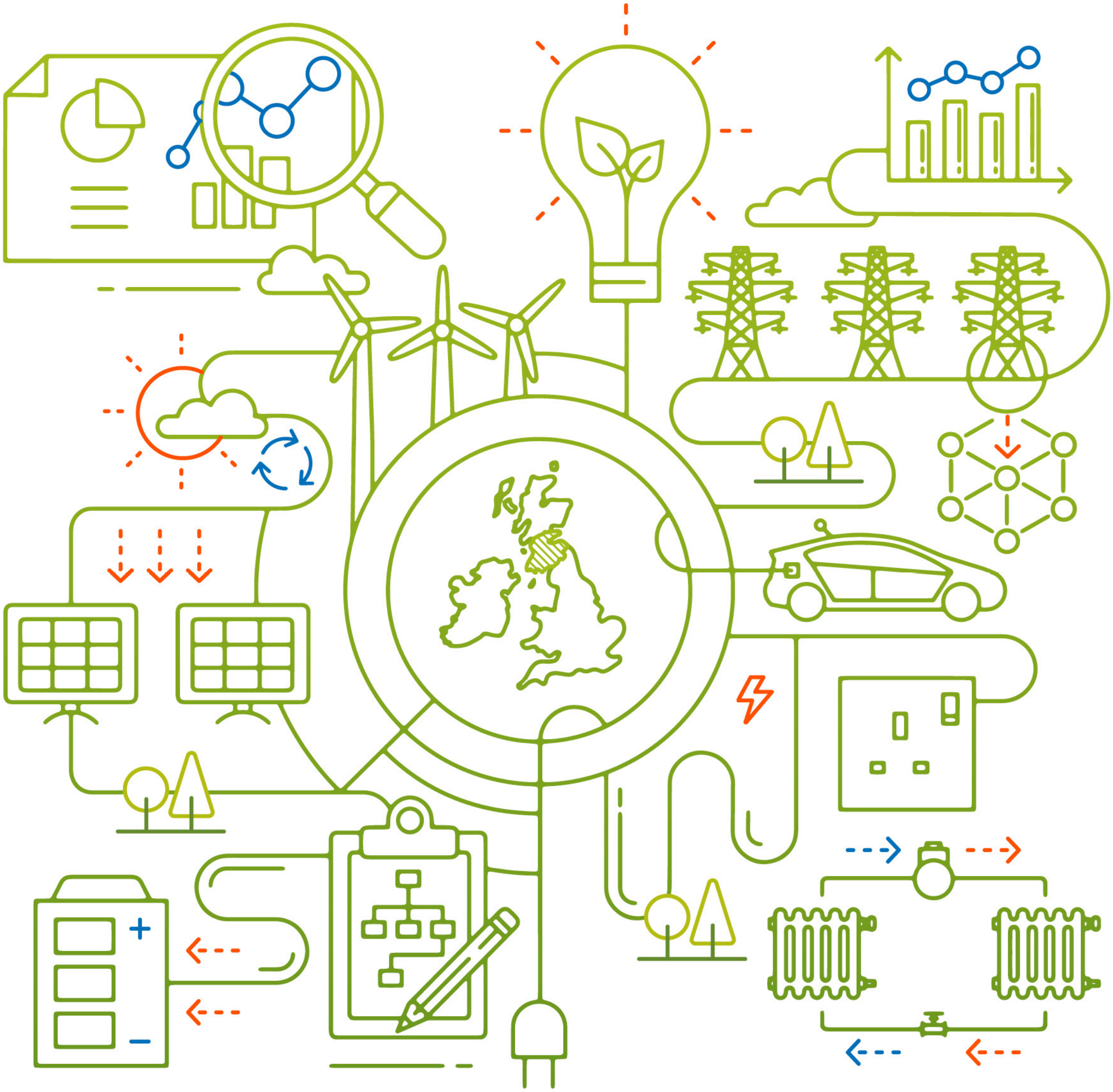
SP ENERGY
NETWORKS

RIIO-T2

Central and Southern Scotland Electricity Scenarios 2018



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Commissioned partners:

Baringa
Brighter together

Supported by:

elementenergy

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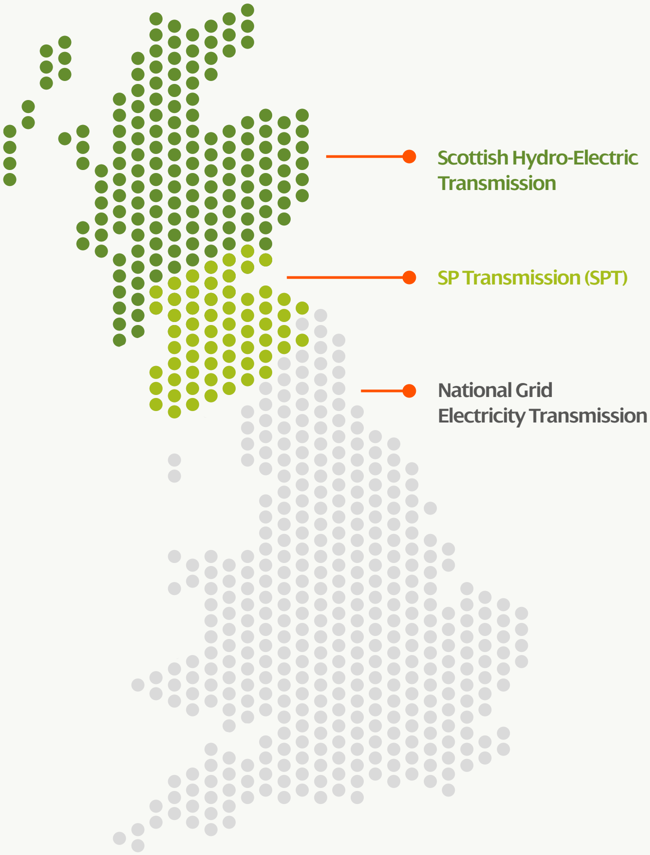
Introduction

SP Energy Networks are responsible forthe transmission of electricity in central and southern Scotland. We take electricity from power stations, windfarms and other utilities and transport it through our extensive transmission network. The SP Transmission system comprises approximately 4000 km of overhead line and cable. We have 152 substations operating at 400, 275 and 132kV supplying approximately 2 million customers across an area of 22,951 square kilometers. There is currently over 7.5GW of generation connected in the SP Transmission area, including 33 power stations and windfarms directly connected to the SP Transmission system.

The transmission network is vital to the security of supply, facilitating the energy market and achieving the delivery of the Government's renewable energy objectives. Due to our network's location in an area of outstanding renewable resource we have a unique role in connecting renewable generation and providing the bulk transfer of renewable energy from the north of Scotland into England & Wales benefiting stakeholders well beyond our licence area.



We are developing our investment plan for the transmission network spanning the period 2021-2026 in advance of it being submitted to Ofgem as part of the RIIO-T2 process in 2019. As we look towards this period and beyond, we recognise the significant challenges which face the energy industry and the transmission network. Over the next decade we expect to see major changes to the way the network operates including:

- Continued decarbonisation of electricity generation with further volumes of renewable generation connecting, most notably large volumes of offshore wind.
- The continued reduction in synchronous generation in Scotland with the closure of the large nuclear power stations, which will change the dynamics of the system in Scotland.
- A move to electrifying transport and heat, increasing customers' dependency on electricity as an energy source.
- A move to a more decentralised system, where more electrical energy is generated locally by smaller renewable generators.
- Increasing flexibility with evolving energy markets and new business models where electricity is a more readily traded commodity at a local level as well as nationally.
- Demand and storage will provide services to new network operators as the DSO (distribution system operator) model is established.

Our RIIO-T2 investment plan will set out the needs of the future transmission network to accommodate the transition to a low carbon energy system. Our plans will seek to accommodate the needs of all supply and demand customers, help facilitate overarching decarbonisation objectives and target investments only where needed to keep costs low for end-users. This document provides an introduction to how we are planning for this future and we are seeking your views to help shape this.

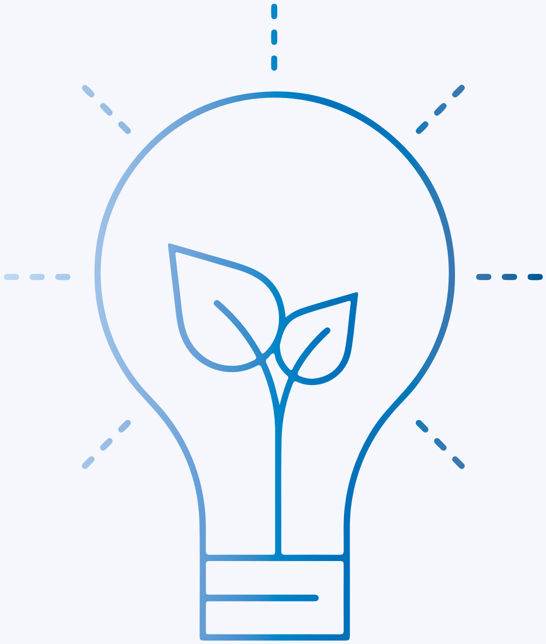
Your Feedback

Feedback from stakeholders is vital to ensure our plans meet the needs of our customers. Views on the following areas would be welcomed by the 28th September 2018 and can be emailed to **RIIO_T2@spenergynetworks.co.uk**

1. The scenarios we have considered look at a variety of different pathways that could develop in the future. Do you agree that these are a reasonable range of scenarios to consider for planning purposes?
2. Are there any other major issues which we should be planning for the transmission network to accommodate which we have not detailed in this document?
3. Do you have any views on a particular scenario which we should be using as the basis for building our RIIO-T2 plan?
4. In addition to the use of scenarios, do you have any suggestions on how we should be factoring in the range of uncertainty in our business plan?
5. In this document, we identify an important longer term dependency on flexibility to move peak demand around in order to minimise the impact on the network. One of the key areas is the charging profile of electric vehicles. Do you agree that this is a reasonable assumption?

2

Future Challenges for the Network



The Scottish and UK governments have committed to a significant change to the energy system in response to global climate change initiatives. The Scottish Government's Climate Change Plan[1] and Scottish Energy Strategy[2] identify a number of ambitions which will have a direct impact on the electricity network. Some of the most notable ambitions include:

- By 2030, the equivalent of 50% of the energy for Scotland's heat, transport and electricity to be supplied from renewable sources.
- Scotland should have the capacity, connections, flexibility and resilience necessary to maintain secure and reliable supplies of energy to all of our homes and businesses as our energy transition takes place.
- By 2032, phase out the need to buy petrol and diesel cars or vans.

The evolving energy landscape will require changes to the transmission network in different ways:

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[1] www.gov.scot/Publications/2018/02/8867

[2] www.gov.scot/Publications/2017/12/5661

Generation

New connections	As new generators seek to connect to the transmission network, new assets are required to do so. This can include overhead lines, cables or substations depending on the location and size of the generator. This may also result in increasing the capacity at other points on the network to allow power to get to the areas of demand.
Changes to existing connections	As existing generators such as windfarms increase capacity, this may require new assets, but at other times can be managed using smarter techniques to manage the generator within the existing equipment limits.
Removal of generation	As generation plant comes to end of life; the removal of generation can impact the operating conditions of the wider network. The loss of thermal generation in the SPT network area has had an impact on system inertia which changes how the system as a whole reacts to faults. We are also seeing greater fluctuations in the transmission voltage as the generation mix changes. This can trigger reinforcement in other areas of the network to ensure the system continues to be safe and operates reliably.

