Distribution Future Electricity Scenarios and Regional Insights

November 2018

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Bringing energy to your door

Contents

Welcome
Powering the North West's future

Future of energy in the North West has never been so important. New technologies and changing customer requirements are transforming the way that companies, communities and customers generate, distribute and consume electricity. Our regional networks are becoming smart and flexible at a significant pace. Existing passive networks are being redefined to connect additional demand, generation and storage more efficiently and empower our customers. As the region's electrical network operator it's our responsibility to plan for the future and support local economic development and transition to a low carbon future.

Steve Cox
Engineering and Technical Director

No one can be certain to what extent or when these changes will happen, so we have developed the range of credible views of the North West's future electricity requirements presented here in our first Distribution Future Electricity Scenarios and Regional Insights publication. We emphasise the importance of working closely with our customers; we are encouraging further conversations with North West stakeholders to better inform our forecasts and looking to enhance their understanding of the electrical network.

We are unique in our forecasting approach that uses intelligent tools for projecting demand and generation based on local stakeholder information and conditions down to postcode level. In this way, we can understand the differing future electrical needs of our customers across our region and the uncertainties around them.

This publication is only the start of our work to communicate what we envisage the needs of our customers and network will be. Our engineers and analysts continually consider what the range of future electricity scenarios means for our network to ensure that it is safe, reliable, affordable and sustainable for all outcomes.

In the regional insights sections we demonstrate the impact of our regional forecasts on local networks. We are sharing insights into local network needs to provide a useful contribution to stakeholders' thinking and plans.

Where we are projecting future network constraints we have not identified any specific network solutions. We are applying new approaches for solving network constraints through whole system co-ordination and from market participation. We will continue to actively engage and seek customer involvement to provide flexible services to emerging problems.

Get involved

We plan to publish our Distribution Future Electricity Scenarios and Regional Insights annually for the benefit of our stakeholders. So we would appreciate your feedback to help us to improve our ability to serve you better.

You can contribute to the conversation about the future of energy in the North West by contacting our network planning team at development.plans@enwl.co.uk

Regional insights

- Large forecast increases in demand in the Manchester area are driving the strategic development of our network.
- Our network in the Cumbria region is challenged by the significant amount of forecast generation and by the uncertainty of the development of a major power station there.
- Although network capacity appears to be available in our Lancashire region, the large variation in demand growth within the region is expected to lead to localised issues.
- We have identified insufficient future network capacity in the south of the Peak region as the forecast demand there exceeds the available network capacity.

Electricity demand in our region could nearly double by 2050; it could grow to **7.7 GW** from the current level of 4.4 GW

We are forecasting up to **1.5 GW** of energy storage

Renewable generation connected to our distribution network continues to grow significantly, potentially more than tripling to **7.9 GW** by 2050

There will be up to **2.5 million** electric vehicles in our supply region by 2050

Up to **50%** of our customers' properties will be warmed by heat pumps by 2050

Who is Electricity North West?

Electricity North West are one of 14 Distribution Network Operators (DNOs) in the UK regulated by Ofgem. We operate the local electricity network and distribute electricity to 2.4 million homes and businesses in the North West.

We are responsible for maintaining and upgrading our distribution network which is one of the most reliable in the country and we are investing £1.9bn by 2023 to ensure we continue to deliver a reliable, safe and affordable service to all our customers.

The low carbon future

Britain's energy mix is changing and the way we manage our electricity network needs to change too.

The low carbon agenda is driven by the Climate Change Act (2008) which commits the UK to reduce carbon emissions by at least 80% of 1990 levels by 2050. Our customers, therefore, are starting to reduce their reliance on fossil fuels like gas and petrol and change to renewable sources of power.

As a result, demand for electricity is expected to increase significantly as customers start to use more low carbon technologies such as electric heat pumps and electric vehicles. We are adapting to accommodate these and also to allow more low carbon generation sources such as wind and solar power to connect directly to our network.

Economic development

Our network needs to accommodate economic development in the North West. According to EY's UK Regional Economic Forecast (December 2017), Manchester's economy is set to grow faster than anywhere else in Britain, with 2.4% annual growth predicted until 2020.

Recent years have seen dozens of organisations, including Amazon, the BBC and Google move to Manchester due to the many benefits the region has to offer. Other major developments in the Greater Manchester area include expansion plans at Manchester Airport, the HS2 rail link and the redevelopment of Eastlands around the Etihad Stadium.

Our vision

As the region's electrical network operator it's our responsibility to plan for the future in order to support expected economic development and the low carbon transition. We are trialling smarter, more affordable techniques to use the existing network more efficiently, which will revolutionise the way we produce, distribute and consume electricity. One key area of our strategy is the use of intelligent forecasting tools to analyse how and when our customers use electricity and how that is changing. We have developed methodologies and tools for forecasting long-term demand and generation down to individual postcodes so we can understand the differing future energy needs of our customers across our region and the uncertainties around them.

Our forecasts are not predictions of what will likely happen, but give an indication of how different influences will change electrical demand and generation in our region. They allow us to explore the implications for our network of underlying conditions such as prosperity and political decisions

In addition to our intelligent forecasting tools, we engage with local authorities and other key stakeholders to understand their future energy requirements and expectations for specific locations.

> Regional forecasts built on local conditions and local stakeholders' information are key to the development of a safe, reliable and affordable distribution network

Document objectives

The purpose of this document is to describe and make available our 'distribution future electricity scenarios' (DFES) to our stakeholders. We are sharing regional information based on the analysis of these credible electricity forecasts to increase understanding and to engage with and assist our stakeholders, as we plan a reliable, affordable and sustainable distribution network for the future.

This is the first issue of our DFES document, the content and presentation of which we expect to evolve, based on feedback from our stakeholders.

The document is intended to:

- **Provide information** on our forecasts and share our insights into regional impacts
- **Support whole system** co-ordination and collaboration
- **Empower stakeholders** to target beneficial developments in appropriate locations
- **Publicise the opportunities** to provide flexible services
- **Provide a deeper understanding** of network needs to inspire customer involvement and new approaches

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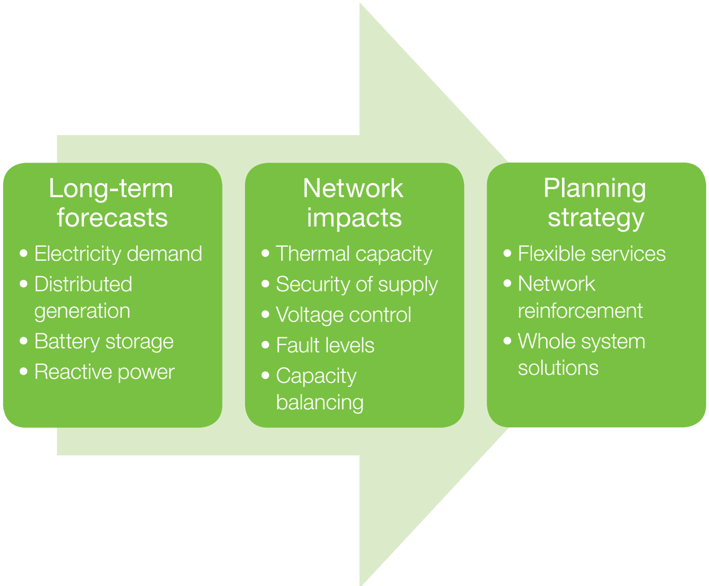
2. 2018 DISTRIBUTION NETWORK FORECASTS

Forecasting used in distribution network planning

As a company we must plan and develop our distribution network for the future needs of our customers across the region. In an increasingly uncertain world, it is important that we understand the range of credible outcomes to ensure that we continue to deliver a safe, reliable and affordable distribution network.



Our strategy to most efficiently meet the needs of our customers uses long-term forecasts of demand and generation in an ongoing cycle of network analysis, strategic planning and decision making to help us develop our network.

Long-term forecasts are essential to ensure that our electricity distribution network can support development in the North West and the transition to a decarbonised world

We consider the type of equipment our customers will use in the future, such as more efficient appliances, electric vehicles and generation, to inform how much electrical energy they will use and when.

These trends in customer behaviour are translated into forecasts which help us understand the future impact on our network. We assess the network impact by undertaking technical studies of its performance and resilience. The results of these studies feed into our planning processes through which we select the most appropriate solutions for the future development of our network. Our decision making process is designed to evaluate end user costs, benefits and risks of different interventions such as flexible services and other innovative solutions against traditional asset investments. We apply specific forecasts to all of our local networks and then analyse the aggregated impact on upstream networks. This approach enables us to evaluate the whole system including interactions between customers and adjacent transmission and distribution networks.

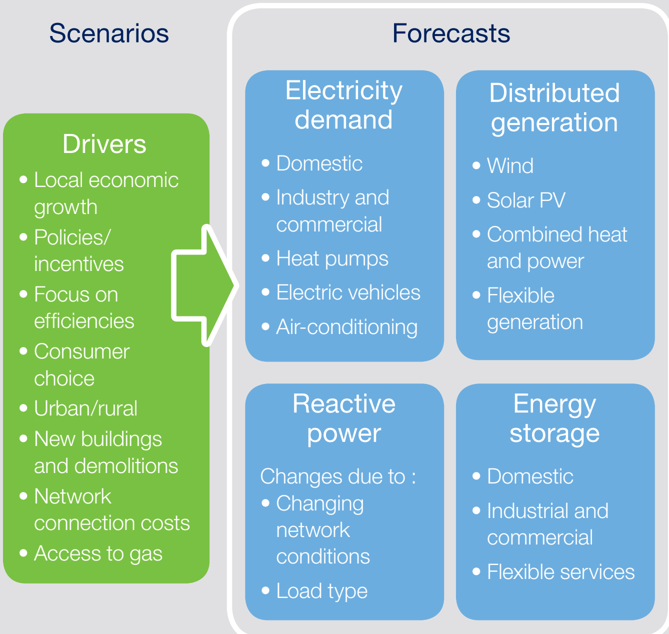
New applications and appliances mean that customers will use electricity at different times in the future. Consequently we produce forecasts for each half-hour for the whole year allowing us to assess these changes. Although we use these detailed time varying profiles in our analysis to maximise network utility and customer flexibility we use maximum and minimum values as representative indicators and these are presented here.

Our bottom-up modelling approach highlights regional differences whilst enabling them to be combined to define the overall trends for larger areas.

Scenarios

Our scenarios are driven by factors which frame regional uncertainties

We use a range of scenarios with differing underlying assumptions on financial and policy conditions to explore future electricity usage within our region. The resultant regional forecasts outline a range of credible electrical requirements that define the associated uncertainty. Scenarios allow us to test the robustness of our plans for the corresponding varying conditions.

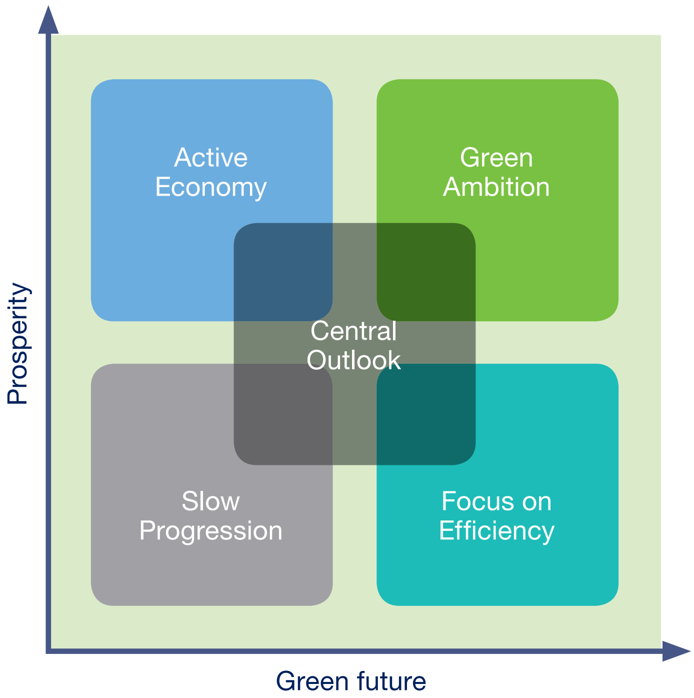


Importantly, the drivers for our scenarios frame regional uncertainties by modelling them at a local level. For example, in Cumbria we expect more wind generation as the open spaces and high winds there make it attractive to developers. We also expect the region to have a higher level of heat pump uptake because much of the area isn't connected to the gas network. In contrast, we forecast more electric vehicles in urban Manchester where commutes are shorter on average compared to Cumbria.

Electricity North West's five 2018 scenarios are Active Economy, Green Ambition, Focus on Efficiency, Slow Progression and Central Outlook. Our scenarios are defined by prosperity with more or less money available not only for domestic and industrial and commercial (I&C) customers, but also for investors in the energy sector and local communities. Similarly, they depend on national and local policy actions supporting a green future based on decarbonisation and increased sustainability.

Increasing prosperity increases electrical demand

Electricity North West future electricity scenarios



There are many uncertainties affecting the uptake of low carbontechnologies and generation connections. We will continue to develop a robust network for any outcome

Future uncertainties modelled by the range of assumptions underlying our scenarios lead to significant differences in the levels of forecast demand and the uptakes of generation and energy storage.

However, engagement with our stakeholders increases the certainty of our forecasting process. This engagement with local authorities, local communities and investors can reveal when and how their development plans are expected to affect future trends.

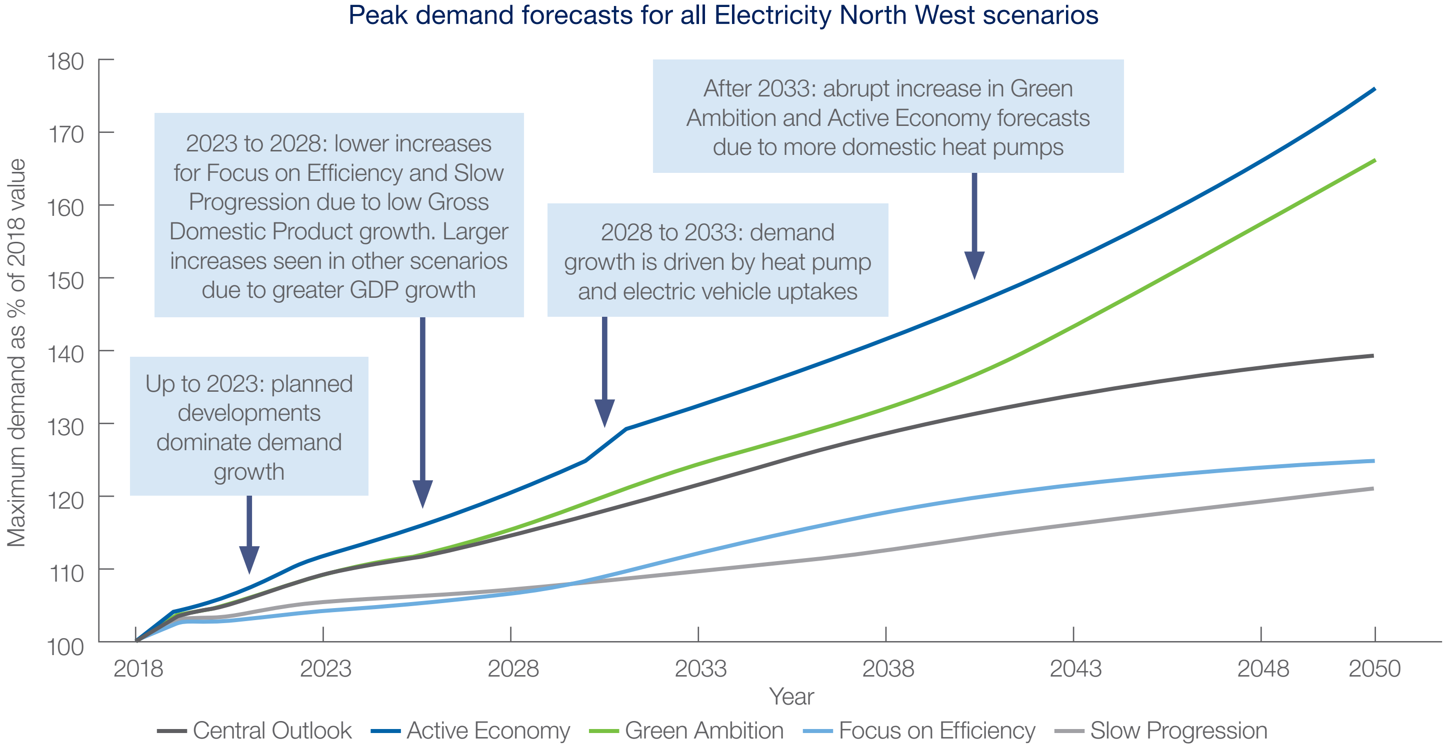
Our distribution future energy scenarios should not be confused with the ESO-FES produced by National Grid.

