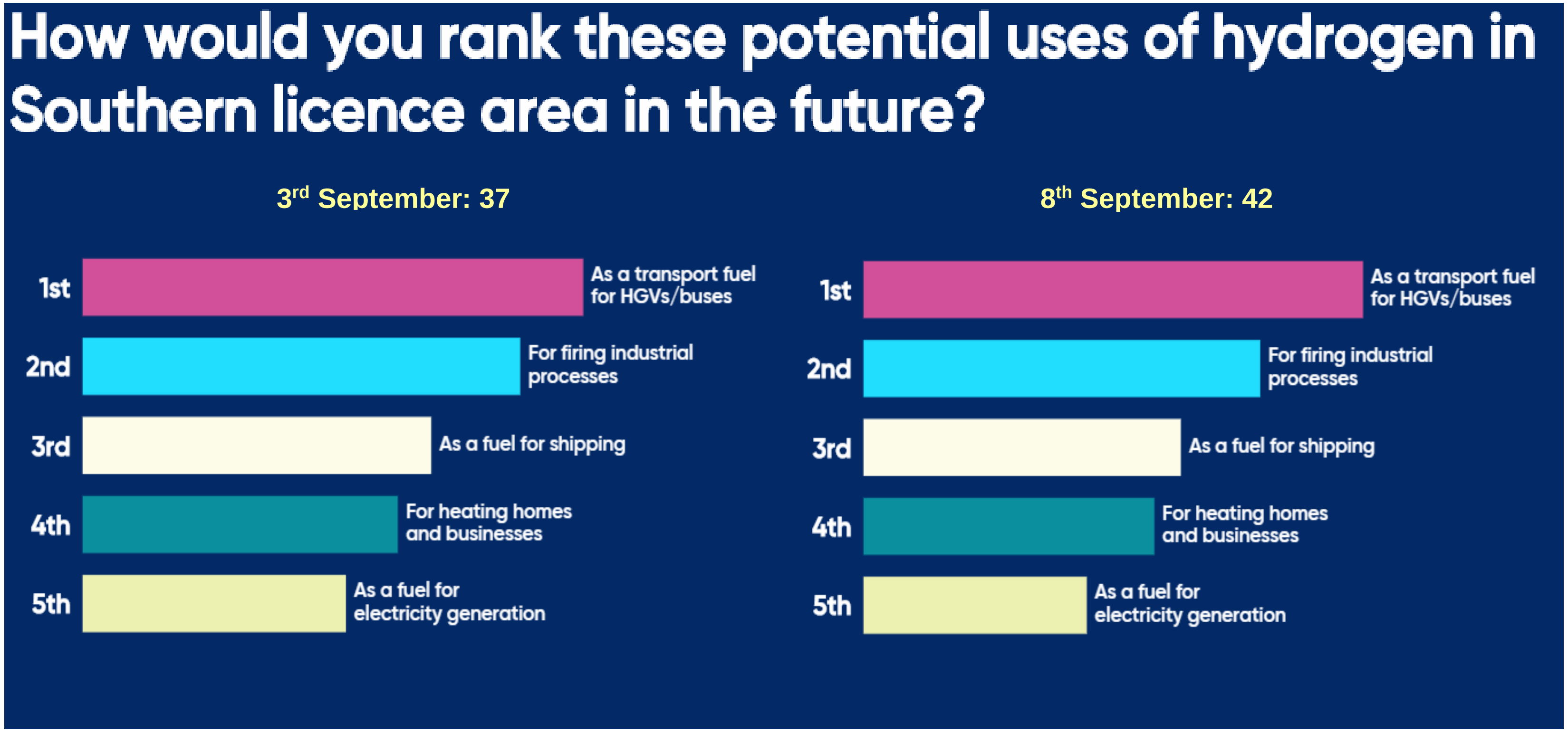


Overview of stakeholder and regional input:

As part of the DFES stakeholder engagement process, Regen delivered a series of webinars with SSEN and the Energy Systems Catapult across August and September. Part of these webinars included discussing some of the key technology sectors in the scope of the DFES, including hydrogen. Participants fed back that transport fuel was the main potential future use of hydrogen. This feedback influenced the DFES analysis and cemented some of the assumptions made around hydrogen refuelling stations as a key factor influencing the development of electrolysis capacity.

