SP Distribution

2023 Distribution Future Energy Scenarios

March 2024

Aligned with FES 2023 scenario framework

SP Energy Networks | DSO

Contents

Commissioned partners:

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Welcome to our DFES

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 out to 2050.

This document presents our annual update to these DFES forecasts following the publication of the Electricity System Operator's Future Energy Scenarios in July 2023.

Scott Mathieson
Director, Network Planning & Regulation

If you have an idea you would like to discuss with my forecasting team, or if you'd like more information on a particular subject, please get in touch via:
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Electricity networks are at the heart of the Net Zero transition. The scale of decarbonisation means that by 2050 the peak demand on our distribution networks is forecast to double, and we could likely see a five-fold increase in connected generation and storage. Over recent years we have seen a steady increase in connection rates of domestic, low carbon technologies. These trends are expected to accelerate, and we forecast that our customers are likely to connect up to eight million electric vehicles and heat-pumps by 2050.

We know from detailed modelling that this new demand, generation, and storage will increasingly push the distribution network beyond what it is designed for, meaning that our network needs to evolve to enable our customers' Net Zero transition. This evolution will affect every area of our business. For example, changing the way that we plan and develop the network – requiring granular forecasts to establish where, when, and how much network capacity we need to add to accommodate customer growth, and to determine the tools, interventions and solutions we need to best deliver that capacity.

The role of network operations – managing the network in real time, keeping the lights on, and keeping our customers and staff safe – will soon involve the dispatching and settling thousands of flexibility service contracts. These are actions taken by our customers who have agreed to operate in ways that free up network capacity and avoid network constraints. Information, visibility, data, and automation will all be essential to enable us to develop and operate this more active distribution system.

It is important that we understand the likely uptake of these new demand and generation technologies, so we know how best to respond. That is the purpose of our DFES – to show the possible decarbonisation routes to Net Zero so that we can develop our network accordingly.

While the overall direction of travel towards Net Zero is clear, there are some areas where detailed local authority and community action plans are still under development. There are also broader factors at play – continuing high energy prices have changed decarbonisation business models; the Ukraine war has promoted the importance of energy security; supply chain issues have delayed some projects. Whilst these are hopefully short-term factors, these uncertainties and the ever-changing energy landscape illustrate that 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.

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 plan the delivery of this capacity. These DFES forecasts are also valuable to the two transmission operators that supply our distribution networks, as they start to assess what investment they need to make in the 2026-31 RIIO-T3 period.

Given the important role of these forecasts, we need to ensure that we have correctly forecast our customers' requirements. That is why stakeholder feedback has been a vital component of every DFES publication. We welcome the feedback we have already received, which has been used in these latest forecasts and previous versions. Whilst we do incorporate and carry forward feedback from previous years, a lot can change in 12 months. Therefore, we thank those who continue to give up their time to share their views with us every year – it is important and valued – and we look forward to continuing to engage with all stakeholders.

1. 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.

SP Energy Networks must ensure our network has sufficient capacity to meet our customers' changing electricity needs, and that our networks are equipped to facilitate the reaching of Net Zero legislated targets (Net Zero by 2045 in Scotland). To do this, we need to understand what our customers' electricity requirements are going to be into the future. This includes how much electricity both existing and new customers might consume (demand) and how much they might produce (generation).

Our DFES

The DFES comprises forecasts of the following key areas:

1. Growth in the volume of Low Carbon Technologies (LCTs), such as heat pumps, district heating and Electric Vehicles (EVs).
2. Changes to demand and consumption as a result of technology and behaviour changes, not least due to the growth in LCTs.
3. Growth in and changes to electricity generation and storage[1]. This is generation connected to our distribution network as opposed to the transmission network; we call this Distributed Generation (DG) or embedded generation.

There are multiple pathways that GB could take to meet Net Zero, influenced by a range of external factors. These external factors – political, economic, social and technological – will all affect the way our customers' needs evolve over time. Therefore, we develop Distribution Future Energy Scenarios (DFES).

Figure 1 | DFES is the first step in our investment planning process

These scenarios provide a range of alternative electricity requirements out to Net Zero. For each scenario we model the impact on our distribution networks.

We use our DFES forecasts to help us understand where and when we might see constrained network capacity. This informs procurement of flexibility services, as well as where and when we need to increase network capacity through conventional or innovative network reinforcement. Ultimately, DFES is the cornerstone of our investment planning as represented by Figure 1.

This document

Sections 3-4 give an overview of demand and generation results, respectively.

Section 5 gives comparisons back to industry GB forecasts.

Section 6 shows how the Climate Change Committee forecasts are incorporated.

Section 7 presents the Net Zero compliant range used for network planning and development.

Section 8 gives a history of stakeholder feedback gathered in the production of this and previous DFES cycles.

Incorporating your views

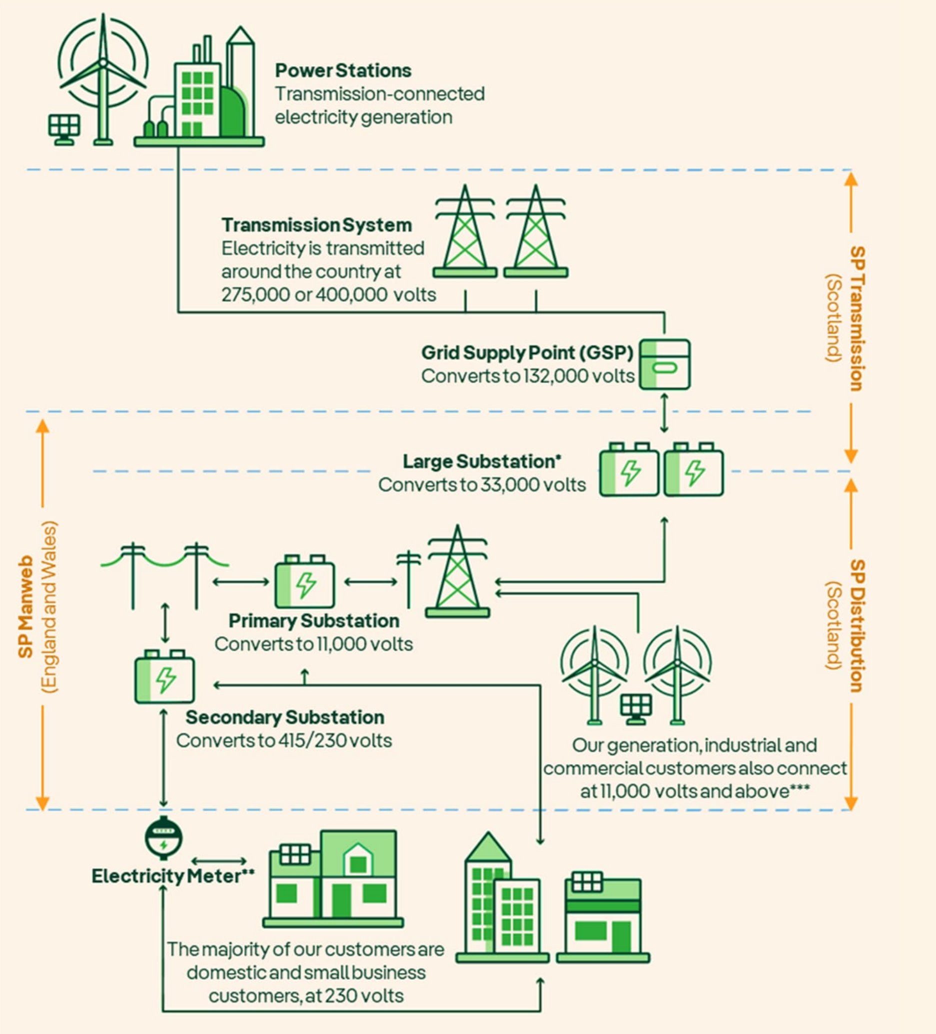
We update our forecasts on an annual basis in line with national and regional projections. As part of this annual process, we engage with a wide representation of our stakeholders to test the forecasts' data, methodology, and outputs.

However, we encourage you to engage with us and shape our forecasts throughout the year, to support the continuous improvement of our DFES. If you have any questions or feedback on our forecasts, they would be gratefully received.

Please provide your feedback via email to dfes@spenergynetworks.co.uk.

[1] *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.*

Figure 2 | Diagrammatic view of transmission and distribution system



**These are GSPs in SPD.*
***We are responsible for the cables and equipment down to the electricity meter. The energy supplier owns the meter, and wiring and equipment beyond-the-meter is customer-owned.*
****These customers have different metering arrangements to domestic customers and sometimes there are dedicated SPEN substations at their site.*

[2] https://www.spenergynetworks.co.uk/userfiles/file/DFES_SP_Manweb_2023.pdf

Our network areas

SP Distribution owns and operates the electricity distribution network – the network at 33 thousand volts and below – across Central and Southern Scotland. It has six operating regions: Central & Fife, Glasgow, Ayrshire & Clyde South, Lanarkshire, Edinburgh & Borders, and Dumfries. Across these regions, we transport electricity to and from circa 2 million homes and business.

SP Distribution is part of SP Energy Networks. SP Energy Networks includes another distribution network company: SP Manweb, the distribution network operator for North Wales, Cheshire, North Shropshire and Merseyside. SP Manweb has its own forecasts, which are available separately[2].

SP Energy Networks also comprises SP Transmission, the transmission network owner for Central and Southern Scotland.

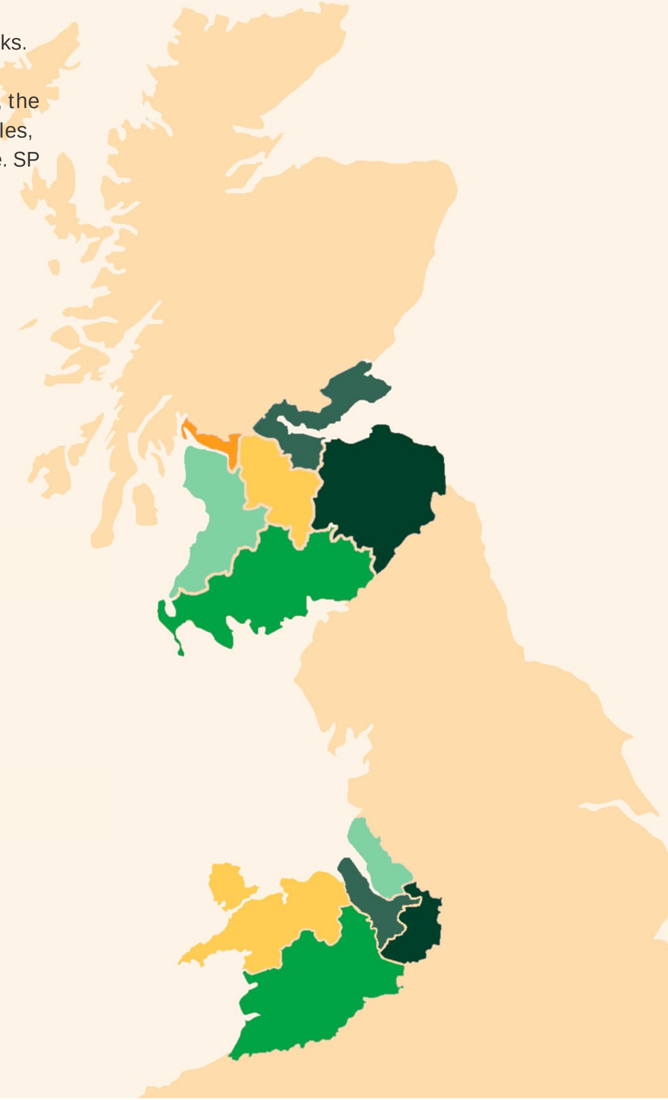
The forecasts in this document are for the SP Distribution network only; they are not forecasts for the whole of Scotland or the UK, or the transmission network. The relationship between the distribution system and the transmission system is shown in Figure 2.

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



2. About our DFES

The DFES are long-term forecasts of electricity demand and generation connected across our networks, which we update and publish annually. This year's DFES 2023 publication is an incremental update to the DFES 2022 publication. This section describes how we created our DFES and what it contains.

The scenarios are aligned to the National Grid Electricity System Operator's (ESO's) Future Energy Scenarios (FES)[3]. 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.

To illustrate their different representations, Figure 3 maps the four scenarios against two metrics: the speed of decarbonisation (how fast low carbon technologies are adopted) and the level of societal change.

Creating our DFES

We start the process by looking at medium- and long-term growth patterns at a regional- and licence-level. For these we gather evidence from the ESO's FES, UK and Scottish governments' legislation (including the incorporation of Net Zero), and regional ambitions and development plans.

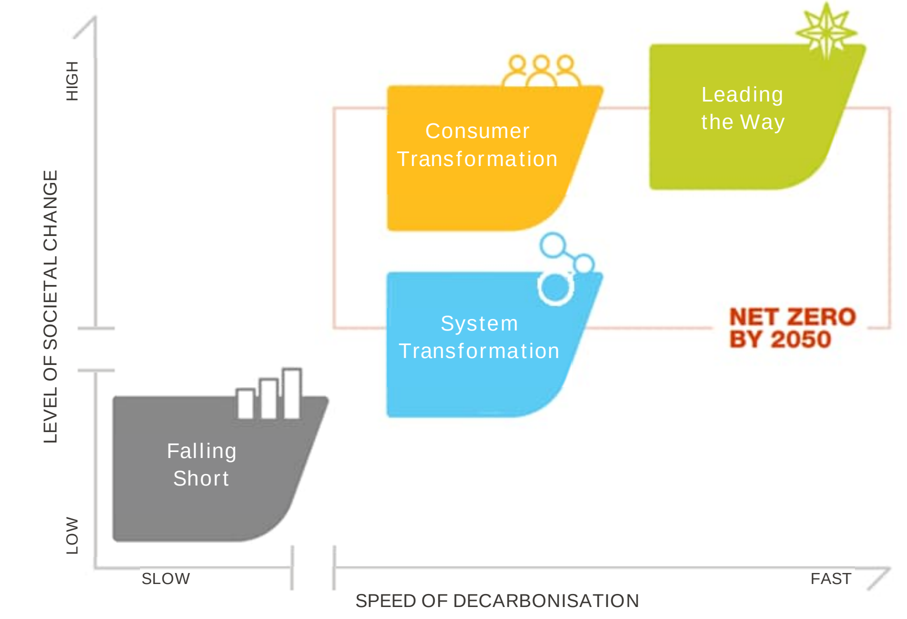
We then ensure these forecasts align with and are underpinned by the detailed information we already have on our networks. For example, incorporating the pipeline of near-term connections of large demand and distributed generation projects.

The forecasts are then spatially disaggregated to two levels of detail:

1. Grid supply point (GSP) level. There are 88 GSP areas across Central and Southern Scotland.
2. Primary substation level. There are 390 primary substation network areas across Central and Southern Scotland. These geographic areas cover, on average, approximately 50km².

We also provide key metrics disaggregated by Local Authority region.

Figure 3 | Overview of the ESO's Future Energy Scenarios



To create these geographically granular forecasts, we use outputs from SP Energy Networks' EV-Up, PACE and Heat-Up projects, as well as other highly spatially disaggregated sources of data (e.g. number of, type of and footprint of buildings in an area).

We also gather stakeholder evidence and feedback at all levels of the DFES. Feedback from customers and stakeholders is vital to ensure that our DFES forecasts reflect the plans and ambitions of the communities we serve.

In Section 6, we present the feedback we have received from this engagement and discuss how this has been assessed and used to update the forecasts. This update incorporates feedback received since our first publication in May 2020.

The resulting DFES forecasts are regionally reflective, geographically granular forecasts out to 2050 for four scenarios.

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 the "SPEN Distribution Future Energy Scenarios – Summary of Methodology" document, developed in conjunction with Baringa[4].

[3] https://www.nationalgrideso.com/future-energy/future-energy-scenarios-fes

[4] https://www.spenergynetworks.co.uk/userfiles/file/Annex%204A.6%20-%20DFES%20Methodology.pdf

External challenges

Forecasting electricity demand and generation in the short term has been challenging in recent years. Since the COVID-19 pandemic, in which we saw peak demand fall by over 7% in one year, we have had a period of high energy prices and a cost of living crisis that continues in the short term. The triggers include the Russian war on Ukraine and various external levers, including Brexit.

These triggers have limited both electricity peak demand growth and energy efficiency improvements, having the overall effect of relatively little change to electricity peak demand in the short term. They have also had a knock-on impact to the uptake of LCTs, with supply issues of new electric vehicles being a key concern in recent years. Furthermore, the UK government announced in September that the ban on the sale of new petrol and diesel cars and vans would be pushed out from 2030 to 2035.

Nevertheless, these pressures are beginning to settle down. Vehicle manufacturers have already set in place plans for the transition to electric power by 2030 so, even if the original target is missed, market factors may act to accelerate this transition. Furthermore, long term strategic visions with regard to Net Zero have remained unchanged. More is discussed in the next section.

ANOTHER DISRUPTOR HAS BEEN THE SIZE OF THE GENERATION AND STORAGE 'PIPELINE' – THE QUEUE OF PROJECTS CONTRACTED TO CONNECT TO OUR NETWORKS IN THE FUTURE.

A key challenge faced across GB at present is the time being quoted to connect renewable generation to the network due to rapid expansion of the GB connections queue. At the end of 2023, about 500GW of generation was contracted to connect across GB transmission and distribution networks. For comparison, this is over eight times the GB electricity peak demand. Notably, there has been a particular boom in battery storage applications. This has led industry to work together to develop an action plan to accelerate grid connections.

Whilst growth in generation and storage will be central to a decarbonised energy system, we do not expect that all projects in the current transmission and distribution pipeline will progress through to delivery.

However, because this volume of pipeline is unprecedented, exactly where, how quickly and by how much it will reduce are considerable unknowns – and ones that we have to tackle in our energy forecasts.

Our forecasts consider these external challenges, and we have discussed the impact on our forecasts in the results sections of this report.

Legislative context

As above, we ensure that our forecasts are aligned to the targets set out by UK, Scottish and local government bodies. As our DFES underpins the investment plans we have for our network development, this is key to ensuring we maintain a safe and reliable electricity supply that will facilitate Net Zero.

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 Climate Change (Emissions Reduction Targets) Act 2019[5]. 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[6].

The latest report, published in June 2023, shows that emissions reductions fell slightly short of the interim target in 2021[7]. However, the Scottish Climate Change Act interim targets remain unchanged at reductions of 75% by 2030, and 90% by 2040[8].

Building on these targets, the Scottish Government's Climate Change Plan[9] and Scottish Energy Strategy[10] identify a number of ambitions which will have a direct impact on the electricity distribution network.

These 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. 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.

The Scottish Government also published the Update to the Climate Change Plan[11], 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 (though this is likely to stall given the slip of the UK government target date to 2035).
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.

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[5] www.legislation.gov.uk/asp/2019/15/enacted
[6] www.legislation.gov.uk/ukpga/2008/27/contents
[7] https://www.gov.scot/news/scottish-greenhouse-gas-statistics-2021/
[8] https://www.legislation.gov.uk/asp/2009/12/section/2
[9] http://www.gov.scot/Publications/2018/02/8867
[10] http://www.gov.scot/Publications/2017/12/5661
[11] http://www.gov.scot/publications/securing-green-recovery-path-net-zero-update-climate-change-plan-20182032/
[12] http://www.legislation.gov.uk/asp/2021/9/enacted

IN JANUARY 2023, THE SCOTTISH GOVERNMENT PUBLISHED ITS DRAFT ENERGY STRATEGY AND JUST TRANSITION PLAN[13] FOR CONSULTATION.

