March 2024

Beyond 2030

A national blueprint for a decarbonised electricity system in Great Britain

ESO

Navigation

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Download the PDF in Acrobat Reader to view all interactivity.

Page navigation explained

Back a page

Forward a page

Return to contents

From here you can navigate to any part of the publication

Expand content

Rollover or click the plus symbol to expand or enlarge content

Text Links

Click highlighted orange text to navigate to an external link or to jump to another section of the document

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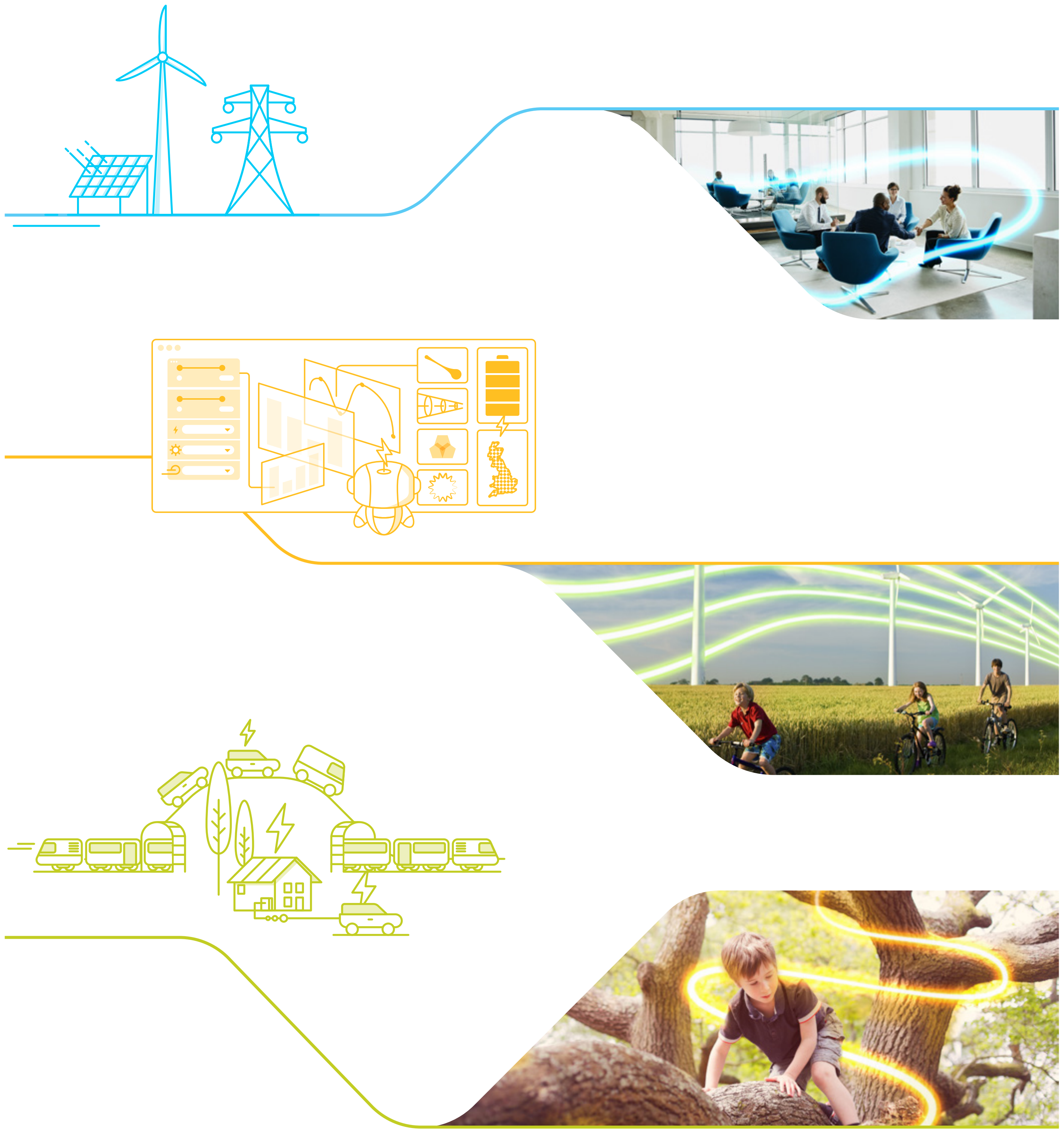
Contents



Executive Summary

Executive Summary

Great Britain has one of the fastest decarbonising electricity grids in the world - we must adapt to accommodate a rapidly changing mix of electricity generation while ensuring a safe and reliable supply of electricity to homes and businesses.

The grid's current reliability can be traced back to the building of the 'supergrid' in the 1950s. The supergrid was a once in a generation expansion of the electricity grid, similar to building several large 'motorways' to transport electricity from a core set of large fossil fuel generators in the centre of the country to homes and businesses across Britain. Over the last 70 years, this network has, mainly, required only small upgrades, until now.

Britain's electricity needs are set to rise substantially (by up to nearly 65 per cent) by 2035, as our everyday lives become more digitally intertwined and we move towards more electrified heat and transport options. Coupled with this, the UK Government have set an ambition to have a fully decarbonised electricity system by 2035. This means producing more electricity and transporting it in a smarter, cheaper, and greener way. A key part of this is efficiently connecting the offshore wind being built around Great Britain in a coordinated way.

Britain has already made significant strides towards achieving this target, with 2023 being the first year in which renewable generation exceeded fossil fuels. The current electricity grid is reaching its capacity and is unable to transport much more electricity without reinforcing the network.

Investment in renewable energy generation has exceeded investment in transmission capacity over the past decade, resulting in bottlenecks on the electricity network. Currently, energy is being wasted as the grid cannot transport it to where it can be used. Because of these bottlenecks, as the system operator, we sometimes have to ask wind farms to switch off to prevent the grid becoming overloaded – wasting cheap, sustainable, home-grown wind power.

Beyond 2030 / Executive Summary 05

We are recommending a new and upgraded network

Our energy networks are the backbone of our economy - they charge our devices, power our hospitals and manufacturing industries, and help produce the food we need.

In 2022 we, the ESO, recommended a new electricity network design called the Pathway to 2030 Holistic Network Design (the HND). The HND connects 23 GW of offshore wind power and helps deliver the UK Government's target of 50 GW of offshore wind by 2030. The HND is currently being refined before it goes through the consenting process. However, the HND grid upgrades only get Great Britain so far in its journey towards producing the greener and cheaper electricity that will be needed.

Last year, the UK Government asked us to go further by building on the HND and designing for more offshore wind to connect to the onshore electricity network. If the transmission assets can be delivered under the timeframes set out in the UK Government's Transmission Acceleration Action Plan (TAAP), this network plan, combined with the timely delivery of additional generation and developer led offshore transmission assets will enable the UK to meet its Sixth Carbon Budget.

The design facilitates the connection of an additional 21 GW of offshore wind directly as a result of the ScotWind leasing round, enabling Great Britain to have the single largest offshore wind fleet in Europe and exceeding the offshore wind capacity of the United States of America by the mid 2030s. This design also facilitates the connection of a wide range of other low-carbon electricity generation, including Sizewell C and Hinkley Point nuclear power plants.

To achieve this, a countrywide effort over the next decade is needed to upgrade the network in a coordinated manner to minimise impact on communities and ensure the benefits of this evolving energy system can be seen across the breadth of Great Britain.

Beyond 2030 / Executive Summary 06

Executive Summary

Our design lays the foundations for a decarbonised electricity system

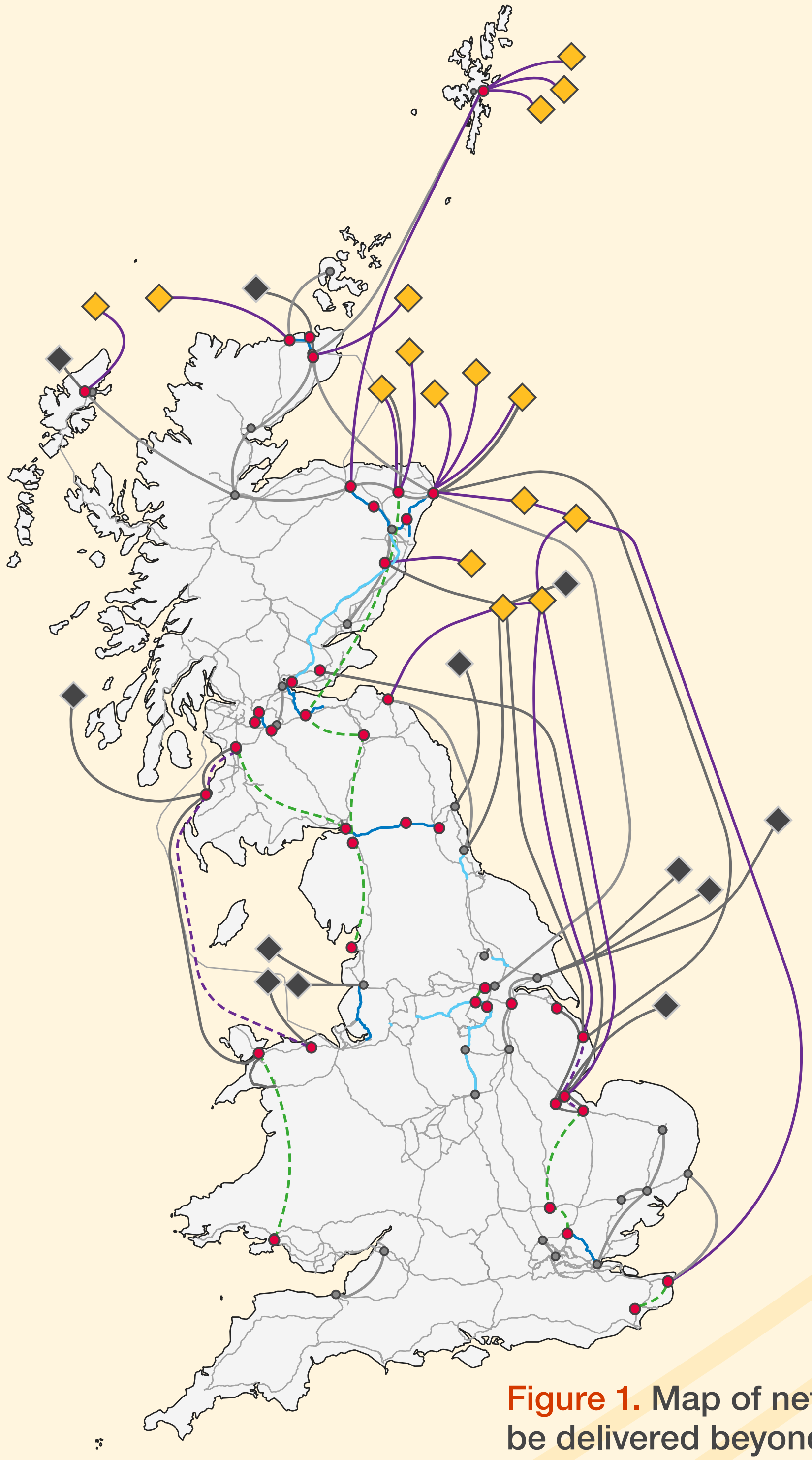
In collaboration with Great Britain's Transmission Owners (TOs), we have undertaken a network assessment that lays the foundations for a decarbonised electricity network. This involved assessing around 200 network options to recommend an optimised high-level network design.

Combined with the HND, this design will see over three times as much undersea cabling laid compared with new onshore routes, linking electricity being produced in the seas around our shores onto the mainland at appropriate points.

In addition to this significant offshore network build, there is a need for reinforcement from North East Scotland to North West England, to provide north-south transfer of power. This could potentially form a new arterial transmission route. Furthermore, by enhancing the capacity between the west coast and the east coast of England, the links between the primary arterial routes are strengthened. This increased coast-to-coast connectivity balances power flows across the country, improving security and ensuring that renewable power can always be accessed regardless of where it is generated.

Network infrastructure must be developed in the right place, at the right time, while also considering its impact on communities and the environment. The ESO believes this proposed network design, although high level, balances these needs while also enabling the UK Government's energy targets. New infrastructure of any kind can be challenging for communities during construction and once in use. However, we believe these challenges can be minimised by developers through optimisation of network designs, early engagement with communities, innovation, and appropriate community benefit packages. It is therefore welcome that the UK Government has set out proposals for a substantial financial incentive scheme for directly impacted communities.

Cumulatively, the proposed infrastructure projects within this plan could add up to £15 billion to the UK economy and support over 20,000 jobs each year. Ninety per cent of these benefits will be outside of London and the South East, according to independent research.



Category	Key
New offshore network infrastructure	
New onshore network infrastructure	
Voltage increase on network	
Existing network upgrade	
Substation upgrade or new substation	
Substations delivered for 2030	
In scope wind farm	
HND wind farm	
Existing Network	
Reinforcements delivered for 2030	

*Dashed lines represent low maturity options.

Note: all routes and options shown on this map are for illustrative purposes only.

Figure 1. Map of network infrastructure to be delivered beyond 2030

Beyond 2030 / Executive Summary 07

Executive Summary

Strategic demand is key to our recommendations

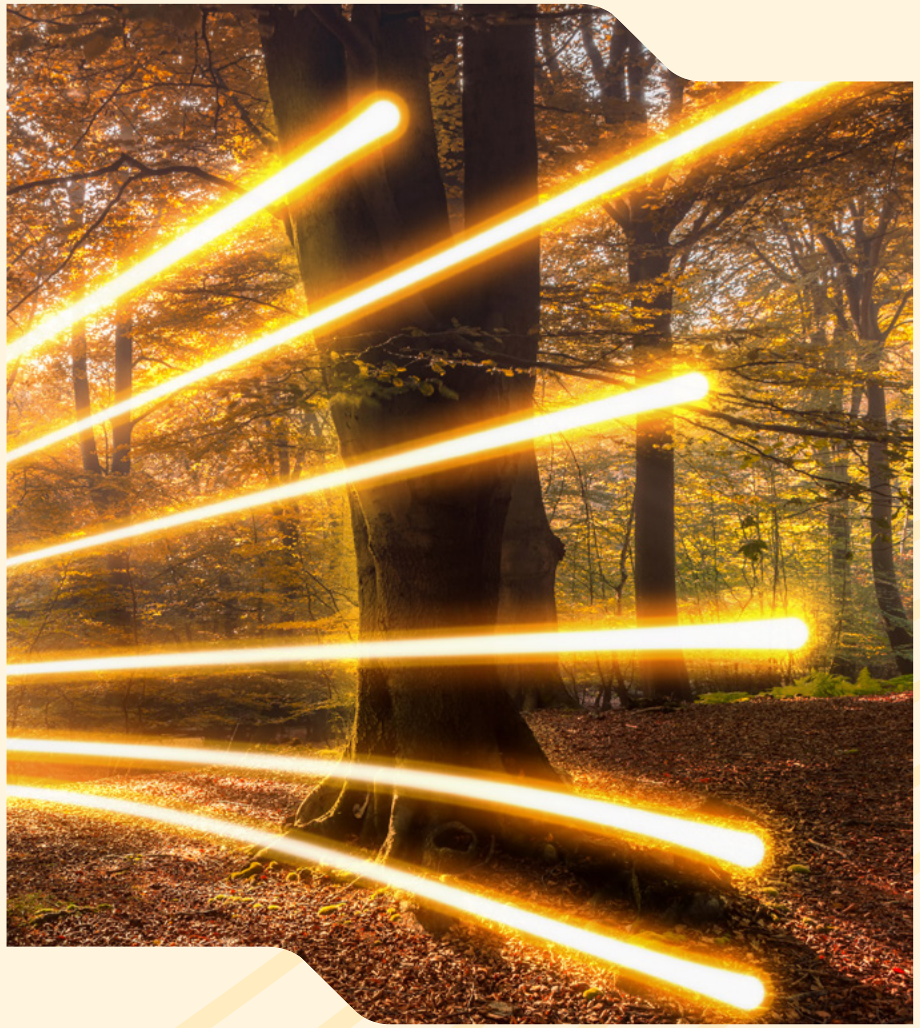
Designing a holistic electricity network does not just mean building more network infrastructure. The ESO's engineers also find innovative solutions that ensure the system is designed securely and affordably, negating the need for more network infrastructure in some circumstances through utilising existing route corridors and where possible existing infrastructure.

This publication also identifies regions of strategic importance where large-scale demand users, such as hydrogen electrolysers or data centres, could be located as an alternative to building additional network infrastructure. Our planning processes already assume a 5 GW increase in demand in Scotland as our energy landscape evolves between now and the mid 2030s. In addition to this assumption, our analysis shows that locating up to 5 GW of flexible demand (a 10 GW demand increase in total) behind bottlenecks on the network could save consumers £5 billion and may avoid the need for some network reinforcements, such as additional subsea circuits from Scotland to England or Wales, and the associated infrastructure this could bring.

We are looking at future solutions to build a strategic, flexible energy system

Looking out to the late 2030s, there will be more solutions that could cater for Great Britain's rising energy needs. These vary from potentially faster network delivery enabled by competition, the creation of a spatial energy plan directing the optimal locations of generation and demand assets as well as potential reforms to the wholesale electricity market.

This recommended electricity network design facilitates the connection of ScotWind and enables the Government to meet its decarbonisation target. But to realise these benefits, network infrastructure build must be sped up in line with the actions set out within the Government's Transmission Accelerated Action Plan. Communities must also be incentivised to host this infrastructure and crucially will be consulted by industry when these recommendations become more refined. For recommendations with low maturity, we expect industry to present an array of alternative options to communities through the consenting process.



Beyond 2030 / Executive Summary 08

Executive Summary

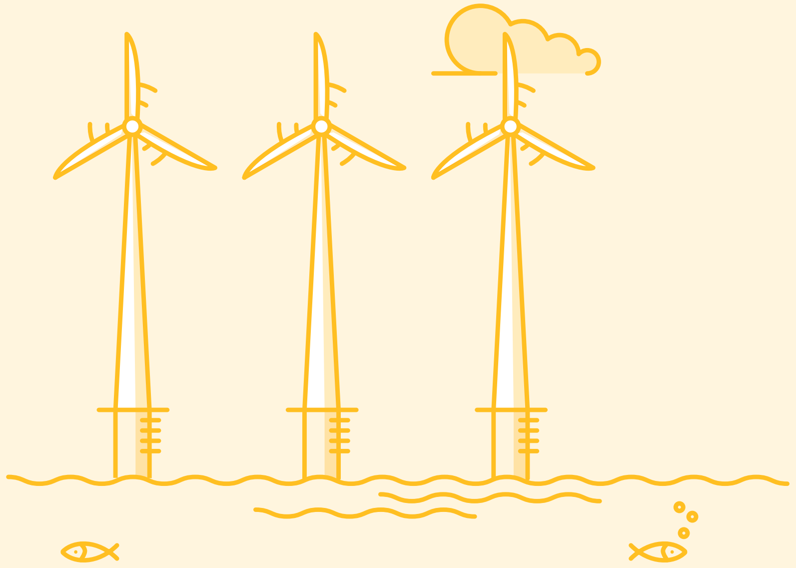
Key Messages

The Electricity System Operator (ESO) has produced the first ‘Beyond 2030’ report, mapping the way to a clean, secure and affordable energy future whilst delivering on the Climate Change Committee’s Sixth Carbon Budget and Crown Estate Scotland’s ScotWind leasing round.

1

This plan facilitates the connection of an additional 21 GW of offshore wind, laying the foundations for a decarbonised electricity system in Great Britain.

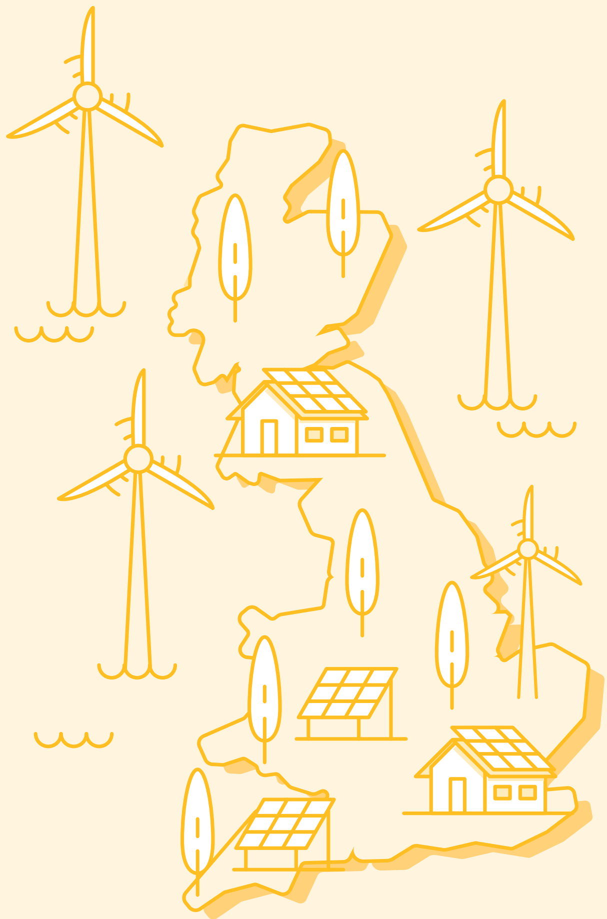
86 GW
of potential offshore wind generation could connect to GB by 2035



2

By enabling the integration of more home grown and low carbon technologies, this plan delivers cheaper electricity for consumers than fossil fuel alternatives, by reducing our reliance on imported gas which has recently been subject to high price volatility.

64%
forecast growth in our electricity demand between now and 2035



Beyond 2030 / Executive Summary 09

Executive Summary

3

20,000
annual jobs can be created and sustained by our plans for 2030 and beyond

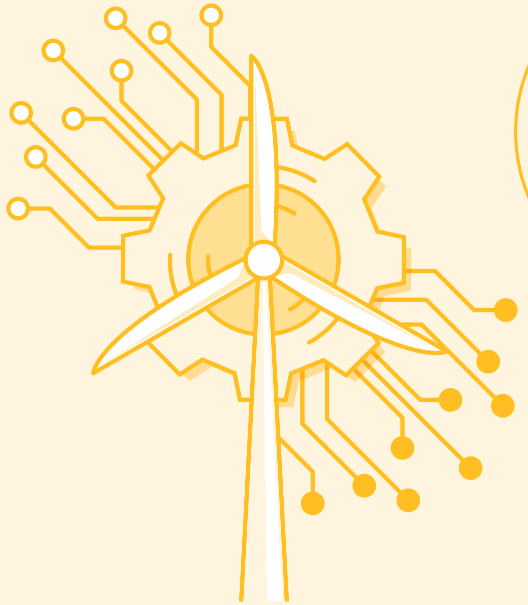
We are recommending an additional £58 billion of direct investment in electricity networks. Cumulatively, this will create and sustain over 20,000 jobs annually, with 90 per cent of these benefits being felt outside of London and the South East of England.

4

Delivering these benefits requires a once in a generation expansion of Great Britain's electricity grid. By 2035, three times as much undersea cabling will be laid than onshore infrastructure across Great Britain with significant additional power flow capability required onshore and offshore from north to south in the future.

3x
new undersea cabling recommended for delivery by 2035 compared to new onshore routes

5

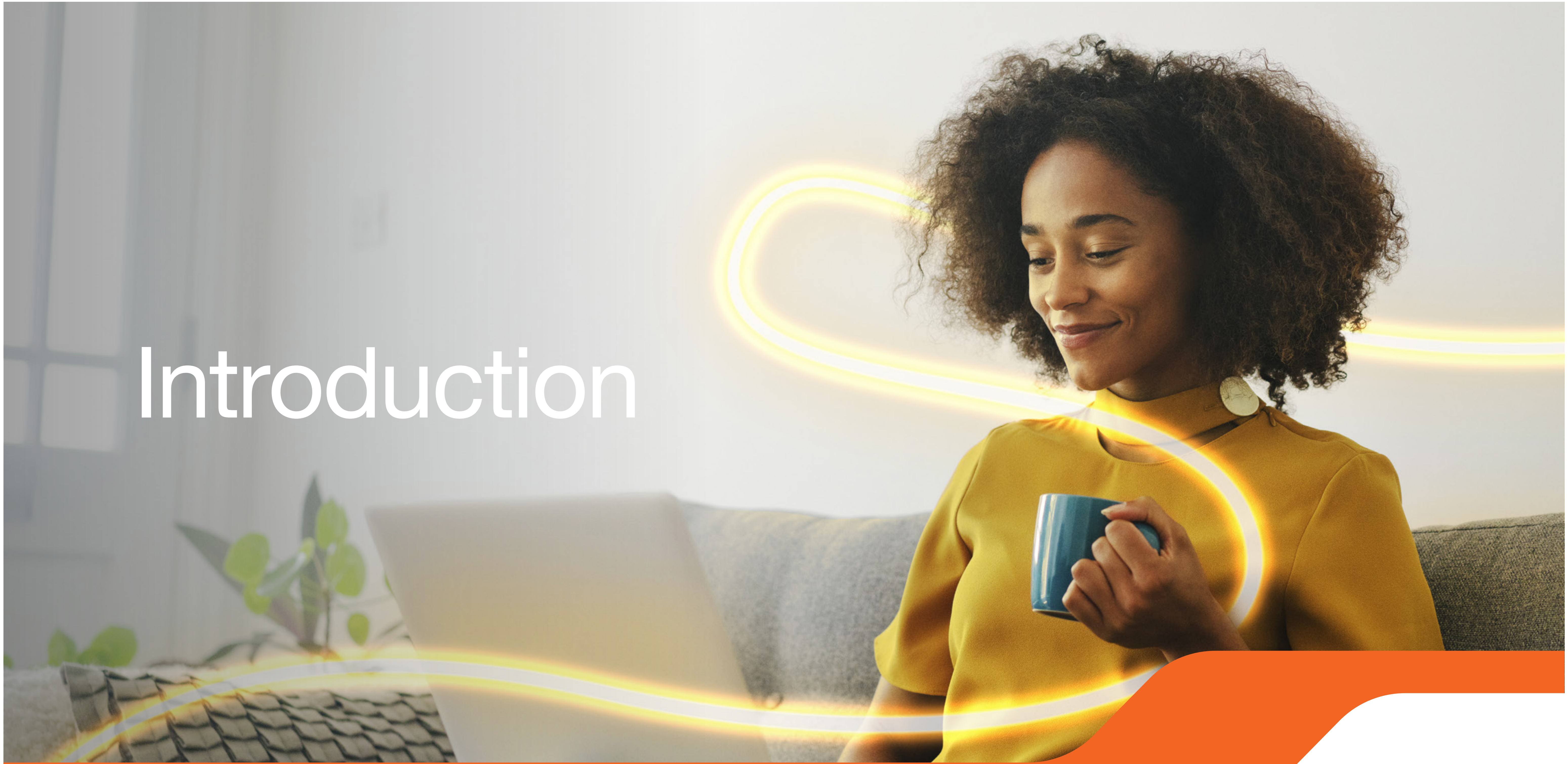


£58 billion
of further, direct investment in electricity networks recommended

With little over a decade to 2035, progress must be swift and coordinated if we are to meet our Sixth Carbon Budget target. Further design optimisation will be required to ensure impacts on communities are minimised and wider benefits are seized upon.

Beyond 2030 / Executive Summary 10

Introduction



ESO

Introduction

As the Electricity System Operator (ESO) for Great Britain, our role is to operate Great Britain's electricity transmission system, while building a secure, clean, and fair system for tomorrow. We transport electricity around the system to ensure there is enough supply to match demand, second by second, 365 days a year.

We work in partnership with governments, the Office of Gas and Electricity Markets (Ofgem), and industry to guide Great Britain on what energy resources, markets, and networks are required to securely accelerate the transition away from fossil fuels into new energy technologies and economies.

We do not generate or sell electricity, nor do we own or build infrastructure the electricity travels through. This ensures the ESO is independent of companies with a commercial interest in generating electricity or building network infrastructure.

With the passing of the Energy Act 2023, we are transitioning into an independent public corporation named the National Energy System Operator (NESO) in the summer of 2024. We will not only immediately pick up new responsibilities for planning the gas transmission network, but we will also grow additional capability to undertake strategic planning across multiple energy vectors.

Beyond 2030 / Introduction 12

What is the electricity transmission system?

The electricity transmission network is often compared to Great Britain's motorways. It is used to transport high voltage electricity over long distances, ensuring cities and towns are connected and supplied. This high voltage electricity is then moved through distribution networks, which can be thought of like the country's A and B roads, before it is then converted into a lower voltage for homes and businesses to use every day.

The network spans across Great Britain and comprises a mixture of overhead, underground and subsea cables – these assets can operate at a range of voltages such as 400 kV, 275 kV and 132 kV. These are all linked together via substations across Great Britain to connect generators, interconnectors to other countries, large demand users (such as transport links and factories), and distribution networks which supply our homes and businesses. Distribution networks carry electricity at lower voltages (132 kV and below in England and Wales, and 66 kV and below in Scotland) to homes and businesses.

Great Britain has three onshore Transmission Owners (TOs) that own, maintain, and develop their networks, namely National Grid Electricity Transmission (NGET), SP Transmission (SPT) and Scottish and Southern Energy Networks Transmission (SSEN). The map on this page illustrates their boundaries. There are also several offshore developers that own the assets that connect offshore wind farms to the transmission or distribution network.

Did you know?

400 kV or 400,000 volts is more than 1,500 times the voltage of electricity outlets in our homes. High voltages are used because they are very effective for transmitting electricity over long distances.

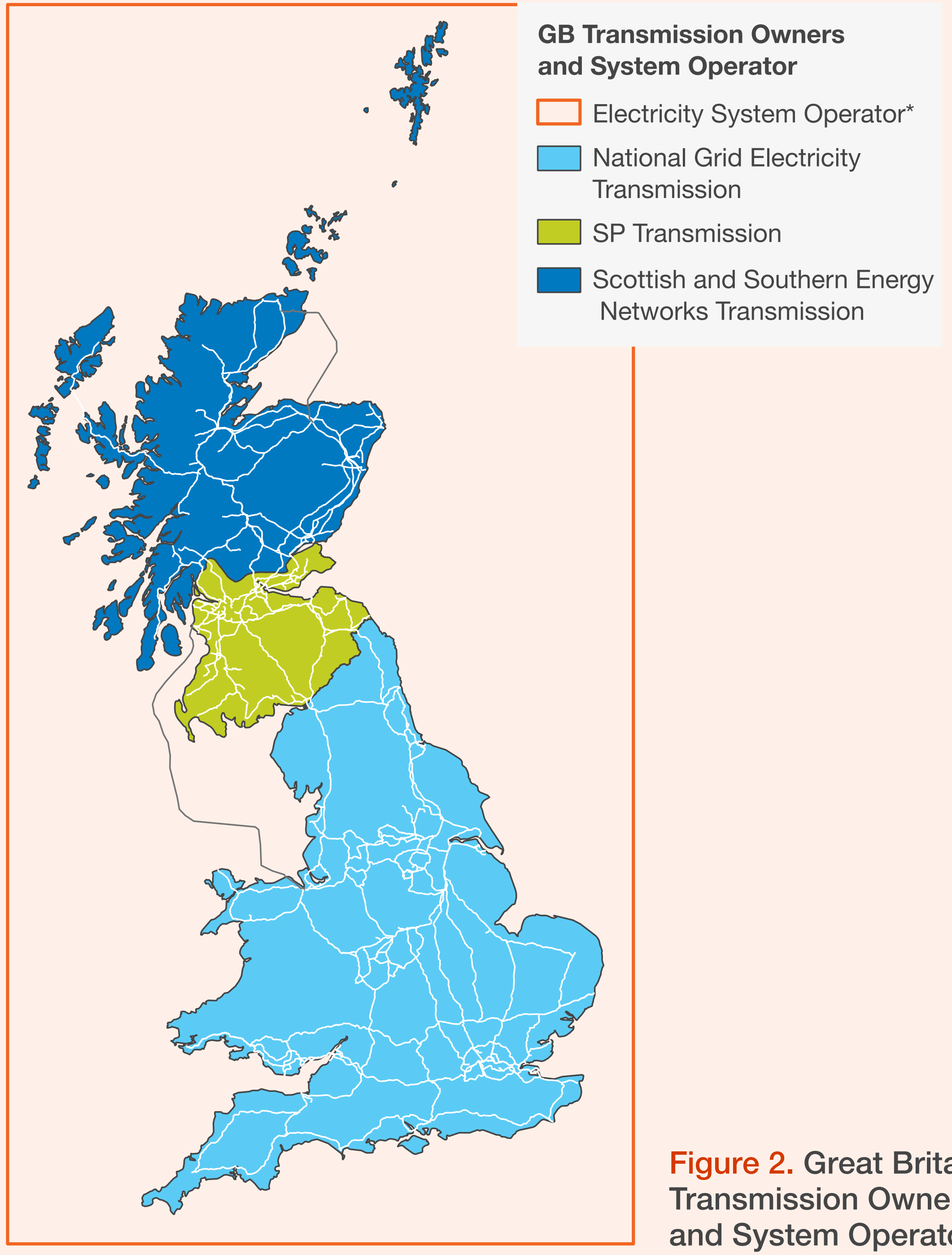


Figure 2. Great Britain Transmission Owners and System Operator

*Shetland will become part of the GB transmission system when its high voltage connection commissions later this year.

Introduction

Our role in the electricity transmission network planning process

One of our key responsibilities is to assess Great Britain's future electricity supply and demand needs and design a high-level coordinated network to meet those needs in a safe, efficient, and affordable way.

This process involves assessing a range of different network options to ensure electricity can get to where it is needed, when it is needed, and we work in close collaboration with TOs throughout this process.

Our role is to develop a set of recommendations for network reinforcement and stress test network options provided to us, primarily by the three TOs, against a range of different future energy scenarios and ensure that any proposed new network infrastructure is balanced against four high-level design objectives.

Objective	Our approach
Economic and efficient	We used **economic assessment tools** to determine the optimal economic design from a wide range of proposed options, ensuring the best value for consumers.
Deliverable and operable	We applied a **deliverability assessment framework** that considered a range of factors including supply chain of technologies, construction timeframes and consenting challenges ensuring our design is delivered in a timely and practical way.
Considers impact on environment	We conducted **assessments of environmental constraints** using a range of geospatial data sources to determine the location and sensitivity of environmental constraints. We did this in consultation with Statutory Nature Conservation Bodies (SNCBs) ensuring our design minimises the impact, where possible, on the natural environment.
Considers impact on communities	We conducted **assessments of community constraints** using a range of geospatial data sources to determine the location and the sensitivity of community constraints, ensuring our designs minimise the impact, where possible, on local communities that host this infrastructure.