Under **System Transformation**, hydrogen for heating homes and as a fuel for electricity generation is assumed to come from natural gas. In **Consumer Transformation**, hydrogen for these uses has been included through four large electrolyser plants.

Engagement with ITM Power highlighted the potential for electrolysis plants to also be used to supply hydrogen refuelling stations, by delivering hydrogen by truck, and then used for heating and electricity as a secondary application. These would likely be on the distribution network, with larger scale electrolysers connecting to the transmission network.



References and data sources:

Online trial project research, FES 2020 data workbook, ITM Power product specifications.

[xxvii] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf
[xxviii] https://h2me.eu/
[xxix] https://www.itm-power.com/hgas1se
[xxx] H2Mobility project: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/192440/13-799-uk-h2-mobility-phase-1-results.pdf
[xxxi] https://www.legislation.gov.uk/ukdsi/2019/9780111187654
[xxxii] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/803086/industrial-clusters-mission-infographic-2019.pdf
[xxxiii] https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2020-documents
[xxxiv] https://www.itm-power.com/products
[xxxv] Developments in the global hydrogen market: Electrolyser deployment rationale and renewable hydrogen strategies and policies, ITM Power: https://www.itm-power.com/index.php?option=com_k2&Itemid=145&id=17_efe0fbe138fd8fde2d892df0c8b0151e&lang=en&task=download&view=item

17. Data centres in the Southern England licence area

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. **There is no corresponding DFES building block.**

Data summary for new datacentre demand in the Southern England licence area:

Demand capacity (MW)	2020	2021	2022	2023	2024	2025	2026
All scenarios	0	132	333	522	593	651	665

Overview of technology projections in the licence area:

- New data centres have the potential to significantly increase electricity demand on the distribution network. They could also potentially become enablers for battery storage, DSR flexibility and sources of heat for heat networks. They have therefore been included in the SSEN DFES 2020 for the first time.
- There are 13 proposed data centre developments with accepted connection offers in the Southern England licence area, totalling 665 MW.
- Four of these data centres have an accepted import capacity of more than 100 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.
- This represents a significant amount of new electricity demand on the distribution network in the Southern England licence in the 2020s.
- Once committed, Data Centre projects tend to have a high acceptance rate and likelihood of being commissioned. The projections have therefore been applied across all four scenarios.
- Beyond these known projects, no additional capacity has been projected, due to the lack of future development data, FES 2020 scenario projections and publicly available information.

Reconciliation with National Grid FES 2020:

- Data centres do not feature as individual capacity projections in the National Grid FES 2020.

Factors that will affect deployment at a local level:

For this year's DFES, known data centres have been mapped to their geographic location and allocated to an ESA based on their connection agreement. For future iterations of DFES it would be worth considering other distribution factors that may drive the location of data centres in the future, including proximity to renewable generation and the opportunity to use waste heat resources.

References: SSEN connection data

18. New property developments in the Southern England licence area

Summary of modelling assumptions and results.

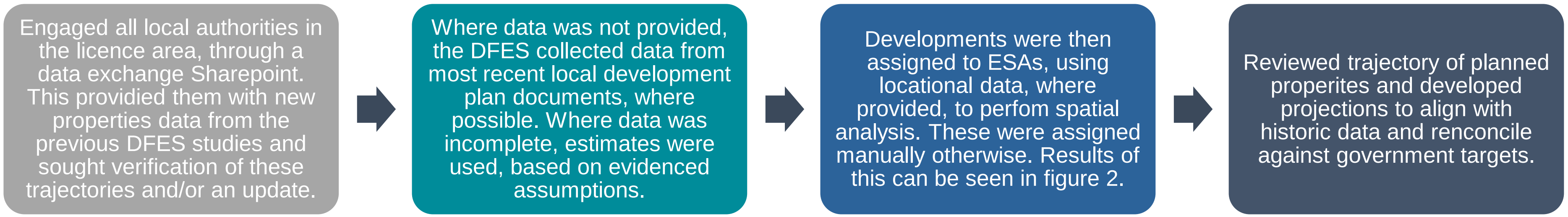
Specification:

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 the DFES analysis for the Southern England licence area. Local authorities within the licence area were contacted to aid the collation of planned new properties, through a data exchange Sharepoint. The information fed back from the local authorities were collated into a central projection for new housing and C&I properties. Engagement with local authorities is a key aspect of the DFES' stakeholder evidence around not just property developments, but also local energy strategy. The ESO FES 2020 does not have an equivalent projection for property developments and therefore there is no technology building block.