Demand

Existing demand	The electricity being consumed by all types of customers; domestic, industrial or commercial, has an impact on the power which flows through the network. Over the last ten years we have seen a progressive decrease in demand due to changes in the industrial landscape in Scotland as well as major progress in energy efficiency such the replacement of inefficient lighting, appliances and processes.
New demands	The move towards electrifying transport will result in increasing demand for electricity. The decarbonisation of heat may also result in more buildings being heated by electric heat pumps.
Flexibility	The time at which electric vehicles are charged will need to be flexible to minimise the impact on the network. An example of this is when an electric vehicle is charging overnight, it may be cost effective to delay the charge until an off peak time overnight.

Other changes

Interconnection in Great Britain	The SP Transmission network is interconnected with SSEN to the north and National Grid to the south. In these respective areas, the generation mix and consumption profile is quite different. For large parts of the year, power is transmitted from Scotland to England due to the amount of wind generation located here. At other times, the flows can reverse due to the increasing volumes of solar generation in England as well as other traditional generation when the wind levels in Scotland are low. Across Great Britain, the number of points of connection with Europe is increasing. This creates other new dynamics to help support the wider system.
Storage	Historically electricity has been difficult to store at large scale, only pumped hydro was technically and economically feasible. We are now seeing a greater interest in large scale batteries connecting to the distribution and transmission network. This allows power to be stored when it is plentiful and low cost, and provided back to the network when generation is constrained.
Decentralisation	As energy is increasingly generated locally and decentralised, the transmission network will continue to play a role to link and allow for coordination of these different resources nationally. In the SPT area, we are already experiencing high levels of generation connected to the distribution network and are now exporting onto transmission.

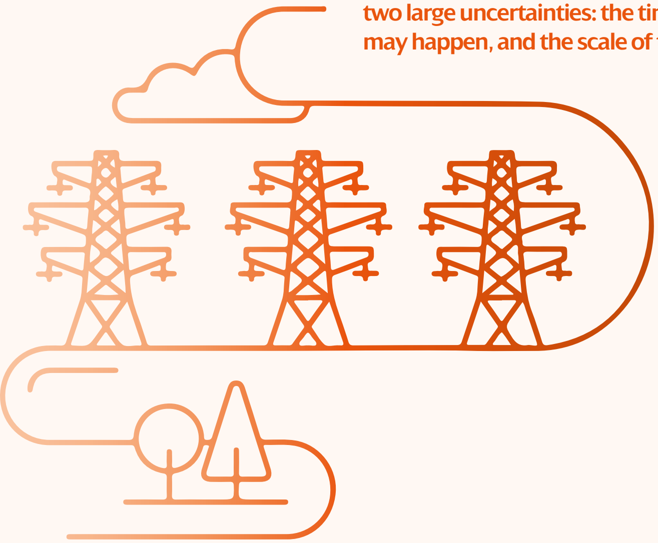
What is Decentralisation?

Decentralisation reflects the extent to which energy supply is sited closer to the point of demand (or is even undertaken by consumers themselves) via the use of smaller-scale technologies such as solar photovoltaics and local energy storage. This is in contrast to the current electricity system, which is focused around generation from large-scale sources such as gas or nuclear that are often located far from the point of demand. As a result, this may change the number of generators directly connected to the transmission network, but the transmission network is expected to continue to play an important role in moving power around the country to locations where decentralised energy cannot meet local demand e.g. when the wind is not blowing.

3

The Role of the Transmission Network

It is important that the transmission network can facilitate changes in demand and generation cost effectively and in a timely manner to ensure they meet customers' needs. All of these changes create two large uncertainties: the time at which the change may happen, and the scale of the change.



Throughout this transition, the transmission network continues to play an important part in the overall operation of an efficient energy system.

Facilitating an open energy market – The wide array of generation sources such as wind, solar, hydro and nuclear are all located in different parts of the country depending on resource availability. Demand can however be a long distance from this generation, and demand patterns change throughout the day. The transmission system plays an important part linking the different regions of the country to allow the available generation to serve this demand. Without this, the generation would be more heavily constrained as the power could not feed those areas of demand, and generators would not be as able to sell power to the wider GB market which would impact the prices users pay. This will continue to be important, even in a decentralised scenario.

Connecting generation – Large scale generation continues to be cost effective, and new large scale generation sources are becoming more prevalent such as offshore wind. For many of these, connection at a transmission voltage level is the only viable option to transfer large quantities of power.

Cost effective – Transmission voltages are the most economic means for moving power around the country and minimises the electrical losses that are experienced at lower voltages or through the use of storage.

Reliability – The SP Transmission network has a reliability level of 99.99998% and plays an important part in the UK economy. As customers become more reliant on electricity for heating and transport, this reliability will become even more critical.

Blackstart – in the event of a total loss of power in Great Britain, the restoration and coordination of the whole system would be highly dependent on the transmission system. Key generation stations would be vital to restarting the grid and linking the various parts of the country in a coordinated way.

4

How are we considering these issues?

The creation of our business plan is dependent on a number of factors. We recognise the importance of the transmission network but are aware that the future requirements are less certain. As such, we need to be able to plan carefully to ensure the needs of customers are met in a cost effective and efficient way.

There are three key elements in how we will build our plan for RIIO-T2.

Being led by stakeholders	Our business plan is created in coordination with customers and stakeholders. We have already been engaging with stakeholders through a number of forums as well as taking feedback from our day-to-day activities to ensure our forward plans meet their needs.
Whole system approach	The transmission network does not operate in isolation and we are committed to ensuring a coordinated approach with the wider system. This includes the distribution network, SSEN, National Grid as Transmission Owner and System Operator, as well as other energy sectors such as gas and transport.
Using energy scenarios	Our future plans need to consider the changes that may arise. To do this, we are using a scenario based approach to help understand the future evolution of energy supply and demand on our network through RIIO-T2 and beyond. Scenarios allow a number of different pathways for the future evolution of the electricity system to be considered, and then provides a range over which the system is designed. This is more beneficial than picking a single best view as this gives no indication of the range and uncertainties which impact this.

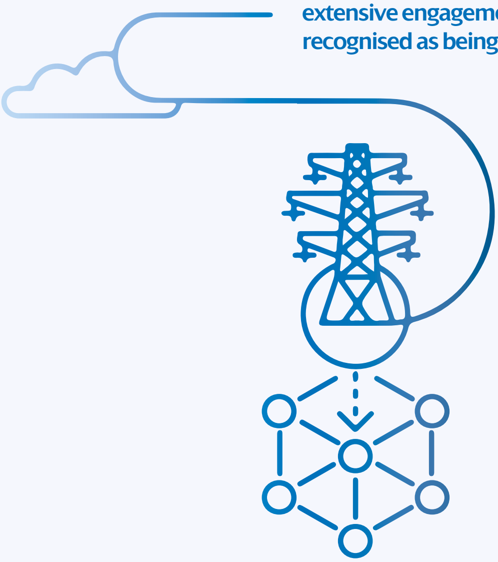
We commissioned Baringa Partners, supported by Element Energy, to help develop these scenarios. We will use the scenarios to examine the reinforcement that we may need to undertake to ensure the transmission network can respond to these changes, and as a means of a stress test. We will not necessarily design our plans to be able to accommodate all scenarios, however we will ensure that we can demonstrate that our plans are flexible enough to meet the range of uncertainties that the scenarios identify.

The replacement of our ageing assets is also a significant part of our future plans. As part of our planning process, we are considering the interaction between the modernisation of existing assets along with the future scenarios.

5

Alignment with the Future Energy Scenarios

The SPT scenarios use the four National Grid 2018 Future Energy Scenarios[3] as the starting point, and run from 2017 to 2040. The Future Energy Scenarios are intended to identify a range of credible scenarios across gas and electricity on a GB-wide basis. They are developed through extensive engagement with stakeholders and are widely recognised as being a reference point.



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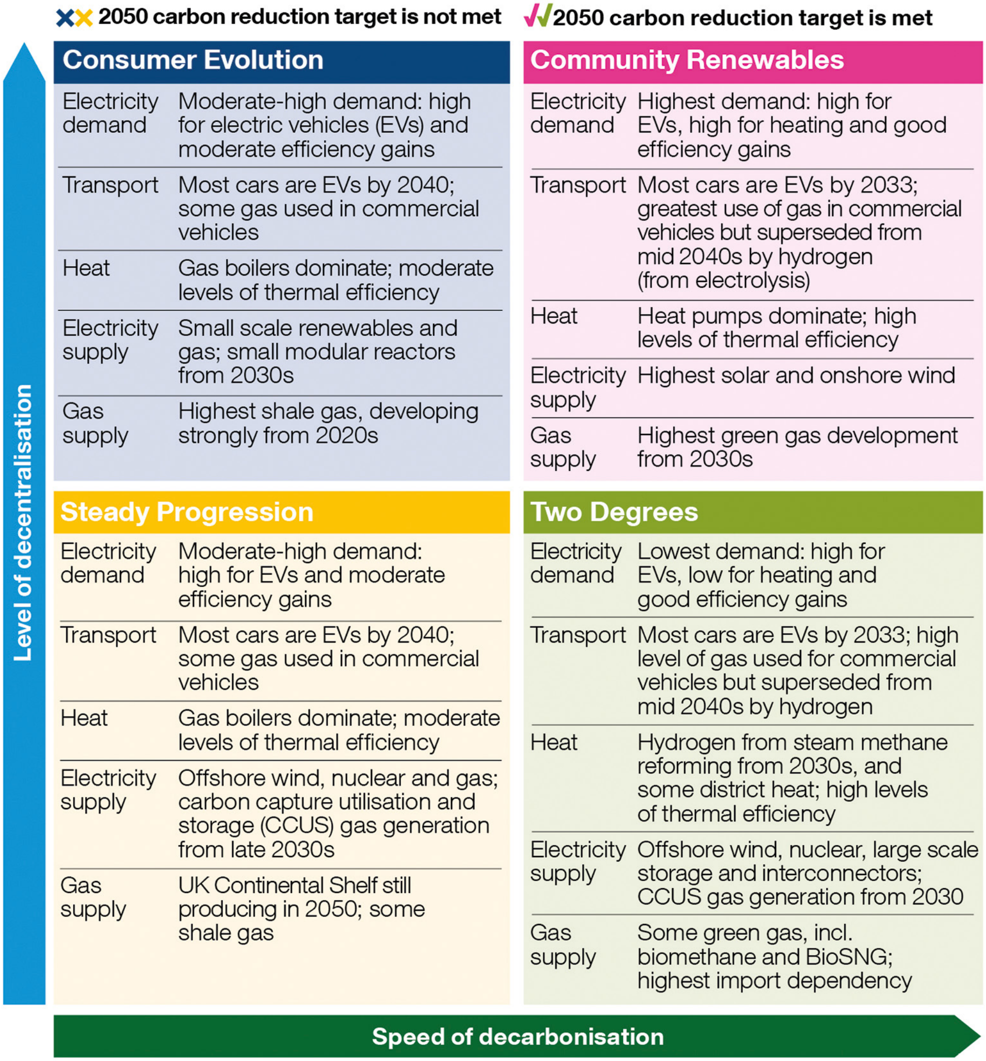
[3] www.nationalgrid.com/uk/publications/future-energy-scenarios-fes