WE MUST ENSURE THAT THESE PLANS ARE CAPTURED BY OUR DFES SO THAT OUR ELECTRICITY NETWORK IS ALSO READY TO SUPPORT THIS JUST TRANSITION – TO MAKE SURE THAT LOW CARBON TECHNOLOGIES CAN BE UTILISED EQUITABLY BY ALL CUSTOMERS ACROSS OUR REGION.

The plan reinforces previous targets set out by previous strategies – including the Heat in Buildings Strategy[14] – and sets out some new policy positions and a route map of actions with a focus out to 2030.

Relevant to our Distributed Generation forecasts, we have observed the following notable points:

1. An ambition for more than 20GW of additional low-cost renewable electricity generation capacity by 2030, including 12GW of onshore wind.
2. Reportedly, an ambition for 4-6GW of solar power by 2030[15].
3. A call for hydro-power to play a greater role in the energy transition[16].

For the decarbonisation of heat:

1. From 2024, new buildings are to use heating systems which produce zero direct emissions at the point of use. Indeed, we have already begun to see this shift towards heat pumps in new developments.
2. By 2030, more than 1 million homes and 50,000 non-domestic buildings to use zero emissions heating systems.

For the decarbonisation of transport:

1. Support will be provided to people on lower incomes and in remote or rural communities to switch to zero-emissions vehicles.
2. Ambition to reduce car kilometres by 20% by 2030, and investment made in public transport (namely bus and rail) growth and decarbonisation.
3. Consultation feedback expressed the importance for electric vehicle charging infrastructure to be ready.

For industrial decarbonisation:

1. Ambition for renewable and low-carbon hydrogen production of 5 GW by 2030, and of 25 GW by 2045.
2. Target for industrial decarbonisation of 43% from 2018 levels by 2032.

The latter would be met with efficiency measures, which could reduce some electricity demand, or by Carbon Capture, Usage and Storage (CCUS); however, we expect this will be more than offset by a shift to electrification of key industrial processes.

The Heat in Building Bill proposal was also released for consultation in November 2023[17] and sets out the following:

1. Reconfirms that the use of polluting heating systems will be prohibited after 2045.
2. Plan to require those purchasing a home or business to end their use of polluting heating systems within a fixed period (to be confirmed) following completion of the sale.
3. Plan to require homeowners to make sure that their homes meet a reasonable minimum energy efficiency standard by 2033, and 2028 for private landlords.
4. Plan to require people and businesses to end their use of polluting heating when a heat network becomes available.

There is still uncertainty when and by how much these plans will impact electricity use for heating: for this, exemptions and timescales will be critical, which we expect to be confirmed in the final bill. However, these proposals continue to strongly signal a commitment to transition to low carbon heating technologies in Scotland.

AT THE TIME OF PRODUCING THIS DFES CYCLE (OCTOBER 2023), LOCAL AUTHORITIES HAVE BEGUN TO PUBLISH THEIR LOCAL HEAT AND ENERGY EFFICIENCY STRATEGIES (LHEES)[18].

These strategies will give more details on heat decarbonisation plans, including possible future locations and scales for heat networks. We will be working closely with Local Authorities to provide the data they require to develop these strategies, as well as ensure that our DFES forecasts align to their own local forecasts.

The distribution network is key 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.

[13] https://www.gov.scot/publications/draft-energy-strategy-transition-plan/pages/2/
[14] http://www.gov.scot/publications/local-heat-energy-efficiency-strategies-delivery-plans-guidance/pages/2/
[15] *This was announced in October 2023 by Lorna Slater MSP about the forthcoming Energy Strategy and Just Transition Plan.*
[16] *Our scenarios show a steady but only small increase in embedded hydro-power from today's level of around 0.2GW, but we will continue to follow policy and market indicators in this area.*
[17] https://www.gov.scot/publications/delivering-net-zero-scotlands-buildings-consultation-proposals-heat-buildings-bill/
[18] https://www.gov.scot/publications/local-heat-energy-efficiency-strategies-delivery-plans-guidance/

Developments in industry scenario planning

Over the course of 2023, Ofgem have been working on the role and responsibilities of the Future System Operator, that will be launched in summer 2024. This role, undertaken by the NG ESO, will be responsible for planning Britain's electricity and gas networks as well as continuing to operating the electricity system.

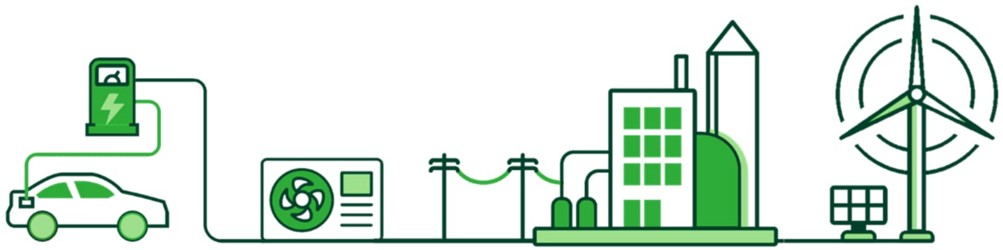
Part of the role is development of the Centralised Strategic Network Plan (CSNP) which will set out how the system should develop to decarbonise the electricity system by 2035. It will identify a firm delivery pipeline of work for transmission network development for the first 12 years, and a longer-term pathway covering a 25-year horizon that will identify future strategic options.

In August 2023, the new Electricity Networks Commissioner published his recommendations[19] for accelerating the rollout of electricity transmission infrastructure. One of his key recommendations with significant impacts on network planning is the proposal for a Strategic Spatial Energy Plan (SSEP). The SSEP will coordinate the timing, mix and location of generation and storage to meet forecast demand and net zero targets. In November 2023, government confirmed that the SSEP should indeed be developed by the FSO, and that it should inform the longer-term CSNP.

Whilst the SSEP and CSNP will focus on the strategic planning of transmission networks, this work will influence our distribution scenario planning.

Not least, NG ESO have indicated that the FES will undergo key changes – such as a move from a wide scenario range towards a framework of pathways, with a narrower range of future decarbonisation options. Additionally, the FES will seek to include near-term transmission constraints.

We do not yet know the full extent of the impact that these changes to GB system-level future planning will mean for DFES 2024 and beyond, but we are working closely with the NG ESO and other Distribution Network Operators (DNOs) to ensure we maintain a holistic approach.



Regional Energy Strategic Planner (RESP)

Ofgem have announced it will create regional energy planning roles across Great Britain. Regional Energy Strategic Planners (RESPs) will aim to ensure there is appropriate accountability and effective coordination for whole system strategic planning at a subnational level. RESPs will be responsible for the development of strategic energy pathways at the regional level that are cross-vector and fully consider regional priorities. This is intended to provide critical planning assumptions to inform system and network needs.

In developing a strategic plan, the RESPs are expected to develop a cross-vector, regional view using a wide range of inputs – including national forecasts, electricity and gas network operator data, heat networks and local plans (e.g. the LHEES).

We think the RESP role presents a significant opportunity to support our customers' ambitions to decarbonise and to enable true cross-vector coordination. We recognise the advantages of defining regional Net Zero pathways that lead to a common understanding of what different actors need to deliver.

The RESP will need to build on industry best practice, avoid duplication and maintain clear accountability. For example, the interplay between RESP pathways and DNO responsibilities will need to be defined in detail.

RESP boundaries are still to be finalised, but they will total between 10 and 13 across Great Britain (GB) – one in Wales, one or two in Scotland, and between eight and ten in England. SP Energy Networks operates in England, Wales and Scotland and will likely overlap with three or more individual RESPs.

More will be known on the future interactions between DFES and the RESP strategic plans as progress the detailed design for RESP progressing throughout 2024. Ofgem intend to consult on their plans in summer 2024.

[19] https://www.gov.uk/government/publications/accelerating-electricity-transmission-network-deployment-electricity-network-commissioners-recommendations

Scenario overview

Key assumptions characterising each of the scenarios are described as follows.

In SPD Falling Short (FS) decarbonisation progress is the slowest of all scenarios. While home insulation improves, there is still heavy reliance on natural gas, particularly for domestic heating. Electric vehicle uptake 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. Domestic heating is almost fully electrified by 2050. 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 produced using a combination of natural gas with carbon capture and storage, electrolysis, and biomass gasification.

In SPD Leading the Way (LW) rapid decarbonisation occurs 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 mostly from electrolysis powered by renewable electricity.

	Falling Short	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)	Medium	Medium	High	High
Home EV charging	Medium (High by 2050)	Medium	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	High
Solar PV generation (>1MW)	Low	Medium	Medium	High
Onshore wind	Low	Medium	High	High
Medium duration electricity storage	Low	Medium	Medium	High

DFES outputs:

1. Demand

Outputs 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 3.

2. Flexibility

For demand components, we also consider the potential for flexibility. This is also included in Section 3.

3. Generation

Outputs which affect electricity generation and storage. These are set out in Section 4.

For each metric we have forecast we include, where possible, both a measure of the absolute number (e.g. number of electric vehicles); and its impact on electricity demand or generation capacity (shown in MW). Demand forecasts are shown as ‘peak demand’. This is because the 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.

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 that can 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.

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 the DFES forecasts will capture nearly all demand and medium-scale, smaller-scale and domestic-scale generation in central and south Scotland

3. Electricity demand

This section sets out the forecasts for demand, which is forecast to increase significantly in Scotland's journey to Net Zero through the electrification of transport, heat and industrial processes.

Peak demand

Each part of our network is designed to safely and reliably transport the maximum flow of electricity through it. Understanding how electricity demand will evolve on our network is key to informing the need for network intervention to 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, and the speed of this uptake;
3. 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). This is shown as the sum of the GSP forecast maximum half-hourly averaged demands, in MW, that are forecast at each GSP across the network over the course of each year[20]. It shows the 'true demand', which is the total demand used by our customers. In other words, this includes the gross power provided by both the transmission system, and that provided by embedded generation connected directly to our distribution network.

For comparison, the grey area of Figure 4 shows the forecasted range (i.e. the difference between the lowest and highest scenario) from our 2022 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 Net Zero targets, 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 Falling Short 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.

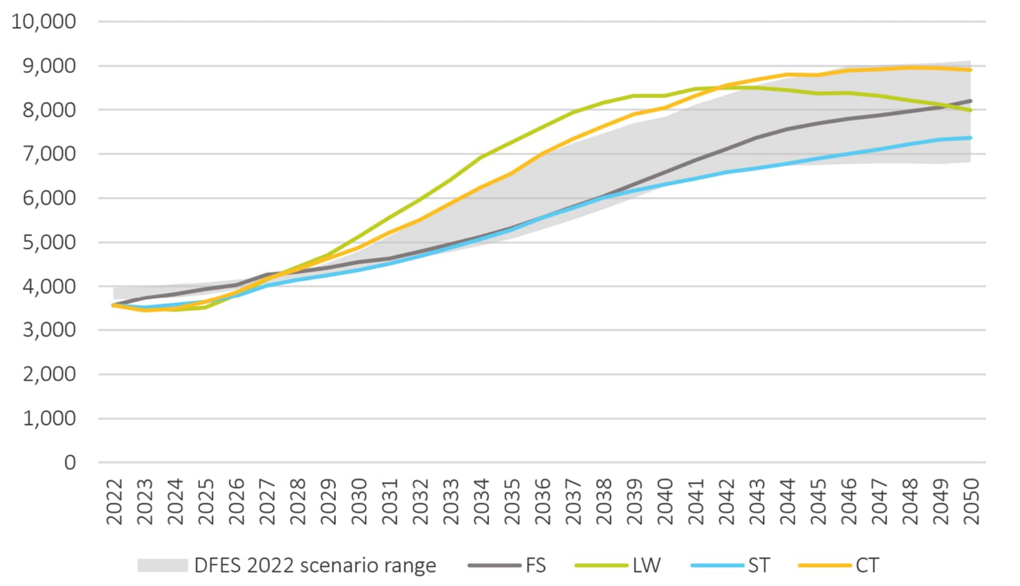
Historically, our most ambitious decarbonisation scenarios forecasted that, before demand begins to significantly increase as we transition to Net Zero, we would observe a demand decrease in the early 2020s. This was driven by more ambitious energy efficiency measures in these scenarios (e.g. low-emissions lighting and home insulation), which reduced both overall consumption and also the power requirements at peak times.

Due to the COVID-19 pandemic, we observed a step decrease in peak demand across our network in the year 2020/21, beyond what we had previously forecast even in our Leading the Way scenario. In the last two years, we have seen marginal recovery, but peak demand is still not at the levels forecast pre-pandemic. We believe this observed reduction is less likely due to deliberate measures to be 'green', and instead more closely linked to the sustained period of high energy prices that coincided with the end of the pandemic.

We therefore forecast that further demand reductions could occur in the short term due to postponed energy efficiency measures. On the other hand, with energy prices still higher than pre-pandemic levels, this may continue to limit both energy efficiency investment and energy consumption.

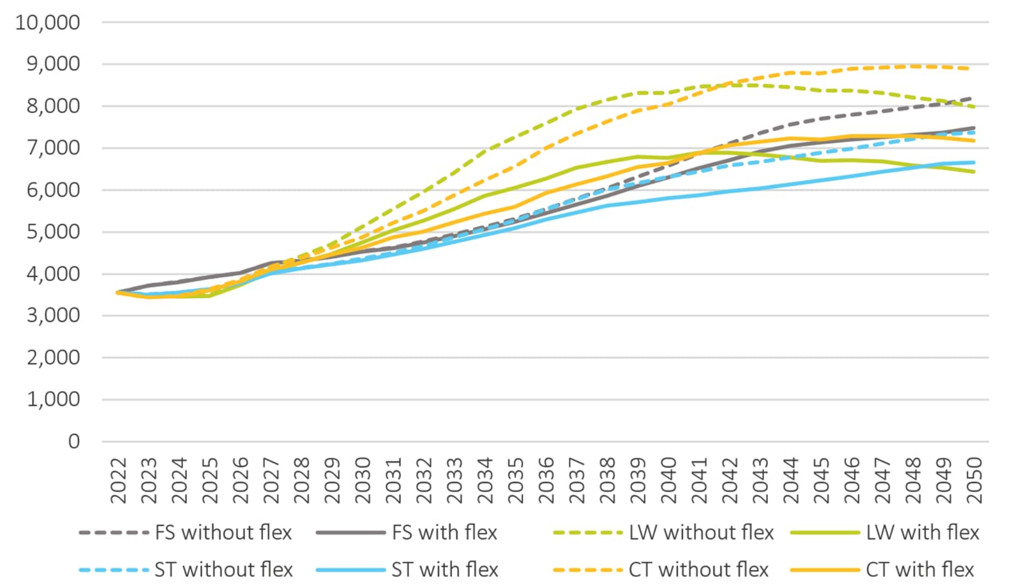
Without flexibility, demand could increase by as much as 44% by 2030 and more than double by 2045.

Figure 4 | Electricity peak demand without flexibility *Peak demand (MW)*



[20] Note that this is different to the 'SP Distribution system peak', which is the maximum demand across all GSPs in any one, single half-hourly period. We use the per-GSP peak demand forecasts to calculate a 5-year system peak forecast in our Long Term Development Statement.

Figure 5 | Electricity peak demand with and without flexibility *Peak demand (MW)*



The overall effects of these competing drivers on our scenario range are as follows:

1. The starting point is slightly lower in all scenarios, and demand growth is lower in the first three-five years.
2. We now see a more pronounced dip in the Net Zero compliant scenarios, arising from further energy efficiency measures. This is aligned to the trend in the NG ESO's 2023 FES.

The SPD Falling Short scenario, which does not have such ambitious energy efficiency actions, remains a credible scenario in the short term due to energy prices.

The forecast scenario range realigns with previously forecast levels by 2027/28. This is mainly driven by accelerated industrial process electrification towards the end of the decade, in effect 'making up for lost time' to meet decarbonisation strategies. This pushes up underlying industrial and commercial demand. This remains, however, sensitive to energy prices.

In presenting the case without flexibility, Figure 4 shows what the forecast 'worse case' peak demand, as it assumes that no existing or new demand has any flexibility. In reality: we expect that 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. Figure 5 shows how demand flexibility (excluding vehicle to grid) could reduce the SP Distribution total peak demand. This 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. We forecast that flexibility could reduce peak demand by up to 7% by 2030 in the Leading the Way scenario. This means it is important that we utilise flexibility as far as possible where we can, to better enable demand growth whilst reducing network impact.

To better illustrate what is driving the changes in demand out to 2050, and to show where the demand flexibility is coming from, Figure 6 shows a breakdown of the components of peak demand. The solid bars show the non-flexible demand, and the dashed bars show how much peak demand is forecast to be avoided through flexibility in each scenario.

> With flexibility, demand could increase by as much as 34% by 2030 and double by 2045.