Summary:

Domestic housing and non-domestic commercial and industrial property growth projections were created using the methodology described in Figure 42. The new property development analysis for DFES 2020 built on and updated the analysis that was previously completed in the SSEN licence areas in 2019.

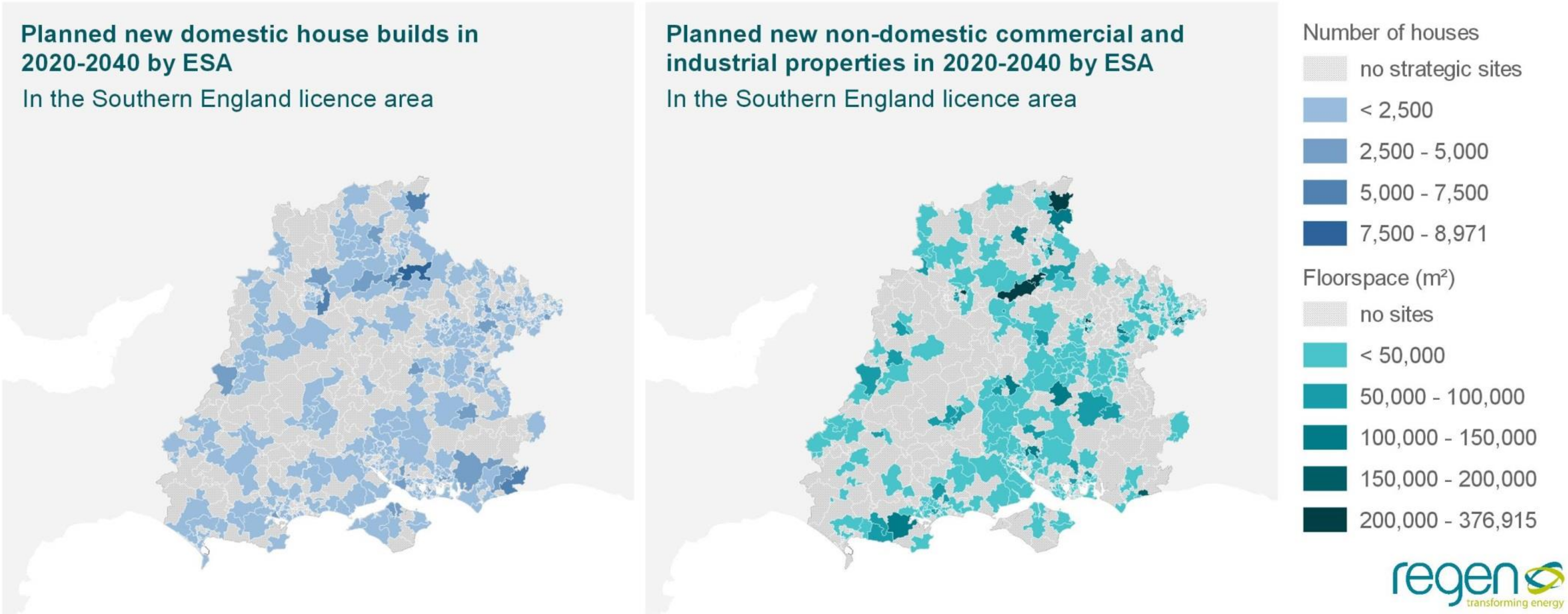
Figure 42 – Summary of methodology for the assessment of new developments



In this year's DFES analysis, new properties data was refreshed through a Sharepoint data exchange between Regen and all local authorities within the licence area. Approximately half of the local authorities in the Southern England licence area updated the databases themselves, which requested information around location, likely use, development stage, size (e.g. number of homes or C&I floorspace) and expected completion years. Some local authorities sent information separately via email and where there was no response, the database was updated using published planning documents for that local authority area.