Figure 1 | Overview of National Grid's 2018 Future Energy Scenarios



✗✗ **2050 carbon reduction target is not met**

✓✓ **2050 carbon reduction target is met**

Consumer Evolution

Electricity demand	Moderate-high demand: high for electric vehicles (EVs) and moderate efficiency gains
Transport	Most cars are EVs by 2040; some gas used in commercial vehicles
Heat	Gas boilers dominate; moderate levels of thermal efficiency
Electricity supply	Small scale renewables and gas; small modular reactors from 2030s
Gas supply	Highest shale gas, developing strongly from 2020s

Community Renewables

Electricity demand	Highest demand: high for EVs, high for heating and good efficiency gains
Transport	Most cars are EVs by 2033; greatest use of gas in commercial vehicles but superseded from mid 2040s by hydrogen (from electrolysis)
Heat	Heat pumps dominate; high levels of thermal efficiency
Electricity supply	Highest solar and onshore wind
Gas supply	Highest green gas development from 2030s

Steady Progression

Electricity demand	Moderate-high demand: high for EVs and moderate efficiency gains
Transport	Most cars are EVs by 2040; some gas used in commercial vehicles
Heat	Gas boilers dominate; moderate levels of thermal efficiency
Electricity supply	Offshore wind, nuclear and gas; carbon capture utilisation and storage (CCUS) gas generation from late 2030s
Gas supply	UK Continental Shelf still producing in 2050; some shale gas

Two Degrees

Electricity demand	Lowest demand: high for EVs, low for heating and good efficiency gains
Transport	Most cars are EVs by 2033; high level of gas used for commercial vehicles but superseded from mid 2040s by hydrogen
Heat	Hydrogen from steam methane reforming from 2030s, and some district heat; high levels of thermal efficiency
Electricity supply	Offshore wind, nuclear, large scale storage and interconnectors; CCUS gas generation from 2030
Gas supply	Some green gas, incl. biomethane and BioSNG; highest import dependency

- The Future Energy Scenarios are framed by two key drivers of change:
  1) Whether the scenarios meet the overarching 2050 carbon reduction targets.
  2) The degree of decentralisation of the energy system (see box previous page).
- Whilst our analysis covers the period 2017-2040 it is the potential pace of change through the RIIO-T2 period - 2021-2026 - and in the years shortly thereafter that is of most importance to SPEN when planning investment for our RIIO-T2 submission.
- Whilst each scenario reflects a complex combination of factors, at a high level the Community Renewables scenario appears most closely aligned to the ambitions set out in the Scottish Government's Climate Change Plan; in terms of expansion of renewable electricity - particularly wind - and uptake of electric vehicles and heat pumps to help drive decarbonisation of the wider energy system.

The National Grid Future Energy Scenarios already contain a spatial breakdown within SPT's licence area by grid supply points[4]. However, this breakdown is generally based on simple GB-wide proxies and hence a key focus of this analysis has been to tailor better the final scenarios to SPT's area. This was undertaken via a number of routes including use of supplementary data sources, refinement of the methodology to disaggregate to grid supply point level, and feedback from SPEN and external stakeholders.

What does it mean?

Grid Supply Points (GSP) are the interface points between transmission and distribution. The aggregated demand and supply at this point makes up the overall demand seen by the transmission system, and is therefore the key focus for Transmission planning.

All data in the scenarios reflects the SPT network area of central and southern Scotland. Data is projected out to 2040 although the main analysis covers the period out to 2030. This encompasses the RIIO-T2 period as well as the early years following that to consider the impact on the network.

The Future Energy Scenarios also consider gas and the future role of hydrogen. No modelling has been undertaken of these at a local level, as it has been assumed that the FES projections apply within central and southern Scotland.

[4] This is not published as part of the main FES publication.

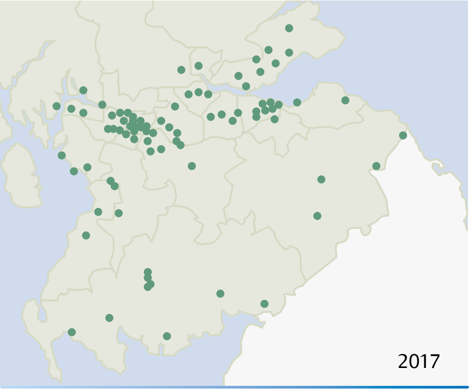
Inputs

Data from SP Transmission (SPT), SP Distribution (SPD) and other sources to reflect factors specific to SPT's network.

Scenarios aligned at a high level with National Grid's 2018 Future Energy Scenarios.

Extensive engagement with stakeholders through bilateral discussions, workshops and other engagement to inform results.

Grid supply points within SPT's network area



Approach

Holistic scenarios considering all supply and demand within the SPT area from 2017 to 2040, disaggregated down to each of the 90 individual grid supply points, including:

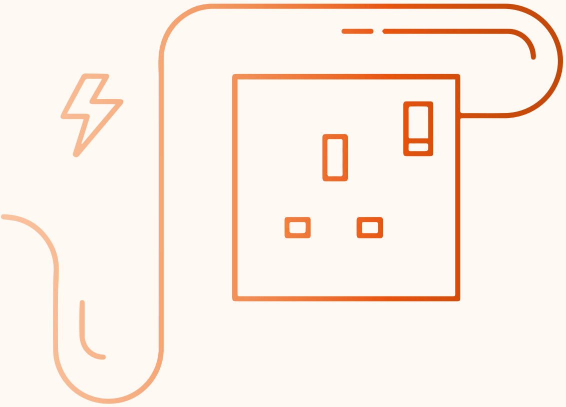
- Transmission and distribution network connected generators and storage
- Transmission and distribution network connected consumers
- “Behind the Meter”: generators such as small scale solar or storage at building level

Outputs

The outputs of the scenario analysis take the form of a report and supporting spreadsheet of scenarios results. This will be used to Inform SPT's wider analysis as part of their RIIO-T2 price control submission.

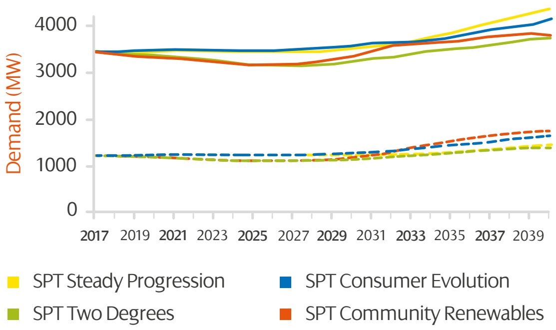
6

Overview of Electricity Demand



Understanding how electricity demand could evolve on SPT's network is a key factor informing the need for reinforcement. The situation is made more complicated by the uncertainty surrounding the speed of introduction of new sources of demand such as electric vehicles and heat pumps, as well as the degree to which both existing and new load can be shifted or reduced at times of system peak demand.

Figure 2 | Evolution of expected winter peak and summer minimum demand



In the near to medium term overall peak electricity demand is not expected to change significantly.

This reflects reductions in core domestic electricity demand (e.g. due to efficiency improvements) which are offset to some extent by new sources of demand (electric vehicles and heat pumps) which have a degree of flexibility at peak.

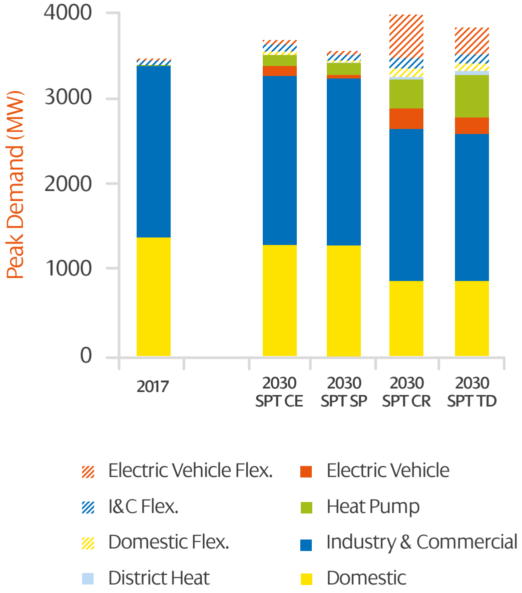
Note: Solid lines represent winter peak and dashed lines summer minimum. Demand is net of behind the meter generation and storage output.

What does it mean?

Winter Peak – Point in time during the winter months when the GB system as a whole sees the highest demand. It is an important study condition, to ensure that the network can accommodate this need.

Summer Minimum – Point in time during the summer months when the GB system as a whole sees the lowest demand. It is another important study condition as a lightly loaded network can lead to voltage control issues.

Figure 3 | Breakdown of expected winter peak demand



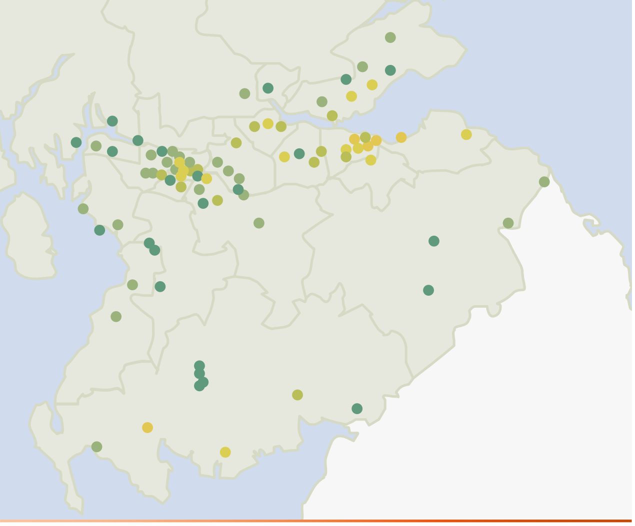
The pace of growth of new demand sources through the RIIO-T2 period and on to 2030 is relatively modest, but accelerates rapidly after this point.

However, it is the flexibility of new demand, particularly that from electric vehicles, which is a critical determinant of whether peak demand increases.

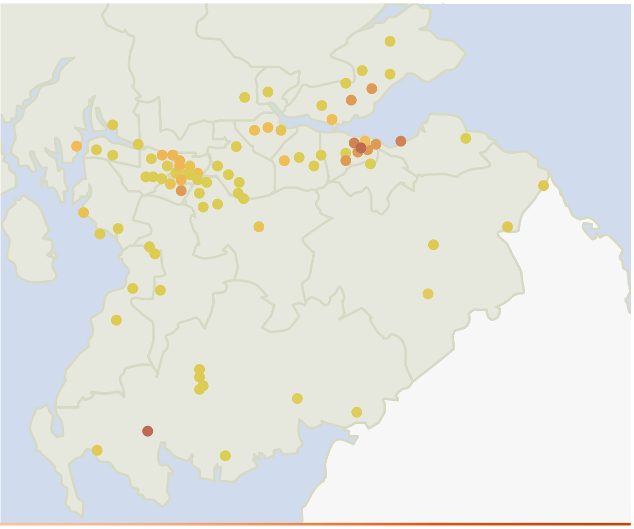
What does it mean?

Flexibility of demand is the ability to move or change the pattern of demand in reaction to a signal. With the push towards electrification of heat and transport, moving demand away from peak times will become more and more important to minimise network reinforcement and the amount of additional generation required.