Our distribution future electricity scenarios:

- follow a bottom-up approach to reflect and aggregate regional trends,
- aim to provide forecasts to help develop a strategy for a resilient regional distribution network for the future,
- aim to frame future uncertainties in distribution systems to inform cost and risk efficient network planning,
- do not define future worlds of the whole energy landscape based on decarbonisation or other policy targets, and
- focus only on the future of the electricity system (e.g. not on the future of gas networks).

Our scenarios and the forecasting methodology have been developed in our ATLAS project.

Demand forecast

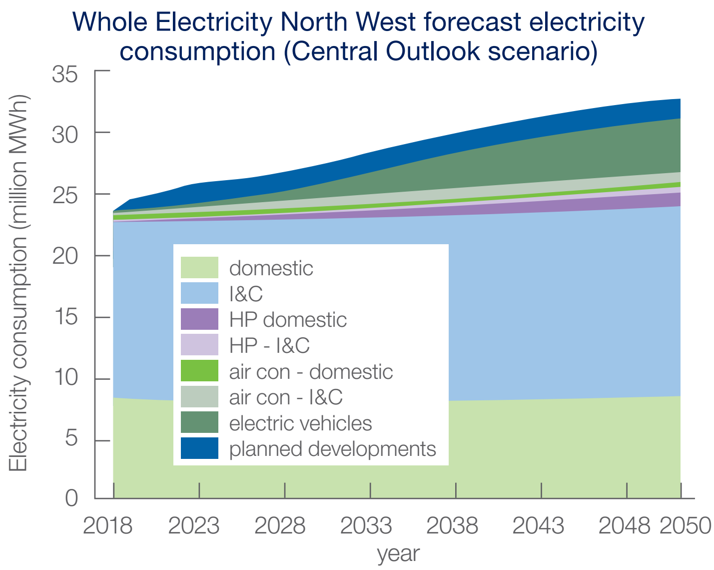


Electricity demand is expected to grow significantly in our region by 2050

Our forecasts indicate that overall maximum demand across our region increases from the current level of 4.4GW by between 122% and 176% by 2050.

A variety of factors affect our maximum demand forecasts and their rate of increase. Short-term demand growth is most affected by planned developments, whereas it is anticipated that the electrification of heat and transport will drive long-term growth. These increases are counter balanced by expected reductions in electrical consumption due to more efficient buildings, processes becoming more efficient and shifts in demand due to the roll out of smart-meters. The greatest future maximum demand forecasts correspond to the scenarios with the greatest levels of prosperity, as reflected in their Gross Domestic Product (GDP) growths (i.e. 1.8% per year for Active Economy and Green Ambition compared to 1.3% for Slow Progression and Focus on Efficiency).

It should be noted that growth in maximum demand is not consistent and homogeneous across the whole of our network. The impact of this regional variation in growth is presented in our regional insights section of this report.



Our forecasts allow us to understand the annual electricity consumption of each individual component of the demand. Electric vehicles and heat pumps are key contributors in the future increase in electricity consumption. Specific domestic and I&C developments as advised by our stakeholders are expected to increase consumption of electrical energy within the next 5 to 10 years.

When assessing the impact of maximum demands on our network, we consider all half hourly values as they may occur at different times of the day and year. For example, maximum demands could occur during summer daytimes in urban areas with significant amounts of air conditioning, whilst in rural areas the maximum may occur during winter evenings when electricity is used for heating.

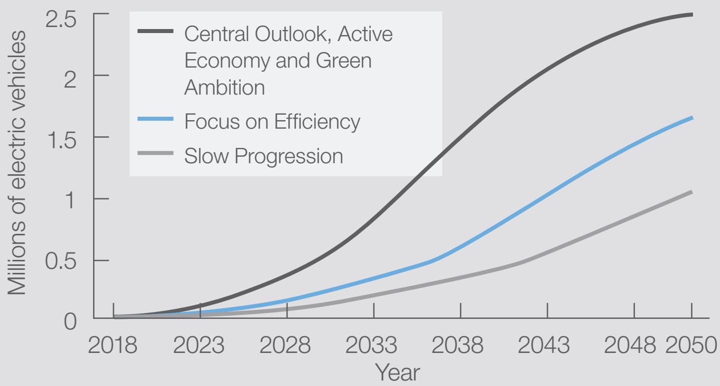
Electrification of transport and heat forecasts

Up to 2.5 million electric vehicles in our supply region by 2050 have a significant impact on our demand forecasts

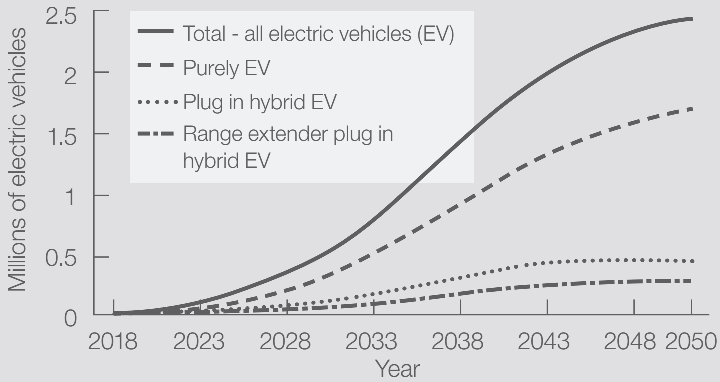
The greatest uptake of electric vehicles is forecast for three of our scenarios which align with the current Government pledge to end sales of new vehicles with conventional internal combustion engines in 2040. In these cases, most electrical vehicles are forecast to be battery types, although we are indicating up to a third being hybrid vehicles beyond 2040. Even with our least growth scenario, Slow Progression, we are forecasting 1 million electric vehicles motivated by carbon reduction intentions and technological developments.

Knowing when electric cars will be charged can be difficult to predict, but we have used evidence gathered from electric vehicle trials to understand what the forecast number of vehicles means in terms of electrical demand. Also, we have modelled overnight smart charging of domestic electric vehicles meaning that the effects during the day are less severe. Nonetheless, even overnight charging has an impact on our network because our assets are used on a more continuous basis which reduces the available network capacity.

Future numbers of electric vehicles in the Electricity North West supply region



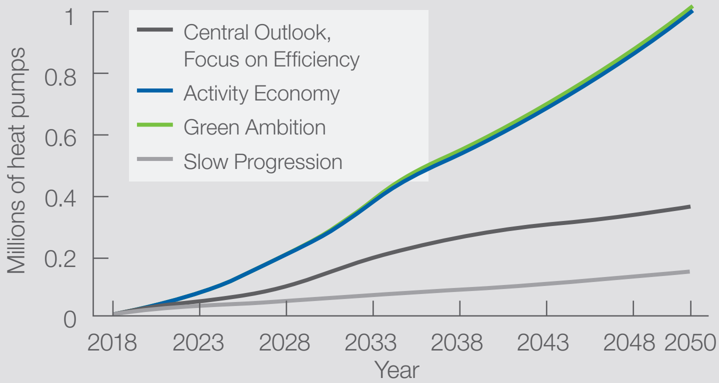
Breakdown of Central Outlook scenario values



Up to nearly 50% of our customers' properties could be warmed by heat pumps by 2050

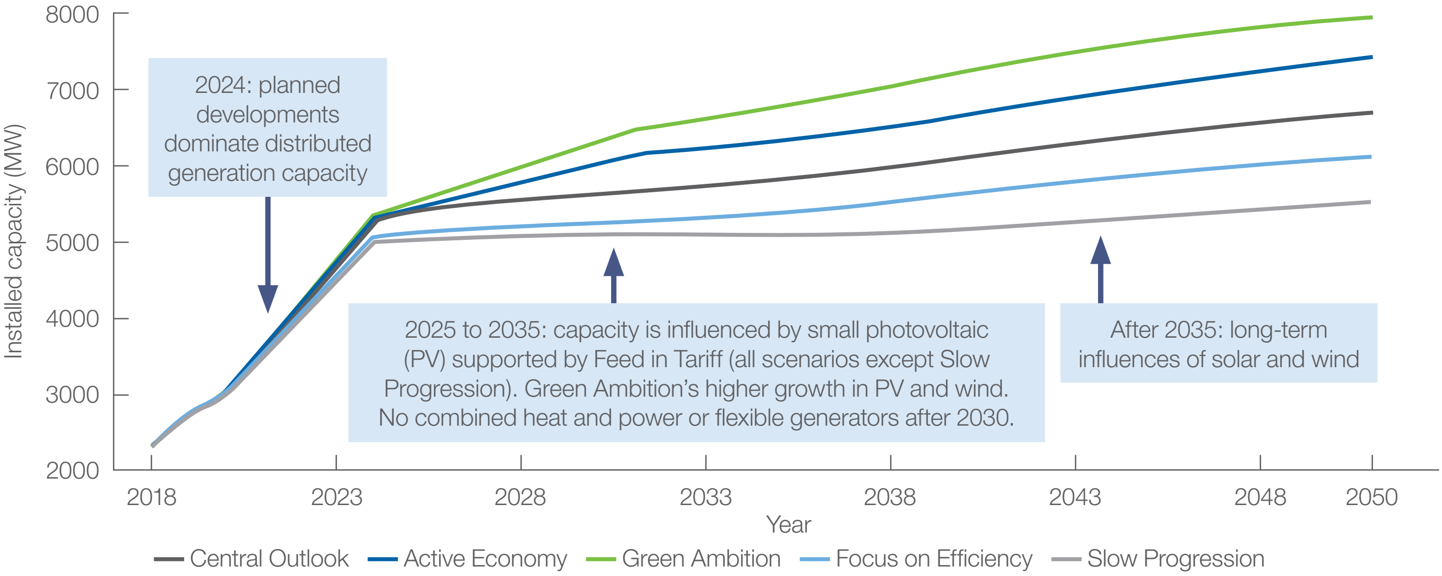
Our Green Ambition and Active Economy scenarios predict more than one million heat pumps by 2050 driven by both increased prosperity and government incentives. The small difference in heat pump uptake between the Active Economy and Green Ambition scenarios is due to the fact that Green Ambition assumes that heat pumps are installed in industrial and commercial buildings in addition to those installed in our homes as assumed in both scenarios. Heat pumps are forecast to have a significant impact on winter maximum demand because we are expecting more to be installed in our homes than in industrial buildings. Importantly, the uptake of heat pumps and therefore the impact on our network varies greatly over our region due to both variations in geography and social influences on the inclination to install them.

Future numbers of heat pumps in the Electricity North West supply region



Distributed generation forecast

Distributed generation forecasts for all Electricity North West scenarios



Renewable generation connected to our distribution network continues to grow significantly under all scenarios

The transition to a decarbonised world will mean more distributed renewable generation along with increased use of energy storage. Energy storage will pay a key role in the smarter operation of our network allowing us to maximise the utilisation of existing assets through the balancing of network capacity.

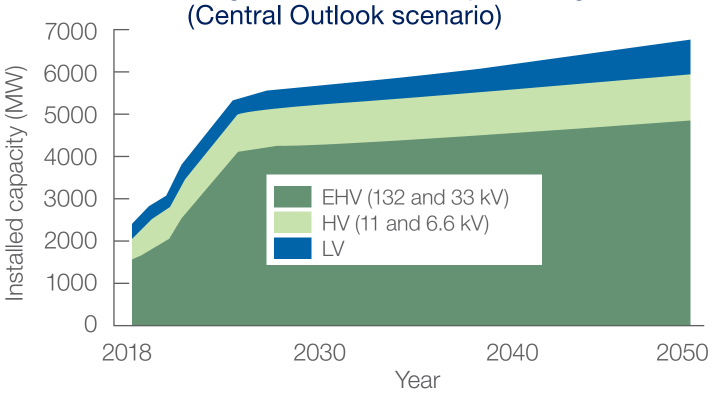
Our forecasts indicate that the aggregate capacity of distributed renewable generation increases from the existing 2.3 GW to between 5.5 GW and 7.9 GW by 2050. Regardless of the scenario, the trends show that the installed capacity is expected to more than double within the next decade particularly driven by the connections that are already planned and affected by government incentives.

Nonetheless, these trends are not homogeneous. For example, more large scale wind and solar photovoltaic (PV) installations are expected in Cumbria rather than close to Greater Manchester. The disparity leads to greater impacts in some areas compared to others as presented in section 3.

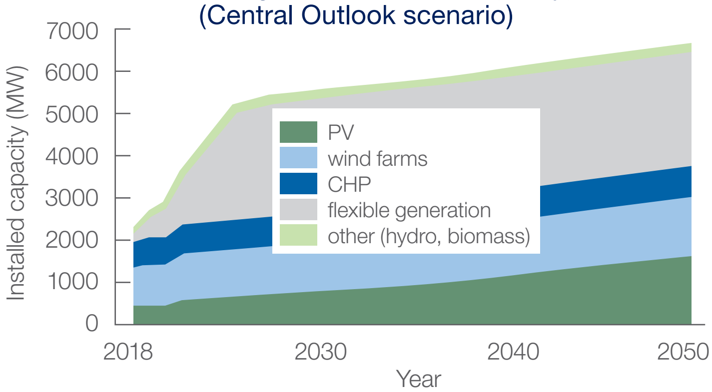
Generation fuel type, i.e. wind or solar PV, influences when a generator exports power and therefore alters its impact on the network. The expected scale of flexible generators (gas and diesel fuelled) which operate intermittently to provide flexible services to assist in the stable operation of the country's networks, are such that they are likely to connect at 33 kV or above and we are forecasting an abrupt rise in the following five years due to the existing pipeline of developments. Our forecasts show little increase in the capacity of combined heat and power plants (CHPs) as policies for decarbonisation and reduced capital cost for renewable plants makes further developments less likely. In contrast, we are forecasting significant growth in wind and solar generators; as their technologies are advanced further and costs reduce meaning they are better able to participate in the wholesale electricity market.

The voltage level at which a generator connects affects where on the network the impacts are experienced. Despite the overall capacity of distributed generation being dominated by generators connected at 33 kV and above, there is a significant increase in generators expected to be installed on house roofs and connect at low voltage. Associated network issues and corrective action is expected where such low voltage generation occurs in clusters.