Figure 6 | Electricity peak demand breakdown for 2030 and 2050 *Peak demand (MW)*

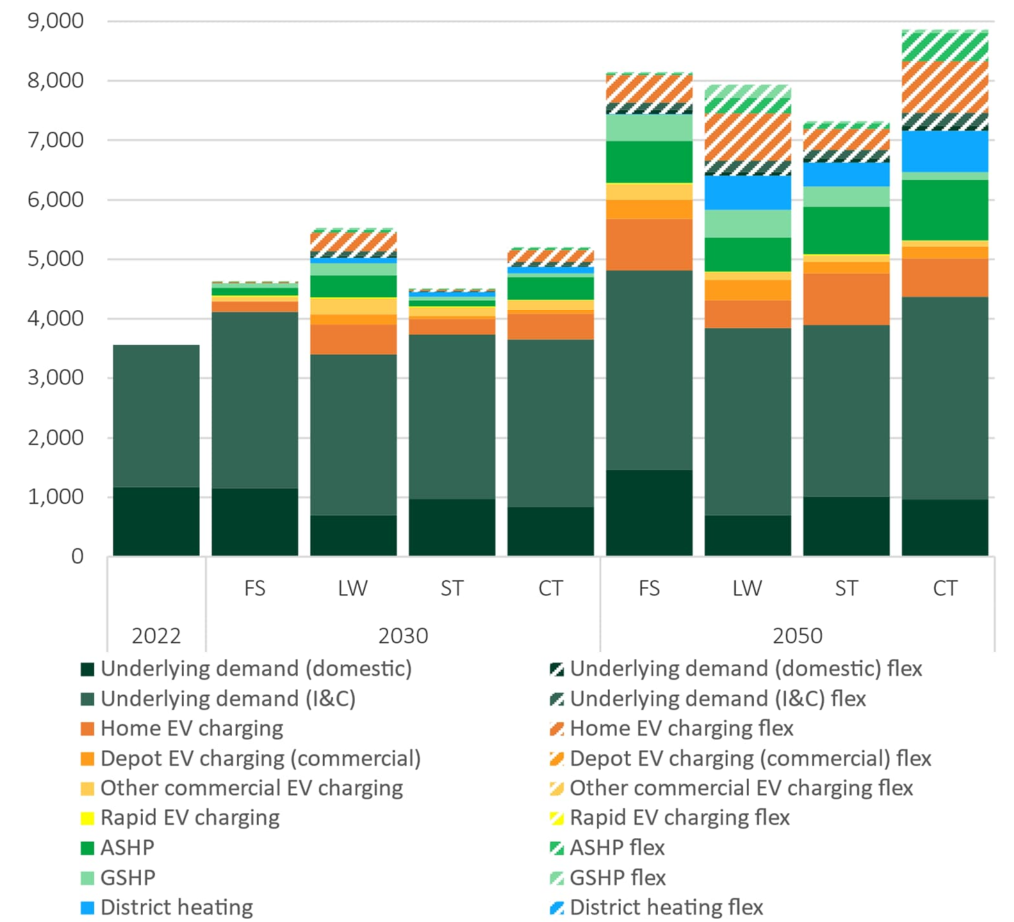


Figure 7 | Electricity peak demand changes from 2020 by primary substation area   *Peak demand growth (MW)*

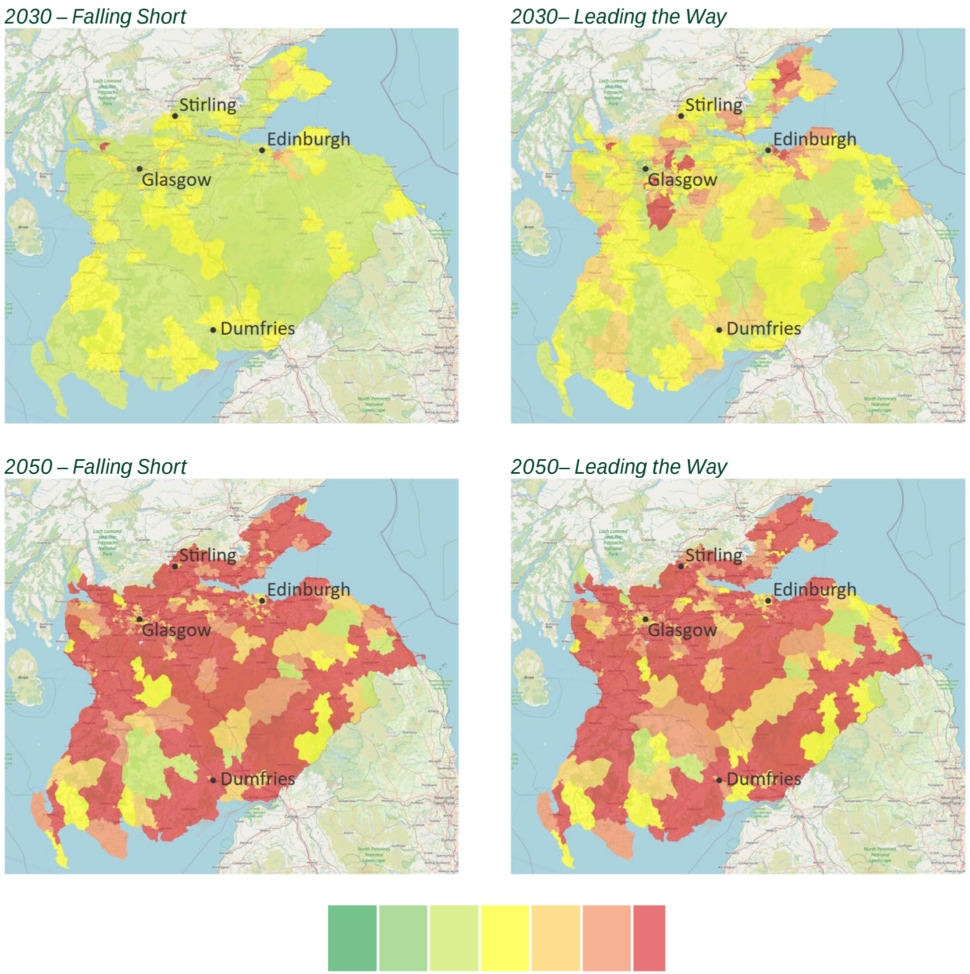


Figure 5 and Figure 6 show increasing electricity demand for all scenarios in the medium to long term. These forecasts and trends are the total values for Central and Southern Scotland. However, different regions will see different increases in demand at different times, based on a range of factors. 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. This may well present the industry with a challenge, as these focussed regions of particularly high growth could develop into hot spots of required reinforcement.

Overall peak demand trends:

1. All scenarios show increasing demand by 2030 and more so by 2050. This means that the distribution network will certainly need intervention to facilitate Net Zero.

2. Demand flexibility can reduce peak demand, and we should utilise this as far as possible. However, even with the most ambitious forecasts of flexibility, networks will still need to expand significantly to meet a growing need.

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.

Electric vehicles

One of the key contributors to growth in both electricity consumption, and therefore the size of the peak electricity demand our networks must provide, is the electrification of road transport.

By the end of 2022/23, we estimate the number of electric vehicles (EVs) – both plug-in electric hybrid vehicles (PHEVs) and battery electric vehicles (BEVs) – registered within the SP Distribution area was over 50,000, which is within the range we forecast in the 12 months prior.

Figure 8 shows the forecast numbers of residential BEVs[21] in the SP Distribution region. For comparison, the grey area shows the forecasted range (the difference between the lowest and highest scenario) from our 2022 DFES: this year is only an incremental update to the EV results. There has been very little change to the forecast numbers of vehicles across all scenarios out to 2050 and assumptions have remained constant.

Figure 8 shows that all scenarios forecast there will be up to 1.8 million domestic BEVs within the SP Distribution network area, but the scenarios reach this value at different rates.

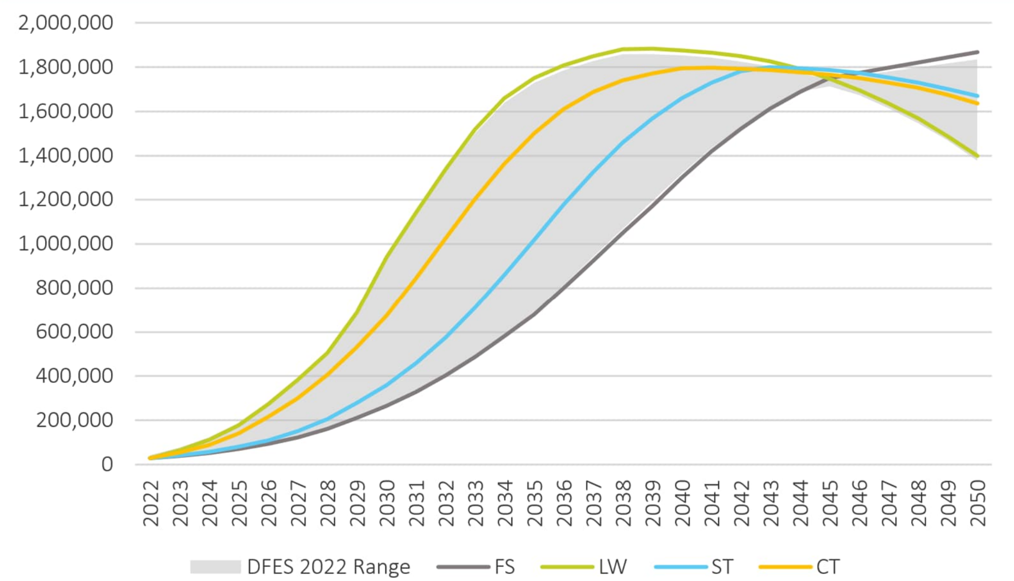
Across the scenarios, the share of residential BEVs rises from around 30,000 now to between 269,000-949,000 in 2030. The reason for this high level of variance in the 2030s is the differing levels of ambition between scenarios for phasing out the sale of new petrol and diesel cars and vans.

The SPD Leading the Way scenario has the fastest uptake: it forecasts that compared to today, there could be 30 times more BEVs by 2030, and 60 times more by 2040. SPD Leading the Way and SPD Consumer Transformation both assume that the sale of new internal combustion engine vehicles ends in 2030, in line with the UK government's original target date.

Our SPD Falling Short and SPD System Transformation scenarios contain a much slower uptake of residential battery electric vehicles up to 2030. The SPD Falling Short scenario doesn't meet Net Zero targets, and the SPD System Transformation scenario assumes that the UK Government's previous 2030 target for a ban on new internal combustion engine vehicles is only met in 2035. Growth rates pick up in the early 2030s for SPD System Transformation and in the mid-2030s for SPD Falling Short, reaching around 1.8 million by 2043 and 2048, respectively.

All scenarios except Falling Short see a reduction in residential electric vehicles in the 2040s due to a reduction in car ownership and a move towards methods of transport with a lower environmental impact. This reduction is earliest and most pronounced in the SPD Leading the Way scenario.

Figure 8 | Residential battery electric vehicle uptake — *Number of vehicles*



It has been reported across various media that EV sales have plateaued; however, according to our estimates based on DVLA statistics[22], the number of newly registered BEVs and PHEVs in the 2022/23 financial year[23] as a percentage of total new registrations GB has continued to grow compared to the 12 months prior.

However, BEV growth remains in the bottom of the scenario range. Additionally, PHEVs continue to be a large part of the market – indicating that the switch to pure electric has not happened as quickly as expected in the more ambitious decarbonisation scenarios.

In September 2023, the government goal to end the sale of petrol, diesel and hybrid vehicles was indeed pushed back to 2035. This could support the findings that volumes will be towards the bottom of the scenario range in the short term.

All scenarios forecast that the SP Distribution network will have to accommodate 1.8 million or more domestic, battery electric vehicles by or before 2045.

[21] *For the purposes of demand-modelling, we assume that PHEVs have a very limited contribution to peak demand and therefore the analysis in this chapter focusses on BEVs.*

[22] *UK Government Vehicles statistics published by the Department for Transport (DfT) and Driver and Vehicle Licensing Agency (DVLA):* https://www.gov.uk/government/collections/vehicles-statistics

[23] *April 2022 to March 2023,or Q2 2022 to Q1 2023 inclusive. BEV and PHEV sales in the 12 months up to and including Q3 2023 (which is the latest available data at the time of writing) have also increased compared to the previous 12 months, as a percentage of total registrations. Source: VEH1153.*

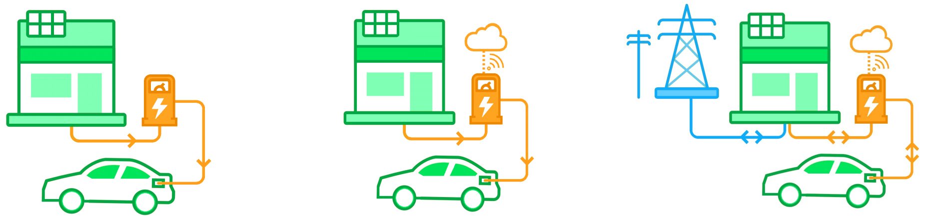
Widespread adoption of electric vehicles is expected to provide a significant challenge to the electricity sector due to the resultant large increases in peak demand.

Electric vehicle charging could have a significant impact on the SP Distribution peak demand if left unmanaged. Smart charging and vehicle to grid (V2G) 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 with and without smart charging and V2G.

It shows the development of these capabilities could considerably reduce peak demand, delivering significant benefits for our customers by avoiding required network reinforcement.

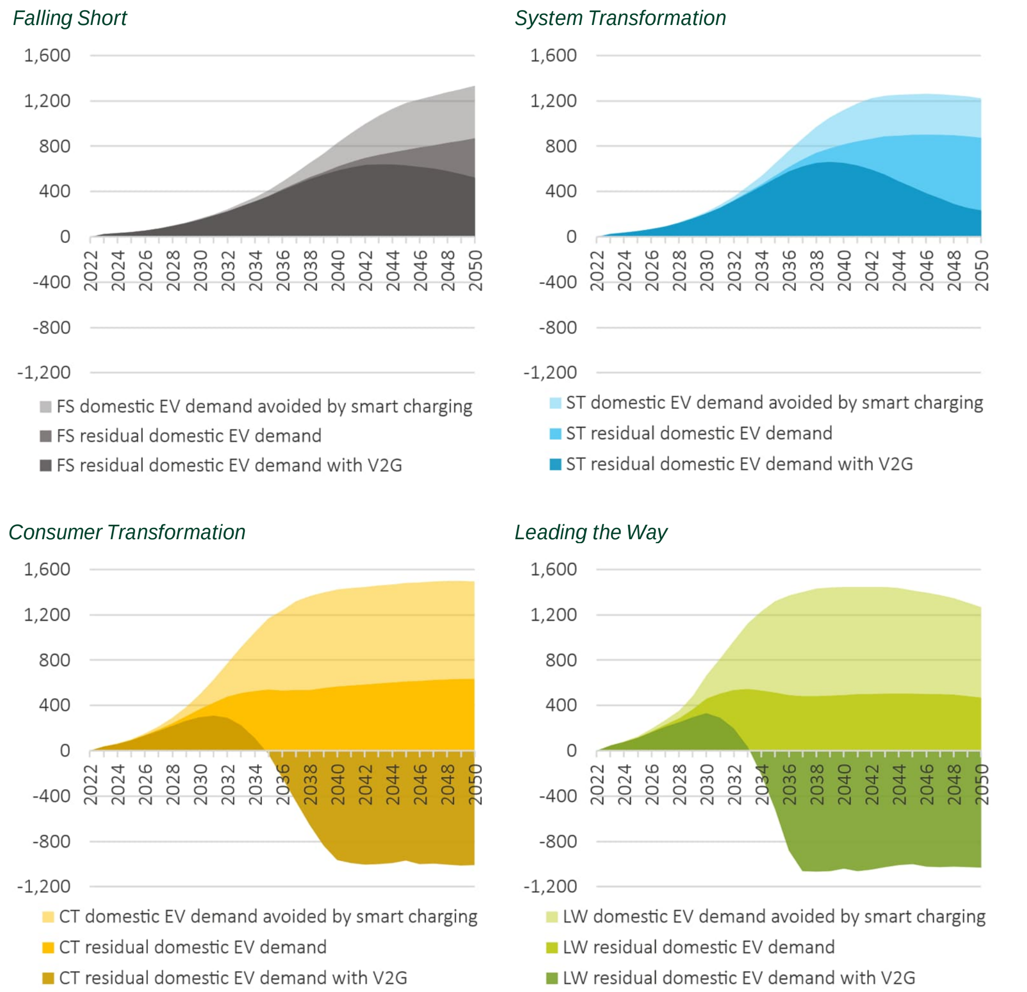
However, the scenario range shows significant variance, reflecting a large degree of uncertainty in the impact of these technologies, particularly V2G[24]. This is because customers have concerns about technology capability, impact on battery life and the ability to use their EV on full charge on demand. There is also uncertainty in the market; it is unknown what smart charging and V2G products and services will ultimately be available to consumers, and how much networks will be able to rely upon these services.



By 2030		
EV charging could add to SPD's peak demand between 161-665MW	Smart charging could reduce this contribution by 4-31%	V2G could reduce this contribution to as low as 154MW

By 2050		
EV charging could add to SPD's peak demand between 1,223-1,495MW	Smart charging could reduce this contribution by 28-63%	V2G could reduce overall peak demand by as much as 1,034MW*

Figure 9 | Home EV contribution to peak demand *Peak demand contribution (MW)*



[24] V2G could reduce peak demand by up to 182% in 2050. A total peak demand reduction above 100% means vehicle to grid has gone beyond offsetting the peak demand contribution from electric vehicles.

** V2G more than offsets the peak demand contribution of domestic EV charging in the SPD Consumer Transformation and SPD Leading the Way scenarios.*

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 sociodemographic 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 by 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 11 shows that in Central & Southern Scotland, residential battery electric vehicles are predominantly found in densely populated areas such as Glasgow, Edinburgh, North Lanarkshire, South Lanarkshire or Fife, where each could see over 75,000 electric vehicles by 2030, increasing to over 140,000 by 2050.

Figure 10 | Potential range of residential battery EV uptake by Local Authority *Number of vehicles*

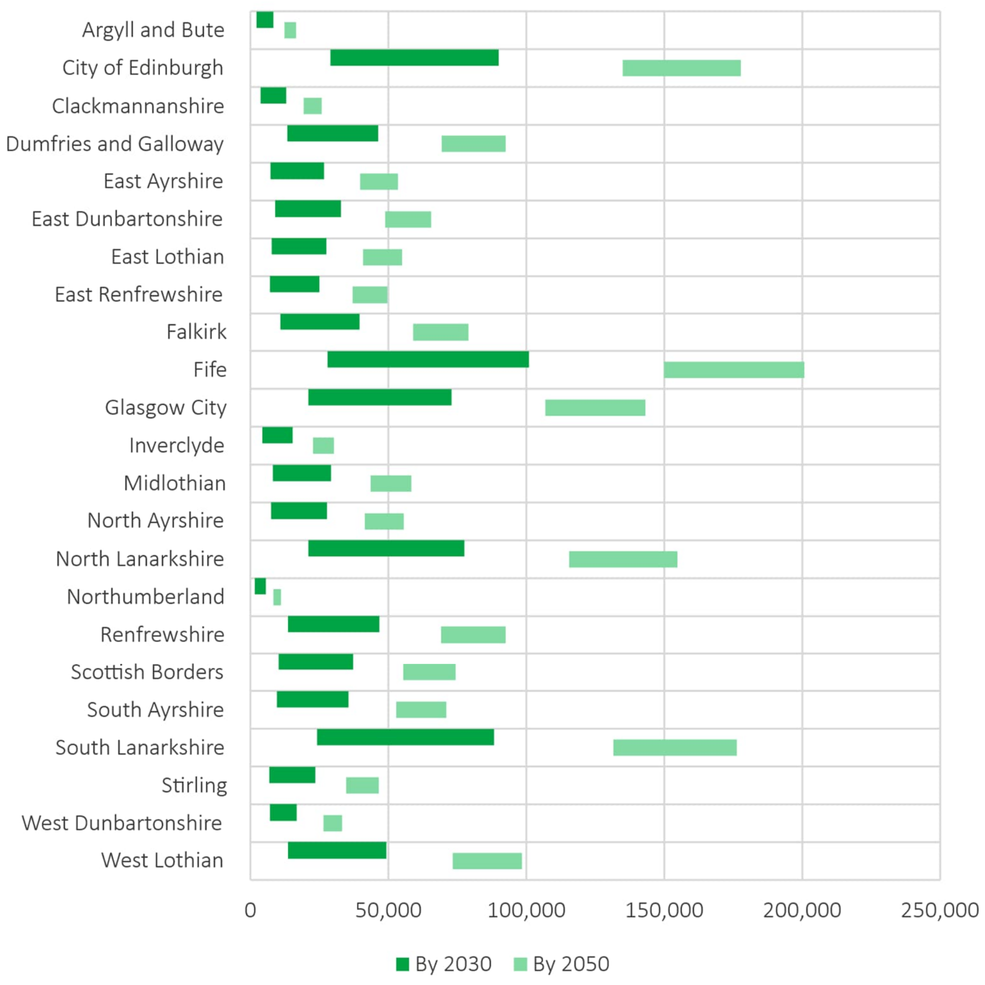
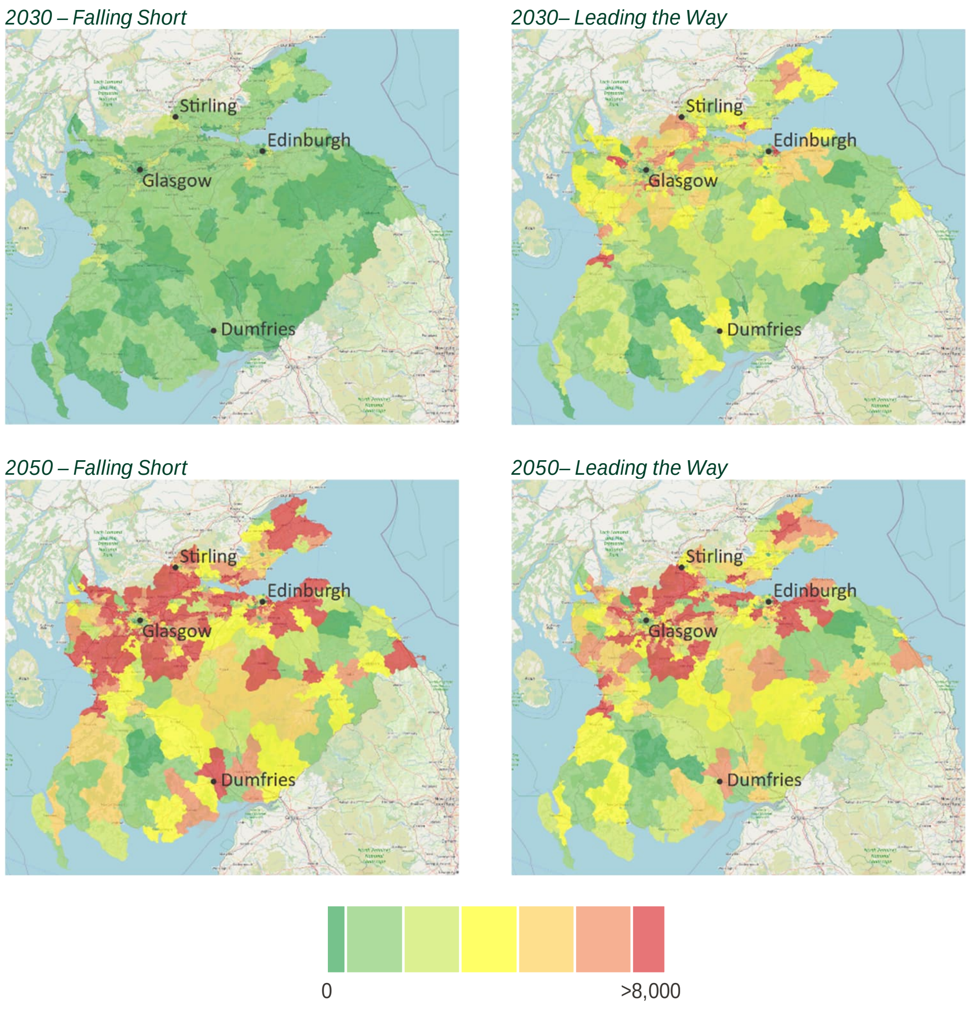