Figure 4 | Percentage change in peak demand by 2030 cf. 2017 by grid supply point (Low / High over all scenarios)



2030 Community Renewables peak demand changes relative to 2017



2030 Consumer Evolution peak demand changes relative to 2017

Aggregate trends for SPT's area as a whole can mask greater variation at individual grid supply point level, which is a more direct driver of the need for specific network reinforcements.

Given the variation across the scenarios, in some cases this can represent **more than a 10% increase in load at a grid supply point by 2030 while in others it leads to a decrease of over 15%.** Without flexible load peak demand could increase by over 30% at some points.

Conclusions:

- Aggregate demand at winter peak and summer minimum in the coming years is seen to remain relatively constant, especially over the RIIO-T2 period, across the four scenarios.
- Spatial breakdown shows the potential for greater demand changes at specific locations within the network, however with the addition of flexible demand, and the decrease of underlying demand, changes in demand throughout RIIO-T2 period is not anticipated to drive significant investment.

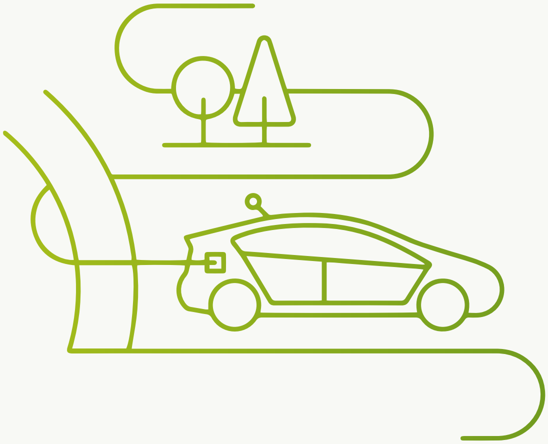
% change relative to 2017

● ● ● ● ● | ● ● ● ●

-15% 10%

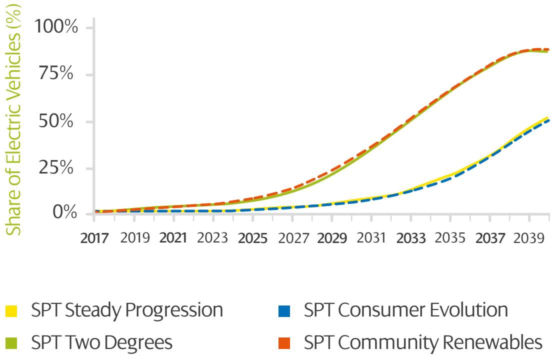
6.1

New Demand: Electric Vehicles



The number of electric vehicles – both plug-in hybrids and full electric – registered within SPT's area is currently very small; just over 4000 within a vehicle population of almost 3 million cars. However, momentum in support of electric vehicle adoption is building, leading to uncertainty over how fast the rollout may occur.

Figure 5 | Share of electric vehicles in car population

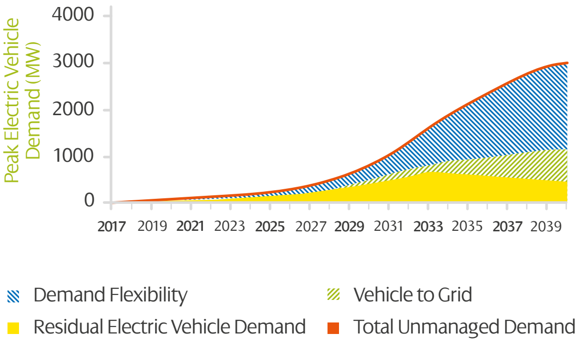


Across the scenarios, the share of electric vehicles rises from virtually nothing to between 4% and 20% by 2030, with deployment accelerating more rapidly shortly after this point.

In the Steady Progression and Consumer Evolution scenarios this means 1 million electric vehicles on the road in SPT's area by 2039, whereas in Two Degrees and Community Renewables this milestone is reached by 2033.

Despite the large range, the upper end is more closely aligned with our stakeholders' views. It is also consistent with the 20% share in 2030 assumed by the Scottish Government and the Committee on Climate Change for what is feasible in Scotland.

Figure 6 | Minimising peak electric vehicle charging in the Two Degrees scenario

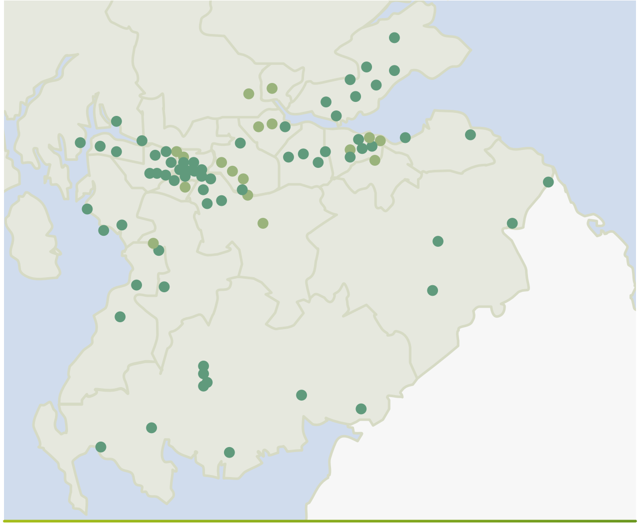


At the upper end of the uptake range the impact on peak demand could be significant, with an additional 3000MW in 2040 in the Two Degrees scenario if left unmanaged.

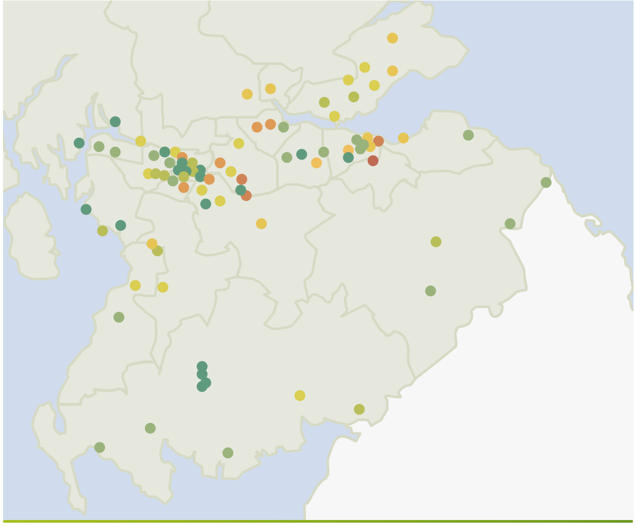
This increase can be mitigated by the extent to which flexible load can be shifted away from peak e.g. through smart charging, reducing peak down to a maximum of 500MW in this scenario.

In addition, some electric vehicle owners may be incentivised to not only shift their charging, but to export energy back to the grid ("Vehicle to Grid" or "V2G") at times of peak system demand.

Figure 7 | Ownership of electric vehicles (low / high over all scenarios) in 2030



2030 Consumer Evolution electric vehicle ownership



2030 Community Renewables electric vehicle ownership

Finally, the degree of "clustering" of early electric vehicle adoption will also be a key determinant of the extent to which this drives network reinforcement.

As can be seen from the scenario results this clustering effect can be significant for specific grid supply points even by 2030.

A general growth in electric vehicles across the network would have little effect on the transmission network as a whole, however clustering around certain grid supply points may lead to earlier network reinforcements.

Conclusions:

- Electric vehicle growth does not drive significant transmission network investment in RIIO-T2 on the basis that the load profile is managed through demand flexibility. However, we expect a significant impact on distribution networks.
- The greatest impact will be seen in the urban areas of central Scotland. It is recognised that electric vehicle charging may take place at a location away from home and this will need to be considered separately.

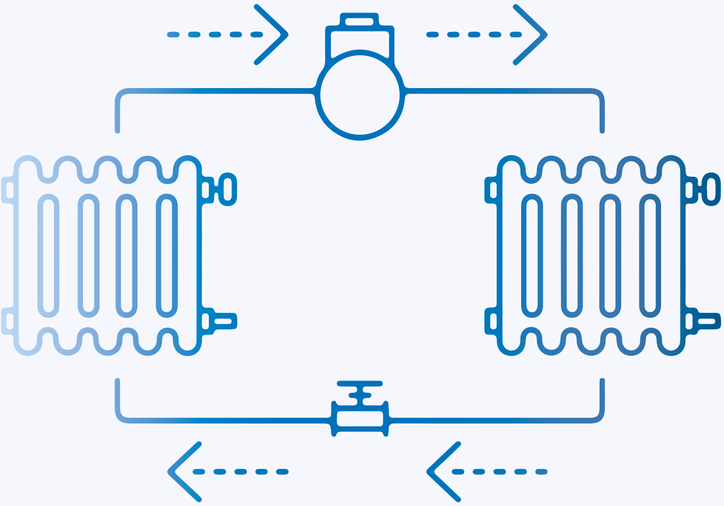
Number of EVs by GSP

● ● ● ● ● ● ● ● ●

0 16,000

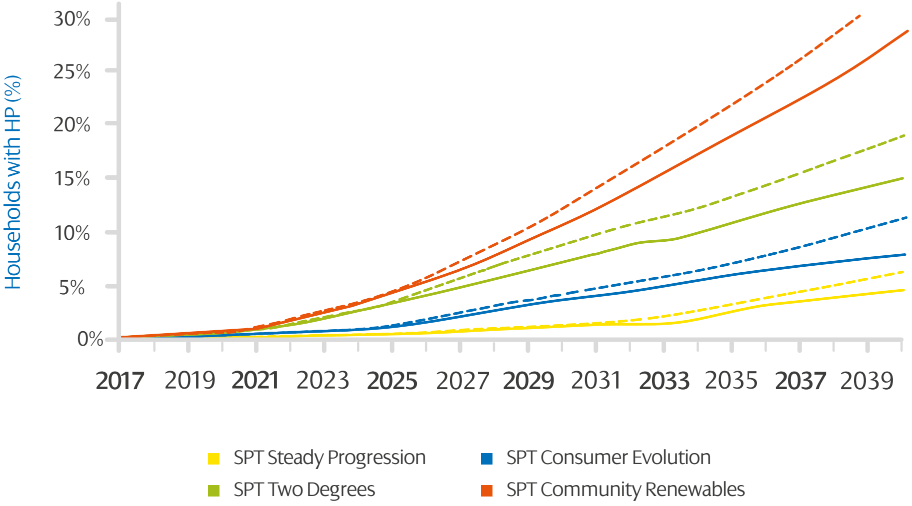
6.2

New Demand: Heat Pumps



Heat pumps – both air source and ground source – represent another change to the future electricity demand. Deployment is currently very low, representing under 3000 households within a total stock of circa 2 million households in SPT's area. Heat pumps can also take the form of hybrid systems where a gas boiler is used at times of peak demand, as well as larger scale heat pumps used for district heating.

