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SP ENERGY NETWORKS

SP Distribution Future Energy Scenarios

May 2021

Commissioned partners: Baringa Brighter together

Supported by: Field Dynamics

Contents

1 Foreword

Welcome to our Distribution Future Energy Scenarios (DFES). This document sets out our forecasts for how electricity generation and consumption may evolve in Central and Southern Scotland over the next 30 years. This document is an update to our December 2020 publication – our forecasts haven't changed, but we've now added information to show how they compare against other industry forecasts.

A changing landscape

The energy landscape is changing fast as the way our customers generate, consume, and interact with energy evolves. To deliver Net Zero carbon targets, a significant proportion of transport and building heating will need to be electrified. We are also going to see a further leap in renewable generation capacity as fossil fuel power stations close. This new demand and generation will push the distribution network beyond what it is designed for, meaning that our network will need to evolve to enable our customers' Net Zero transition. It is important that we understand the likely uptake of this new demand and generation, so we know how best to respond.

While the overall direction of travel towards Net Zero is clear, there are some areas where detailed action plans are still under development. How will the local authorities turn their Climate Emergency status into action? How will domestic heating decarbonise beyond the UK Government's 2028 Energy White Paper target? Which communities will move faster than others?

Given these uncertainties and the ever changing energy landscape, creating a single forecast risks being misleading. Instead we set out four forecast scenarios which cover a range of credible pathways to describe the potential decarbonisation routes which our customers may follow.

Scott Mathieson
Network Planning & Regulation Director

Working together

Our main role is to provide the safe, efficient, and reliable network capacity needed to enable the decarbonisation route that our customers and communities choose. To achieve this, these DFES forecasts are used to assess future network capacity requirements, and the RIIO-ED2 investment needed to deliver this capacity.

Given the important role of these forecasts, we need to ensure that we have correctly forecast our customers' requirements; feedback from our stakeholders is vital for this. We welcome the feedback we have already received, which has been used in these latest forecasts. However, given the rate of change in the energy landscape, it is important that this stakeholder input is not a one-off, but a regular process. We therefore look forward to continuing to engage with you and understanding your insights, so we can ensure our network continues to meet your needs.

A final note: regardless of the decarbonisation pathway that our customers end up treading, we recognise that the distribution networks are a key enabler. We are already evolving the way we design, build and operate our networks, implementing innovative solutions, and embracing new technologies. Our RIIO-ED2 business plan will deliver the capacity and capabilities that our customers need, so that we can continue to provide them with a safe, reliable, and good value electricity supply, whatever the future holds.

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Scottish Government

Our Distribution Future Energy Scenarios have been developed collaboratively with Scottish Government to meet their policies and legislated targets.

“SP Energy Networks works closely with Scottish Government throughout the development of their scenarios.

In December 2020 the Scottish Government published an Update to the Climate Change Plan, showing how we intend to move towards ending Scotland’s contribution to climate change by 2045. The update highlights ambitious policies and actions that Scottish Government is taking to meet our statutory interim target of a 75% reduction in greenhouse gas emissions by 2030, and shows how the effort to decarbonise needs to be shared across the whole of the economy.

It is clear that electricity distribution networks will be critical to our ambition in several areas: supporting the connection of zero carbon heating, charging of electric vehicles, and potential electrification of industrial processes. Over the period 2020 to 2030 emissions from our Transport sector will need to reduce by 41%. As well as reducing car kilometres by 20% over this period, we will also ensure that the need for petrol and diesel cars and vans is phased out with electric vehicles commonplace across Scotland. In our buildings sector, emissions need to reduce by two thirds over the decade. Scottish Government has committed to spend £1.6 Billion on heat and energy efficiency over the next parliament which will help deliver the doubling of the rate at which low carbon heating systems are installed every year until at least 2025.

Finally, the update highlights that emissions from electricity generation need to fall from low carbon to zero carbon by the end of the decade. This will mean continuing to grow renewable generation throughout the 2020s at all levels, from large-scale offshore wind to rooftop solar. The distribution networks will continue to play an important role in ensuring that Scotland’s renewable generation capacity grows by between 11 and 16 GW by 2032.

Today the SPD network connects around 2 million households across central and southern Scotland along with 15% of Scotland’s total renewable generation capacity. This electricity and wider energy system that the SPD network serves will need to change dramatically over the coming years; the Leading the Way and Consumer Transformation scenarios indicate the scale and the pace of this change. The Scottish Government believes that everyone across Scotland has the right to secure, affordable and increasingly low carbon energy. Electricity distribution networks have a central role to play in realising these ambitions.”

Simon Gill,
Head of Whole System and Technical Policy
Directorate of Energy and Climate Change, Scottish Government

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Impact of Covid-19

Covid-19 has impacted every part of our society and the UK economy. The long-term impact of Covid-19 on electricity consumption and generation is still uncertain, as it depends on a complex range of societal and economic factors.

Our ways of working, socialising, and living have all changed over this last year. These changes have affected GB electricity consumption, reducing national demand to record low levels[1]. Even though demand for electricity had started to recover, it has remained lower than pre-Covid expectations for the majority of the year. However, for this summer GB electricity demand is not expected to be as low as the previous year[2]. It is important to highlight that, during this challenging time, SP Energy Networks is focussed on continuing to provide a safe, secure and reliable supply for all our customers.

The longer-term impact of Covid-19 on customer demand and generation is still uncertain, as it depends on a complex range of societal and economic factors. Whilst Covid-19 is still having an immediate impact on our network operations and plans, we have seen government and industry reverting to ensuring society is tackling the climate change crisis. If anything, our Covid-19 experience has underlined the importance of this; it has challenged how we think about resilience and sustainability, and how we enact our response to this imperative. In this context, electricity networks will endure as vehicles for driving forward government plans for achieving Net Zero.

In the post Covid-19 period, electricity networks also have increased importance in acting as an economic catalyst in recovery; advisors to government have recommended green economic recovery investment in infrastructure for this reason. The recently published Ten-Point Plan[3], Energy White Paper[4], and the update to the Climate Change Plan[5] for Scotland lay the foundation for a Green recovery. We believe that investing to deliver Net Zero targets presents a critical opportunity to restart our economy, deliver much needed jobs, and inject sufficient pace into the Net Zero transition. The role our networks can play is especially important to us as we consider both the national and devolved governments that we serve.

To realise this ambition, it will be important that Ofgem continues to regulate objectively; the need to invest in our networks has never been more important than it is now.

We will keep the impact of Covid-19 under review and, as the understanding of its long-term impact on the energy system develops, we will incorporate this into future updates. In considering the impact of Covid-19, we would note that our DFES forecasts are long-term, looking out to 2050. Net Zero legislated targets will remain, and so the need for decarbonisation is unchanged.

[1] Source: https://data.nationalgrideso.com/backend/dataset/b3c55e31-7819-4dc7-bf01-3950dccbe3c5/resource/ebd7e133-96da-4a8d-a5b6-039918717c8a/download/ngeso-covid-19-preparedness-01-07-vfinal.pdf

[2] Source: https://www.nationalgrideso.com/document/189741/download

[3] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf

[4] https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future

[5] https://www.gov.scot/publications/securing-green-recovery-path-net-zero-update-climate-change-plan-20182032/

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Introduction

We are SP Energy Networks. We own and operate the electricity distribution network in the SP Distribution licence area covering Central and Southern Scotland. It is through this network of underground cables, overhead lines, and substations that 2 million homes, businesses, and public services are provided with a safe, economical, and reliable supply of electricity.

A safe and reliable electricity supply is key to most people's lives – we depend on it to light our homes, keep our food fresh, power our businesses, and enable our connected lifestyle. In the future, we will also increasingly rely on it to heat our homes and power our transport as we decarbonise our society.

4.1 The DFES forecasts

In order to ensure our network has sufficient capacity to meet our customers' changing electricity needs, we need to forecast what their electricity requirements are going to be into the future (we forecast out to 2050). These forecasts need to cover how much electricity existing and new customers might consume (demand) and how much they might produce (generation). We call these forecasts Distribution Future Energy Scenarios (DFES).

We use the understanding of future customer needs forecasted by the DFES to plan and design our network – the DFES forecasts help us understand where we might need to create more network capacity, and how our operational and maintenance activities should be undertaken. This in turn helps us calculate what financial investment is required, and to seek approval for this expenditure from Ofgem, via the RIIO business plan process. The DFES forecasts are the foundation on which we are producing our RIIO-ED2 Business Plan[6] to meet our customers' needs.

[6] RIIO-ED2 is the distribution network price control period which runs from 1 April 2023 to 31 March 2028. (https://www.spenergy-networks.co.uk/pages/our_riio_ed2_business_plan.aspx)

[7] https://www.spenergynetworks.co.uk/dfes

4.2 Incorporating your views

Since our first DFES publication on 1st May 2020, we engaged with a wide representation of our stakeholders to test the forecasts' data, methodology, and outputs. That engagement generated a range of feedback which we assessed and used to update the forecasts in our July 2020 publication. This update still incorporates that feedback. Please see Section 7.2 for a summary of the feedback we received and how we have used it.

The main change in this May 2021 publication is that we now show how our forecasts compare to the Electricity System Operator's (ESO) and Climate Change Committee's (CCC's) forecasts. These are in Sections 8-10.

Given that different stakeholders will be interested in different levels of detail, we have created a range of documents to explain our DFES forecasts[7]. These are:

1. "SPEN Distribution Future Energy Scenarios – Summary of Methodology". A document that elaborates on the detailed methodology to create each forecast.

2. "SP Distribution Future Energy Scenarios". This document, containing the main forecast trends.

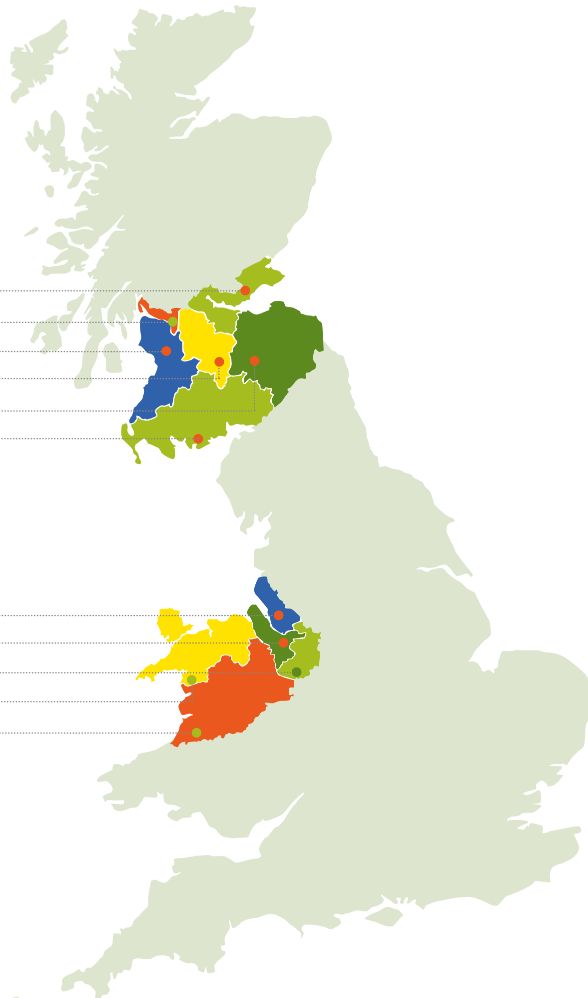
3. SP Distribution Future Energy Scenarios – Key Findings". A short document which summarises the key findings.

If you have any questions on these forecasts, please do not hesitate to contact us at RIIO_ED2@spenergynetworks.co.uk.

4.3 Other SP Energy Networks forecasts

SP Distribution is part of SP Energy Networks. SP Energy Networks includes two other electricity network companies: SP Manweb, the distribution network operator for North Wales, Cheshire, North Shropshire and Merseyside, and SP Transmission, the transmission network owner for Central and Southern Scotland. These two companies each have their own forecasts, which are available separately[8]. The areas of operation of SP Distribution, SP Manweb and SP Transmission are shown in Figure 1.[9]

Figure 1 | SP Energy Networks' three electricity network companies



SP Transmission PLC (SPT)
SP Distribution PLC (SPD)

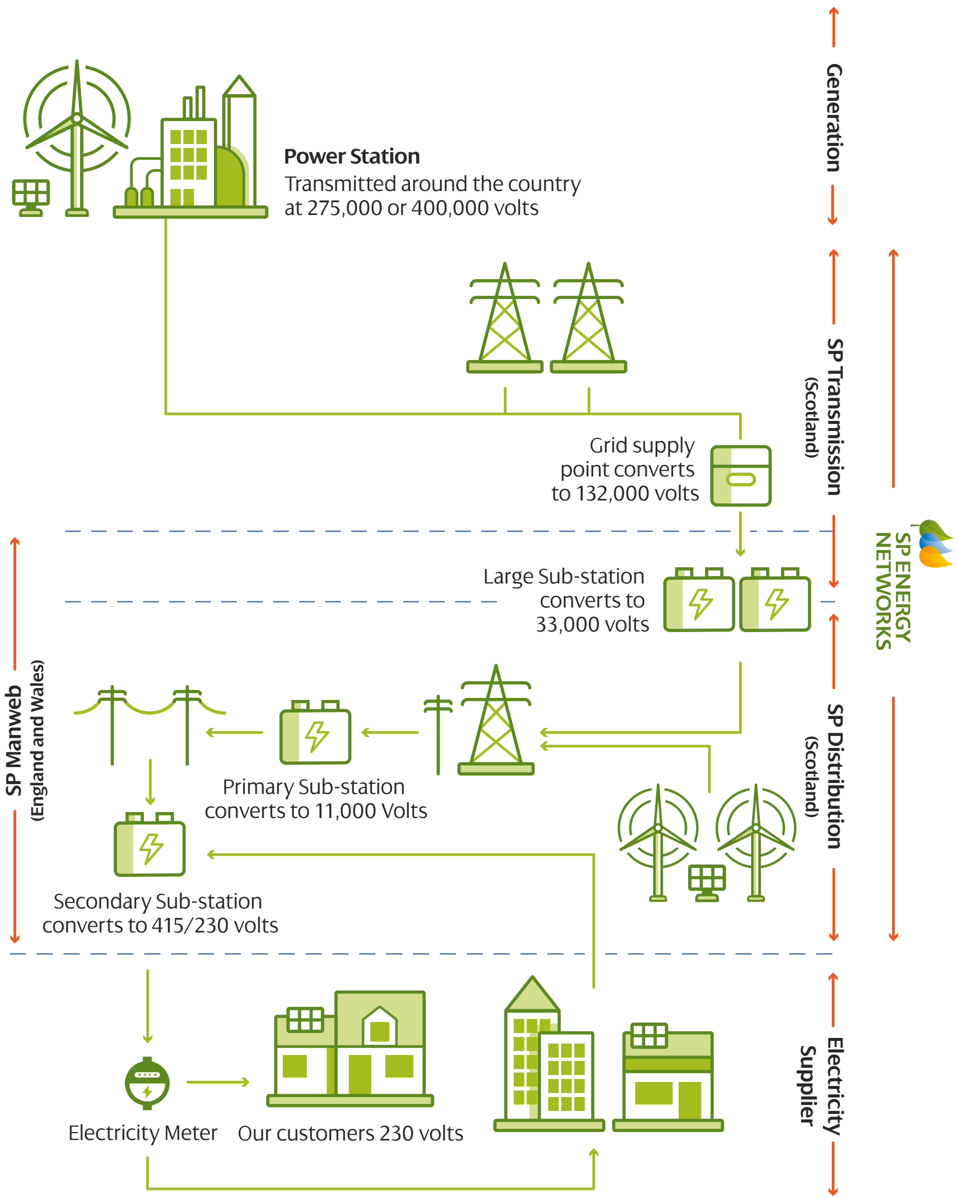
- Central & Fife
- Glasgow
- Ayrshire & Clyde South
- Lanarkshire
- Edinburgh & Borders
- Dumfries

SP Manweb PLC (SPM)

- Merseyside
- Wirral
- Mid Cheshire
- North Wales
- Dee Valley & Mid Wales

[8] www.spenergynetworks.co.uk/userfiles/file/SPEN_Energy_Scenarios_2019_update.pdf

[9] SP Distribution and SP Transmission are shown as operating the same geographic area – this is because SP Distribution operates the distribution network in that area, whilst SP Transmission operates the transmission network in that area.