- Only strategic domestic housing developments were recorded, defined as 50 homes or more for the Southern England licence area, unless otherwise flagged by the local authority. Non-strategic developments, which make up a small proportion of new builds, were estimated and also included in the projection.
- There are no assumptions within the ESO FES 2020 regarding property construction. Hence, in the DFES a single central projection was created around which sensitivity analysis can be conducted
- Reflecting potential delays in roll-out of new properties, and a noted "optimism bias" in development plans, the model shifts a proportion of the planned properties to subsequent years.
- For housing developments, over the first decade the DFES analysis models 22,000 new houses a year, which is the average number of new builds per year on record for the licence area[xxxvi], with a slow decrease following Office for National Statistics data[xxxvii]. With the projection being based on known new housing developments, the rate of new builds drops notably after 2030 when projections become of less value.
- No statistical data is available for non-domestic developments.

Figure 43 – Distribution of planned property developments over licence area



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

Classification of new property development	Near-term projections of known new developments up to 2030			Projections of known new developments beyond 2030 to 2050			
	2020	2025	2030	2035	2040	2045	2050
Domestic (number of houses)	22,794	137,877	245,808	318,471	350,515	358,386	359,133
Non-Domestic (floor space m^2)	787,175	4,394,037	7,210,450	8,356,188	8,586,533	8,604,063	8,605,263

Projection results:

Initial analysis year (2020)

Across 2020, the DFES has modelled some 23,000 new houses, (of which 2,500 are non-strategic), and c.787,000 m^2 of new non-domestic developments in the Southern England licence area. For houses, this is slightly higher than the historic average of 22,000 for the licence area, as shown in Figure 44.

- The Bicester (Cherwell) ESA has the highest number of domestic housing developments in 2020 with 468 new homes.
- The Milton (Vale of White Horse) ESA has the largest area of non-domestic floorspace added for 2020 with 48 thousand m^2 of new non-domestic developments.

The COVID-19 pandemic has had a notable impact on housing development in 2020, with quarterly new build rates in the second quarter of 2020 falling to their lowest level since the year 2000[xxxviii]. This introduces uncertainty for the housing builds due to have been completed this year and planned in the coming years.

The new developments in this initial year of the analysis account for 90% of the planned new developments from local authority data, with the residual 10% of the domestic and non-domestic developments being delayed to later years.

Near term (2021 – 2030)

There is a total of 245 thousand new houses and 7,210 thousand m^2 of new non-domestic property developments in the Southern England licence area over the near term. The new developments are evenly spread across the decade, but most densely in the first half and reducing by on average 440 new houses each year. It is estimated from Office for National Statistics projection that the net number of new houses is expected to fall by around 360 homes a year over the period in the licence area[2]. (Refer to the 'net new houses projection' graph in Figure 44)