Figure 11 | Residential battery EV uptake numbers by primary substation area *Number of vehicles*



Heat pumps

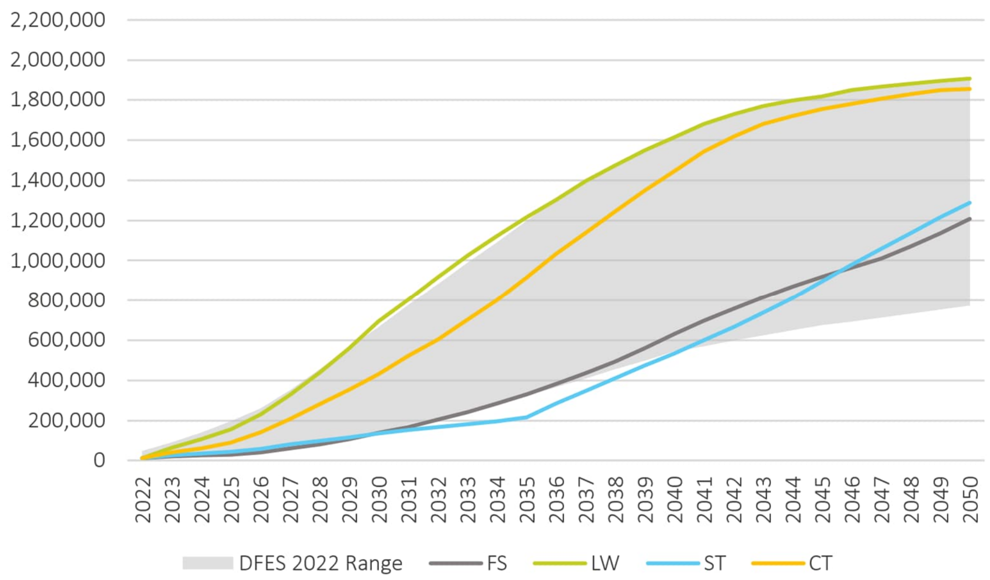
Heat pumps use electricity to heat buildings and provide hot water. Heat pumps – both air source and ground source – represent another change to the future electricity demand.

Heat pumps can also take the form of hybrid systems where an alternative heating system (such as a methane or hydrogen boiler) is used at times of peak demand, as well as larger scale heat pumps used for district heating.

Deployment is still currently low, estimated at about 0.7% of total households within a total stock of circa 2 million households in the SP Distribution area. This is in the range we forecast in our 2022 DFES. Although towards the lower end, we are now observing a faster connection of heat pump technologies than in previous years. Under the New Build Heat Standard that comes into effect in April 2024, changes to building regulations will mean new homes and buildings will not be allowed to use polluting heating systems, such as oil and gas boilers. We have observed the switch towards heat pumps in new housing developments across our region has already started.

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 2022 DFES.

Figure 12 | Electric heat pump uptake *Number of heat pumps*



There is significant variance between the heat pump forecasts as follows:

- SPD Consumer Transformation assumes that the decarbonisation of heat will predominantly be met by electricity – either via heat pumps, or district heat networks. The growth in heat pumps is initially expected to be in-line with new housing growth, but the rates of new installations increase to over 100,000 per year by the mid-2030s as more of our customers begin to retrofit old heating systems with heat pumps.
- SPD Leading the Way, being the most ambitious decarbonisation scenario, has a slightly faster uptake, assuming a quicker switch to retrofitted heat pump systems, even in the short term. Installation rates reach nearer 120,000 per year in the late 2020s.
- The SPD Falling Short scenario, which does not meet Net Zero by 2050, has low installation rates, possibly below even the rate of new build houses.
- SPD System Transformation, which may not meet Net Zero by 2045, also has very low installation rates, as this scenario assumes hydrogen will play a key role in the decarbonisation of space heating. As a result, in System Transformation, homes and business will continue to use gas for heat into the mid-2030s before switching to hydrogen, at which point hybrid heat pumps become a very popular technology. The sharp uptake in 2035 is due to a significant increase in hybrid heating systems. As a result, more heat pumps are installed in the 2040s in SPD System Transformation than in any other scenario.

The total proportion of homes with a heat pump could reach 33% by 2030.

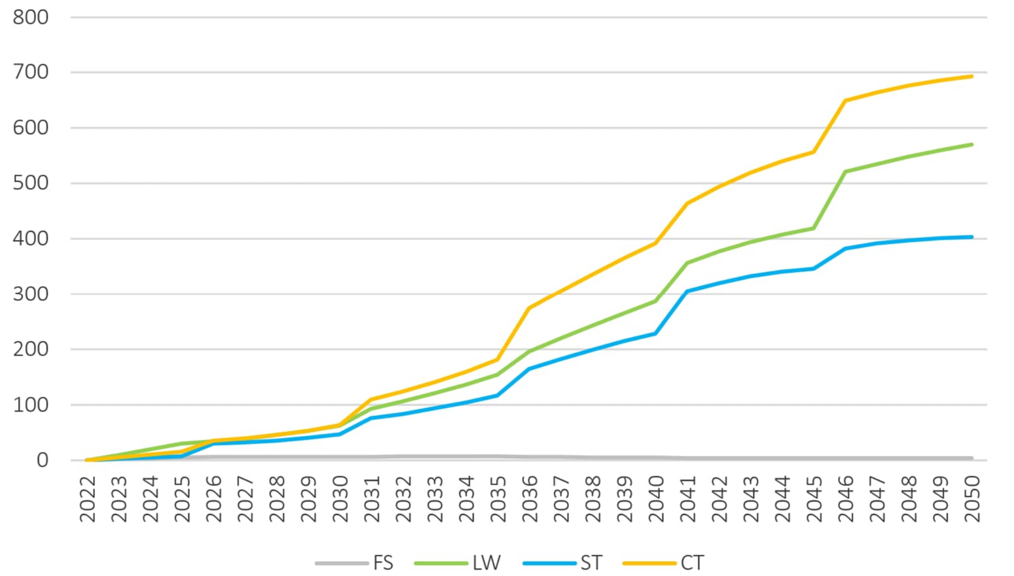
Figure 13 shows the impact on peak demand. It show that by 2050, all scenarios broadly have the same impact at the time of peak, but the scenarios get there in different ways.

The SPD Falling Short and SPD System Transformation scenarios steadily increase out to 2050 as heat pump numbers are still increasing; notably, they do not meet all Net Zero by 2045 targets.

SPD Consumer Transformation has a much earlier impact on peak demand given the greater volume of heat pumps, but the potential impact is reduced from 2030 onwards due to a notable shift towards demand flexibility – i.e. avoiding some heat pump demand at the times of day when the electricity network is busiest. SPD Leading the Way is very similar but the impact of flexibility is greater, and efficiency is slightly higher.

Figure 13 | Heat pump contribution to peak demand *Peak demand contribution (MW)*

Figure 14 | District heat contribution to peak demand *Peak demand contribution (MW)*



The development of effective heat pump flexibility could reduce their associated peak demand contribution by up to 32% by 2045. This volume is significant, although there is a limit to how much flexibility can be delivered by heating technologies alone. Electricity peak demand is most likely to occur in the early evening on a cold, winter weekday – this is when it is dark, workplaces are still open and functioning, but back home to houses that have been empty all day. It is unlikely this pattern of behaviour will shift completely, and so there will always be a demand for a boost of heat around this time.

A prevalent low-carbon alternative to heat pumps in SP Distribution network is likely to be district heating, or heat networks. These are likely to be larger-scale, and therefore connect into higher voltage levels. We forecast this will be another significant contributor to peak demand in all scenarios except SPD Falling Short, as shown in Figure 14.

We have disaggregated the results to show heat pump roll-out forecast across the region.

Figure 15 gives the approximated per-Local Authority numbers, and Figure 16 shows the roll-out forecast by primary substation area. The values shown in Figure 15 represent the range between the low and high forecasts. We have estimated the Local Authority numbers by looking at the overlap of our primary substation supply areas with the Local Authority boundaries. For all local authorities, we only provide forecasts for the area of that local authority which we serve.

The degree of geographical clustering of heat pump adoption is less than for EVs, but it is still key to determining the local impact on the network. Although the most populated areas do have larger numbers of heat pumps by nature of there being more properties, we see a higher density of properties with heat pumps in some of the more rural areas – particularly Dumfries and Galloway and Scottish Borders. These areas are associated with high areas of off-gas-grid properties. In our model, heat networks would be least suitable for many of the properties on these areas.

Figure 15 | Potential range of heat pump uptake by Local Authority *Number of heat pumps*

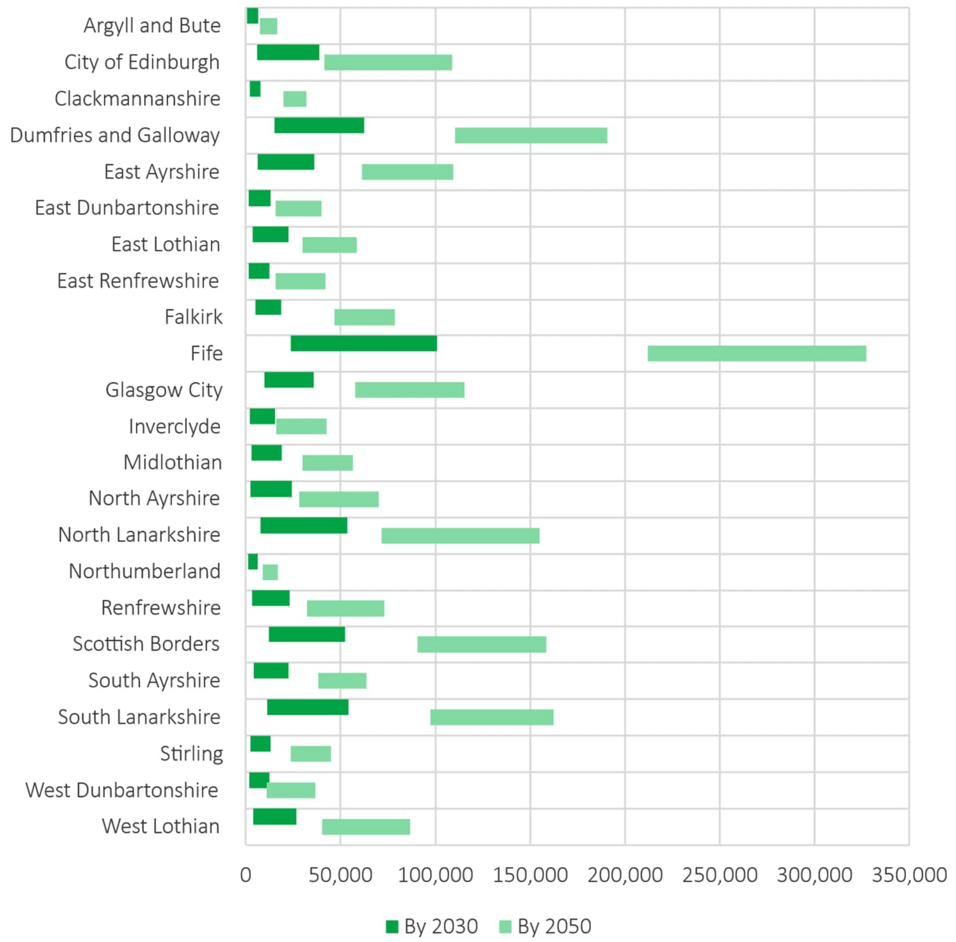
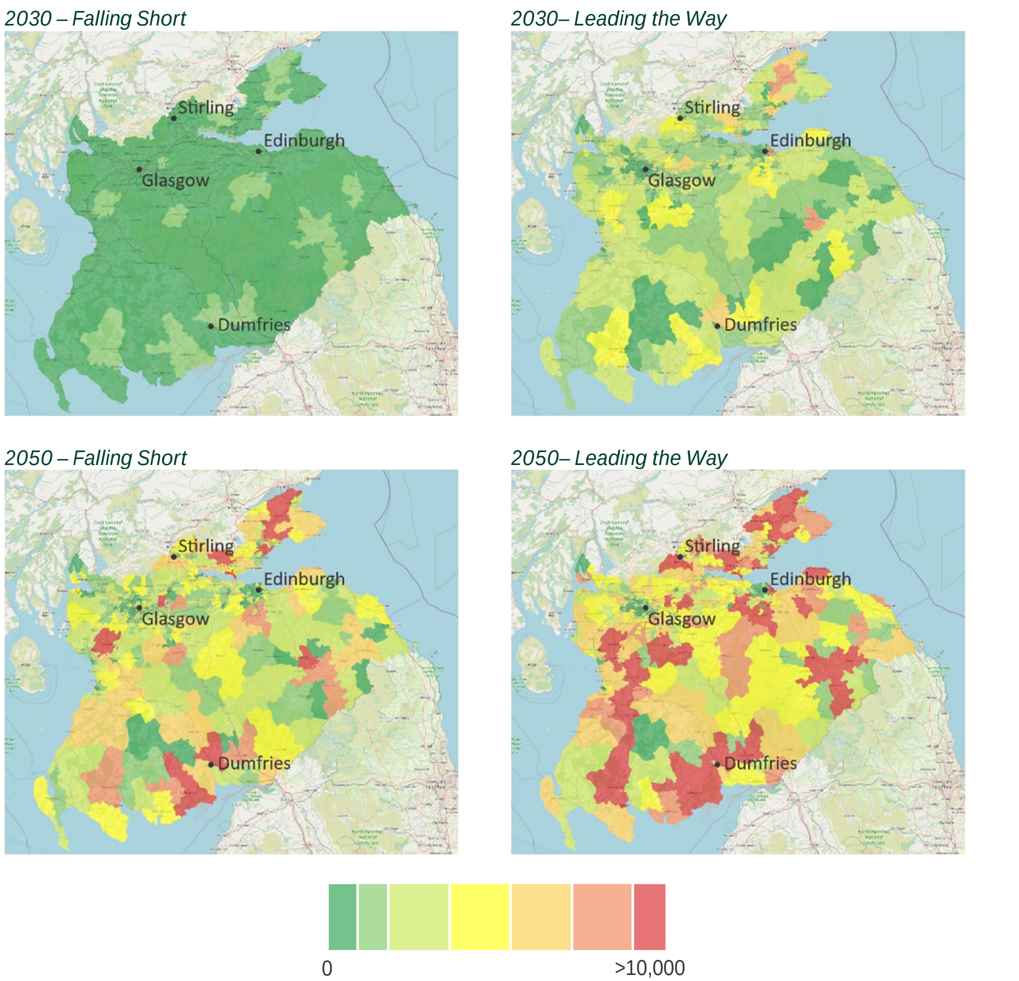


Figure 16 | Heat pump numbers by primary substation area *Number of heat pumps*



4. Electricity generation and storage

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

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).

Generation and Storage Overview

Figure 17 shows the geographic location of our baseline and pipeline. Our baseline position outlines the scale of generation and storage technologies connected to our SP Distribution licence area - the starting point for our forecasts. Our pipeline outlines the scale of our contracted generation and storage projects which are a key driver of our short-term forecasts.

Our baseline contains circa 2.7GW of connected generation and storage of which approximately 65% is onshore wind. Solar is the next most prominent technology with over 10% of connected generation and storage – a notable increase in small scale solar since December 2022 DFES. Non-renewable technologies such as non-renewable Combined Heat and Power (CHP) or non-renewable engines account for circa 10% of the baseline position.

With the significant increase in connections activity, our generation and storage pipeline has continued to grow to 8.9GW, an increase of 60% since December 2022 DFES. A majority of the pipeline – 61% - is driven by contracted storage projects. Figure 17 highlights that a high percentage of these planned storage projects are closely located to demand centres or other generation technologies. As expected, our pipeline indicates minimal growth in non-renewable technology during the short term with continued growth in both solar and wind.