5 External context

The Scottish and UK governments have committed to a significant change to the energy system in order to reduce greenhouse gas emissions.

In response to the global climate change challenge, the Scottish Government introduced the Scottish Climate Change (Emissions Reduction Targets) Act 2019[10].

This introduces a legally binding target for Scotland to achieve Net Zero (greenhouse gas emissions) by 2045. This is five years ahead of the UK target of Net Zero greenhouse gas emissions by 2050[11]. In addition, the Scottish Climate Change Act sets interim targets for emission reductions of 75% by 2030, and 90% by 2040. Given that these targets depend on switching from fossil fuel use to electricity, they require a significant change to Scotland's electricity distribution network.

Building on these targets, the Scottish Government's Climate Change Plan[12] and Scottish Energy Strategy[13] identify a number of ambitions which will have a direct impact on the electricity distribution network.

Some of these ambitions include:

1. By 2030, the equivalent of 50% of the energy for Scotland's heat, transport and electricity should be supplied from renewable sources.
2. By 2032, phase out the sale of new petrol and diesel cars and vans.
3. Scotland should have the capacity, connections, flexibility, and resilience to maintain secure and reliable supplies of energy to all homes and business during the energy transition.

More recently, the Scottish Government published the Update to the Climate Change Plan, which lays the foundation for a Green recovery, and introduced the Heat Networks (Scotland) Act 2021[12] including a target for heat networks to supply no less than 6TWh of heat demand by 2030.

The updated plan includes:

1. Phase out the sale of new petrol and diesel cars and vans by 2030.
2. By 2030, around 50% of buildings will need to convert to low or zero carbon heating to achieve the interim statutory target.
3. The development of 11-16GW of renewable generation capacity by 2032.

At a more local level, a number of Scottish local authorities have declared climate emergencies. We expect this to feed into regional development plans, further impacting the electricity distribution network.

The distribution network is the key enabler to realising these targets and ambitions – regardless of forecast scenario, the distribution network will need to accommodate significantly more demand through the electrification of heat and transport, and more renewable generation to decarbonise our electricity supply. Given this key Net Zero enabling role, the importance of these DFES forecasts has never been greater.

[10] www.legislation.gov.uk/asp/2019/15/contents/enacted
[11] www.legislation.gov.uk/ukpga/2008/27/contents
[12] www.gov.scot/Publications/2018/02/8867
[13] www.gov.scot/Publications/2017/12/5661
[14] www.legislation.gov.uk/asp/2021/9/contents/enacted

6 How we create our DFES forecasts

Our DFES forecasts are unchanged from our December 2020 publication. This section explains how they were created.

6.1 The starting point – July 2020 DFES

We used the SP Distribution DFES forecasts published in July 2020, as the starting point.

These DFES forecasts were based on the ESO's 2019 Future Energy Scenarios (FES), augmented with regional and local data including:

1. UK and Scottish governments' legislation (including the incorporation of Net Zero).
2. Regional ambitions and development plans.
3. Network data we already have, for example views on near term connections of distributed generation.
4. Outputs from SP Energy Networks' EV-Up and PACE projects, and interim results from Heat-Up.
5. Other highly spatially disaggregated sources of data (e.g. number of, and footprint of buildings in an area).
6. Stakeholder evidence and feedback.

To create sufficiently geographically granular forecasts, all of the key scenario elements were spatially disaggregated to two levels of detail:

1. UK Grid supply point (GSP) level. There are 86 GSP areas across Central and Southern Scotland.
2. Primary substation level. There are 391 primary substation network areas across Central and Southern Scotland. These geographic areas cover, on average, approximately 50km^2.

The resulting DFES forecasts were regionally reflective, geographically granular forecasts out to 2050 for four scenarios. Each scenario was disaggregated to show forecasts for individual demand and generation metrics, for example electric vehicle (EV) uptake, solar photovoltaic (PV) capacity etc.

We have retained the approach of forecasting for four scenarios, as we feel it is important to represent a range of credible pathways. To see any previous DFES publications please visit **www.spenergynetworks.co.uk/dfes**

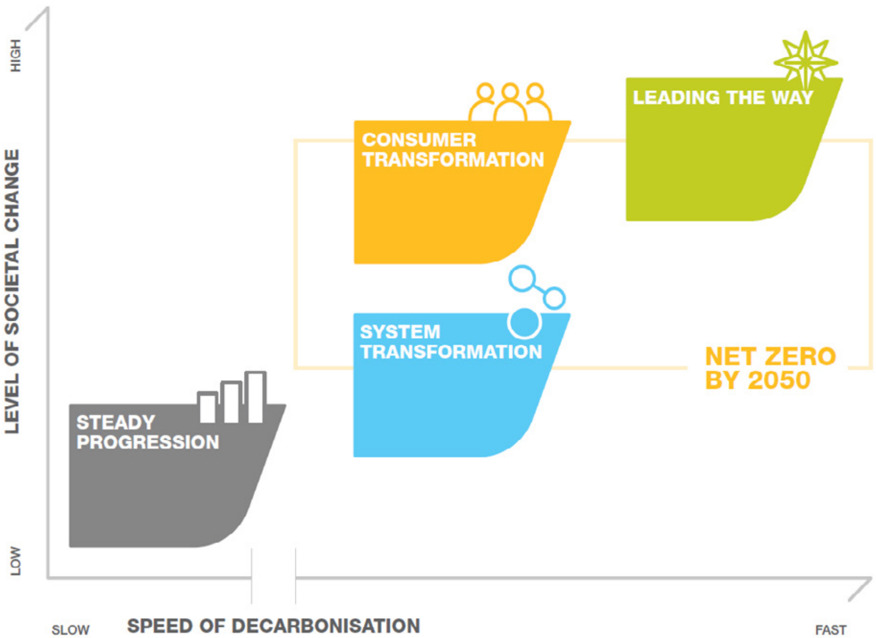
6.2 Incorporation of the ESO's 2020 FES

After our DFES publication in July, the ESO updated its Future Energy Scenarios[15] (2020 FES), which explore different pathways to reach Net Zero. These are four GB-wide holistic energy scenarios out to 2050, considering gas and electricity supply and consumption. These four scenarios are designed to represent a range of credible energy scenarios, representing differing levels of consumer ambition, government/ policy support, economic growth and technology development. The scenarios are developed through extensive engagement with stakeholders and are widely recognised as being an industry reference point.

These DFES forecasts incorporate the ESOs' 2020 scenario framework.

To illustrate their different representations, Figure 2 maps the four scenarios against two metrics: the speed of decarbonisation (how fast low carbon technologies are adopted) and the level of societal change.

Figure 2 | Overview of the ESO's 2020 Future Energy Scenarios



[15] https://www.nationalgrideso.com/document/174541/download

Key scenario assumptions

	Steady Progression	System Transformation	Consumer Transformation	Leading the Way
Residential electrical energy efficiency	Low	Medium	Medium	High
Residential consumer engagement	Low	Medium	High	High
Battery electric vehicles (BEVs)	Low	Medium	High	High
Home EV charging	Medium	Low	High	High
Home thermal efficiency levels	Low	Medium	High	High
Heat pumps	Low	Medium	High	High
District heating	Low	Medium	High	High
Solar PV generation (<1MW)	Low	Medium	High	Medium
Solar PV generation (>1MW)	Low	Medium	Medium	High
Onshore wind	Low	Medium	High	High
Medium duration electricity storage	Low	Medium	Medium	High

6.3 DFES outputs

We have retained the same level of detailed outputs as in our previous DFES:

1. We have forecast four scenarios, as we feel it is important to represent a range of credible pathways.
2. We have forecasts for all key customer demand and generation metrics. These key metrics are forecast for each scenario at a GSP and primary substation geographic level, and for each year out to 2050.

This level of detail gives us a greater understanding of the potential timing, magnitude and location of our customers' requirements. Therefore, we can make more timely, targeted and efficient interventions in the network.

We have arranged the outputs of the DFES forecasts into two main categories:

1. Those which affect electricity demand. The main drivers here are electric vehicles and heat pumps, so we show disaggregated forecasts for these. These are set out in **Section 7.3**.
2. Those which affect electricity generation and storage[16]. These are set out in **Section 7.4**.

[16] From a technical perspective, storage increases both demand (when it imports electricity) and generation (when it exports), so it could have been included in either group. However it is legally deemed to be generation, so is included within the generation forecasts.

For each metric we have forecast we include, where possible:

1. A measure of the absolute number (e.g. number of electric vehicles); and
2. Its impact on electricity demand or generation capacity (shown in MW). Demand forecasts are shown as 'peak demand'; this is because the contribution of additional demand at peak demand periods will have the most network impact – we have to plan and design our network to accommodate peak demand. Generation forecasts are shown as 'capacity'; this represents the total installed generation capacity.

For demand components (e.g. electric vehicles, heat pumps), we also consider the potential flexibility of each component. Flexibility is the measure of the capability of that component to operate at different times of day. For example, a factory process which always has to operate at the same time is not flexible, whereas an electric vehicle which could be charged at different times of the day has some flexibility. Flexibility is relevant as it means electricity consumption can be moved from peak demand times to less busy times of the day, or to periods of high generation output, which in turn reduces the network impact and the requirement for network interventions – this will be to the benefit of customers.

The creation of this DFES was undertaken with the support of Baringa, an expert consultancy. For further details on the methodology to create the forecasts, please refer to "*SPEN Distribution Future Energy Scenarios – Summary of Methodology*" document, developed in conjunction with Baringa.

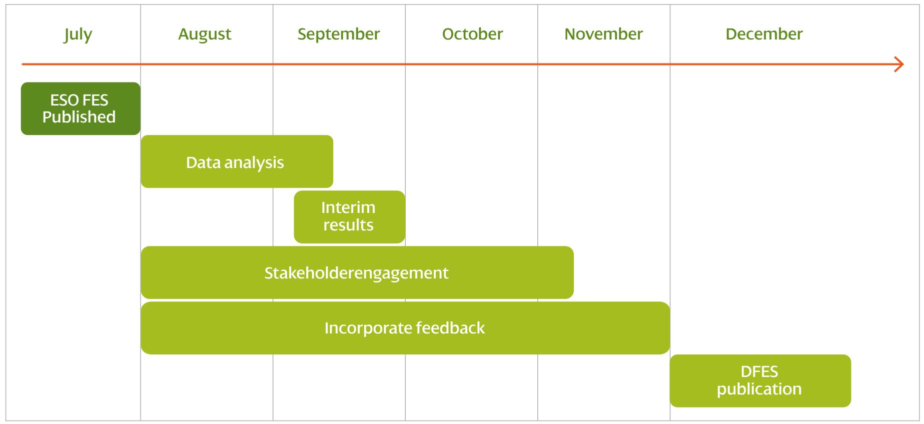
6.4 Updating the DFES

We will update and publish our DFES forecasts annually, as shown in **Figure 3**. For each main annual update there will be the opportunity for stakeholders to provide feedback. Feedback from customers and stakeholders is vital to ensure that our DFES forecasts reflect the plans and ambitions of the communities we serve.

We will consider all information we receive from stakeholders to help shape our forecasts. As these forecasts will inform the network we deliver for our customers, we also have a duty to our customers to ensure that all information included is well evidenced and credible. We will therefore consider the extent to which information we receive should be used to update the forecasts. For information relating to specific developments in the shorter-term, we will consider how developed that scheme is and its underlying drivers.

In the meantime, if you have any further questions or feedback, please do not hesitate to email us at **RIIO_ED2@spenergynetworks.co.uk**

Figure 3 | Annual process to create our DFES



7

Our DFES Forecasts

This section sets out our demand and generation DFES forecasts for each scenario out to 2050. These are unchanged from our December 2020 update.

All the forecast values are for the SP Distribution network only; they are not forecasts for the whole of Scotland or the UK, or the transmission network[17].

7.1 Scenario overview

Our DFES forecasts reflect the ESO's 2020 FES scenario framework. A description of each scenario[18] is provided below:

In SPD Steady Progression (SP): progress is made on decarbonisation, however it is slower than in the other scenarios. While home insulation improves, there is still heavy reliance on natural gas, particularly for domestic heating. Electric vehicle take-up grows more slowly than in other sectors, displacing petrol and diesel vehicles for domestic use, however decarbonisation of other vehicles is slower with continued reliance on diesel for heavy goods vehicles. In 2045 this scenario still has significant annual carbon emissions, some way short of the 2045 Net Zero Scottish target.

In SPD Consumer Transformation (CT): the 2045 Net Zero target is met with measures that have a greater impact on consumers and is driven by greater levels of consumer engagement in the energy transition. For example, a typical domestic consumer will use an electric heat pump with a low temperature heating system and an electric vehicle, they will have had extensive changes to their home to improve its energy efficiency and most of their electricity demand will be smartly controlled to provide flexibility to the system. The system will have higher peak electricity demands that will be managed with flexible technologies including energy storage, demand side response and smart energy management.

In SPD System Transformation (ST): the 2045 Net Zero target is met, following a pathway that has the least consumer impact to do so. The typical domestic consumer will experience less disruption than in Consumer Transformation as more of the significant changes in the energy system happen on the supply side, away from the consumer. For example, a typical consumer will use a hydrogen boiler with a mostly unchanged heating system and an electric vehicle or a fuel cell vehicle, they will have had fewer energy efficiency improvements to their home and will have lower engagement with opportunities to use their demand to provide flexibility to the system. Total hydrogen demand is high, and it is mostly produced from natural gas with carbon capture and storage.