Distributed generation forecast per voltage (Central Outlook scenario)



Distributed generation forecast per type (Central Outlook scenario)



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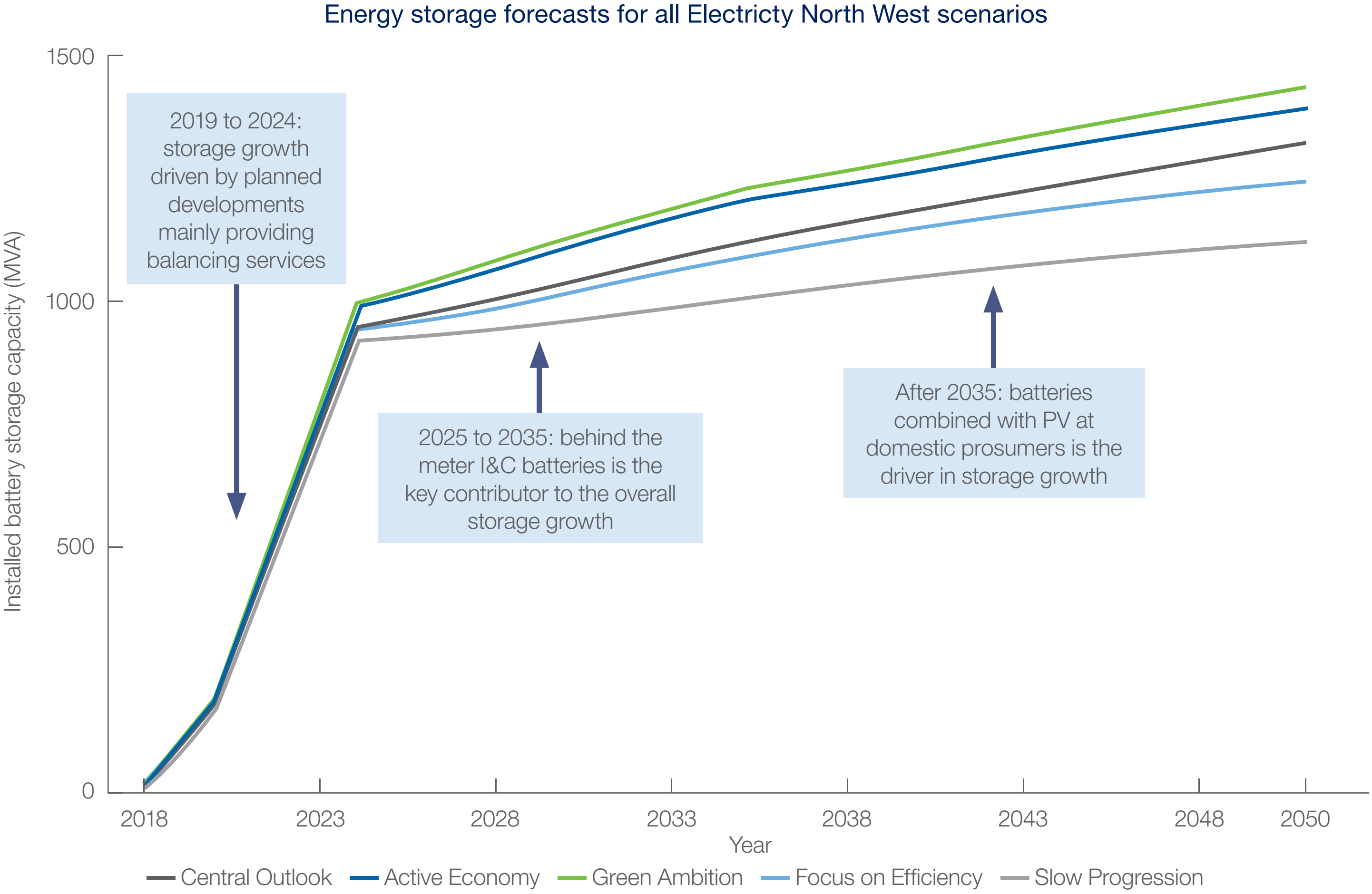
Energy storage forecast

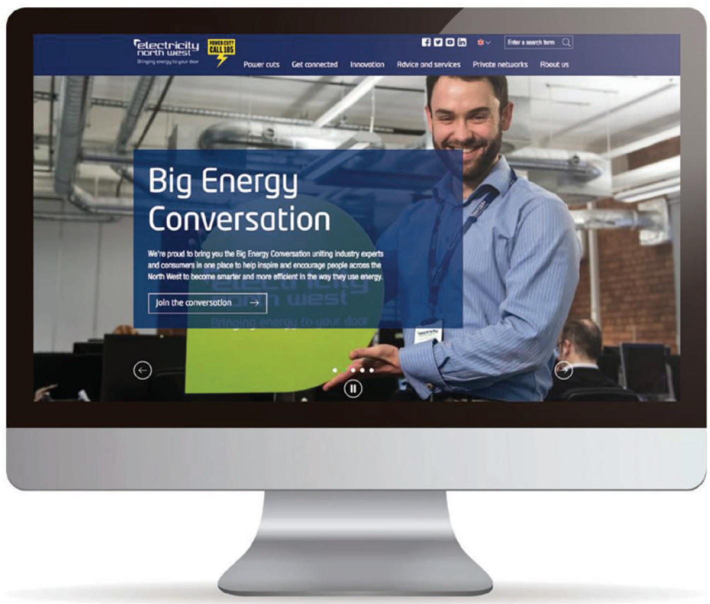


Up to 1.5 GW of energy storage is forecast to be connected to the Electricity North West distribution system by 2050

Similar to the trend for distributed generation, the capacity of energy storage connected to Electricity North West's network is expected to be driven until 2025 by the connection of developments which are already planned and are mainly aiming to provide services for the transmission system operator. We are also forecasting that some industrial and commercial customers will connect storage behind the meter to reduce and change the times of their maximum demand whilst providing services to the transmission operator.

Our forecasts show that increasing cost competitiveness in batteries will result in more domestic customers installing energy storage, particularly combined with PV to reduce electricity consumption and potentially provide network services.

When battery storage will charge and discharge will depend on the purpose that it is being operated, however, at the extreme it can be considered as an additional 1.5 GW of demand and 1.5 GW of generation capacity.



Reactive power forecast

A component of power, known as reactive power, flows through power networks as a consequence of delivering useful power to our customers. It is necessary to maintain the correct level of reactive power in our network to ensure that system voltages remain within limits. However, reactive power demand across UK and other European countries is declining and in some places the flow has been reversed. This downward trend is adversely affecting voltages in the transmission system, particularly during periods of minimum demand. Consequently, it is important for the satisfactory operation of the whole system that we have a thorough understanding of future reactive power flows, in particular at our interfaces with the transmission network, to inform the requirement for any corrective action within our network.

Electricity North West has pioneered reactive power forecasting through our ATLAS project and have incorporated this into our normal processes in advance of the other GB DNOs.

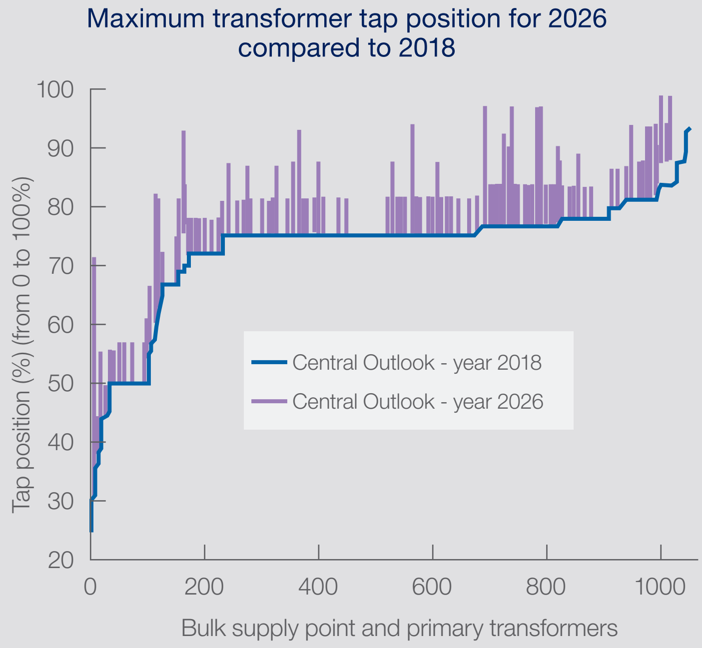
Just like our demand and generation forecasts, we prepare reactive power forecasts for each of the different scenarios to define the uncertainty around future levels of reactive power. Our method for forecasting reactive power is technically robust with detailed consideration of reactive power historical trends and consideration of future interactions of forecast demand and generation within our network.

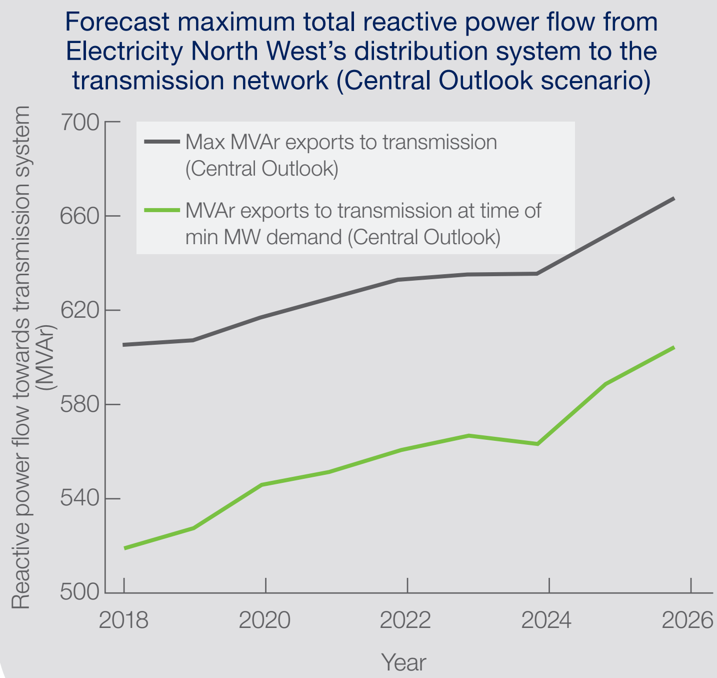
We forecast reactive power flows for each half hour, but the maximum and minimum values are useful in National Grid's analysis of the impact on transmission system voltages. The Central Outlook scenario trend shows significant future increases in the maximum total flow of reactive power from Electricity North West's network to the transmission system.

Apart from the effects on the transmission system, we are also expecting that the predicted reduction in reactive power demands will make it more difficult to adequately control voltages within our distribution system. We may require voltages to be adjusted more than the capability of our existing transformers which can only control voltages within a certain range. Our transformers are already reaching the limits of their ability to manage voltages using their 'tap changers' and could become inadequate. We are predicting that they will have to operate under conditions which are increasingly different from those for which they were designed. This change is driven by changes in the type of appliances our customers are using and due to the connection of more distributed generation. Our studies of 2026 power flows corresponding to the Central Outlook scenario show that a significant number of transformers will be operating closer to their voltage control limit as indicated by their tap position.

Electricity North West's network will be significantly affected by future trends in reactive power

Under the Central Outlook scenario, many of our transformers are expected to operate at higher tap positions in less than a decade from now. Other scenarios with more distributed generation and lower minimum demands present even greater voltage control challenges for both us and the transmission network operator.



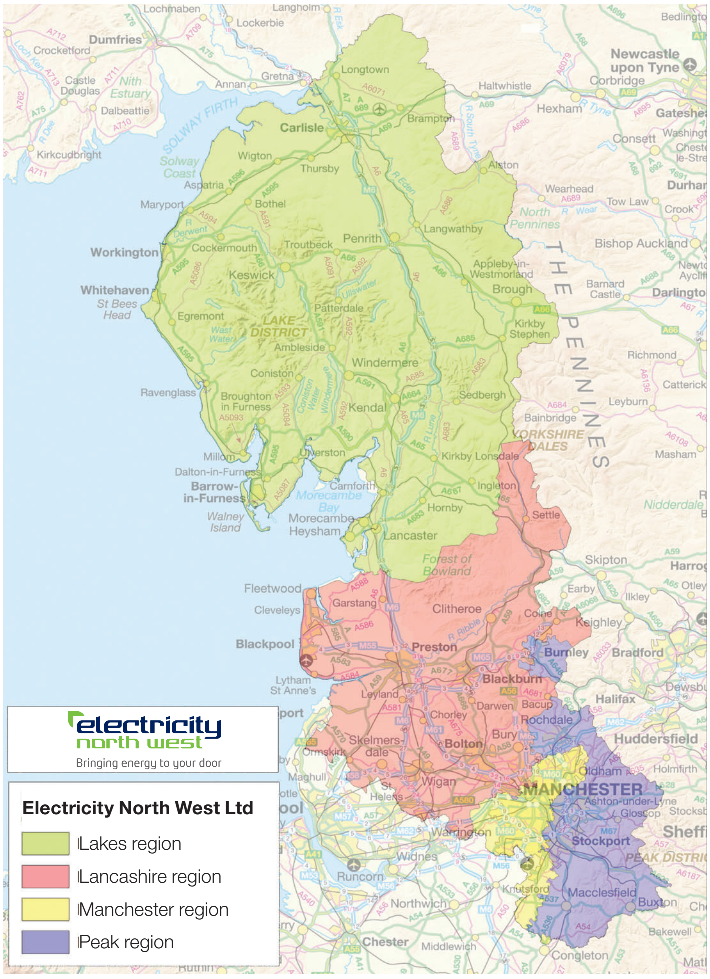


3. REGIONAL INSIGHTS

Regional analysis overview

We have used the Central Outlook scenario forecasts for more than 400 supply points across our network to assess the impact of projected future demands and the uptake of distributed generation up to 2050. Our results are used to inform our network development plans and are shared here to inform our customers where local opportunities exist and forewarn them of likely constraints in advance of any future connection to the network.

Four regions with distinguishing characteristics in terms of their forecasts, the types of customers and the composition of the existing network have been considered in our impact assessment. This approach has allowed us to identify distinctive regional challenges. In particular, we have gained detailed understanding of the likely types of constraints, where the connection of distributed generation is expected to have the greatest impact on our network and where demand growth including the electrification of transport and heating lead to network issues.



Although our analysis considers the interaction of the forecasts for different types of demand and generation as their operation varies throughout the day and year, we have presented our results separately for demand and generation drivers for each region to highlight the differences in the regional impacts. Our impact analysis has focused on 132/33 kV Bulk Supply Point (BSP) and 33/11 kV or 33/6.6 kV primary capacity along with the associated 132 kV and 33 kV networks. Throughout this section we present the results of our analysis of primary capacity in terms of wider supply areas. This representation reflects the ability to transfer load between neighbouring primary substations to mitigate overloading.

Our demand impact results are shown as heat maps using the same colour coding throughout.

More than 100% overloaded
Between 50% and 100% overloaded
Up to 50% overloaded
Between 50% and 100% loaded
Less than 50% loaded
No BSP or 33 kV network

We have focused on the 132 kV and 33 kV networks because we require greater forewarning of their issues as it takes longer to develop them and also because we have greater confidence in the forecasts for larger distribution areas as they are the sum of often very diverse projections for numerous smaller areas down to postcode level. There will however be interventions required in our lower voltage networks, as our LV distributed generation, electric vehicle and heat pump forecasts indicate a major impact there.

In this section we present for each region demand capacity, export considerations and fault levels for just the Central Outlook scenario for simplicity.

Consideration of all five of our scenarios leads to different types of network impacts in different locations and at different times. We consider the uncertainty defined by our forecasts and their varying impacts to identify which developments are required under all scenarios and to inform low-regret strategic investments to support our customers. We choose to mitigate the similar issues that may be encountered for more than one scenario, but just occur sooner with one scenario than with another. Should the future demand uptake match our Active Economy scenario, we would see the impact we have simulated based on the Central Outlook scenario 2050 forecast much earlier, at approximately 2035. Similarly, if the future generation uptake matches our Green Ambition scenario, then the simulated distributed generation impact for the Central Outlook scenario 2050 forecast would occur in approximately 2035.

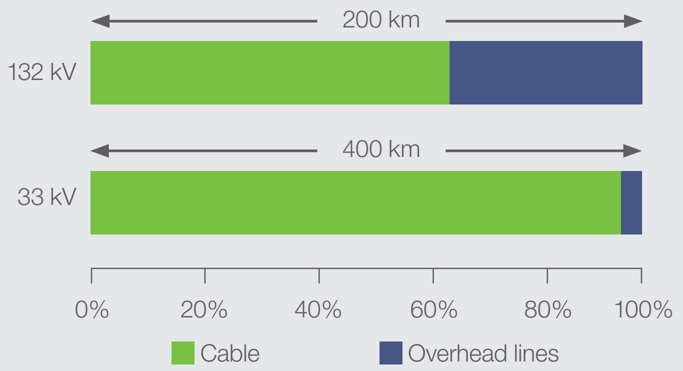
Our future network

We are using existing network capacity to accommodate new connections and our impact assessment has shown where there is still capacity available and when that is expected to be used up. Our results have also shown immediate network issues and those expected in the short-term, thus confirming the need for our planned reinforcement projects. We have not identified the specific network solutions required where we are projecting there to be insufficient capacity in the longer term. Instead the results provide valuable insight into how and where our network will be constrained in the future. Specific network reinforcements will be decided nearer the time with consideration of capacity requirements, the range of the latest forecast scenarios, costs and practicalities including the availability of flexible services, land and the need to replace aging assets. We recognise the value to be obtained by operating flexibly to avoid expensive extensions to our network and are already accommodating additional connections by applying Active Network Management (ANM) approaches to constrain distributed generation to avoid operating outside network limits. We shall seek to solve all future network constraints using flexible services engaged via requests for proposals for flexible services, the first of which was issued in April 2018.

3.1. MANCHESTER REGIONAL INSIGHTS

At a glance

- The region's network supplies 581,000 customers which is equivalent to around 26% of our customer base.
- With an area of just 430 km^2 the region has 1350 customers / km^2 the highest customer density of any part of our network and 35 times greater than in our Cumbria region.
- Our forecasts show that the region will experience a 40% growth in maximum demand by 2023.
- There is more 132 kV cable than average and less 33 kV overhead line than average.



Manchester supply region

Although it is the smallest of the four regions, Manchester's constituent areas exhibit a wide range of demand profiles. The central business district consists mainly of commercial and retail customers, whereas the surrounding areas have a mix of residential and industrial load centres.