Beyond 2030 / Introduction 14

The network planning process at a glance

1. Scenarios

We produce and use a range of industry consulted credible futures that each decarbonise our energy system differently. These scenarios provide the starting point for our analysis.

2. Requirements

We determine the capability needs of the system across each of the scenarios identifying where future bottlenecks might occur on the system.

3. Solutions

The TOs propose potential onshore and offshore solutions to resolve network requirements. We can propose further offshore solutions as well as commercial arrangements to meet the needs of the system. All solutions vary in their level of maturity.

4. Assessment

We assess all solutions iteratively against our four design objectives considering: cost, deliverability, impact on the natural environment and impact on the local community.

5. Recommendations

We make a final set of high level network recommendations that balance the design objectives forming the design or blueprint for the future transmission system. Our scenarios allow us to make robust recommendations against a backdrop of uncertainty.

6. Detailed Design

The energy industry take forward our recommendations, developing them further carrying out a detailed design process that includes technology choices, routeing and consenting processes and extensive stakeholder engagement.

Read more on how this process is evolving

Beyond 2030 / Introduction 15

The current electricity transmission cycle

As set out in 2022 and in addition to the initial HND, we were tasked by the UK Government to connect a further 21 GW amount of offshore wind to the onshore electricity network. Building on the first HND, this publication recommends both the onshore and offshore electricity network requirements beyond 2030 – laying the foundations needed to operate a decarbonised electricity system by 2035.

We have undergone a network options process in collaboration with the TOs, assessing nearly 200 different design options in total to propose a holistic electricity network fit for our future needs. We arrived at our recommendations through extensive engagement with stakeholders, which includes (but is not limited to) TOs, Ofgem, the Department for Energy Security and Net Zero and Devolved Governments. The recommendations highlighted in this publication have gone through an internal governance process, and been formally approved through that process.

All onshore network solutions recommended within this publication have been proposed by the TOs and independently assessed by us as the ESO. Some offshore routeing options proposed in the 2030s have been designed by us and some by the TOs, with onshore landing points being selected from options provided to us by the TOs. We will continue to work with the TOs to collaboratively investigate alternative options that meet our design criteria, ensuring that selected options provide the most benefit at the lowest cost while mitigating environmental and community impacts.

On our journey towards whole-systems network planning, and for the first time in this publication, we are considering the role of large-scale energy demand users (such as factories and hydrogen electrolysers), and regions of strategic importance where new large-scale demand could be located, as a potential alternative to additional network infrastructure.

What happens next?

As previously stated, this network design is high-level, in practice what this means is the network recommendations within this report are of varying maturity, and recommendations may be subject to further optioneering, optimisation and consideration of alternative non-network build solutions.

Now the initial high-level network planning phase has concluded, companies will begin the Detailed Network Design (DND) process where they will analyse the designs and refine them further. This will be ahead of engaging with communities, identifying transmission routes, technology choices and where other onshore and offshore assets should be located.

Depending on the level of maturity of the network option, the process of refinement undertaken by the TOs can take multiple paths. Each network option in this report has a corresponding development status (maturity level).

Our proposed Great Britain-wide design assumes coordination in both planning and construction to minimise impacts to communities and the environment, and companies developing designs are encouraged to continue with that coordination. The DND and consenting process will be conducted by the party responsible for developing each asset. It is during this process that statutory consultations and relevant environmental assessments will take place.

Communities will be consulted by industry when these recommendations become more refined. For recommendations with low maturity, we expect industry to present an array of alternative options to communities through the consenting process.

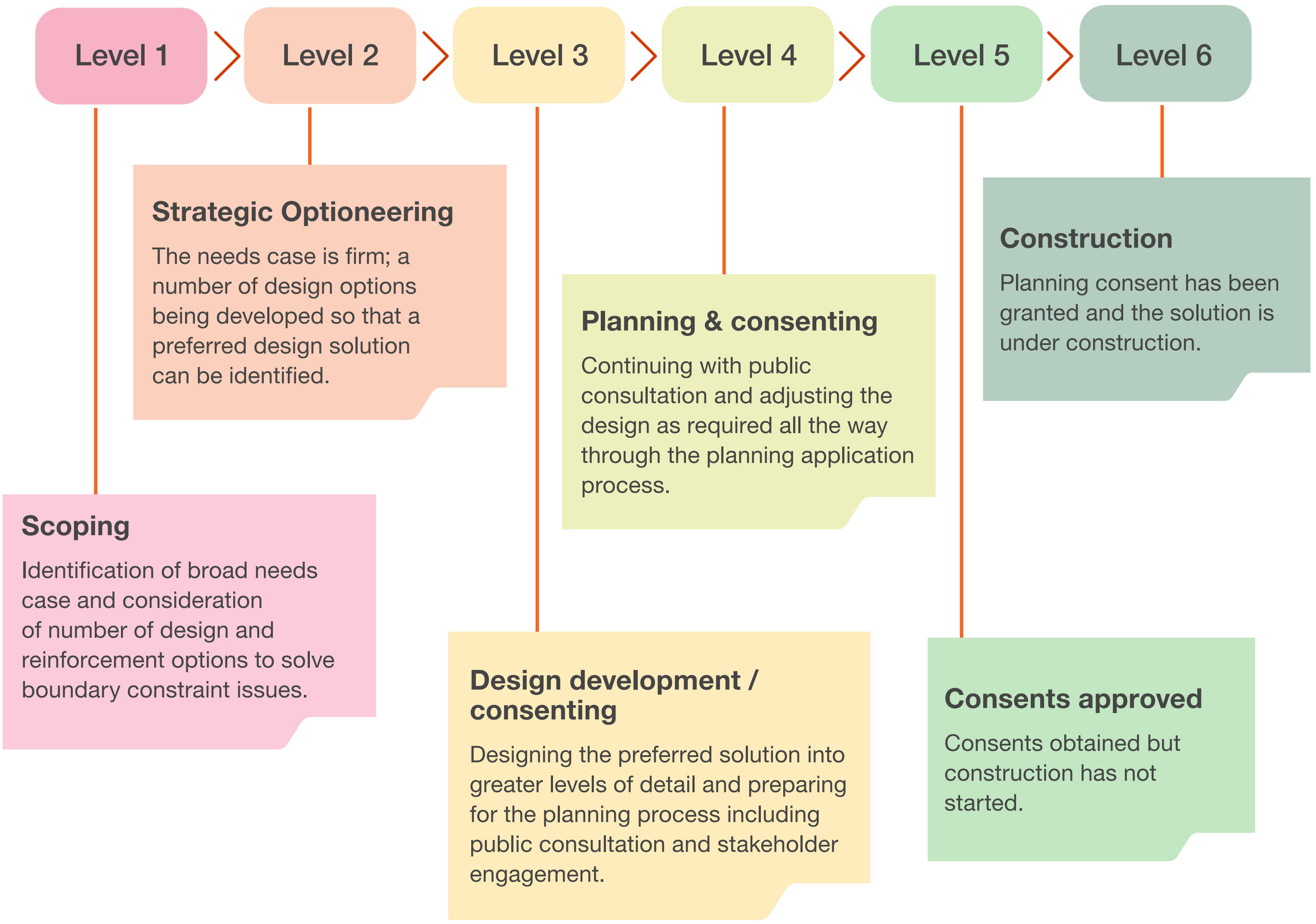


Figure 3. Maturity level timeline

Beyond 2030 / Introduction 17

Introduction

Navigating the suite of documents

This report is laid out in four sections.

System Needs gives an overview of why Great Britain's electricity grid looks like it does today, and the societal and technological needs that are driving the grid's future development.

National Blueprints provides a snapshot of what we are recommending a holistic and modern grid should look like to meet these evolving needs. It sets out clearly where we are recommending new infrastructure and flexible demand after 2030, and in what timeframes.

Regional Blueprints goes into detail on how energy is linked to our lives in every region of Great Britain, and what benefits communities across the country could see from the energy transition.

Way Forward sets out the transformation that will be seen in the industry following this plan and why this matters to all of us – including our transformation into the National Energy System Operator (NESO), and how we are working to build a 'whole system' plan for the future, with a broader reach than just electricity.

For more details, please see our wider suite of documents that explore our processes and recommendations in greater detail.

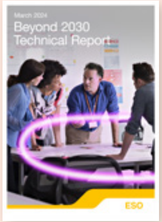
1. Our ***Beyond 2030 Technical Report*** sets out our holistic design considerations for both our onshore and offshore network recommendations in greater detail. It outlines the benefits of each of our shortlisted offshore network designs and how we made our final recommendations. It also discusses the alternative onshore and offshore wider network reinforcements we have considered.

2. The ***Comprehensive List Of The Onshore And Offshore Network*** document summarises all of the onshore and offshore network reinforcements outlined in this publication in one easy to read list alongside any formal recommendations.

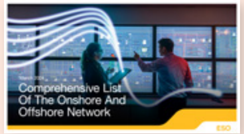
3. Our ***Interconnector Analysis Report*** outlines the bespoke analysis we have conducted to determine what volume of future electrical interconnection to other countries could be optimal for Great Britain, as well as neighbouring countries.

4. Our ***Stakeholder Approach, Engagement And Feedback Report*** outlines how we have embedded stakeholder engagement into our process and considered the feedback we have received in shaping our recommendations.

5. Our standalone ***Glossary*** explains the more technical terms used across this suite of documents.



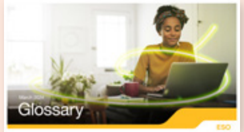
Beyond 2030 Technical Report



Comprehensive List Of The Onshore And Offshore Network

Interconnector Analysis Report

Stakeholder Approach, Engagement And Feedback Report



Glossary

Beyond 2030 / Introduction 18

System Needs

ESO

System Needs

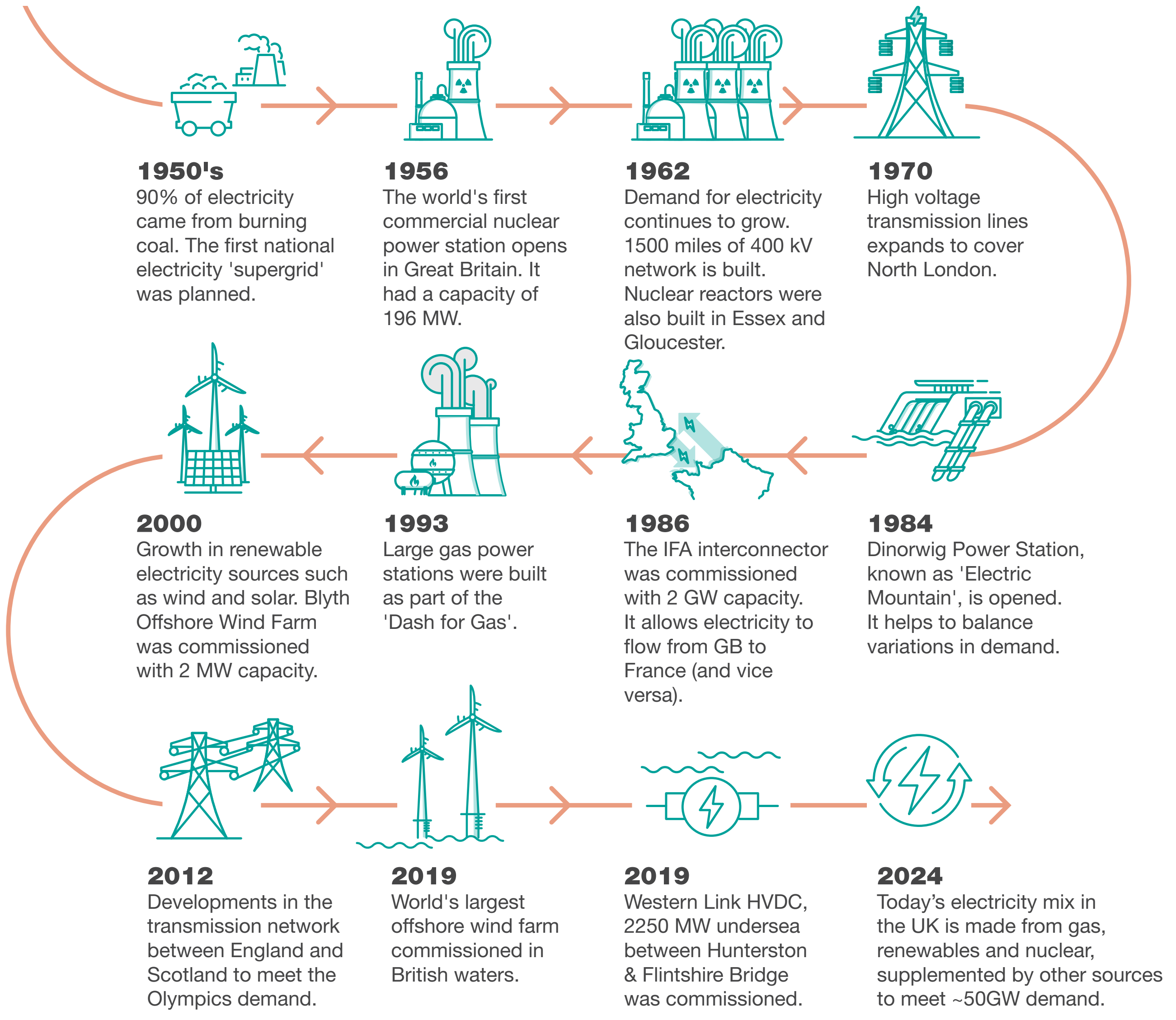
Since the 'super grid' was established in the 1950s, where and how electricity is generated and used has changed significantly. As a result, the transmission system needs to evolve to continue to deliver for consumers as we transition to net zero.

The transmission system we know today was designed to take generation from large power stations that were built close to coal fields, to the cities and industrial heartlands of Great Britain. This included the development of network 'rings' around cities such as Sheffield and Newcastle which supported their specialised heavy industries. Because of the relatively lower need for electricity, there is typically less network capacity in more rural and coastal parts of Great Britain.

Today, we are in the process of a seismic transition towards a large and growing portfolio of renewable generation. Over the past 20 years, the UK has established itself as a world leader in onshore and offshore wind with the second largest fleet of offshore wind farms in the world. These projects have been essential in reducing our reliance on fossil fuels. In the early 2000s approximately 80 per cent of the electricity consumed in Great Britain came from coal and gas, whereas in 2023, zero-carbon electricity made up more than half of the total supplied.

Despite Great Britain transitioning away from using fossil fuels to generate electricity, as a nation we currently rely on short-term contracts for imported gas to meet domestic demand. This means that global gas supplies and other external factors can have a knock-on impact on our energy prices. These challenges have been brought into sharp focus over the past few years, most recently with the Russian invasion of Ukraine and the subsequent reduction in Russian gas flows to Europe. As a result, in August 2022, UK gas prices jumped nearly six times higher than the average annual price over the previous five years. This is one of the key factors in the cost-of-living crisis, which has resulted in consumers using less energy overall.

Great Britain's energy history



Looking ahead, as Great Britain continues to reduce its dependency on fossil fuels while electrifying key elements of our everyday life such as heating and transport, there will be an even greater need for clean electricity.

Currently, the largest sources of CO_2 emissions in the UK are from heating and transportation, which are both dependent on large amounts of fossil fuels. To reduce these emissions we need to transition to cleaner fuels or zero carbon electricity. To help meet the legally binding Sixth Carbon Budget (CB6), the UK Government has set an ambition of operating a zero-carbon electricity system in Great Britain by 2035. That means, excluding fossil fuel generation combined with Carbon Capture and Storage (CCS) or securing supply for remote communities, no electricity will be produced using coal, oil or gas. This is crucial, as much more clean electricity is needed to decouple both heat and transport from fossil fuels.

This transition will be visible through the ban on the sale of new petrol and diesel cars and the phasing out of fossil fuel heating systems. From 2035 onwards all new vehicles will be electric vehicles (EVs) or, to a lesser extent, other zero-emission vehicles such as hydrogen. Similarly, our domestic heating systems will begin transitioning to cleaner alternatives throughout the 2020s. By 2035 Great Britain's electricity demand is expected to rise by up to 60 per cent from what we see today as we electrify these processes.

This transition is enabling innovative new businesses while supporting our traditional, high-skilled, manufacturing base to have access to clean and reliable sources of electricity. This will also drive jobs across nearly all sectors of the economy as supply chains will need to be upscaled, and a new generation of secure jobs created to facilitate and maintain the energy transition.

The new opportunities and jobs resulting from this transition are expected to add up to £15 billion to the UK economy, supporting an average of over 20,000 jobs each and every year up to 2050 according to independent research.

How will we generate enough clean electricity?

Today's electricity generation mix is primarily made up of gas, renewable energy sources (such as wind and solar), electricity imported from our neighbours through cables called 'interconnectors', and a relatively 'older' set of nuclear power stations. In the future we will need to generate significantly more electricity. We project that by 2035, demand for electricity may rise by up to 65 per cent and that by 2050 demand could more than double.

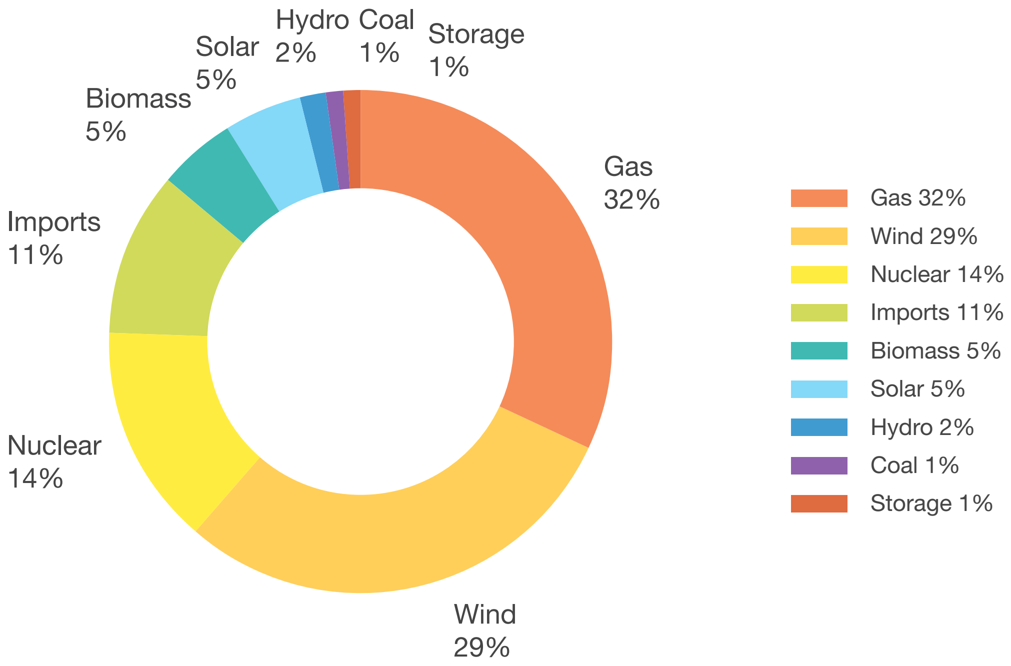


Figure 4. Electricity supply in 2023

System Needs

Crucial to moving away from the fossil fuel generated power that we see today is the massive pipeline of renewable energy projects being developed. The largest of these projects are associated with offshore wind farms.

The Crown Estate and Crown Estate Scotland have and continue to lease significant amounts of the seabed for the development of offshore wind. In 2022, Crown Estate Scotland announced the results of their ScotWind leasing round which awarded a total capacity of approximately 28 GW for development around the Scottish coastline. These leasing rounds help support the UK Government's ambition to connect 50 GW of offshore wind by 2030.

Today, we have 14 GW of offshore wind connected to the system and the rapid deployment of offshore wind turbines over the next decade will require significant investment in our transmission network so that this generation is able to connect in a timely and efficient way. The image map of Great Britain shows the current extent of seabed leases for offshore wind projects. The areas in green are those which have been included in holistic design exercises. Those in blue represent Crown Estate Scotland's Innovation and Targeted Oil and Gas (INTOG (Scotland)) and The Crown Estate Round 5 (South West) leasing rounds both of which we the ESO and relevant Transmission Owners (TOs) are currently assessing holistically. Areas in grey represent wind farms that are either operational or are too far developed to be included within the holistic network design process.

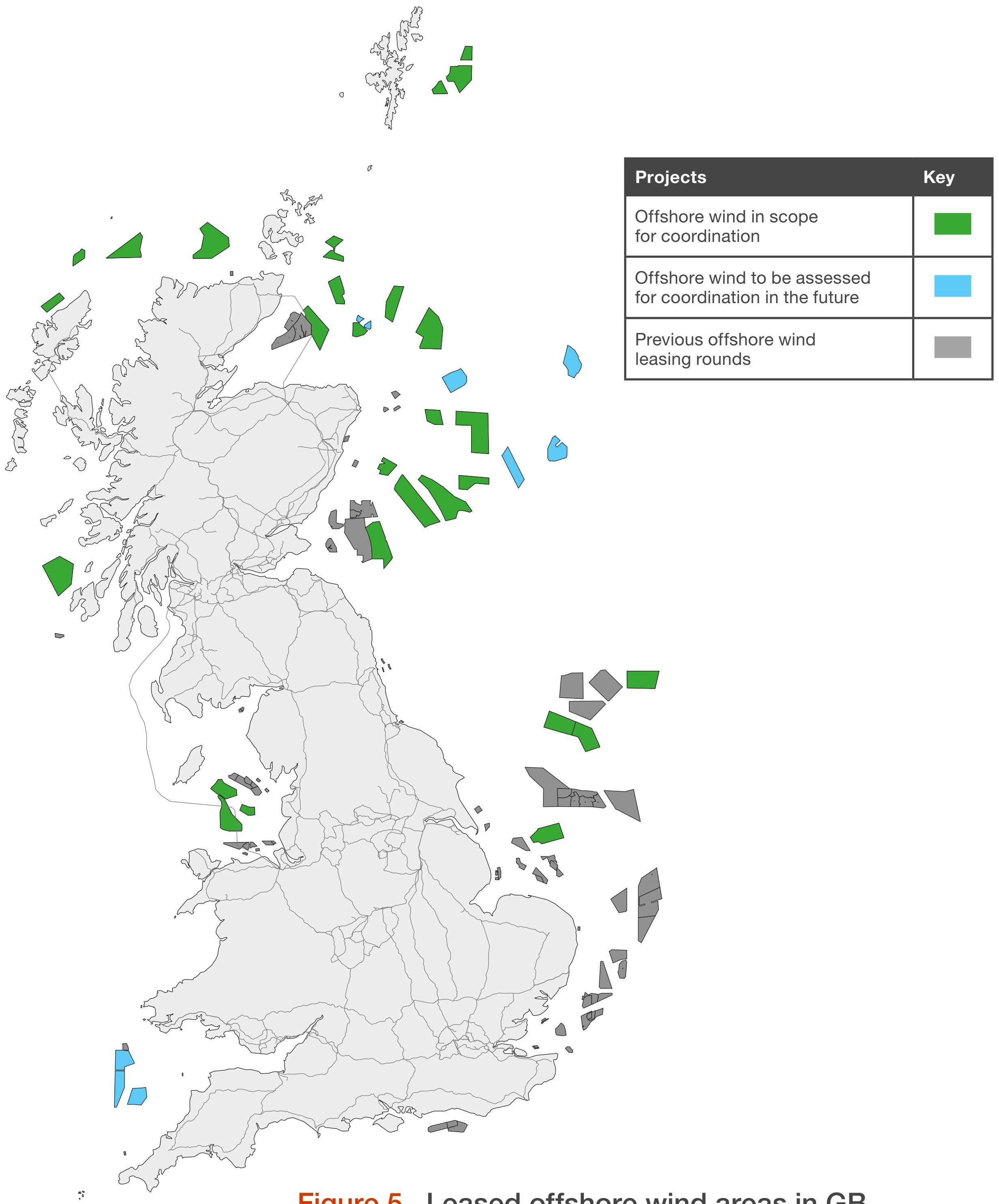


Figure 5. Leased offshore wind areas in GB

Beyond 2030 / System Needs 22

System Needs

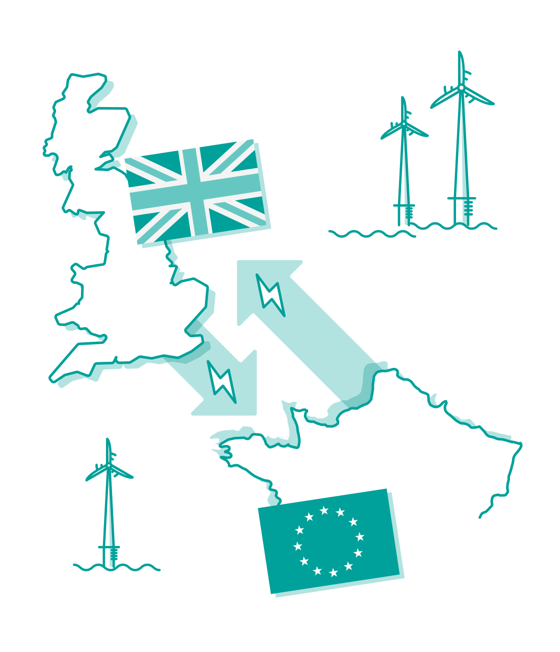
We also see similar ambition for onshore wind. The Scottish Government have an ambition to have 20 GW of onshore wind installed by 2030, almost doubling the current capacity in Scotland.

The industry also predicts a significant rise in solar generation from 15 GW today to 41 GW by 2030. By this time, we also expect to see the introduction of the first industrial clusters, which combine gas generation with Carbon Capture and Storage (CCS) technology with other carbon intensive processes, such as manufacturing cement, to reduce emissions on a regional basis. There are also proposals for these clusters to host the first trials of using hydrogen gas as a clean power source.

By 2035, we forecast that over the course of a year twice as much electricity may be produced compared to last year (2023). This transition will come with challenges – Great Britain is known for its unpredictable weather, and this can impact the output of renewable generation that relies on light or wind. It is therefore essential that we work to diversify both the location and type of low-carbon electricity supplies and develop new tools and techniques to ensure that there is always the right level of electricity available to meet our demand.

One of the most important factors in enabling this transition will be ensuring that the capability of the transmission network increases over time. This is vital as renewable energy sources are generally developed in remote locations where the current transmission network may have been built at a lower capacity, or in some cases there may not be any network at all. Establishing a robust network brings many benefits – most importantly it allows for electricity to be shared across Great Britain. A transmission network with lots of capacity across Great Britain helps to smooth out regional disparities.

This new network will also enable Great Britain to continue to benefit from diverse links to Europe. Currently there is over 9 GW of capacity between Great Britain and Europe, and our analysis suggests that the development of at least a further 5 GW of interconnection would be beneficial. Great Britain is currently a net importer of power, primarily from France, however we predict that as Great Britain continues to develop renewable energy, we will become net exporters to the continent.



One of the biggest problems Great Britain faces is the inability to easily store large volumes of electricity. Grid-scale storage is becoming increasingly important in managing peaks and troughs in the electricity system. Currently this is being done through large-scale batteries and hydro schemes, however it is unlikely that it can be built out in sufficient quantities to manage long-term fluctuations in output.

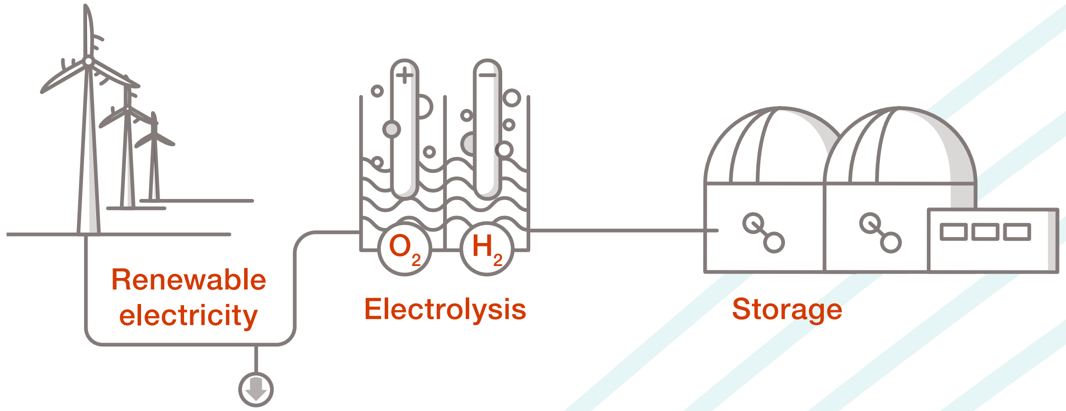
Beyond 2030 / System Needs 23

System Needs

As an alternative to storage, we can consider how we can use electricity differently. The public saw this for the first time through our Demand Flexibility Scheme (DFS), where customers are financially incentivised to reduce their electricity consumption to help manage the energy system at times of peak electricity demand. As our lives are further integrated with smart, home-energy management technologies these types of schemes are likely to become more widespread as they present a cost-effective and low-impact solution to meeting our energy needs. Further, our flexibility strategy (due Summer 2024) will outline some of the steps we are taking to use assets more flexibly at different times. Hydrogen and bioresources may play a significant role in storing energy for long periods of time in the future. The Government is currently exploring the various roles hydrogen could play as part of the energy system and what the potential business models to support this would look like.

In the longer term, we may also have the opportunity to develop large-scale strategic or flexible demand closer to sources of generation. Connecting large-scale demand sources near to power generation can reduce the amount of new or additional transmission infrastructure required. The type of demand could vary - from hydrogen production that can be used as an alternative to fossil fuels, data centres powering Great Britain's technological infrastructure, or large-scale manufacturing plants. As well as reducing the amount of network infrastructure that needs to be built, locating strategic demand can also provide wider societal benefits, often creating opportunities in emerging economies.

The recommendations in this report build upon the forecasts outlined above which form the background and starting point for our analysis. While our system flexibility, interconnection, storage and hydrogen production forecasts can reduce the stress on the network, our understanding of the significant increase in electricity generation and demand that will be seen through both decarbonisation and energy self-sufficiency aims continues to drive the need to redevelop parts of the transmission network.



System Needs

Great Britain is about to embark upon the biggest change to the electricity network since the high voltage transmission grid was established back in the 1950s.

The process for determining how to get electricity from where it is generated to where it is used is complex. Each part or regional area of the electricity transmission network has a finite capacity at which it can transfer electricity from A to B. As the network was built, rural network capabilities were often less than that of urban or industrial areas because these areas had lower requirements to either connect generation to the system or supply power to local networks. Despite network upgrades throughout the decades, some parts of the network still have limited capability and cannot carry enough electricity during times of high supply and demand. As the volume of generation increases, we will need additional capacity, and new routes on the network to allow electricity to flow from where it is generated to the people and businesses that need it.

When the level of electricity being carried exceeds the capability of the network, we must take actions to protect it from damage and ensure that the power supply is secure. These events are known as system constraints and can be thought of in the same way as congestion on our roads which cause bottlenecks. Without proper management of the network, electricity system congestion could result in damage or failure of physical assets on the network.

At these times, as the Electricity System Operator (ESO), we will typically need to pay generators to stop generating electricity in constrained areas, while paying other generators to come online in areas that are free of constraints. This is known as a balancing action and forms part of the everyday running of the electricity system to help us reduce the strain on the network at certain times. However, when these balancing actions become significant or prolonged, the economic impact of managing constraints must be weighed up against the investment required to increase the capability of our network. Overall, we make recommendations for the TOs to upgrade their networks when this is more cost effective for consumers than having to pay for the ongoing cost of balancing actions.

The electricity industry considers a wide range of options when looking to expand the capability of the network, especially in places where there are transmission bottlenecks (i.e., constraints).

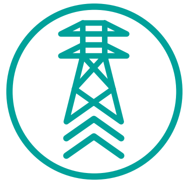
Options available to reinforce the transmission network

- Reconfigure existing network
- Upgrading existing circuits
- Install smart power management devices
- Develop new offshore and onshore circuits

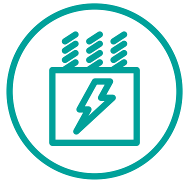
Beyond 2030 / System Needs 25

System Needs

The first consideration is always to look at optimising and upgrading the existing network, as this is often more cost effective and efficient. However, once all useful options on the existing network have been exhausted, and should a need for additional capacity still be required, new infrastructure will be considered.



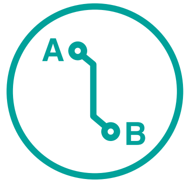
One common solution that can improve the capability of the existing network is to replace the wires on existing circuits with ones that have a higher rating, allowing more power to flow through the same circuit. A similar solution involves increasing the voltage at which some circuits operate at, however, this is only possible in some areas of the network. Increasing the voltage of circuits usually requires replacing the pylons on the existing route with taller ones to meet required safety clearances.



Alternatively, it may be possible to reconfigure the way the network is set up in some areas, this can improve efficiency by better managing power flows at a localised level. These solutions can provide a moderate improvement in the capability of the network. Smaller capability gains can further be achieved through the use of smart monitoring devices which can provide greater information on current assets allowing more power to be squeezed from them or through the installation of power-control devices which can reroute power away from bottlenecks.

While these solutions improve the overall capability of the transmission network and generally have a lower impact than establishing new infrastructure, it cannot provide the significant increase in capability offered by new infrastructure.

New infrastructure options include new circuits, these can either be developed onshore or offshore and will carry large amounts of electricity across the country. These power lines are like “motorways” and significantly increase the capability of the network. With a large capacity of new generation coming from offshore sources, new network infrastructure will be critical in connecting Great Britain to clean, renewable electricity.