In SPD Leading the Way (LW): rapid decarbonisation with high levels of investment in world-leading decarbonisation technologies. Consumers are highly engaged in acting to reduce and manage their own energy consumption. This scenario includes the highest and fastest improvements in energy efficiency to drive down energy demand, with homes retrofitted with insulation such as triple glazing and external wall insulation, and a steep increase in consumer participation in smart energy services. Hydrogen is used to decarbonise some of the most challenging areas of society such as some industrial processes, with this hydrogen produced solely from electrolysis powered by renewable electricity.

[17] Only large-scale offshore and onshore generation, and very large individual demand customers, are likely to be directly connected to the transmission network. This means that these forecasts will capture nearly all demand and medium-scale, smaller-scale and domestic-scale generation in central and south Scotland.

[18] Source: scenario descriptions based on the ESO's 2020 FES (https://www.nationalgrideso.com/sites/eso/files/documents/introducing-the-fes-2020-scenarios_1.pdf)

7.2 Incorporating your views

Following the publication of our first DFES document on the 1st May 2020, we engaged with a wide range of stakeholders.

We received feedback from government bodies, local authorities, electricity and gas network companies, electricity suppliers, consumer groups, community energy groups, renewable generation developers, electric vehicle charge point operators, manufacturers and other interested parties. This engagement included bilateral meetings, responses to our DFES consultation, feedback via surveys, and workshops. We have considered all feedback in creating our DFES forecasts and to inform the development of our RIIO-ED2 Business Plan.

Section 7.2.1 summarises this feedback, and Section 7.2.2 explains how it has been incorporated within our DFES forecasts.

7.2.1 Summary of feedback

Our stakeholders agree the journey towards Net Zero will increase the reliance on electricity and the overall demand on the network, however the rate of decarbonisation will not be geographically uniform and clusters are likely to emerge.

Electric vehicles: Based on Scottish Government's own detailed assessment work and feedback, we updated our SPD Leading the Way scenario to include an accelerated electric vehicle uptake. This is because their legislated target of 75% greenhouse gas emission reductions by 2030 could feasibly accelerate electric vehicle uptake beyond the FES baseline high uptake scenario.

Most stakeholders think there is increased momentum in support of electric vehicles due to a range of factors. Stakeholders thought that air quality concerns, whole life costs becoming comparable to petrol/ diesel equivalents, improving battery quality and range, and increasing vehicle choice, will support the growth of electric vehicles. One stakeholder thought that electric vehicle uptake is likely to see a knee point around 2025-2026 once the second-hand car market develops – this is in line with the high uptake scenarios (SPD Leading the Way and SPD Consumer Transformation). Some stakeholders thought fleet vehicles would be amongst the early electric vehicle adopters.

Some stakeholders thought that increased home working, an increased use of public transport, and the expected development of autonomous and shared vehicles could drive a reduction in vehicle ownership towards 2050. SPD Consumer Transformation and SPD System Transformation scenarios reflect this decrease from the late 2030s to early 2040s. One stakeholder also sees an increased adoption of fuel cell cars contributing to a reduction in electric vehicles, potentially from 2030.

Stakeholders thought that some geographic areas will see a faster uptake than others, which is broadly aligned with the learning from EV-Up (see section 7.3.2).

Our stakeholders generally agreed that electric vehicle smart charging can provide flexibility. They broadly agreed with our forecasts that the majority of this would be from home charging; they generally did not expect much flexibility from rapid charging as this will mainly be used to charge vehicles mid-journey. Overall, stakeholders were satisfied with the smart charging capability forecast in the scenarios.

Our stakeholders believed that, whilst vehicle to grid (V2G) is technically possible, they did not expect it to offer material levels of flexibility within the next eight to ten years. This was for a range of reasons: most electric vehicle manufacturers currently void the warranty if this service is offered; limitations of existing battery technology; and limitations of existing charging technologies. This feedback is aligned with our forecasts.

Heat pumps: Based on Scottish Government's own detailed assessment work and feedback, we have updated our SPD Consumer Transformation scenario to include an increased heat pump uptake, mainly from 2025 onwards. This is because their legislated target of 75% greenhouse gas emission reductions by 2030 could feasibly accelerate heat pump deployment beyond the FES baseline high uptake scenario.

Other stakeholders saw the decarbonisation of heat as an area with greater uncertainty – the different 2050 scenario forecasts reflect that uncertainty. It was generally thought that there is no single way to decarbonise heat and there could be a combination of technologies coming into play; for example, heat pumps, district heating, bio-LPG and hydrogen. However, hydrogen was broadly thought not to be a mainstream option until the mid to late 2030s. This is consistent with the assumptions used across the scenarios.

Our stakeholders were in agreement that heat pump uptake is more likely to occur in new build properties and off-gas grid properties. This was because, for other property types, there were concerns about costs and the feasibility of retrofits given space availability. Even though there were mixed views regarding the extent of the retrofits, it was agreed that a degree of retrofits will be required.

The majority of our stakeholders considered there to be little scope for flexibility from heat pumps. This is primarily because customers will naturally want their heating on when they return home from work (the timing of which typically aligns with peak demand periods), and will be reluctant to compromise on heat comfort levels. It was agreed that hot water tank storage could enable some flexibility, but the associated cost and space requirements do not make this feasible for every household. We feel that our forecast range of heat pump flexibility (2-5% reduction of heat pump contribution to peak demand in the SPD Steady Progression scenario to between 2-32% in the SPD Consumer Transformation scenario) reflects this feedback.

Distributed Generation: There was strong consensus from stakeholders that the amount of distributed generation will significantly rise in the transition towards Net Zero. The specifics of the growth rate will likely depend on future policy, network capacity, project economics, and planning timescales.

Our stakeholders were in agreement that onshore wind is the generation technology most likely to increase significantly to meet Net Zero by 2045, and will most likely follow the SPD Consumer Transformation scenario. Considerable growth is also expected for solar PV technologies due to their low cost. Storage is also expected to grow and potentially be co-located with other forms of renewable generation.

Rural areas are anticipated to see more renewable generation than urban areas due to better space availability.

Some stakeholders also indicated that hydrogen could also be used for electricity generation in dispatchable power stations. Such a model would ideally use excess solar PV and wind generation to produce hydrogen through electrolysis for these plants.

7.2.2 How we updated our forecasts

We applied a number of updates to our scenarios to reflect what our stakeholders told us. The table below summarises the feedback we received and explains the resulting action we took. These changes were all incorporated in our December 2020 update; this May 2021 publication does not make any further changes to these.

Electric vehicles	
Stakeholder feedback	**Actions we took**
Consider a more rapid uptake of electric vehicles to help achieve the legislated target of 75% carbon reduction by 2030.	We updated the electric vehicle forecast for the SPD Leading the Way scenario to show a faster adoption rate.
By 2050 the number of vehicles is expected to decrease due to autonomous and shared vehicles, and increased home working.	We believe this is an area of great uncertainty. However, our assumptions for autonomous vehicles were updated in line with the ESO's 2020 FES, other than in SPD Leading the Way scenario.
Bus electricity consumption is expected to be around 1.6kWh/mile.	We updated our assumptions for electricity consumption for buses in all scenarios. This change had limited impact on peak demand, as most bus charging will occur outside of peak demand periods.
Destination charging at popular tourist spots could be a significant challenge, particularly in remote areas.	We updated all scenarios to incorporate the contribution from destination charging at popular tourist spots.
The uptake of electric vehicles may see a "hockey stick" around 2025-26 as the second-hand car market picks up.	Our EV-Up project considers different socio-economic groups and their likelihood of purchasing new and second-hand cars. Our SPD Consumer Transformation and SPD Leading the Way scenarios already reflect that knee point, so we did not make updates.
Smart charging is key to the integration of electric vehicles in the network. The volume of flexibility from smart charging is likely to partly depend on the level of cost savings for electric vehicle owners.	We agree that smart charging will enable flexibility to connect more electric vehicles. Our flexibility assumptions already captured the potential for considerable peak demand impact reduction due to charging electric vehicles in a more flexible way.

Electric vehicles *continued*

Stakeholder feedback	Actions we took
Most car manufacturers do not cover battery degradation within their warranty if the vehicle is used for V2G services. This means V2G flexibility will likely be low. Another barrier is battery technology as battery cycling currently reduces battery life.	We agree with our stakeholders that V2G capability will be low in the coming decade. We updated our assumptions in line with the ESO's 2020 FES, which show V2G making an increasing contribution from the 2030s – we did not adjust this further as we anticipated that rapid improvements in battery technology could mean that warranties and battery degradation may not be a such a barrier to V2G over the longer term. We will continue to monitor further technology developments in this area.

Heat pumps

Stakeholder feedback	Actions we took
Consider a more rapid uptake of heat pumps to help achieve the legislated target of 75% carbon reduction by 2030.	We updated the heat pump forecast for the SPD Consumer Transformation scenario to show a faster adoption rate.
Air source heat pumps (ASHPs) will not materialise in grade 1 and 2 listed buildings.	We refined our heat pump allocation methodology to exclude these types of buildings. All scenarios were updated with this refinement.
Heating demand is likely to be less flexible than electric vehicle demand, as there is less appetite to compromise on comfort levels.	Stakeholders felt there to be little scope for flexibility from heat pumps. We slightly increased the range of potential flexibility response, in line with the ESO's 2020 FES.

Hydrogen

Stakeholder feedback	Actions we took
Electricity demand is expected to increase due to hydrogen production through electrolysis.	Electrolysis is one potential option for hydrogen production. Our analysis assumed that electrolysis would primarily take place at transmission level, and so will not impact distribution peak demand. We therefore did not update our forecasts.

Distributed Generation

Stakeholder feedback	Actions we took
In rural areas high uptakes may be more prevalent, whereas this would not be realistic for urban areas.	We improved our rurality assumptions used in the allocation of the different generation technologies and storage. All scenarios were updated with this change.
Storage is likely to develop in high energy industrial and commercial (I&C) and urban areas for peak shaving.	
No large-scale solar PV and wind generation is likely to be sited in Areas of Outstanding Natural Beauty (AONBs).	We improved our allocation methodology for generation to limit the size of the developments close to National Parks and AONBs. All scenarios were updated with this change.
Non-renewable generation is likely to reduce to achieve Net Zero, as it would require negative emissions.	We updated our forecasts to incorporate hydrogen fuelled generation and a reduction in non-renewable generation.
Hydrogen could be used for electricity generation in the future.	
Storage is expected to account for at least 25%, rising over time.	In our forecasts, electricity storage accounts for 20-26% of the total generation capacity. This does not include the inherent storage capacity in electric vehicles.

7.3 Electricity demand

This section sets out the forecasts for demand. The two main drivers of increased demand are the electrification of transport and heat, so we provide disaggregated forecasts for each.

7.3.1 Demand overview

Understanding how electricity demand could evolve on the SP Distribution network is the first key factor informing the need for network intervention to increase or manage network capacity.

Electricity demand out to 2050 will be affected by:

1. energy efficiency and underlying demand trends;
2. the extent of new sources of demand, i.e. how much heating and transport is electrified;
3. the speed of the uptake of new sources of demand and when this happens;
4. the degree to which both existing and new load can be shifted or reduced at times of system peak demand (flexibility).

Figure 4 shows how the SP Distribution total peak demand will vary for the four scenarios, assuming that none of the demand is flexible (i.e. it can't be shifted away from the peak to less busy periods, which would have the effect of reducing peak demand). For comparison, the grey area shows the forecasted range (the difference between the lowest and highest scenario) from our July 2020 DFES.

There is a material split between the scenarios. Even though SPD System Transformation, SPD Consumer Transformation and SPD Leading the Way all achieve the Scottish Government's 2045 Net Zero target, this is achieved through differing levels of electrification. Both SPD Consumer Transformation and SPD Leading the Way involve a near total shift to the electrification of cars and light goods vehicles, and increasing levels of electric heating. These factors significantly increase the peak demand. In comparison, SPD System Transformation and SPD Steady Progression involve less electrification of heat and transport, with more reliance on other energy vectors (e.g. petrol, diesel, natural gas, hydrogen) for these two activities. As a result, these two scenarios do not increase electricity peak demand to the same extent.

Figure 4 | Electricity peak demand without flexibility

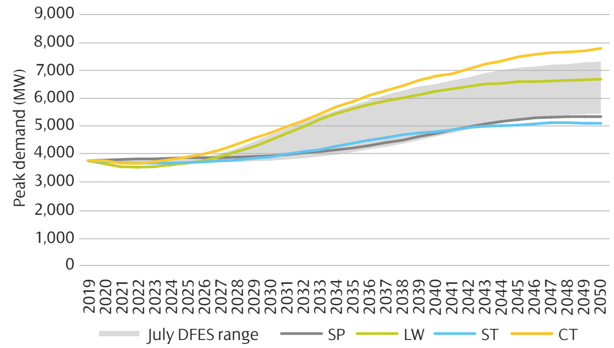


Figure 4 shows the 'worse case' impact, as it assumes that no existing or new demand has any flexibility. This does not reflect reality: some existing demand could shift to other times of the day and some new demand could be controlled in a smart way to avoid certain hours of the day when the distribution network is seeing more demand, for example when charging electric vehicles.

Without flexibility, demand could increase by 26% by 2030 and double by 2050.

With flexibility, demand could increase by 15% by 2030 and 55% by 2050.

Figure 5 shows how demand flexibility (excluding vehicle to grid) could reduce the SP Distribution total peak demand.

It shows that flexibility could reduce peak demand by 3-13% by 2030 compared with no demand flexibility, depending on the scenario. Such a reduction will directly deliver benefits for consumers as it will require less investment in the network, resulting in lower electricity bills. SPD Consumer Transformation and SPD Leading the Way involve greater levels of heat and transport electrification. There are therefore greater levels of electric vehicle and heat pump flexibility for these two scenarios.

To better illustrate what is driving the changes in demand, and where the demand flexibility is coming from, Figure 6 shows a breakdown of the components of the Figure 5 peak demand forecast for 2030 and 2050. The difference between the solid (flexible) and dashed (non-flexible) forecasts in Figure 5 are shown by the shaded components in Figure 6 – the shaded components represent what can be flexibly controlled.

Given the benefits of flexibility, all subsequent demand forecasts in this report assume flexibility will be available to the extent shown in Figure 5 and Figure 6 (e.g. where an electric vehicle forecast shows the impact on peak demand, those forecasts assume electric vehicle demand flexibility).