Historically the region has experienced a relatively low uptake of distributed generation as its urban nature affords limited space for large scale renewable developments. There is however significant potential for growth in user driven distributed generation, such as small to medium scale photo voltaic installations. The rapidly developing flexible generation and storage market is also well placed to utilise the region's portfolio of brownfield land.

Future development

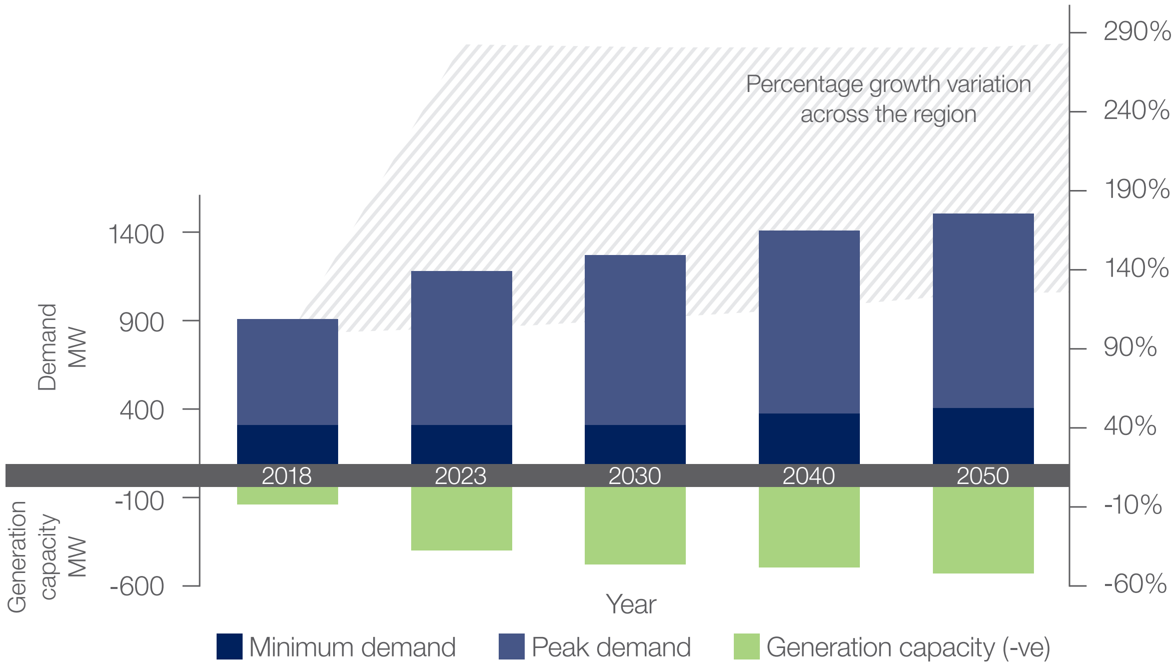
Greater Manchester Combined Authority (GMCA) has ambitious decarbonisation plans which are set out in their document Spring Board to a Green City Region. As the distribution network operator for the region we will be a key partner in this transition. These plans, particularly the decarbonisation of transport and heating, will increase the amount of electrical energy to be delivered by our network. In order to continue to provide the quality of service that our customers expect we are acting now to future proof our network.

Our forecasts predict that the Manchester region will experience the greatest year on year growth in demand of any of the four regions. Maximum demand in the region is expected to grow overall by 40% by 2023 and localised growth is expected to be more than double this in some areas. The areas that will see the highest growth are Manchester city centre and the area bordering upon the airport. This correlates with the plans to create approximately 10,000 new homes in Greater Manchester each year and to expand the business and transport hub centred on the airport.

581,000 customers

430 km^2

1,350 customers / km^2



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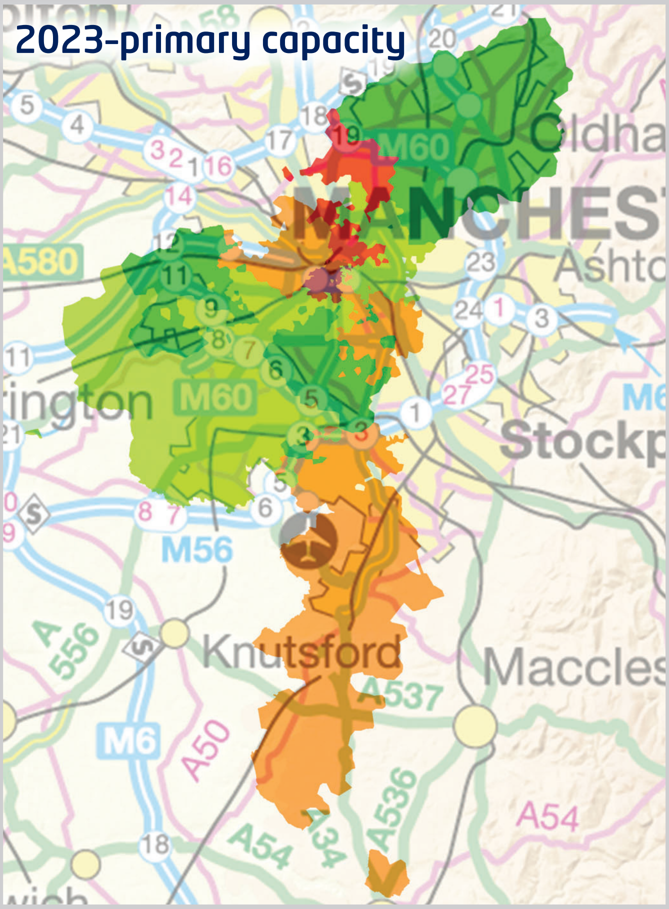
Manchester region primary capacity short-term impact assessment (2023)

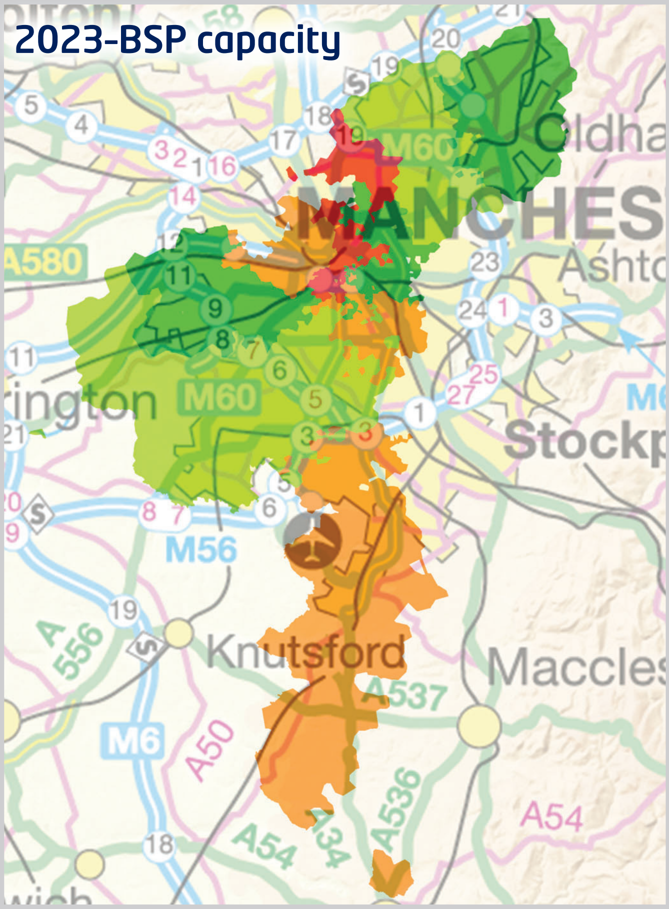


We are strategically investing to provide additional primary capacity so the region can realise its development ambitions

Over the coming years there are a large number of developments planned for Manchester that have the potential to significantly increase network loading. These include city centre redevelopments such as those outlined in Manchester City Council's Strategic Regeneration Frameworks, the arrival of HS2 and the continued expansion of Manchester Airport City Enterprise Zone.

Our impact assessment shows that by 2023 demand will out strip primary capacity in both Manchester city centre and in the south of the region. Given the severity of the overloading predicted by the Central Outlook scenario, we are already planning strategic intervention to provide additional primary capacity so that the region can realise its development ambitions.

Manchester region bulk supply point (BSP) capacity short-term impact assessment (2023)

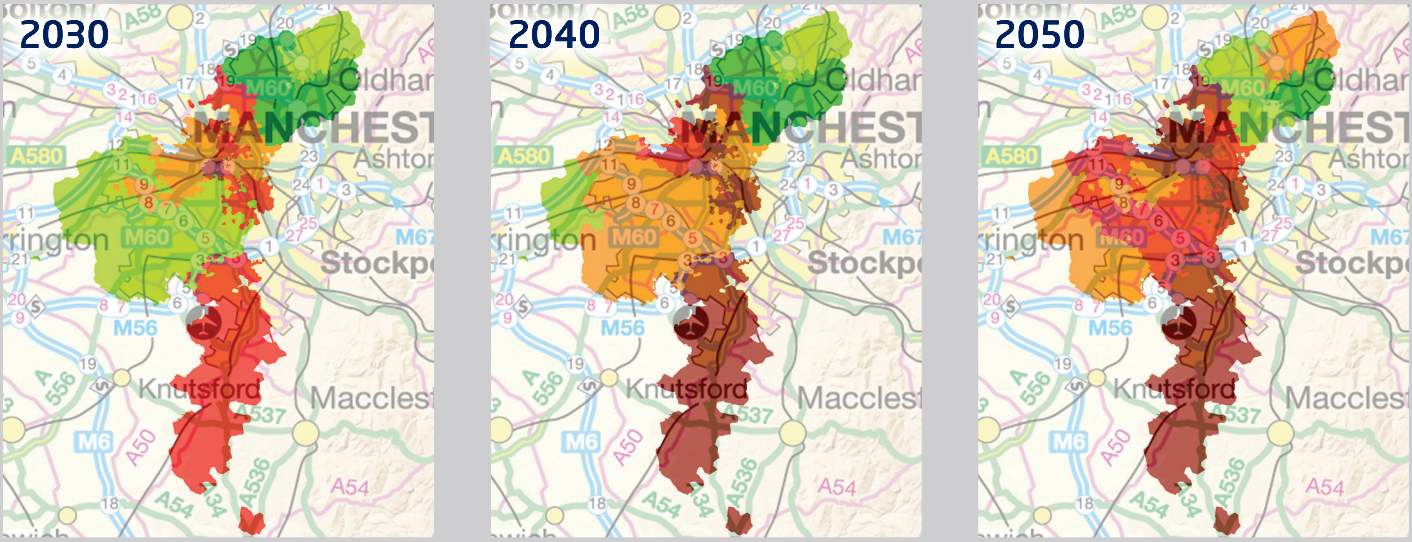


The additional capacity created by the upgrade of Stuart Street BSP will play a key role in alleviating city centre overloading

Maximum demand is predicted to significantly exceed existing BSP capacity by 2023. For this reason we have already started work to upgrade Stuart Street BSP. The additional capacity created by the upgrade of this substation will play a key role in alleviating city centre overloading.

Insufficient BSP capacity is also predicted in the south of the region. Given the level of the overloading it is not anticipated that this will represent a major reinforcement driver in 2023. It is envisioned that this overload, along with any additional overloads in the city centre, will present an opportunity to engage with flexibility service providers. We shall continue to monitor the situation to ensure that we can provide the required capacity efficiently when needed.

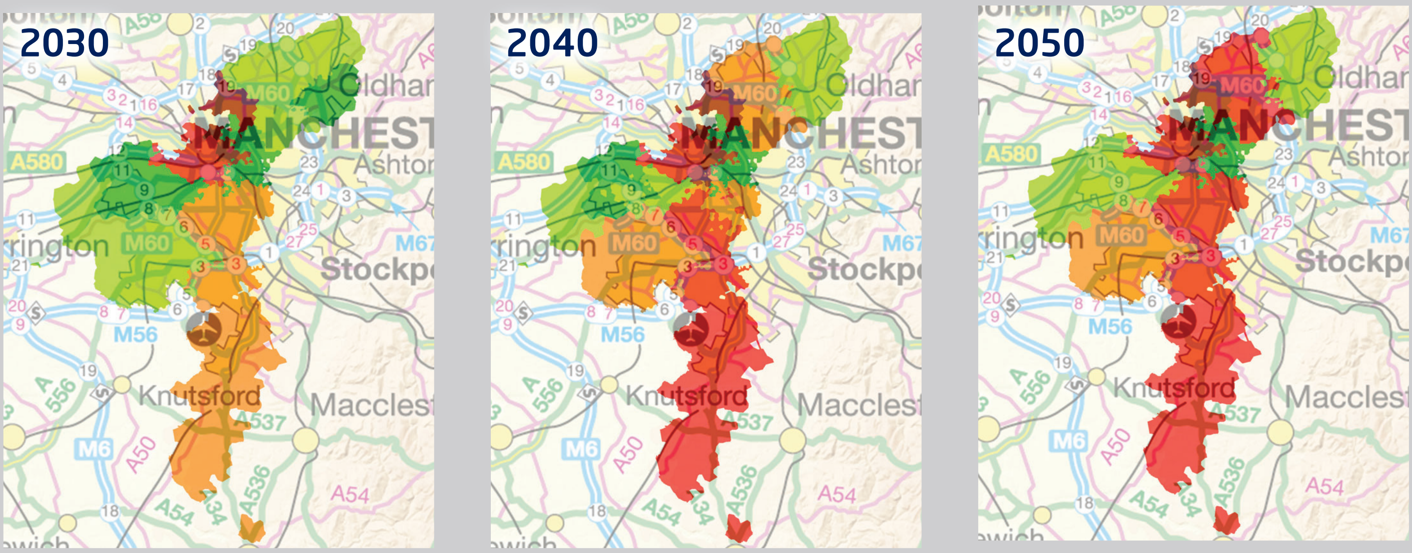
Manchester region primary capacity long-term impact assessment



Driven by ambitious plans for development of the region, increases in electrical demand are expected to be the main influence on the need for investment in the region's primary distribution capacity

The long-term impact assessment shows further worsening of the predicted overloading in the centre of Manchester and in the area surrounding Manchester Airport. By 2040 it is forecast that over 50 MVA of additional primary capacity will be required in two BSP areas alone. From these results it is evident, that significant investment in the region's primary distribution infrastructure is required. Outside the areas highlighted in the short-term forecast, significant overloading starts to occur to the south-west of Manchester city centre between 2030 and 2040. These overloads will be managed when they materialise using a mixture of flexible services and traditional reinforcement. By 2050 spare capacity will still remain in the north-east of the region. The existing loading in this area is lower than the rest of the region and it is projected to experience lower levels of demand growth.

Manchester region BSP capacity long-term impact assessment



Low-regret short-term reinforcement of the region's BSP capacity is required considering the extent of the projected overloads in neighbouring areas

Between 2030 and 2040 loading in the southern area of the region becomes significant and reinforcement will likely be required. Demand in the centre of Manchester continues to grow, emphasising the importance of increasing central Manchester BSP capacity which can be carefully planned and located to mitigate constraints in neighbouring areas. Moderate overloading outside the southern and central areas does start to occur from 2040 onwards. In these areas it is envisioned that it will be possible to defer reinforcement through the use of flexible services.