Figure 8 | Share of households with a heat pump



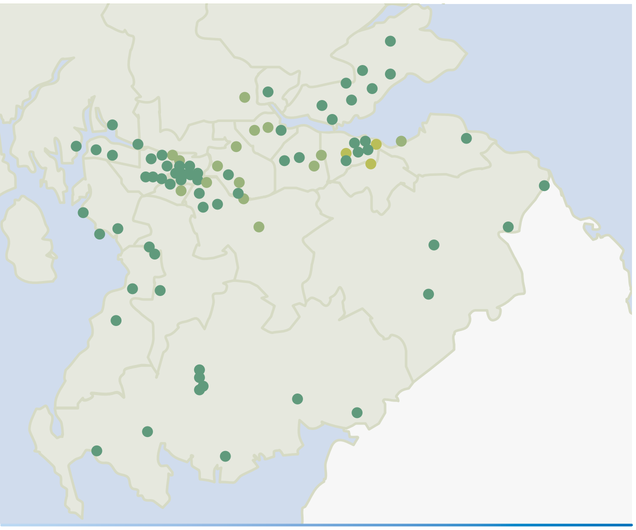
Note: Dotted line includes both dedicated and hybrid heat pumps.

There is a wide spread of uncertainty around heat pump deployment to 2030. The Scottish Government Climate Change Plan aims for a share of low carbon heat by 2030 of around 35% (albeit not only from heat pumps) and the Committee on Climate Change's Scottish analysis assumes around 18%.

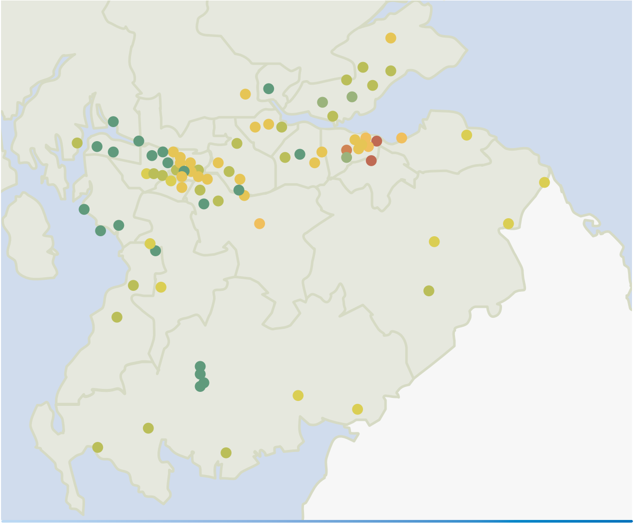
The majority of external stakeholders engaged through the process thought that the mid-range of the Future Energy Scenarios, circa 5% by 2030, was more realistic, with the overall pace of heat electrification expected to lag behind that of electric vehicles.

Material use of large heat pumps for district heating is only expected in scenarios where additional effort is applied to decarbonise heating to help meet the UK's overarching targets. However, even at the high end this only represents heat supply for a few tens of thousands of households.

Figure 9 | Heat pump uptake by 2030 cf. 2017 by grid supply point (Low / High over all scenarios)



2030 Steady Progression heat pump uptake



2030 Community Renewables heat pump uptake

Some targeting of heat pump deployment is expected. This is focused primarily on new build properties and off-gas grid properties where the economics of heat pumps look more favourable.

Conclusions:

- Although the rate of growth of heat pumps may seem high, the starting point is low. Throughout the RIIO-T2 period is it not anticipated that heat pumps will have a significant impact on the transmission network in this period.
- The ongoing uncertainty over changes to heat also make this one of the most difficult areas to consider as a number of different approaches could be taken to decarbonising heat in the future.

2030 Steady Progression heat pump uptake

● ● ● ● ● ● ● ● ●

0 11,000

no. of households

7

Overview of Electricity Supply

In parallel to the evolution of future demand, understanding how electricity supply and large-scale storage are likely to evolve within SPT's network is a key determinant of the need for future reinforcement. In particular, the extent to which new distribution and behind the meter supply may help to offset increases in demand, or where large increases in supply – particularly from renewables such as wind and solar – may lead to increasing exports across SPT's network.

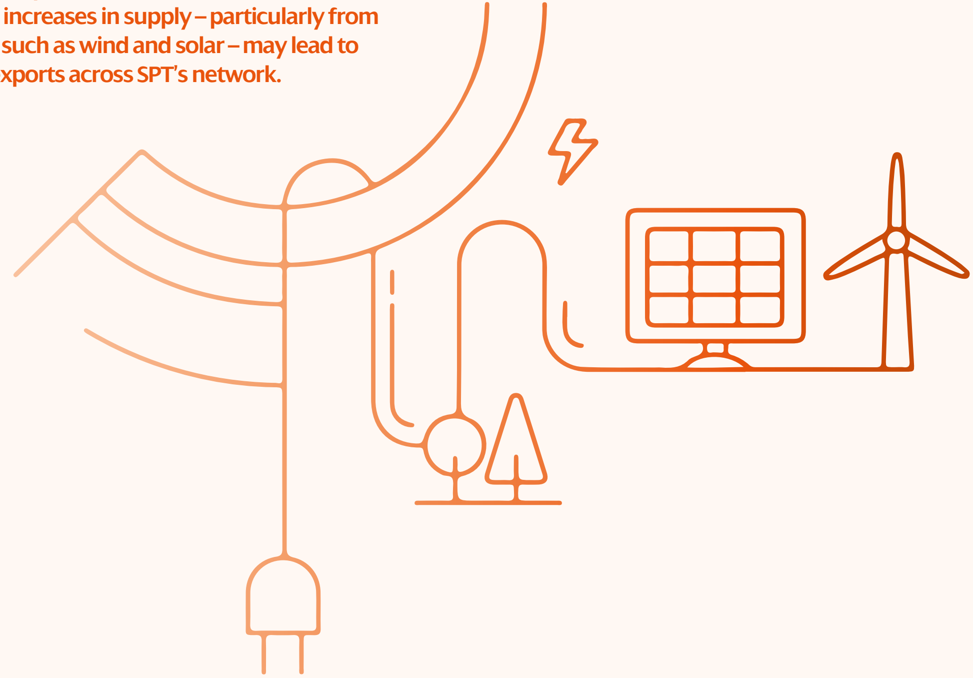
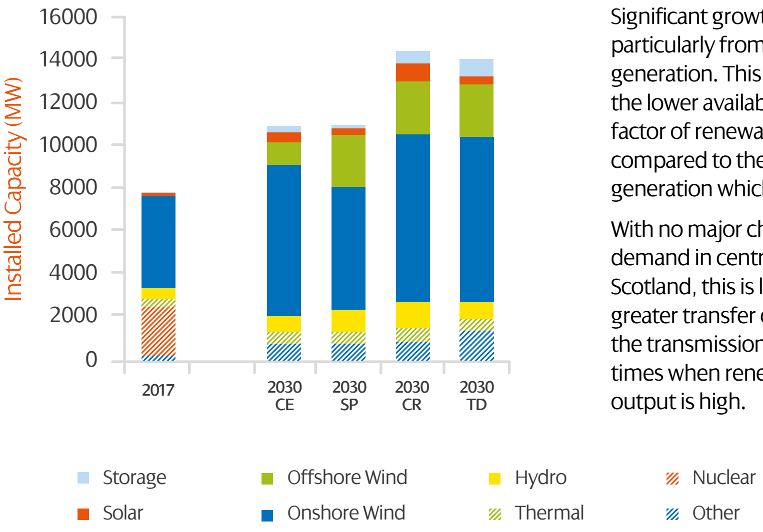


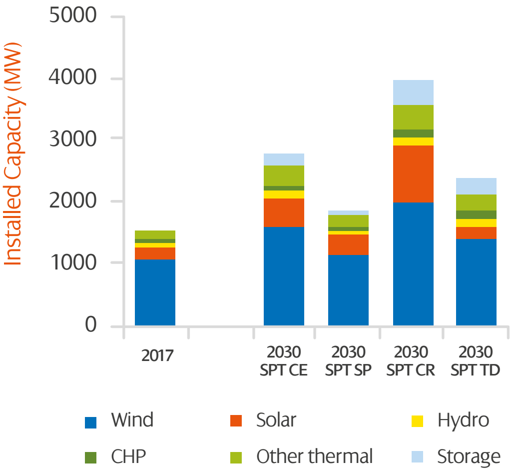
Figure 10 | Total installed capacity across distribution and transmission



Significant growth is expected, particularly from renewable generation. This is required due to the lower availability and capacity factor of renewable generation compared to the thermal generation which it has offset.

With no major changes to peak demand in central and southern Scotland, this is likely to result in greater transfer of power across the transmission network at times when renewable generation output is high.

Figure 11 | Installed distribution (<30MW) and "Behind the Meter" generation capacity by type

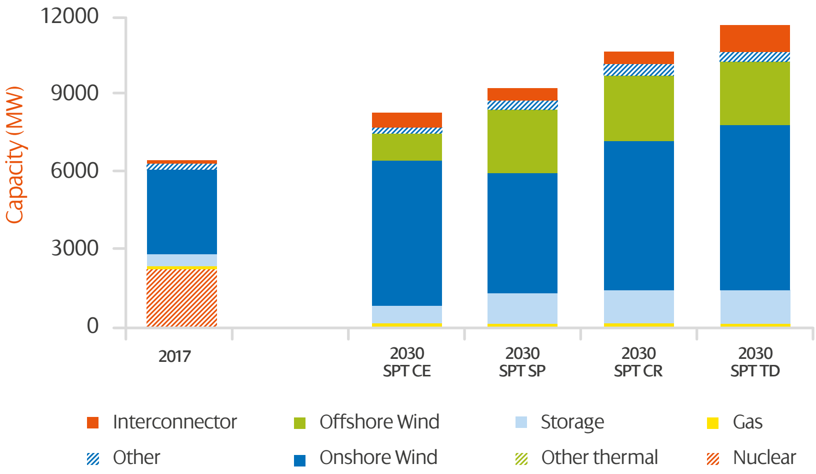


A moderate increase in new supply, providing extra local capacity is expected in the next couple of years as known projects with connection requests come online.

Beyond this, future growth is expected to be modest in the centralised scenarios, but could more than double the amount of small scale generation in the two decentralised scenarios by 2030.

The majority of the increase in capacity to 2030 is expected to come from wind, solar, controllable renewable capacity (e.g. bioenergy plants) and storage.

Figure 12 | Installed transmission and large embedded generation capacity by type



At the transmission level, there is less uncertainty around future thermal capacity with the two existing nuclear plants expected to close by 2030 and no new gas plant expected to be built before this point.

The greatest level of uncertainty relates to the expansion of new wind, particularly offshore.

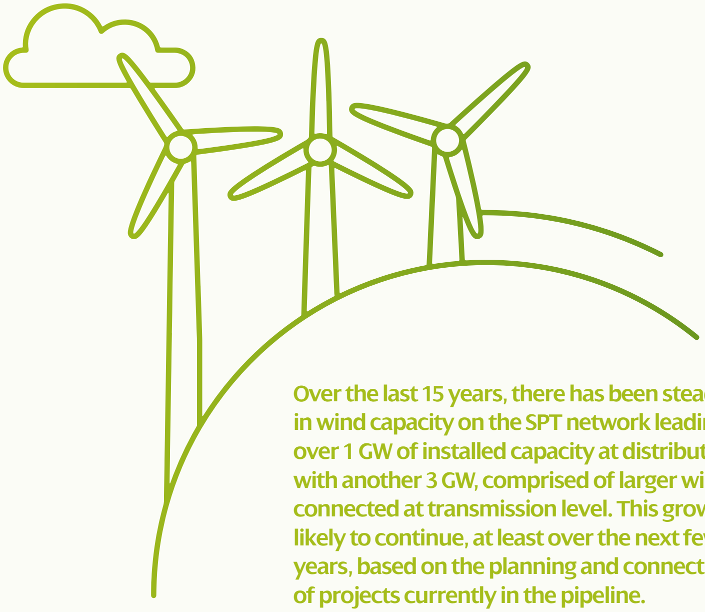
There is increased electrical interconnection with the rest of Europe in all scenarios, reaching 1GW the Two Degrees scenario.