Figure 17 | Geographic view of generation and storage baseline (top) & pipeline (bottom)

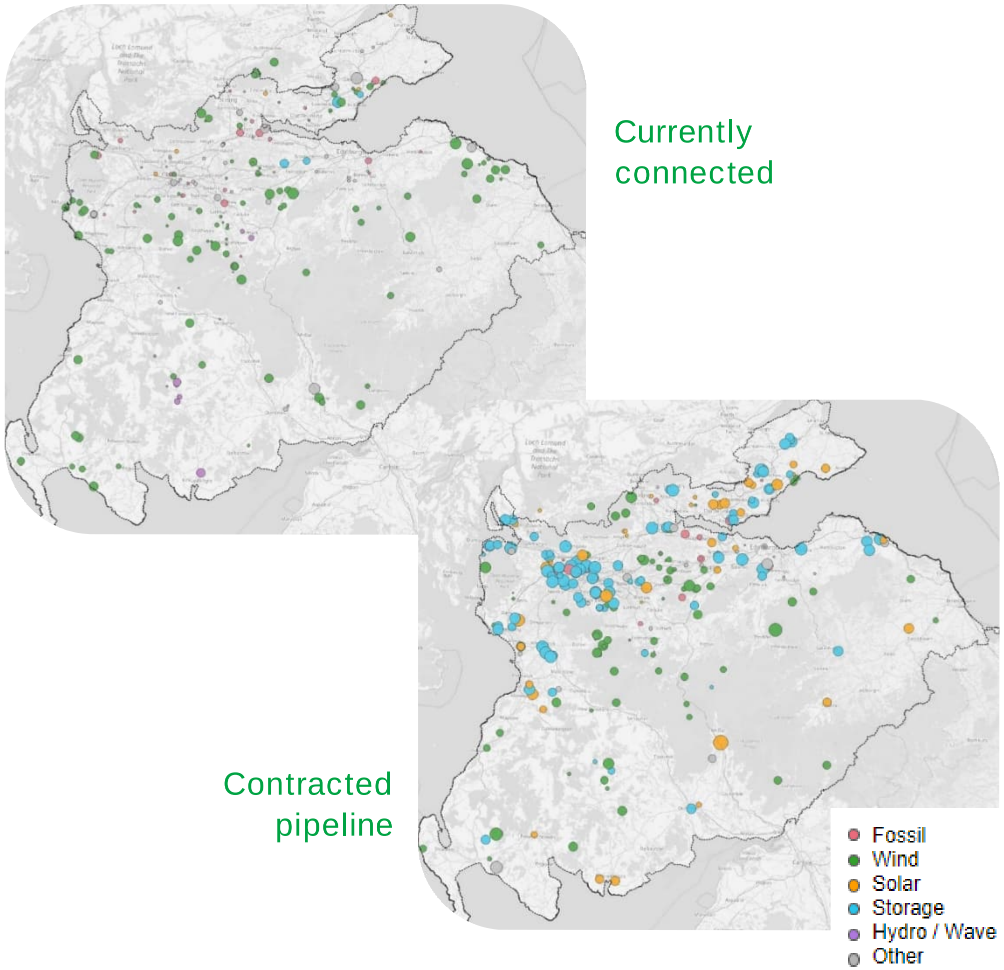


Figure 18 shows how the total generation and storage capacity connected to the Central and Southern Scotland distribution network will vary for the four scenarios. For comparison, the grey area shows the forecasted range (the difference between the lowest and highest scenario) from our December 2022 DFES. Our DFES 2023 generation forecast updates have been incremental. The driver for the medium-term growth is the growth of our generation pipeline, particularly in solar technology.

Figure 18 outlines our scenarios forecast, with distributed generation and storage capacity in our SP Distribution region to be approximately three times higher than today by 2030. By 2050, our scenarios indicate there could be as much as five 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 Falling Short and SPD System Transformation scenarios but could continue to grow to over 16GW in the SPD Leading the Way scenario by 2050. To better illustrate what is driving the changes in generation, Figure 19 shows a breakdown of the generation and storage forecasts from Figure 18 by technology type, for 2030 and 2050.

Figure 19 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[25]. 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 18 and Figure 19 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. needed.

By 2030, connected generation and storage could triple, reaching up to almost 9 GW

OVERALL GENERATION AND STORAGE TRENDS:

1. All scenarios show a significant growth in generation and storage capacity by 2030 and again by 2050. 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 growth in generation and storage is not geographically uniform – some areas of the network will be impacted earlier, and to a greater extent, than others.

Figure 18 | Total installed generation and storage capacity *Installed capacity (MW)*

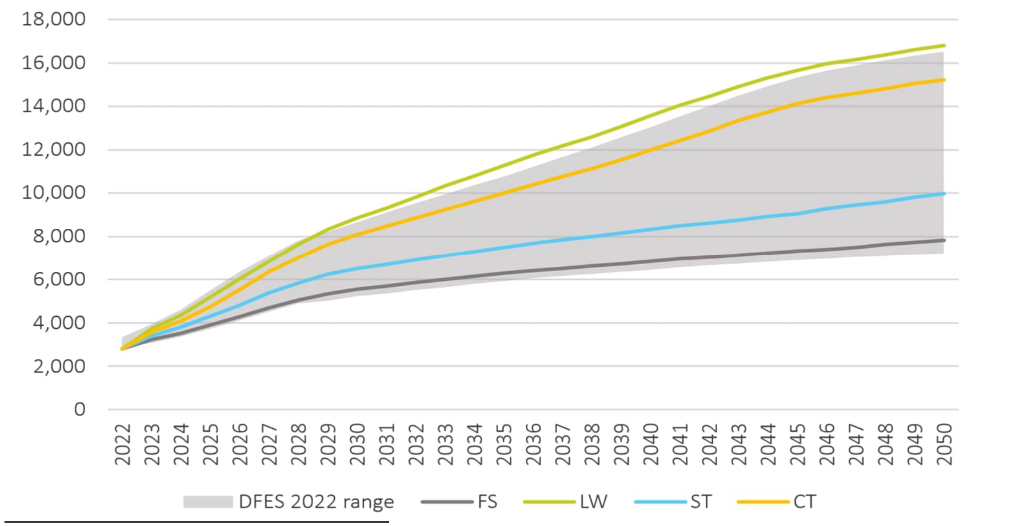
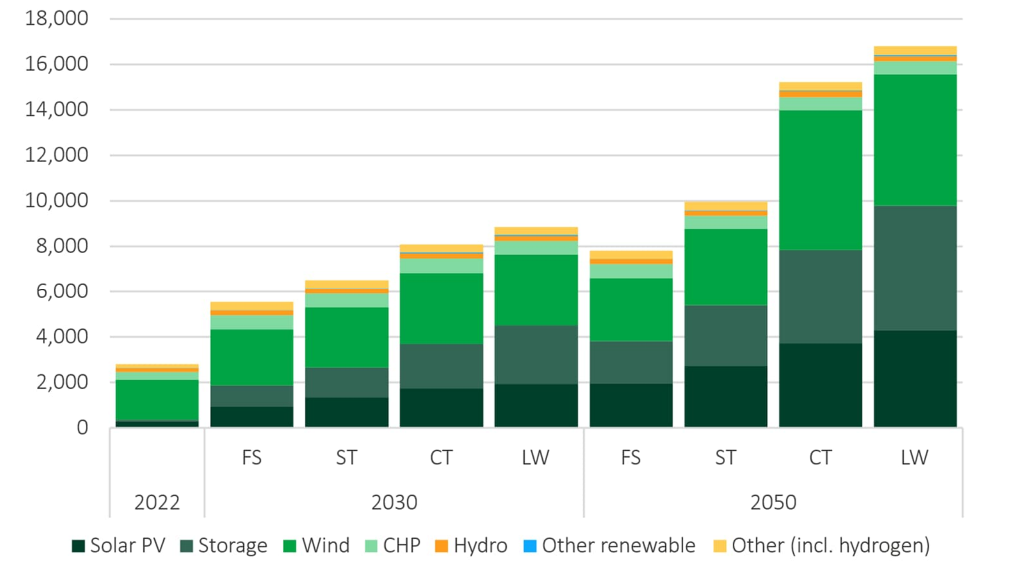


Figure 19 | Breakdown of installed generation capacity by technology *Installed capacity (MW)*



[25] 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 20 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 21 shows a similar representation, for domestic-scale and smaller-scale generation and storage at the primary substation level.

Figure 20 | Installed generation and storage capacity by GSP area — *Installed capacity (MW)*

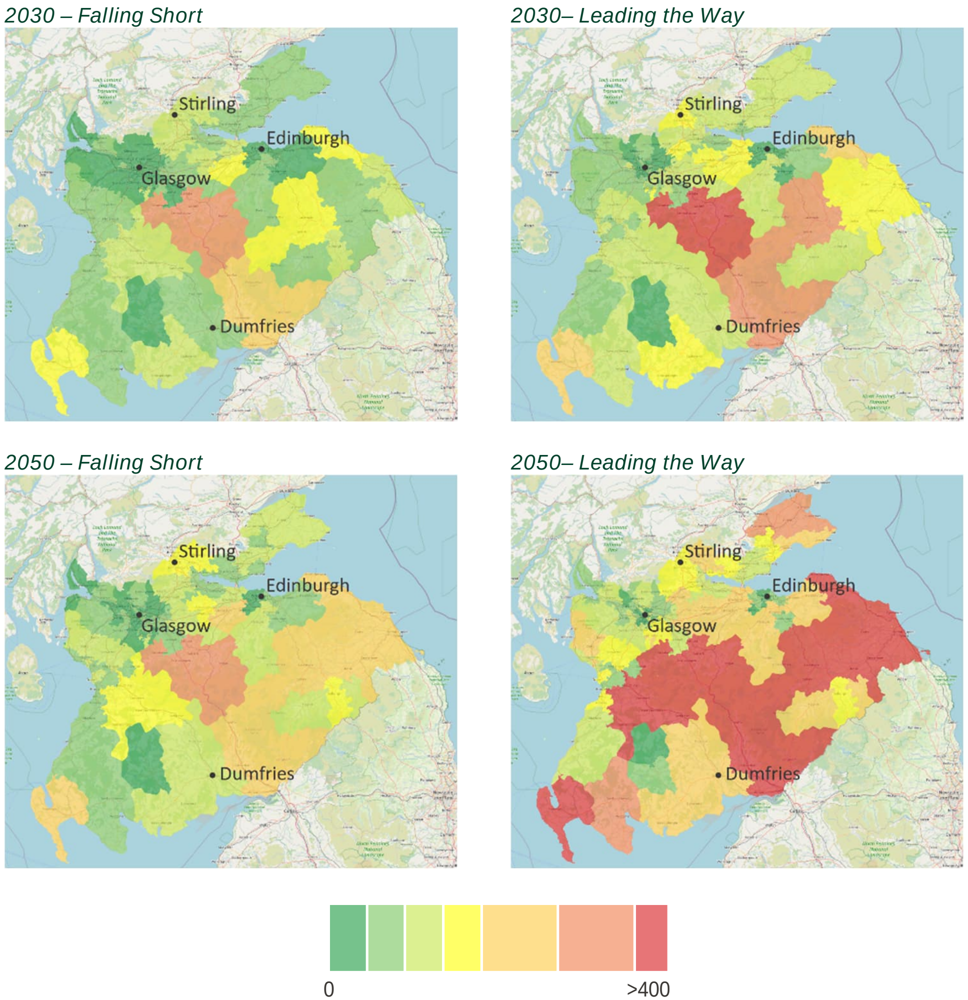
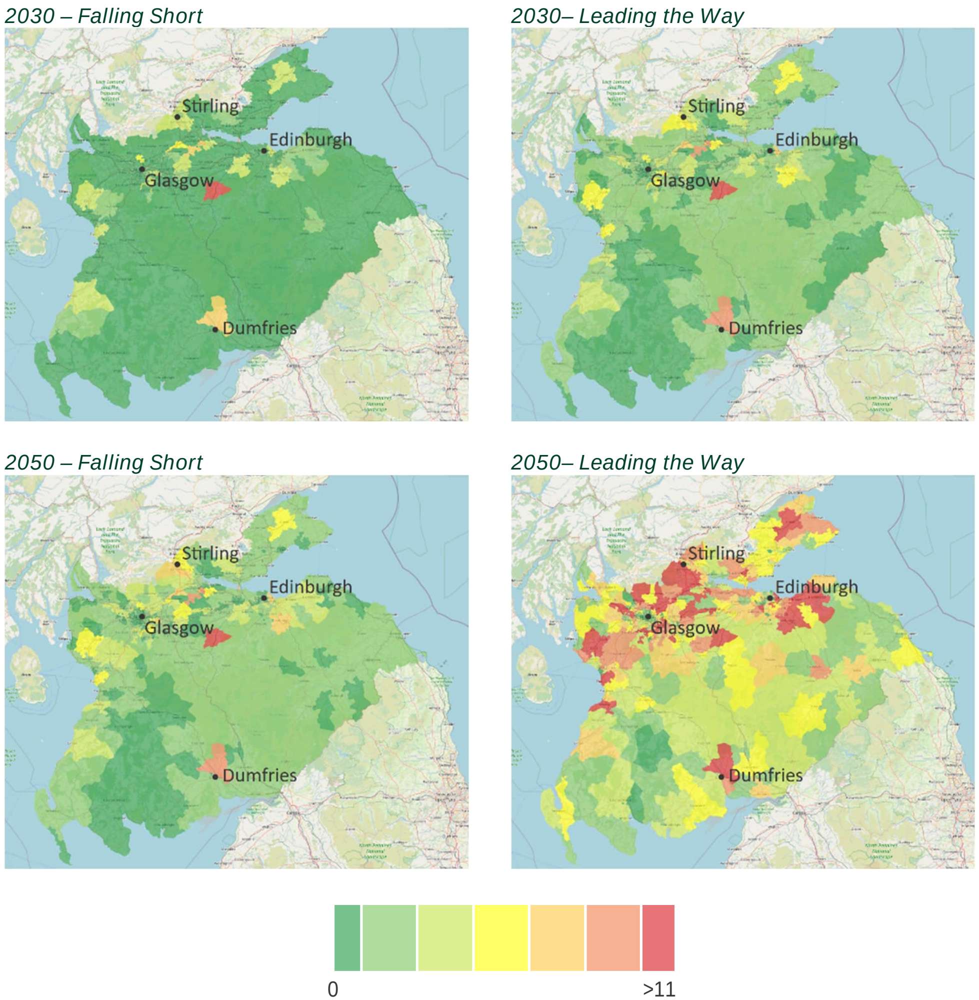


Figure 21 | Domestic-scale and smaller-scale installed generation and storage capacity by primary substation area — *Installed capacity (MW)*



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, our forecasts have projected significant growth in solar to facilitate the further decarbonisation of electricity generation.

In our previous DFES, we uplifted both our short-medium term solar forecasts due to our growing pipeline of solar projects and our longer-term forecasts in line with regional drivers. Since our previous DFES, we have experienced a further significant increase - over 50% – in solar PV that is contracted to connect to the network. This has slightly increased our medium-term forecast further.

With approximately 50% of the installed solar generation in Scotland being connected to our SP Distribution network, this increase also provides closer alignment with the reported Scottish Government ambition for up to 4-6GW of solar power by 2030.

However, this has minimal impact on the long-term outlook, where we are largely aligned with our December 2022 DFES across all but our SPD Falling Short scenario.

In our SPD Falling Short scenario the increase in pipeline driven - medium term - growth results in an upward shift in the long-term capacity forecast. This results in a tightening of our DFES solar PV forecast range, reflecting the significant role that solar generation is expected to play in any view of the future.

Figure 22 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 over six times from current levels by 2030 and 14 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). We might expect to see more solar PV generation co-located with energy storage as a way to utilise a greater generation potential.

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 23 shows a breakdown of the Figure 22 solar PV forecasts for these two categories, for 2030 and 2050.

Figure 23 shows that, for all scenarios, the largest 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 over six times greater than today by 2030.

Figure 22 | Installed solar PV generation capacity *Installed capacity (MW)*

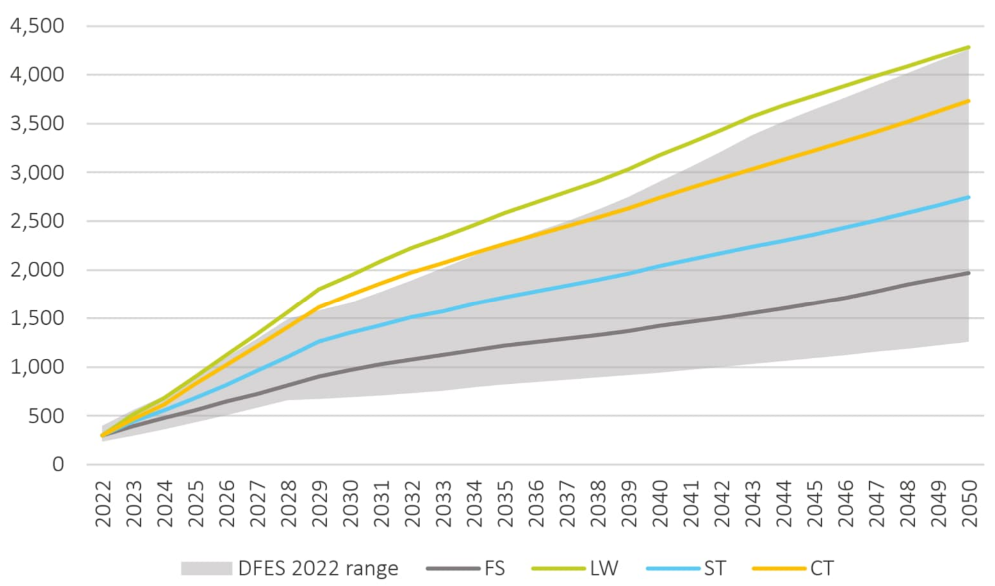
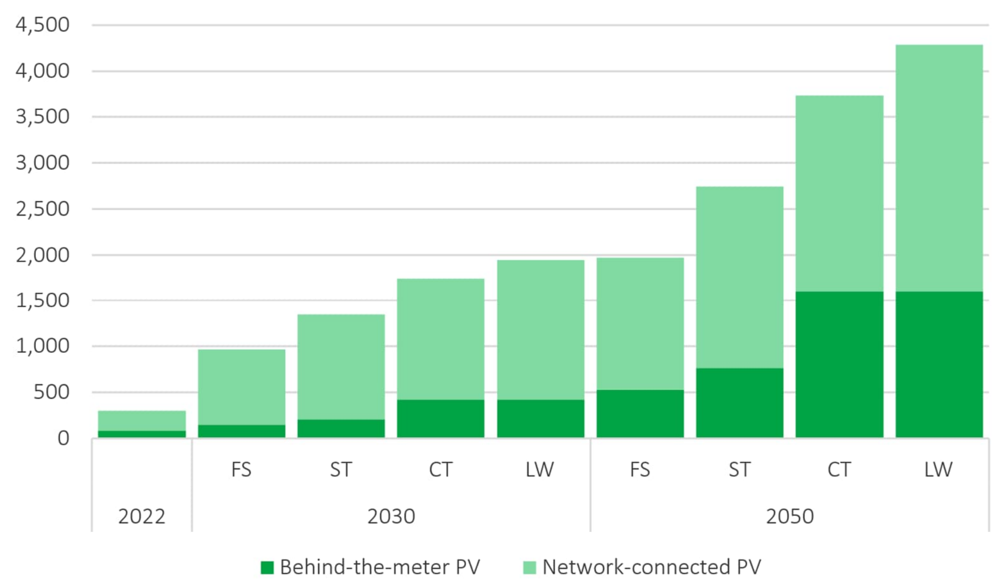


Figure 23 | Distribution connected and BtM solar capacity *Installed capacity (MW)*



Wind

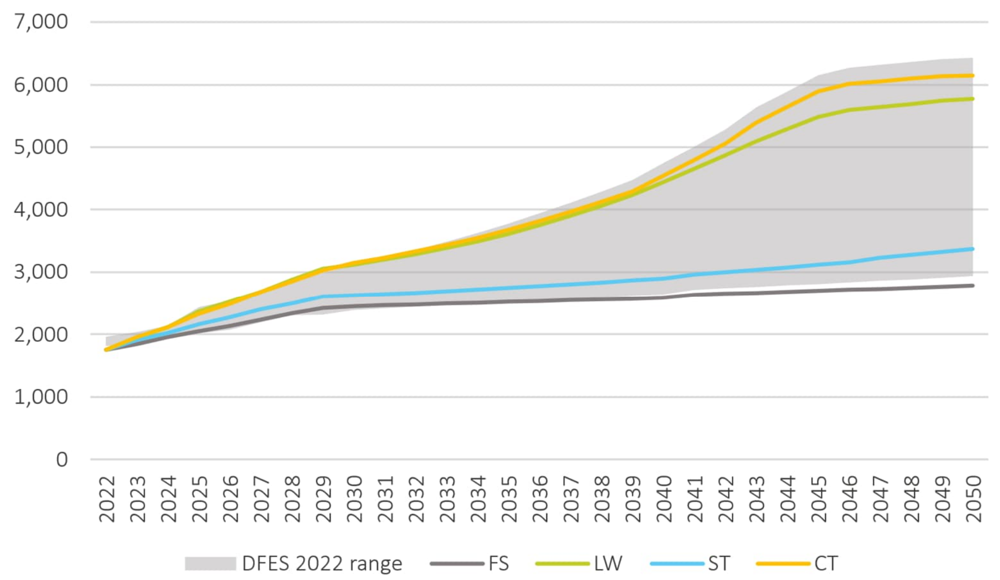
Over the last ten years, there has been steady growth in wind capacity on the SP Distribution network leading to circa 1.8GW of installed capacity – the largest connected capacity of any generation technology.