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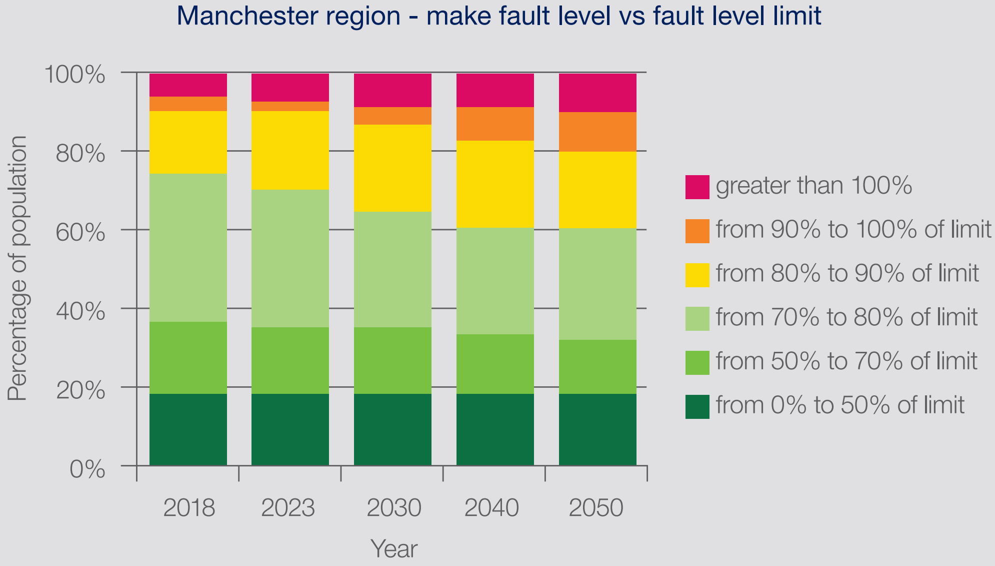
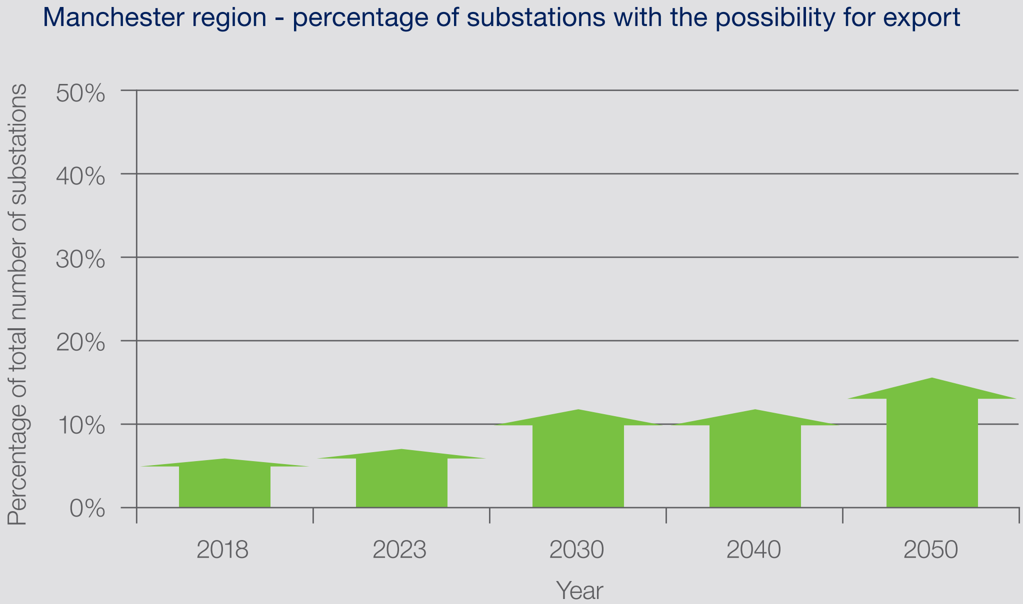
Manchester region fault level impact assessment



Our impact assessment has indicated increasing fault levels across the Manchester region. Currently fault levels are less than 80% of their limit at 75% of BSP and primary locations across the region. This reduces to 60% of locations by 2050.

Due to the comparative size of the populations the results are dominated by primary substations where the fault level contribution from downstream generation has the greatest influence. Our forecasts show that, in the Manchester region the main source of generation growth below our primaries is from roof mounted photo voltaic installations. The fault level contribution from this type of generation is low and as such the increase in primary fault levels in the region is also forecast to be low. Our forecasts do however show a greater increase in BSP fault levels in the region which is mainly driven by the forecast connection of a large amount of flexible generation.

Manchester region reverse power forecast

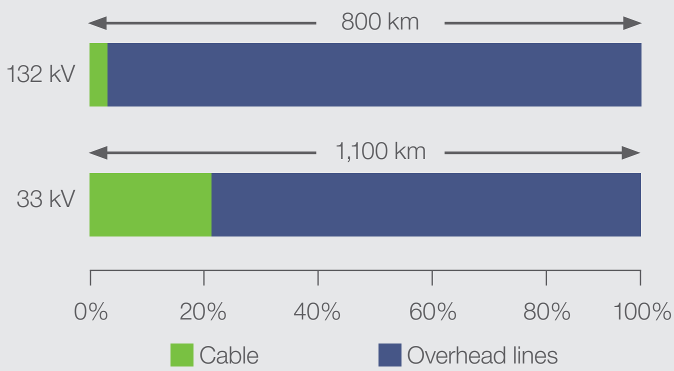


Due to Manchester's high demand to generation ratio the number of primary substations with the potential for reverse power is low with only 15% predicted to export power by 2050. For this reason, reverse power flow is not predicted to be a dominant reinforcement driver in the Manchester region. However, there could be localised issues if future generation is clustered.

3.2. CUMBRIA REGIONAL INSIGHTS

At a glance

- The Cumbria region has the lowest population of any of the four regions. despite the fact that, at 7,400km², it covers approximately 60% of our supply area. This results in a population density of only 40 customers / km².
- There is approximately 480 MW of generation in Cumbria already connected to the distribution network at bulk supply points (BSPs) and below. When including 132 kV connected offshore wind generation, wind capacity in Cumbria corresponds to 67% of the total wind generation capacity connected to the whole of our network.
- Circuits here comprise long overhead lines.



Cumbria supply region

Although it is predominately of rural nature, the region has areas of heavy industry. These include the towns of Barrow and Workington and the nuclear reprocessing centre at Sellafield.

The region's high wind resource and low population density make it attractive to both onshore and offshore wind developers. This has lead to the region currently having the highest ratio of distributed generation to demand of any of the four regions.

Future development

Our forecasts predict continued uptake of distributed generation in the region. This is in line with the ambitions of the Cumbrian Local Energy Plan to increase the amount of micro-generation on farms, hotels and schools along with the connection of more large scale wind, solar, and hydro projects. This will pose a significant challenge to our network.

The existing high penetration of distributed generation means that there is limited capacity to accommodate more. With total generation capacity forecast to even exceed the region's maximum demand, our studies indicate that the capacity of our existing network in the region will be insufficient to accommodate the anticipated export.

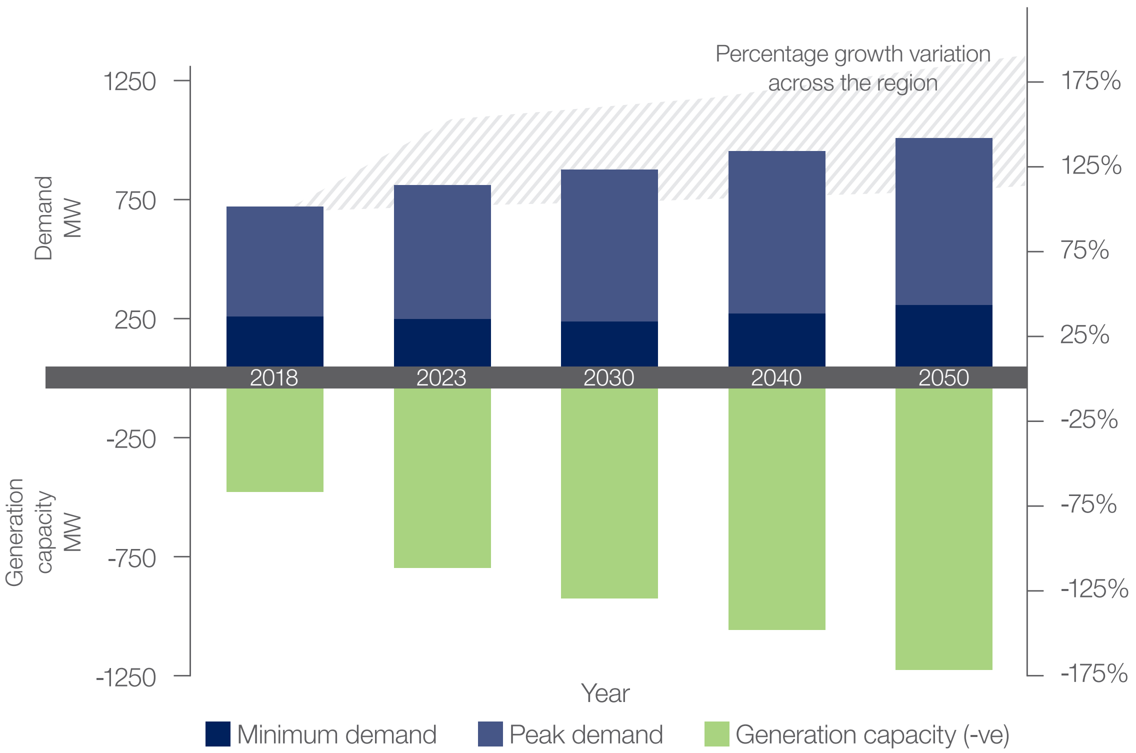
The integration of further distributed generation will not only prove a challenge for our network; the capacity of the local transmission network operated by National Grid is already limited. Although we are working with National Grid to resolve this issue as soon as possible, it is likely that transmission system capacity will remain a constraint to the further integration of large scale distributed generation for the short to medium term.

Potential development of Moorside nuclear power station to be located near to the existing Sellafield site would result in major changes for our network and represents a major uncertainty for the Cumbrian network.

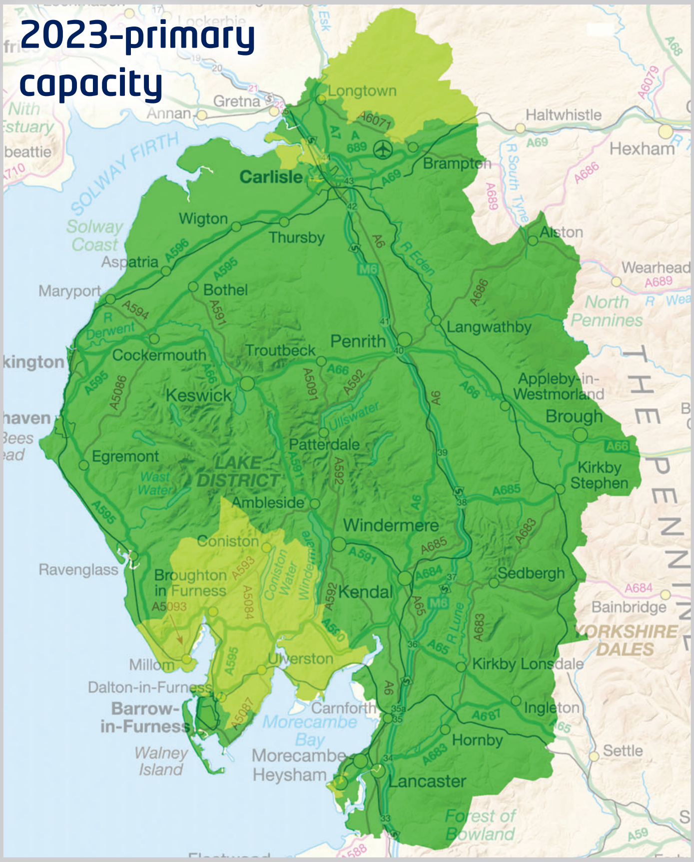
60% of our supply area

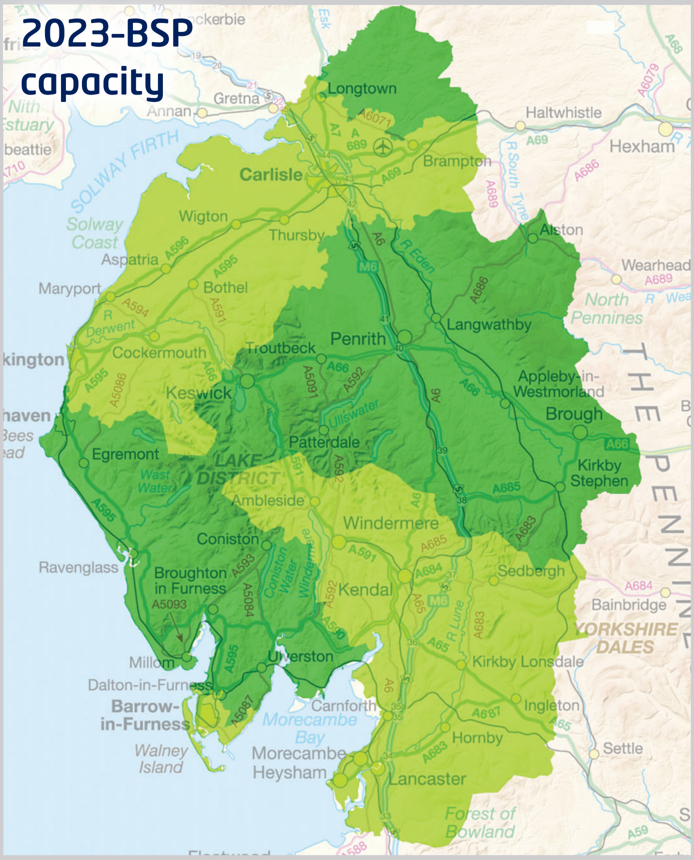
480 MVA of existing generation

40 customers / km²



Cumbria region primary and bulk supply point (BSP) capacity short-term impact assessment (2023)





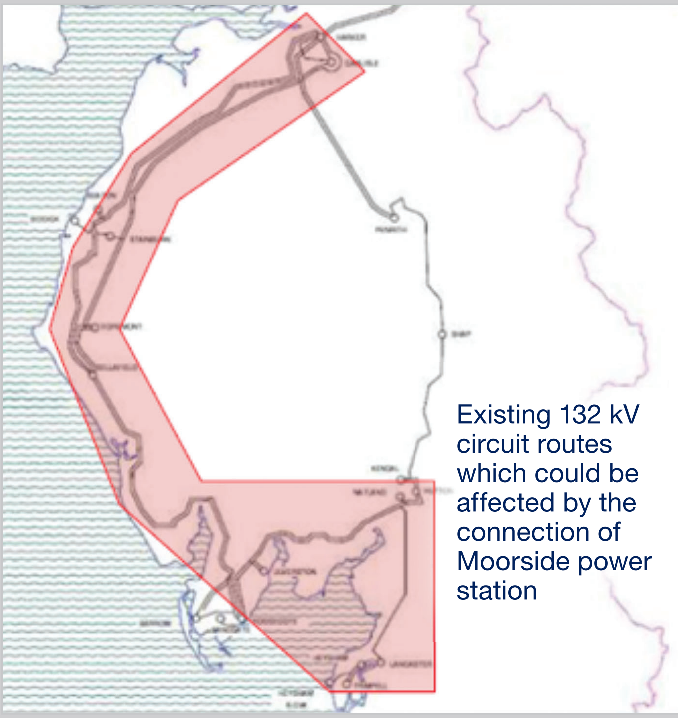
Overall, our Cumbrian network is expected to have sufficient capacity to accommodate 2023 forecast demands and generation is likely to be a bigger influence on network developments

Our analysis indicates that the region will have sufficient primary and BSP capacity to meet the forecast maximum demand in 2023. It should however be noted that, given the rural nature of the network, there is an increased probability that individual primary substations will become overloaded within this timeframe. Cumbrian substations tend to be in comparatively more rural areas with less interconnectivity. It is therefore often more difficult overcome overloading by transferring load between substations.

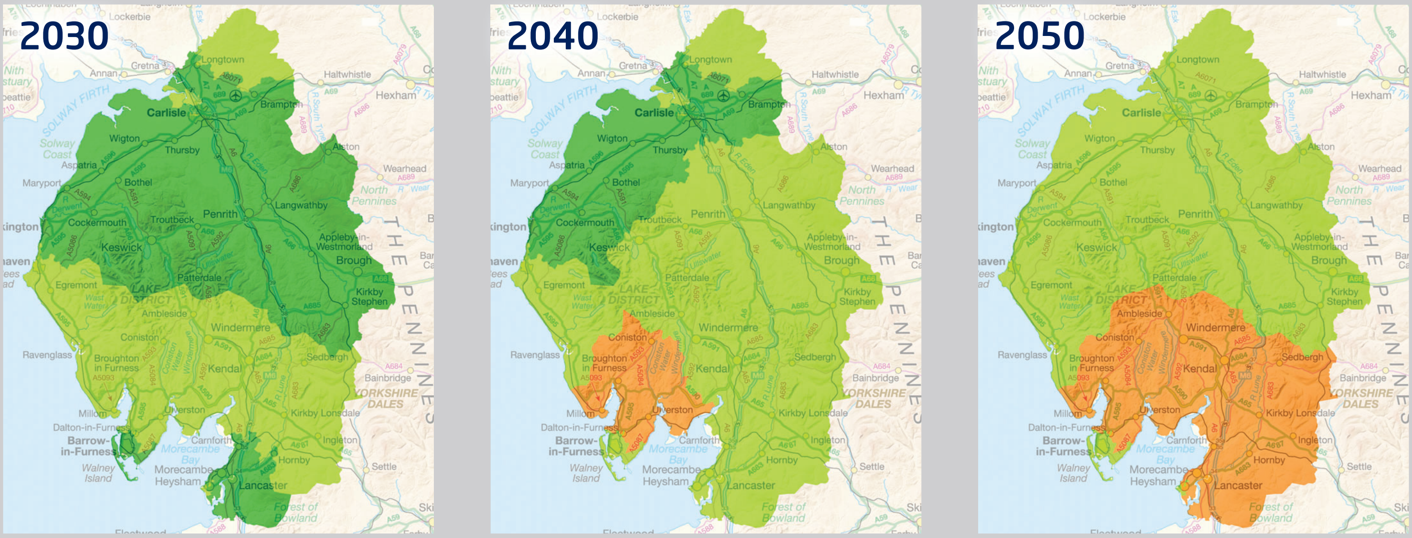
Moorside connection

Plans for more than 3 GW of capacity at Moorside nuclear power station near Sellafield are now uncertain, but it is likely to require significant changes to our Cumbrian network beyond those associated with accommodating our forecasts.