Conclusions:

- A number of projects are already well under development for connection in RIIO-T2, but it is the latter part of RIIO-T2 where the greatest uncertainty lies.
- Delivering government targets are increasingly dependent on a small number of large sites, in particular offshore windfarms which the transmission network will need to cater for.
- Coordinated network planning will be required to accommodate the growing levels of generation on the system, particularly with greater volumes of distribution connected generation. The transmission network will play a key role in moving power from areas with the highest volumes of distribution connected renewables to other parts of the country which don't have this resource if a decentralised scenario develops.

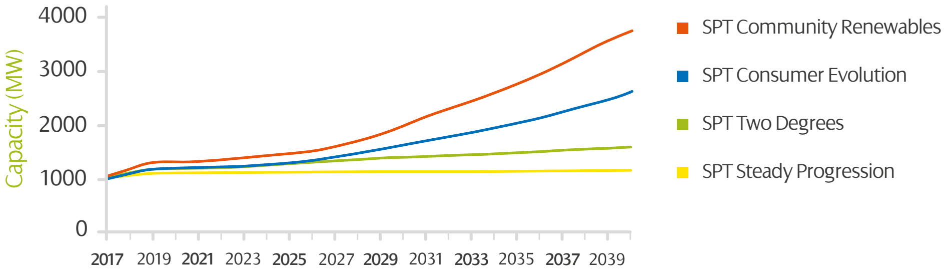
7.1

New Supply: Wind



Over the last 15 years, there has been steady growth in wind capacity on the SPT network leading to over 1 GW of installed capacity at distribution level with another 3 GW, comprised of larger windfarms, connected at transmission level. This growth is likely to continue, at least over the next few of years, based on the planning and connection status of projects currently in the pipeline.

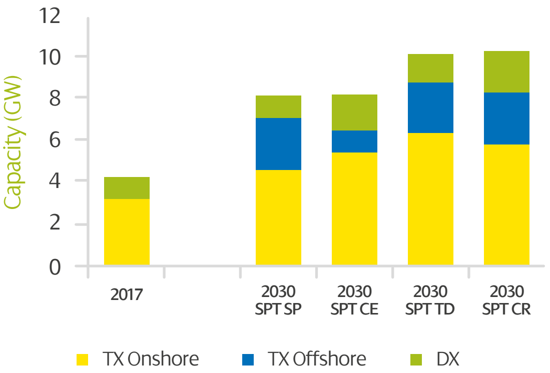
Figure 13 | Installed distribution wind capacity



Beyond projects currently in the pipeline, growth in distribution connected onshore wind capacity is expected to be continue but could be modest across RIIO-T2 with the current uncertainty over support for renewable generation.

Post 2030 this could start to rise more significantly, with an estimated 1700MW added between 2030 and 2040 in the Community Renewables scenario, as wind becomes increasingly cost-effective compared to other sources of generation.

Figure 14 | Overall wind capacity



Note: TX = Transmission and DX = Distribution.

Growth in transmission-connected wind (both onshore and offshore) on SPT's network is expected to be significant to 2030, more than doubling in capacity across most scenarios, largely driven by offshore wind.

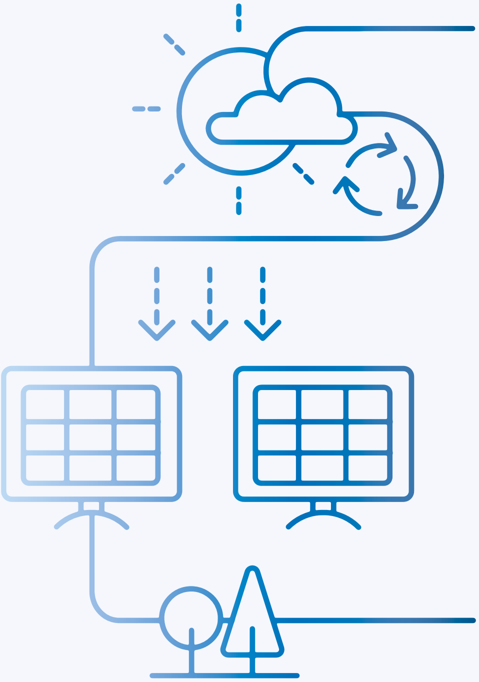
The strong growth in overall wind capacity aligned with the majority of external stakeholders' views. Any increase in distribution connected wind to 2030 is expected to be sited near to existing windfarms, taking advantage of more favourable wind conditions and existing network access.

Conclusions:

- As in the RIIO-T1 period, onshore and offshore wind is set to have the biggest impact on the transmission network and coordinated network planning and the timing of investment is critical to accommodate this.

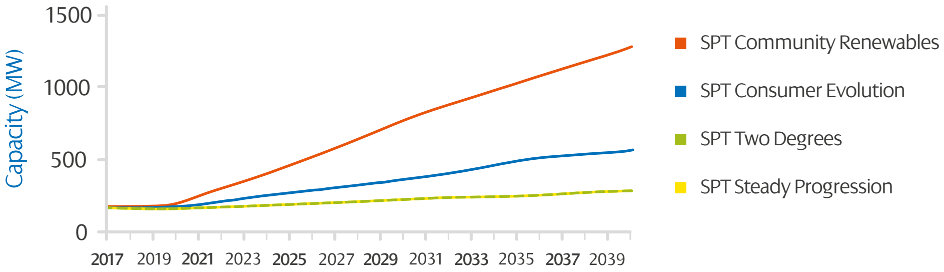
7.2

New Supply: Solar Photovoltaics



Solar photovoltaics (PV) capacity can be split broadly into small-scale building rooftop (or "Behind the Meter") schemes and larger scale solar farms, which connect directly into the distribution network. To date around 200 MW of capacity has been installed, the vast majority on rooftops, which equates to installations on only around 50,000 of the circa 2 million households in SPT's area.

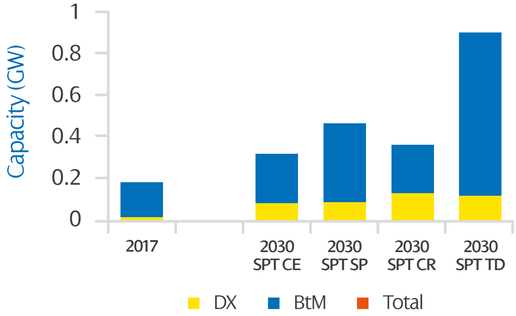
Figure 15 | Installed "Behind the Meter" solar capacity



Future increases in solar capacity are highly uncertain, but could be significant by 2030, with approximately 250,000 installations in the Consumer Renewables scenario.

However, the impact of solar by itself on the network is more limited given its low output, particularly at times of winter peak which coincide with the times of least daylight in Scotland.

Figure 16 | Overall solar capacity



The expansion of solar to 2030 is expected to be driven primarily by behind the meter schemes, with only a small number of larger distribution connected solar farms.

Compared to other areas there was far less consensus from external stakeholders around the expected scale of growth in solar capacity.

Note: *No specific solar targets, but estimated capacity consistent with Scottish Government ambitions for overall growth in renewable electricity in its Climate Plan. **DX** = **Distribution and BtM** = **Behind the Meter.**

Additional capacity for behind the meter solar is expected to be focused in areas that have already had some uptake due to subsidy support from Feed-in-Tariffs.

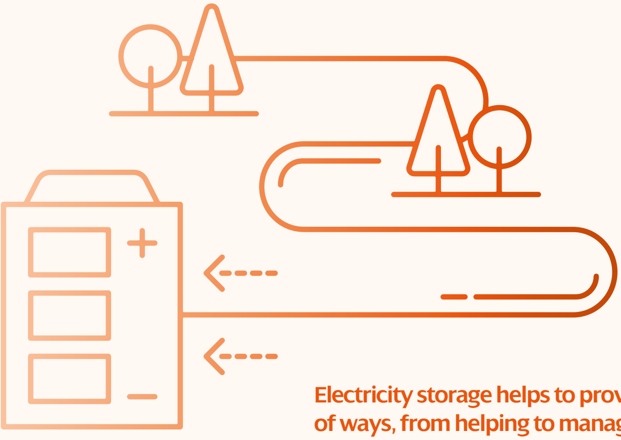
Larger distribution-scale schemes are expected to be deployed in more rural areas, due to the additional land area needed.

Conclusions:

- The rate of solar uptake on the system is set to increase, however this is from a low starting point. Across the RIIO-T2 period this will not have a significant impact on the transmission system.
- We expect that solar will have a minimal impact on winter peak in Scotland, and have a relatively low impact on summer minimum demand.

7.3

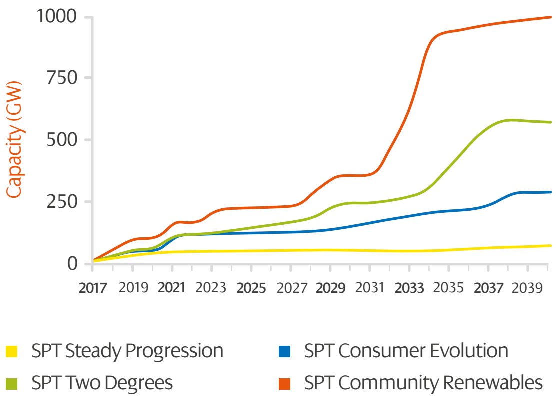
New Supply: Storage



Electricity storage helps to provide 'flexibility' to the system in a number of ways, from helping to manage peak demand or network constraints, 'smoothing' renewables output, or providing ancillary services such as frequency response. As with solar, storage can be categorised broadly into that which connects directly into the distribution (or transmission) network and that at building or "Behind the Meter" scale.

At present, storage capability is largely limited to pumped hydro which is accounted for separately, within the hydro generation projections. A small number of other storage devices, such as batteries, have started to connect to the distribution network in 2018.

Figure 17 | Installed distribution storage capacity

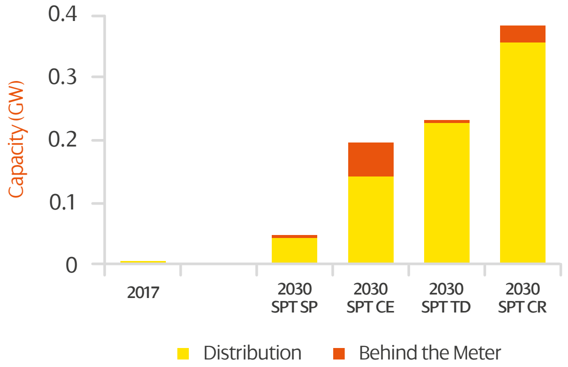


Moderate growth in distribution connected storage capacity is expected to 2030.

Beyond this, growth could be substantial in scenarios where there is more decentralised generation, in particular solar, that storage would help to manage.

It is likely that new markets for flexibility will need to be developed to incentivise the high growth rates seen after 2030 in some scenarios.