Figure 5 | Electricity peak demand with and without flexibility

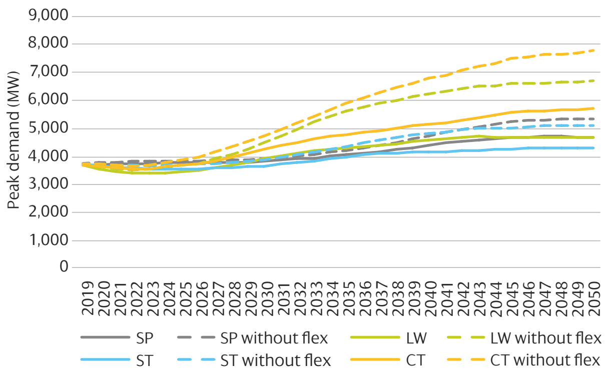


Figure 6 | Electricity peak demand breakdown for 2030 and 2050

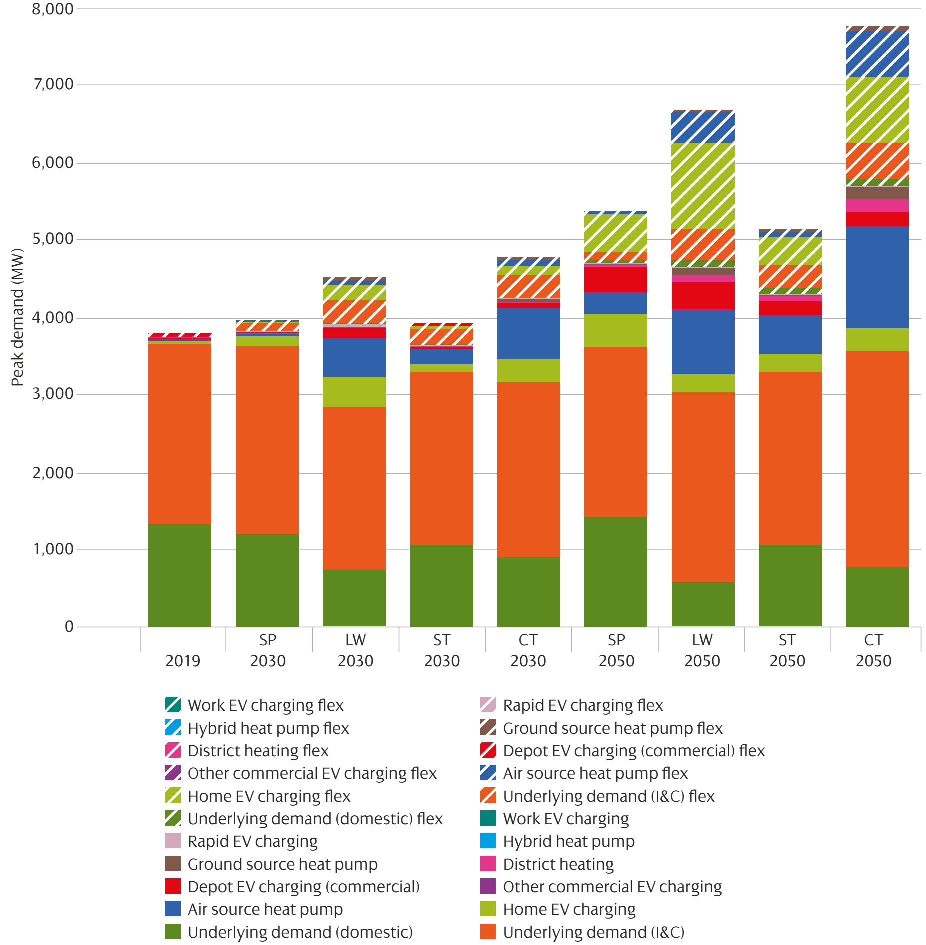
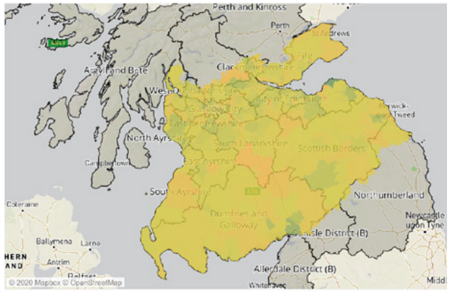


Figure 5 and Figure 6 show increasing electricity demand for all scenarios in the medium to long term. These forecasts and trends are the total values for Central and Southern Scotland. However, different regions will see different increases in demand at different times, based on a range of factors. Figure 7 shows the geographical breakdown for how the demand could change from current levels for the highest and lowest forecast scenarios.

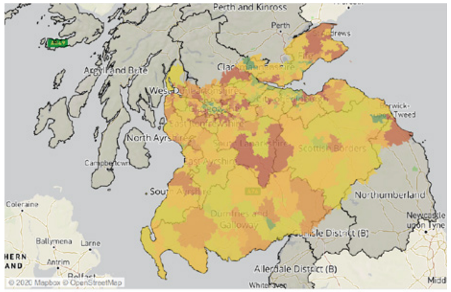
Figure 7 shows there is clear variance in the demand changes seen in different regions.

Figure 7 | Electricity peak demand changes from 2019 by primary substation area *Scale range: -3MW to >5MW*

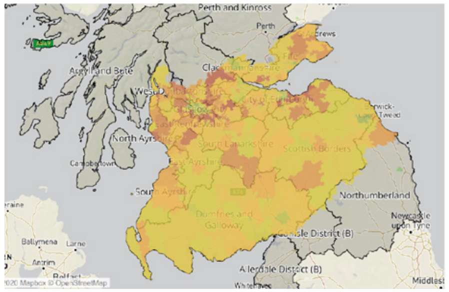
2030 – Low



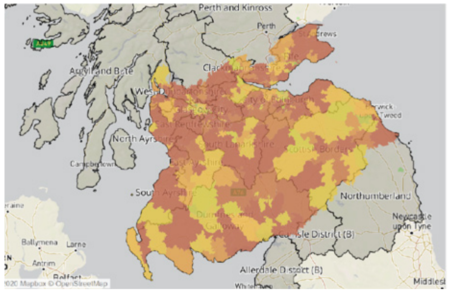
2050 – Low



2030 – High



2050 – High



Overall demand trends:

1. All scenarios show increasing demand. This means that the distribution network will need intervention to facilitate Net Zero.
2. Demand flexibility can help reduce peak demand. This would deliver benefits to consumers. This means that we should all be working to enable flexibility.
3. The increase in demand is not geographically uniform – some areas of the network will be impacted earlier, and to a greater extent, than others.

7.3.2 Electric vehicles

The number of electric vehicles – both plug-in hybrids and battery electric – registered within the SP Distribution area is currently over 11,000. However, momentum in support of electric vehicle adoption is building quickly. While there has been a drop in petrol and diesel vehicle registrations this year, electric vehicle sales have increased almost three times compared to the previous year.

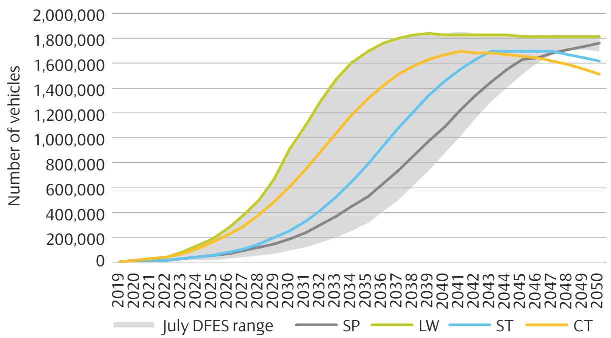
Figure 8 shows the forecast numbers of residential battery electric vehicles in the SP Distribution region. For comparison the grey area shows the forecasted range (the difference between the lowest and highest scenario) from our July 2020 DFES.

Figure 8 shows that across the scenarios, the share of residential battery electric vehicles rises from circa 5,000 in 2019 to between 193,000-914,000 by 2030. The high end of this range reflects Scotland's previous ambition for no new petrol and diesel cars and vans by 2032 – this is captured in our SPD Consumer Transformation scenario, with SPD Leading the Way being a few years further ahead, and the legislated targets for carbon emission reductions accelerating the uptake of electric vehicles. Compared to today, this would mean around 200 times more battery electric vehicles by 2030 and over 410 times more by 2040 in our SPD Leading the Way scenario.

Our SPD Steady Progression and SPD System Transformation scenarios contain a much slower uptake of residential battery electric vehicles between 2020-2030 followed by a much higher adoption from the early 2030s onwards, reaching over 1.6million by 2050.

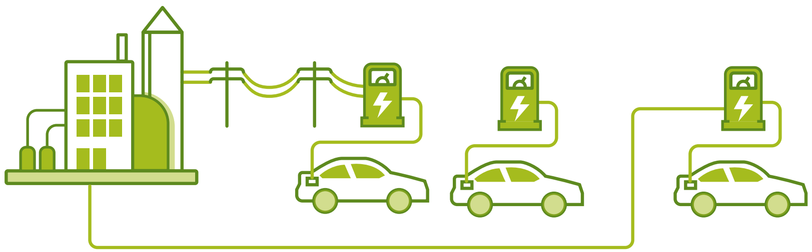
Whilst there is significant variance between scenarios across the 2030s and early 2040s, the total number of electric vehicles by 2050 is broadly similar across all scenarios.

Figure 8 | Residential battery electric vehicle uptake



Widespread adoption of electric vehicles is expected to provide a significant challenge to the electricity sector due to the resultant large increases in peak demand.

By 2030



EV charging could add to SPD's peak demand between

131-592MW

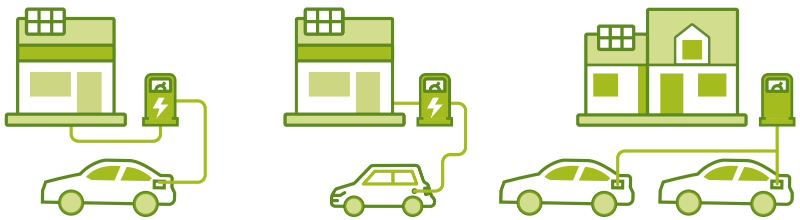
Smart charging could reduce this contribution by

6-35%

V2G could help decrease this by a further

0-22%

By 2050



EV charging could add to SPD's peak demand between

871-1,325MW

Smart charging could reduce this contribution by

54-83%

V2G could help decrease this by a further

28-165*%

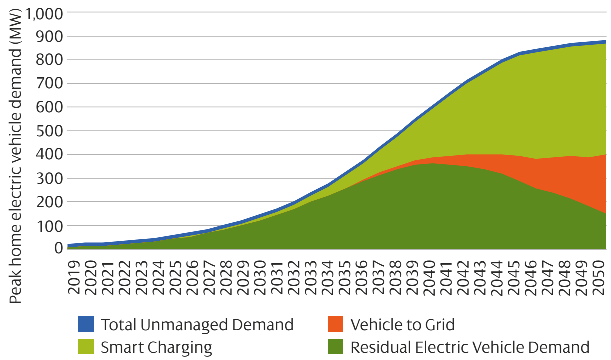
*The peak demand reduction above 100% means vehicle to grid has gone beyond offsetting the peak demand contribution from electric vehicles.

Electric vehicle charging could have a significant impact on the SP Distribution peak demand if left unmanaged. Smart charging and vehicle to grid are two ways to add flexibility to electric vehicle demand; respectively they help reduce this peak demand impact by shifting electric vehicle charging to a different time of day, and enabling electric vehicles to release electricity back to the network. Figure 9 shows the expected contribution from domestic electric vehicle charging at the time of peak, and the benefits of smart charging and vehicle to grid.

Figure 9 also shows that the development of effective smart charging and vehicle to grid capabilities could considerably reduce peak demand compared to not having this capability. This means that the development of smart charging and vehicle to grid could deliver significant benefits for customers.

There could be as many as 914,000 EVs within the SP Distribution network area by 2030.

Figure 9 | Home EV contribution to peak demand



The degree of geographical clustering of electric vehicle adoption will also be a key determining factor of the impact on the network – if there are high concentrations of electric vehicles in certain areas then there may be insufficient network capacity in those areas.

We have used our EV-Up project to provide a highly spatially disaggregated view of where the uptake of electric vehicles is likely to occur. The model combines detailed spatial analysis to determine off-street parking availability at an individual property level, and socio-demographic information to understand the probability of specific areas to transition to electric vehicles.

We have aggregated the results to show residential battery electric vehicle roll-out forecast by local authority area (Figure 10) and primary substation area (Figure 11). For all local authorities, we only provide forecasts for the area of that local authority which we serve. The values shown in Figure 10 represent the range between the low and high forecasts.

Figure 10 | Potential range of residential battery EV uptake by local authority (by 2030 and 2050)

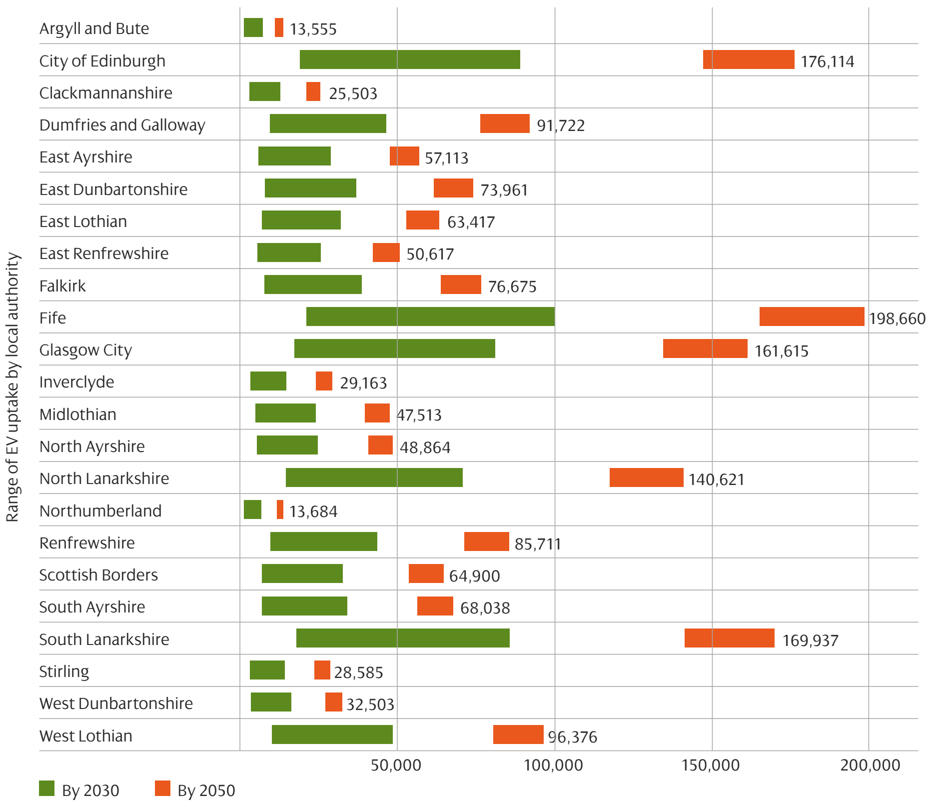
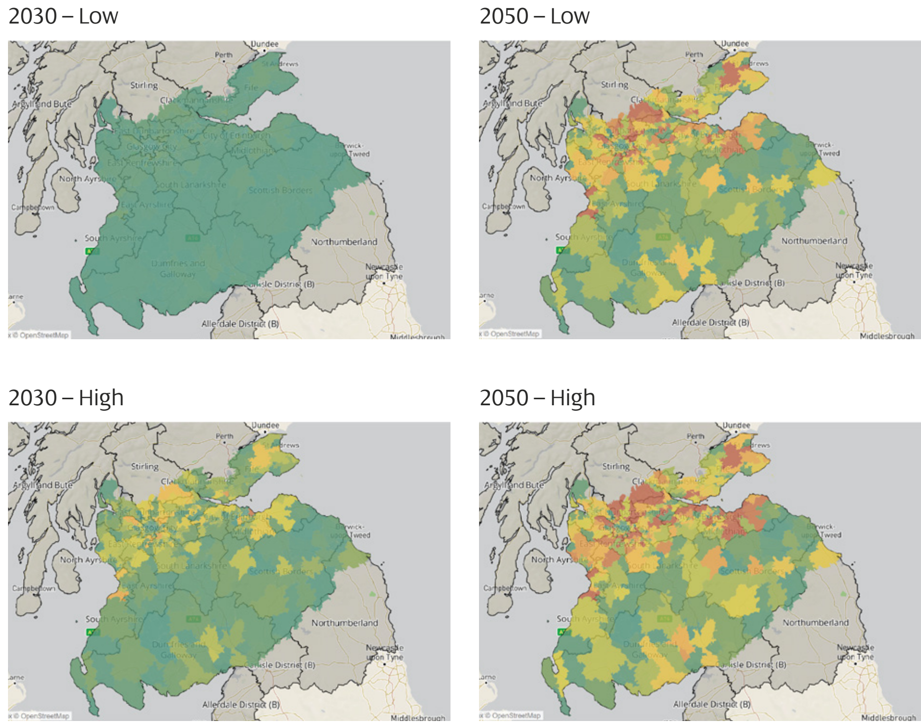


Figure 10 shows that in Central & Southern Scotland, residential battery electric vehicles are predominantly found in densely populated areas such as Glasgow, Edinburgh, South Lanarkshire or Fife, where each could see over 80,000 electric vehicles by 2030, increasing to over 160,000 by 2050.