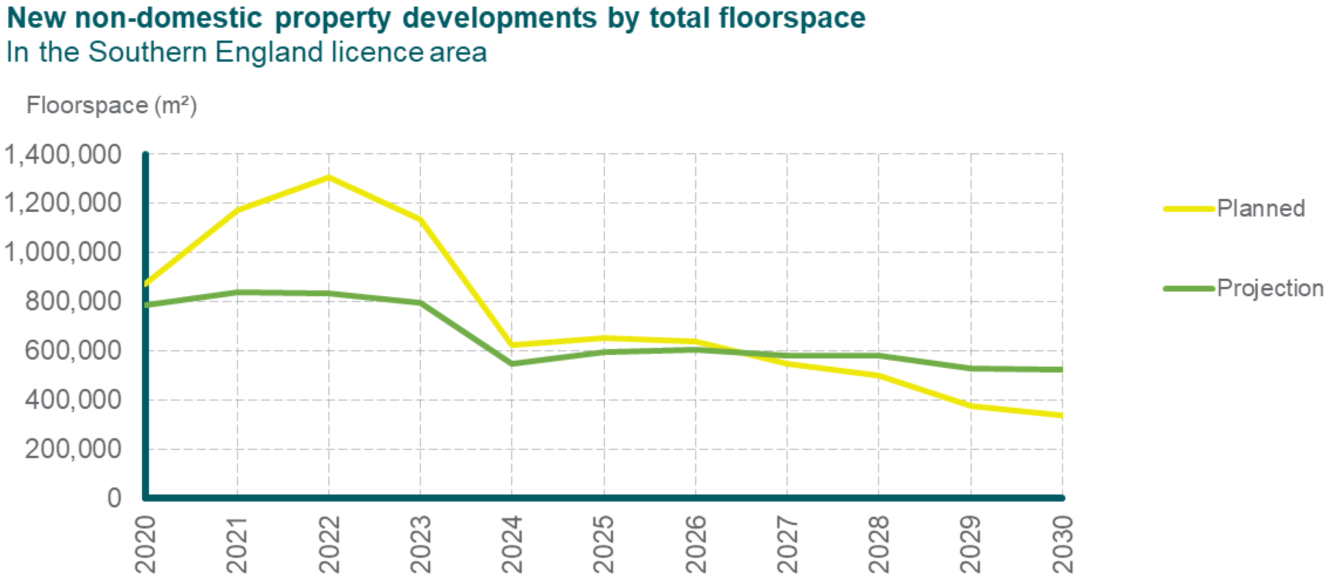
- ESAs identified with 3 thousand new houses in the near term period are Bicester (Cherwell), Bilsham (Arun), Milton (Vale of White Horse), and Chalvey (Slough). For these ESAs, this is the result of a consistent addition of one to five hundred new homes a year over the period.
- Two ESAs see the addition of over 260 thousand m^2 of new non-domestic commercial and industrial property developments, namely Wantage and Milton, both in the Vale of White Horse.
- Of the planned new houses and non-domestic developments an increasing proportion of the developments are delayed over the decade to following years. Specifically, of the planned properties modelled to be completed in their initially proposed year, 80% are included in 2021 and 50% are included in 2030.

Beyond 2030 (2031 – 2050)

The data after 2030 has limited value as a licence area projection. While there are planned developments in the pipeline after 2030, their aggregation is significantly lower than a level of development which should be expected. This is a reflection of the modelling method being predominantly based on new developments with document plans for which there are few beyond 2030.

Figure 44 - Aggregated domestic housing properties over whole licence area

Figure 45 - Aggregated non-domestic commercial and industrial properties over whole licence area



Summary of Assumptions:

- Non-strategic housing developments make up 4% of the total homes built. An additional fraction of non-strategic homes is added to strategic home locations.
    - Previous new developments studies undertaken by Regen across multiple regions and licence areas suggest that approximately 4% of planned new homes are in developments of under 20 homes
- The DFES modelling methodology has sought to apply a delay factor to the planned developments, where some developments are modelled to complete in later years:

Property type	2020	2021	2022	2023	2024	2025	2026	2027 onwards
Domestic	10%	20%	40%	40%	40%	45%	45%	50%
Non-Domestic	10%	30%	40%	40%	40%	40%	40%	40%

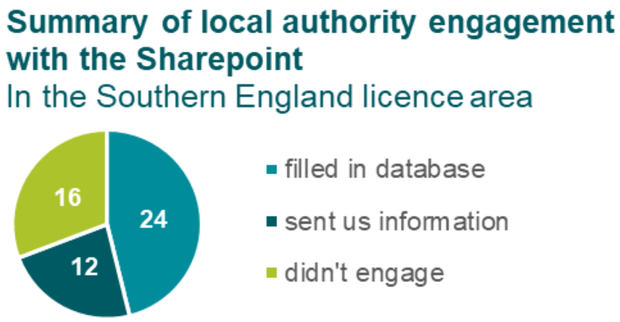
- Developments in the near term have full planning permission or have already begun construction, whereas the plans for later developments are less prescriptive. The likeliness of delay therefore increases further in later years.
  - The delayed housing developments are spread in increments of 5% over the subsequent years. For example, of the planned new houses in 2020, 5% are delayed to 2021 and 5% are delayed to 2022.
  - The delayed commercial/industrial properties are spread in increments of 2% and 3% for the first two years respectively and 5% thereafter.
- Where a build plan is not provided one is extrapolated based on a maximum build rate of 20,000 m^2 of floorspace a year and the development stage, i.e. those with full planning permission were scheduled to start in the next 5 years and those with outline permission were scheduled to start after 6 years.
- If the floorspace was not provided it was estimated from the site area based on the category type (office, factory or retail etc.)
  - For example, previous new development studies undertaken by Regen across multiple regions and licence areas suggest that the floorspace to site area ratio can be approximated to 4 for offices and retail, and 3 for factories.
- This historic average is taken from the years 2001-2019 from aggregation of the local authorities in the area[1]. Where local authorities are partially in the licence area, a fraction proportional to the area within the licence area is taken.