Existing circuits would not be adequate to carry power away from Moorside, so one option would be to replace our 132 kV overhead lines with 400 kV circuits. The resulting reconfiguration of our network in the region would mean that the results of our impact assessment would be superceded. The impact on the transmission network's ability to accommodate additional generation could also alter predicted distributed generation uptake. Hence, Moorside introduces uncertainty into our expectations for how the Cumbrian network will cope with forecast demand and generation.



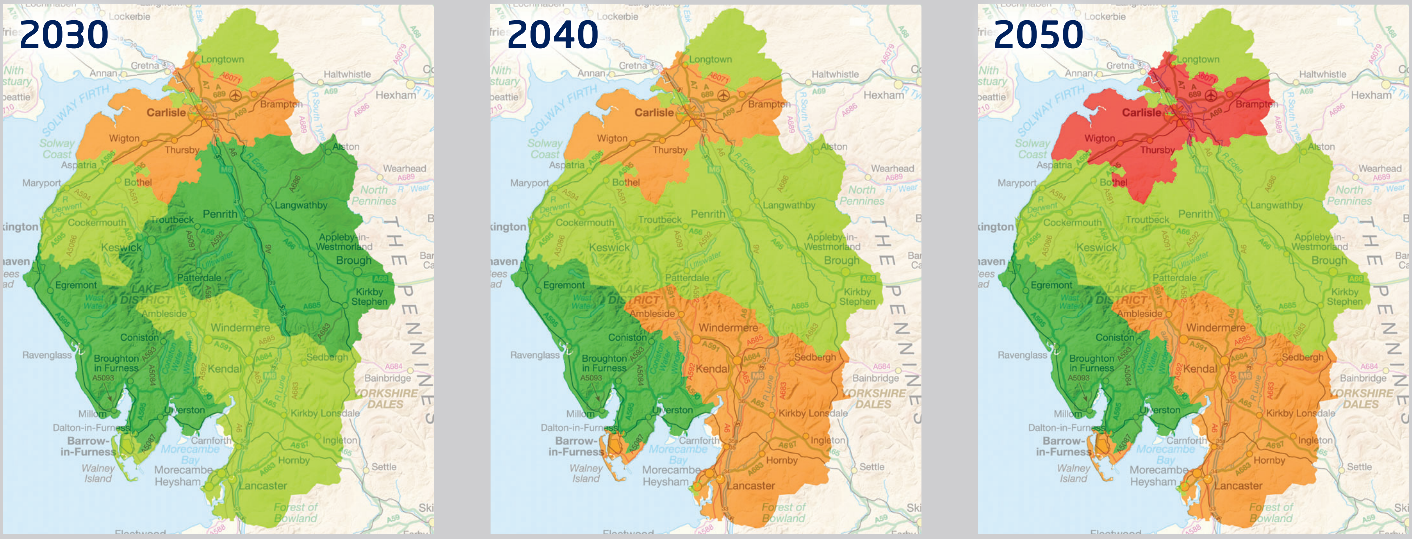
Cumbria region primary capacity long-term impact assessment



Even in the longer term, existing primary capacity in our network in Cumbria is expected to be mainly sufficient for our maximum demand and network enhancements will be required to accommodate generation

Long-term forecasts show that demand will start to exceed primary capacity in the region between 2040 and 2050. Overloading is concentrated in the south in the comparatively less rural areas fed from Ulverston, Lancaster and Kendal. As the predicted overloads are relatively small there may be the opportunity to call on flexible services rather than relying on traditional reinforcement. It should be noted, that given the rural nature of the region, there is an increased probability that individual primary substations will experience overloading much earlier than indicated by the overall pictures shown for 2040 and 2050.

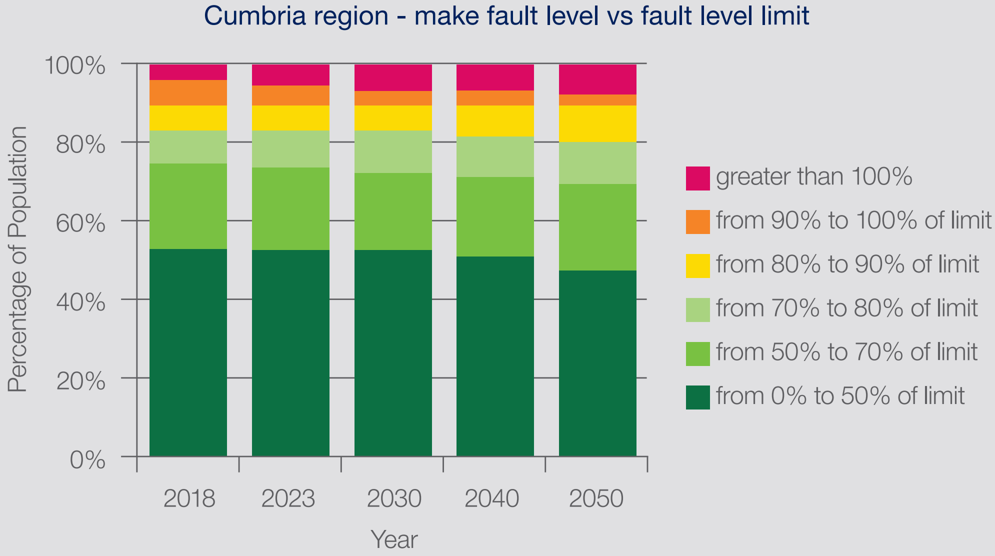
Cumbria region BSP capacity long-term impact assessment



In the longer term, maximum demand is forecast to exceed the existing BSP capacity in north and south Cumbria

Our analysis indicates that minor overloading of Carlisle BSP will have started to occur by 2030. Overloading of this BSP will increase overtime becoming severe by 2050. The three southern most BSPs, Barrow, Kendal and Lancaster, will start to experience overloading in the 2040 – 2050 period. Given the severity of the overloading, it is anticipated that traditional intervention will be required at Carlisle BSP at some point before 2050. However, it may be possible to use flexible services to defer reinforcement for a number of years or use batteries to overcome both issues associated with demand and generation.

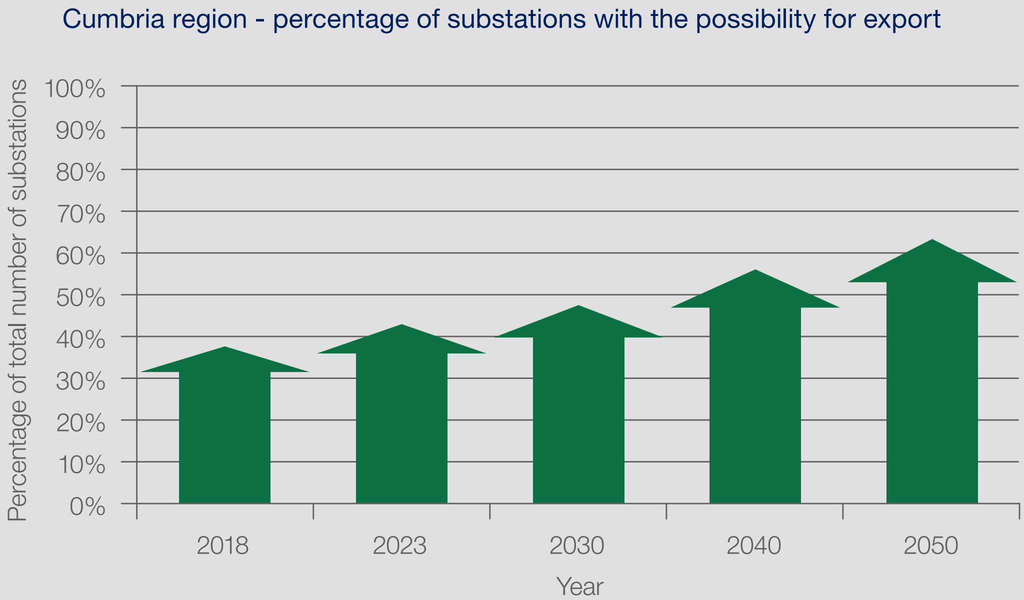
Cumbria region fault level impact assessment



Due to the region's rural nature, our assessment shows that the majority of substations have very low fault levels i.e. fault levels less than 50% of the limit. The Cumbria region has a higher proportion of substations in this band than in any other region. Although low fault levels are advantageous for the integration of distributed generation, they can be indicative of voltage regulation issues which can limit capacity.

In the Cumbria region the substations with high fault levels are typically those close to bulk supply points and grid supply points. Although these substations are normally located in urban areas which are less likely to be of interest to developers of renewable generation such as wind power, the fault levels there are more likely to pose a constraint to the connection of flexible generators and energy storage schemes which are more often built on brownfield sites.

Cumbria region reverse power forecast

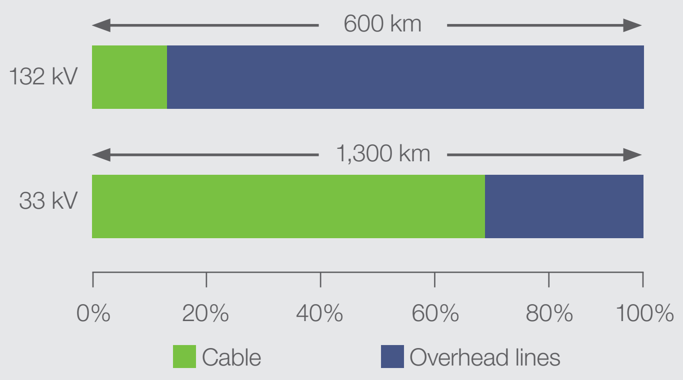


Due to the high levels of existing generation and low levels of demand, the region has the highest number of substations with the potential to export power. Despite the comparatively lower level of future generation uptake in the region our forecasts still show the number of substations with the potential for power export reaching 70% of the population by 2050. Even by 2023, the generation capacity connected at several individual primary substations have been shown to exceed their export capability, indicating the need for mitigation which could be achieved by constraining generators using active network management. Our studies have also indicated overloads of 132 kV circuits in the next few years when the flow of power from distributed generation at times of minimum demand exceeds circuit capacity. We are monitoring this situation closely to establish the most appropriate mitigation depending on when accepted generators begin operating.

3.3. LANCASHIRE REGIONAL INSIGHTS

At a glance

- Covering an area of 3,200km^2 our network in this region supplies 920,000 customers, making it the most populous of the four regions.
- The region's mix of rural and brownfield land makes it attractive to developers of distributed generation. Given the comparatively low historic uptake there is significant capacity for growth. We forecast a 400% increase in distributed generation by 2050 corresponding to our Central Outlook scenario.
- Circuits here comprise slightly less cable than average.



Lancashire supply region

The region is diverse; at its south eastern edge it feeds the northern and eastern parts of Greater Manchester. It also includes the former mill towns of Blackburn and Darwen, the seaside resort of Blackpool and large areas of rural Lancashire.

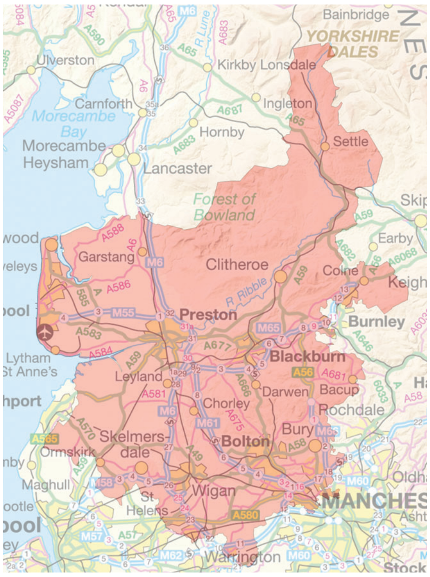
Future development

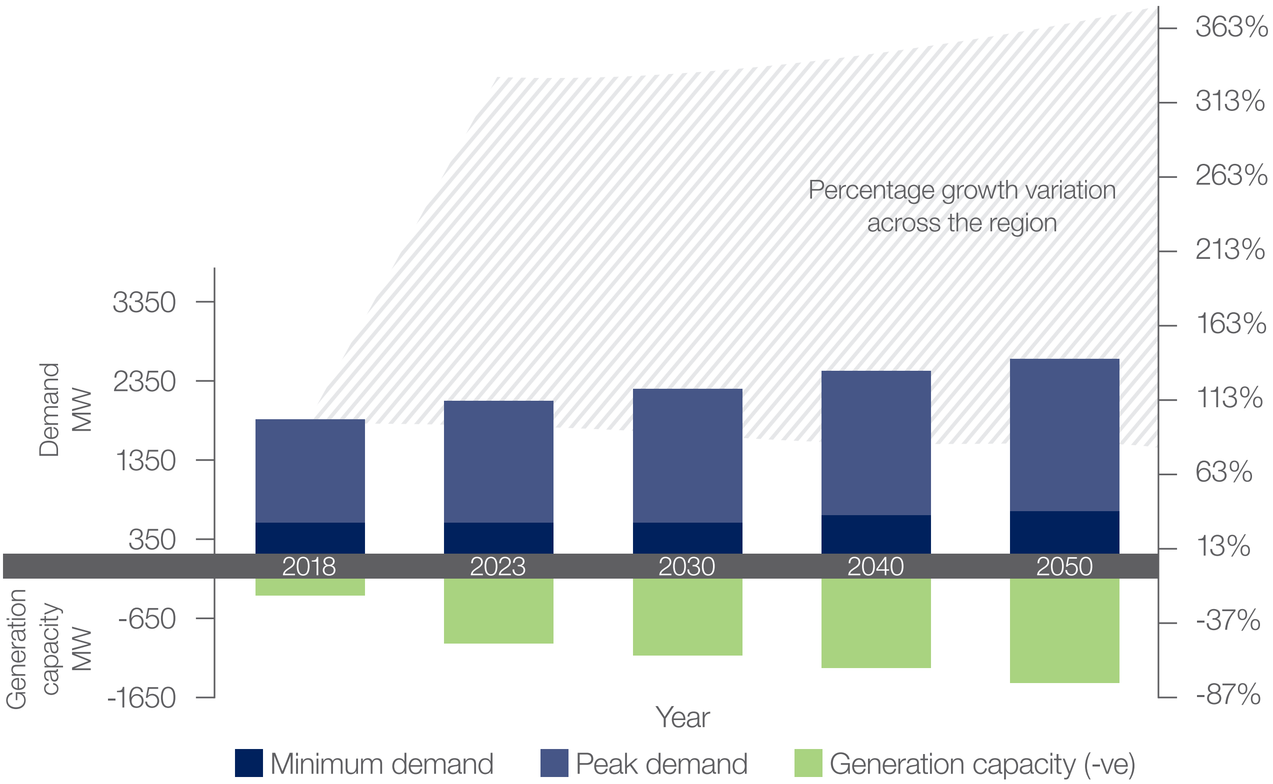
Our forecasts predict significant growth in maximum demand for the region; maximum demand is predicted to grow by 52% by 2050. Despite this there is significant variation across the region with some areas being forecast quadrupling of demands whilst other areas are predicted to see small net reductions in maximum demand due to efficiency drivers outweighing the effect of new connections.

With a mix of former industrial brownfield sites and undeveloped rural land there is the potential for major growth in distributed generation in the area. Renewable generation is strongly promoted in The Central Lancashire Core Strategy and reflected in local plans. Our forecasts predict that installed capacity will exceed minimum demand by 2023 and nearly quadruple by 2050 with respect to today's figures. The predominant technology type in this region is expected to be flexible generation and PV ranging from roof top size to large installations.