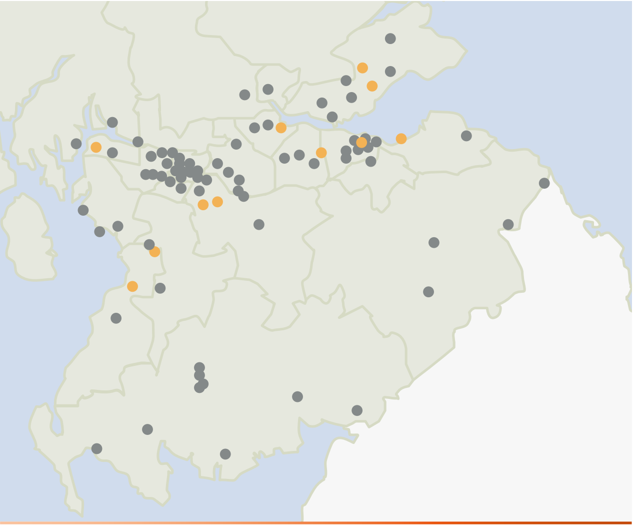
Figure 18 | Overall storage capacity



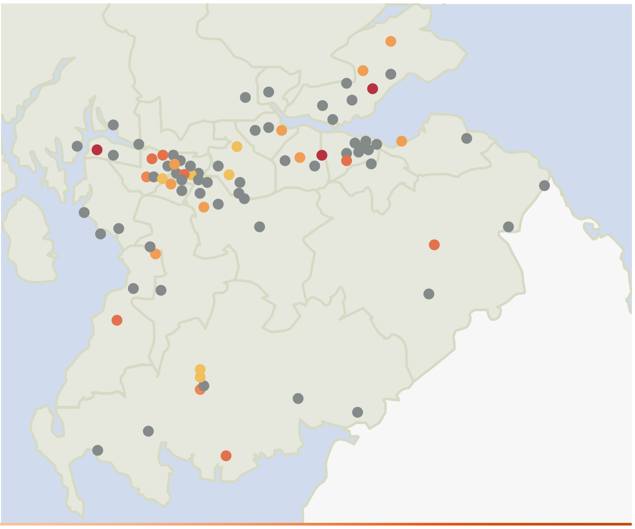
Most of the growth in storage capacity is expected at the distribution level, due to the relatively lower costs, thus no transmission connected storage is anticipated to connect (treating any pumped storage as hydro).

The majority of external stakeholders assumed that progress by 2030 would be towards the lower end of the range, but there was no consensus about the balance of distribution versus "Behind the Meter" storage.

Figure 19 | Siting of distribution storage capacity (low / high across all scenarios) in 2030



2030 Steady Progression storage deployment



2030 Community Renewables storage deployment

"Behind the Meter storage" is assumed to be sited alongside solar installations.

Distribution connected storage is assumed to be sited initially in areas with low network constraints (to allow services to be provided to the wider system) but this switches at different points from 2023-2033 across the scenarios to areas of high constraint, as the value of providing distribution level constraint management services increases.

Conclusions:

- Storage at the large scale has the potential to negate some system reinforcements, however technology and the market is not yet positioned to allow this to be a possibility, and therefore is anticipated to have little to no effect on the transmission system over the RIIO-T2 period.

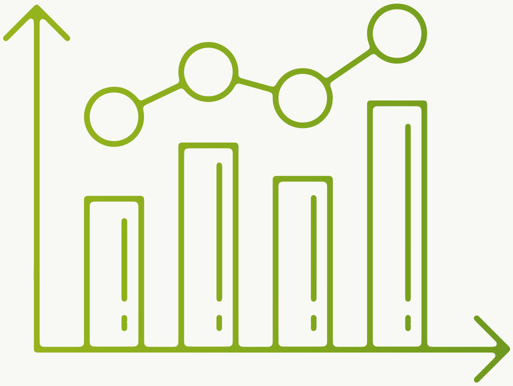
Storage capacity

● ● ● ● ● ●

0 32MW

8

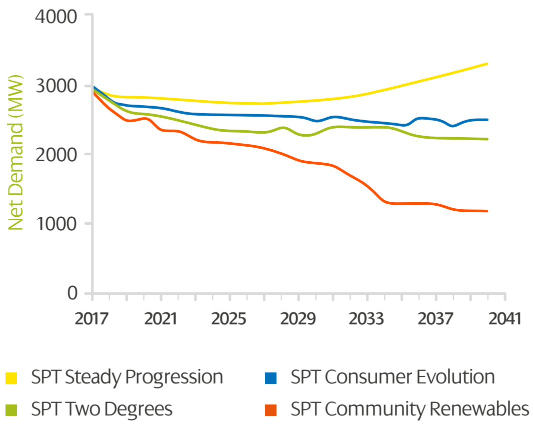
Integrating Supply and Demand



Building on the separate perspectives of demand and supply, it is ultimately important to understand how these interact across SPT's network, particularly at times of system peak to better understand the implications for future reinforcement, and to help inform the forthcoming RIIO-T2 business plan.

To take a view of net demand (i.e. demand less supply) also requires assumptions on the likelihood of different forms of supply being available at times of system peak, particularly intermittent renewables, and the role of flexible load and storage.

Figure 20 | Expected aggregate SPT net demand at winter peak across all grid supply points

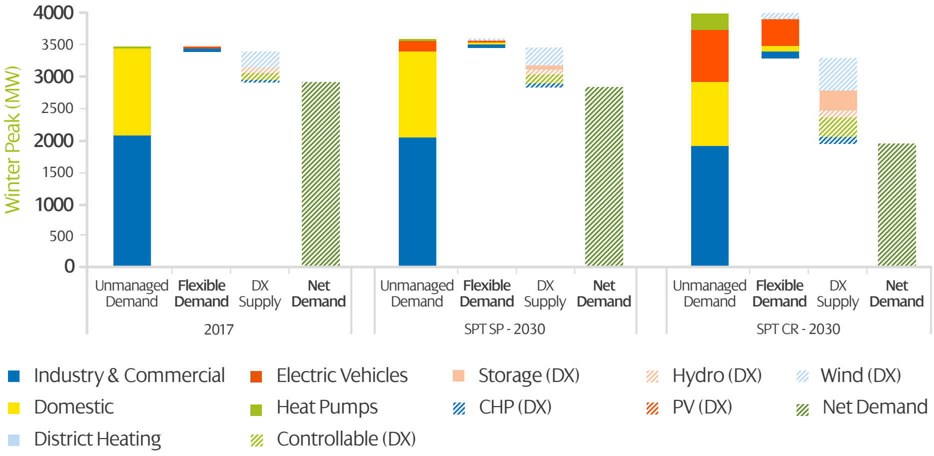


By combining the demand on the Distribution Network (Figure 2) with Generation directly connected (Figure 11) the net position shows a short term decrease at winter peak.

This is followed by relatively flat net demand to 2030 in most scenarios as the effect of the early stages of electrification of heat and transport is offset by increased supply connected to the distribution grid.

The exception is Community Renewables, where distributed generation increases more rapidly, reducing net peak demand on the transmission network.

Figure 21 | Key drivers of expected transmission net demand at winter peak



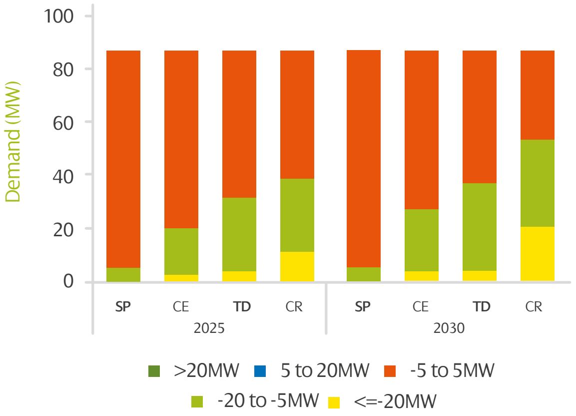
Note: DX = Distribution and BtM = Behind the Meter.

The chart shows how the net demand position is reached in the lowest and highest of the scenarios by 2030, given the use of flexible demand and distributed supply to reduce the total unmanaged demand.

In the Steady Progression scenario it can be seen that underlying and flexible demand are almost unchanged by 2030, with only a modest increase in distribution level supply.

By 2030 in the Community Renewables scenario, the role of flexible demand is significant, but this is still far smaller than distribution level supply, which has increased almost three-fold from 2017.

Figure 22 | Change in expected net peak demand per grid supply point from 2017

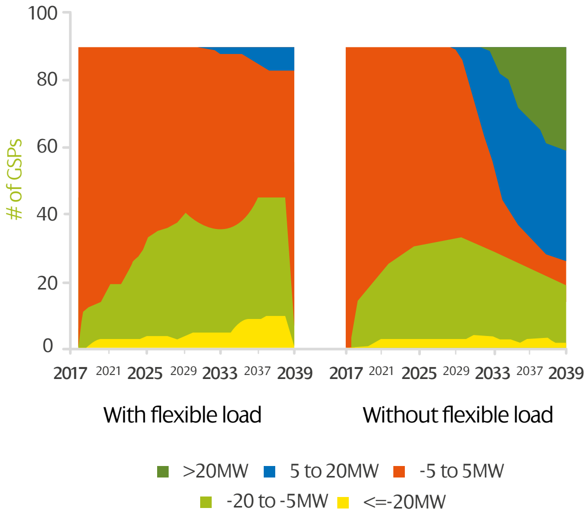


As per the discussion of underlying demand, the aggregate picture of net demand can mask more substantial changes for each grid supply point.

Over the period to 2030 a number of grid supply points start to show lower net demand at peak, due largely to increases in distribution and "Behind the Meter" generation, leading in some cases to net importers to the transmission system, potentially exceed grid supply points capacity for generation.

Note: In 2017 all grid supply points would be in the -5 to 5MW category as this represents the starting position against which to measure and positive or negative change in net demand.

Figure 23 | Change in expected net demand per grid supply point from 2017 in theTwo Degrees scenario with and without flexible load



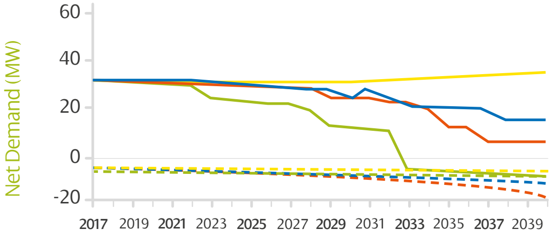
What does it mean?

Importance of assumed flexibility on potential network reinforcements – If this flexibility does not materialise, there is a more significant shift from around 2030 onwards, with over half of grid supply points rapidly moving towards a higher net demand position as new demand from electric vehicles and heat pumps is added without the ability to shift this away from peak.

To better illustrate the changes that may be seen at an individual grid supply point level, three case studies have been considered to show the differences that may be experienced using all of the scenario data.