Figure 11 | Residential battery EV uptake numbers by primary substation area

Scale range: 0 to >10,000



7.3.3 Heat pumps

Heat pumps use electricity to heat buildings and provide hot water. Heat pumps – both air source and ground source – represent another change to the future electricity demand. Deployment is currently very low, representing well under 1,000 households within a total stock of circa 2 million households in the SP Distribution area. Heat pumps can also take the form of hybrid systems where a gas boiler is used at times of peak demand, as well as larger scale heat pumps used for district heating.

We have forecast heat pump uptake given the potential impact they could have on the network. **Figure 12** shows the forecast uptake for each of the four scenarios. For comparison the grey area shows the forecasted range (the difference between the lowest and highest scenario) from our July 2020 DFES.

Figure 12 shows that there is significant variance between the heat pump forecasts.

This is for two reasons:

1. The SPD Steady Progression scenario achieves less decarbonisation overall compared to the other three scenarios.
2. There are low carbon alternatives to small-scale heat pumps: district heating and hydrogen in the gas network are the two lead possibilities. SPD Consumer Transformation and SPD Leading the Way have a much higher degree of heat electrification than SPD System Transformation.

Compared to electric vehicles, where the roll-out rate between scenarios is different but by 2050 the overall volumes are broadly similar, there is significant variance across the four scenarios for heat pumps. This means that there will be very different impacts on the electricity network depending on which heat decarbonisation route is followed.

The total proportion of homes with a heat pump could reach 26% by 2030.

Figure 12 | Electric heat pump uptake

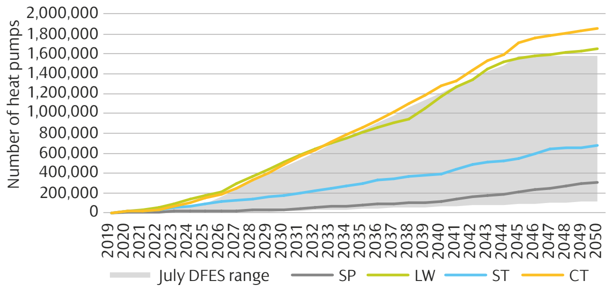


Figure 13 shows the impact on peak demand of the high scenario forecast and the potential of heat pump flexibility. **Figure 14** shows the same information for the low scenario forecast.

Figure 13 shows that the development of effective heat pump flexibility could reduce their associated peak demand contribution by up to 32% by 2050. This means that the development of this flexibility capability could deliver material benefits to network customers.

Heat pumps could have six times the network impact of electric vehicles.

Figure 13 | Heat pump contribution to peak demand (high scenario)

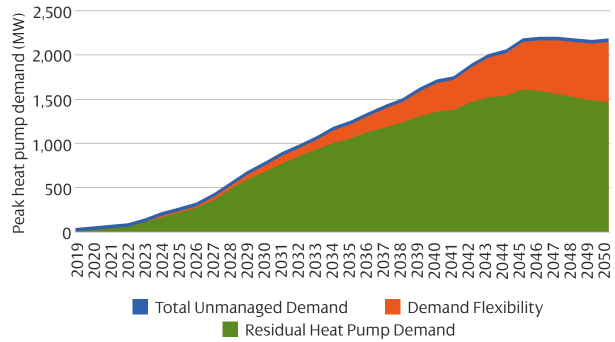


Figure 14 | Heat pump contribution to peak demand (low scenario)

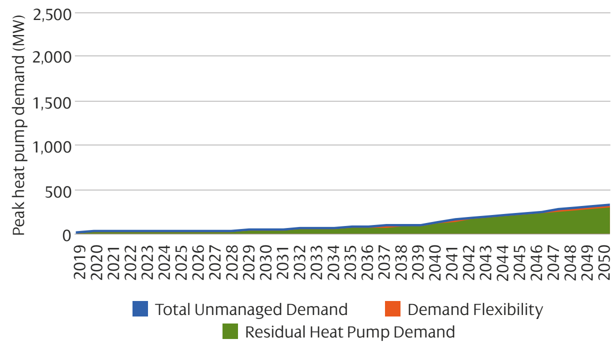
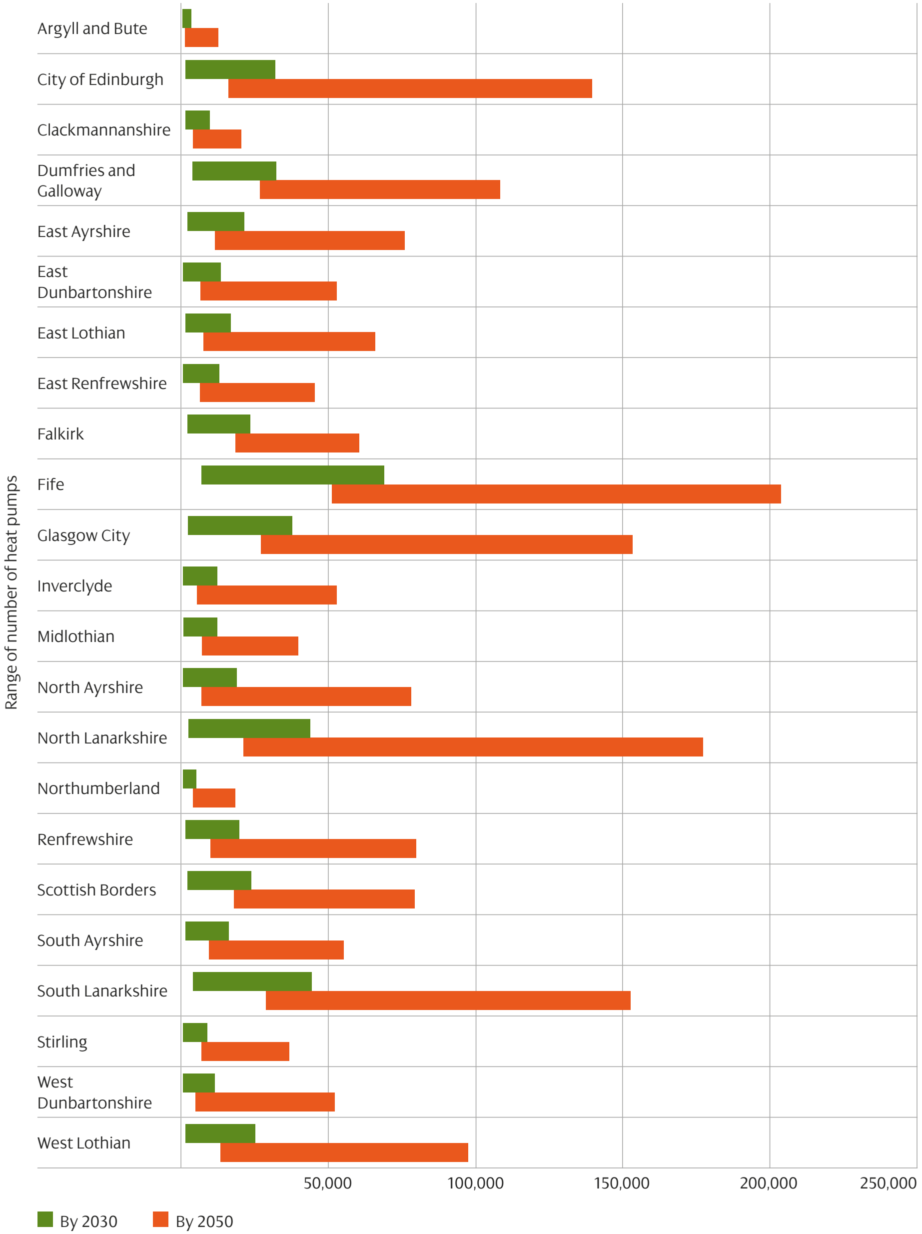


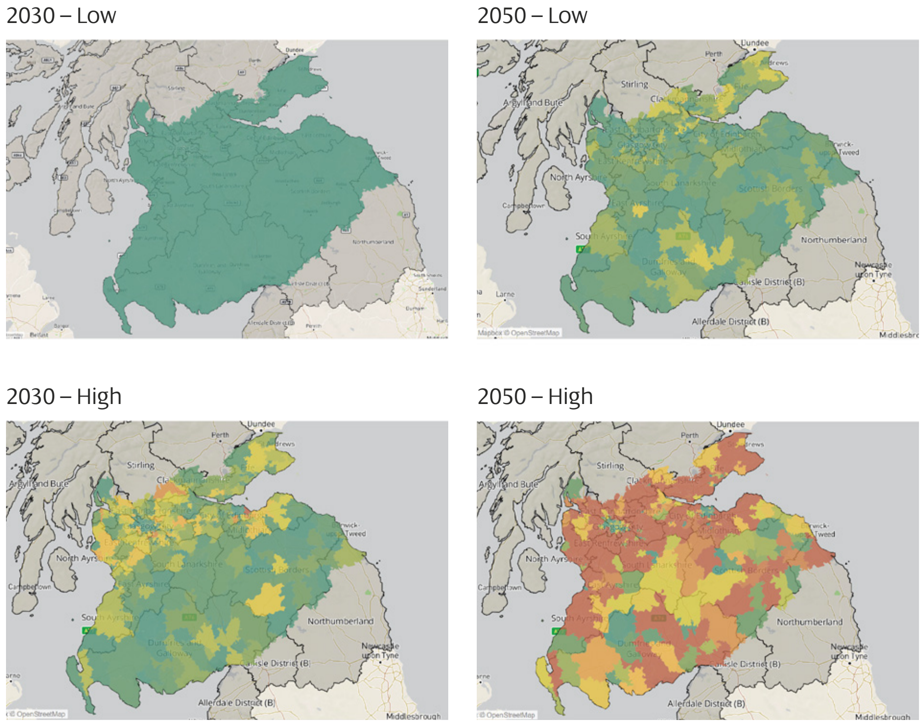
Figure 15 | Potential range of heat pump uptake by local authority (by 2030 and 2050)



The degree of geographical clustering of heat pump adoption will also be a key determining factor of network impact – if there are high concentrations of heat pumps in certain areas then there may be insufficient network capacity in those areas. Some targeting of heat pump deployment is expected; this is focused primarily on new build properties and off-gas grid properties where the economics of heat pumps look more favourable. To help identify heat pump clustering, heat pump roll-out has been forecast by local authority area (**Figure 15**) and primary substation area (**Figure 16**). For all local authorities, we only provide forecasts for the area of that local authority which we serve. The range of forecast values shown in **Figure 15** represents the range between the low and high forecasts.

Figure 16 | Heat pump numbers by primary substation area

Scale range: 0 to >5,000



7.4 Electricity generation and storage

This section sets out the forecasts for generation and storage. The main drivers are increased wind generation, solar PV generation, and storage, so we provide disaggregated forecasts for each.

7.4.1 Generation and storage overview

Understanding how electricity generation and storage could evolve on the SP Distribution network is the second key factor informing the need for more network capacity.

The volume of electricity generation connected to the distribution network in Central and Southern Scotland out to 2050 will be affected by:

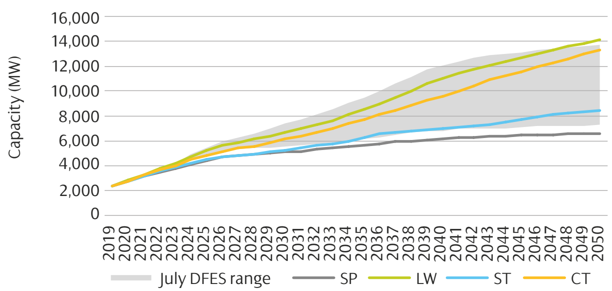
1. the overall requirement for more generation, i.e. how much additional generation capacity is required to supply the increase in demand.
2. the decentralisation effect – how much of that generation will be smaller-scale (and so connected to the distribution network) versus larger-scale (and so connected to the transmission network). This is driven by generation technology, economics and government policy.

These two factors, along with the type of generation, will determine the extent to which distributed generation and behind the meter generation may help offset increases in demand (which would reduce the need for more network capacity), or may lead to greater power flows across the distribution network (which would increase the need for more network capacity).

Figure 17 shows how the total generation and storage capacity connected to the Central and Southern Scotland distribution network will

In the next ten years, the generation and storage capacity on our network is likely to triple, reaching circa 7GW.

Figure 17 | Total installed generation and storage capacity



vary for the four scenarios. For comparison, the grey area shows the forecasted range (the difference between the lowest and highest scenario) from our July 2020 DFES.