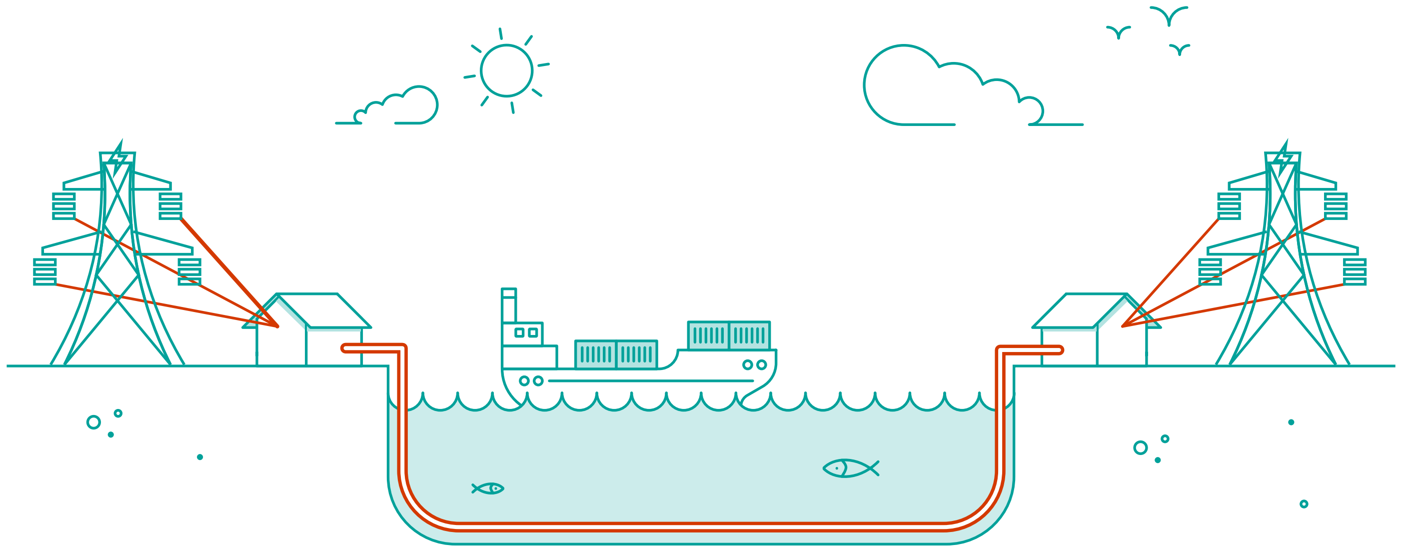


New circuits might include overhead pylons that link one city to another, or in certain circumstances, cables buried underground. Both these solutions can substantially increase the capability of the network, however there are financial, technical, environmental and community considerations that need to be taken account of before recommendations can be made. Onshore circuits require careful route planning to minimise not only the disruption to communities and businesses but also mitigate potential impact on the natural environment. Pylons are typically used for the transmission network because they are around a fifth of the cost and more flexible (i.e. they can be rerouted, offer more operational choice and can be more easily upgraded) than the underground equivalent. Cost is not the only factor when determining the approach for a new circuit, technical limitations must also be noted, for example: underground cables reduce visual impact but may have greater ecological and cultural heritage impact during construction. Underground assets are also harder to access for maintenance and repair. Finally, overhead lines can carry far more electricity with two or three underground cables required to provide the same benefit as a single overhead line.

Beyond 2030 / System Needs 26

System Needs

New circuits can also be located offshore, transmitting power through subsea cables, although this is not without challenges. While offshore cabling has minimal visual impact, the routeing process has similar environmental considerations to those onshore, particularly when considering the landing point of the offshore cables.



The UK has a valuable and unique marine and coastal environment and there are various species, habitats and cultural heritage sites which are protected to promote healthy marine ecosystems and conservation of the UK's historic environment. Large parts of this historic environment, especially around Great Britain's coastline, are protected and this must be taken into account when identifying transmission requirements. From a technical standpoint, much like onshore cables, subsea cables only carry around a third of the power that can be carried through onshore pylons. To bridge this difference in capacity deficit, multiple subsea cables would be required which consequently increases the impact on the marine and coastal environment. This price differential can make offshore solutions up to 8 times as expensive as onshore solutions when considered over short distances.

When transporting significant amounts of power subsea over long distances (e.g., hundreds of kilometres) it can be beneficial to switch to direct current (DC) technology. DC technology helps reduce power losses and improves our ability to operate the system, but it comes with a significant rise in costs. While DC has some environmental advantages by requiring fewer cables, it does require additional DC converter stations upon landfall to convert the power back to the alternating current (AC) used by our onshore transmission system. Lastly, and crucially, this infrastructure being located on the seabed makes accessibility for maintenance and repair even more challenging.

All new infrastructure solutions have unique challenges depending on their local environment. Each element is weighed up and carefully assessed before a recommendation is made. As further detailed design work takes place additional challenges and opportunities may be identified which may refine how this infrastructure is delivered. As a result, diverse solutions that will help us in the short, medium, and longer term are needed and are all recommended in this report.

Beyond 2030 / System Needs 27

National Blueprints

ESO

Introduction

To create a grid fit for future needs, we have taken a holistic approach that combines onshore, offshore, and innovative solutions to create a single, modern, holistic electricity network.

This chapter sets out our independent view of the electricity network needed leading up to 2030 and beyond, and the role that strategic flexible demand can play in reducing the need for future network build. This section will provide snapshots of 2030 and beyond to demonstrate our best view of the way forward. Our 2030 snapshot gives an updated view of the recommendations given in our previous *Pathway to 2030 Holistic Network Design (HND)*.[1] Our Beyond 2030 chapter builds from this point and provides the high level network design required for another 30 GW of offshore wind connections.

To build the grid needed for a decarbonised power system, this chapter and associated annexes provide clear investment signals for businesses to take forward projects and refine designs before they are further assessed. The network recommended by us is high-level with the routes and technologies used unfixed. These recommendations will be optimised further and refined within the Detailed Network Design (DND) phase by other businesses such as Transmission Owners (TOs) and offshore developers. This is so the industry can ensure these network recommendations meet the future needs of the system and are the right solution, in the right place, at the right time.

Looking further out, beyond 2035, the potential solutions that could cater for Great Britain's rising energy needs expands greatly. We want to encourage discussion on how best to address our rising energy needs and would welcome innovative proposals from consumers and industry. As these requirements are still far in the future, the exact nature of any solution will require significant refinement by the responsible parties, although we must continue to ensure progress at pace. Future policy decisions from government will also shape the potential nature of these solutions.

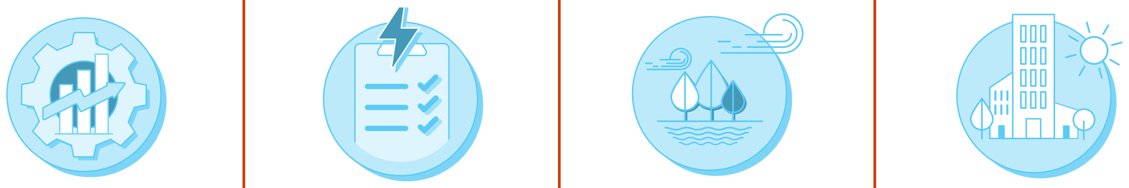
Key to ensuring Great Britain can scale up both its energy generation and network capacity is providing the certainty required by governments and the regulator to support this once in a generation network expansion with the right policies, skills and supply chain support. This will help unlock the multiple benefits that clean cheaper electricity can bring to communities and businesses.

1 https://www.nationalgrideso.com/document/264656/download

Introduction

Network design criteria

The design criteria we use helps us to balance the impacts of new infrastructure with the benefits it can bring. This methodology was originally agreed through engagement in the UK Government's Department for Energy Security and Net Zero led Offshore Transmission Network Review process and later adopted into the Electricity System Operator's (ESO's) wider onshore network planning process. Our equally weighted design criteria for new infrastructure are:



Economic and efficient | Deliverable and operable | Environmental impact | Community impact

By assessing a wide range of data points we can understand high-level environmental and community impacts earlier in the project development process. This allows for better coordination between potential network solutions and enables our design to reduce the overall impact of new transmission infrastructure where it is possible to do so.

Importantly, the methodology we use is high-level; if and when these network options are progressed further by relevant TOs and developers, these companies will undertake more detailed assessments, to help determine any potential cumulative and community impact and local environmental constraints.

This balanced and holistic approach will help us to deliver against Great Britain's legally binding decarbonisation targets in a way that considers the impact on the environment, our communities, and every consumer.

Beyond 2030 / National Blueprints / Introduction 30

2030 National Blueprint

2030 National Blueprint

***The Pathway to 2030 Holistic Network Design (HND)*[2] set out a single, integrated design that supports the large-scale delivery of electricity generated from offshore wind, taking electricity to where it is needed across Great Britain.**

Across 2023, zero-carbon sources outperformed traditional fossil fuel generation providing 51 per cent of the electricity used. Today, the record low-carbon electricity mix (achieved in January 2023) currently stands at 87.6 per cent. Currently, reaching these very high levels of clean generation is dependent on weather and system capacity. By 2030, it will be common for the electricity system to run on 100 per cent renewable sources for extended periods of time. This will be necessary to meet the UK Government's ambition for the year-round electricity mix to be made up of 95 per cent low-carbon power. However, to make this leap, significant investment and change is required in the electricity system.

It is not just the electricity network that is changing - in our most ambitious projections of the route to net zero, gas consumption could fall by up to 40 per cent by the end of this decade. This is partly driven by government ambition to stimulate new green industries around strategic resources. This includes the potential to replace natural gas with hydrogen and the growing opportunities for consumers and businesses alike to harness, cheap, reliable, and low-carbon electricity for heating and transport. Key to this transition is the development of large-scale offshore wind farms. Offshore wind is one of the cheapest ways to generate electricity and can be built at the scale needed to reduce the need for large fossil fuel fired power stations. Great Britain is already a world leader in the technology; however, a new approach of coordinated development can reduce impact of the infrastructure needed to transport the power to where it can be used.

The scale of change required to facilitate this energy transition led to the UK Government establishing the Offshore Transmission Network Review (OTNR). The OTNR tasked us with producing a holistic electricity network design to ensure that transmission connections for offshore wind are delivered in the most appropriate way, meeting the UK Government's ambition of connecting 50 GW of offshore wind by 2030.

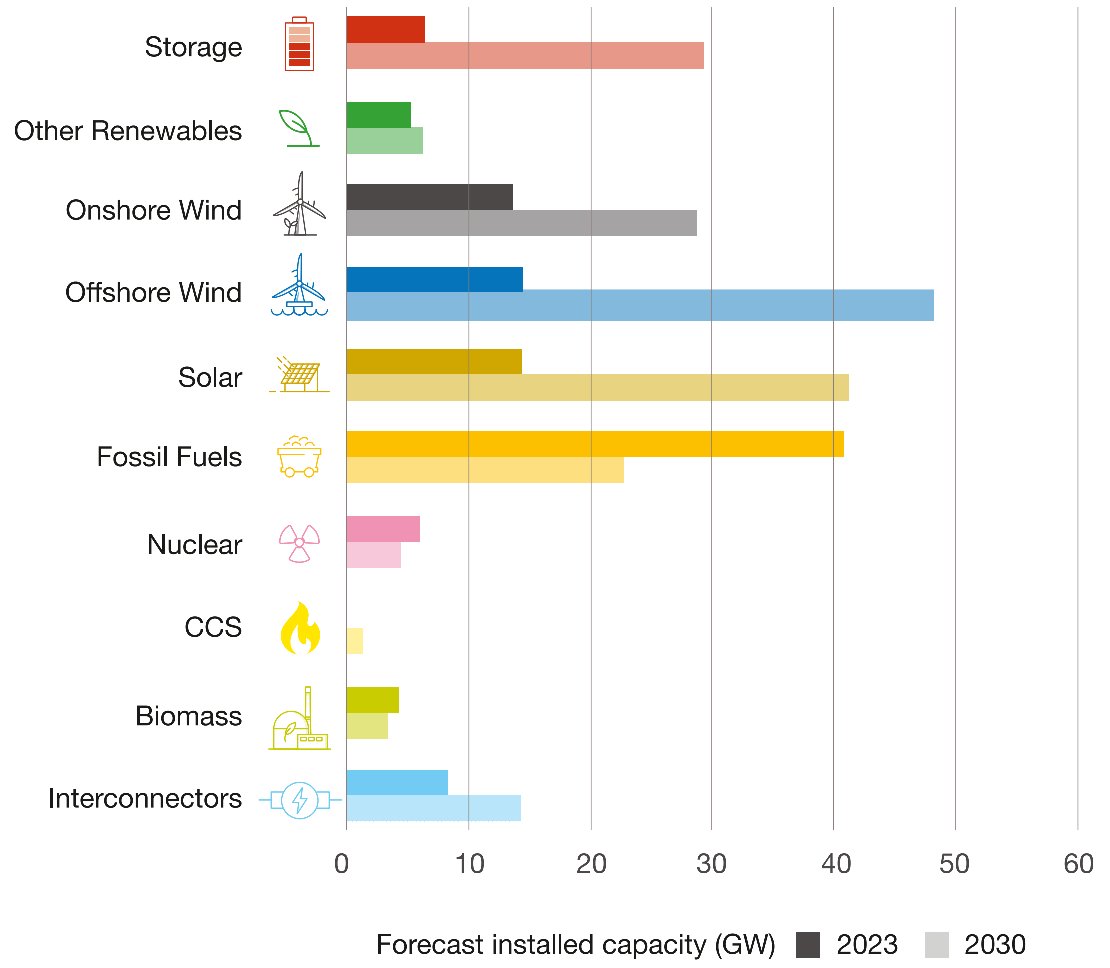


Figure 6. Generation mix now and forecast for 2030

2 https://www.nationalgrideso.com/document/264656/download

Beyond 2030 / National Blueprints / 2030 National Blueprint 32

2030 National Blueprint

What did we design for?

In 2022, we designed a first of its kind plan to connect 23 GW of offshore wind onto the network. Our integrated and coordinated approach is expected to increase the ability of Great Britain to utilise its wind energy potential by providing additional flexibility and capability. Over the 2030s this is equivalent to powering 10 million of today's homes for an entire year. Enabling this wind energy on our doorstep to connect onto the network also dramatically reduces our exposure to imported gas, this renewable energy has the potential to reduce emissions by up to two million tonnes of CO_2 between 2030 and 2032. This is equivalent to grounding all UK domestic flights for a year.

As outlined within the System Needs chapter, the current electricity network as we know it is reaching its capacity - this means a scale of investment is needed to make our networks fit for the future which has not been undertaken since the development of the supergrid in the 1950s. By 2030 we recommend over £60 billion[3] of investment across both onshore and offshore network infrastructure to facilitate the connection of new offshore generation and other new renewable energy sources, while enabling the electricity network to run at the best value for consumers. This investment comprises of two parts, split between the offshore network design and 91 reinforcements to the transmission system. These reinforcements are a combination of network upgrades that ensure we are best utilising our existing infrastructure as well as recommending new circuits and innovative market-led low or no-build solutions.

Given the scale of proposed infrastructure, our aim was to produce a coordinated, optimised network design for 2030 that balanced the potential impact on the environment and communities with consumer value and system security. This was achieved in a variety of ways including coordinated trenching, offshore cabling which will bypass congestion in the onshore transmission network, and by wind farms sharing offshore assets.

By efficiently using the seabed, what we have proposed is not only expected to reduce the footprint of the offshore cabling connecting to shore by a third, but also reduce the need for additional onshore infrastructure. This can be demonstrated by the benefit that the coordinated Holistic Network Design (HND) delivers against a 'radial' or point-to-point design in which there is no shared offshore infrastructure. By offshore wind farms sharing assets it has been possible to reduce forecasted costs associated with network capacity issues by more than £13 billion when compared with the traditional radial approach. The final building block for this revolutionary approach was engaging with Ofgem to make the case for accelerating strategic parts of this infrastructure which may not otherwise be ready for 2030. Ofgem concluded that this acceleration can lead to a net benefit to consumers of up to £2.1 billion[4] from avoiding the costs associated with network congestion and therefore agreed the regulatory acceleration of 26 projects in late 2022.

The map on the following page shows some transmission options with dashed yellow lines. These were deemed to be essential for delivery in 2030 but had delivery dates beyond this. In some cases, these options were insufficiently mature and the regulator therefore provided pre-construction funding to continue their development. These options have been reassessed as part of our Beyond 2030 chapter.

3 These figures have been inflated to 2023/24 prices.
4 As assessed. Prices given in 2021/22 prices.

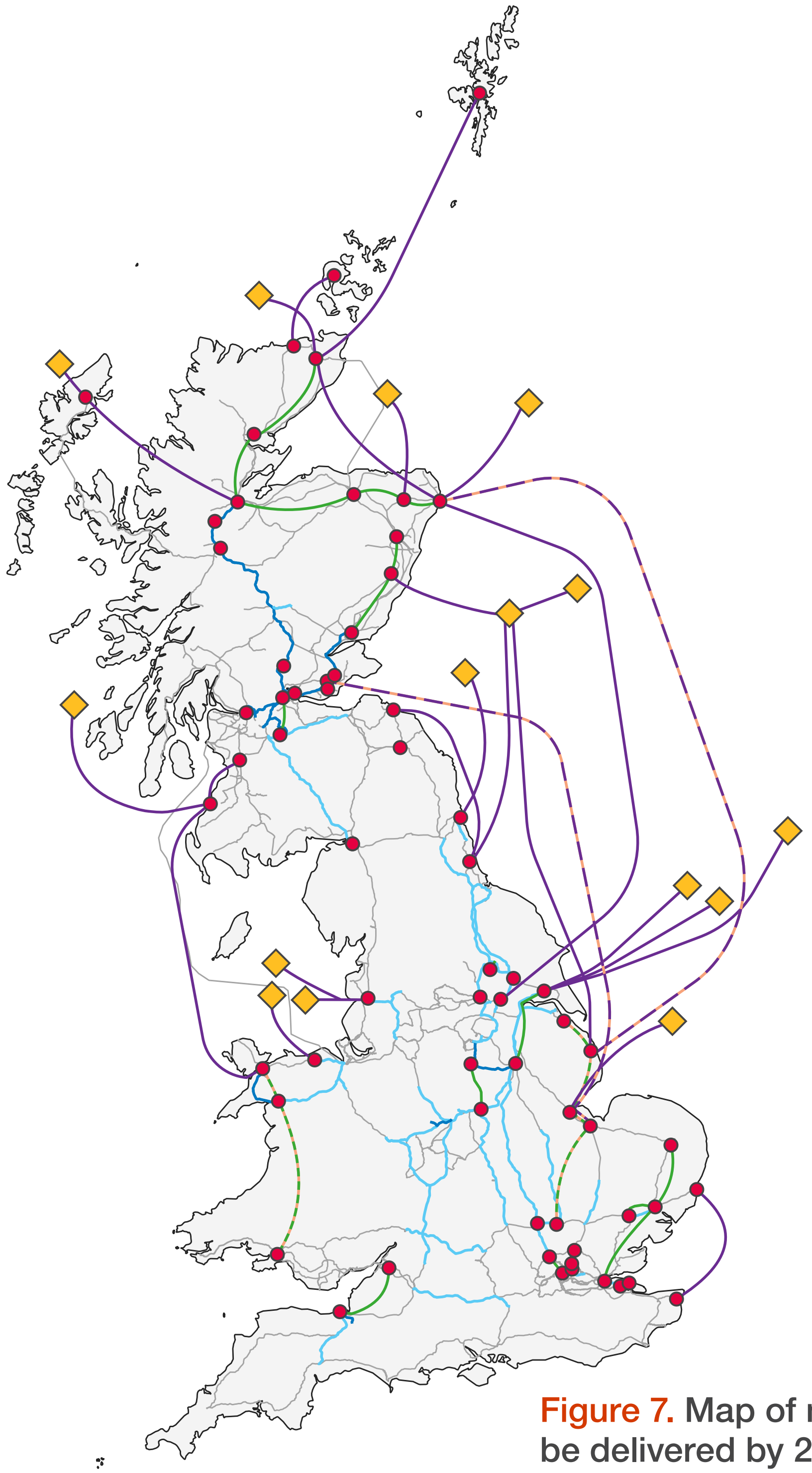
Beyond 2030 / National Blueprints / 2030 National Blueprint 33

2030 National Blueprint

What will this new renewable generation and network infrastructure mean for communities and businesses?

The transformation described in our previous *Pathway to 2030* publication has the potential to not only bring benefits to the electricity network, but it is expected to stimulate new and traditional industries including high voltage direct current (HVDC) cable manufacturing and port upgrades around England, Scotland and Wales.

The offshore wind sector and its supply chains also bring opportunities for regeneration and sustainable growth to coastal communities across the breadth of Great Britain through long-term investment and employment. The Climate Change Committee (CCC) show that 31,000 people across the UK are currently employed in the offshore wind industry, with this number set to more than triple by 2030, and grow further by 2035 – driven by £155 billion of private investment. Areas including Scotland, the North East, Yorkshire, the Humber and the East of England have seen jobs created and investment in their communities as wind farms, their associated infrastructure and the wider supply chain are built.



Category	Key
New offshore network infrastructure	
New onshore network infrastructure	
Voltage increase on network	
Existing network upgrade	
Substation upgrade or new substation	
HND wind farm	
Existing Network	

*Amber dashed lines represent reinforcements required for this blueprint, but current delivery date estimates sit beyond this.

Note: all routes and options shown on this map are for illustrative purposes only.

Figure 7. Map of network infrastructure to be delivered by 2030

Beyond 2030 / National Blueprints / 2030 National Blueprint 34

Detailed Network Design

To progress the delivery of the first HND, offshore wind developers with non-radial connections and Transmission Owners (TOs) will continue to refine the high-level plan as they approach project delivery. As part of this more detailed assessment, the Detailed Network Design (DND), we are working with developers and Transmission Owners to re-analyse elements of the design where needed.

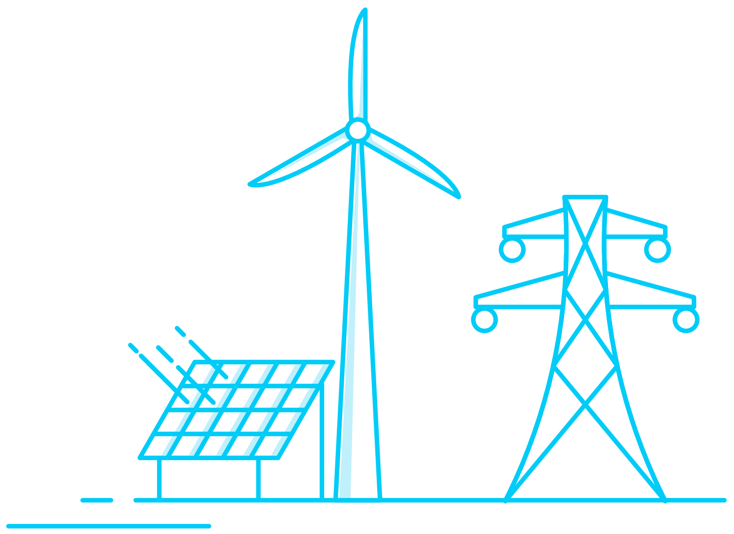
For the DND, we have collaboratively developed a process with TOs and developers to assess the impact of their proposed design changes. These assessments will be conducted against the baseline of the HND and will use the four HND design criteria. This process was implemented in September 2023 and is referred to as the HND Impact Assessment process.

While the HND is non-binding, deviations from the recommendations may have wider implications for the transmission network and other industry processes. It is important therefore that we understand the full impact of any design changes, as there may be consequences which are not immediately obvious.

HND Impact Assessment case study

The first design changes submitted for the Impact Assessment process were proposed by HND developers off the east coast of England and the TOs. These parties are known as the South Cluster, as they are the most southern group of HND projects off the east coast of Great Britain. The request follows recent movements in the global supply chain of HVDC technology making this aspect of the HND network challenging to deliver for 2030.

The Impact Assessment has identified a design which presents benefits across several network design objectives compared to the original HND design. Four design configurations were compared to the original HND design for the region. The best performing design has reduced interconnection for the South Cluster compared to the baseline HND, with the three offshore wind farms of the South Cluster connecting directly to shore at Birkhill Wood via lower capacity cables (1.44 GW) and a single larger capacity cable (2 GW) coming from the Northern Cluster to Lincolnshire providing additional transmission capacity to meet increasing network requirements.



Beyond 2030 / National Blueprints / 2030 National Blueprint 35

There are several factors that have changed since the *HND* was published in 2022 which have led to this outcome: increases in the cost of offshore equipment above the rates of general price increases, challenges in the supply chain for transmission assets, and the identification of opportunities to realise additional electrical and physical capacity. A significant driver of this assessment and outcome is the updated delivery timescales for different technology types provided to us by the Southern Cluster parties, meaning the original HND design would be delayed by a number of years. This new design delivers economic benefits by enabling earlier connection of generators, operability benefits in providing a simpler design, environmental benefits in reducing assets in a marine area that is sensitive to cabling, and a small change in community impact driven by an additional convertor station being required onshore.

This is one example of the DND process. We continue to work with TOs, HND developers and other key stakeholders to adapt to changing external factors and will update the HND design as appropriate. Importantly, our design will continue to evolve in light of our recommendations made for 2030 and beyond so that they represent the most efficient solution across the four HND design objectives.

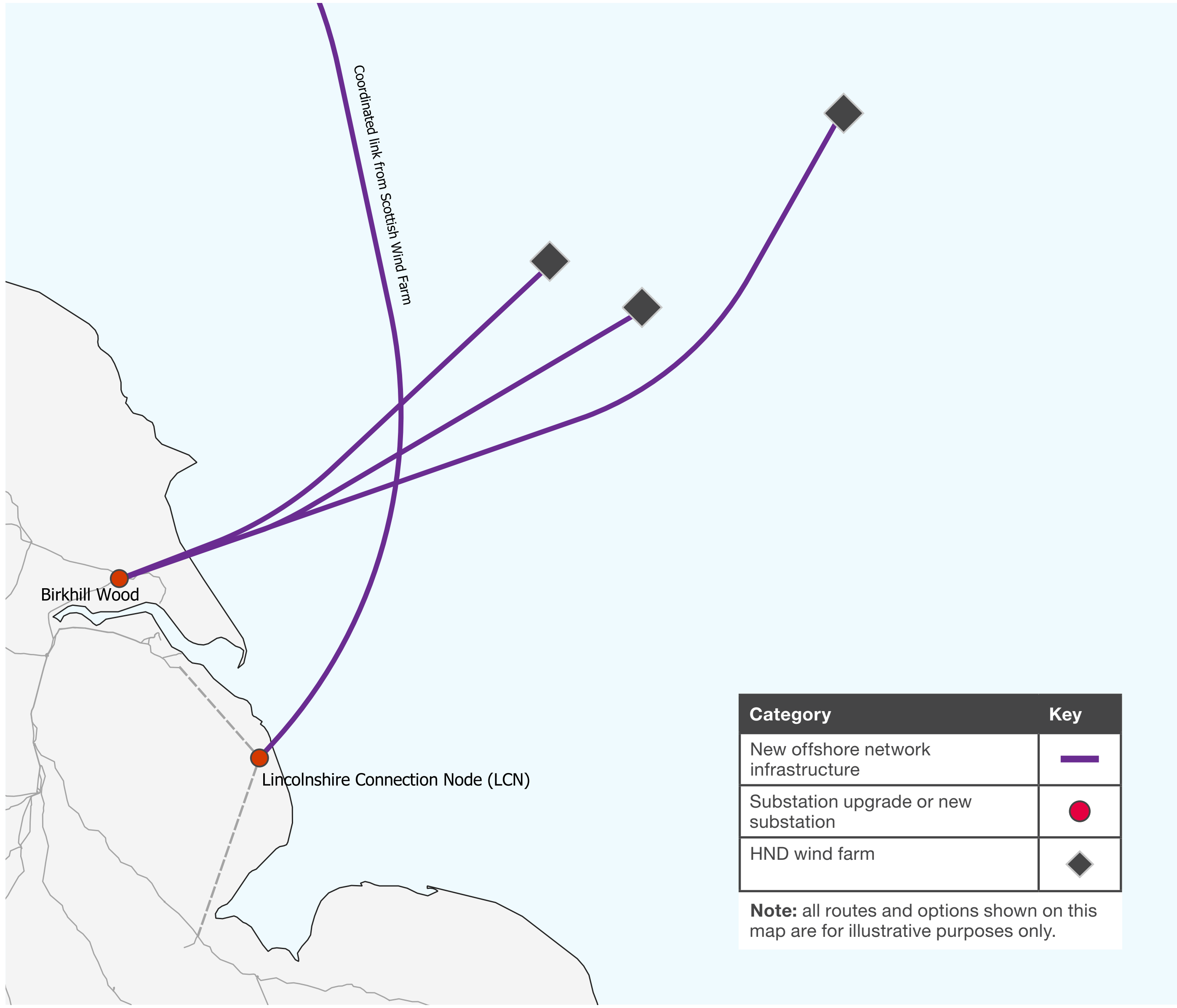


Figure 8. Map of new South Cluster design following Impact Assessment study

Beyond 2030 / National Blueprints / 2030 National Blueprint 36

Beyond 2030 National Blueprint

Beyond 2030 National Blueprint

The UK Government has set an ambition for Great Britain to have a fully decarbonised electricity system by 2035. To deliver this and meet the electricity needs of generations to come, a wide-ranging number of network upgrades are essential. Our recommendations form a crucial strategic view setting us on the path to deliver the wider, legally binding net-zero targets set by the UK, Scottish and Welsh Governments.

From an energy perspective, the world in 2035 will be vastly different to the one we live in today. Many processes will be electrified – the most impactful for everyday life will be related to how we travel and heat our homes. By 2035, the sale of new internal combustion engine cars (ICE) will have been phased out, and only electric vehicles (EVs) or other zero-emission alternatives will be available to purchase new. Similarly, new domestic gas boilers will not be available for new build properties after 2025 (April 2024 in Scotland) and a consultation is ongoing in relation to heat in existing properties in Scotland too. As a result, we project that there could be as many as 30 million EVs on our roads by 2035 and up to 13 million heat pumps installed in homes and businesses. As we switch from fossil fuels for heating and transport to clean, 'home-grown' electricity, our demand for electricity is expected to increase by 64 per cent compared to 2023 levels.

Our increased renewable energy capacity will be pivotal in powering the industries of the future. Innovations in new fields will unlock greater opportunities in Great Britain and abroad, such as clean hydrogen technology which we forecast could have a production capacity of up to 22 GW by 2035.

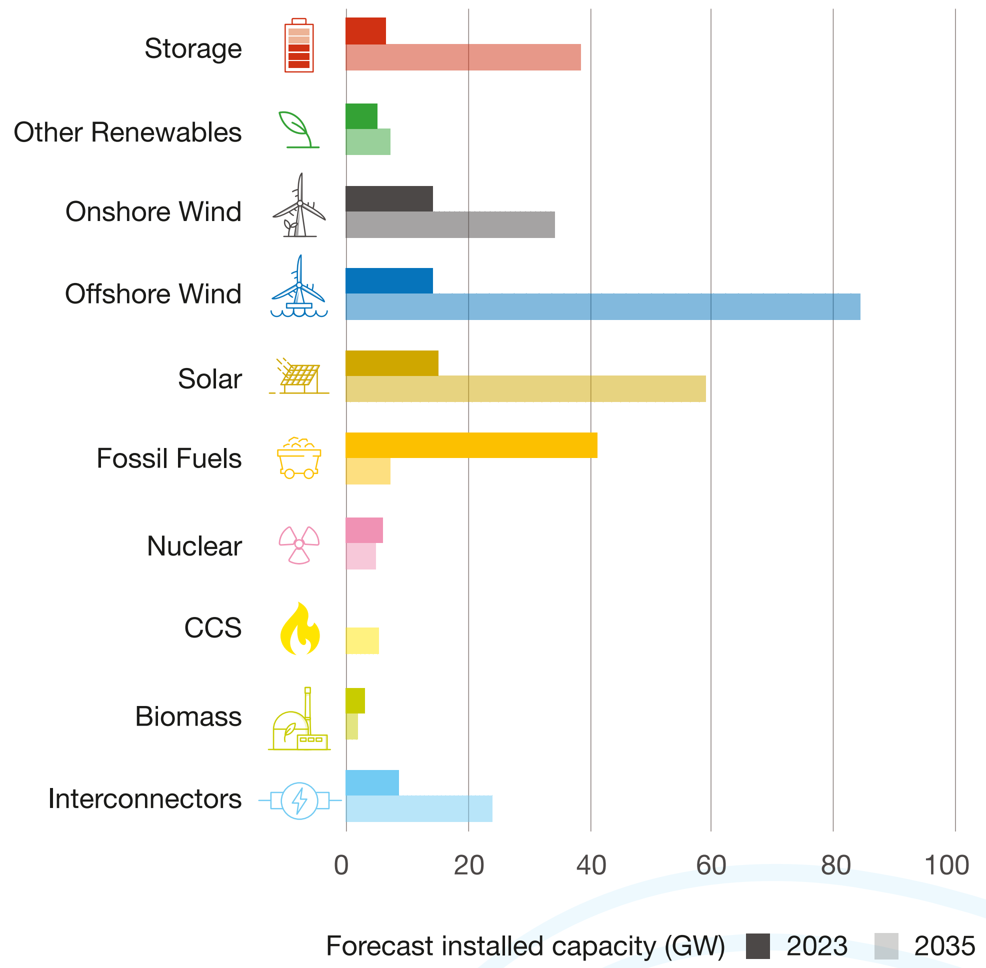


Figure 9. Generation mix now and forecast for 2035

Beyond 2030 / National Blueprints / Beyond 2030 National Blueprint 38

Beyond 2030 National Blueprint

What are we designing for?

This plan sets out the network requirements to facilitate UK, Scottish and Welsh Government targets and connects a further 21 GW of offshore wind from waters around Scotland. This offshore wind is in addition to our 2030 plan which outlined a design to connect 23 GW of offshore wind connections located around the coast of Great Britain. Importantly, the recommendations in our 2030 blueprint are built upon by upgrading our existing network, delivering new infrastructure both onshore and offshore where needed and proposing innovative solutions that can optimise the location of strategic, flexible demand connections in the future.

Crucially, this design has energy security at its heart. It connects an unprecedented amount of renewable generation, allowing electricity to get from where it is produced to where it is consumed. It does this by ensuring that there is sufficient capacity to reach all four corners of Great Britain, so that we will have access to clean, cheap electricity on our doorsteps around the clock. This new generation and network capacity increases Great Britain's self-sufficiency, however, as outlined within our *Interconnector Analysis*,[5] increasing interconnection with our neighbouring countries can also bring billions of pounds of benefit by promoting consumer value and allowing for renewable resources to be better utilised.

As with our 2030 blueprint, there is an established and growing need to transmit electricity from both new offshore sources, primarily off the coast of Scotland, and other onshore renewables spread throughout Great Britain, to the south of the network where the demand for electricity is greater. Our proposed network for 2035 includes a significant amount of coordinated offshore infrastructure, reducing the overall cumulative impact on communities and the natural onshore environment. The coordination of offshore projects can also reduce the offshore environmental impact of new infrastructure through measures including shared cable routes.