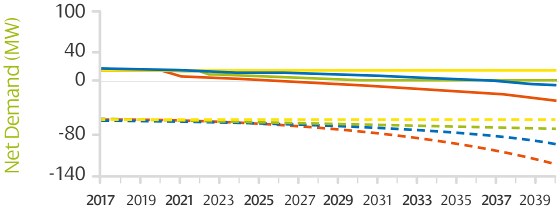
Figure 24 | Expected net demand at selected grid supply points

Galashiels



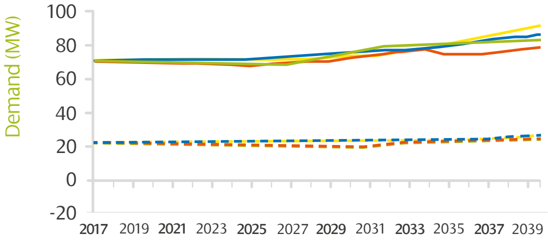
The evolution of expected net demand at Galashiels looks broadly similar to the SPT area as a whole, with relatively flat net demand until the late 2020s. There is a broader spread of outcomes after this point, particularly increased supply from wind and storage in the Community Renewables scenario, which reduces net peak demand to the point of being a net exporter in the early 2030s.

East Kilbride South



By contrast, net demand in East Kilbride South is expected to reduce more gradually in most scenarios. The grid supply point is already a net supply point to the SPT network in summer minimum periods, and due to reductions in net demand in the high decarbonisation scenarios East Kilbride South becomes a net supply point in peak periods from 2026 onwards.

Portobello

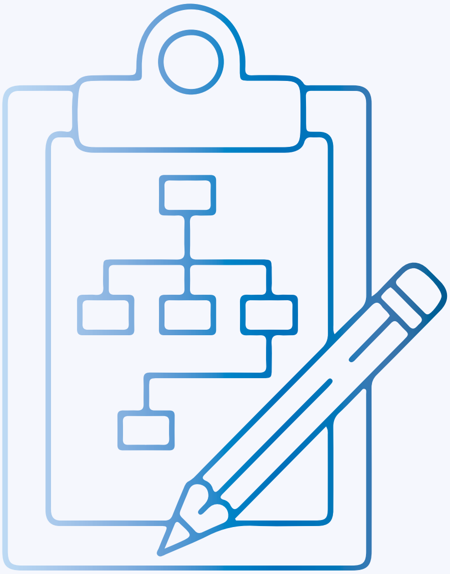


Note: Solid lines represent winter peak and dashed lines summer minimum.

Portobello remains as a high demand grid supply point, with gradual increases seen in net demand in all scenarios due to electric vehicles and heat pumps, and limited distribution connected generation technologies.

9

Implications for SPEN and RIIO-T2



Insights from SPT scenarios

The 2018 Future Energy Scenarios have been subjected to a number of refinements to create a set of scenarios that better reflect the likely evolution of the electricity system within SPT's network area. At a high level, these scenarios demonstrate a number of key insights:

- There is a wide range of uncertainty in the expected levels of demand and supply in the long-term scenarios, but the most rapid change happens from the late 2020s onwards, i.e. after the RIIO-T2 period.
- We expect to see a continued growth in renewable generation, but achieving the government targets will be dependent on a small number of large projects.
- Aggregate SPT level changes can mask more sizeable changes at a small number of grid supply points over the RIIO-T2 period, which could drive the need for reinforcement, but for the majority of them there is a shift towards more decentralised supply in the period up to 2030 and therefore reductions in net demand.
- Electric vehicle growth does not drive significant transmission investment, assuming that the management of electric vehicle charging is carried out in a co-ordinated manner by the distribution network, however if not, electric vehicles could make the transmission load profile more difficult to manage, potentially leading to the need for network investment.
- We don't expect electrification of heat to have a significant impact on our network during RIIO-T2.
- The level of flexibility associated with demand (e.g. from new electric vehicles and heat pumps) is highly uncertain. Without this flexibility being realised, peak demand will grow more rapidly, potentially requiring more than 3GW of additional capacity.
- Network planning through RIIO-T2 also needs to ensure that the network can accommodate the more rapid changes that are seen shortly thereafter, for example, in the early part of RIIO-T3 through to 2030.
- Growth in decentralised generation (small renewables) could be hampered by a range of issues on the interfaces between networks, e.g. fault level constraints. Careful coordination is required to address these in a timely manner.
- We don't expect storage volumes to grow in capacity to the point where they will avoid network reinforcement. Storage schemes under development aim mostly at the frequency response market.
- Different scenarios generally do not change the need for a reinforcement project, but may affect the timing of such projects.

Input from external stakeholders

The testing of data, methodology and outputs with a broad range of external stakeholders has helped to refine the scenarios and provided a degree of consensus on likely changes to 2030 in some areas, for example a relatively rapid expected uptake of electric vehicles and transmission-level wind, but more moderate uptake of heat pumps.

In other areas no real consensus emerged from the stakeholder engagement, for example, on the scale of solar and storage deployment. This partly reflects the high level of uncertainty around related policy and market arrangements. However, feedback indicates that the range of uncertainty bounded by the SPT scenarios appears sensible.

Feedback from stakeholders is vital to ensure our plans meet the needs of our customers. Views on the following areas would be welcomed by the 28th September 2018 and can be emailed to **RIIO_T2@spenergynetworks.co.uk**

1. The scenarios we have considered look at a variety of different pathways that could develop in the future. Do you agree that these are a reasonable range of scenarios to consider for planning purposes?
2. Are there any other major issues which we should be planning for the transmission network to accommodate which we have not detailed in this document?
3. Do you have any views on a particular scenario which we should be using as the basis for building our RIIO-T2 plan?
4. In addition to the use of scenarios, do you have any suggestions on how we should be factoring in the range of uncertainty in our business plan?
5. In this document, we identify an important longer term dependency on flexibility to move peak demand around in order to minimise the impact on the network. One of the key areas is the charging profile of electric vehicles. Do you agree that this is a reasonable assumption?

Next steps

The more detailed outputs underpinning these scenarios will be used as part of SPT's wider suite of analysis to inform its RIIO-T2 price control submission along with the feedback from stakeholders.

Over the course of the next twelve months, we will also be holding further events to share different aspects of our plan and seek further views. If you would like to know about these further, please contact **RIIO_T2@spenergynetworks.co.uk**

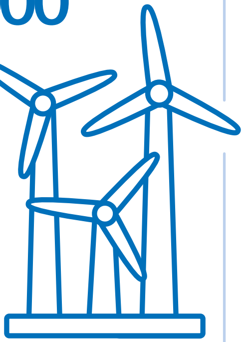
2030 Consumer Evolution

74,000
Heat Pumps

% Flex Domestic Demand
2.6%

120,000
Electric Vehicles

8.7GW
Wind Generation

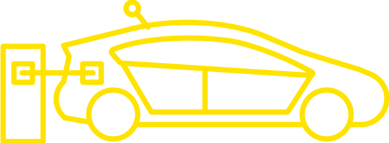


540 MW
PV Generation

% Flex I&C Demand
4.0%

116 MW
Flexible Demand

306 MW
Energy Storage



120,000
Electric Vehicles

% Flex Domestic Demand
1.8%

7.7 GW
Wind Generation

25,000
Heat Pumps

310 MW
PV Generation

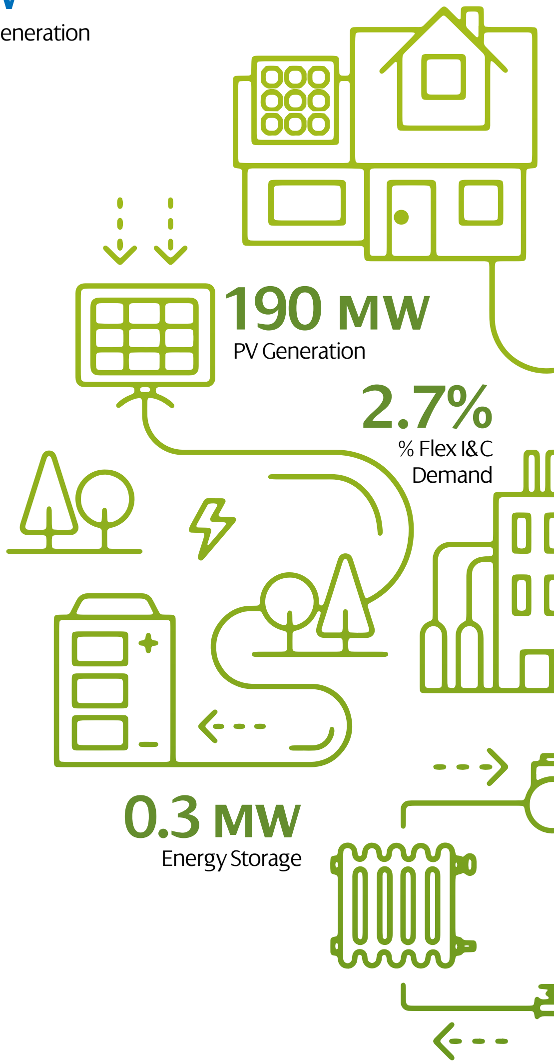
3.6%
% Flex I&C Demand

95 MW
Flexible Demand

184 MW
Energy Storage

2030 Steady Progression

20



190 MW
PV Generation

2.7%
% Flex I&C Demand

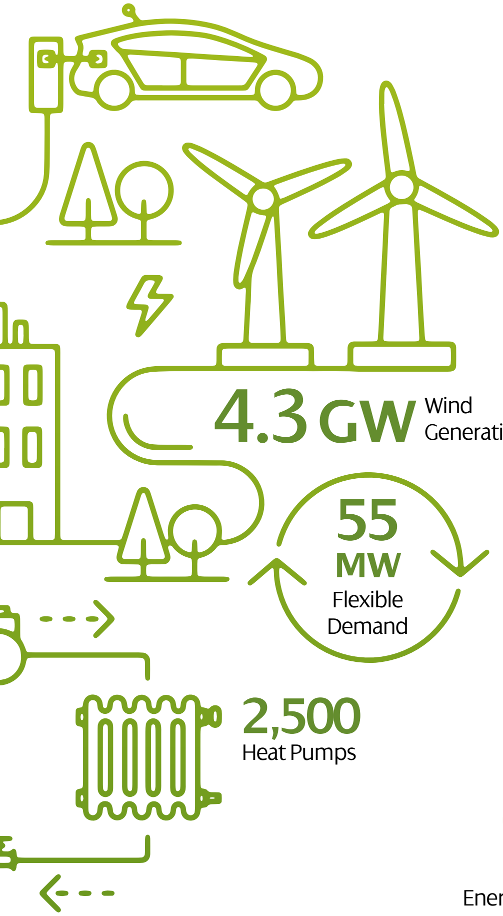
0.3 MW
Energy Storage

Key Figures – Changes from 2017 to 2030

17

0% % Flex Domestic Demand

Number of Electric Vehicles **4421**



4.3 GW Wind Generation

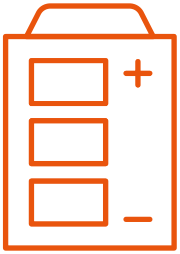
55 MW Flexible Demand

2,500 Heat Pumps

2030 Community Renewables

6.4% % Flex I&C Demand

221 MW Flexible Demand



578 MW Energy Storage

10.3 GW Wind Generation

590,000 Electric Vehicles

% Flex Domestic Demand **10.2%**

970 MW PV Generation

213,000 Heat Pumps

10.2GW Wind Generation

5.7% % Flex I&C Demand

187 MW Flexible Demand

% Flex Domestic Demand **8.6%**

550,000 Electric Vehicles

451 MW Energy Storage

450 MW PV Generation

148,000 Heat Pumps

2030 Two Degrees

SP ENERGY
NETWORKS

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- RIIO_T2@spenergynetworks.co.uk