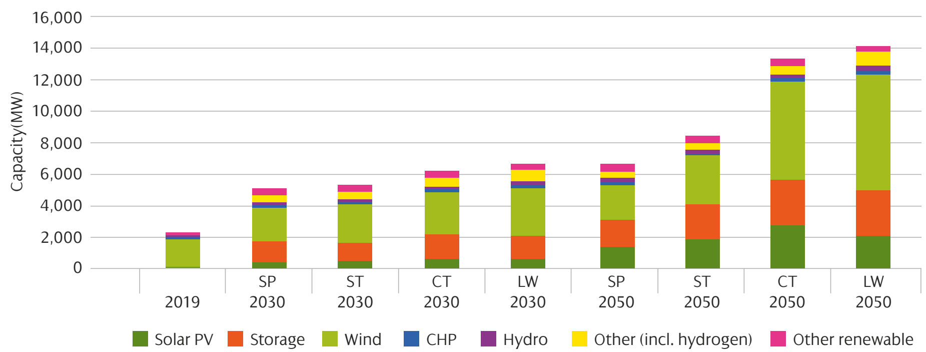
Figure 17 shows that our scenarios forecast the distributed generation and storage capacity in our SP Distribution region to be circa three times higher than today by 2030. By 2050, our scenarios indicate there could be as much as 3-6 times more generation and storage than today.

A significant increase in new generation capacity is expected in the next few years as known projects with connection requests come online. Beyond this, future growth is expected to be modest in the SPD Steady Progression and SPD System Transformation scenarios but could triple the amount of small-scale generation in the SPD Leading the Way scenario by 2030. To better illustrate what is driving the changes in generation, Figure 18 shows a breakdown of the generation and storage forecasts from Figure 17 by technology type, for 2030 and 2050.

Figure 18 shows that significant growth is expected, particularly from renewable generation. The majority of the increase in capacity to 2030 is expected to come from wind, solar PV, and storage. Given that wind and solar PV generation output is weather-dependent, it is unlikely to always occur at the same time as periods of high demand.[19] This means that the distribution network may need intervention to accommodate wind and solar PV generation capacity. It also means that there may be a greater export of power from the distribution network up onto the transmission network, and greater transfer of power across the transmission network, at times when generation output is high and demand is low.

Figure 17 and Figure 18 show increasing electricity generation for all scenarios out to 2050. These forecasts and trends are the total values for Central and Southern Scotland. However different regions will see different increases in generation, based on a range of factors.

Figure 18 | Breakdown of installed generation capacity by technology type

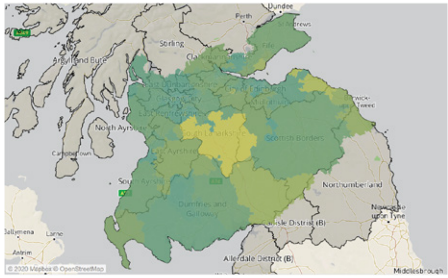


[19] This coincidence of generation and demand would have been beneficial for the network, as it tends to result in lower overall power flows and a lower requirement for network capacity.

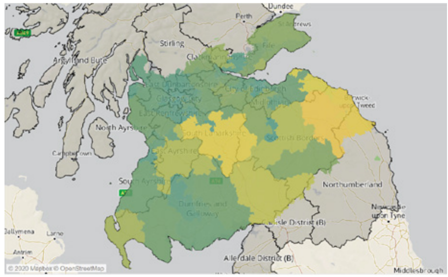
Figure 19 | Installed generation and storage capacity by GSP area

Scale range: 0MW to >500MW

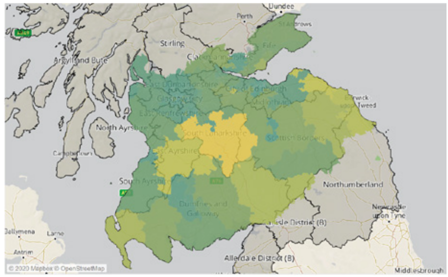
2030 – Low



2050 – Low



2030 – High



2050 – High

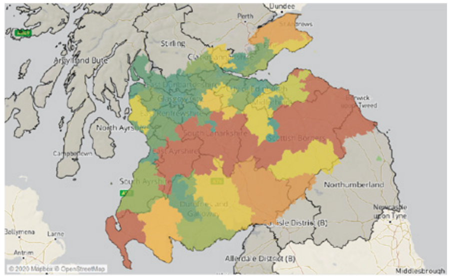
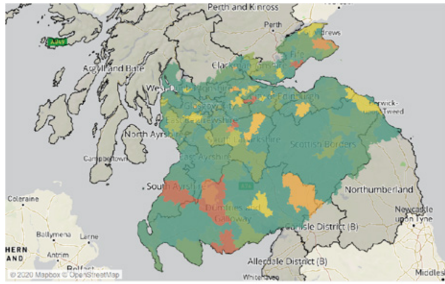


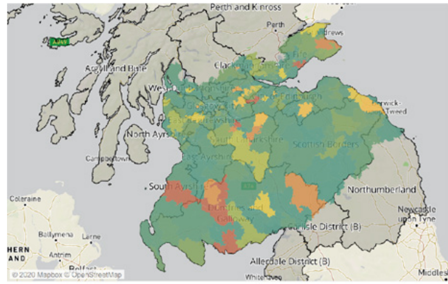
Figure 20 | Domestic-scale and smaller-scale installed generation and storage capacity by primary substation area

Scale range: 0MW to >15MW

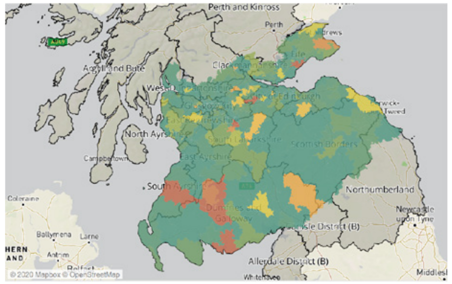
2030 – Low



2050 – Low



2030 – High



2050 – High

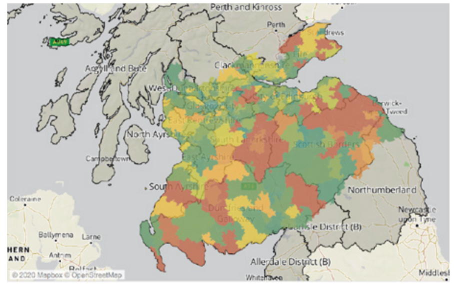


Figure 19 shows the geographical breakdown of how the generation and storage capacity connected to the distribution network could change by 2030 and 2050 from current levels for the highest and lowest forecast scenarios. Figure 20 shows a similar representation, but only for domestic-scale and smaller-scale generation and storage.

Overall generation and storage trends:

1. All scenarios show a significant increase in generation and storage capacity. This means that the network will need intervention to facilitate Net Zero.
2. Generation and storage can help reduce peak demand and deliver real benefits to consumers. This means that we should all be working to enable flexibility.
3. The increase in generation and storage is not geographically uniform – some areas of the network will be impacted earlier, and to a greater extent, than others.

7.4.2 Solar PV

Over the past five years, our distribution network has seen a slower uptake of solar PV generation compared to other technologies such as wind. However, this growth is likely to increase to facilitate the further decarbonisation of electricity generation.

Figure 21 shows the forecast uptake of solar PV for the four scenarios. It shows significant future increases in solar PV capacity across all scenarios, potentially increasing five times from current levels by 2030 and 20 times by 2050. The increase in solar PV across all four scenarios is due to it being a low-cost and tried and tested technology, with a lower visual and noise impact than other forms of renewable generation. Unfortunately, the beneficial impact of solar PV offsetting peak demand on the network is likely to be limited, given that its output does not currently coincide with the times of winter peak demand (as these occur in the hours of darkness).

Solar PV capacity can be split into two categories: small-scale building rooftop schemes, which are connected behind the meter, and larger-scale ground-mounted solar PV farms, which connect directly to the distribution network. Figure 22 shows a breakdown of the Figure 21 solar PV forecasts for these two categories, for 2030 and 2050.

Figure 22 shows that, for all scenarios, the main growth is expected to come from larger-scale ground mounted solar PV. New capacity for behind the meter solar PV is expected to be focused in areas that have already had some uptake due to subsidy support from Feed-in-Tariffs. Larger-scale ground-mounted solar PV schemes are expected to be deployed in more rural areas, due to the additional land area needed.

Solar PV generation could be five times greater than today by 2030.

Figure 21 | Installed solar PV generation capacity

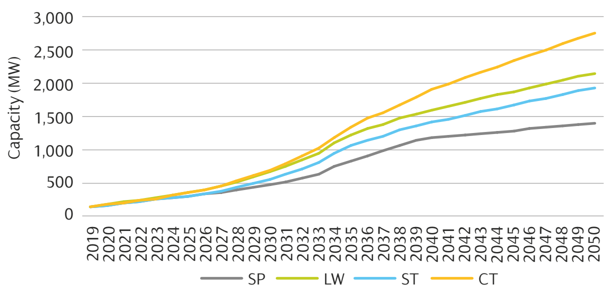
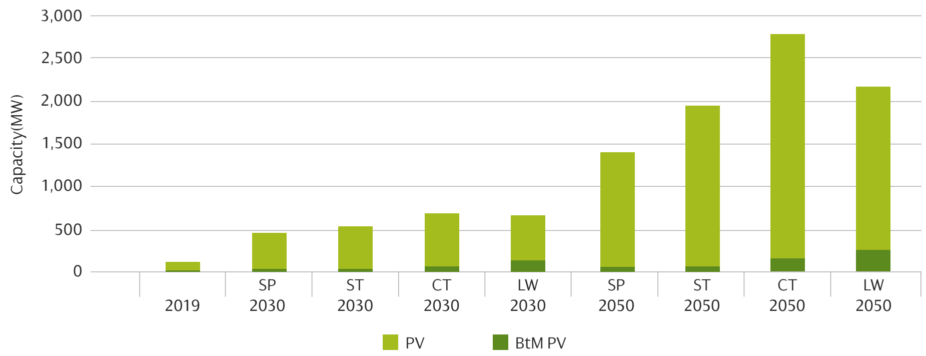


Figure 22 | Distribution connected and behind the meter solar PV capacity



7.4.3 Wind

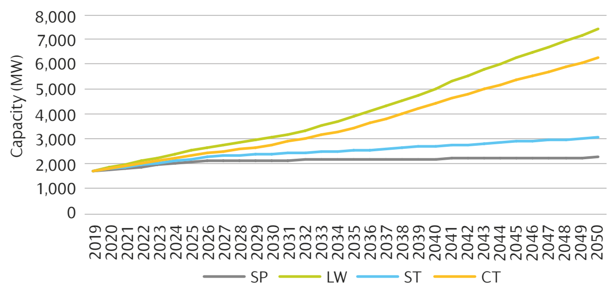
Over the last ten years, there has been steady growth in wind capacity on the SP Distribution network leading to circa 1.7 GW of installed capacity.

Figure 23 shows significant variance in the levels of wind generation across the four scenarios. Wind generation is a cost-effective established technology, so the extent of new wind generation will likely depend on the onshore planning regime, government/policy support, and local support for individual schemes. Any increase in distribution connected wind is expected to be sited in rural areas, taking advantage of more favourable wind conditions.

The beneficial impact of wind generation offsetting peak demand on the network could be limited, given that it is weather-dependent.

Wind generation could increase by up to 80% by 2030.

Figure 23 | Installed wind generation capacity



7.4.4 Storage

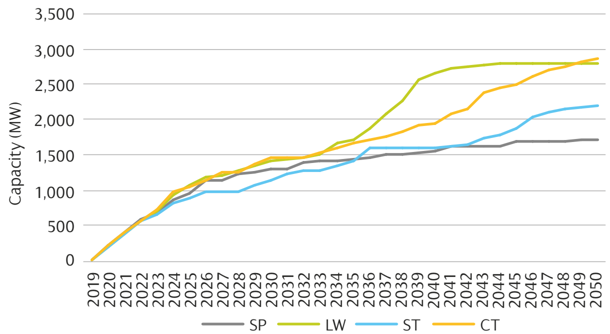
Electricity storage means any technology which can import, store and export electricity. It can range from large-scale pumped hydro schemes down to domestic-scale battery units. Electricity storage can help manage peak demand (by exporting to reduce local demand) and provide valuable system services (such as frequency response). As we move to a decarbonised system with renewable generation, storage is likely to play a valuable role in balancing that generation and ensuring system stability.

Figure 24 shows the forecast uptake of electricity storage for the four scenarios. Given the many different storage technologies and their evolving nature, we have not created individual forecasts for each technology.

Figure 24 shows significant growth in distribution connected storage capacity is expected through the 2020s and early 2030s. Beyond 2035, growth could be substantial in scenarios where there is more decentralised generation, in particular solar PV, that storage would help to manage.

In the next five years there is likely to be more storage growth than in any other generation technology.

Figure 24 | Installed storage capacity



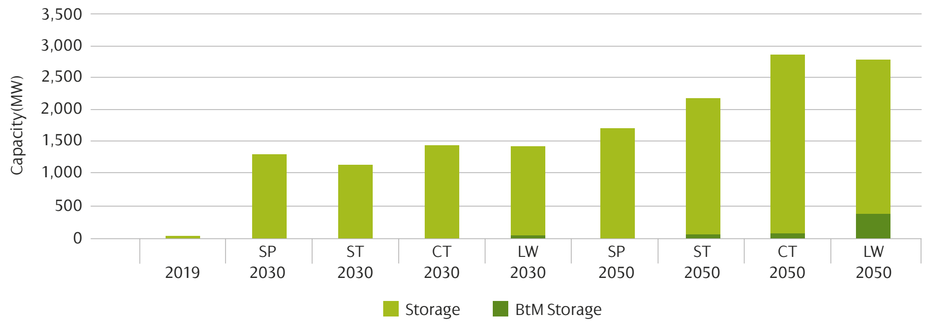
Distribution connected storage is assumed to be sited initially in areas with low network constraints (to allow services to be provided to the wider system). At different points in time, depending on the scenario, the siting of storage then shifts to areas of high network constraint, as the value of providing distribution level constraint management services increases.

Storage capacity can be split into two categories: small-scale storage at individual properties, which are connected behind the meter, and larger-scale standalone storage, which connects directly to the distribution network. Behind the meter storage is generally assumed to be sited alongside rooftop solar PV installations. Figure 25 shows a breakdown of the Figure 24 storage forecasts for these two categories, for 2030 and 2050.

Figure 25 shows that, across all scenarios, the majority of storage growth is for standalone storage. It is worth noting that, the forecasts in Figure 24 and Figure 25 do not include the inherent storage capacity in electric vehicles. When plugged in, electric vehicles could be another widespread form of electricity storage – smart charging and vehicle to grid technologies would enable this capability.

Storage capacity could be over 70 times higher than today by 2030.

Figure 25 | Distribution connected and behind the meter storage capacity



8

Reconciliation with the ESO's 2020 FES

This section provides a comparison between the SP Distribution forecasts and the ESO's 2020 FES for key building blocks.

As we explain in Section 6, we use the ESO's FES as a starting point for our DFES forecasts. However the FES is not detailed enough for our requirements, so we significantly augment it to provide a much more regionally reflective and geographically granular view. This is done using a combination of top-down and bottom-up assessments, stakeholder feedback, devolved government policy and plans, and other regional data.