920,000 customers

400% increase in distributed generation by 2050





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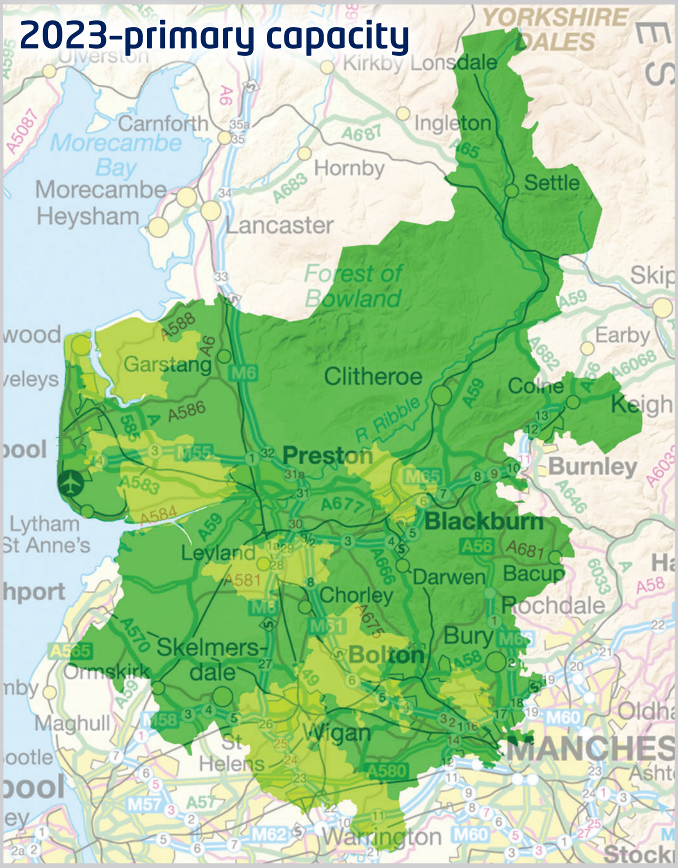
Lancashire region primary capacity short-term impact assessment (2023)

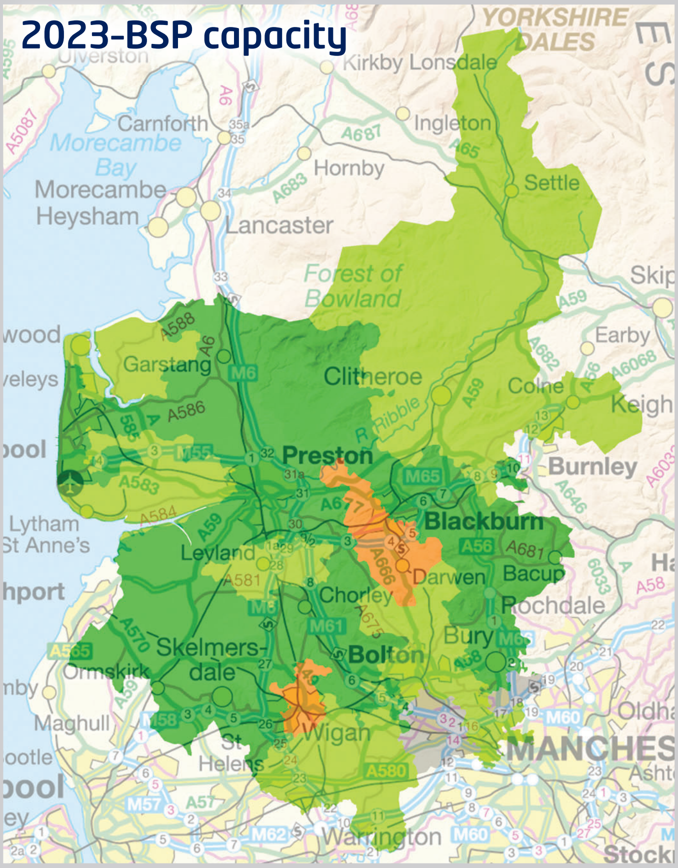


The overall primary capacity in the region is sufficient to meet the predicted short-term growth in demand , however localised overloads may occur

Our analysis of the forecast data does not predict any overloaded areas by the year 2023. However, it is possible that localised overloading will occur at individual primary substations. There are also a number of areas where demand headroom is limited. This makes the results in these areas sensitive to new large developments.

We shall endeavour to mitigate any overloads by transferring demand between substations whenever possible. This allows us to gain the most benefit from our existing assets. Our philosophy of maximising the use of existing assets means that we will also consider using flexible services where appropriate. The predicted high uptake of flexible generation and storage in the region makes it particularly well suited to this approach.

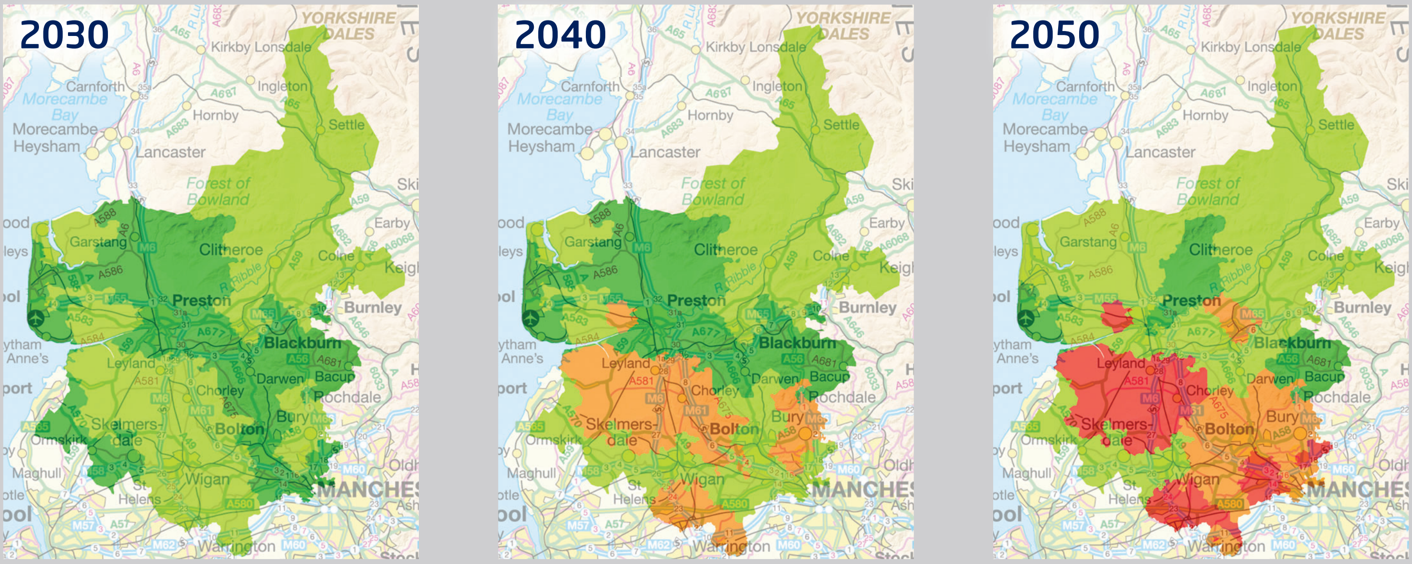
Lancashire region bulk supply point (BSP) capacity short-term impact assessment (2023)



The region has sufficient BSP capacity to meet the forecast short-term demand growth

Our analysis indicates that, by 2023, there will be two BSPs where maximum demand is greater than the capacity of the installed assets. Overloading is predicted in both Darwen and Wigan; it is predicted that the overloads will be relatively small and that the surrounding areas will have spare capacity. As such, it may be possible to resolve these overloads using load transfers or by engaging flexible services.

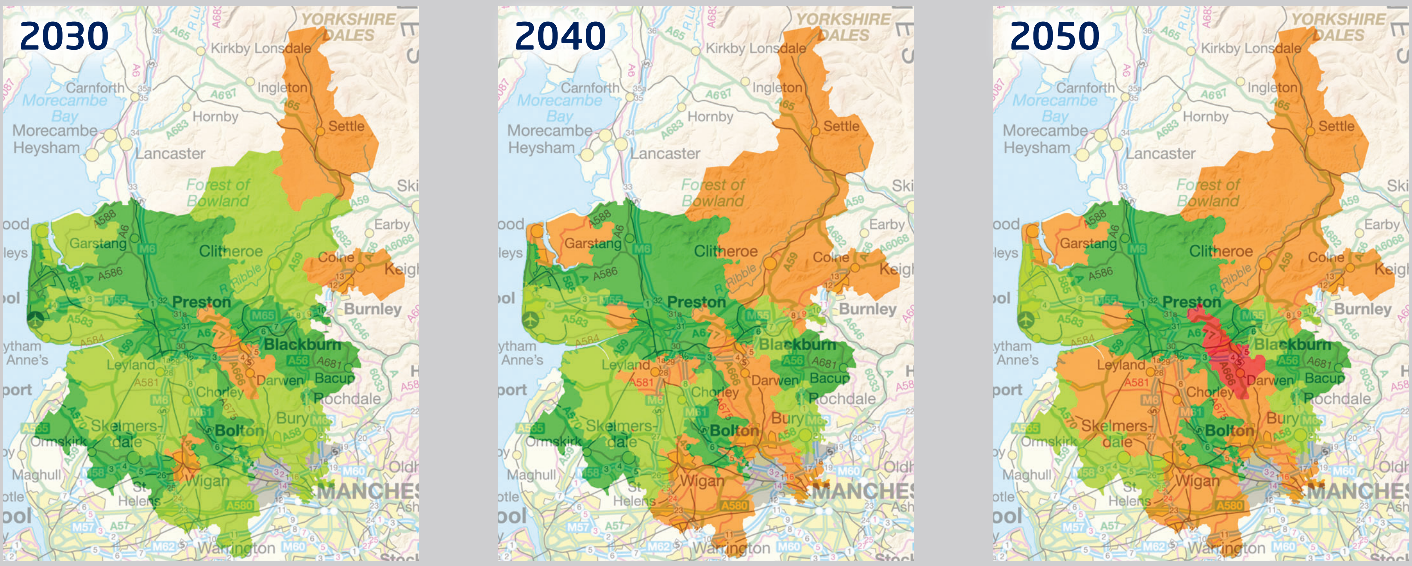
Lancashire region primary capacity long-term impact assessment



In the short-term the region has sufficient primary capacity to meet forecast demand growth, however in the mid to long-term overloading will occur concentrated in central and southern areas

Our analysis indicates that there is sufficient primary capacity to meet predicted demand growth until at least 2030. By 2040 overloading will have started to occur in central and southern areas, becoming severe in a number of areas by 2050. The severity of overloading predicted means that it is inevitable that reinforcement will be required by 2050. It may however be possible to defer reinforcement when overloading first occurs in the period between 2030 and 2050 by the use of flexible services.

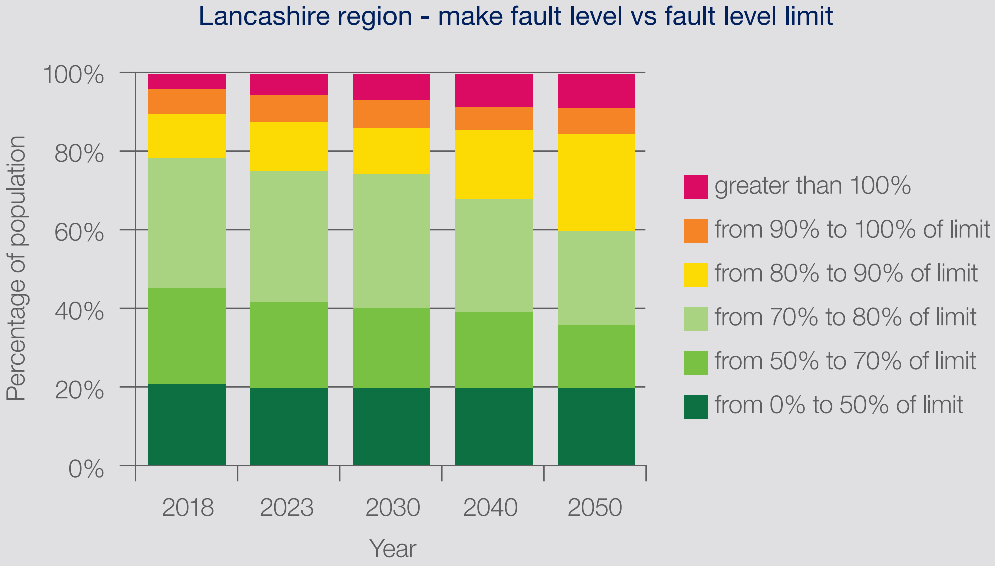
Lancashire region BSP capacity long-term impact assessment



In the long-term, reinforcement will be required to resolve BSP overloading in the region; it may be possible to defer reinforcement in the short to medium term using smart solutions including flexible services

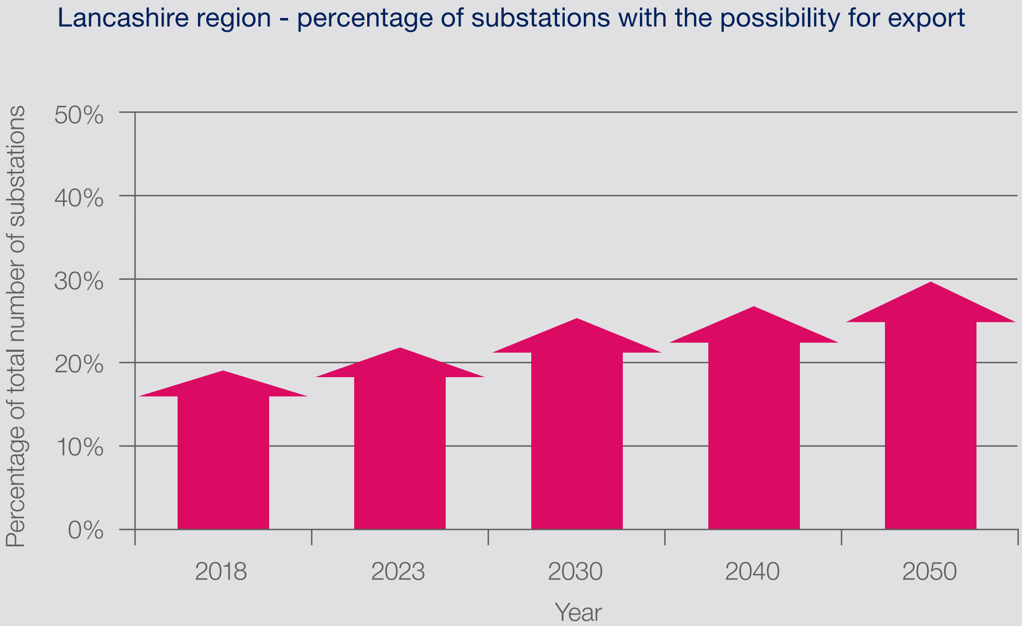
It is predicated that, by 2050, BSP overloading will occur across the region. The number and severity of overloads suggests that reinforcement will be required in a number of cases. It may be possible to defer reinforcement in some places by using flexible services.

Lancashire fault level impact assessment



The parts of the region that fall within the Greater Manchester area are very similar, in terms of fault level profile, to parts of the Manchester supply region. The issues that we face in these areas are similar e.g. large areas of 6.6 kV network and demand related overloads. The region does however have large rural areas with lower fault levels.

Lancashire reverse power forecast

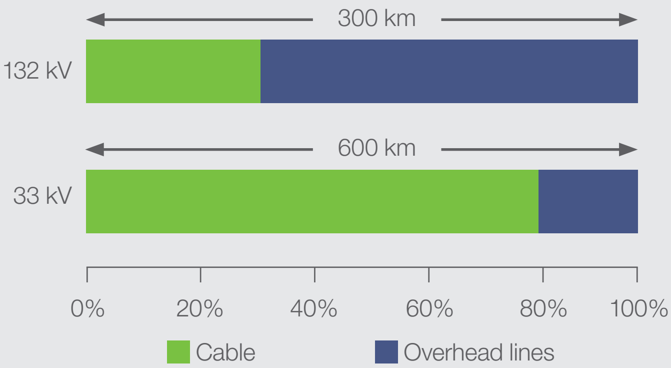


Compared to the Cumbria supply region, we forecast Lancashire will have a lower ratio of installed generation to demand. As such substations in this region have a lower potential for export; substations within the region with the capacity to export power increase from 20% to 30% by 2050. The generation to demand ratio in the urban south east of the region is lower than the much higher ratio in areas to the north and centre of the region where we are forecasting large scale photo voltaic installations on Lancashire's large areas of flat rural lowland.