5 https://www.nationalgrideso.com/document/264656/download

Beyond 2030 National Blueprint

Our recommendations

Our recommended design, combined with our 2030 blueprint, facilitates Crown Estate Scotland's full ScotWind leasing capacity, which now stands at a total of more than 28 GW of offshore wind. It should be noted that some reinforcements in our design are in the very first stage of the development cycle and more detailed design work will be progressed which may change how these options look in the future. The Transmission Owners (TOs), who are responsible for building and maintaining their networks will now take forward our recommendations and work on the detailed design, in collaboration with offshore wind developers where appropriate, to refine and improve on these high-level recommendations. These low maturity level options have been identified on the map using dashed lines to demonstrate that greater work is required before establishing the specifics.

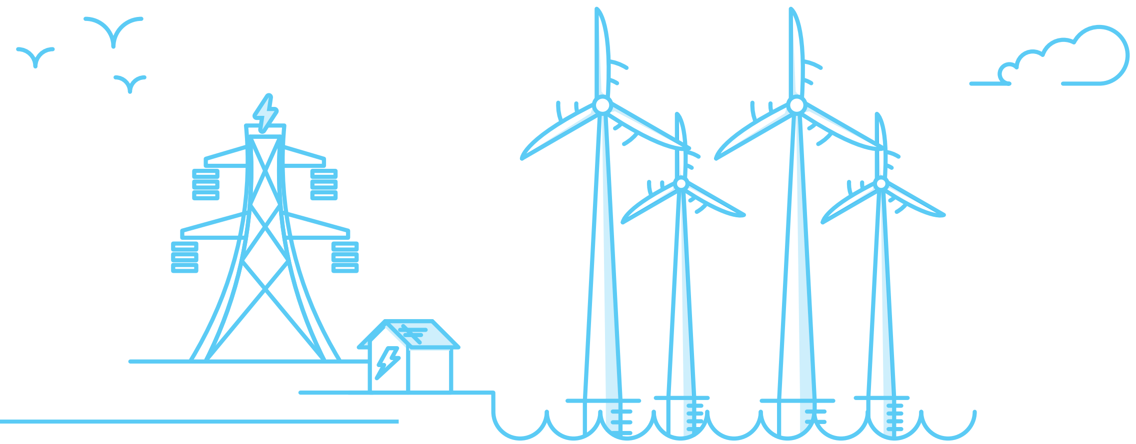
For the first time, our design also includes offshore wind farms located off the coast of Shetland. With nearly 3 GW in capacity and a fraction of this needed locally, this presents an excellent opportunity to co-locate large-scale strategic demand.

Several large-scale wind farms are planned across the north coast of Scotland, with a maximum capacity of 12 GW of clean renewable power landing along the coastline of mainland Scotland at any one time. To facilitate this volume of electricity, new network capability is essential. Our design achieves this through a combination of upgrading existing assets and establishing new power lines both on and offshore. This will complement the six previously recommended offshore high voltage direct current (HVDC) links from Scotland to England.

Our design further coordinates the connection of offshore wind farms off the east coast of Scotland. A continuous offshore link is formed connecting Peterhead in the North East to the Torness area in the South East of Scotland. This facilitates the coordination of four large-scale wind farms onto the onshore network while reducing the number of landing points in Scotland. Long distance offshore cabling is also established to bring the power from these wind farms to Lincolnshire and Kent directly, reducing the impact of onshore infrastructure.

While a significant amount of the future requirement to transport power from where it will be generated to where it will be consumed is done via offshore links, it is vital that new onshore circuits are also developed. This is because onshore pylons are not only cheaper and more flexible than offshore circuits but can carry significantly more power. Given the requirements to export power from new ScotWind capacity, we are recommending a potential new high-capacity electrical spine that will run from the North East of Scotland, through to the North West of England.

To replicate the benefits of this proposed solution several offshore assets would be required to offer an equivalent electrical capacity. Due to challenges navigating the seabed's protected natural environment and the variety of other purposes it is used for (such as telecoms and gas pipelines) there are limited viable offshore routes available. Laying additional subsea cables also further impacts coastal areas that would have to host converter stations at both landing points so that this power can be fed back into the main grid.



Beyond 2030 / National Blueprints / Beyond 2030 National Blueprint 40

Beyond 2030 National Blueprint

Our proposed electrical spine will not only increase accessibility to low-cost, clean energy but also improve the robustness of our network, facilitating alternative pathways for electricity to flow. By doing this, upgrades to existing infrastructure can become beneficial, further reducing the costs associated with congestion on the electricity network while minimising wider impact to the environment and communities.

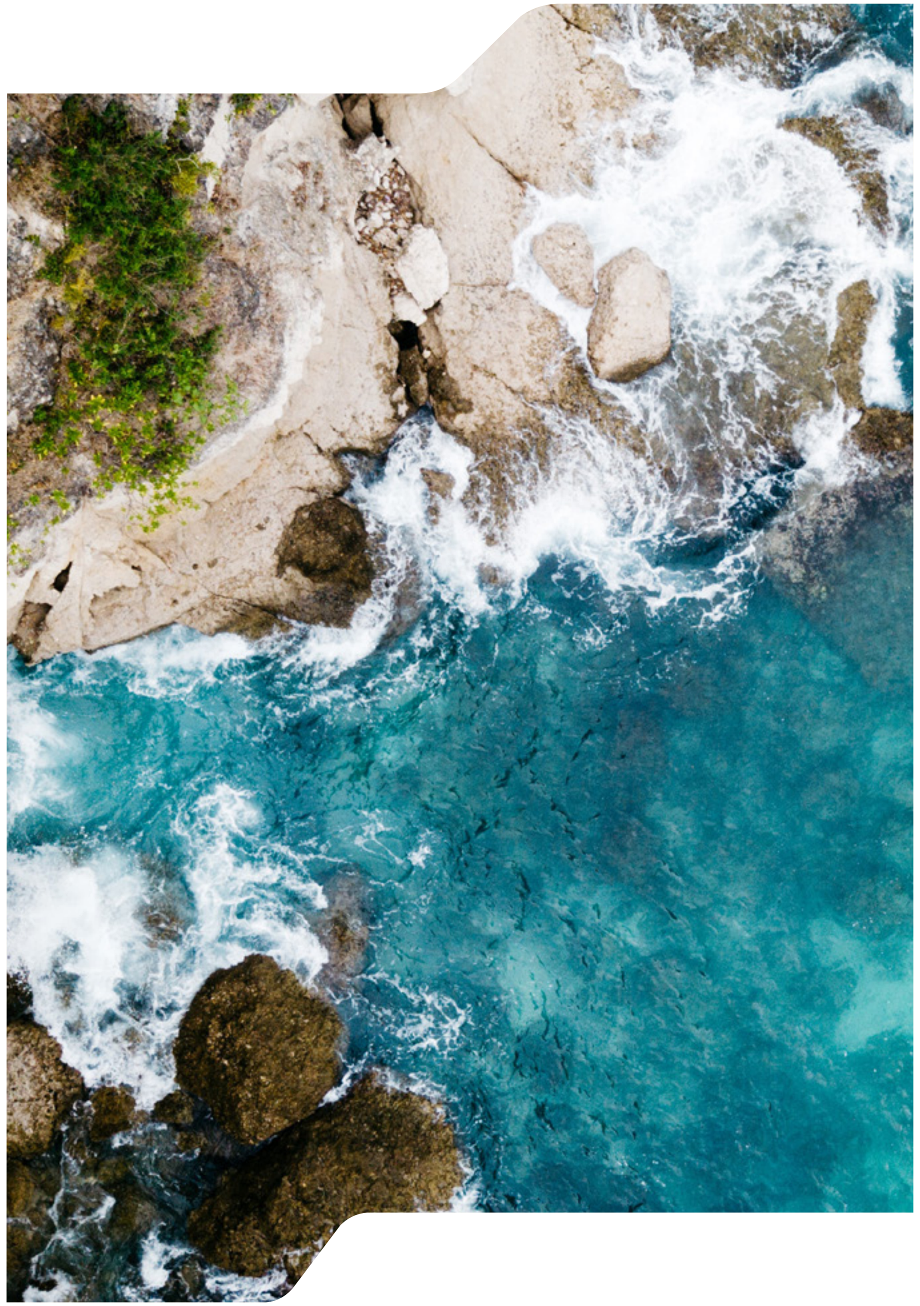
Importantly, this recommendation for a new central spine encompasses several reinforcement projects that work in concert. Some components of the proposal have been recommended for several years whereas others are still in the early stages of development.

All our recommendations will continue to be designed in greater detail, assessed alongside alternative solutions, including additional offshore reinforcements, and refined as necessary. These steps ensure that the final network solutions that are delivered have been robustly tested and are the right, long-term approach to take for the country.

In addition to the above we recommend strengthening the link between Scotland and North Wales. This involves doubling up on the offshore circuit between the two nations, previously proposed in our 2030 blueprint. This reinforcement improves power flows and complements the previously recommended circuit that, for the first time, directly links North and South Wales.

Moving further south on the network, our recommended design utilises a new offshore connection hub along the coast of Lincolnshire. Routeing offshore cables to this allows us to reduce the impact on protected marine areas in The Wash and around the coast of East Anglia. The abundant electricity flowing through the proposed Lincolnshire node has the potential to be among the cleanest sources in Europe and could stimulate new high-growth industries. Landing these connections in Lincolnshire also offers economic benefits to the wider system when compared to landing points that are further north in the network. This is due to congestion in the North of England which would mean that there would likely be times in which these offshore routes would not be able to transmit power.

In a revision to one of our previous recommendations we have found that an option from the TO to modify the scope of the third Eastern Green Link is beneficial. It will continue to be routed offshore from Scotland to Lincolnshire but will now also link the new offshore connection hub in Lincolnshire with the network further south.



Beyond 2030 / National Blueprints / Beyond 2030 National Blueprint 41

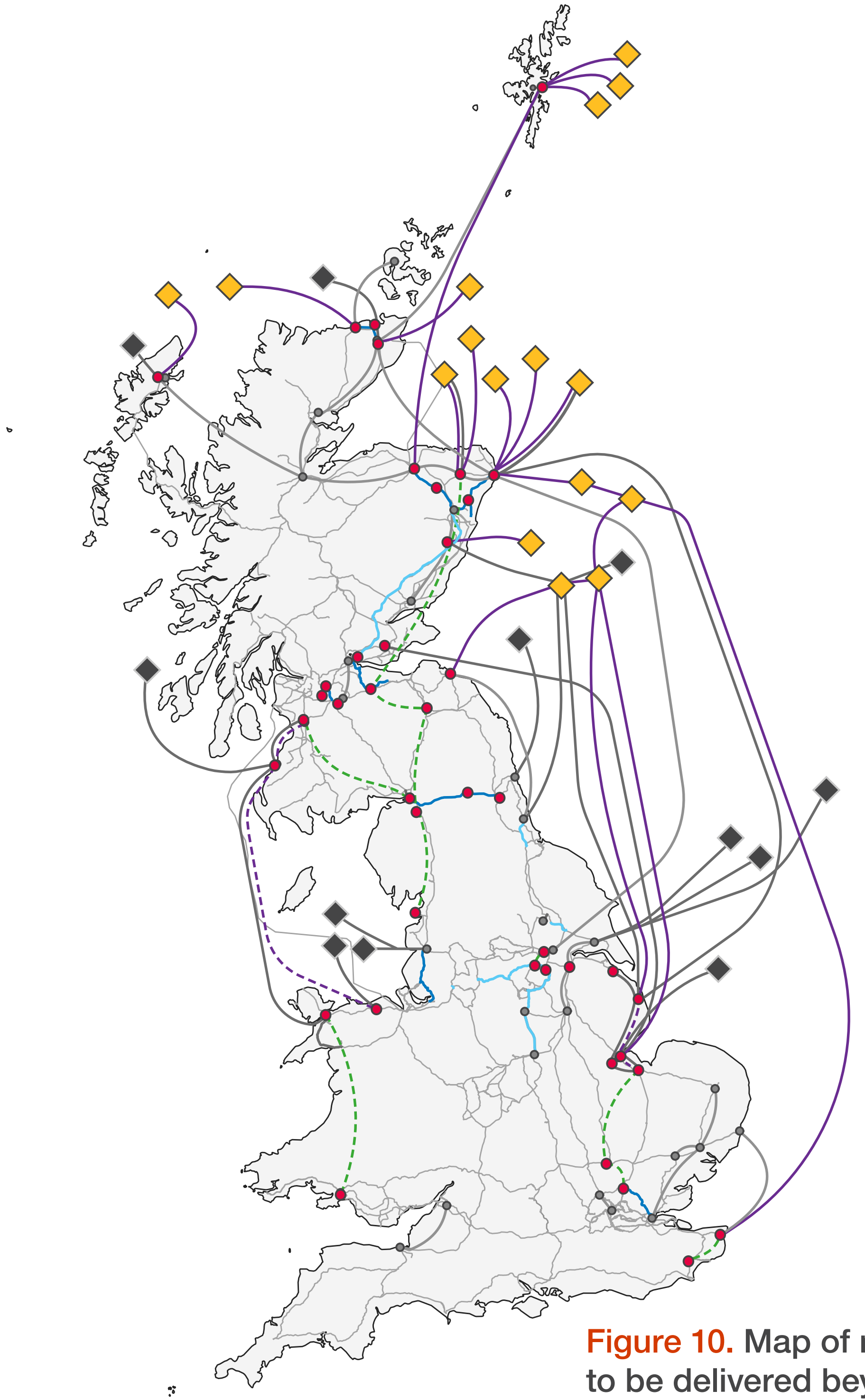
Beyond 2030 National Blueprint

This has led to a revision to another previous recommendation in which an additional onshore transmission circuit was required between the new offshore connection node and the Home Counties. This route has now been shortened, with the northern end of the circuit being moved further south. This route provides significant capacity, as it finalises a continuous high-capacity pathway from wind farms off the coast of Scotland to North London.

Finally, a high-capacity link from a Scottish wind farm to Kent is recommended. Drawing power directly from Scotland will further diversify the renewable energy supply in the South East of Britain. To ensure that the transmission system can reliably handle this volume of power, a new circuit is currently required to strengthen the existing network across Kent. Not only will this improve the capability of the local network, it will also facilitate the transfer of clean electricity to and from Europe.

These recommendations, in combination with those presented in the previous blueprint for 2030, represent a generational shift in our collective energy networks. They will facilitate a fair, and timely transition while ensuring we meet our target of being able to operate the electricity system with net-zero carbon emissions in 2035. This is essential if we are to meet the legally binding commitments of the Sixth Carbon Budget as well as our wider 2050 net-zero target.

It should also be noted that further, additional reinforcements beyond those set out in this report may be identified in future driven by other generation connections in the pipeline. Each generation connection impacts the network differently and has the potential to drive their own unique set of works to connect them to the system.



Category	Key
New offshore network infrastructure	
New onshore network infrastructure	
Voltage increase on network	
Existing network upgrade	
Substation upgrade or new substation	
Substations delivered for 2030	
In scope wind farm	
HND wind farm	
Existing Network	
Reinforcements delivered for 2030	

*Dashed lines represent low maturity options.

Note: all routes and options shown on this map are for illustrative purposes only.

Figure 10. Map of network infrastructure to be delivered beyond 2030

Beyond 2030 / National Blueprints / Beyond 2030 National Blueprint 42

What will this new renewable generation and network infrastructure mean for communities and businesses?

A decarbonised electricity system is a key enabler to sustainable economic growth. As energy is a crucial input into almost all processes, it is essential that we make sure that it is clean, reliable, and affordable. Access to clean energy is often the first major step for many existing energy intensive industries to help reduce their emissions.

Access to renewable energy can also stimulate future industries. The growth of data intensive processes has led to the establishment of large power-hungry facilities required to store and compute data. These facilities do not just enable us to stream media, they are also an essential resource for specialist fields such as cancer research, drug development and the manufacture of state-of-the-art semiconductors and other electronics. As we move towards a more digitalised society these processes will gain further importance and require clean power to ensure that they can operate in a zero-emission way.

Increased energy security is another key benefit of greater access to renewable generation potential that is located both on and off the shores of Great Britain, providing an opportunity for us to increase Great Britain's self-sufficiency and reducing our reliance on imported gas. This can be further improved through flexible grid-scale solutions such as electrolysis and new pumped hydro which will allow us to capture abundant renewable energy that would otherwise not be utilised and allow us to store up this energy across multiple seasons.

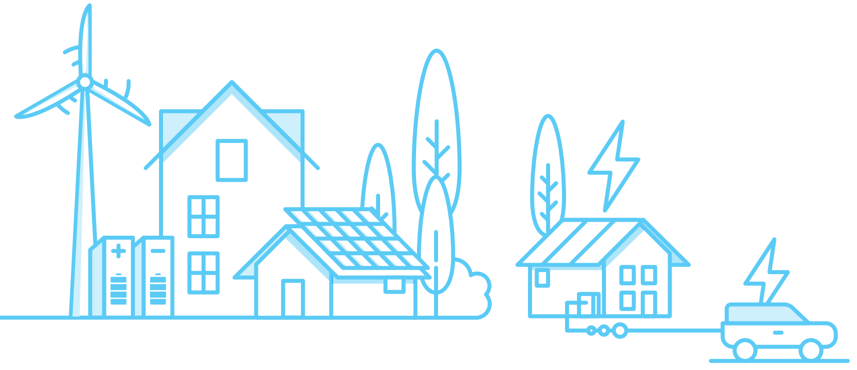
Underpinning all these developments will be a generational shift in creating, maintaining, and improving on our net-zero work force across Great Britain.

The role of strategic, flexible demand

Strategic demand is strategic in the sense that it can be located and operated in a way that is beneficial for the operation of the electricity system or that can improve our design against our Holistic Network Design objectives. Flexible demand is any electrical demand that can respond at short notice, increasing or decreasing its requirements to support the operation of the electricity system. The combination of these two elements allows for placement of demand which can be changed to suit the requirements of the electricity network, reducing overall network running costs.

Flexible demand can be delivered in many ways, with one notable existing example being pumped hydro power stations. This type of plant generates electricity by releasing water from an elevated reservoir to turn a turbine, but it also requires electricity to pump water back up to refill the reservoir. Examples of strategic flexible demand can also include the development of energy intensive industries such as data centres which can adjust when they complete electricity intensive background tasks, 'shifting' the demand to a different time or 'smoothing' out peaks in demand. Alternatively, the production of 'green' hydrogen (producing hydrogen with electricity from renewable sources) can also flex its requirements for electricity.

Strategic, flexible demand plays a major part in our recommendations by reducing, but not eliminating, the need to establish new north to south transfer capability in the electricity transmission system. For the first time, we have also conducted analysis where we simulate the most complementary way in which future strategic demand growth could happen.



Beyond 2030 / National Blueprints / Beyond 2030 National Blueprint 43

Beyond 2030 National Blueprint

Our modelling determined the optimal placement of future large-scale demand sources in each year. It identified these locations with the aim of minimising the cost to consumers by reducing congestion on the electricity system. In summary, this recommends that demand for electricity is placed closer to where it is produced to reduce congestion across the system.

Our analysis reaffirms the assumptions made within our holistic design process that pairing weather dependent generation capacity with strategic and flexible demand can be of great benefit to the transmission system. Our planning processes already assume a 5 GW increase in demand in Scotland as our energy landscape evolves between now and the mid 2030s. In addition to this assumption, our analysis shows that locating an additional 5 GW of flexible demand (a 10 GW demand increase in total) behind transmission bottlenecks within Scotland could save consumers £5 billion and may avoid the need for some network reinforcements such as additional subsea circuits from Scotland to England or Wales, and the associated infrastructure this could bring. The maximum benefit from adding strategic, flexible demand to the existing energy system (as shown in green on the colour scale), can be found by locating this additional demand in the north of the electricity network, with increasing benefit the further north it is placed. This is driven by the large volumes of renewable generation capacity and relatively smaller network capabilities within Scotland and the North of England.

Opportunities to locate significant hydrogen production capability in the north may also link with establishing a national hydrogen transmission system which may include repurposing of specific parts of the existing national gas transmission system which begins in the North East of Scotland. In the future, this system could deliver significant quantities of storable energy throughout Britain in the form of hydrogen.

Our analysis at this stage is indicative, but it outlines the clear benefit of locating more strategic flexible demand in the north of Great Britain. This is one of the first steps in our journey to operating a whole energy system. Over the coming years we will be looking to optimise the electricity and gas networks to deliver a holistic and efficient, multi-energy transmission system through our role as the National Energy System Operator (NESO).

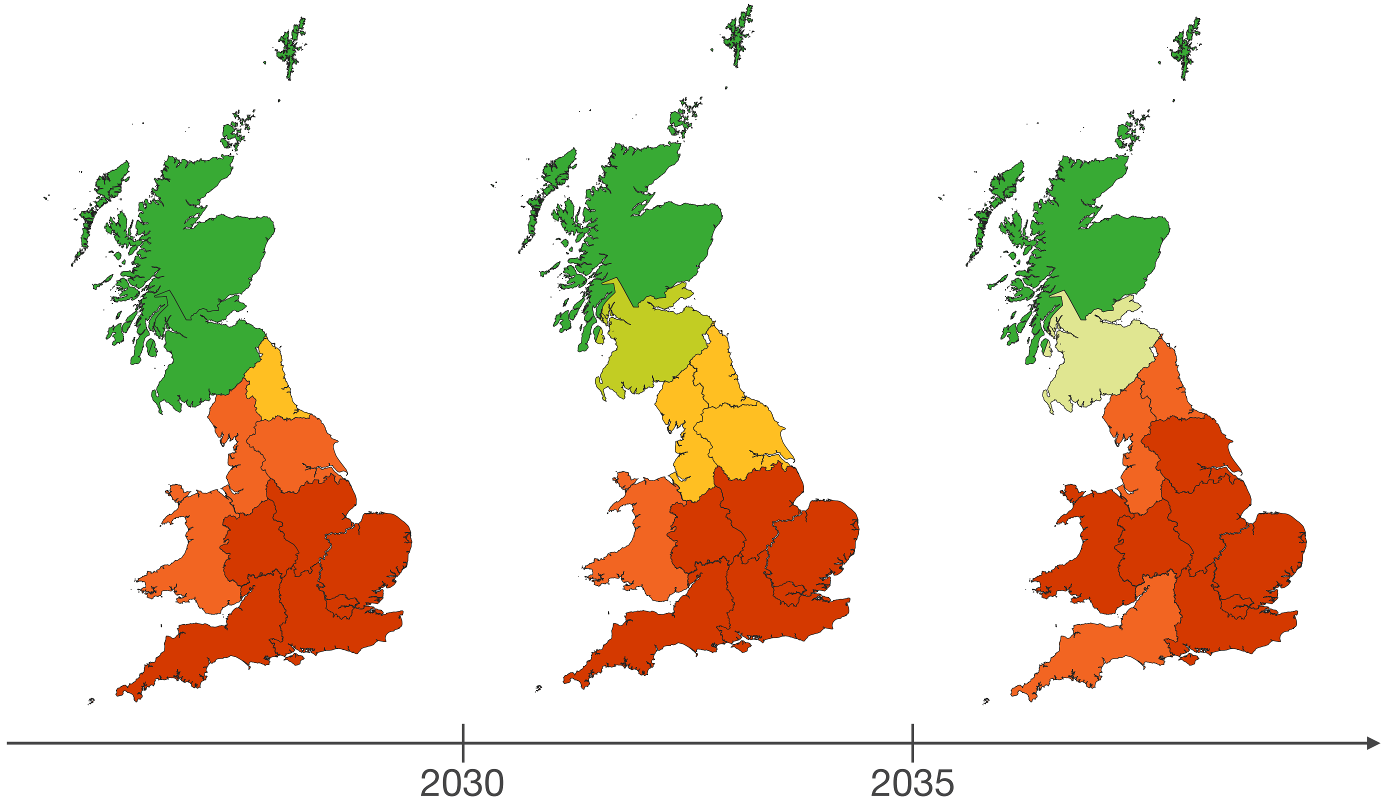


Figure 11. Strategic demand heatmaps across 2025, 2030 and 2035

Beyond 2030 / National Blueprints / Beyond 2030 National Blueprint 44

Regional Blueprints

ESO

Introduction

Each region has a different role to play in Great Britain's clean and secure energy future and the benefits from this investment have the potential to be felt across the country.

The UK Government's independent review of net zero[6] showed that the transition presents the growth opportunity of the 21st century, with the potential for prospects to be realised across Great Britain, through both direct and indirect benefits. Direct benefits include the ability for Great Britain to be more self-sufficient for its electricity needs, with lower costs to consumers and a cleaner energy mix, while indirect benefits could be far reaching such as jobs, supply chain opportunities, more supportive environments for businesses, and regeneration projects.

Importantly, every region is different and the infrastructure that is needed for a secure and clean electricity grid will vary. This is because each part of the network sees different power flows, has different existing infrastructure, and different amounts of generation and demand. It also means that the options available for us to consider in each region will vary. Not all options are available in all areas and differences in geography, pre-existing infrastructure and energy demand mean that each region requires a bespoke approach.

While economic growth will be felt in each region, a large amount of benefit will be felt in Northern England, the English Midlands, and Northern Scotland, supporting those communities directly through the transition to a net-zero economy while also contributing to growth for Great Britain as a whole.

Independent analysis commissioned by us as the Electricity System Operator (ESO) suggests that by 2035, the recommendations in this report could add up to £15 billion to the UK economy and support an average of 20,000 jobs each year. A third of these benefits (£5.2 billion to 2035 and over 6,000 jobs per year) are likely to be in Scotland, with 90 per cent of these benefits occurring outside London and the South East. The research also forecast significant benefits to the manufacturing and construction industries, with half of the jobs supported in manufacturing (such as iron and steel). A further 30 per cent of jobs are in the construction industry.

6 gov.uk/government/publications/review-of-net-zero

Beyond 2030 / Regional Blueprints / Introduction 46

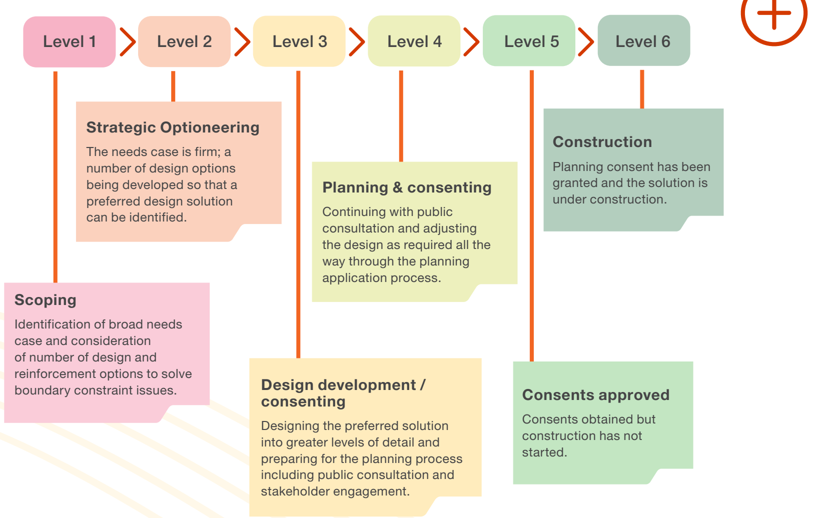
Regional Blueprint – Introduction

How to read this chapter

This chapter is divided into sections, each focusing on a different region or country. Each section shows the background behind the current electricity network in that area, how it fits into the national picture, and the required infrastructure we have identified. It also looks at the benefits each area can receive from Great Britain's secure, net-zero energy future.

As our recommendations include a range of solutions at different stages of development, we have included a key in our recommendation tables that indicates a project's maturity level. These maturity levels are intended to provide a high-level view. Each project is on its own development path and will sit at smaller sub-steps within these maturity levels. A summary of each of the maturity levels and a brief description is provided below.

Communities will be consulted by industry when these recommendations become more refined. For recommendations with low maturity, we expect industry to present an array of alternative options to communities through the consenting process.



Click on a region name to jump straight to the relevant section or see each section in turn by scrolling through the document.

Beyond 2030 / Regional Blueprints / Introduction 47

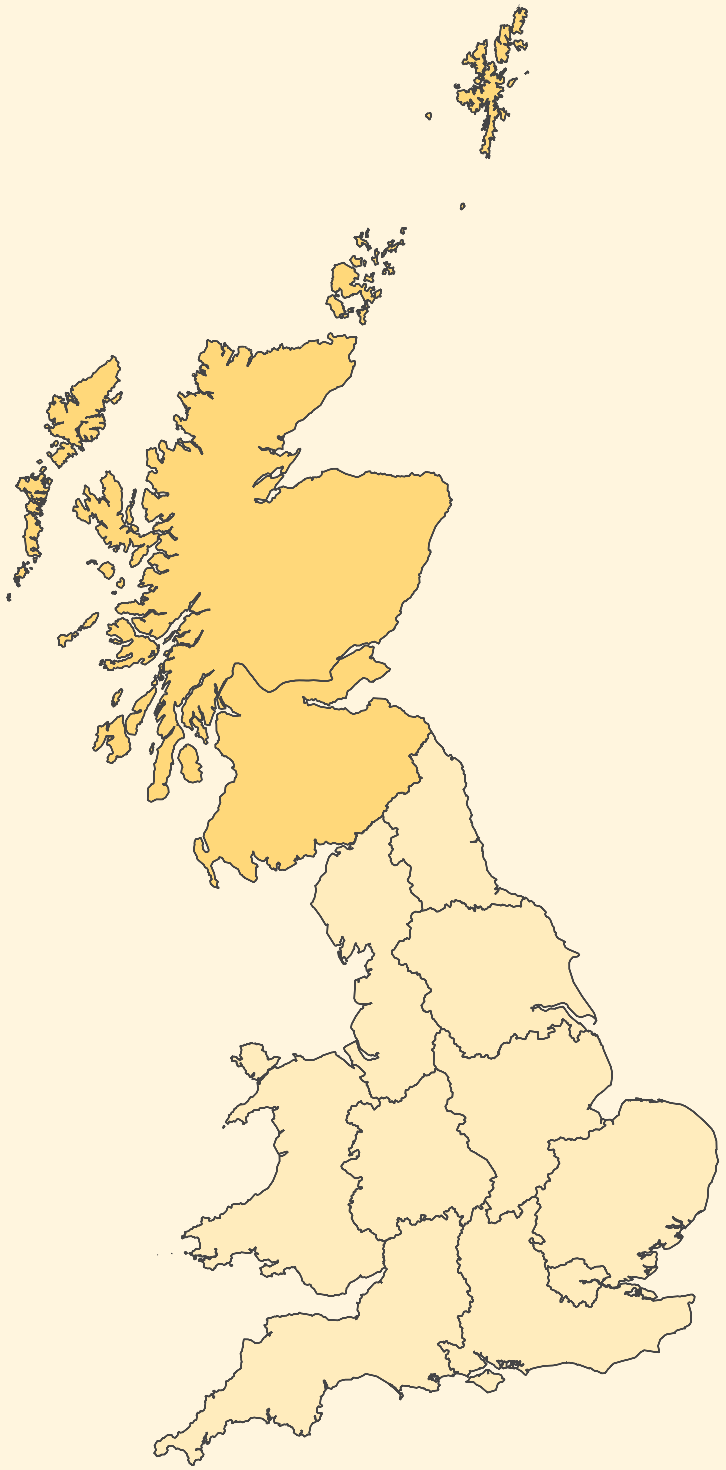
Scottish Government Policy and Background

From powering the aluminium smelting plants of the late 19th century to bringing power to Highland communities for the first time in the middle of the 20th century and powering the transition to net zero in the 21st century, Scotland has a long and distinguished history in the energy sector.

Today, Scotland has a world leading commitment to reach net zero by 2045, a goal currently only matched by one G20 country – Germany. This ambition is supported by stretching renewable deployment ambitions, which have the potential to aid not only Scotland's legally binding commitments but those of Great Britain as a whole. Progress has been swift for the decarbonisation of electricity generation in Scotland, and over the last 10 years the country has seen the closure of its remaining coal fired power stations, with only a handful of fossil fuel fired power stations remaining. This reduction in fossil fuel generation has been replaced with renewables and, as of Q2 2023, Scotland has nearly 15 GW of operational renewable capacity deployed including nearly 9.5 GW of onshore wind.[7]

Importantly, despite these seismic changes, there is not a lack of electricity generation capacity, as electricity demand in Scotland is relatively small compared to the country's generation capabilities. In the first half of 2022, the average hourly demand for all of Scotland was just over 3 GW, with a winter peak of around 5 GW. The crucial change is that this power is now coming predominately from renewable generation projects with wide variations in generation capacity.

The Scottish Government wants to go further, with the *2022 Onshore Wind Policy Statement* setting an ambition for 20 GW of onshore wind in total by 2030. New and revised ambitions are also being considered for other renewable technologies, such as offshore wind and solar, through the development of the Scottish Government's *Energy Strategy and Just Transition Plan*.[8] Following consultation last year, the final strategy is due to be published by summer 2024.