Wind generation is commonly split into two categories: onshore wind and offshore wind. Very few large-scale offshore wind projects are expected to connect to the distribution network. There are currently no offshore wind projects connected or contracted to connect within our SP Distribution licence area. As a result – and to align with FES - we forecast zero growth in offshore wind capacity in all four of our December 2023 DFES scenarios; the growth outlined in Figure 24 is expected to be onshore.

Any increase in distribution connected wind is expected to be sited in rural areas, taking advantage of more favourable wind conditions. Our generation pipeline reflects this with a further 1.6GW contracted to connect to our SP Distribution network, mostly in our rural area with the closest proximity to demand centres. This pipeline of contracted projects drives our short-term growth, of which we could see up to a 78% increase by 2030.

In the long term, Figure 24 shows significant variance in the levels of wind generation across the four scenarios. As Wind generation is a cost-effective established technology, the extent of new wind generation post-2030 will likely depend on the onshore planning regime, government/policy support, and local support for individual schemes. These factors are scenario specific and are reflected with our DFES scenario range.

Figure 24 | Installed wind generation capacity *Installed capacity (MW)*



However, these refreshed values within our updated DFES scenario range are largely aligned to our December 2022 DFES, with a slight reduction in the long-term forecast in-line with updates to >1MW onshore wind in the ESO's July 2023 FES.

The maximum installed capacity in SPD Consumer Transformation and SPD Leading the Way are still reached in the mid-2040s, which maintains alignment with Scotland's 2045 Net Zero target.

Installed wind capacity is forecast to be the larger generation technology in all DFES scenarios. This continues to highlight that wind is expected to play a key role in electricity generation in any view of the future.

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 78% by 2030.

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

Figure 25 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. 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; this does not include vehicle to grid storage capacity.

Figure 26 shows a breakdown of the Figure 25 storage forecasts for these two categories, for 2030 and 2050. Figure 26 shows that, across all scenarios, the majority of storage growth is for network-connected storage.

In 2022, SPD experienced a step-change in battery storage applications, leading to over 3GW of contracted storage projects. This significant increase in activity led to a substantial uplift between our November 2021 DFES and December 2022 DFES storage forecast. Our updated storage forecasts represent incremental change from our December 2022 DFES. Short-term growth has slightly slowed to better reflect the current rate at which we are seeing projects transition from our contracted pipeline to a network connection. Another driver for the update is how recently a large majority of the pipeline contracted.

In the last year we have had an additional 2GW contract to connect which has led to a storage pipeline in excess of 5GW, a 60% increase on the previous year. However, this is not reflected in an increase to our SPD Leading the Way scenario due to a refinement in our modelling of storage pipeline attrition which effectively delays pipeline uptake to the medium-term. As there was already significant growth in this time range this has resulted in minimal movement from our December 2022 DFES.

Given the high degree of uncertainty in this area, we continue to take learnings from the extensive work undertaken by industry working groups and monitor this area closely.

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

Figure 25 | Installed storage capacity — *Installed capacity (MW)*

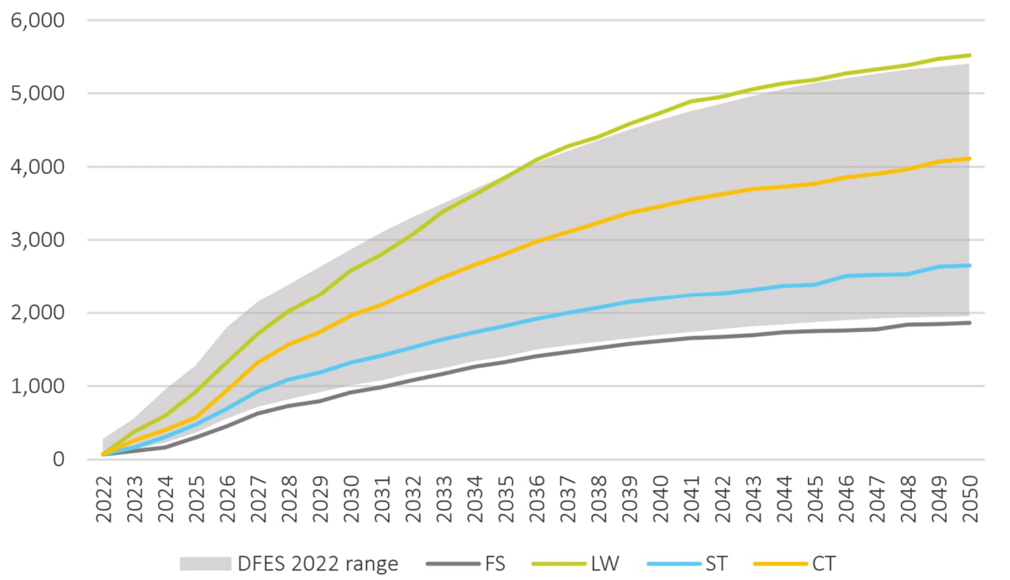
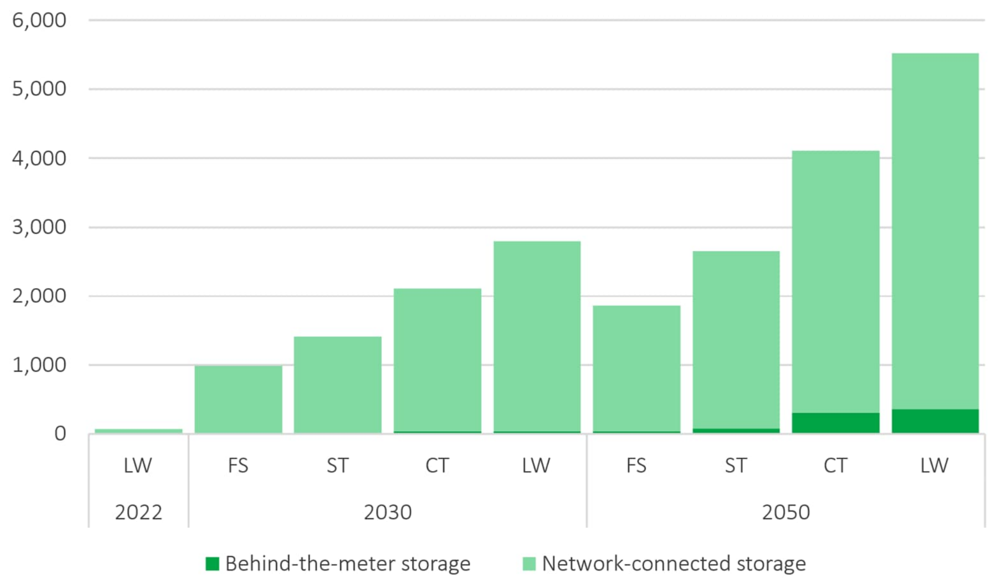


Figure 26 | Distribution connected and BtM storage capacity — *Installed capacity (MW)*



5. Comparing back to FES

This section provides a comparison between the SP Distribution forecasts and the ESO's 2023 FES for key building blocks.

As we explained in Section 3, 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 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[26] and FES regionalisation[27] to compare our DFES forecasts to the FES forecasts.

This section provides a comparison of our DFES forecasts to the regionally equivalent ESO's 2023 FES for key building blocks. Other building block data is available in the DFES data workbook[28].

[26] 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.

[27] 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) breakdown 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.

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

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 27.

However, based on the 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 is five years earlier than the rest of the UK, an 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).

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

Figure 27 | Battery electric vehicle uptake comparison (Lct_BB001 and Lct_BB003) — *Number of vehicles*

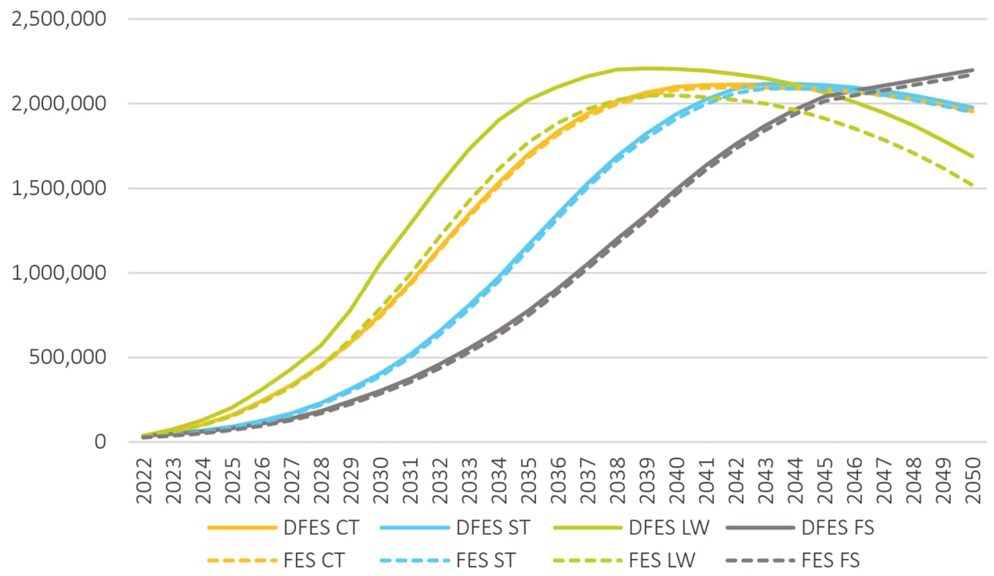


Table 1 | Battery electric vehicle volumes by 2030 — *Thousands*

		Cars, vans and motorbikes *Lct_BB001*	Other vehicle types *Lct_BB003*
DFES	Falling Short	302	1
	System Transformation	403	2
	Consumer Transformation	746	2
	Leading the Way	1050	4
FES	Falling Short	283	1
	System Transformation	385	2
	Consumer Transformation	736	2
	Leading the Way	783	3

Heat pumps

A reduction in FES forecasted uptake of heat pumps results in our comparatively lower December 2022 DFES forecasts in the SP Distribution network broadly aligning with FES, as shown in Figure 28.

The FES forecast for the uptake of heat pumps has notably dropped from the July 2022 FES in our SP Distribution licence area across the forecasted range. This reduction in FES heat pump uptake results in closer long-term alignment between the DFES and FES forecasts.

In the short-term, FES have greatly reduced uptakes in all scenarios; this is notable until circa 2027. To ensure we reflect the ambition of the interim 75% greenhouse gas emission reduction target by 2030, we have not reflected this reduction in our SPD Leading the Way or SPD Consumer Transformation scenarios.

Our forecasts have been revised previously to align with the Scottish Government's Heat in Building Strategy. This sets out their plans to achieve Net Zero emissions in buildings by 2045, and the pace of transition over the next 10 years. The only scenario we have revised in our updated forecasts is the SPD Leading the Way scenario, as other scenarios are broadly aligned with the December 2022 DFES uptakes. Table 2 provides a comparison with FES for heat pumps by 2030.

Figure 28 | Heat pump uptake comparison (Lct_BB005 to Lct_BB008) *Number of heat pumps*

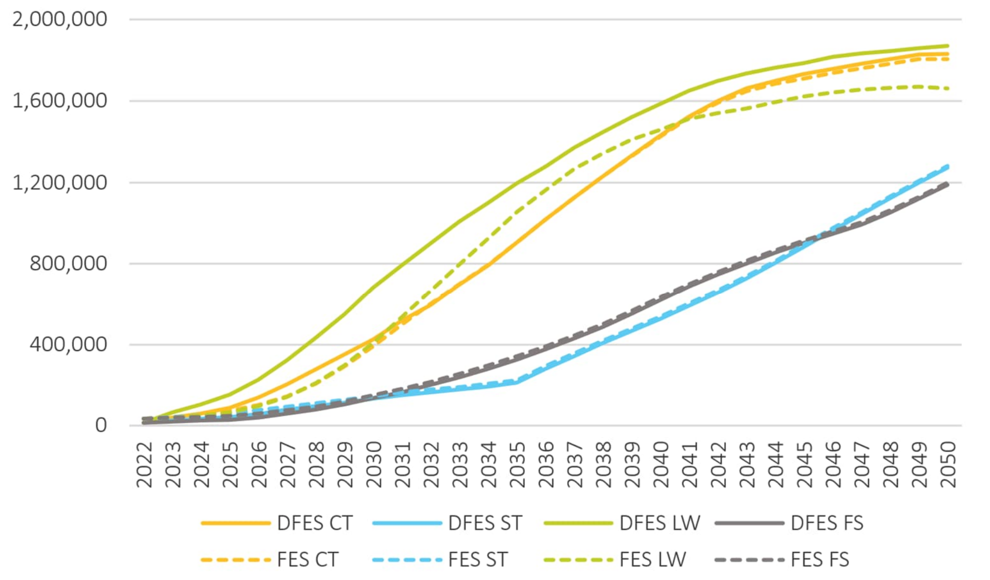


Table 2 | Heat pump volumes by 2030 *Thousands*

		Non-hybrid *Lct_BB005 & Lct_BB007*	Hybrid *Lct_BB006 & Lct_BB008*
DFES	Falling Short	118	19
	System Transformation	105	29
	Consumer Transformation	305	75
	Leading the Way	614	67
FES	Falling Short	131	19
	System Transformation	114	31
	Consumer Transformation	321	69
	Leading the Way	369	38

Overall distributed generation and storage capacity

Our distributed generation forecasts show a faster uptake in the short-term for all scenarios and a comparative growth trend to FES in the medium to longer term, as shown in Figure 29.

This results in an overall higher installed capacity. The faster uptake in the earlier years is mainly driven by the 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.

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

With circa 20% of Scotland's total generation capacity connected to our SP Distribution network, the increase in Generation and Storage growth better reflects the Scottish Government's ambition for more than 20GW of additional renewable generation by 2030.

Figure 29 | Distribution generation and storage capacity comparison (Gen_BB001 to Gen_BB023, Srg_BB001 to Srg_BB004) *Installed capacity (MW)*

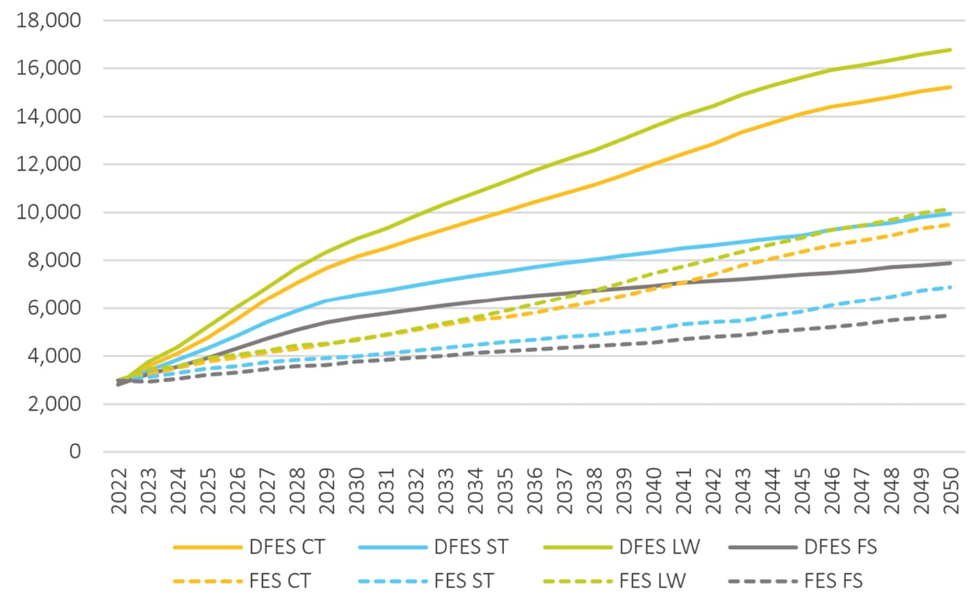


Table 3 | Additional capacity by 2030 *Installed capacity (GW)*

		Total DG *Gen_BB001-Gen_BB023, Srg_BB001-Srg_BB004*	Solar PV *Gen_BB012-Gen_BB013*	Wind *Gen_BB014-Gen_BB016*	Storage *Srg_BB001-Srg_BB004*
	Currently Connected	2.8	0.3	1.8	0.1
DFES	Falling Short	2.8	0.7	0.7	0.8
DFES	System Transformation	3.2	1.1	0.9	0.7
DFES	Consumer Transformation	4.7	1.4	1.4	1.3
DFES	Leading the Way	5.3	1.6	1.4	1.7
FES	Falling Short	0.8	0.2	0.2	0.3
FES	System Transformation	1.0	0.3	0.3	0.3
FES	Consumer Transformation	1.7	0.6	0.7	0.4
FES	Leading the Way	1.7	0.7	0.7	0.4

Solar PV generation

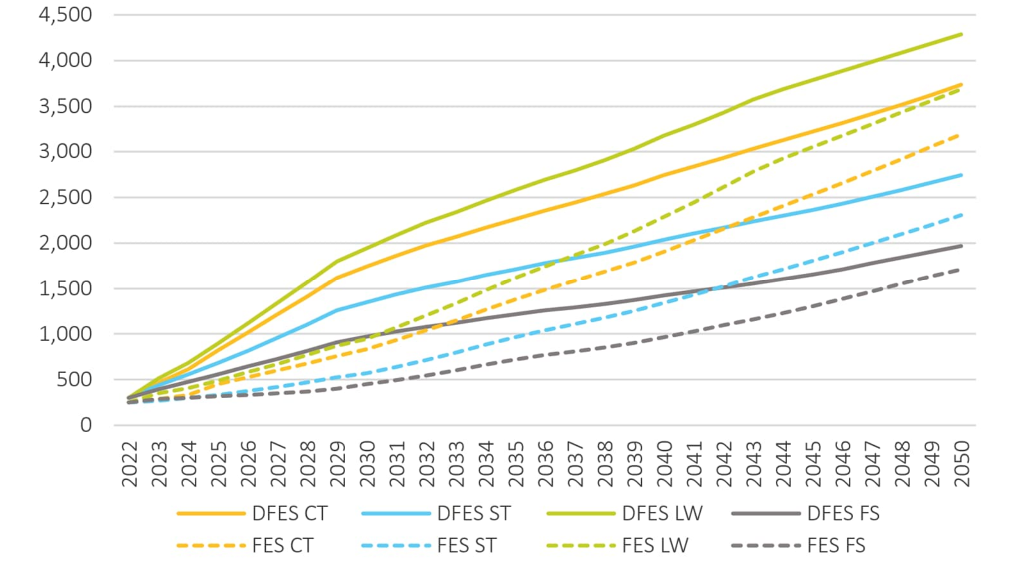
Our solar PV generation forecasts show a faster uptake in the short-term, as shown in Figure 30. This is driven by the number of known generation projects that are in development.