3.4. PEAK REGIONAL INSIGHTS

At a glance

- The region covers 1,150 km² and supplies 456,000 customers.
- Covers the southernmost areas of our network including parts of Cheshire and Derbyshire.
- There is already around 120 MW of wind generation capacity.
- 33 kV circuits here comprise slightly more cable than average.



Peak supply region

The Peak supply region is a mixture of rural and urban areas. Within the urban areas, circuits are predominately constructed from underground cable, whilst overhead lines dominate the more rural parts of the region.

Historically the region has seen a low uptake of distributed generation. There are however a number of large onshore wind farms to the north of the region. In recent years there has also been a significant increase in the amount of flexible generation connected to this part of our network.

Future development

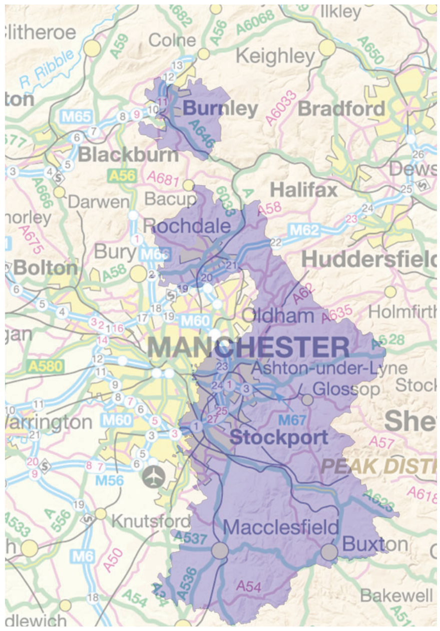
Our forecasts for the region indicate that it will experience significant growth in overall maximum demand with it predicted to have increased by 52% by 2050. There is however marked variation across the region with the maximum demand nearly tripling in some areas but others experiencing up to a 20% reduction in maximum demand in the same time period. This reduction in maximum demand is attributed to the effect of energy efficiency savings drivers, such as the replacement of appliances and homes with more efficient alternatives, outweighing new connections. Through their Energy Efficiency Scheme the Local Enterprise Partnership for Derby, Derbyshire, Nottingham and Nottinghamshire, D2N2, are helping reduce electrical energy consumption in the area by providing grants and expert guidance. The areas which see the greatest growth in demand are those that border Manchester city centre.

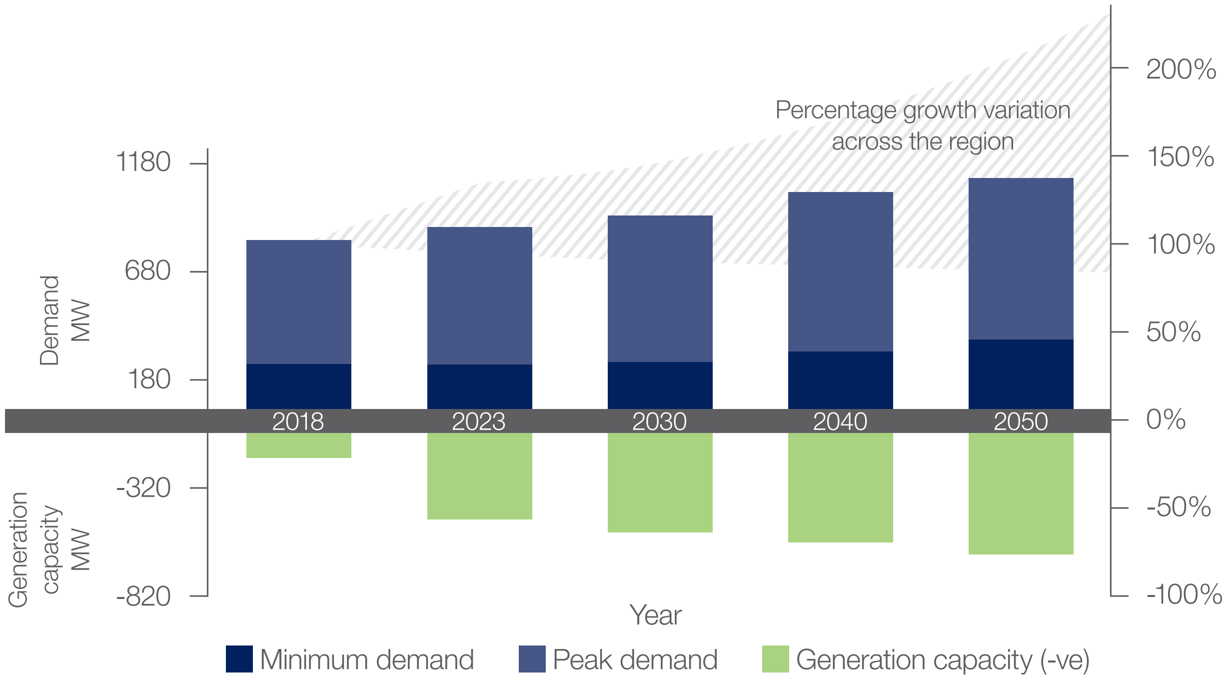
We predict a large increase in distributed generation in the region. Our forecasts indicate that the amount of distributed generation connected in the region will almost quadruple by 2050.

456,000 customers

1150 km²

120 MW of existing generation





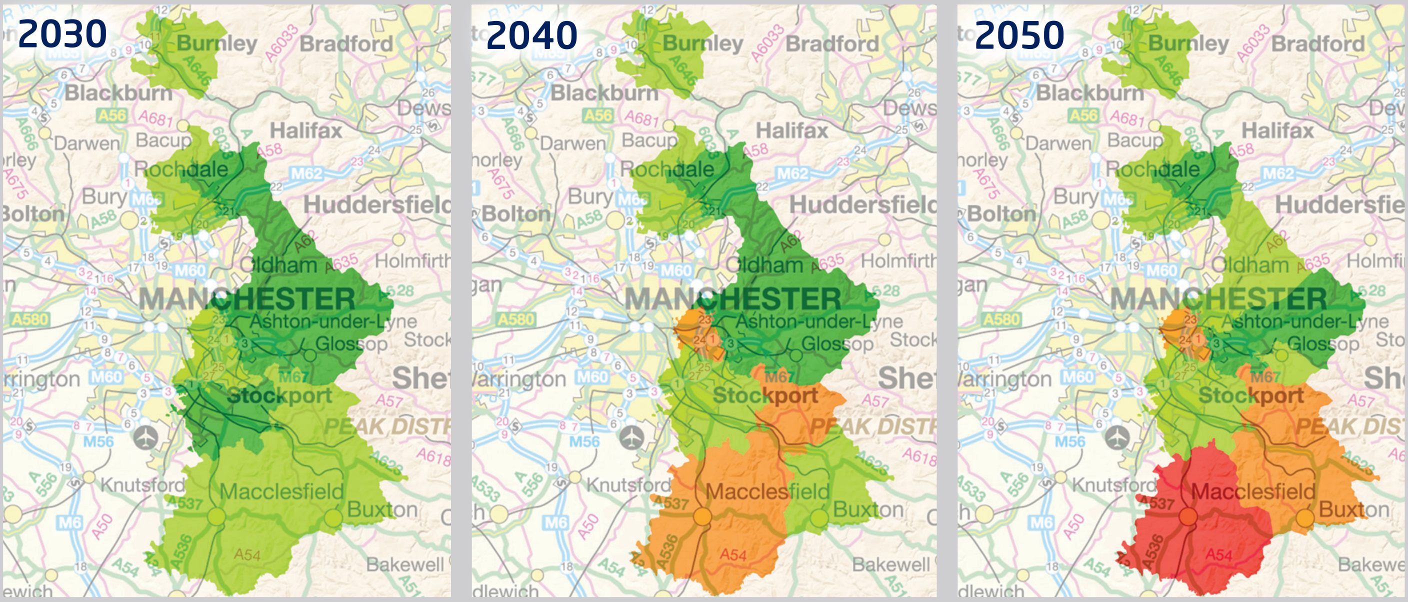
Peak region primary and bulk supply point (BSP) capacity short-term impact assessment

The region has sufficient primary and BSP capacity to meet forecast demand growth until at least 2023

Our forecast indicates that there is sufficient primary and BSP capacity to meet the region's growth requirements until at least 2023.

Large parts of the region lie next to the high growth areas of Manchester and there is a significant differential in loading across this border. As such it is envisioned that load transfer between these areas will form part of the strategic solution to resolve overloading in central and southern Manchester.

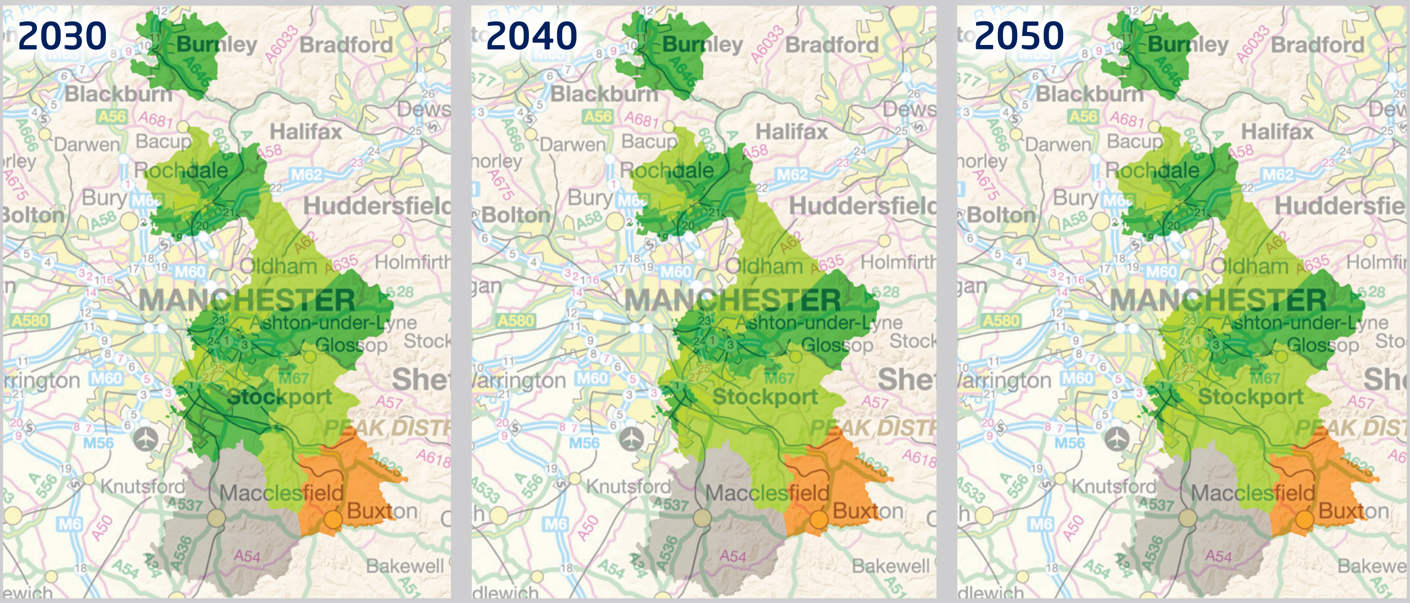
Peak region primary capacity long-term impact assessment



Long-term forecasts predict overloading of primary capacity in the south of the region and on the border with central Manchester

Our analysis indicates that there is sufficient primary capacity to meet forecast load until at least 2030. By 2040 overloading will start to occur to the south of the region and in the area boarding on central Manchester. It may be possible to initially defer this reinforcement using flexible services. However, once these issues become more severe, traditional reinforcement will be required.

Peak region BSP capacity long-term impact assessment

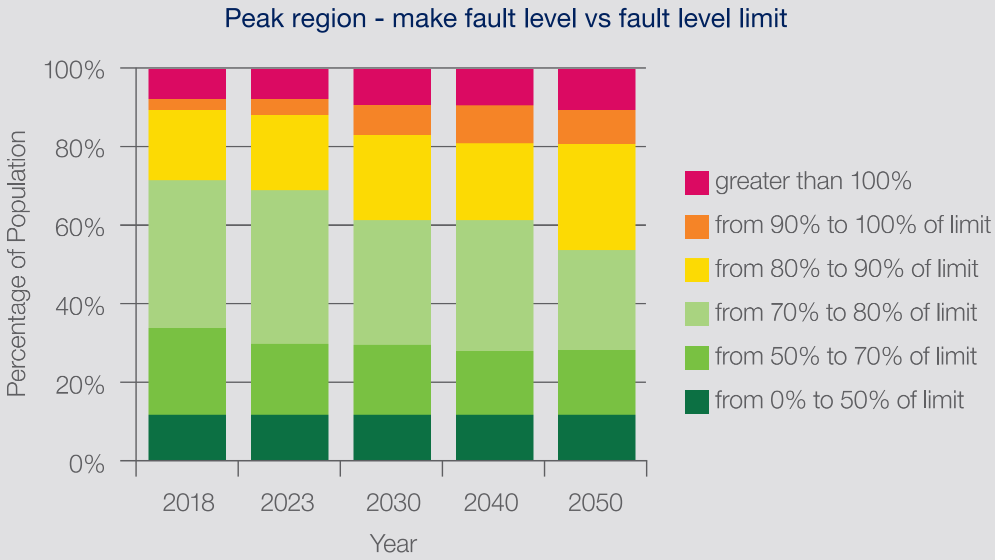


The regions's BSP capacity will be sufficient to accommodate forecast demand growth except at Buxton where intervention will be required

Our analysis indicates that, by 2030, Buxton BSP will be overloaded. No other overloads were identified. There are however a number of areas where headroom is limited. The results in these areas are sensitive to new developments.

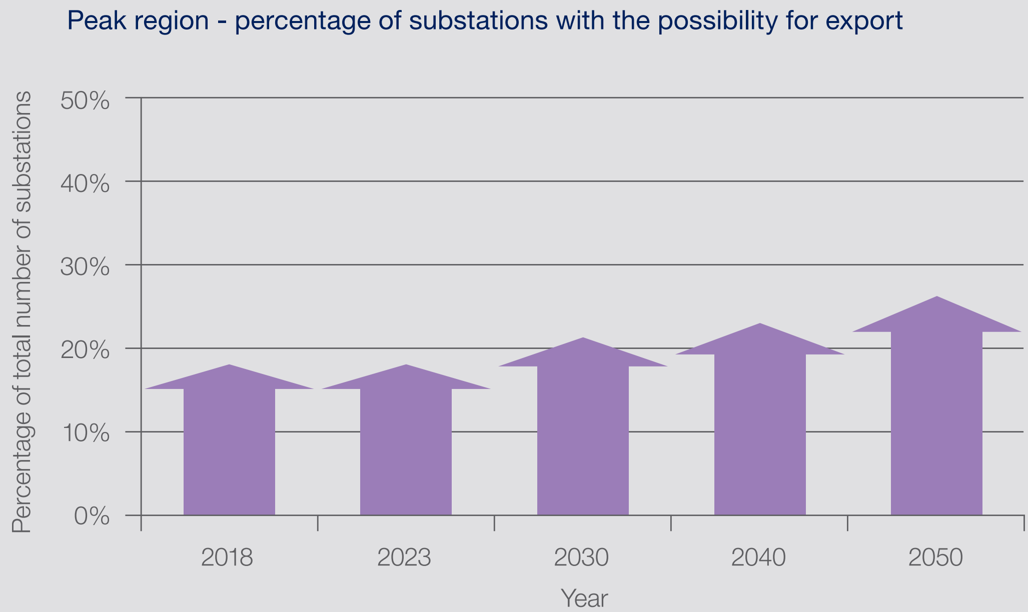
3.4. PEAK REGIONAL INSIGHT

Peak region fault level impact assessment



Currently the majority (70%) of substations have a fault level which is less than 80% of the limit. Due to the uptake of distributed generation it is predicated that this will decrease to 53% by 2050. The Peak supply region has a similar fault level profile to the Lancashire supply region. The urban areas within the Greater Manchester region have high fault levels and are constrained by lower equipment ratings associated with 6.6 kV networks. However, the region does also have large rural areas network where fault levels are comparatively lower.

Peak region reverse power forecast



Due to the comparatively lower ratio of distributed generation to demand, less than 20% of substations within the region have the capacity to export power. This is predicted to rise to nearly 30% by 2050.

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