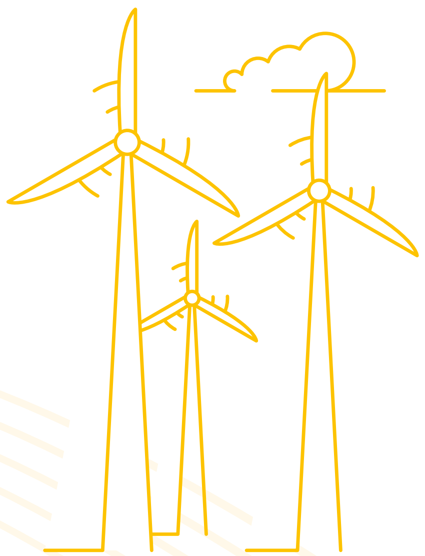
7 scotland.shinyapps.io/sg-scottish-energy-statistics/?Section=RenLowCarbon&Subsection=RenElec&Chart=RenElecCapacity
8 gov.scot/publications/draft-energy-strategy-transition-plan/

Beyond 2030 / Regional Blueprints / Scottish Government Policy and Background 48

Scottish Government Policy and Background

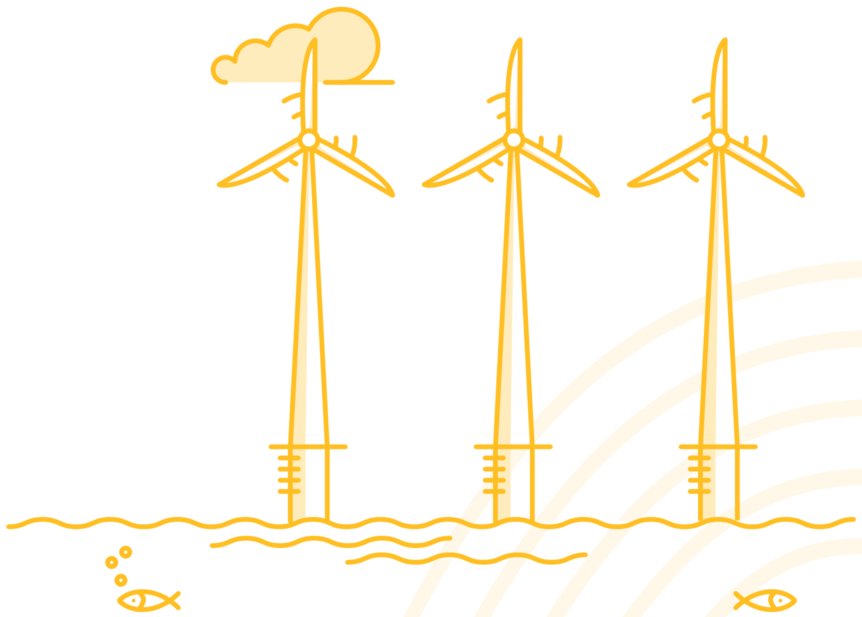
There is also a strong focus on ensuring a Just Transition, which provides the maximum benefits to Scotland's workers and communities. In 2021, Crown Estate Scotland (which is a devolved body, separate from The Crown Estate organisation that has responsibility for the rest of the UK) leased nearly 28 GW of offshore wind capacity in the ScotWind leasing round. This capacity has the potential to meet almost half of Great Britain's peak electricity demand that we see today (around 58 GW). The renewable power potential is not the only advantage to the programme; lease fees and the potential for supply chain benefits also provide wider advantages to the economy of Scotland (and of Great Britain as a whole).

To achieve these ambitious targets, the electricity network in Scotland will need to expand significantly to ensure that the power produced can flow to centres of demand. In addition to considering how to expand the capacity of the network in Scotland, our analysis is also considering the potential of locating strategic flexible demand in the region, such as hydrogen production facilities to reduce the need for transmission infrastructure.



Given the extraordinary pace and scale of offshore wind development in Scotland, the UK Government asked us to carry out analysis to determine if coordinating the connections of certain wind farms could be beneficial to consumers and communities. We also holistically assessed the rest of the transmission network across Great Britain to ensure that our recommendations took all circumstances and a diverse range of scenarios into account. We found that coordination of connections was not beneficial in every situation, due to cost, environmental impact, and the very large size of some offshore wind developments (which can limit the possibility of coordination due to the capacity of currently available cables).

The upgrades to the grid across Scotland will enable the country to realise its full potential as a renewable energy powerhouse, providing benefits and opportunities for the Scottish economy and supporting communities across Great Britain as they transition away from a reliance on fossil fuels to the next stage of decarbonisation.



Beyond 2030 / Regional Blueprints / Scottish Government Policy and Background 49

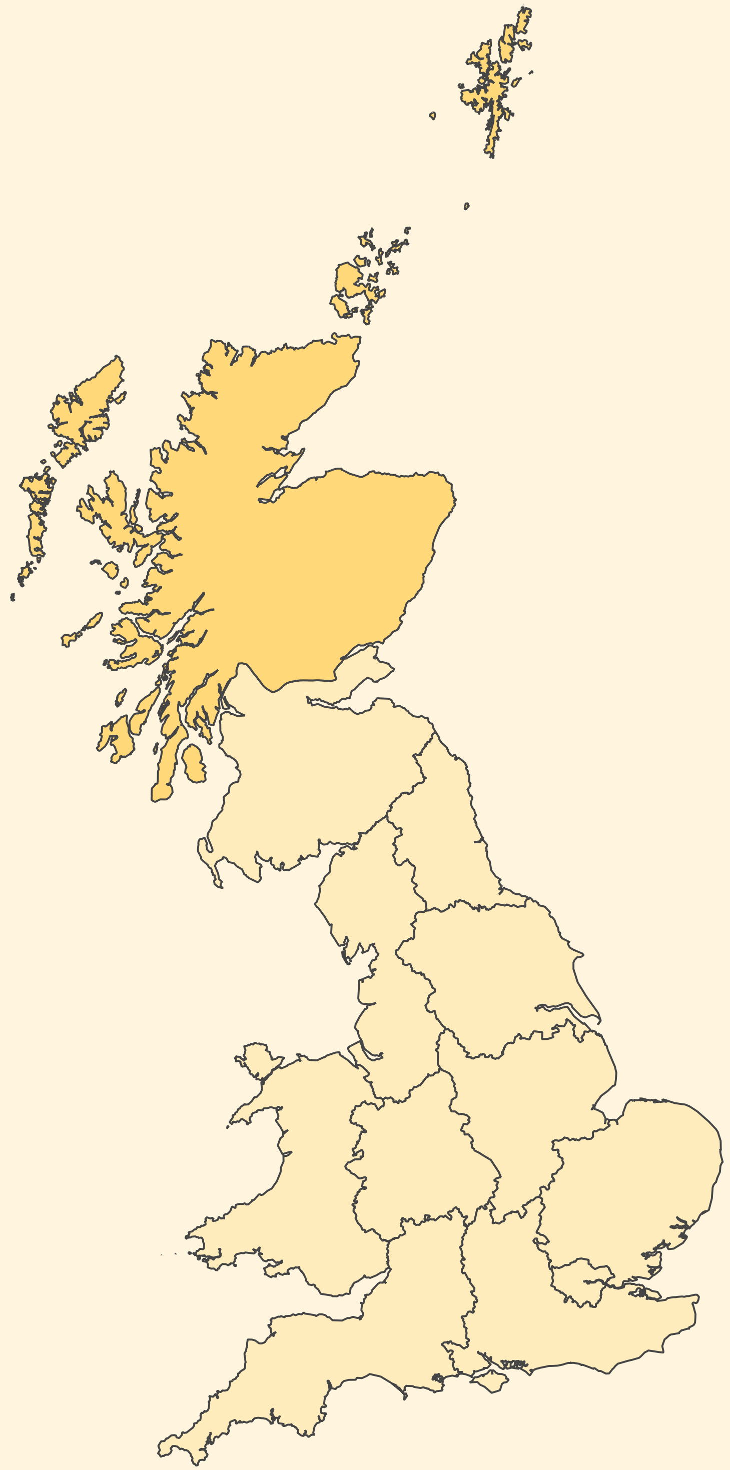
North of Scotland

In previous decades and to the present day, the oil and gas industry has dominated the economy of the North East of Scotland. Recent decisions and investments, however, have seen a transition away from oil and gas, towards renewables – with a strong focus on decarbonisation.

The North of Scotland region covers the area of the transmission network owned and maintained by Scottish and Southern Electricity Networks (SSEN) – starting at the northern coast of the country and reaching down towards Perth.

In addition to its already mature onshore wind industry, the offshore wind industry has found a home in the region's waters – the area's high wind levels and skilled workforce have made it a trailblazer in offshore wind development, with a reputation for innovation. For example, Hywind Scotland was the world's first commercial wind farm to use floating wind turbines and was commissioned in 2017. This was followed by the Kincardine floating offshore wind farm, which was the third ever commercial floating wind farm in the world, with the North of Scotland now home to half of the world's pioneering floating commercial wind farms.

This innovation has also included considering how to decarbonise the operations of oil and gas platforms while energy from fossil fuels is still required. In 2022, Crown Estate Scotland launched the INTOG (Innovation and Targeted Oil & Gas) offshore wind leasing round, aiming to boost innovation, develop technologies (such as floating wind turbines), and reduce carbon emissions from offshore oil and gas extraction by connecting wind farms to offshore platforms (reducing the need for massive diesel generators). The leasing round generated significant interest, and at least 13 projects (totalling over 4 GW of capacity) have been offered exclusivity agreements.



Beyond 2030 / Regional Blueprints / North of Scotland 50

North of Scotland

The existing transmission network in the region will need significant investment to manage the considerable electricity flowing from these new generation sources. This is in part because the region has traditionally had relatively low power needs and generation capability and so most of the transmission infrastructure in this region operates a significantly lower voltage compared to the rest of Great Britain, meaning the power lines are unable to transport as much electricity as the transmission network in the rest of Great Britain.

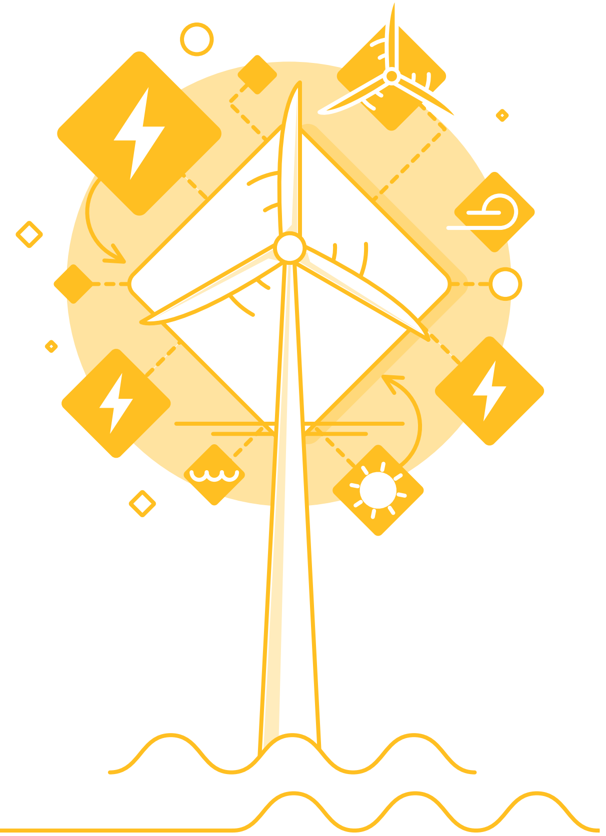
To achieve the required grid capacity in the region, existing circuits will need to be upgraded to use high capacity 400 kV conductors and some new circuits will also need to be built. Many of these circuits can be located offshore, as ‘superhighway’ links that run along Great Britain’s east coast to other parts of the country, but this is either not suitable or possible for all circuits – with offshore environmental constraints (such as Marine Protected Areas) restricting available offshore options. Our appraisal process weighs up which is the appropriate solution (be it upgrading or establishing new onshore, or offshore infrastructure) for a location based on our four design criteria.

In some cases, both solution types are required. An example of this is the new circuits being recommended between Caithness and Peterhead for 2030. Before ScotWind was announced, our previous recommendations had used the Scottish Government ambition that there would be 11 GW of offshore wind capacity in Scotland by 2030. This led us to recommend either the construction of an offshore link between the two points, or a series of onshore circuits along the north coast of Scotland. Following the significant ScotWind leasing announcement, we, in conjunction with the Transmission Owners (TOs), have found that both sets of solutions are now required to maintain a secure and reliable system.

Our previous recommendations for 2030 also included upgrades and additions to the existing transmission infrastructure throughout Scotland to complement the large volumes of offshore power landing across the north coast of Scotland. These will improve the capability of the existing network to move power from the north to the south of Scotland along both the west and east coasts.

For the first time, our offshore network design has included an assumption of major strategic demand being developed in the North of Scotland throughout the 2020s and the early 2030s. This can serve to reduce the requirements for new electricity transmission network build in the 2030s and beyond if the abundant renewable electricity is consumed locally. Solutions such as green hydrogen production (electrolysis) could meet this requirement. All our subsequent recommendations are predicated on stimulating this level of strategic demand within the North of Scotland.

To facilitate further offshore wind capacity off the North East of Scotland, this plan has identified that it is necessary to further strengthen the network in the area. This will require additional, high-capacity pylon routes to transport power from the coast to the existing transmission corridors. This is needed to handle the massive volumes of renewable electricity being generated and to ensure that the network is secure regardless of conditions. These conditions can include planned outages, where parts of the network are routinely taken out of service for scheduled maintenance, or for connecting new demand customers to the transmission system.



North of Scotland

Large parts of this future offshore capacity will be coordinated via a series of offshore circuits that will link Peterhead in the North of Scotland with the Torness area in the South of Scotland via four major wind farms. This will serve to reduce the number of landing points to shore, reducing the cumulative impact of new offshore cable landing points on coastal communities.

In addition to this, our recommendations include a high voltage direct current (HVDC) link between Shetland and mainland Great Britain. This will provide the isles with a second link to the mainland network (with the first becoming operational this year) and efficiently coordinates the local offshore wind farms. This has the potential to reduce the reliance on diesel back-up generation and enable further renewable developments in the archipelago. We can also see the value of locating more strategic demand on the Shetland Islands, which has the potential to contribute to the local economy.

The Western Isles currently have a small electricity link to the mainland which has enabled some renewable generation to be developed on the isles already. The opportunity has also been identified to connect offshore wind farms to the isles necessitating more connectivity. Our first holistic network design for 2030 identified that the Western Isles was a suitable landing point for one of the wind farms north of Lewis. Subsequently, our second holistic network design also recommends that the neighbouring wind farm also connects into the Western Isles.

Finally, our analysis has identified the potential need for a new, high capacity electrical ‘spine’ capable of transmitting large volumes of electricity from the North of Scotland, through to the North West of England. Without a high-capacity solution, electrical constraints within the region would result in growing costs to consumers across Great Britain. This lack of capacity could also mean that renewable generators may be sitting idle much more frequently, unable to generate clean energy that could be used.

Beyond 2030 / Regional Blueprints / North of Scotland 52

North of Scotland

Our recommendation for a new electrical spine is in its very first stage of development, but the concept of such a spine will be crucial to handling the influx of power from offshore wind from off the north coast of Scotland. Alternative offshore solutions have been explored and tested; however, based on initial assessments, the proposed solution outperformed them against all design criteria. Onshore solutions also offer additional benefits. Establishing new substations along the route allows for the connection of additional onshore generators (diversifying supply within Scotland and beyond) and the demand supply points that power local networks and communities.

Further detailed design development will now be undertaken by the TOs to understand and complete appraisals on viable solutions, including additional offshore reinforcements. In addition, we are currently working closely with the TOs to produce a future network design to integrate the recent outcomes of the Crown Estate Scotland's INTOG leasing round. More information on this will be published when our assessment has concluded.

The map in this section provides a visual summary of the blueprint for the region. It shows our new recommendations, our recommendations made in previous network planning processes, and other works. This section of the report is interactive, providing the opportunity for readers to explore in more detail the specifics of any new recommendations in the region.

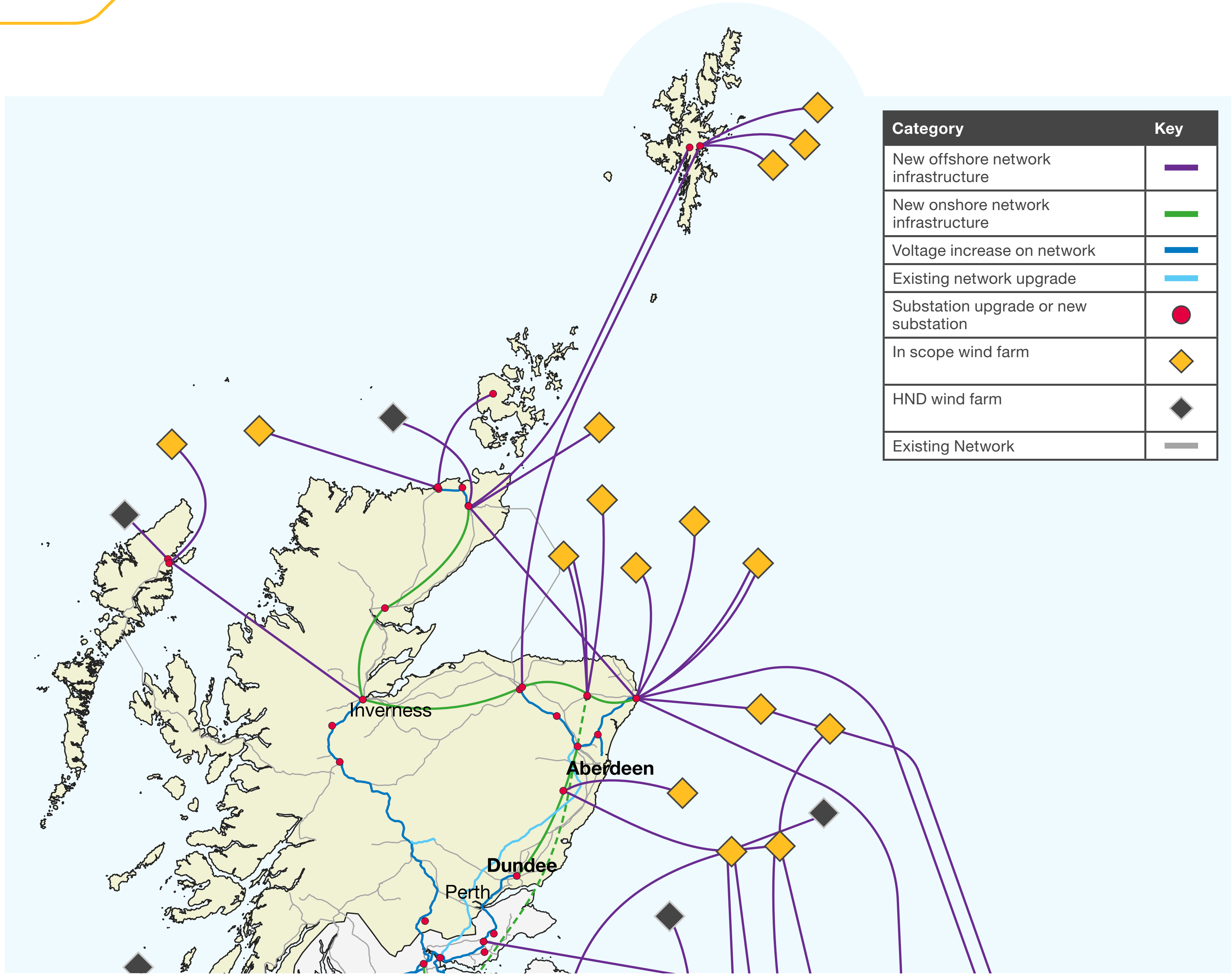


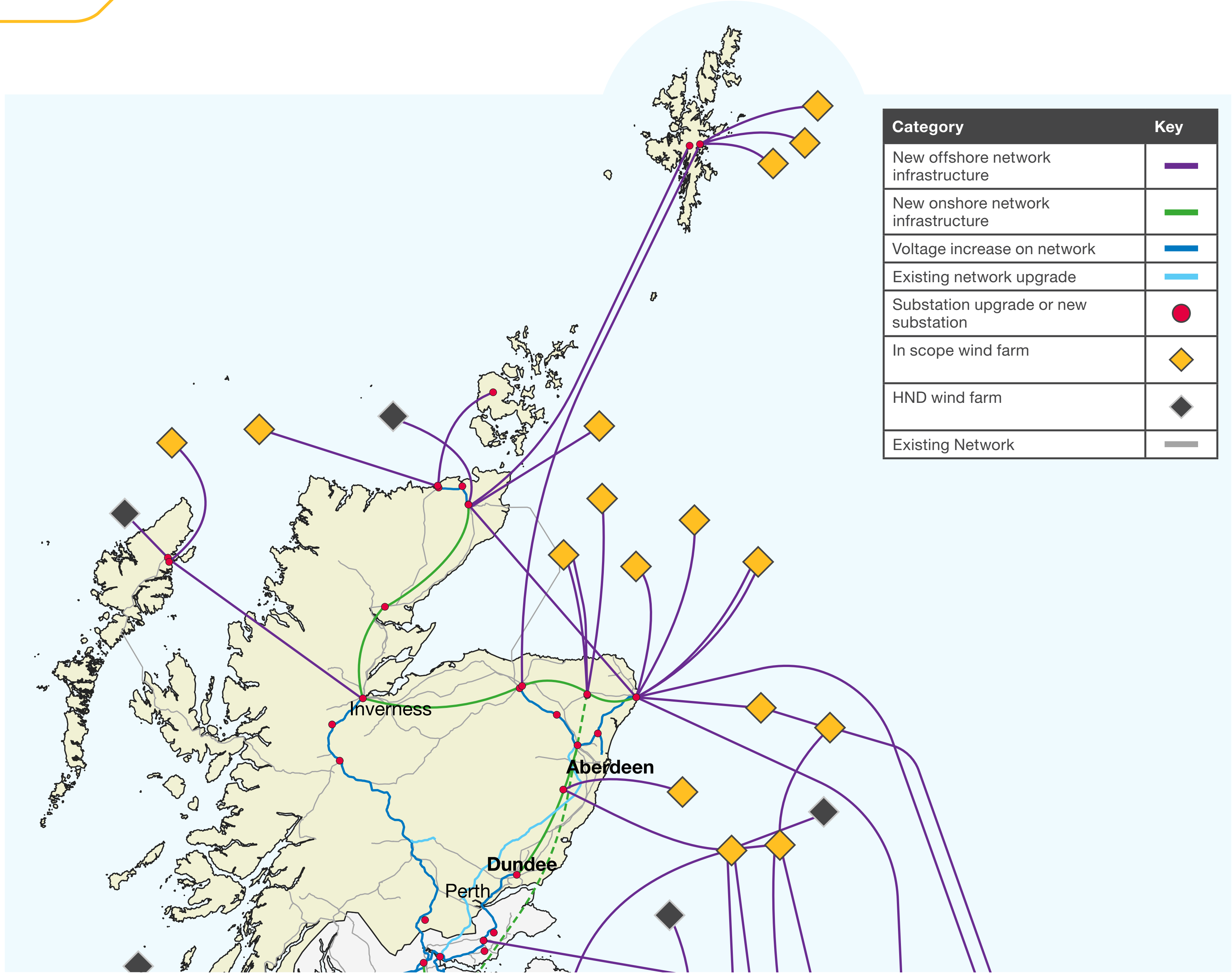
Figure 12. Map of all reinforcements in the North of Scotland region

*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

North of Scotland

New infrastructure

Code	Description	Maturity Level
NHNC	New circuit from north east Scotland to the Central Belt	■□□□□□
NNNC	New circuit between New Deer and Greens (New Deer 2)	■■■■□□
Shetland Hub	Offshore network cable connecting wind farms in Shetland to the Scottish mainland	■■□□□□
SW_E1c_1 to SW_E1c_2	Offshore network cable interconnecting platforms within the SW_E1c wind farm	■■□□□□
SW_E1c_2 to SW_E1a	Offshore network cable interconnecting the SW_E1c and SW_E1a wind farms	■■□□□□
SW_E2a_1 to SW_E2a_2	Offshore network cable interconnecting platforms within the SW_E2a wind farm	■■□□□□
SW_E2a_2 to SW_E1c_1	Offshore network cable interconnecting the SW_E2a and SW_E1c wind farms	■■□□□□
SW_E2b	Offshore network cable from a coordinated series of wind farms connecting to Longside (Peterhead 2)	■■□□□□
SW_E2b to SW_E2a_1	Offshore network cable interconnecting the SW_E2b and SW_E2a wind farms	■■□□□□
SW_E3	Offshore network cable from a single wind farm connecting to Hurlie (Fiddes)	■■□□□□
SW_N2	Offshore network cable from a single wind farm connecting to Dounreay	■■□□□□



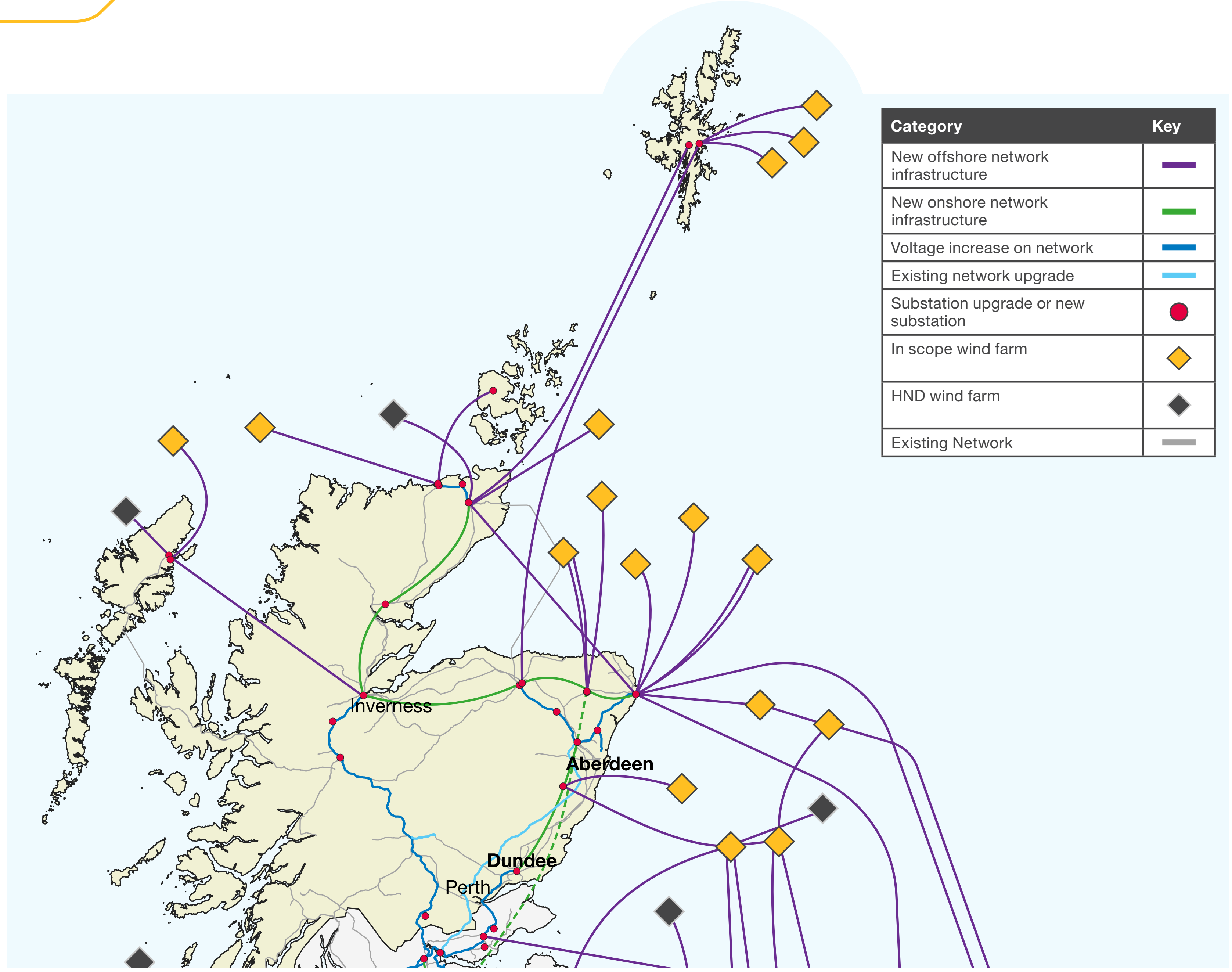
*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Beyond 2030 / Regional Blueprints / North of Scotland 54

North of Scotland

New infrastructure continued

Code	Description	Maturity Level
SW_N3	Offshore network cable from a single wind farm connecting to Lewis	
SW_NE1a	Offshore network cable from a single wind farm connecting to Shetland	
SW_NE1b	Offshore network cable from a single wind farm connecting to Shetland	
SW_NE1c	Offshore network cable from a single wind farm connecting to Shetland	
SW_NE2	Offshore network cable from a single wind farm connecting to Banniskirk (Spittal)	
SW_NE3	Offshore network cable from a single wind farm connecting to Greens (New Deer 2)	
SW_NE4	Offshore network cable from a single wind farm connecting to the New Deer area	
SW_NE6	Offshore network cable from a single wind farm connecting to Longside (Peterhead 2)	
SW_NE7	Offshore network cable from a single wind farm connecting to Longside (Peterhead 2)	
SW_NE8	Offshore network cable from a single wind farm connecting to Peterhead	



*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

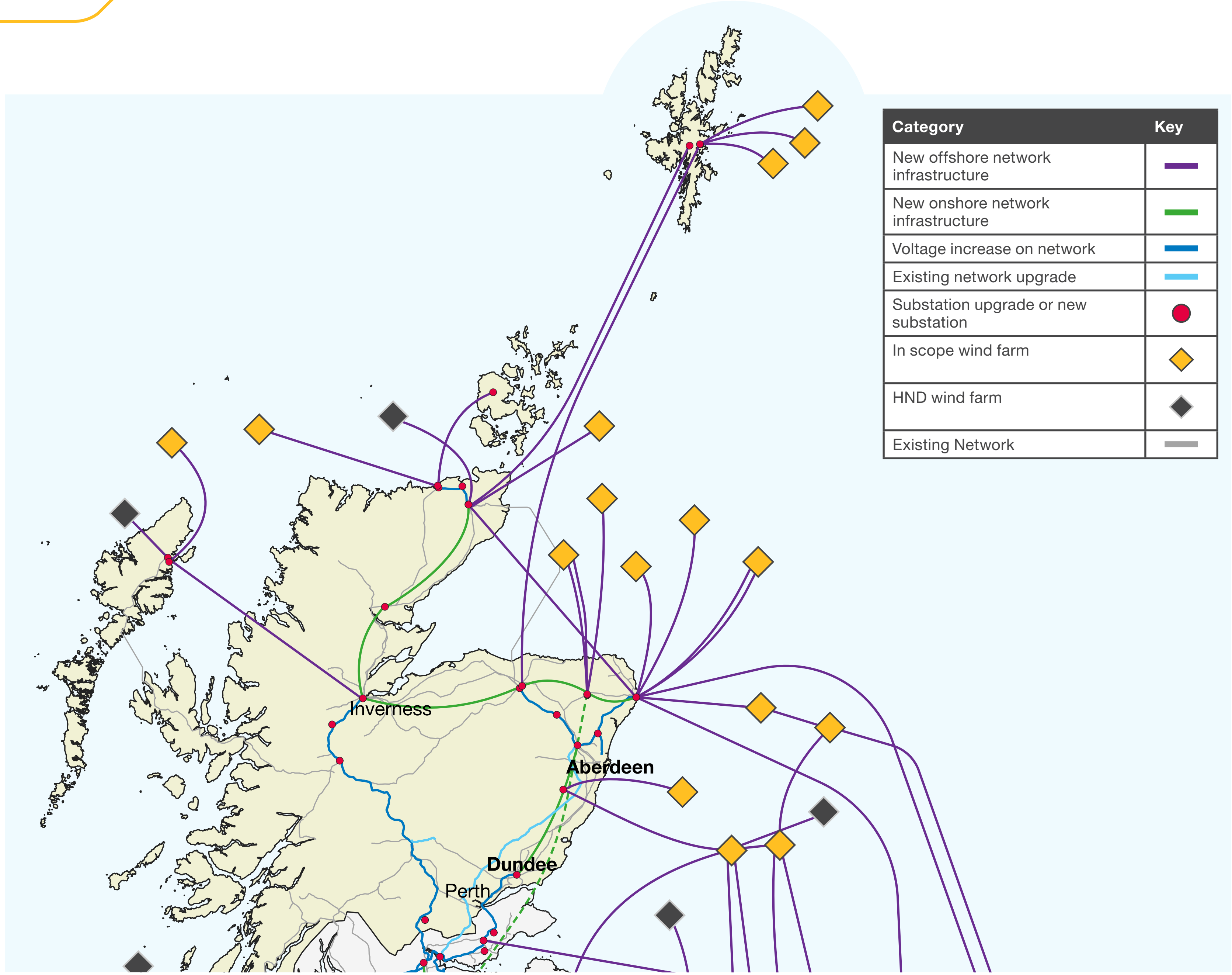
Click code for further information

Beyond 2030 / Regional Blueprints / North of Scotland 55

North of Scotland

New upgrades

Code	Description	Maturity Level
BKUP	Upgrade the existing network to a higher voltage between Blackhillock and Kintore	■■■□□□
DSUP	Establish further connection capacity between Dounreay, Banniskirk (Spittal), and Thurso	■■■□□□
ECRE	Replace the conductors on a short section of the existing circuit between Errochty and Clunie with higher capacity conductors	■■■□□□
PKUP	Upgrade and/or rebuild the circuits and equipment between Longside (Peterhead 2), Peterhead, Persley, Kintore, Fetteresso, Alyth, and Kincardine	■■■□□□



*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Beyond 2030 / Regional Blueprints / North of Scotland 56

Beyond 2030 / Regional Blueprints / North of Scotland 57

North of Scotland

The following reinforcements have previously been recommended for this region.
For more information on these options please see the ESO's Pathway to 2030 publication.[9]

Previously recommended

Code	Description	Maturity level
BBNC	New circuit between Beauly and Coachford (Blackhillock 2)	■■■■□□
BDUP	Upgrade the existing network to a higher voltage between Beauly to Denny	■■■■□□
BLN4	New circuit between Carnaig (Loch Buidhe) and Beauly	■■■■□□
BPNC	New circuit between Coachford (Blackhillock 2) and Peterhead	■■■■□□
E4D3	New offshore HVDC link between Peterhead and Drax (Eastern Green Link 2)	■■■■□□
E4L5	New offshore HVDC link between Peterhead and the East Coast of England (Eastern Green Link 3)	■■■■□□
PSDC	New offshore circuit between Banniskirk (Spittal) and Longside (Peterhead 2)	■■■■□□
SW_E1A_2	Offshore network cable from a coordinated series of wind farms connecting to Hurlie (Fiddes)	■■□□□□
SLU4	New circuit between Banniskirk (Spittal) and Carnaig (Loch Buidhe)	■■■■□□
SW_N1	Offshore network cable from a single wind farm connecting to Banniskirk (Spittal)	■■□□□□
SW_N4	Offshore network cable from a single wind farm connecting to Lewis	■■□□□□
SW_NE4	Offshore network cable from a single wind farm connecting to the New Deer area	■■□□□□
SW_NE7	Offshore network cable from a single wind farm connecting to Longside (Peterhead 2)	■■□□□□
TKUP	New circuit from Kintore to Emmock (Tealing) and upgrade elements of the existing Emmock to Westfield and Alyth to Emmock circuits	■■■■□□
Western Isles – Beauly HVDC link	New offshore circuit between the Western Isles and Beauly	■■■■□□

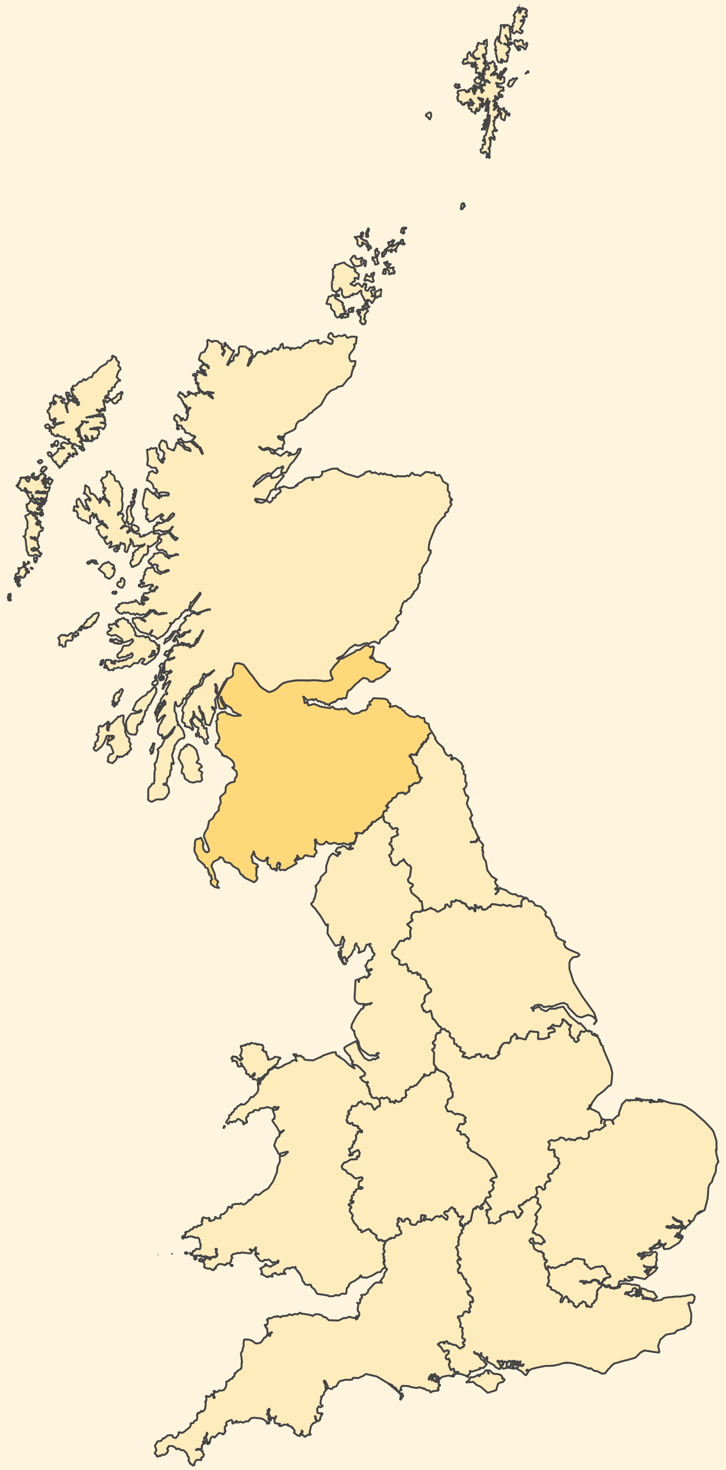
9 https://www.nationalgrideso.com/document/264656/download

Central and Southern Scotland

The Central and Southern Scotland region reaches from the Central Belt to the Anglo-Scottish border and reflects the footprint of the network owned and maintained by SP Transmission. It is a geographically diverse region covering the urban areas of Edinburgh and Glasgow, and the rural Southern Uplands.