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[29].

This growth is expected to also increase with increased support from the Scottish Government for small scale generation and storage in building, set out in their Update to the Climate Change Plan. This is supported by the reported ambition of the Scottish Government to connect an additional 4GW-6GW of solar generation by 2030.

These targets translate into faster uptakes across the scenarios which provides closer alignment to the reported Scottish Government plans. In the longer term, our growth trend is aligned to FES, resulting in a higher installed capacity.

Figure 30 | Solar PV generation capacity comparison (Gen_BB012 and Gen_BB013) *Installed capacity (MW)*



Wind generation

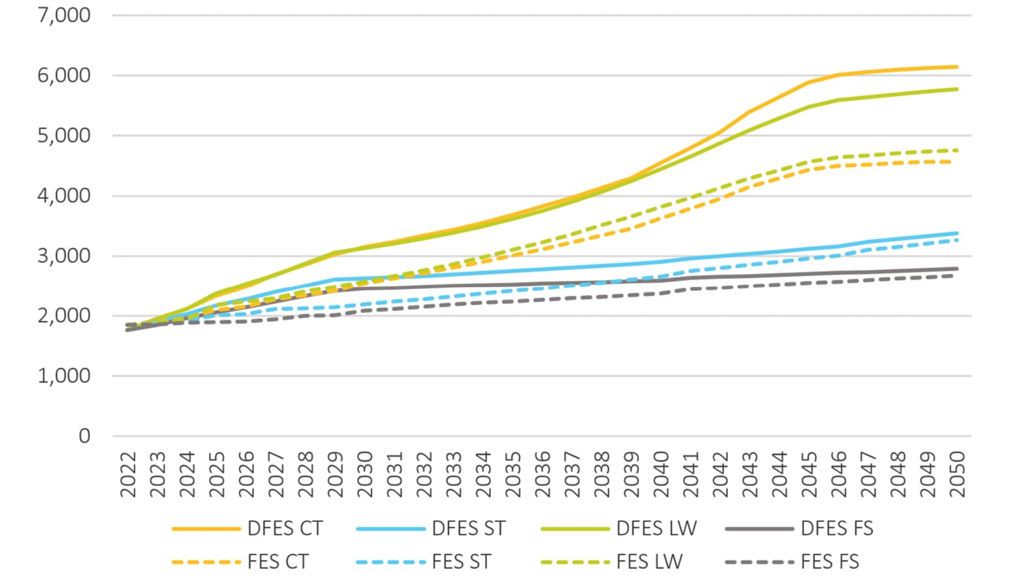
Scotland has a higher availability of wind resource than other parts of the UK. Onshore wind represents 62% of the total generation capacity in Scotland[30], out of which over 18% is connected to the SP Distribution network.

Our wind generation forecasts a faster uptake in the short-term for all scenarios, as shown in Figure 31.

This faster uptake in the earlier years is mainly driven by the number of known generation projects that are in development. The increased growth rate compared to FES is also supported by the Scottish Government ambition to deliver an additional 12GW of onshore wind which is outlined in the Draft Energy Strategy and Just Transition Plan.

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 31 | Wind generation capacity comparison (Gen_BB014, Gen_BB015 and Gen_BB016) *Installed capacity (MW)*



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

[30] https://www.gov.scot/publications/energy-statistics-for-scotland-q4-2022/pages/renewable-electricity-generation/

Storage

Since 2021 we have seen a step change in the level of connection enquiries for storage, including hybrid sites combing wind or solar PV with battery storage.

In 2021, battery storage accounted for 28% of our pipeline; this year it accounts for 61% of our pipeline. This means we anticipate a significantly faster growth in this technology over the short and medium term compared to FES.

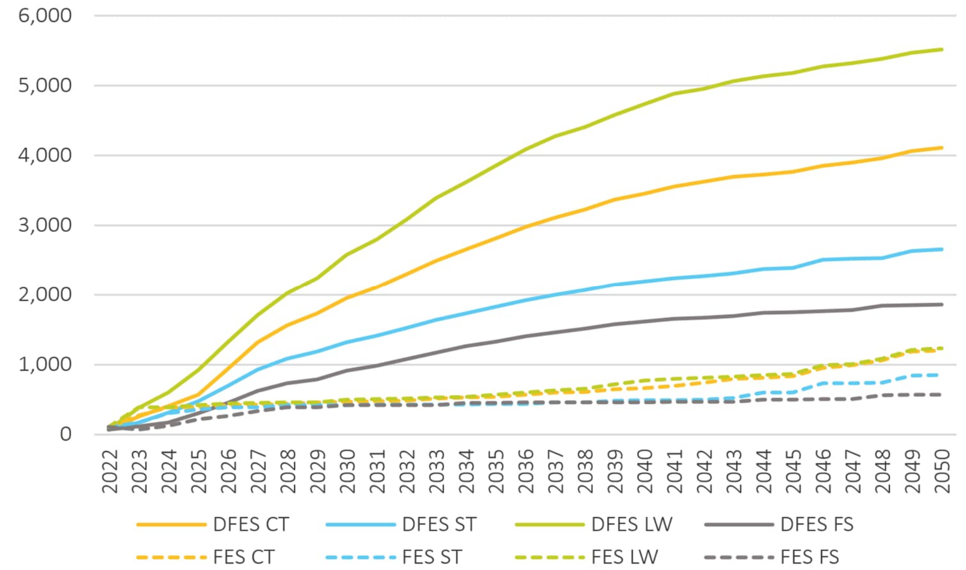
Our growth rate in the longer term in all scenarios is also higher, although more moderately so in the SPD System Transformation and SPD Falling Short scenarios, resulting in a large scenario range by 2050.

We are also expecting storage to connect at a higher percentage of GSPs. We have a storage pipeline at over 70% of our GSPs, compared to just 12% of GSPs in FES by 2030.

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 32 | Storage capacity comparison (Srg_BB001 and Srg_BB004)

Installed capacity (MW)



6. Integrating the CCC scenarios

The Climate Change Committee (CCC) published The Sixth Carbon Budget report in November 2021[31], setting recommendations for the UK's path to Net Zero.

The CCC developed five scenarios to explore different pathways of achieving Net Zero. Key assumptions characterising each of the scenarios are shown in the table on the right-hand side of the page.

This section provides an overview of the forecasts from the CCC, and compares them to the ESO's 2023 FES, and our SP Distribution DFES forecasts.

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 the UK's emission reduction targets. These are a requirement under the Climate Change Act 2008[32].

The Sixth Carbon Budget 22 (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.

Regionalisation of CCC scenarios

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

In order to compare the national CCC forecasts on a like-for-like basis with our regional 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.

This section provides a comparison between the DFES forecasts, the regional GSP results from the ESO's 2023 FES, and for the regionally equivalent CCC forecasts for the SP Distribution network from battery electric vehicles (BEVs) and heat pumps. We have shown these two metrics as they are the main drivers of increasing demand.

Tables and charts of these scenario comparisons are shown overleaf.

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

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

Figure 33 shows the total volume of BEVs considered across all scenarios. Table 4 shows the same data at 2030, 2040 and 2050.

Figure 34 shows the total volume of heat pumps considered across all scenarios. Table 5 shows the same data at 2030, 2040 and 2050.

	Balanced NZ pathway	Headwinds	Widespread engagement	Widespread innovation	Tailwinds
Internal combustion engine ban (new cars and vans)	2032	2035	2030	2030	2030
Heavy Goods Vehicles (HGVs)	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%

Figure 33 | Battery electric vehicle (BEV) uptake comparison *Number of vehicles*

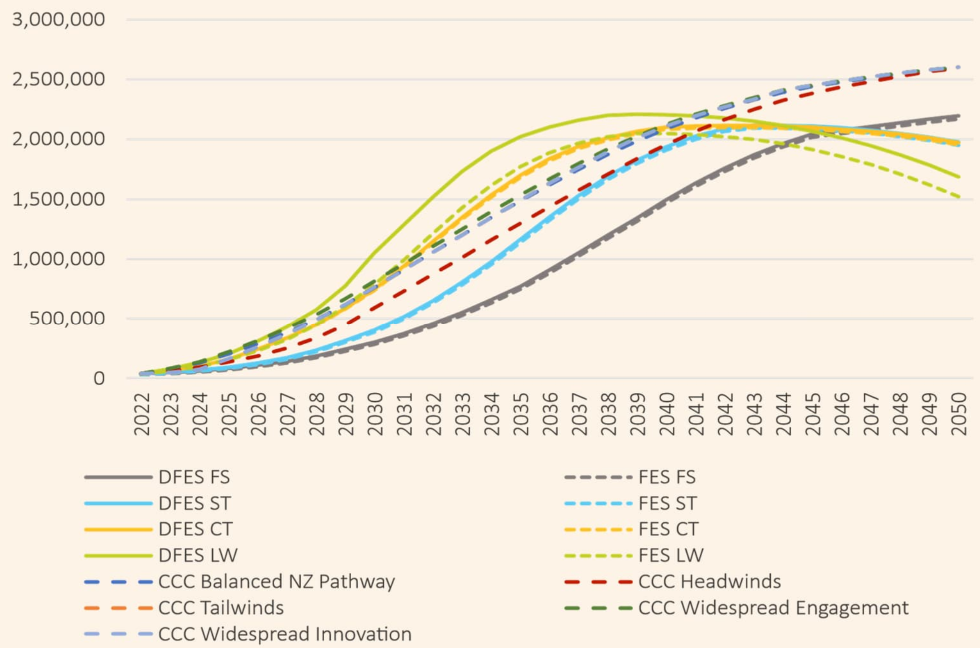


Table 4 | Industry forecasts for BEVs *Millions*

		2030	2040	2050
DFES	Falling Short	0.30	1.49	2.20
	System Transformation	0.40	1.94	1.98
	Consumer Transformation	0.75	2.10	1.97
	Leading the Way	0.95	1.88	1.41
FES	Falling Short	0.28	1.47	2.17
	System Transformation	0.39	1.91	1.95
	Consumer Transformation	0.74	2.08	1.95
	Leading the Way	0.79	2.05	1.52
CCC 6th Carbon Budget	Balanced Net Zero Pathway	0.76	2.09	2.60
	Headwinds	0.59	1.96	2.59
	Widespread Engagement	0.81	2.12	2.60
	Widespread Innovation	0.77	2.11	2.60
	Tailwinds	0.77	2.11	2.60

Figure 34 | Heat pump uptake comparison *Number of heat pumps*

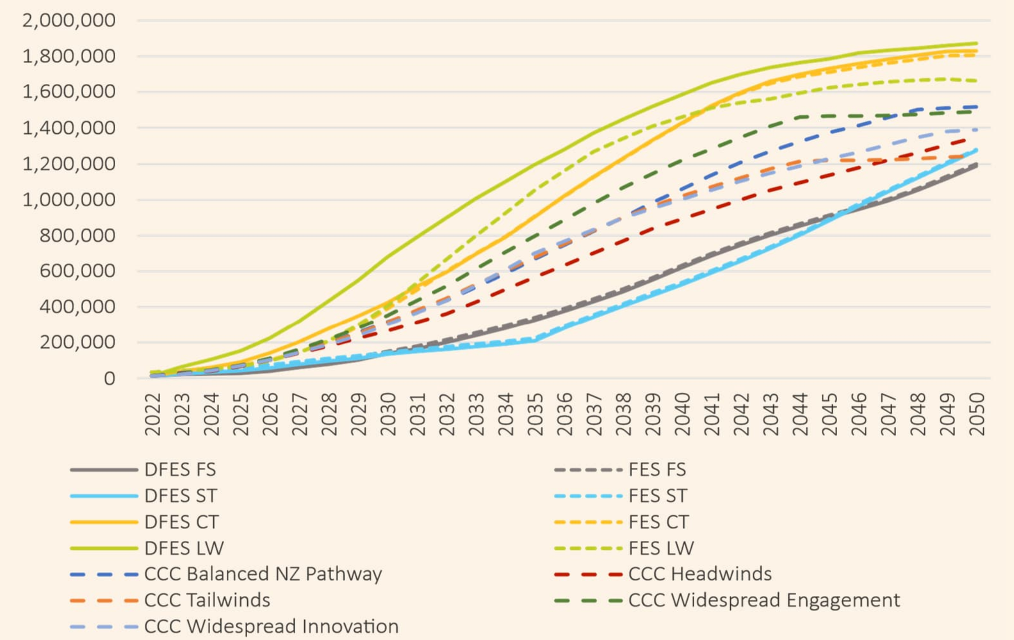


Table 5 | Industry forecasts for heat pumps *Millions*

		2030	2040	2050
DFES	Falling Short	0.14	0.62	1.19
	System Transformation	0.13	0.53	1.27
	Consumer Transformation	0.43	1.43	1.83
	Leading the Way	1.05	2.21	1.69
FES	Falling Short	0.15	0.63	1.20
	System Transformation	0.14	0.54	1.28
	Consumer Transformation	0.39	1.43	1.81
	Leading the Way	0.41	1.46	1.66
CCC 6th Carbon Budget	Balanced Net Zero Pathway	0.32	1.06	1.52
	Headwinds	0.27	0.89	1.35
	Widespread Engagement	0.35	1.33	1.49
	Widespread Innovation	0.30	1.00	1.39
	Tailwinds	0.31	1.02	1.24

7. Range of Net Zero compliant pathways

Electricity distribution networks will play a key role in society being able to reach Net Zero. They must be ready for the millions of EV chargers and heat pumps needed for Net Zero, for the renewable generation needed to power these new technologies, and for the GW of energy storage needed to maintain stability and supplies.

Our DFES forecasts, combined with the ESO's FES and the CCC's own scenario outputs, underpin our understanding of future energy needs in SP Distribution. We use them to develop a pathway for our networks to reaching Net Zero.

DFES: the starting point for network planning

The new demand, generation, and storage that is forecast in these future scenarios will increasingly push the distribution network beyond what it is designed for, meaning that our network needs 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. Therefore, we use the information in our DFES (and wider industry scenarios) to understand when, where and how we must develop our networks.

The Net Zero range and Baseline View

We must endeavour to ensure that any interventions we make are futureproof and will facilitate the Net Zero transition. Taking this long-term view ensures our network is ready to accommodate the energy use and supply requirements of our customers as they decarbonise. By making interventions that we know will stand the test of time, we ensure best value for money for our customers in the long term and efficiently maintain the safe and secure network that our customers can rely on.

WE THEREFORE DEVELOP A VIEW OF THE CREDIBLE RANGE OF NET ZERO COMPLIANT SCENARIOS AND OUR BASELINE SCENARIO FOR PLANNING PURPOSES.

The 2023 Net Zero compliant range was developed with the previous year's range as an input. To develop this range, we consider the ESO's FES and other industry scenarios (including the CCC 6th carbon budget scenarios). We then discounted DFES and FES scenarios that do not achieve Net Zero or interim targets.

THE FOLLOWING TWO SCENARIOS WERE DISCOUNTED:

1. Falling Short (FS): this scenario does not meet Net Zero and so it is excluded.
2. System Transformation (ST): we consider this unable to meet Scottish Government legislative target or interim emission reduction targets, and so it is excluded.

The remaining DFES scenarios (Consumer Transformation (CT) and Leading the Way (LW)) and the five CCC Sixth Carbon Budget scenarios collectively form the Net Zero compliant scenario range. This range meets UK Government and Scottish Government legislative targets, policies, and proposals.

The range also comprises our Baseline View scenario against which we can undertake network assessments and investment plans that represent the best approach for our customers – this is the minimum investment needed to enable Net Zero.

We must also plan to have agility within our delivery strategy to meet anywhere within the low to high scenario range, and so test the whole of the range in our impact assessments and optioneering processes. An overview of the steps in our investment planning process is shown in Figure 35.

Our Baseline View scenario is set to achieve Net Zero, including interim targets and devolved government policies, and tracks marginally above the low end of the Net Zero compliant scenario range due to Scottish Government targets. This means we have a high confidence that LCT uptakes will be at least this level to achieve Net Zero.

IN SETTING OUR BASELINE SCENARIO WE INCORPORATE THE JUSTIFICATION CRITERIA, AS DEFINED IN OPEN NETWORKS (WS1B P2):

Category 1: Justification criteria for alignment with existing/announced policies.

Category 2: Justification criteria for stakeholder engagement inputs.

Category 3: Justification criteria for regional and local characteristic inputs.

More on these criteria is discussed overleaf.

Figure 35 | DFES is the first step in our investment planning process

Category 1: Alignment with existing/announced policies

This range of Net Zero compliant scenarios meets UK and Scottish Net Zero legislation; the requirements of the UK Government's Ten-Point Plan, Energy White Paper, and Heat and Buildings Strategy; and the Scottish Government's update to the Climate Change Plan and Heat in Buildings Strategy. Our Baseline scenario also considers emerging policy and thinking as it becomes available.

Category 2: Stakeholder engagement inputs

Our Baseline scenario incorporates well-justified stakeholder evidence and feedback to capture regional requirements. Stakeholder feedback is used to inform: the timing/level/location of LCT uptake; the underlying factors which affect the forecasts; and to influence the weighting we ascribe to different scenarios during our network analysis. Feedback is reviewed and only included where sufficiently justified based on substantiated evidence, level of consensus and stakeholder ability to influence the metric

We continue to work alongside local authorities to incorporate their latest thinking and provide support in the development of their Local Heat and Energy Efficiency Strategies (LHEES), as part of our Strategic Optimiser role.

Category 3: Regional and local characteristic inputs

Our Baseline incorporates the granular outputs of our innovation projects (EV-Up, Heat-Up, PACE), new connection projects that are in development and a review of the contracted project pipeline against progression criteria such as project design, submission and granting of planning, project finance, past or recent connection requests, or commencement of delivery.

We will continue to reflect categories 1, 2, and 3 feedback into our DFES scenarios and our Baseline scenario.

	UK	Scotland
Net Zero target	2050	2045
% GHG emission reduction target	68% by 2030 78% by 2035	75% by 2030 90% by 2040
EV targets	End the sale of new petrol and diesel vehicles by 2035.	
Heat targets	Ban on gas boilers in new homes from 2025. Install 600,000 heat pumps every year by 2028.	By 2024 all new homes must use renewable or low carbon heat. By 2030, around over 1 million homes and the equivalent of 50,000 non-domestic buildings will need to convert zero emissions heating.
Renewable generation targets	50GW offshore wind by 2030. A five-fold increase in solar power (up to 70GW) by 2035. Up to doubling the renewable energy capacity in the next CfD. By 2035 the UK to be powered entirely by clean electricity, subject to security of supply.	Renewable generation to supply 50% of energy consumption by 2030, and almost 100% of energy consumption by 2050. The development of 11-16GW of renewable generation capacity by 2032.