Local authority engagement overview:

A previous study of the licence area undertook detailed data collection from local authorities. For this study, it was opted to refresh the data, by sharing it with the authorities using a Sharepoint, which almost half the local authorities successfully updated themselves, (see Figure 46). This process significantly reduced the data processing time.

Under a quarter of the local authorities showed no engagement. This is partly a reflection of resource constraints for local authorities, compounded by the COVID-19 crisis. See the appendix at the end of this section for a specific record of local authority engagement.

Figure 46 – Local authority data exchange engagement



Appendix: Record of local authority engagement with Sharepoint

Local Authority name	Notification for domestic data change in Sharepoint	Notification for non-domestic data change in Sharepoint	Any evidence of engagement?
Arun	Y		Y
Basingstoke & Deane	Y		Y
BCP (Bournemouth)	Y		Y
BCP (Christchurch)	Y		Y
BCP (Poole)			Y
Bracknell Forest			Y
Cherwell			N
Chichester			N
Chiltern	Y		Y
Cotswold			Y
Dorset (East Dorset)			Y
Dorset (North Dorset)			Y
Dorset (Purbeck)	Y		Y
Dorset (West Dorset)			Y
Dorset (Weymouth and			Y
Ealing			Y
East Hampshire	Y	Y	Y
Eastleigh	Y		Y
Fareham			Y
Gosport	Y		Y
Guildford	Y		Y
Hart			N
Havant	Y		Y
Hillingdon	Y	Y	Y
Horsham			N
Hounslow			N
Isle of Wight	Y	Y	Y

Mendip	Y	Y	Y
New Forest	Y	Y	Y
Oxford			N
Portsmouth			Y
Reading			N
Runnymede			N
Rushmoor			N
Slough			N
South Bucks	Y	Y	Y
South Oxfordshire			N
South Somerset			Y
Southampton	Y	Y	Y
Spelthorne	Y		Y
Surrey Heath	Y	Y	Y
Swindon			N
Test Valley	Y	Y	Y
Vale of White Horse			Y
Waverley	Y		Y
West Berkshire	Y		Y
West Oxfordshire			N
Wiltshire	Y		Y
Winchester	Y		Y
Windsor and Maidenhead			N
Wokingham			N
Wycombe			N

References:

[xxxvi] See table 122 of the housing supply: net additional dwellings: https://www.gov.uk/government/statistical-data-sets/live-tables-on-net-supply-of-housing
[xxxvii] See the Office of National Statistics principle projection: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/householdprojectionsforenglanddetaileddataformodellingandanalysis
[xxxviii] See MHCLG Housing supply indicators January to June 2020: https://www.gov.uk/government/statistics/housing-supply-indicators-of-new-supply-england-january-to-june-2020

19. Domestic air conditioning in the Southern England licence area

Summary of modelling assumptions and results.

Technology specification:

The analysis covers domestic air conditioning (AC) units in the Southern England licence area.

The National Grid FES 2020 does not give a projection for the number of installations or the total capacity (MW) of domestic AC units. However, the FES 2020 does give a projection for residential AC consumption and some usage assumptions from which the number of units can be derived.