Once we create DFES forecasts, it is important to reconcile them back to the ESO's FES. This is to identify any significant discrepancies. We reconcile back using common building blocks[20] and FES regionalisation[21] to compare our DFES forecasts to the FES forecasts.

This section provides a comparison of our DFES forecasts to the regionally equivalent ESO's 2020 FES for key building blocks. Other building block data is available in the DFES data workbooks[22].

8.1 Electric vehicles

Our forecasts for the uptake of battery electric vehicles in the SP Distribution network are broadly aligned with FES, as shown in Figure 26. However, based on Scottish Government's own detailed assessment work and feedback, we have updated our SPD Leading the Way scenario to include an accelerated electric vehicle uptake. This is because their legislated target of Net Zero by 2045, five years earlier than the rest of the UK, and interim 75% greenhouse gas emission reductions by 2030 could feasibly accelerate electric vehicle uptake beyond the FES Leading the Way scenario (the FES's highest EV uptake scenario).

[20] As part of ENA Open Networks' project, all DNOs committed to preparing their DFES using the same scenario framework as the ESO GB FES and to share data using a common set of building blocks.

[21] To compare the national FES forecasts to our regional DFES, we need to know what proportion of the total FES forecasts equates to our licence area. We do this using the grid supply point (GSP) break-down contained in the FES – the FES contains forecasts for each building block for every GSP. We compare our DFES forecasts to the aggregate of the FES forecasts for the GSPs within our licence area.

[22] www.spenergynetworks.co.uk/dfes

Figure 26 | Battery electric vehicle uptake comparison (Lct_BB001 and Lct_BB003)

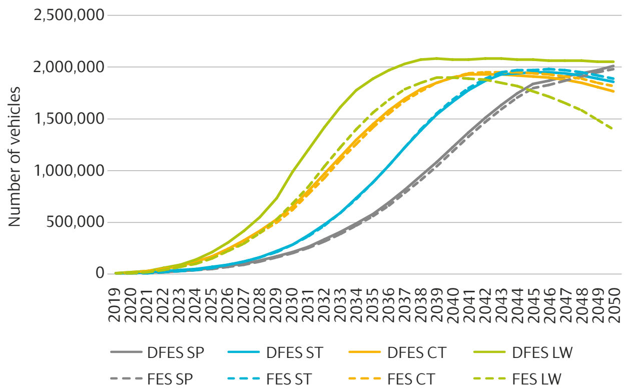


Table 1 provides a comparison with FES for battery electric vehicles by 2030.

Table 1 | Battery electric vehicle volumes by 2030

Volumes at 2030		Cars and motorbikes Lct_BB001	Other vehicle types Lct_BB003
DFES	Steady Progression	0.20	0.01
	System Transformation	0.27	0.02
	Consumer Transformation	0.63	0.03
	Leading the Way	0.93	0.06
FES	Steady Progression	0.19	0.01
	System Transformation	0.26	0.02
	Consumer Transformation	0.60	0.03
	Leading the Way	0.63	0.05

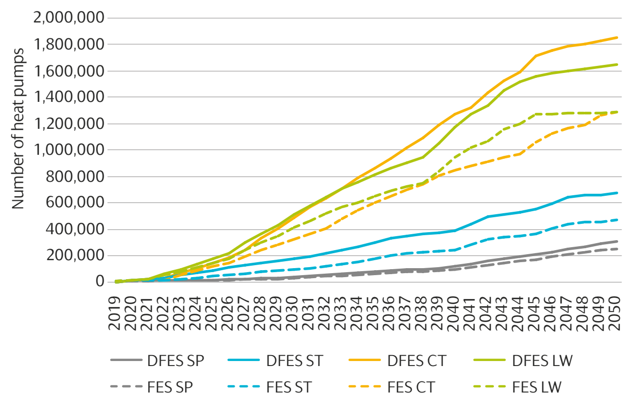
8.2 Heat pumps

Our forecasts for the uptake of heat pumps in the SP Distribution network consider a higher uptake of heat pumps, mainly from 2025 onwards, as shown in Figure 27. This is for two reasons.

Firstly, the ESO's FES does not include the Scottish legislated target of Net Zero by 2045 and interim 75% greenhouse gas emission reductions by 2030, meaning heat pump uptake in Scotland could feasibly accelerate beyond the FES baseline.

Secondly, the Scottish Government has recently published their Heat in Buildings Strategy consultation[23]. This sets out their plans to achieve Net Zero emissions in buildings by 2045, and the pace of this transition over the next 10 years. This includes over 1 million homes and 50,000 non-residential properties switching to low carbon heating systems to meet 2030 targets. This Strategy was published after the ESO's 2020 FES, so the FES forecasts did not incorporate it. We revised our forecasts based on engagement with the Scottish Government.

Figure 27 | Domestic heat pump uptake comparison (Lct_BB005 and Lct_BB006)



[23] https://www.gov.scot/publications/heat-buildings-strategy-achieving-net-zero-emissions-scotlands-buildings-consultation/pages/1/

Table 2 provides a comparison with FES for domestic heat pumps by 2030.

Table 2 | Domestic heat pump volumes by 2030

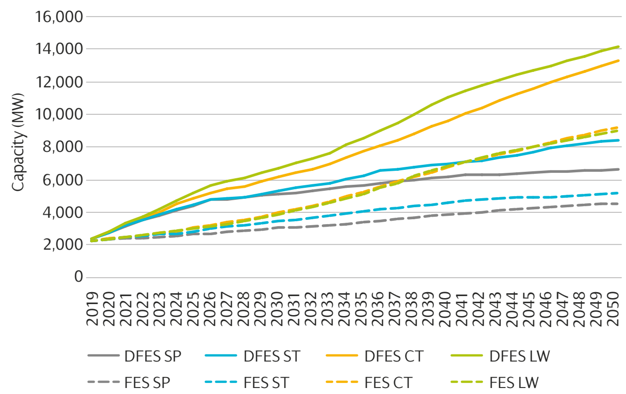
Volumes at 2030		Domestic non-hybrid Lct_BB005	Domestic hybrid Lct_BB006
DFES	Steady Progression	0.02	0.02
DFES	System Transformation	0.12	0.06
DFES	Consumer Transformation	0.44	0.05
DFES	Leading the Way	0.35	0.16
FES	Steady Progression	0.01	0.02
FES	System Transformation	0.05	0.05
FES	Consumer Transformation	0.29	0.04
FES	Leading the Way	0.28	0.13

8.3 Overall distributed generation and storage capacity

Our distributed generation forecasts show a faster uptake in the short-term for all scenarios and a similar growth trend to FES in the medium to longer term. This results in an overall higher installed capacity. This faster uptake in the earlier years is mainly driven by the number of known generation projects currently in development, and review of the remaining pipeline of contracted generation connections.

We reviewed these projects against progression criteria such as project design, submission and granting of planning, project finance, past or recent connection requests, or commencement of delivery.

Figure 28 | Distributed generation and storage capacity comparison (Gen_BB001 to Gen_BB023, Srg_BB001 to Srg_BB004)



The main growth in distributed generation capacity is driven by three technologies: solar PV, wind, and storage. Table 3 below provides a summary of the expected overall growth and for these three technologies, for each scenario by 2030, in addition to the current baseline.

Table 3 | Additional generation and storage capacity by 2030

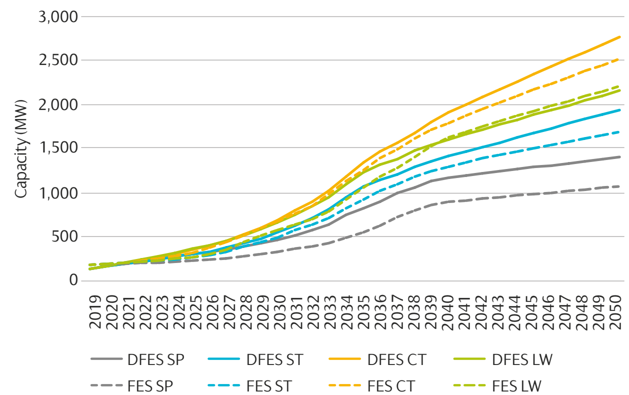
Additional GW at 2030		Total DG Gen_BB001-023 Srg_BB001-004	Solar PV Gen_BB012-013	Wind Gen_BB014-016	Storage Srg_BB001-004
Currently connected		2.4	0.1	1.7	0.0
DFES	Steady Progression	2.7	0.3	0.4	1.3
DFES	System Transformation	2.9	0.4	0.7	1.1
DFES	Consumer Transformation	3.8	0.6	1.1	1.5
DFES	Leading the Way	4.3	0.5	1.4	1.4
FES	Steady Progression	0.8	0.2	0.4	0.2
FES	System Transformation	1.2	0.3	0.5	0.2
FES	Consumer Transformation	1.8	0.5	0.8	0.4
FES	Leading the Way	1.7	0.4	0.8	0.3

8.4 Solar PV generation

Our solar PV generation forecasts show a similar growth trend to FES in the short-term, with a slightly faster uptake in the SPD Steady Progression scenario, as shown in Figure 29. This is driven by the number of known generation projects that are in development.

In the medium to longer term, growth in renewable energy sources is expected to significantly increase to reach 50% of the energy for Scotland's heat, transport and electricity. This growth is expected to also increase with increased support from the Scottish Government on small scale generation and storage in buildings, set out in their Update to the Climate Change Plan. These targets translate into slightly faster uptakes across the scenarios.

Figure 29 | Solar PV generation capacity comparison (Gen_BB012 and Gen_BB013)



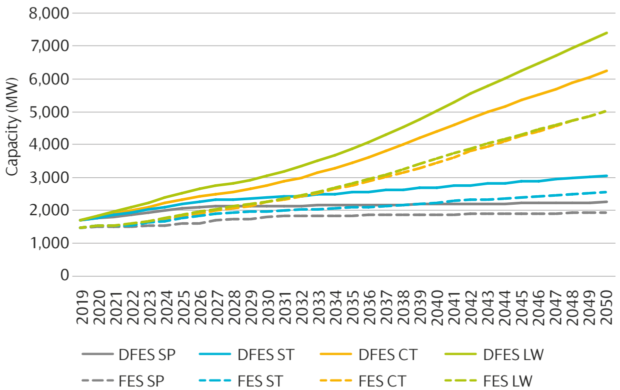
8.5 Wind generation

Scotland has a higher availability of wind resource than other parts of the UK. Onshore wind represents 72%[24] of the total generation capacity in Scotland, out of which over 19% is connected to the SP Distribution network.

Our wind generation forecasts show a faster uptake in the short-term for all scenarios, as shown in Figure 30. This faster uptake in the earlier years is mainly driven by the number of known generation projects that are in development. Wind generation in SP Distribution represents circa 37% of the currently accepted generation connection offers greater than 1MW, adding up to 0.9GW.

In the medium to longer term, our forecasts for wind show a similar growth trend to FES, resulting in an overall higher installed capacity.

Figure 30 | Wind generation capacity comparison (Gen_BB014, Gen_BB015 and Gen_BB016)



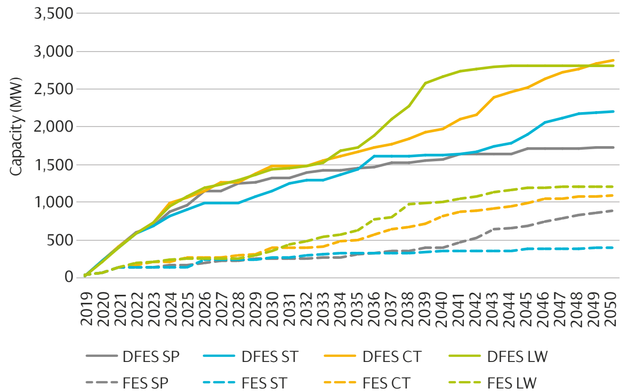
[24] https://www.scottishrenewables.com/our-industry/statistics

8.6 Storage

In recent years we have seen a significant increase in the level of connection enquiries for storage, including hybrid sites combining wind or solar PV with battery storage, leading to 28% of our current pipeline being battery storage. This means we are anticipating a faster growth in this technology over the short and medium term compared to the FES.

This growth is expected to also increase with increased support from the Scottish Government on small scale generation and storage in buildings, set out in their Update to the Climate Change Plan. These targets translate into faster uptakes across the scenarios.

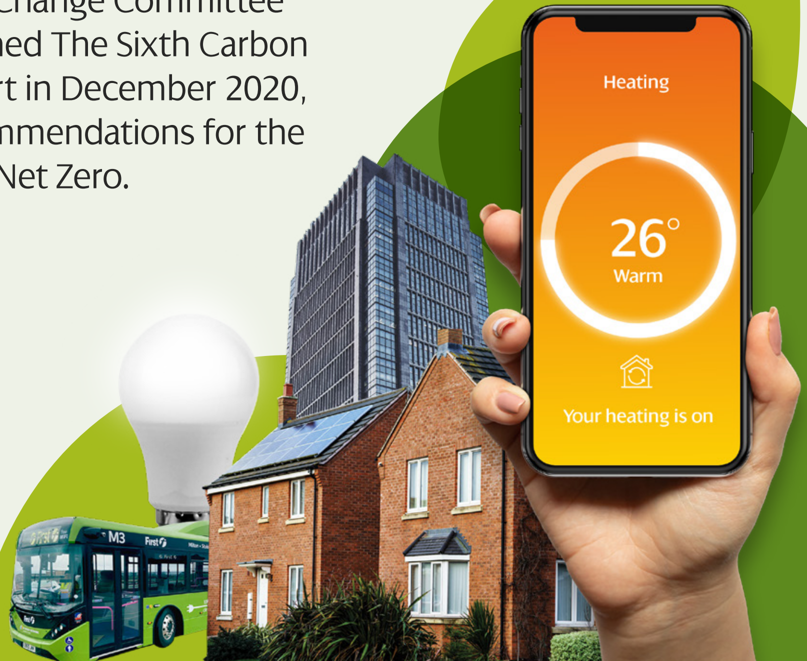
Figure 31 | Electricity storage capacity comparison (Srg_BB001 to Srg_BB004)



9

Incorporating the Climate Change Committee scenarios

The Climate Change Committee (CCC) published The Sixth Carbon Budget report in December 2020, setting recommendations for the UK's path to Net Zero.



This section provides an overview of the forecasts from the CCC, and compares them to the ESO's 2020 FES, and our SP Distribution DFES forecasts.

9.1 CCC's Sixth Carbon Budget

Carbon budgets are statutory caps for the level of greenhouse gas emissions over a five-year period, to provide a path towards achieving UK's emission reduction targets. These are a requirement under the Climate Change Act 2008[25].

The Sixth Carbon Budget[26] (for the period 2033-2037) is the first carbon budget publication after the UK introduced a legally binding target to achieve Net Zero by 2050, and Scotland by 2045. Some of the recommendations and conclusions included in this publication are:

- An emission reduction of 78% by 2035, compared to 1990 levels.
- All new cars and vans, as well as domestic and non-domestic boiler replacements to be low carbon (mainly electric) by the early 2030s.
- By 2035, UK electricity generation to be zero carbon.
- Demand for electricity increasing by half in the next 15 years and 2-3 times in the next 30 years due to decarbonisation of transport, heating, and industry.