As the level of energy ambition in Scotland scales up, existing challenges on the electricity network become more dominant. Currently, one of the most congested areas on Great Britain's electricity network is the area around the border between Scotland and England. This congestion is projected to get worse, and significant investment is required to ensure the system can be run in an economic and efficient manner. Without this investment, this one specific part of the network has the potential to cost consumers across Great Britain hundreds of millions of pounds per year. This is because, in the absence of the investment recommended, renewable electricity generated in Scotland will not be able to be moved to where it can be used because of these capacity constraints. This means that renewable generators in Scotland will have to be paid to turn off, while additional gas and other non-renewable generation would have to be switched on across the south of the network in order to balance supply and demand - but the recommended investments would heavily reduce the requirement to do this. If network capacity in the region is not improved, the costs to consumers and the amount of renewable electricity generators we would need to pay not to generate will grow year on year.

We are looking to address this congestion in part by designing a network that provides significant additional capacity using offshore cables (which was recommended, in part, by our previous network planning recommendations), reducing, although not avoiding, the need for new infrastructure throughout the Central Belt and Borders. We are also recommending further upgrades to the existing onshore system and new infrastructure to further increase transmission capacity.



Beyond 2030 / Regional Blueprints / Central and Southern Scotland 58

Central and Southern Scotland

As a result, we have long recommended the need to upgrade infrastructure in this region with significant offshore and onshore investments, with construction work on new HVDC infrastructure off the east coast due to commence next year. Our newest recommendations include an offshore wind farm connection into the East Lothian region, further increasing access to renewable electricity and enabling the best use of network capacity in the region. This coordination also provides another offshore route to the south of the network so electricity can be diverted away when there is congestion in Scotland.

Our recommendations also include the construction of multiple new substations – helping to connect more circuits together and improve network operability. These new substations also provide opportunities to connect future renewable electricity or strategic flexible demand projects, as well as meeting the forecasted growth in the demand for electricity.

As the North of Scotland hosts the majority of Scotland's offshore wind generation, there will be an increase in power flows from the North of Scotland towards the south and as such there will be a need to strengthen the capacity of the network between the north and south of Scotland to handle this volume of electricity.

To achieve this requirement, our recommendations include a new electrical 'spine' of upgrades and infrastructure. These projects are in their very first stage of development, but the concept of such a spine will be crucial to handling the influx of power from offshore wind from off the north coast of Scotland. Alternative offshore and onshore solutions have been explored and tested; however, based on initial assessments, the recommended solution outperformed them against all design criteria. Onshore solutions also offer additional benefits and establishing new substations along the route allows for the connection of additional onshore generators (diversifying supply within Scotland and beyond) and the demand supply points that power local networks and communities.

Beyond 2030 / Regional Blueprints / Central and Southern Scotland 59

Central and Southern Scotland

Map key

This spine builds upon previous recommendations for new circuit routes from the South West and South East of Scotland to the North West of England. This will provide significantly more capability across the Anglo-Scottish border. In addition to this, we are recommending that the capacity of western coordinated offshore network between Scotland and Wales is doubled. This solution is recommended as it has a smaller impact on the natural environment and communities because it can follow the route of the solution recommended in our holistic network design.

Further detailed design development will now be undertaken by the relevant Transmission Owners (TOs) to understand and complete further appraisals on viable solutions, including offshore and onshore routeing. It should be noted however, that to provide an equivalent capability increase to the network, several offshore circuits would be required (as opposed to a single onshore 'spine' of solutions), increasing the impact on the marine environment, and substantially increasing costs.

The map in this section provides a visual summary of the blueprint for the region. It shows our new recommendations, our recommendations made in previous network planning processes, and other works. This section of the report is interactive, providing the opportunity for readers to explore in more detail the specifics of any new recommendations in the region.

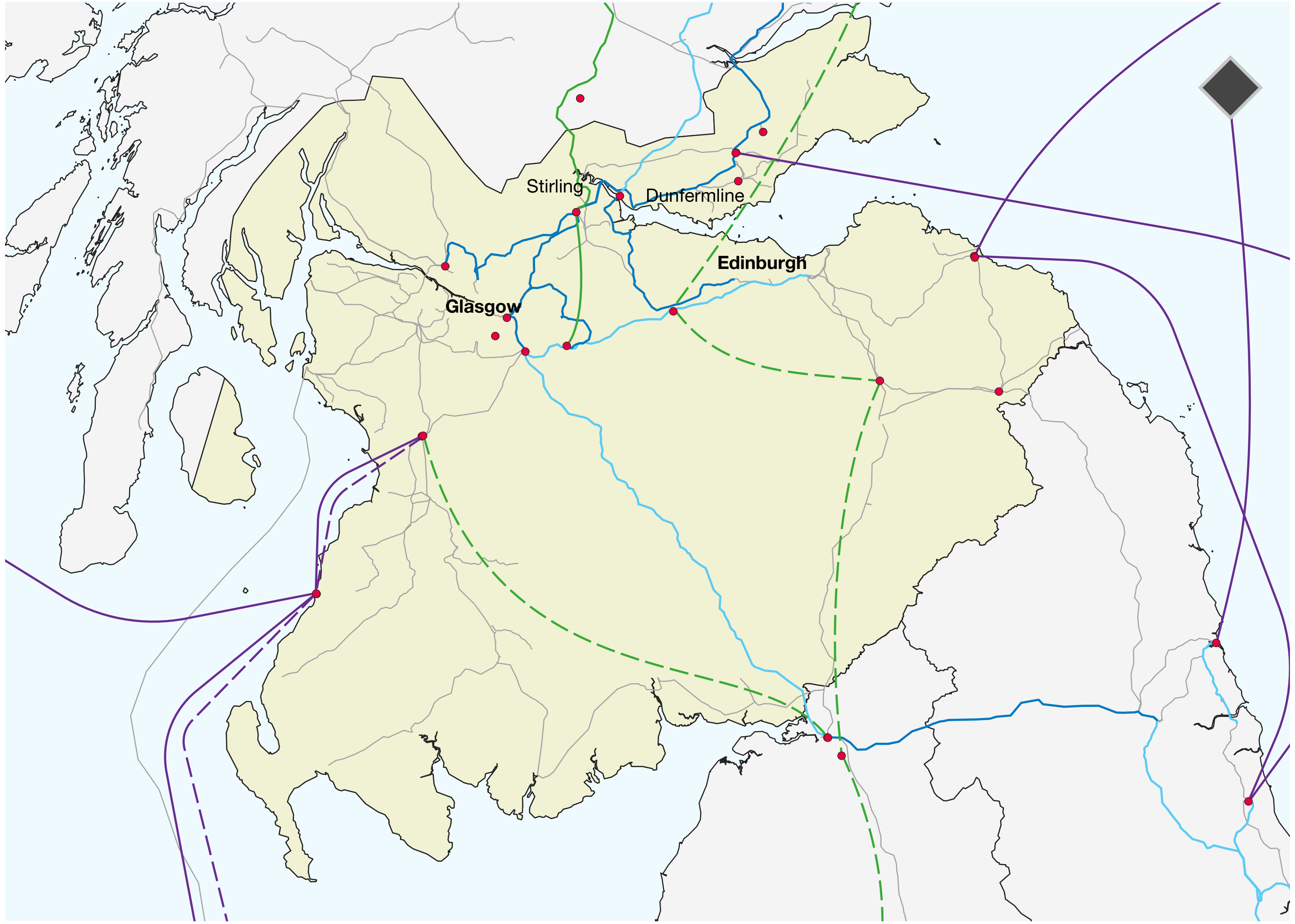


Figure 13. Map of all reinforcements in the Central and Southern Scotland region

*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Central and Southern Scotland

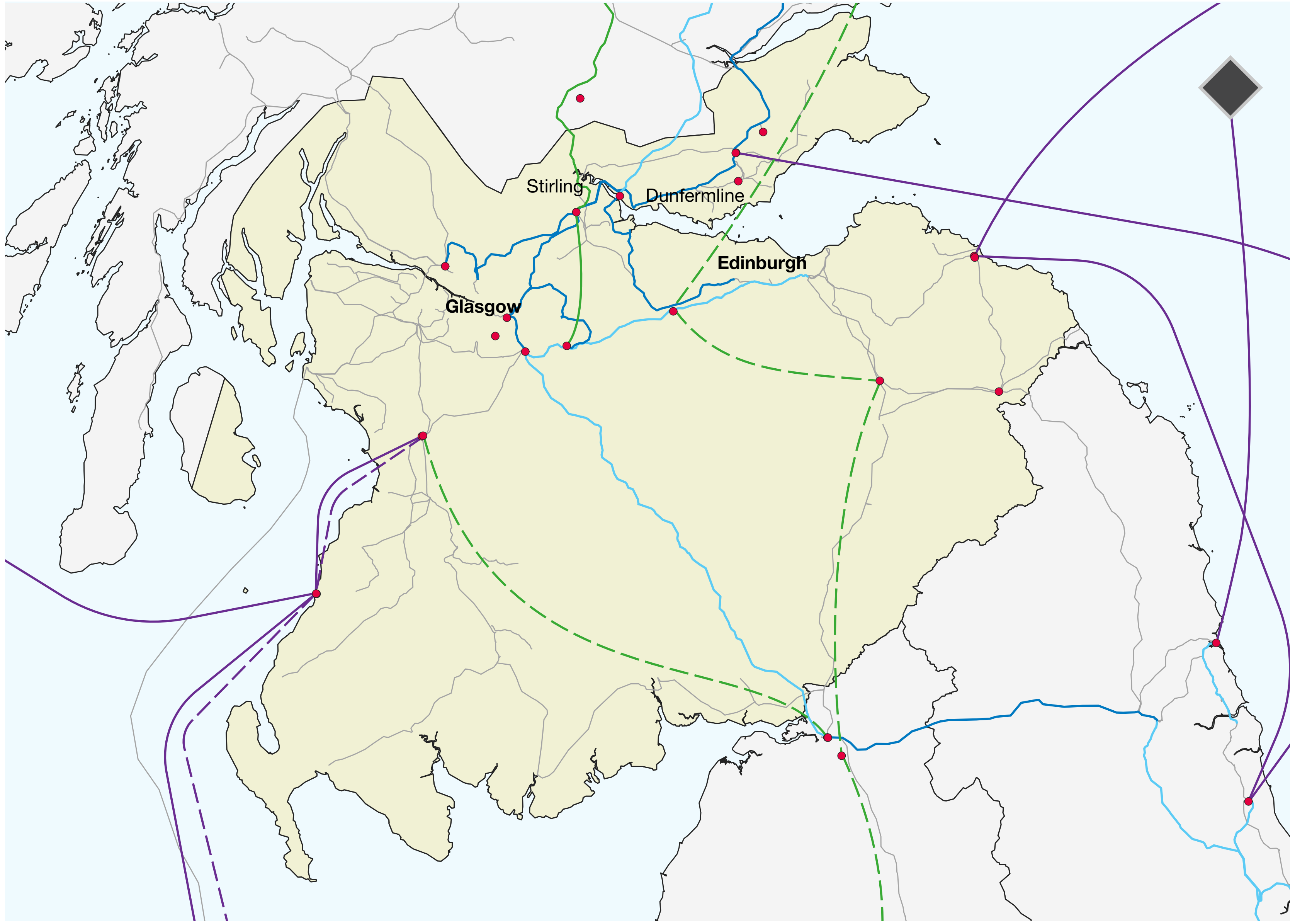
Map key

New infrastructure

Code	Description	Maturity Level
CMN3	New circuit between south east Scotland and north west England	1 of 6
HGNC	New circuit between Harburn and Gala North	1 of 6
NHNC	New circuit from north east Scotland to the Central Belt	1 of 6
SW_E1a	Offshore network cable from a coordinated series of wind farms connecting to the Branxton area	2 of 6
WCD4	Increase the capacity of the proposed HND1 West Coast offshore HVDC link between Scotland and Wales	1 of 6
WCN2	New circuit between south west Scotland and north west England	1 of 6

New upgrades

Code	Description	Maturity Level
CVUP	Upgrade the existing network to a higher voltage between Clydes Mill and Strathaven	1 of 6



*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Click code for further information

Beyond 2030 / Regional Blueprints / Central and Southern Scotland 61

Beyond 2030 / Regional Blueprints / Central and Southern Scotland 62

Central and Southern Scotland

The following reinforcements have previously been recommended for this region.
For more information on these options please see the ESO's Pathway to 2030 publication.[10]

Previously recommended

Code	Description	Maturity level
DLUP	Upgrade the existing network between Windyhill, Lambhill and Denny North, including increasing elements to a higher voltage	■□□□□□
DWNO	Upgrade existing circuits and establish a new route between Bonnybridge and Glenmavis	■■■□□□
DWUP	Upgrade the circuit between Kincardine to Wishaw, including increasing elements to a higher voltage	■■■□□□
E2DC	New offshore HVDC link between Torness and Hawthorn Pit (Eastern Green Link 1)	■■■■□□
EHRE	Replace the conductors on the existing circuit between Elvanfoot and Harker with higher capacity conductors	■□□□□□
LCU2	Adjust the existing network to form a circuit from Kincardine North towards Strathaven and Smeaton using existing pylon routes	■□□□□□
LWUP	Build a new substation north of Kincardine and connect this to Denny North	■■■□□□
SW_W1_1	Offshore network cable from a single wind farm connecting in south west Scotland, to enable power flow on two coordinated cables to Kilmarnock South and Pentir	■■□□□□
SW_W1_2	Offshore network cable allowing power flow between Kilmarnock South and Pentir, while coordinating with a wind farm connecting in south west Scotland	■■□□□□
SW_W1_3	Offshore network cable allowing power flow between Kilmarnock South and Pentir, while coordinating with a wind farm connecting in south west Scotland	■■□□□□
TGDC	New offshore HVDC link between east Scotland and the East of England (Eastern Green Link 4)	■■□□□□
TKUP	New circuit from Kintore to Emmock (Tealing) and upgrade elements of the existing Emmock to Westfield and Alyth to Emmock circuits	■■■■□□
VERE	Replace the conductors on the existing circuit between Strathaven and Elvanfoot with higher capacity conductors	■□□□□□
VSRE	Replace the conductors on the existing circuit between Strathaven and Smeaton with higher capacity conductors	■□□□□□

10 https://www.nationalgrideso.com/document/264656/download

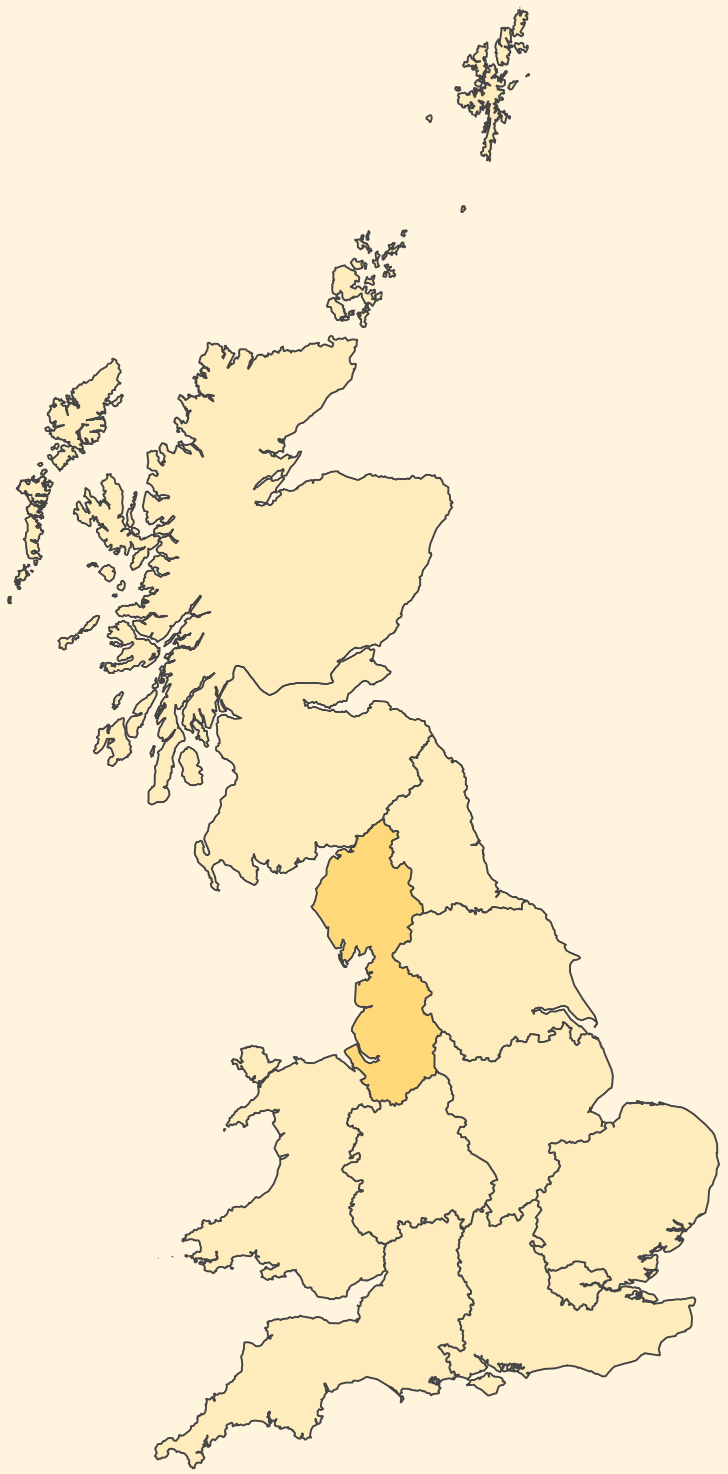
North West

The North West is a region with a strong industrial and rural heritage. As the area which built the Royal Navy's first submarine, hosted the UK's first nuclear power station and the first canal of the industrial revolution, the North West's proud history in manufacturing and innovation will enable it to play a key role in facilitating the net-zero transition.

The North West of England is a region of incredible diversity ranging from the grandeur of the Pennines and the Lake District National Park which has inspired countless authors and poets, to the metropolitan hubs of Manchester and Liverpool further south, home of 1990s Britpop. The region is also famous from an energy perspective, being the birthplace of the modern nuclear energy industry, with Calder Hall, the first nuclear power station in Great Britain in 1956.

The urban areas of the North West have been highly industrialised since the industrial revolution with slate quarries, textile manufacturing, defence and shipbuilding all key parts of the region's history.

Today, the defence and energy industries continue to have a large presence in the North West, for example in Barrow-in-Furness which is currently home to the Dreadnought class submarine programme. This sector employs tens of thousands of people across the region, and thousands more across Great Britain and has a need for large volumes of secure power.



Beyond 2030 / Regional Blueprints / North West 63

North West

The region will be home to several projects that will help the UK achieve its net zero targets, including multiple offshore wind farms. The area of the Irish Sea off the coast of the North West has proved to be an attractive area for future offshore wind, with many smaller offshore wind farms already in operation. Further development is also planned following The Crown Estate's Round Four leasing announced in 2021. These wind farms are much larger in capacity, the largest of which can generate enough renewable electricity to power every home in Merseyside.

In 2022, our first holistic offshore design proposed the connection of two of the three Round Four wind farms into the North West region. The design sought to minimise disruption to communities and the natural environment by taking a coordinated approach to bringing cables from these wind farms to shore.

While there is an extensive transmission network across the cities in the south of the North West region, large parts of this operate at lower voltages (around two thirds of the voltage of other circuits). These lower voltage rings were often built around industrial centres when the super grid was first established - but have a lower capacity than higher voltage circuits. Further north, there is a single circuit connecting Scotland to Lancashire and beyond.

Sharing a border with Scotland, the North West region sees a greater need to transport electricity through its network from more offshore wind that connects to the grid further north. Alongside our broader, nationwide recommendations for several offshore cables to transport this power south on the east and west of Great Britain we have also identified the need for a new, high capacity electrical 'spine'. Without a high-capacity solution, electrical constraints within the region would result in growing costs to consumers across Great Britain. This lack of capacity could also mean that renewable generators may be sitting idle, unable to generate clean energy that could be used. Our recommendation for a new electrical spine is in its very first stage of development, but the concept of such a spine will be crucial to handling the influx of power from offshore wind.

Beyond 2030 / Regional Blueprints / North West 64

North West

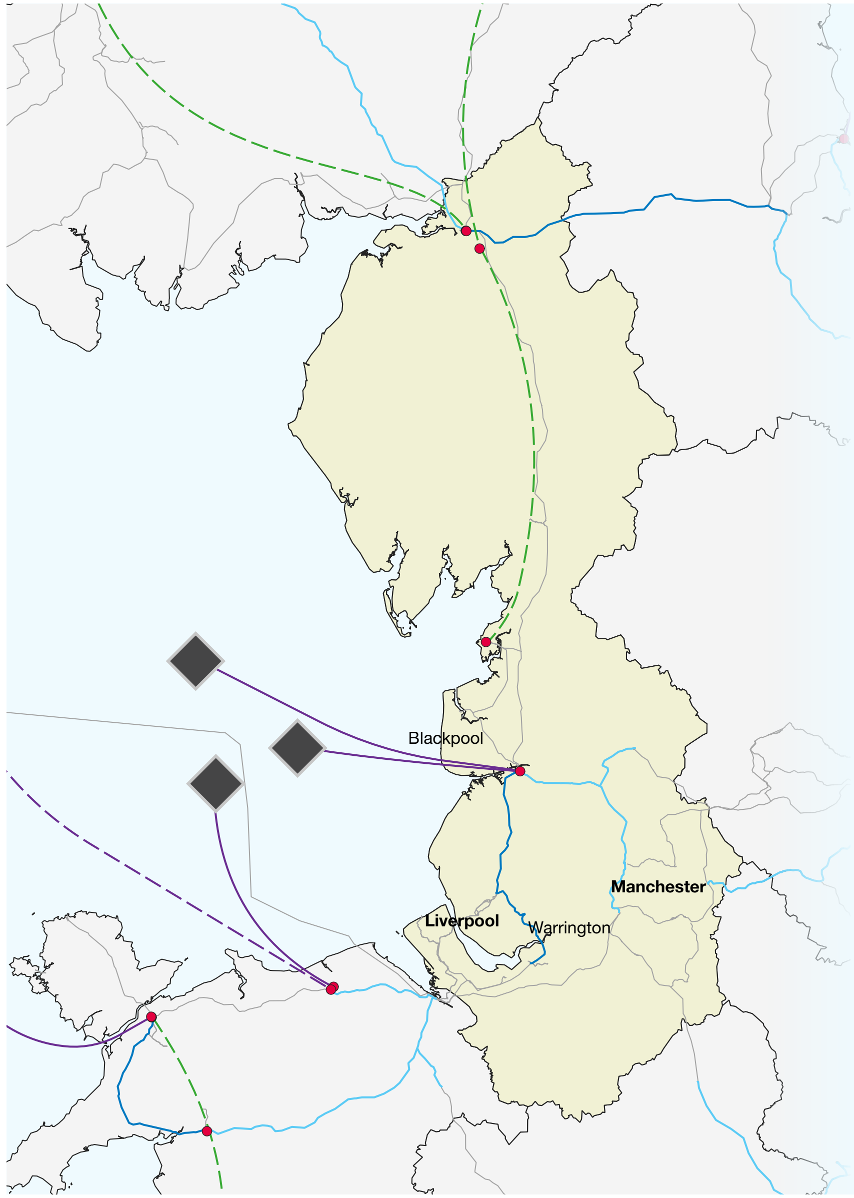
This spine builds on a long-standing network recommendation to establish a second west coast onshore circuit through the North West and this circuit now links into two new routes near the Anglo-Scottish border forming the lower half of the 'spine'.

We have also made some updates to our recommendations in this region, and we are no longer recommending a direct offshore link from Lancashire to North Wales. This option has been replaced by newly proposed solutions that include increasing the capacity of the offshore network proposed in our holistic network design between Southern Scotland and Wales, reducing the need to transmit power onshore, and uprating the currently lower capacity part of the network that forms the 'Mersey Ring'.

Upgrading the lower voltage, lower capacity elements of the network known as the 'Mersey Ring' to a higher voltage means we are able to significantly increase the amount of electricity that is able to flow through the existing network efficiently and with a lower impact on the environment and communities.

Finally, to better balance the power flows between the North West and North East, an upgrade to the existing circuit linking the two is required. This will increase the voltage of this circuit improving the robustness and security of the wider system.

The map in this section provides a visual summary of the blueprint for the region. It shows our new recommendations, our recommendations made in previous network planning processes, and other works. This section of the report is interactive, providing the opportunity for readers to explore in more detail the specifics of any new recommendations in the region.



Category	Key
New offshore network infrastructure	
New onshore network infrastructure	
Voltage increase on network	
Existing network upgrade	
Substation upgrade or new substation	
In scope wind farm	
HND wind farm	
Existing Network	

Figure 14. Map of all reinforcements in the North West region

*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Beyond 2030 / Regional Blueprints / North West 65

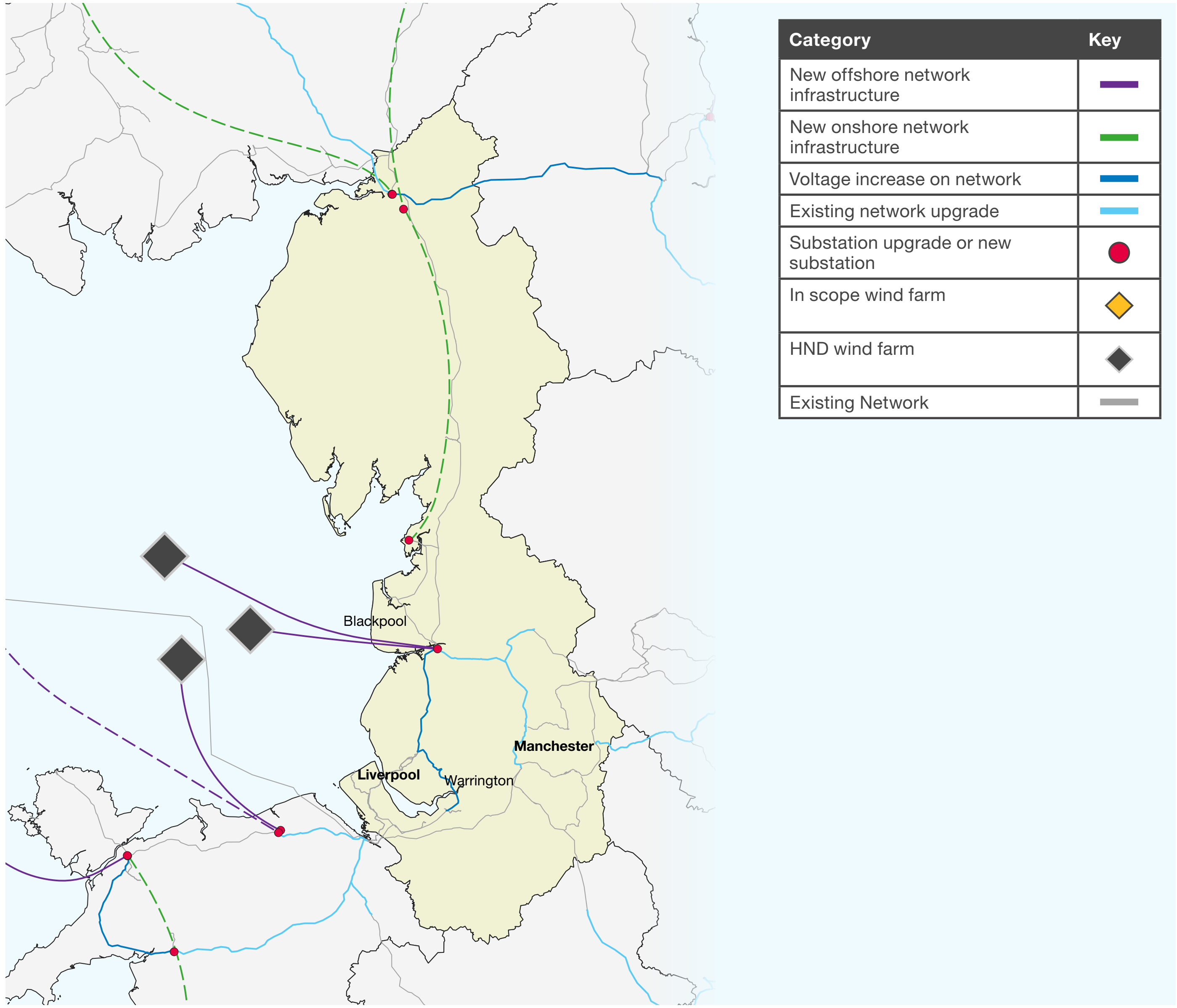
North West

New infrastructure

Code	Description	Maturity Level
CLN2	New circuit across North West England	
CMN3	New circuit between South Eastern Scotland and North West England	
WCN2	New circuit between south west Scotland and north west England	

New Upgrades

Code	Description	Maturity Level
DCR4	Replace the conductors on the existing circuits between Carrington and Daines with higher capacity conductors	
ESCF	Reconfigure the network between Stalybridge and Thorpe Marsh	
FSU1	Upgrade the existing network to a higher voltage between Harker and Stella West	
MRU1	Upgrade the existing Mersey ring of circuits and substations to allow for more capacity (Phase 1 of 2)	
MRU2	Upgrade the existing Mersey ring of circuits and substations to allow for more capacity (Phase 2 of 2)	



*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Click code for further information

Beyond 2030 / Regional Blueprints / North West 66

North West

The following reinforcements have previously been recommended for this region.
For more information on these options please see the ESO's Pathway to 2030 publication.[11]

Previously recommended

Code	Description	Maturity level
CDP1	Add power control devices to the existing circuit between Cellarhead and Drakelow	■■□□□□
CDP2	Increase rating of power control devices installed on the existing circuit between Cellarhead and Drakelow	■■□□□□
CDP3	Further increase rating of power control devices installed on the existing circuit between Cellarhead and Drakelow	■■□□□□
EHRE	Replace the conductors on the existing circuit between Elvanfoot and Harker with higher capacity conductors	■□□□□□
PCR1	Replace the conductors on the existing circuits between Carrington and Penwortham and Penwortham and Padiham with higher capacity conductors	■□□□□□
PWMS	Install voltage support equipment at Penwortham	■■□□□□
R4_5	Offshore network cable from a single wind farm connecting to Penwortham	■■□□□□
R4_6	Offshore network cable from a single wind farm connecting to Penwortham	■■□□□□

11 https://www.nationalgrideso.com/document/264656/download

Beyond 2030 / Regional Blueprints / North West 67

North East

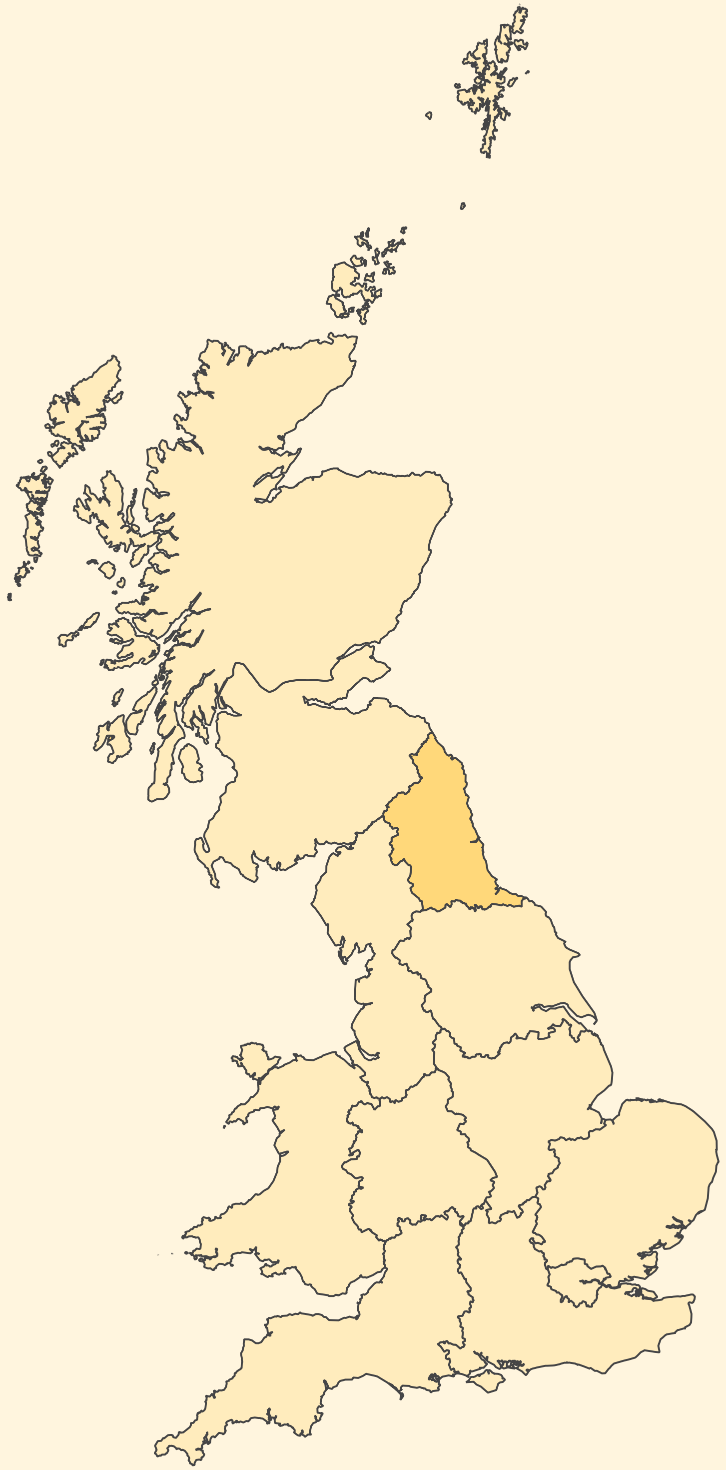
The North East of England has always been at the forefront of industry and innovation. As we transition to net zero, our recommendations will support and protect this heritage.