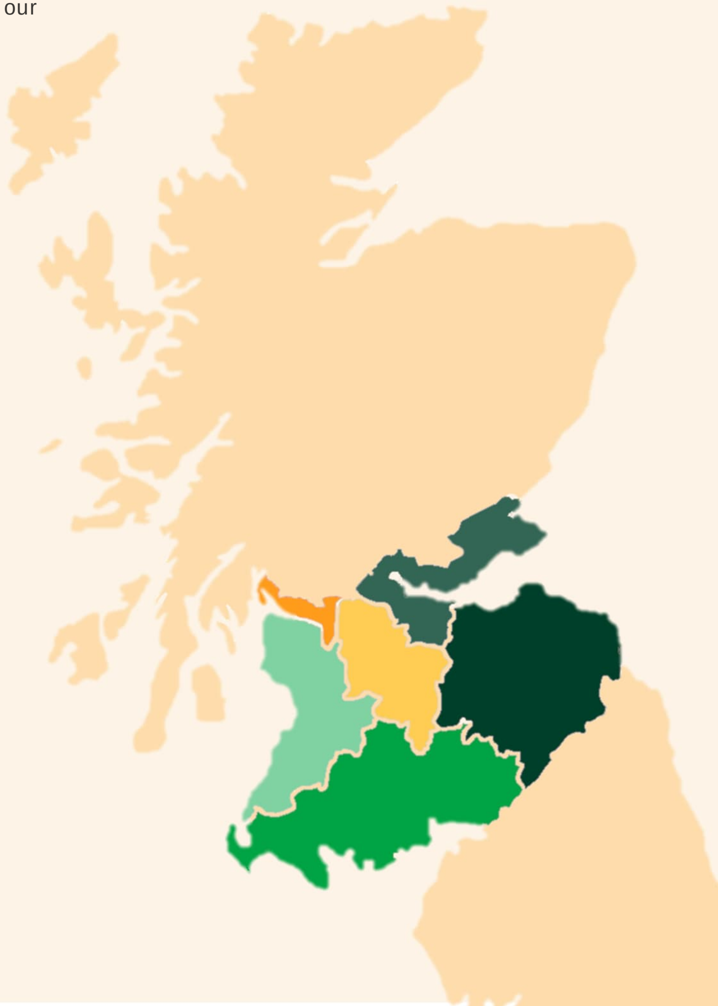


Figure 36 | Total BEV Net Zero range *Number of vehicles*

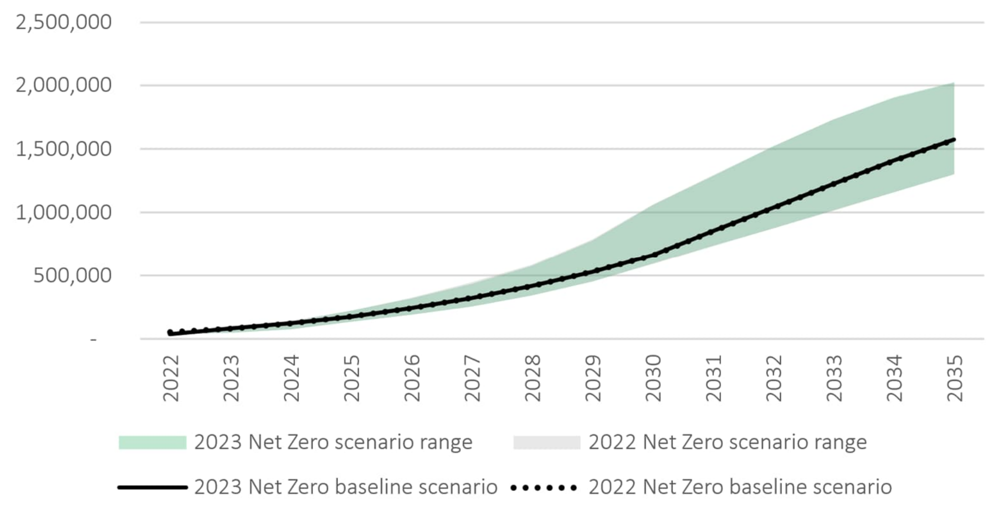


Figure 36 and Figure 37 show our baseline scenario and the range of the Net Zero compliant industry forecasts for the uptake of battery electric vehicles and heat pumps respectively. We have shown these two metrics as they are the main drivers of increasing demand.

Figure 38 shows our baseline scenario and the range of the Net Zero compliant industry forecasts for distributed generation and storage.

Also plotted is the range at the time of last year's DFES 2022 publication, to show how the range is evolving over time. There have been only incremental changes to the ranges this year meaning in the most part, the two years' ranges overlay.

Figure 37 | Total heat pumps Net Zero range *Number of heat pumps*

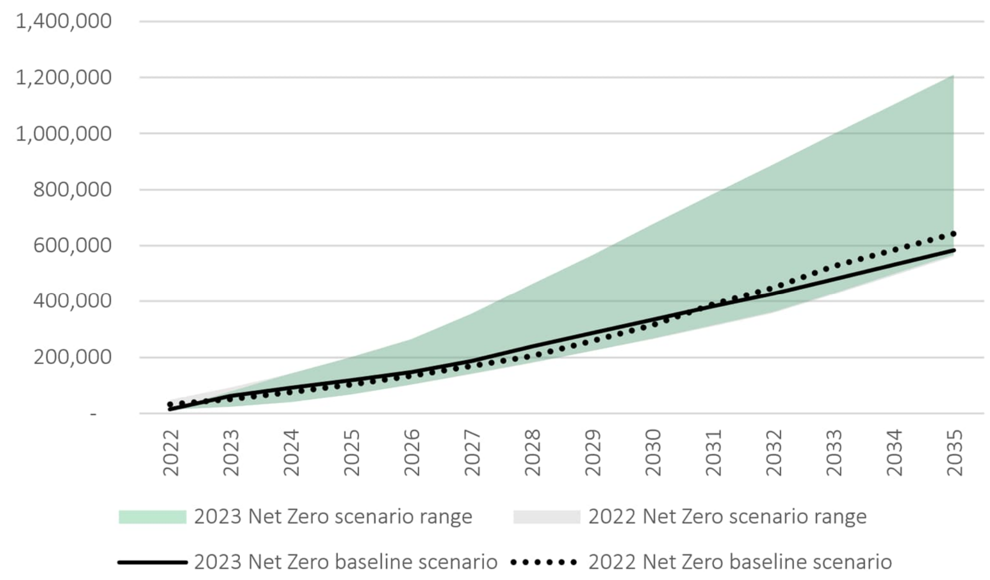
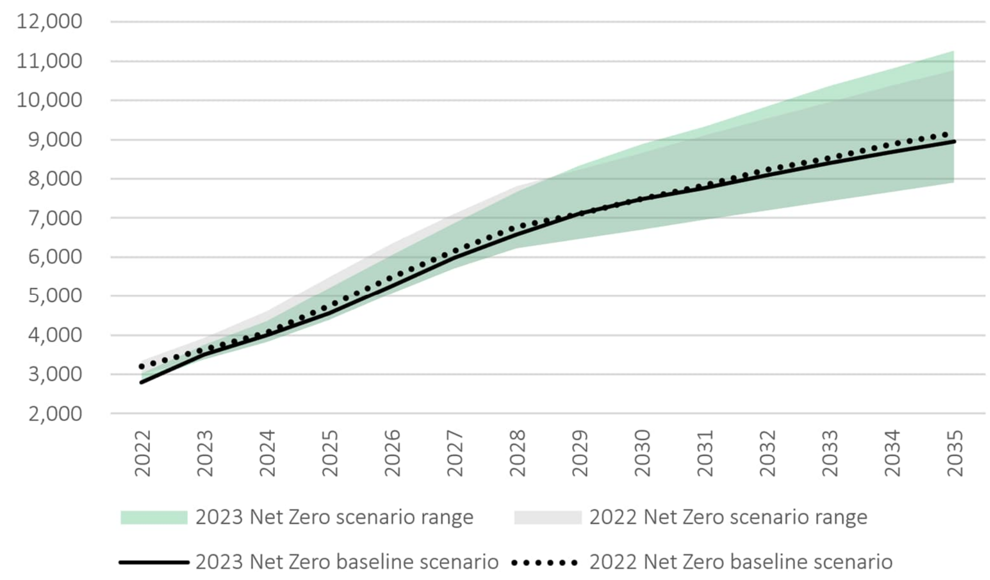


Figure 38 | Generation and storage Net Zero range *Capacity (MW)*



8. Stakeholder engagement

Since the publication of our first DFES document in 2020 we have engaged with a wide range of stakeholders, including 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.

This section summarises this feedback and explains how it has been incorporated within our DFES forecasts.

Summary of feedback

Our stakeholders agree that 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 the 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. There was broad support amongst stakeholders for the range the scenarios covered.

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, with some no longer ordering new petrol/diesel replacements.

The establishment of Clean Air Zones within city centres could encourage more residents to switch to EVs, but stakeholders also saw the lack of on-street chargers, particularly in town centres, as a potential barrier to the fast uptake of EVs.

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, System Transformation and Leading the Way 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 our learning from EV-Up.

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 the Scottish Government's own detailed assessment work and feedback, we have updated our SPD Consumer Transformation scenario to include an increased heat pump uptake in the short to medium term. This is because their legislated target of 75% greenhouse gas emission reductions by 2030, could feasibly accelerate heat pump deployment. There was broad support amongst stakeholders for the range the scenarios covered.

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, with some stakeholders concerned about the uncertainty in pricing and availability in the short-term leading to the adoption of heat pumps and district heat. 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.

Stakeholders were concerned this year about the impact historically high energy prices will have on the short term adoption of heat pumps. However, stakeholder expectations that developers will start moving towards heat pumps in the short term have strengthened, due to the approaching introduction of the New Build Heat standard and expected ban on direct emissions heating systems from April 2024. Stakeholders had reservations about the viability of district heating schemes.

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 Falling Short scenario to between 3-32% in the SPD Leading the Way 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.However there were mixed views on the uptake of large-scale wind projects due to land availability. 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. Some stakeholders thought that as the price of battery storage decreases, more behind the meter storage solutions will be viable for domestic premises. Overall there was broad support for the range of storage capacity the scenarios cover.

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.

How we updated our forecasts

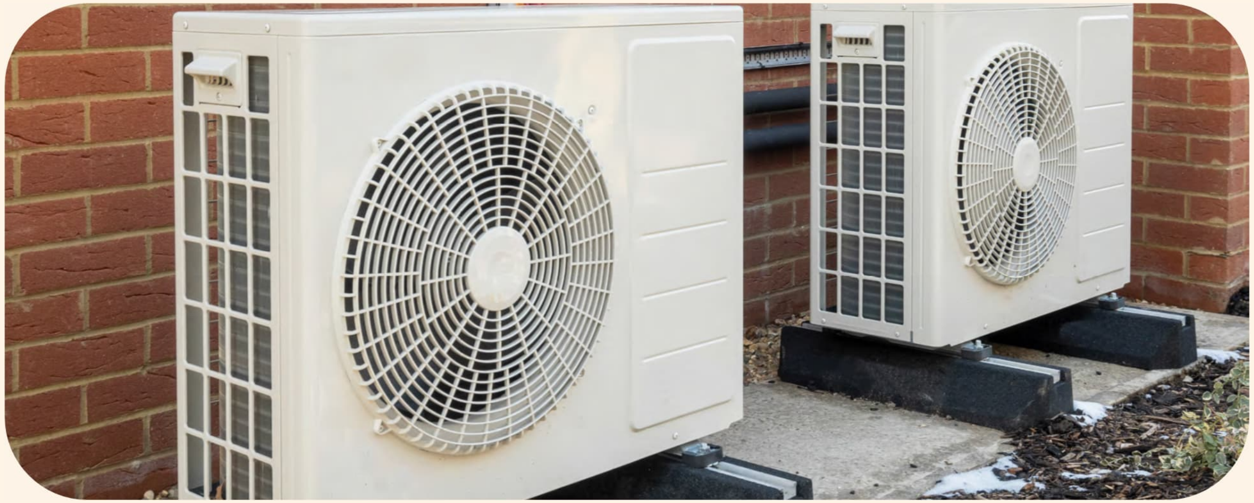
We applied a number of updates to our scenarios to reflect what our stakeholders told us. The tables below summarise the feedback we received and explains the resulting action we have taken.

Electric Vehicles

<table>
<tr><th>Stakeholder feedback</th><th>Actions we have taken</th></tr>
<tr><td>It is important to ensure Local Authority (LA) electric vehicle charging projects and ambitions outlined within Local Heating and Energy Efficiency Strategies (LHEES) flow into SP Energy Networks planning process and DFES.</td><td>Along with our Strategic Optimiser team, we have created the Strategic Project Tracker. This aims to capture projects in early planning which can flow into our DFES pipeline. This allows us to capture projects within our scenarios for DFES, NDP and investment planning.</td></tr>
<tr><td>Consider a more rapid uptake of electric vehicles to help achieve the legislated target of 75% carbon reduction by 2030.</td><td>We have updated the electric vehicle forecast for the SPD Leading the Way scenario to show a faster adoption rate.</td></tr>
<tr><td>By 2050 the number of vehicles is expected to decrease due to autonomous and shared vehicles, and increased home working.</td><td rowspan="2">We believe this is an area of great uncertainty. However, all scenarios except Falling Short show a decrease in total electric vehicles from 2040. This is most pronounced in our Leading the Way scenario, which sees the biggest transition towards other forms of transport and home working. This is in line with the trends in ESO's 2023 FES. We have ensured a greater impact of industrial and commercial electric vehicle contribution to peak demand in our updated forecasts.</td></tr>
<tr><td>Whilst total electric vehicle numbers may decrease beyond 2040, the peak demand contribution is not likely to follow similar trends as number of industrial and commercial electric vehicles would continue to grow.</td></tr>
<tr><td>Destination charging at popular tourist spots could be a significant challenge, particularly in remote areas.</td><td>We have updated all scenarios to incorporate the contribution from destination charging at popular tourist spots.</td></tr>
<tr><td>The uptake of electric vehicles may see a “hockey stick” around 2025-26 as the second-hand car market picks up.</td><td rowspan="2">Our EV-Up project considers different socioeconomic 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 have not made updates.</td></tr>
<tr><td>Rural areas may see more electric vehicles as there is often a lack of public transport alternative.</td></tr>
<tr><td>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.</td><td>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.</td></tr>
<tr><td>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.</td><td>We agree with our stakeholders that V2G capability will be low in the coming decade. We have updated our assumptions in line with the ESO's 2022 FES, which show V2G making an increasing contribution from the 2030s – we have not adjusted this further as we anticipated that rapid improvements in battery technology could mean that warranties and battery degradation may not be such a barrier to V2G over the longer term. We will continue to monitor further technology developments in this area.</td></tr>
<tr><td>There is greater uncertainty around uptake of LCTs such as electric vehicles and heat pumps given the current cost-of-living crisis.</td><td>Our scenarios were not updated, as they already cover a large range of uptake scenarios. DFES must consider the various pathways to achieving Net Zero; however, the Falling Short scenario already provides a low LCT uptake view that does not meet carbon targets. Additionally, it is assumed any impact of current economic conditions will have a short-term influence on uptake which will be negligible on the medium- and long-term outlook.</td></tr>
</table>

Heat pumps

Stakeholder feedback	Actions we have taken
It is important to ensure Local Authority (LA) heat decarbonisation projects and ambitions outlined within Local Heating and Energy Efficiency Strategies (LHEES) flow into SP Energy Networks planning process and DFES.	Along with our Strategic Optimiser team, we have created the Strategic Project Tracker. This aims to capture projects in early planning which can flow into our DFES pipeline. This allows us to capture projects within our scenarios for DFES, NDP and investment planning.
Strong emphasis on social housing and off-gas grid decarbonisation. Local Heat and Energy Efficiency Strategies will reduce the geographical and technological uncertainty on heat decarbonisation.	We proposed to adopt a Strategic Optimiser role in RIIO-ED2 to provide advice and support to all local authorities, across our network areas, on the development of their heat and transport decarbonisation plans. Ongoing collaboration will work in both directions as this will enable local authorities to make more informed and optimal whole system choices, and will enable us to refine forecasts and deliver our future network plans more efficiently.
Scotland is likely to see a higher uptake of district heating schemes.	We believe our forecasts facilitate the Scottish Government's 2030 target of at least 6TWh of heat demand supplied through heat networks.
There is greater uncertainty around uptake of LCTs such as electric vehicles and heat pumps given the current cost-of-living crisis.	Our scenarios were not updated, as they already cover a large range of uptake scenarios. DFES must consider the various pathways to achieving Net Zero; however, the Falling Short scenario already provides a low LCT uptake view that does not meet carbon targets. Additionally, it is assumed any impact of current economic conditions will have a short-term influence on uptake which will be negligible on the medium- and long-term outlook.
Consider a more rapid uptake of heat pumps to help achieve the legislated target of 75% carbon reduction by 2030.	We have updated the heat pump forecast for the SPD Consumer Transformation scenario to show a faster adoption rate in the short to medium term.
Air source heat pumps (ASHPs) will not materialise in grade 1 and 2 listed buildings.	We have refined our heat pump allocation methodology to exclude these types of buildings. All scenarios have been 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.	In DFES 2021, we slightly increased the range of potential flexibility response, in line with the ESO's 2021 FES. This is reflected in our updated forecasts.



Generation

Stakeholder feedback	Actions we have taken
In rural areas high uptakes may be more prevalent, whereas this would not be realistic for urban areas.	We have improved our rurality assumptions used in the allocation of the different generation technologies and storage. All scenarios have been updated with this change.
Storage is likely to develop in high energy industrial and commercial (I&C) and urban areas for peak shaving.	In our forecasts, storage uptake in the short term is driven by our pipeline of known future projects. These tend to cluster around urban and industrial areas in our SP Distribution licence area which is shown in Figure 17.
No large-scale solar PV and wind generation is likely to be sited in Areas of Outstanding Natural Beauty (AONBs).	We have improved our allocation methodology for generation to limit the size of the developments close to National Parks and AONBs. All scenarios have been updated with this change.
Non-renewable generation is likely to reduce to achieve Net Zero, as it would require negative emissions.	We have 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.	Our forecasts include growth in hydrogen-fuelled generation from the late 2020s in our SPD Leading the Way, SPD Consumer Transformation and SPD System Transformation scenarios. However, our growth is aligned with FES which suggests that the install capacity of hydrogen-fueled generation connected to our SP Distribution network is likely to be limited to approximately 100MW.
Storage is expected to account for at least 25%, rising over time.	In our forecasts, electricity storage accounts for between 17-33% of the total generation capacity by 2030. In our DFES 2022 update we have included a significantly increased storage pipeline. This does not include the inherent storage capacity of electric vehicles. We consider this an area of high uncertainty and will continue to monitor evolving trends around energy storage.
Battery storage has been installed alongside electric vehicle charging points and in domestic properties to great effect. Where finances allow this will be a preferable strategy. For the fair and equal decarbonisation of social housing, battery storage may also play an important role when solar PV is unsuitable.	This feedback reinforced what we have already experienced through our generation connections pipeline. During 2022 we have seen a rapid step-change in battery storage connection applications, our forecasts reflect a large growth within the technology.

9. Glossary

Behind the meter (BtM) – 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.

GW – gigawatt - 1,000MW (see 'MW)

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

kW – kilowatt – 0.001MW (see 'MW')

MW – megawatt is a unit of power (not energy). It is the amount of electricity that is flowing at any instant. We can measure both the amount of power that a demand user is consuming at any instant (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"). For scale, 1MW is about 400 full kettles all boiling at once. The largest onshore wind turbines in GB are about-3-4MW in size.

Minimum demand – the point in the year, typically during the summer months, when our distribution network as a whole sees the lowest demand (measured in MW). 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 (measured in MW). 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 – an interface point between the 33kV and 11kV networks.

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.

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

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.

True Demand – the total demand used by our customers. This includes the gross power provided by both the transmission system, via our Grid Supply Points, and that provided by embedded generation connected directly to our distribution network.

Vehicle to grid (V2G) – 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.

SP Energy Networks
Distribution Future Energy Scenarios 2023

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