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

Total number of homes with air conditioning units	Baseline	2020	2025	2030	2035	2040	2045	2050
Steady Progression	25,117	25,325	52,001	101,795	249,196	406,279	725,270	1,469,916
System Transformation		25,325	47,024	83,313	154,064	272,221	417,104	765,051
Consumer Transformation		25,325	47,008	83,284	153,791	271,747	415,088	761,408
Leading the Way		25,325	26,194	26,814	27,564	28,314	29,064	29,814

Overview of technology projections in the licence area:

- The baseline of existing domestic AC units has been based on an assumption that nationally, c.1% of homes on average across GB currently have AC units[xxxix]. These AC units are likely to mostly be in flats and apartment buildings. With some areas of the Southern England licence area having notable population density (including more multi-occupancy buildings) and a hotter climate in Southern England, the national figure of 1% has been applied to the licence area to determine the baseline. This equates to a little over 25,000 AC units in 2019.
- Based on the National Grid FES 2020 residential energy consumption datasets, domestic AC unit capacity (kW) and assumptions around operating hours, the DFES analysis has projected a significant range of results for AC deployment across the scenarios by 2050:
  - The highest number is seen in **Steady Progression**, with just under 1.5 million units (c.44% of all homes in the licence area).
  - The lowest number is seen in **Leading the Way**, with just under 30,000 units (c.1% of all homes in the licence area).

Methodology and assumptions:

- There is no absolute projection of the number of domestic AC units in the National Grid FES 2020 data workbook. Therefore, the following data sources were used to determine the DFES projections out to 2050 in the licence area.
    - The FES 2020 scenario projections for total GB annual energy consumption (GWh) from domestic AC out to 2050
    - The FES 2020 assumptions around domestic AC unit load (stated to be 2.7kW, undiversified) and annual operating hours
    - A total count of GB domestic properties out to 2050, based upon a summation of FES 2020 domestic heating technology projections
- After an inflation was applied to the number of operating hours out to 2050 (reflecting higher temperatures across GB by 2050), the FES 2020 data was combined to provide a set of national GB figures for the percentage of homes with AC units, under each scenario, out to 2050:

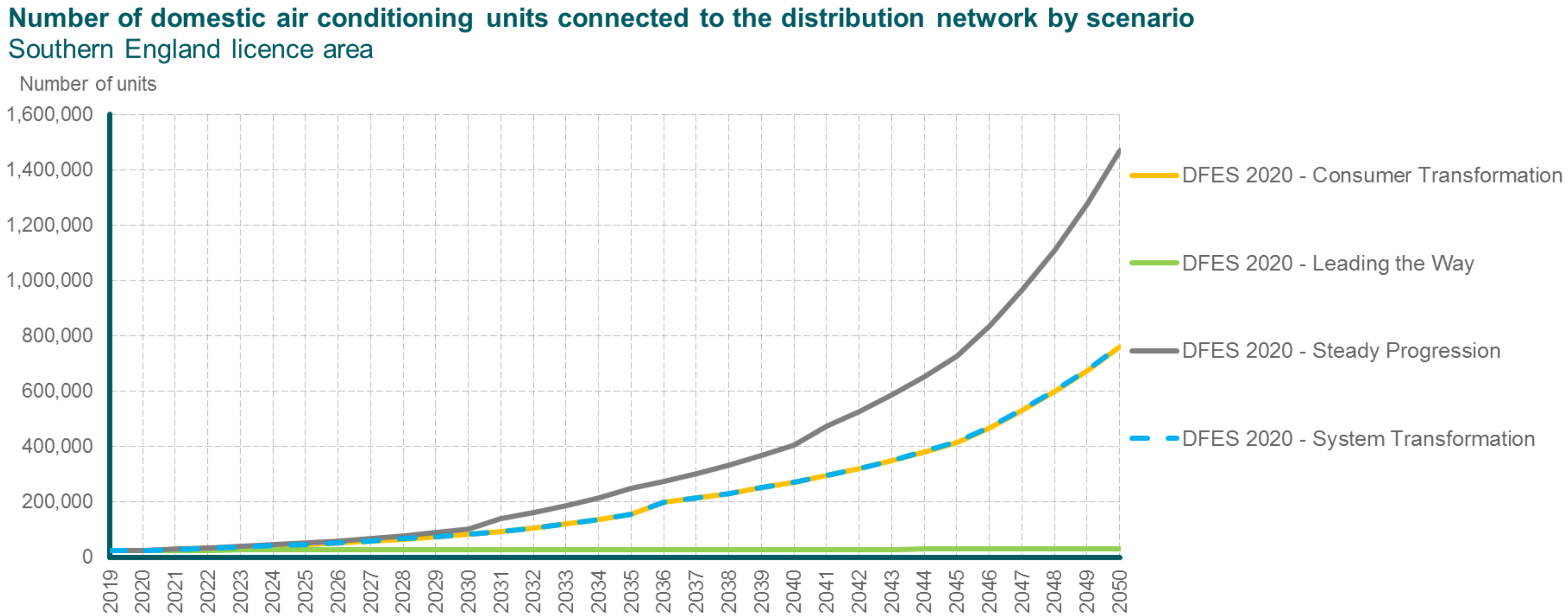
Percentage of GB homes with domestic AC units	Baseline	2020	2025	2030	2035	2040	2045	2050
Steady Progression	1%	1%	2%	4%	7%	12%	19%	38%
System Transformation		1%	2%	3%	5%	8%	12%	21%
Consumer Transformation		1%	2%	3%	5%	8%	12%	21%
Leading the Way		1%	1%	1%	1%	1%	1%	1%