[25] https://www.legislation.gov.uk/ukpga/2008/27/contents

[26] https://www.theccc.org.uk/publication/sixth-carbon-budget/

The CCC developed five scenarios to explore different pathways of achieving Net Zero. Some of the key scenario assumptions are summarised below[27]:

	Balanced NZ pathway	Headwinds	Widespread engagement	Widespread innovation	Tailwinds
Internal combustion engine ban (new cars and vans)	2032	2035	2030	2030	2030
HGV	Most cost-effective technology mix	Mostly hydrogen	Substantial electric road systems network	Mostly electric	Mix of low carbon technologies
Home energy efficiency	Medium	Low	Medium-High	Low	High
Residential building heating technology	Hybrid heat pumps, with 14% homes using hydrogen	Widespread conversion to hydrogen (86% of homes)	Fully electrified	Hybrid heat pumps, with 12% homes using hydrogen	Fully electrified except for areas by industrial clusters. 13% homes using hydrogen
Heat networks	Fully electrified	Hydrogen & large-scale HP	Fully electrified	Fully electrified	
Renewable Generation (% of total)	80%	75%	85%	90%	90%
Dispatchable Generation (% of total)	10%	15%	10%	8%	7%

[27] Source and full set of assumptions on: https://www.theccc.org.uk/publication/sixth-carbon-budget/

9.2 Regionalisation of CCC scenarios

The Sixth Carbon Budget dataset[28] provides scenario data for the whole of the UK and also splits the totals for Northern Ireland, Scotland, and Wales.

So we can compare the national CCC forecasts on a like-for-like basis with our regional DFES forecasts, the CCC forecasts have been disaggregated to produce regionally equivalent forecasts for each metric based on the FES GSP building block share.

These regionalised CCC scenarios enable stakeholders and us to understand what they mean for our networks. We have not applied any adjustment to the assumptions behind the CCC scenarios. We will seek stakeholder feedback through 2021, as part of our DFES process.

9.3 Range of future pathways

This section provides a comparison between the DFES forecasts, the regional GSP results from the ESO's 2020 FES, and the regionally equivalent CCC forecasts for the SP Distribution network for battery electric vehicles (BEVs) and heat pumps – we have shown these two metrics as they are the main drivers of increasing demand.

[28] The dataset is available on the CCC website.

9.3.1 Electric vehicles

Figure 32 shows the total volume of battery electric vehicles considered across all scenarios. Table 4 shows the same data at 2030, 2040, and 2050.

Figure 32 | Battery electric vehicle uptake comparison

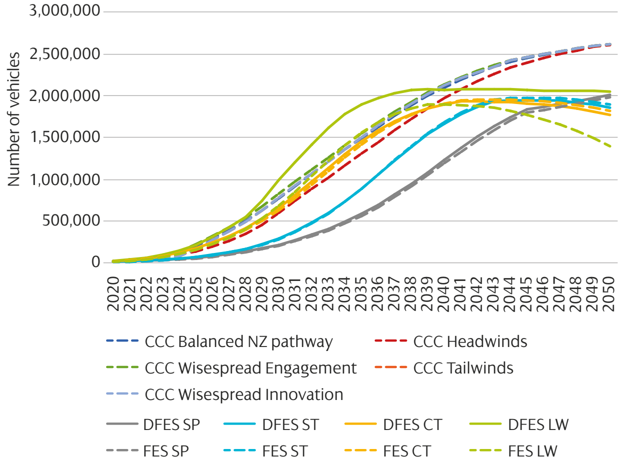


Table 4 | Industry forecasts for BEVs

Volumes (millions)		Electric vehicles		
		2030	2040	2050
DFES	Steady Progression	0.21	1.23	2.01
	System Transformation	0.29	1.67	1.86
	Consumer Transformation	0.65	1.90	1.77
	Leading the Way	0.99	2.07	2.05
FES	Steady Progression	0.20	1.19	1.98
	System Transformation	0.28	1.68	1.89
	Consumer Transformation	0.62	1.90	1.81
	Leading the Way	0.68	1.90	1.40
CCC 6th Carbon Budget	Balanced Net Zero pathway	0.77	2.10	2.61
	Headwinds	0.60	1.97	2.61
	Widespread engagement	0.82	2.13	2.61
	Widespread innovation	0.77	2.12	2.61
	Tailwinds	0.77	2.12	2.61

9.3.2 Heat pumps

Figure 33 shows the total volume of heat pumps considered across all scenarios. Table 5 shows the same data at 2030, 2040, and 2050.

Figure 33 | Heat pump uptake comparison

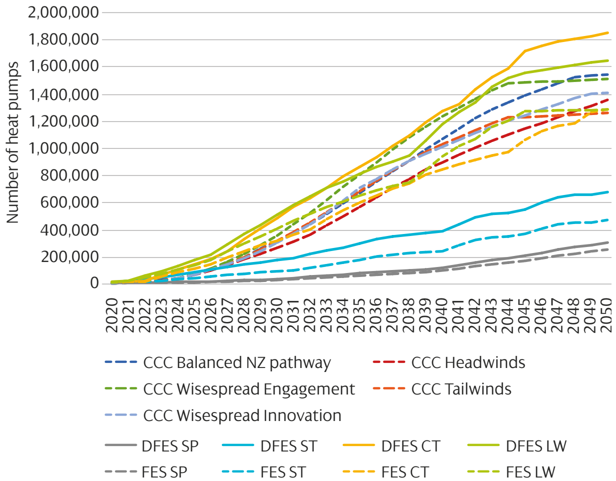


Table 5 | Industry forecasts for heat pumps

Volumes (millions)		Heat pumps		
		2030	2040	2050
DFES	Steady Progression	0.04	0.12	0.31
	System Transformation	0.18	0.39	0.68
	Consumer Transformation	0.49	1.27	1.85
	Leading the Way	0.51	1.18	1.65
FES	Steady Progression	0.03	0.10	0.25
	System Transformation	0.10	0.24	0.47
	Consumer Transformation	0.32	0.85	1.29
	Leading the Way	0.41	0.94	1.29
CCC 6th Carbon Budget	Balanced Net Zero pathway	0.32	1.07	1.54
	Headwinds	0.27	0.90	1.36
	Widespread engagement	0.36	1.23	1.51
	Widespread innovation	0.31	1.01	1.41
	Tailwinds	0.32	1.03	1.26

10

Range of Net Zero compliant pathways

This section provides an overview of the range of Net Zero compliant industry forecasts for the SP Distribution network.

These Net Zero compliant scenarios are key to understanding the range of future possible pathways that the SP Distribution network needs to accommodate. We use this information to efficiently plan and develop our networks.

We need to develop a view of the credible range of Net Zero compliant scenarios. This is to help us efficiently plan and develop our network, and we use this to develop our RIIO-ED2 business plan.

To develop this range, we considered all DFES, FES, and CCC forecast scenarios. We then discounted two DFES and FES scenarios:

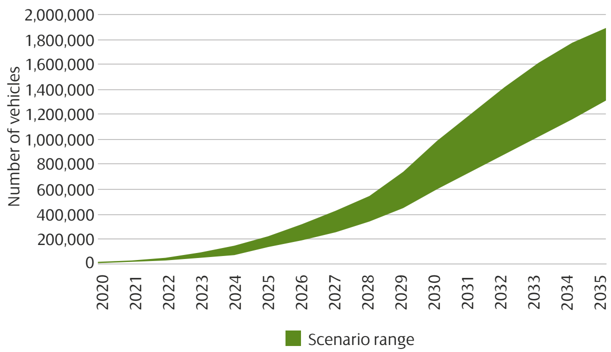
1. Steady Progression (SP):
this scenario does not meet Net Zero and so it has been excluded.

2. System Transformation (ST):
this scenario is significantly lower than the rest of the Net Zero compliant scenarios. We consider it unable to meet Scottish Government legislative targets or UK interim emission reduction targets, and so it has been excluded.

The remaining DFES/FES scenarios (Consumer Transformation and Leading the Way) and the five CCC Sixth Carbon Budget scenarios collectively form the Net Zero compliant scenario range. This range of scenarios meets UK and Scottish Net Zero legislation, the requirements of the UK Government's Ten-Point Plan, and the Scottish Government's Update to the Climate Change Plan and Heat in Buildings Strategy.

Figure 34 shows this range of the Net Zero compliant industry forecasts for the uptake of battery electric vehicles and heat pumps – we have shown these two metrics as they are the main drivers of increasing demand.

Figure 34 | Range of Net Zero compliant industry forecasts



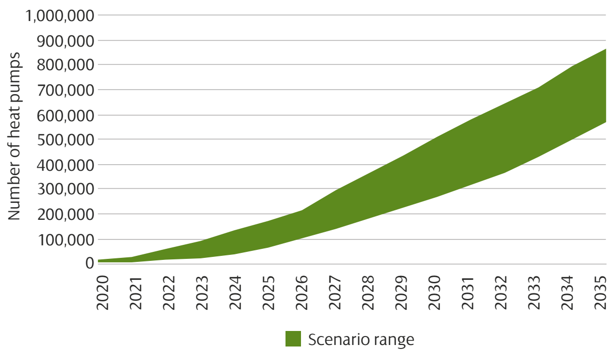
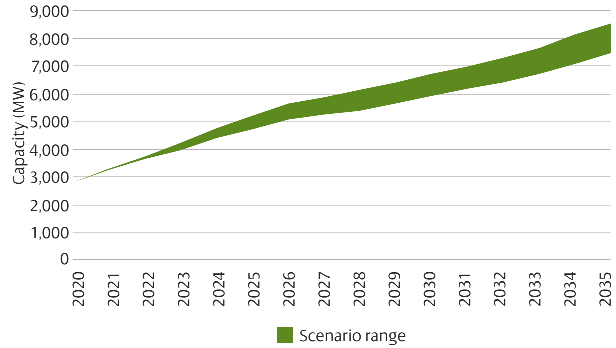
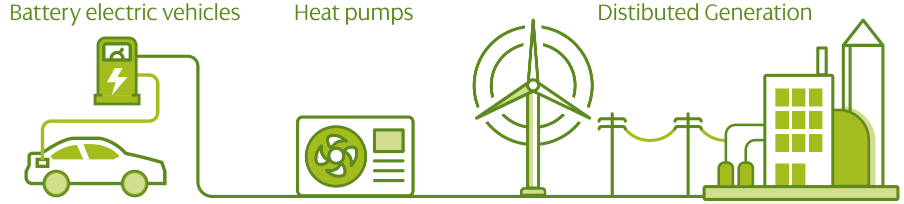


Figure 35 shows Net Zero compliant forecasts for distributed generation.

Figure 35 | Range of Net Zero compliant distributed generation forecasts





	Battery electric vehicles	Heat pumps	Distibuted Generation
2019	5,026	282	2.4GW
2030 High	0.99 million	0.51 million	+4.3GW
2030 Low	0.60 million	0.27 million	+3.5GW

11 Glossary

Behind the meter – generation and storage which is connected within a domestic, commercial, or industrial building as part of that site's internal electricity system (e.g. rooftop solar PV panels on a domestic property). This is as opposed to a dedicated generation or storage site (e.g. a wind farm) which has no other major demands or processes within the same site.

Decarbonisation – the process to reduce the amount of carbon dioxide (CO_2) and other greenhouse gas emissions by introducing new low carbon alternatives and technologies. Much of the decarbonisation strategy is based on switching carbon energy vectors (e.g. petrol and diesel for transport, and natural gas and oil for heating) to electricity, and then using renewable generation to provide zero carbon electricity.

Decentralisation – this reflects the extent to which generation is sited closer to demand consumption (or is even undertaken by consumers themselves) via the use of smaller-scale technologies such as solar PV and local energy storage. A less decentralised system would be characterised by fewer, larger-scale generators sited further from where the electricity is ultimately consumed (demand); a more decentralised system would be characterised by more smaller-scale generators sited closer to demand.

Distributed generation – generation connected to the distribution network, as opposed to the transmission network.

Distribution network – in England and Wales this consists of overhead lines, underground cables and other network infrastructure that operate at 132kV and below; in Scotland this is the infrastructure that operates at 33kV and below. The distribution network delivers electricity from the transmission network and distributed generation to end users (consumers/demand). Nearly all demand in the UK is connected to the distribution network; only very large demand users (e.g. the rail network) are connected to the transmission network. Nearly all medium-scale and smaller scale generation in the UK is connected to the distribution network; typically only large fossil fuel power stations, offshore generation, and large onshore generation are connected to the transmission network.

Flexibility – the ability of a consumer or generator to change their operation (i.e. their generation/consumption levels) in response to an external signal. With the push towards the electrification of heat and transport, being able to flexibly utilise demand and generation will help minimise the amount of additional network capacity required, balance the system and provide system stability – these can all help reduce customer electricity bills.

Grid Supply Point (GSP) – the interface points between the transmission network and the distribution network.

MW – megawatt is a unit of power (not energy). It can describe both the amount of power that a demand user is consuming (e.g. "this town's peak demand has increased by 3MW due to an increase in electric vehicles and heat pumps"), and the amount of power that a generator is producing (e.g. "3MW of solar PV generation has been installed in this area").

Minimum demand – the point in the year, typically during the summer months, when our distribution network as a whole sees the lowest demand. It is an important study condition (along with peak demand) as a network with low demand can experience voltage control issues.

National Grid Electricity System Operator (ESO) – the company responsible for operating the GB transmission network.

Peak demand – the point in the year, typically during the winter months, when our distribution network as a whole sees the highest demand. It is an important study condition (along with minimum demand) as it places the greatest need on network capacity – our network must be sized to accommodate peak demand.

Primary substation – the interface points between the 33kV and 11kV networks.

SP Transmission (SPT) – the Transmission Network Owner for Central and Southern Scotland, that owns the transmission network at 132kV, 275kV and 400kV.

SP Distribution (SPD) – the Distribution network Operator for Central and Southern Scotland, that owns the distribution network at 33kV, 11kV and LV into the home.

SP Manweb (SPM) – the Distribution Network Operator for Merseyside, Cheshire, North Shropshire and North Wales, that owns the distribution network at 132kV, 33kV, 11kV and LV into the home.

Transmission Network – the high voltage electricity network used for the bulk transfer of electrical energy across large distances. The transmission network takes electricity from large generators (e.g. coal, gas, nuclear and offshore wind) to supply large industrial customers and the distribution network.

Vehicle to grid – this is where plug-in electric vehicles, such as battery electric vehicles, plug-in hybrids or hydrogen fuel cell electric vehicles, can flexibly alter their demand consumption, either by reducing their charging rate or exporting their stored electricity back onto the network. Like other flexibility, this can help reduce the need for new network capacity, balance the system and provide system stability – these can all help reduce customer electricity bills.

Notes

Notes

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