The North East has a long history of electricity innovation. In 1868, William Armstrong built what is believed to be the world's first hydroelectric power station by creating new lakes on his Northumberland estates and then installing a hydraulic engine and a dynamo.

The region is an industrial heartland and home to vital manufacturing sectors (including the chemical, pharmaceutical and steel sectors). Sunderland is well known for its car manufacturing plant, which has been producing electric vehicles (EVs) for over a decade.

Currently, the North East has a pair of electricity transmission circuits, transporting power from north to south. There are also several circuits along the coast spanning the towns and cities from Blyth to Teesside, creating a 'ring' of transmission infrastructure serving the local population.

The area is home to several energy related projects, including the North Sea Link interconnector and the East Coast Carbon Capture and Storage (CCS) Cluster. The North Sea Link interconnector became the world's longest subsea electricity interconnector when it was commissioned in 2021. The 720 km subsea high voltage direct current (HVDC) cable connects Great Britain and Norway, with the British end of the cable landing near Blyth. The link can provide enough clean electricity to power all the homes in the North East and is helping to fortify the energy security of both countries. This world-leading project plays a key part in enabling the UK's transition to net zero while also supporting local, highly skilled jobs.



Beyond 2030 / Regional Blueprints / North East 68

The region's carbon capture projects have also been at the forefront of the UK's rapidly growing carbon capture industry. In March 2023, the Department for Energy Security and Net Zero selected three carbon capture projects around Teesside to be first to connect to the East Coast Cluster by 2027. The cluster aims to remove 50 per cent of the UK's industrial cluster CO_2 emissions through its CCS infrastructure. This will help establish the region as a globally competitive climate-friendly hub for industry and innovation.

Great Britain's future electricity network needs the capacity to transport clean, renewable electricity from generation centres in Scotland and parts of the North of England, to demand centres elsewhere in the North of England, the Midlands and the South of England (often in industrial or densely populated areas). Proposed offshore links along Great Britain's eastern coast will meet a large amount of this need, reducing the impact on local communities. However, supporting onshore infrastructure will still be required.

In August 2022, the Office of Gas and Electricity Markets (Ofgem) set out a list of system upgrades and improvements which needed to have their delivery accelerated to meet the UK's offshore wind targets, with this being done through the new Accelerated Strategic Transmission Investment (ASTI) process. Some of the infrastructure covered by ASTI includes new infrastructure around Norton, near Stockton-on-Tees.

When making decisions on network upgrades, our design criteria place an emphasis on upgrading existing infrastructure where possible. Upgrading existing infrastructure can reduce the overall impact of infrastructure on communities and be more cost effective for consumers where upgrades are feasible.

Beyond 2030 / Regional Blueprints / North East 69

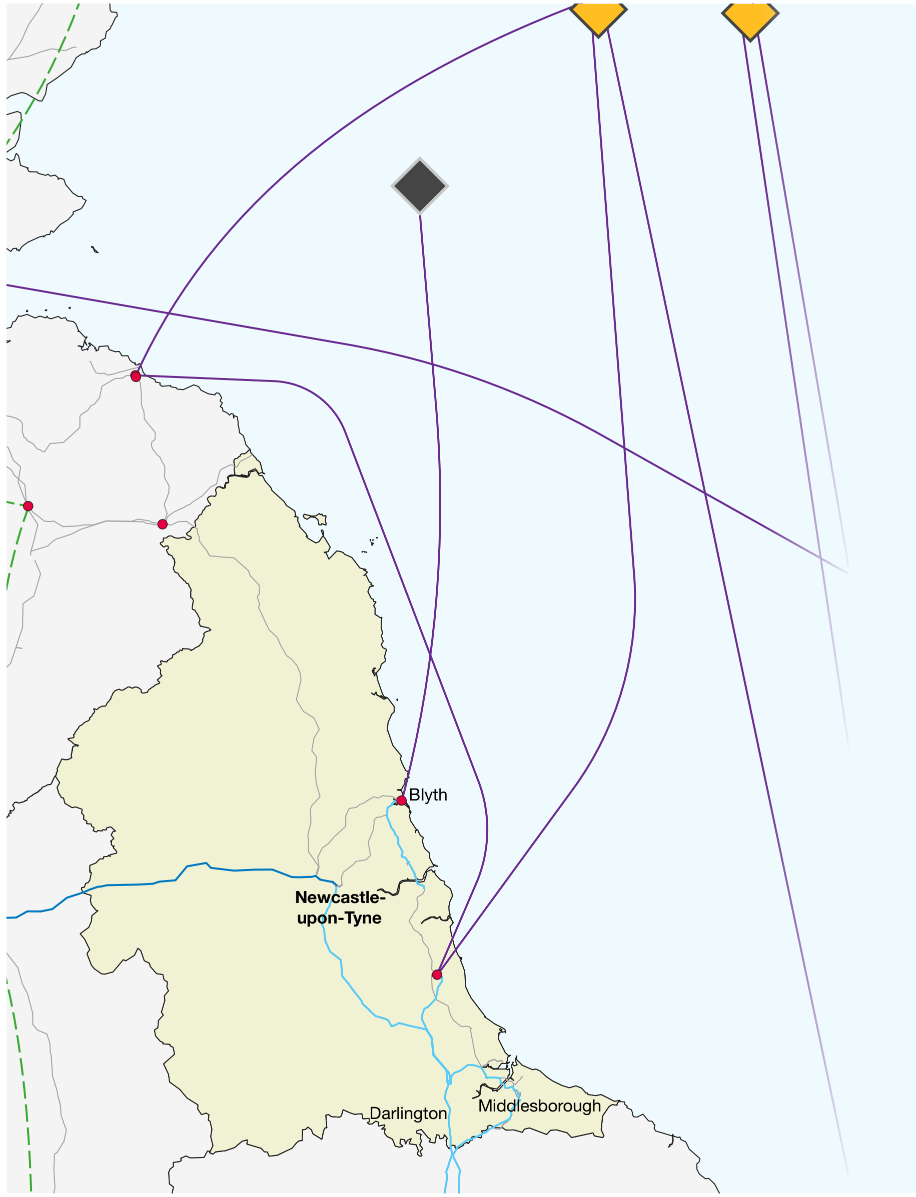
North East

Previously, we have recommended new infrastructure in the area, and the detailed designs behind our recommendations are currently being developed by the Transmission Owners (TOs). In addition to this, we have identified and are recommending additional infrastructure in the region. This recommended infrastructure includes both onshore reinforcements to the network and upgrades to existing network.

Large parts of the work which is newly recommended within the North East involves upgrading the capacity of the wires on the existing pylons between Tyneside and Teesside. By replacing the existing wires with higher capacity ones, the capability of the network can be increased while minimising the impact on communities and the natural environment.

This process is not always possible or sufficiently beneficial to the electricity network though and in such cases, new infrastructure is required. The North East will host the southern end of the first offshore Eastern Green Link which will bring clean power from Scotland while bypassing the congestion on the Anglo-Scottish border. Our coordinated offshore wind network designs have recommended that wind farms in Scottish waters to directly connect to the North East of England to reduce the requirement for an onshore circuit from South East Scotland to North East England. Finally, to better balance the power flows between the North West and North East, an upgrade to the existing circuit linking the two regions is required. This will increase the voltage of this circuit improving the robustness and security of the wider system and help maximise the power flow from north to south (and vice versa) on other existing circuits.

The map in this section provides a visual summary of the blueprint for the region. It shows our new recommendations, our recommendations made in previous network planning processes, and other works. This section of the report is interactive, providing the opportunity for readers to explore in more detail the specifics of any new recommendations in the region.



Category	Key
New offshore network infrastructure	
New onshore network infrastructure	
Voltage increase on network	
Existing network upgrade	
Substation upgrade or new substation	
In scope wind farm	
HND wind farm	
Existing Network	

Figure 15. Map of all reinforcements in the North East region

*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Beyond 2030 / Regional Blueprints / North East 70

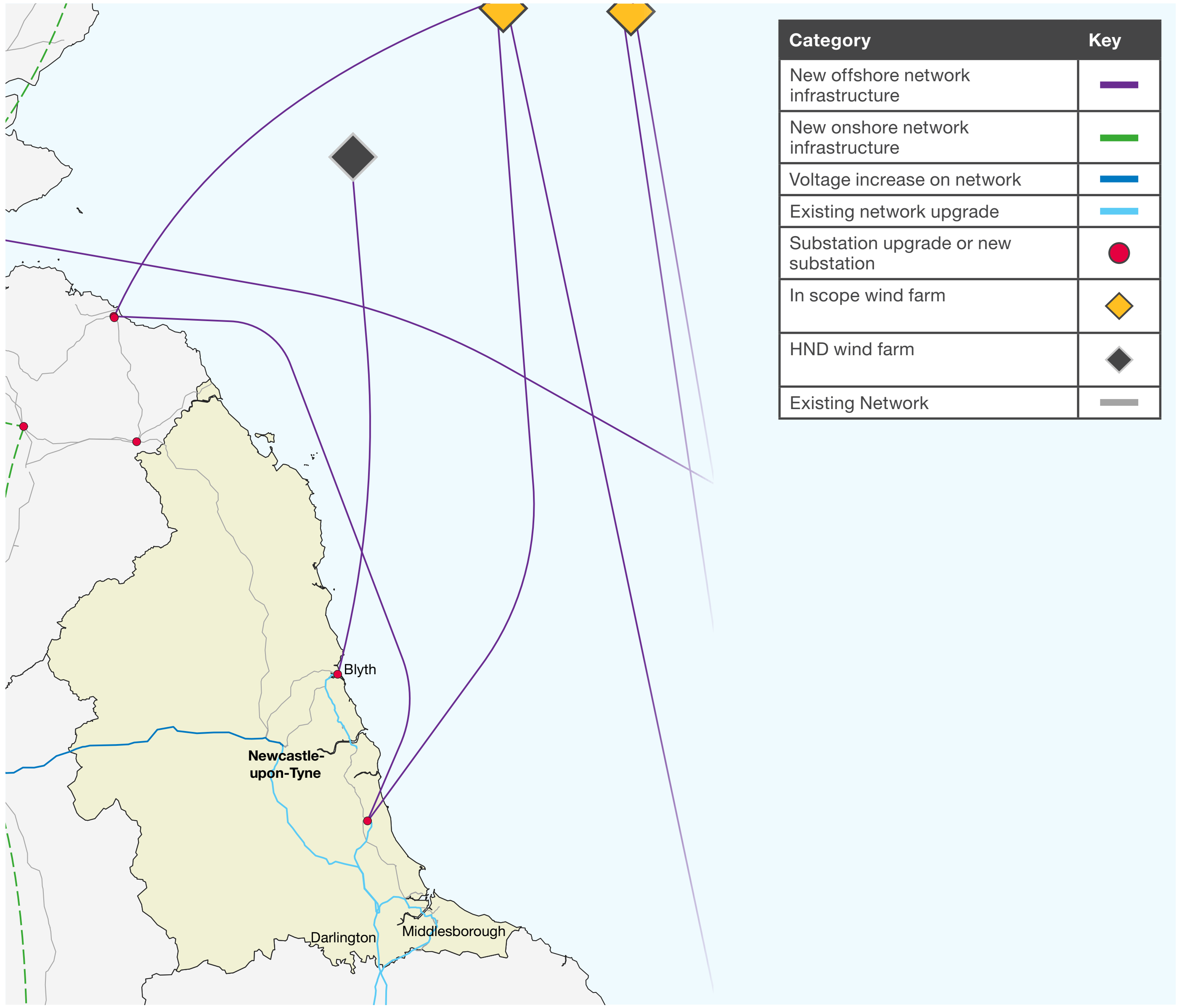
North East

New infrastructure

No new infrastructure is currently required in this region.[12]

New upgrades

Code	Description	Maturity Level
FSU1	Upgrade the existing network to a higher voltage between Harker and Stella West	■□□□□□
HNRE	Replace the conductors on the existing circuits between Hawthorn Pit and Norton with higher capacity conductors	■□□□□□
LTRE	Upgrade the existing circuits between Lackenby and Thornton to allow for more capacity	■□□□□□
NOR6	Replace the conductors on the existing circuit between Norton and Osbaldwick with higher capacity conductors	■□□□□□



Category	Key
New offshore network infrastructure	
New onshore network infrastructure	
Voltage increase on network	
Existing network upgrade	
Substation upgrade or new substation	
In scope wind farm	
HND wind farm	
Existing Network	

*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

12 The relevant TO also identified a further issue which needs to be resolved, potentially by a new circuit in the North East (BSNC). It is not included in this plan as further work is required to clarify the specific driver behind this reinforcement, its timing and the best solution.

Click code for further information

Beyond 2030 / Regional Blueprints / North East 71

North East

The following reinforcements have previously been recommended for this region.
For more information on these options please see the ESO's Pathway to 2030 publication.[13]

Previously recommended

Code	Description	Maturity level
E2DC	New offshore HVDC link between Torness and Hawthorn Pit (Eastern Green Link 1)	■■■■□□
LNRE	Replace the conductors on the existing circuit between Lackenby and Norton with higher capacity conductors	■□□□□□
NEMS	Install voltage support equipment within the North East region	■■□□□□
NEP1	Add power control devices to the existing circuits between Blyth and Tynemouth and Blyth and South Shields	■■□□□□
PA_2	Offshore network cable from a single wind farm connecting to Blyth	■■□□□□
SNRE	Replace the conductors on the existing circuit between Spennymoor to Norton with higher capacity conductors	■□□□□□
SPRE	Replace the conductors on the existing circuit between Spennymoor to Stella West with higher capacity conductors	■□□□□□
SSHW	Carry out thermal upgrading on the existing circuit between Stella West and Spennymoor	■■□□□□
SW_E1A_1	Offshore network cable from a coordinated series of wind farms connecting to Hawthorn Pit	■■□□□□
PT2030-CW20	Change the configuration of the existing circuits between Blyth and Stella West	■■□□□□
PT2030-CW22	Replace the conductors on the existing circuit between Lackenby and Thornton with higher capacity conductors	■■□□□□
PT2030-CW40	Replace the conductors on the existing circuit between Norton and Osbaldwick with higher capacity conductors	■■□□□□

Beyond 2030 / Regional Blueprints / North East 72

13 https://www.nationalgrideso.com/document/264656/download

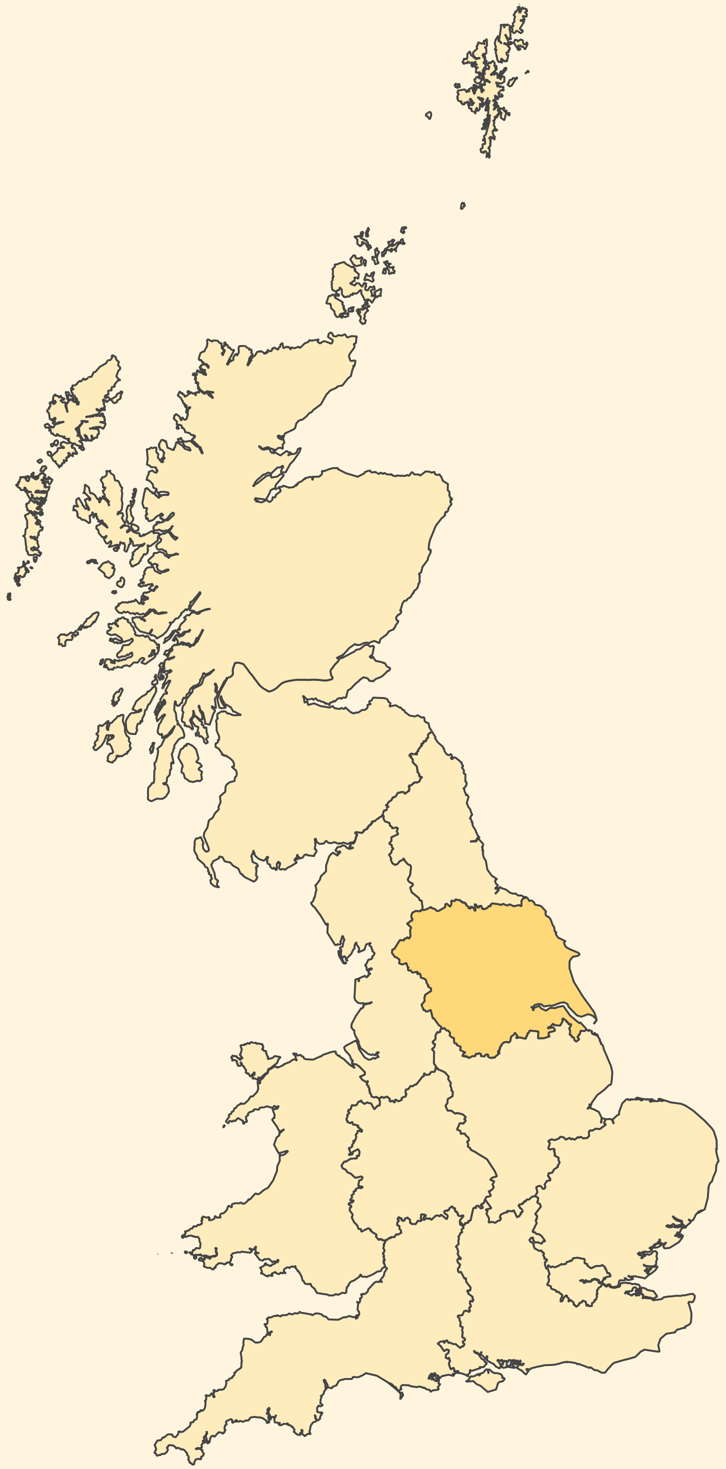
Yorkshire and the Humber

Yorkshire and the Humber used to be one of the UK's biggest coal producers. Now, it is one of the world's biggest generators of offshore wind.

Yorkshire and the Humber is a very important region for Great Britain – it covers a large area, has a population bigger than New Zealand and a bigger economic output than some EU countries.

With its strategic location around the Humber Estuary, the main port of Hull has historically been important for the fishing industry. The Humber ports have underpinned a rich industrial history, supporting the development of oil refineries, fishing and food industries in the region. The region's wider industrial history includes the mining heritage of South Yorkshire and steel manufacturing in Sheffield and Scunthorpe. Today, Yorkshire and the Humber is leading the UK's manufacturing sector, outperforming any other region in Great Britain.

With past and present heavy industry requirements, the region was home to large power stations - including Drax, Ferrybridge and Eggborough coal fired power stations as well as several gas fired stations on the south bank of the Humber. This large generation capacity required support from significant network infrastructure, including two high-capacity 400 kV transmission circuits running east to west, from Hull to Bradford, and Grimsby to Sheffield and beyond. Further transmission circuits enter from the north via York and others exit south via Scunthorpe. Lastly, the area is home to a 'ring' of 275 kV circuits around the Sheffield area that was built to support the steel industry in the area – moving electricity from large, inland power stations to large demand sources.



Beyond 2030 / Regional Blueprints / Yorkshire and the Humber 73

Yorkshire and the Humber

The transition away from coal, and then towards renewable energy has meant that almost all the region's coal power stations are now closed. Drax power station has been converted to biomass and there is a rapid growth in both the manufacturing and deployment of offshore wind farms off the coast of the region.

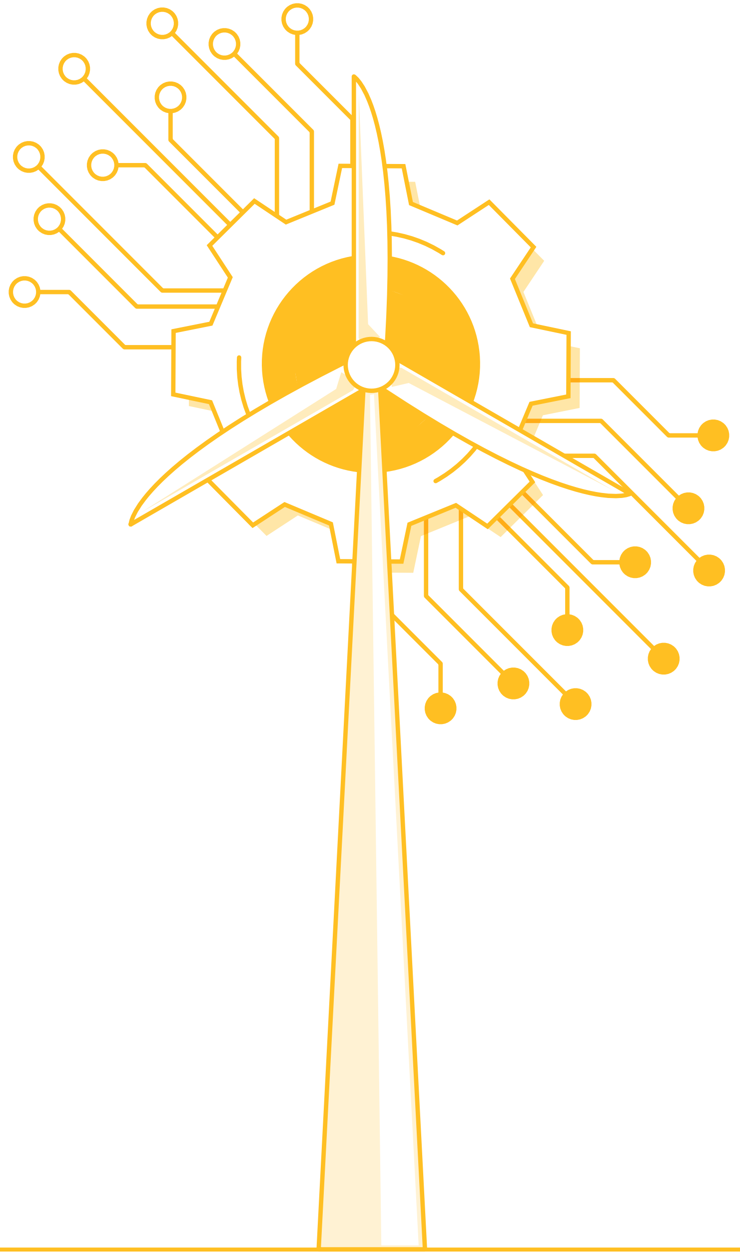
The move to renewables has attracted significant investment into the region and it is now home to two of the largest offshore wind farms in the world – with even more projects being taken forward in the region.

The investment seen in ports, communities, and wider local areas has been significant, with billions invested in the region by wind farm developers and businesses in other parts of the supply chain. Grimsby and the surrounding area have received an exceptional amount of investment, with the town becoming the operational hub to some of the world's largest offshore wind farms. Offshore wind developers have also invested heavily in community facilities and infrastructure, with millions of pounds of investment across the region to date.

The region is expected to support innovative trials to consider how existing industries can adapt through the energy transition and continue to thrive. These trials also look at how new industries can be supported, using technologies such as Carbon Capture and Storage (CCS). The East Coast Cluster is one of the first CCS clusters to be taken forward by the UK Government, with the 'cluster' including hydrogen production, industrial carbon capture and a wide mix of low-carbon projects.

There are also opportunities for hydrogen to be stored in the region, enabling a greener economy – both locally and nationally – and possible further investment into the area. This long-duration energy storage will also be strategically vital to manage peaks and troughs in renewable energy supply.

To ensure the transmission network in the region has sufficient capacity for the region's current and future economy, we are recommending that existing infrastructure should be upgraded to increase the amount of electricity it can carry. This reduces but does not eliminate the need for new infrastructure which will be required in the region.



Beyond 2030 / Regional Blueprints / Yorkshire and the Humber 74

Yorkshire and the Humber

The Hornsea group of wind farms are over 50 miles away from the coast of Yorkshire and were part of the third offshore leasing round conducted by The Crown Estate, the first of these windfarms became fully operational in 2019. The remaining capacity is currently being developed with the final phase expected to be completed in the late 2020s.

Our holistic design for 2030 included projects that were included in the fourth offshore leasing round. These are located in the Dogger Bank area which is even further offshore than the Hornsea group and have a combined potential for over 4 GW of new offshore renewable capacity. The previously recommended substation and circuits at Birkhill Wood (subject to consenting and planning) allow for a suitable connection point for these wind farms to connect to the grid. The landing point for these subsea wind farm connection cables also helps to mitigate environmental impacts by avoiding protected marine environments, and when the cables reach the shore they will continue underground to the connecting substation, to limit the long-term impact on the local community (subject to the planning process).

Since we published our original *Holistic Network Design* in 2022, more detailed design work has taken place which has refined the way these three Round 4 wind farms connect to the grid. Our original design connected these three generators to the shore at Birkhill Wood using two high capacity cables – however, in light of engagement with stakeholders, changes to anticipated technology availability dates and environmental considerations, we have updated our design to use three separate lower capacity cables, improving deliverability and avoiding delays to the connection dates of the wind farms. This does increase the impact on the terrestrial environment, however, our impact appraisal found that this is offset by a reduction in the overall length of new cables needed in an area of marine environment that is sensitive to cabling.

There is also a requirement for infrastructure to accommodate the power flows from the new offshore wind farms included in our holistic design for 2030 to the rest of Yorkshire and the Humber and beyond. We have previously recommended a new circuit in Yorkshire from Birkhill Wood to High Marnham, along with upgrades of existing lower voltage (and currently lower capacity) circuits to increase network capacity in the region.

We also continue to recommend offshore infrastructure to reduce the amount of onshore infrastructure required. High capacity offshore high voltage direct current (HVDC) links will connect Scotland to England to help move electricity across Great Britain. We have previously recommended an offshore connection from Northern Scotland to Drax (which is publicly known as Eastern Green Link 2). This will provide vital capacity to alleviate transmission network bottlenecks across Scotland and the North of England without requiring significant onshore infrastructure, reducing the impact on communities.

Beyond 2030 / Regional Blueprints / Yorkshire and the Humber 75

Yorkshire and the Humber

We have also assessed at the possibility of reconfiguring existing assets so that they best meet the changing needs for the region. Following our analysis, we are recommending that Thorpe Marsh substation, the Thorpe Marsh to Keadby circuit and the Thorpe Marsh to Stalybridge circuits are reconfigured. As our needs change, electricity will flow around the network in different ways, and this can create pinch points in specific places. By changing how the network is configured using small amounts of new infrastructure, we can remove this localised congestion meaning that lots of additional capability can be unlocked. These upgrades come with a significant benefit to the network and consumers, reducing cost to consumers and making the impact on the environment or communities more modest than fully new build options.

The map in this section provides a visual summary of the blueprint for the region. It shows our new recommendations, our recommendations made in previous network planning processes, and other works. This section of the report is interactive, providing the opportunity for readers to explore in more detail the specifics of any new recommendations in the region.

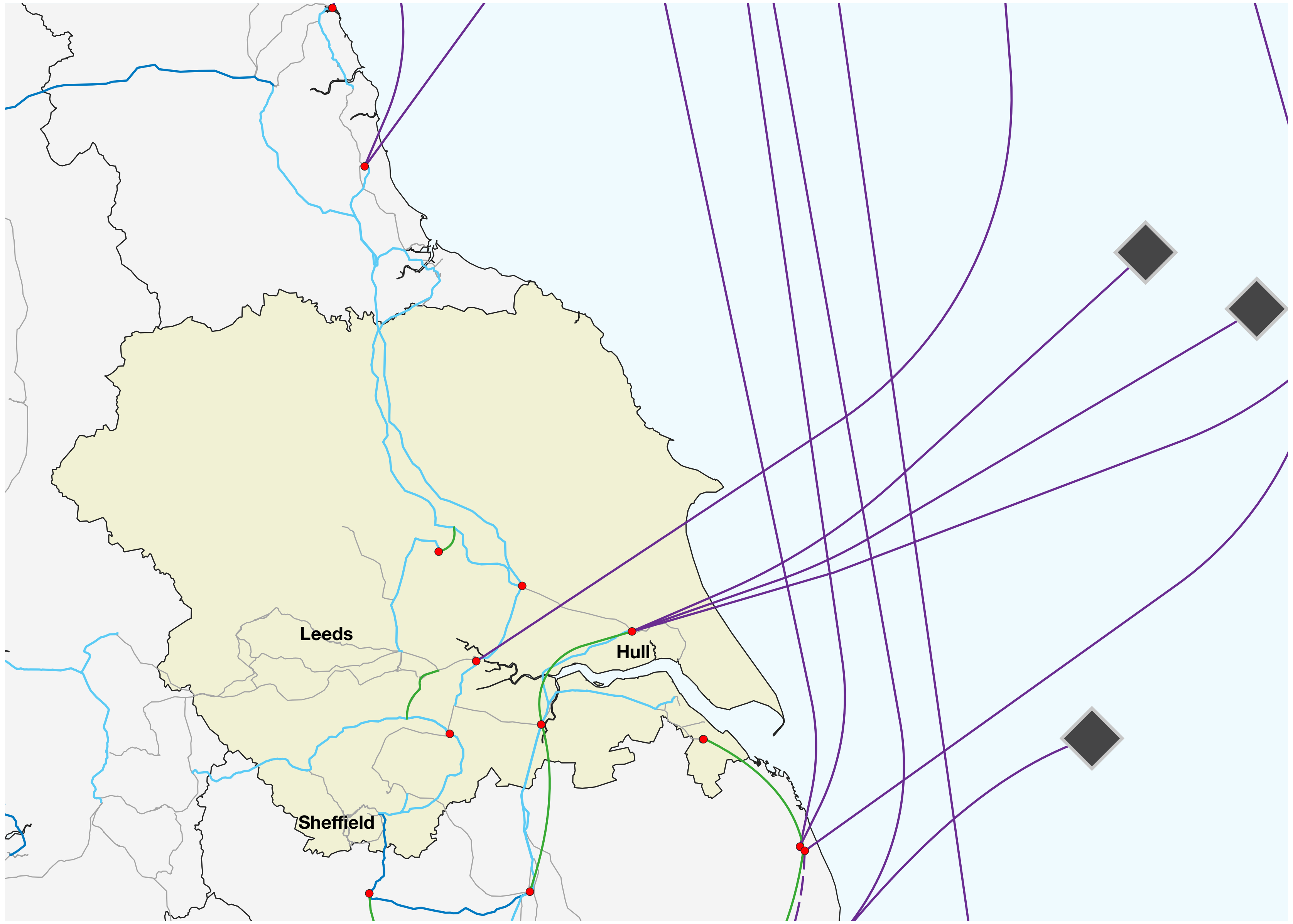


Figure 16. Map of all reinforcements in the Yorkshire and the Humber region

*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Yorkshire and the Humber

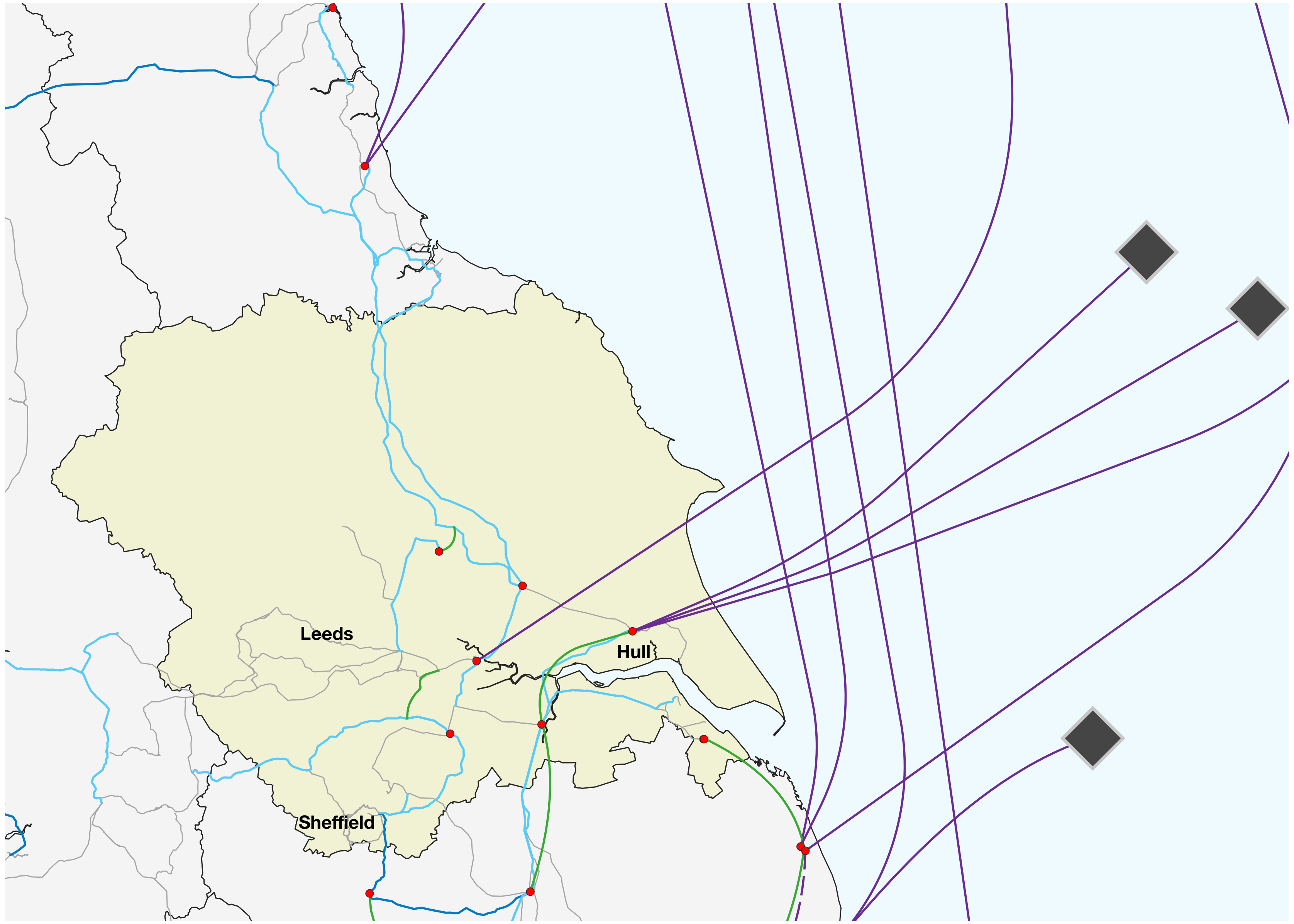
Map key

New infrastructure

No new infrastructure is currently required in this region.