- Analysis was then undertaken of the population density[xl] (as a proxy for multi-occupancy buildings) and cooling degree-days[xli] in the Southern England licence area. This analysis showed:
    - The licence area has the second highest proportion of UK population overall (c.10.5%)
    - It is also the licence area that has the highest percentage of population density that is greater than 100 people per hectare outside of the UKPN London and Eastern England licence areas.
    - The licence area was the region with the second highest number of degree days above 18.5°C, that would require cooling.

- This analysis resulted in applying two adjustment factors to the FES 2020 percentage figures for GB homes with domestic AC units, to reflect a higher population density and hotter climate present in the licence area.
- This resulted in the percentage of homes with AC units to be adjusted to the following:

Percentage of homes with domestic AC units in the Southern England licence area	Baseline	2020	2025	2030	2035	2040	2045	2050
Steady Progression	1%	1%	2%	3%	8%	13%	22%	44%
System Transformation		1%	2%	3%	5%	9%	13%	23%
Consumer Transformation		1%	2%	3%	5%	9%	13%	23%
Leading the Way		1%	1%	1%	1%	1%	1%	1%

Figure 47: Domestic air conditioning units in the Southern England licence area by scenario



Reconciliation with National Grid FES 2020:

There is no FES 2020 regional data to directly compare the DFES results to. However, the DFES analysis has been based on the FES 2020 scenario projections for total annual energy consumption of GB domestic AC, assumptions around unit capacity (in kW) and operating hours and the total number of domestic properties with any heating technology across GB out to 2050.

Factors that will affect deployment at a local level:

- In the baseline and in the near term, domestic AC is distributed to high density urban areas where heat island effects are more common, as well as homes with high levels of affluence.
- Under **Leading the Way**, where domestic AC uptake is very limited, location remains consistent throughout the timeframe to 2050.
- Under **System Transformation** and **Consumer Transformation**, domestic AC becomes more common in less affluent and less dense areas over time. However, more affluent and denser urban areas still see the majority of domestic AC units installed by 2050.
- Under **Steady Progression**, domestic AC becomes extremely common as households react to rising temperatures and active cooling is preferred to passive cooling. Accordingly, the impact of affluence on AC uptake reduces throughout the timeframe of the scenario, with only a small bias towards these types of housing by 2050. Denser urban areas still see the majority of uptake, but air conditioning is seen across all types of urban and rural housing.

Relevant assumptions from National Grid FES 2020:

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

References:

National Grid FES 2020 data workbook, UK Census data, Stark degree-days data.

[xxxix] See National Grid FES 2020 Data workbook, ED2 worksheet Data Item for Residential Air Conditioning: https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2020-documents

[xl] Based on analysis census data: https://www.nomisweb.co.uk/census/2011/qs102uk

[xli] Sourced from 'Degree Days for Free' datasets provided by Stark: https://poweredby.stark.co.uk/SEO/SEO.aspx