New upgrades

Code	Description	Maturity Level
BTR2	Upgrade the existing circuits between Brinsworth and Thorpe Marsh to allow for more capacity	■□□□□□
EDN3	Replace the conductors on the existing circuits between Brinsworth and Thorpe Marsh, Brinsworth and Chesterfield, and Chesterfield and Ratcliffe with higher capacity conductors	■□□□□□
ETRE	Upgrade the existing circuits between Eggborough and Thorpe Marsh to allow for more capacity	■□□□□□
ESCF	Reconfigure the network between Stalybridge and Thorpe Marsh	■□□□□□
LTRE	Upgrade the existing circuits between Lackenby and Thornton to allow for more capacity	■□□□□□
NOR6	Replace the conductors on the existing circuit between Norton and Osbaldwick with higher capacity conductors	■□□□□□
OTHW	Carry out thermal upgrading on the existing circuit between Osbaldwick and Thornton	■□□□□□
TDP4	Add power control devices to the existing circuit between Drax and Thornton	■□□□□□
TMCF	Reconfigure Thorpe Marsh substation	■□□□□□
TMC2	Reconfigure the network between Keadby and Thorpe Marsh	■□□□□□



*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Click code for further information

Beyond 2030 / Regional Blueprints / Yorkshire and the Humber 77

Yorkshire and the Humber

The following reinforcements have previously been recommended for this region.
For more information on these options please see the ESO's Pathway to 2030 publication.[14]

Previously recommended

Code	Description	Maturity level
CGNC	New circuit between Creyke Beck and High Marnham	■■■□□□
CKPC	Add power control devices to the existing circuits between Creyke Beck, Keadby and Killingholme	■■□□□□
DFRE	Replace the conductors on the existing circuit between Drax and Fenwick Tee with higher capacity conductors	■■□□□□
E4D3	New offshore HVDC link between Peterhead and Drax (Eastern Green Link 2)	■■■■□□
EDEU	Upgrade the existing network to a higher voltage between Brinsworth and Chesterfield and Chesterfield and High Marnham. Develop new High Marnham and Chesterfield high voltage substations	■■□□□□
GWNC	New circuit between North Lincolnshire and South Lincolnshire border	■■□□□□
JTHW	Carry out thermal upgrading on the existing circuit between Thurcroft and West Melton	■□□□□□
KCEU	Carry out thermal upgrading of the existing circuits between Creyke Beck, Keadby and Killingholme	■■□□□□
KCRE	Replace the conductors on the existing circuit between Cottam and Keadby with higher capacity conductors	■■□□□□
KWHW	Carry out thermal upgrading on the existing circuit between Keadby and West Burton	■■□□□□
KWPC	Add power control devices to the existing circuit between Keadby and West Burton	■■□□□□
KWP2	Increase rating of power control devices installed on the existing circuit between Keadby and West Burton	■■□□□□
OPN2	New circuit between Osbaldwick and Poppleton	■■■■□□
PA_1	Offshore network cable from a single wind farm connecting to Birkhill Wood	■■□□□□
R4_1	Offshore network cable from a single wind farm connecting to Birkhill Wood	■■□□□□

14 https://www.nationalgrideso.com/document/264656/download

Beyond 2030 / Regional Blueprints / Yorkshire and the Humber 78

Yorkshire and the Humber

Previously recommended continued

Code	Description	Maturity level
R4_2	Offshore network cable from a single wind farm connecting to Birkhill Wood	■■□□□□
SW_E1A_1	Offshore network cable from a coordinated series of wind farms connecting to Hawthorn Pit	■■□□□□
SHNS	New substation in the South Humber area	■■■■□□
PT2030-CW25	Change the configuration of the existing network in northern Lincolnshire	■■□□□□
PT2030-CW26	Carry out thermal upgrading on the existing circuit between Creyke Beck and Keadby	■■□□□□
PT2030-CW28	Replace the conductors on the existing circuit between the Fenwick Tee and Thorpe Marsh with higher capacity conductors	■■□□□□
PT2030-CW29	Replace the conductors on the existing circuit between Drax and Thorpe Marsh with higher capacity conductors	■■□□□□
PT2030-CW30	Add power control devices to the existing circuit between Creyke Beck, Keadby and Humber Refinery	■■□□□□
PT2030-CW36	Carry out thermal upgrading on the existing circuit between Drax and Eggborough	■■□□□□
PT2030-CW39	Install voltage support equipment to support the existing circuit in the Yorkshire and Humber region	■■□□□□
PT2030-CW40	Replace the conductors on the existing circuit between Norton and Osbaldwick with higher capacity conductors	■■□□□□
PT2030-CW41	Install voltage support equipment to support the existing circuit between Keadby and Fenwick Tee	■■□□□□

Beyond 2030 / Regional Blueprints / Yorkshire and the Humber 79

East Midlands

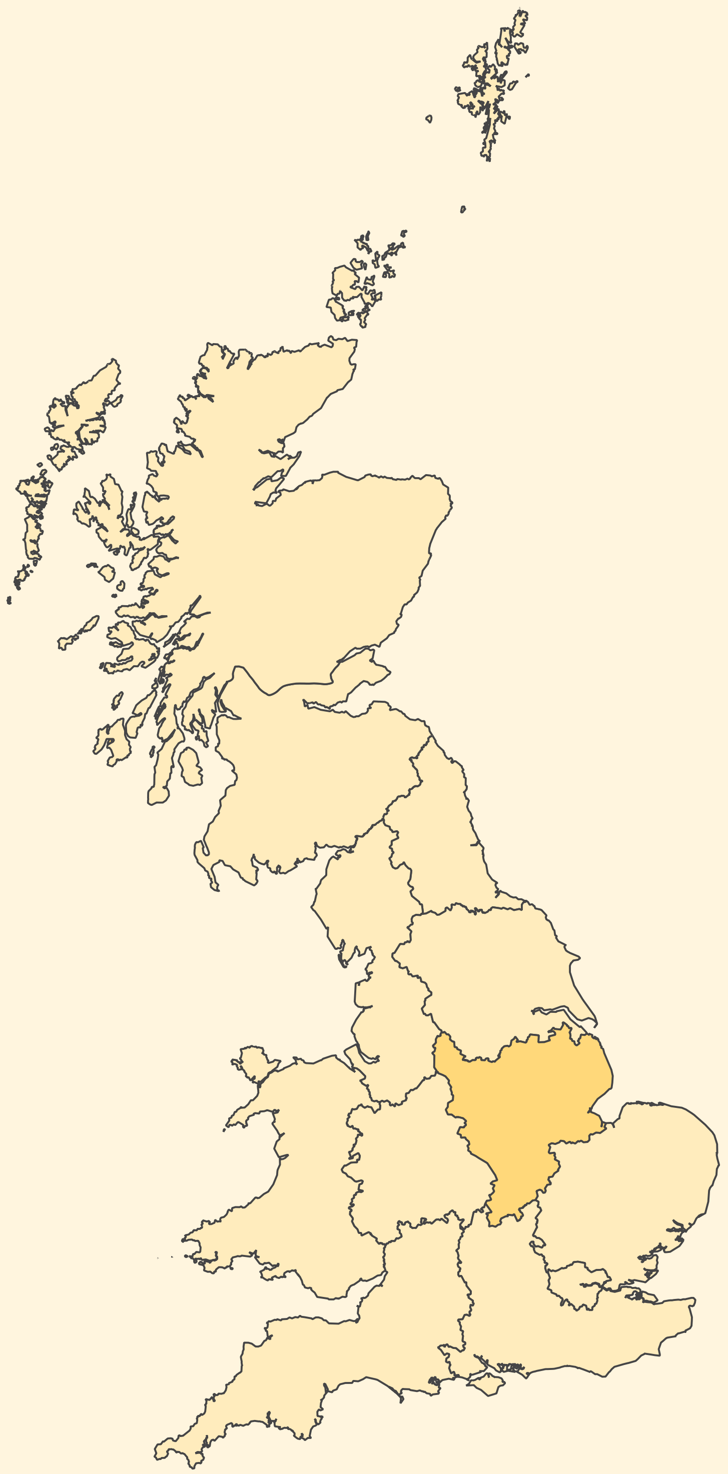
The East Midlands was the birthplace of Great Britain's current electricity grid, and it will be at the heart of Great Britain's future electricity grid.

The East Midlands has a unique place as part of Great Britain's future electricity network. Its people, skills, and location place it at the centre of a secure and decarbonised electricity system.

The region has a tradition of industry and engineering and was the birthplace of many major inventions. Staythorpe in Nottinghamshire for example was where the UK's first 275 kV overhead line was switched on in July 1953 and part of the original supergrid. The line was 40 miles long, linking Staythorpe with West Melton, near Sheffield, and was built to get locally generated electricity to industrial demand centres across the country. This original grid is the core of our modern-day electricity system, with large amounts of this network remaining unchanged since it was built in the 1950s and 1960s.

In previous decades, the River Trent and the Trent Valley were lined with big fossil fuel fired power stations and coal mines, generating large amounts of electricity, and transmitting this to other areas of the country. These power stations gave the area the nickname 'Megawatt Valley'. Over time, several power stations in this area have been decommissioned as they reached the end of their service life. Some were replaced by gas power stations, and are now being complemented with cheaper, newer forms of renewable energy spread across Great Britain. The final coal power stations in the region are due to stop generating by October 2024, following a clear deadline set by the UK Government.

Manufacturing makes up a significant amount of the regional economy. Up to 11 per cent of the people in the region are employed in manufacturing, and the sector contributes 21 per cent of the region's gross domestic profit (GDP (over £20 billion a year)). In order to grow further and ensure a sustainable future this sector will require access to affordable, clean energy more than ever – with a suitable network needed to support this.



Beyond 2030 / Regional Blueprints / East Midlands 80

East Midlands

On top of this, a 2020 report from National Grid,[15] using analysis from an independent research provider, showed that to enable the UK to meet its 2050 net-zero target, over 18,000 new 'net-zero jobs' will need to be created in the East Midlands by 2050 – with more opportunities also enabled through wider investment.

For Great Britain to have the secure, reliable and clean electricity network that is required, there needs to be increased network capacity to move renewable electricity from generation centres (such as Scotland) to demand centres in the English Midlands and Southern England.

The East Midlands has the required geography, location and potential for the growth required to become the heart of Great Britain's future electricity grid, including the landing points of multiple offshore cables which will provide this north to south capacity.

Most of the required infrastructure in the region has previously been identified through past network planning processes, and our latest recommendations do not include any brand new onshore overhead circuits. The detailed design proposals for this infrastructure are currently being developed by the relevant Transmission Owner (TO).

The Office of Gas and Electricity Markets (Ofgem) has also selected a number of these upgrades to be accelerated using the ASTI (Accelerated Strategic Transmission Investment) process helping Great Britain to achieve its 2030 offshore wind targets.

Nottinghamshire, Derbyshire, Northamptonshire, Leicestershire and Rutland

Nottinghamshire currently hosts a large amount of transmission infrastructure, and Derbyshire and Northamptonshire also host notable amounts, but these circuits do not currently provide the north to south capacity the network will need for the future.

Upgrades will also be necessary to the existing infrastructure in the region. Depending on the exact layout, design and capacity of the existing infrastructure, different upgrades can be considered, including lower or no-build solutions. These can include increasing the voltage of the circuit, replacing the line conductors with higher capacity ones, or adding devices to better control how electricity flows along the line. These upgrades reduce the amount of new infrastructure needed but cannot wholly eliminate the need for new infrastructure.

15 nationalgrid.com/stories/journey-to-net-zero/net-zero-energy-workforce

Beyond 2030 / Regional Blueprints / East Midlands 81

East Midlands

Lincolnshire

Some sites along the coastline in Lincolnshire have the required geography and physical characteristics to host cable landing points that will provide connections for offshore electricity 'superhighways', bringing electricity into the region. The existing transmission network in the East Midlands allows for the integration of this infrastructure into the existing grid, but also the flexibility to structure new infrastructure in a resilient, cost-effective way which reduces the impact on communities and the environment.

We are recommending that Lincolnshire is the southern connection point for five of these subsea cables to transport green electricity being produced in the North Sea to the rest of the country, alongside the direct connection of a wind farm into the county. These cables form the backbone of a coordinated offshore network, reducing the amount of onshore infrastructure required to provide the transmission network capacity needed to keep up with rising demand, and to meet the UK's net-zero targets.

We have further identified a 'hub' for an onshore substation in the county which will be a major interface point between the coordinated offshore network and the onshore network. This hub is one of several proposed and in development along the east coast of the country. Coastal hubs will become critically important to Britain's electricity grid as the country connects in more offshore renewables, boosting our energy resilience.

Lincolnshire's position at the heart of the country means its suitable location to electrical host and transfer green energy either across the Midlands or to the south of the country. Our analysis shows there are suitable corridors to connect underground cables to the shore while avoiding protected marine areas and natural habitats.

Rigorous testing was undertaken on a selection of onshore landing points across the east coast of the country provided to us by the Transmission Owners, however both the Humber and East Anglia both already have a significant amount of offshore infrastructure.

The Humber was discounted due to future network capacity constraints that limit the amount of electricity that can pass from north to south through the Humber area meaning landing cables in Lincolnshire that bypass those constraints, reducing overall infrastructure need. East Anglia was discounted due to the protected marine environments above and around Norfolk and the significant amount of offshore wind being developed around those shores at a more advanced stage, reducing the available offshore corridors to shore.

When these cables reach the shore, they will continue underground to their onshore substation connection point where they will integrate with the rest of the transmission network in the region, enabling better network availability for local communities and industry. We recommend and expect relevant developers to coordinate their projects by sharing cable corridors and community engagement, where possible.

As further optioneering and high level appraisals have been undertaken, the TO has revised their proposed plans. This includes a previously proposed onshore circuit connecting Lincolnshire to Hertfordshire, which will now begin at an electrical boundary that borders the outskirts of South Lincolnshire, Cambridgeshire and Northwest Norfolk, bypassing almost all of Lincolnshire. Another onshore circuit that is set to cross Lincolnshire is being proposed to be placed underground – rather than being an overhead line, reducing the impact of the circuit on the surroundings.

Beyond 2030 / Regional Blueprints / East Midlands 82

East Midlands

Map key

What next?

These recommended projects will now be progressed, with detailed designs being further developed by relevant bodies. Before construction begins, projects will have to go through consenting, which will include community engagement and consultation. The planning process will ensure that protected areas (such as The Wolds) are avoided and the impact on communities is kept as low as reasonably possible.

The map in this section provides a visual summary of the blueprint for the region. It shows our new recommendations, our recommendations made in previous network planning processes, and other works. This section of the report is interactive, providing the opportunity for readers to explore in more detail the specifics of any new recommendations in the region.

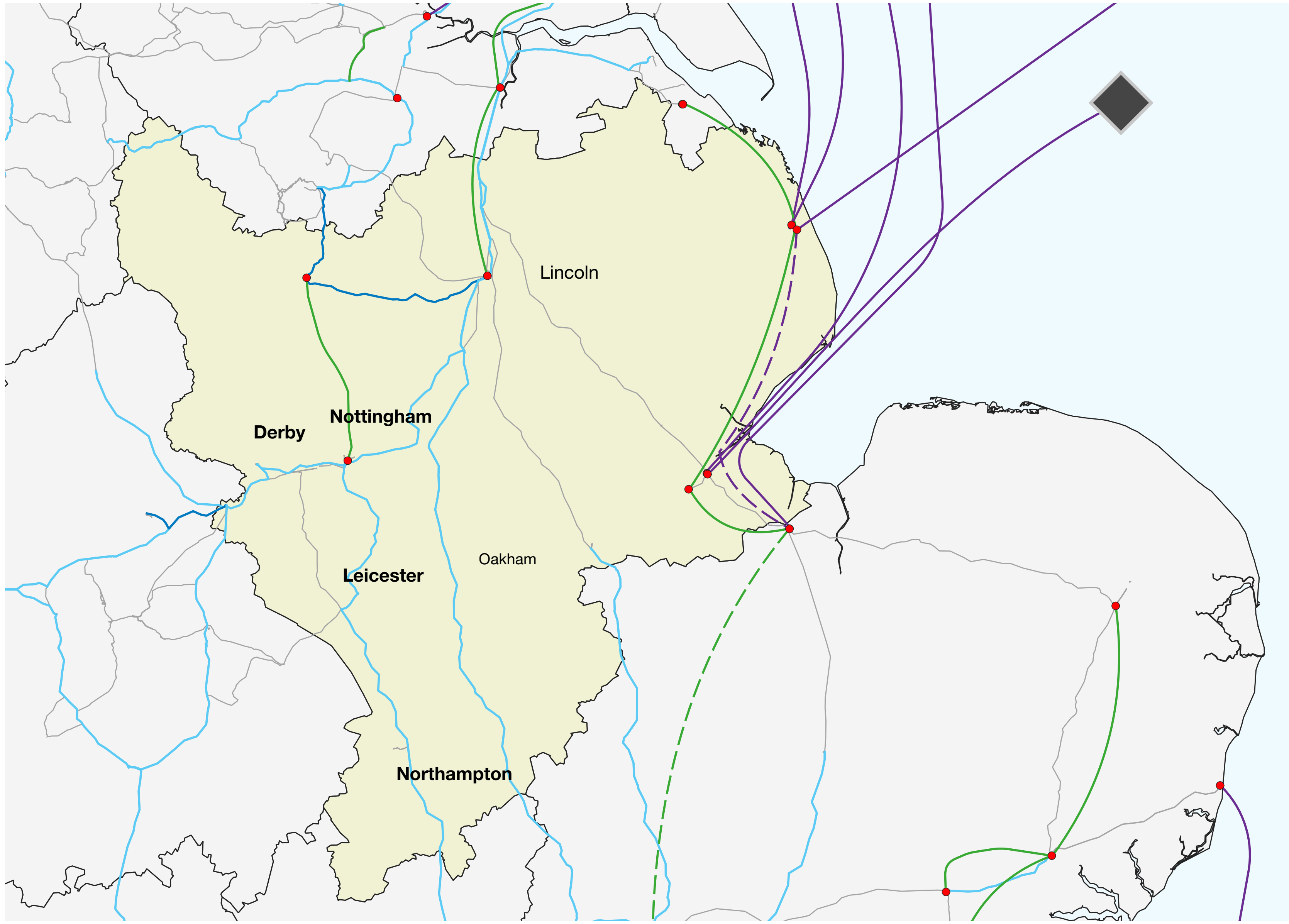


Figure 17. Map of all reinforcements in the East Midlands region

*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Beyond 2030 / Regional Blueprints / East Midlands 83

East Midlands

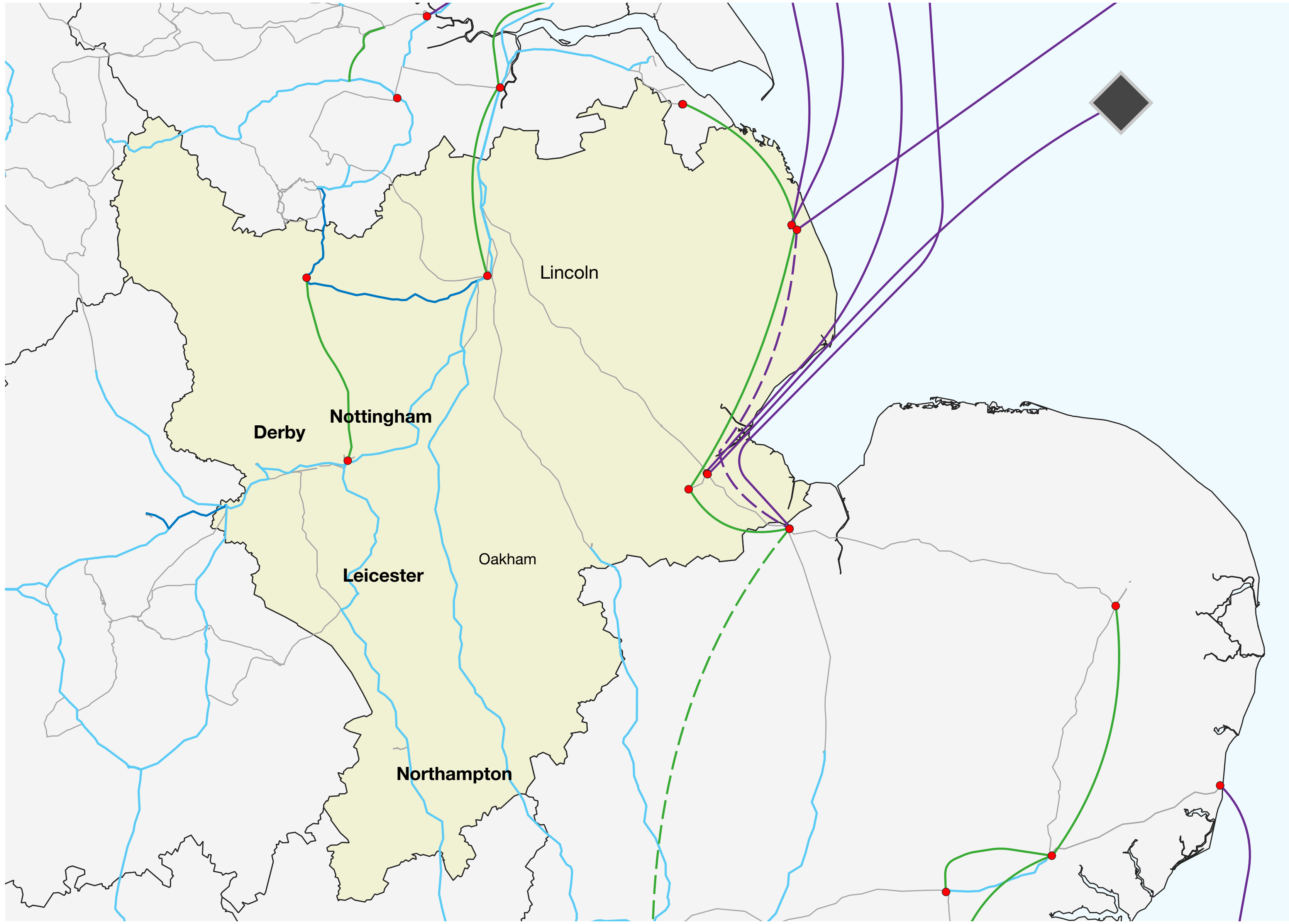
Map key

New infrastructure

Code	Description	Maturity Level
E4L6	Refine one of the proposed offshore HVDC link planned between Scotland and Eastern England with a third connection into Lincolnshire	
LRN6	New transmission capacity between the South Lincolnshire, Cambridgeshire and North West Norfolk boundary to Hertfordshire	
SW_E1c_1	Offshore network cable from a coordinated series of wind farms connecting to Lincolnshire Connection Node	
SW_E1c_2	Offshore network cable from a coordinated series of wind farms connecting to Weston Marsh	

New Upgrades

Code	Description	Maturity Level
EDN3	Replace the conductors on the existing circuits between Brinsworth and Thorpe Marsh, Brinsworth and Chesterfield, and Chesterfield and Ratcliffe with higher capacity conductors	



*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Beyond 2030 / Regional Blueprints / East Midlands 84

Beyond 2030 / Regional Blueprints / East Midlands 85

East Midlands

New upgrades

No new upgrades are currently required in this region.

The following reinforcements have previously been recommended for this region.
For more information on these options please see the ESO's Pathway to 2030 publication.[16]

Previously recommended

Code	Description	Maturity level
CGNC	New circuit between Creyke Beck and High Marnham	■■■□□□
E4L5	New offshore HVDC link between Peterhead and the East Coast of England (Eastern Green Link 3)	■■□□□□
EBRE	Replace the conductors on the existing circuit between Enderby and Patford Bridge and East Claydon with higher capacity conductors	■■□□□□
EDEU	Upgrade the existing network to a higher voltage between Brinsworth and Chesterfield and Chesterfield and High Marnham. Develop new High Marnham and Chesterfield high voltage substations	■■□□□□
EDN2	New circuit between Chesterfield and Ratcliffe-on-Soar	■■□□□□
GCHW	Carry out thermal upgrading on the existing circuit between Cottam and Market Harborough and Grendon	■■□□□□
GWNC	New circuit between North Lincolnshire and the South Lincolnshire border	■■□□□□
KCRE	Replace the conductors on the existing circuit between Cottam and Keadby with higher capacity conductors	■■□□□□
KWHW	Carry out thermal upgrading on the existing circuit between Keadby and West Burton	■■□□□□
KWPC	Add power control devices to the existing circuit between Keadby and West Burton	■■□□□□
KWP2	Increase rating of power control devices installed on the existing circuit between Keadby and West Burton	■■□□□□
R4_3	Offshore network cable from a single wind farm connecting to Weston Marsh	■■□□□□

16 https://www.nationalgrideso.com/document/264656/download

East Midlands

Previously recommended continued

Code	Description	Maturity level
SW_E1A_3	Offshore network cable from a coordinated series of wind farms connecting to Lincolnshire Connection Node	■■□□□□
WRRE	Replace the conductors on the existing circuit between West Burton and Ratcliffe-on-Soar with higher capacity conductors	■■□□□□
PT2030-CW2	Add power control devices to the existing circuit between Rugeley and Drakelow	■■□□□□
PT2030-CW3	Replace the conductors on the existing circuit between Rugeley and Drakelow with higher capacity conductors	■■□□□□
PT2030-CW4	Replace the conductors on the existing circuit between Rugeley and Ironbridge with higher capacity conductors	■■□□□□
PT2030-CW5	Replace the conductors on the existing circuit between Hams Hall and Drakelow with higher capacity conductors	■■□□□□
PT2030-CW11	Install voltage support equipment at Drakelow	■■□□□□
PT2030-CW15	Replace the conductors on the existing circuit between Drakelow and Willington with higher capacity conductors	■■□□□□
PT2030-CW16	Replace the conductors on the existing circuit between Drakelow and Ratcliffe on Soar with higher capacity conductors	■■□□□□
PT2030-CW19	Change the configuration of the existing network in the Midlands and increase the voltage of the existing circuit between Drakelow and Rugeley	■■□□□□

Beyond 2030 / Regional Blueprints / East Midlands 86

East Midlands

Previously recommended continued

Code	Description	Maturity level
PT2030-CW21	Install power flow control devices on the Keadby-West Burton circuit	■■□□□□
PT2030-CW24	Change the configuration of the network between Drakelow and Ratcliffe on Soar	■■□□□□
PT2030-CW26	Carry out thermal upgrading on the existing circuit between Creyke Beck and Keadby	■■□□□□
PT2030-CW27	Install voltage support equipment to support the existing circuit between Keadby and Fenwick Tee	■■□□□□
PT2030-CW28	Replace the conductors on the existing circuit between the Fenwick Tee and Thorpe Marsh with higher capacity conductors	■■□□□□
PT2030-CW30	Install power flow control devices on the Creyke Beck - Keadby - Humber Refinery circuits	■■□□□□
PT2030-CW31	Replace the conductors on the existing circuit between Ratcliffe on Soar and Enderby with higher capacity conductors	■■□□□□
PT2030-CW32	Add power control devices to the existing circuit between Cottam and West Burton	■■□□□□
PT2030-CW38	Add power control devices to the existing circuit between Spalding and Weston Marsh	■■□□□□

Beyond 2030 / Regional Blueprints / East Midlands 87

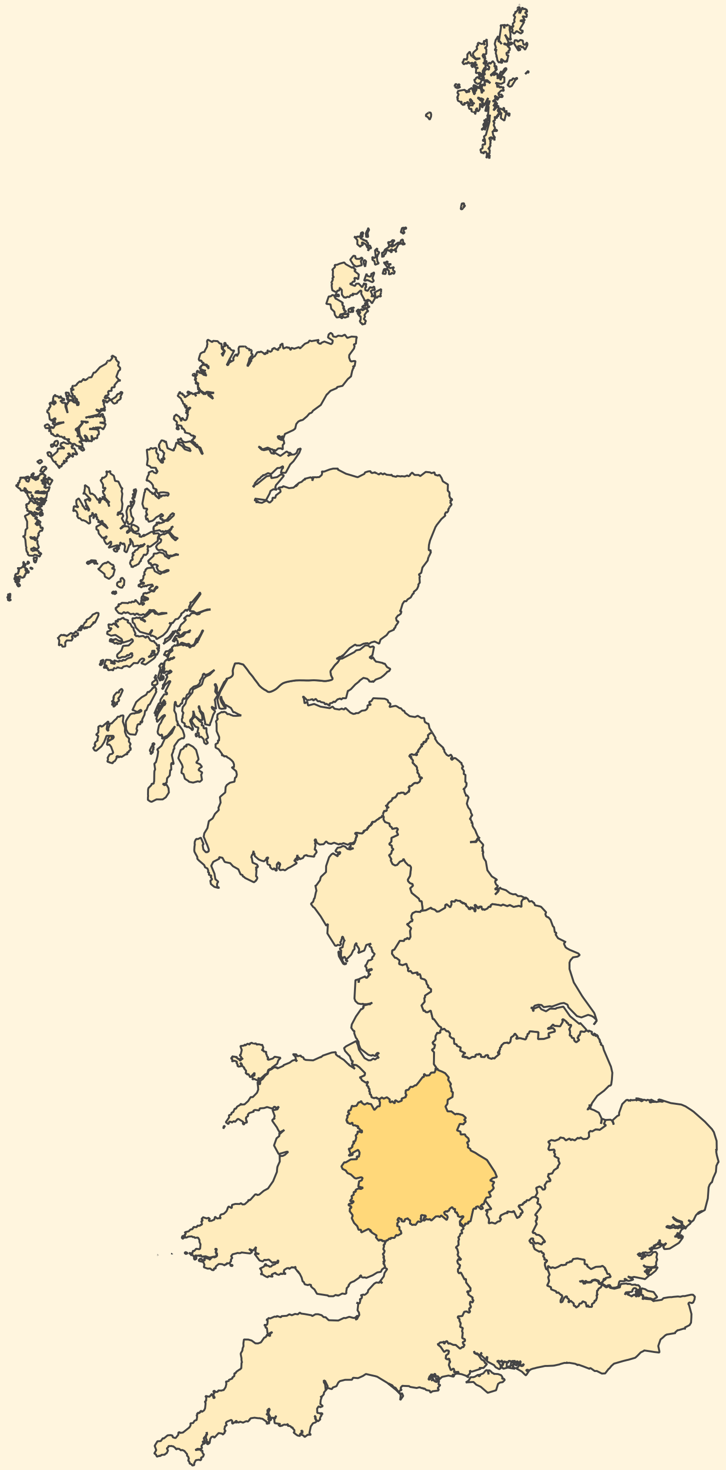
West Midlands

In the 18th century, the West Midlands was the birthplace of the first Industrial Revolution. Now, we are designing a network that will prepare the region for the Green Industrial Revolution.

The West Midlands region is one of the most diverse areas of the UK and home to Birmingham, the UK's second largest city. The region has a historic and vibrant culture across its mixture of dense urban areas, rural towns and rolling countryside.

The region has been an integral part of the British economy since the Industrial Revolution, where Birmingham was known as 'the city of a thousand trades' and was the world's leading manufacturer of metalware. It is home to the Black Country – which had a geology rich in industrial materials and is often considered to be the 'birthplace of industry'. The area was also the centre of the UK automotive industry for decades, greatly accelerating the area's development.

The heavy focus on manufacturing in the region now makes up 18 per cent of the region's gross domestic product (GDP), which is a reduction compared to previous decades. However, the region has an opportunity to benefit from efforts to decarbonise – with the West Midlands Combined Authority[17] saying they want the region to become the home of the Green Industrial Revolution and be an ambitious climate leader. To facilitate this, our proposed network aims to move cheap, clean, and renewable energy across the region, providing the environment needed for industry and businesses in the area to thrive.



17 wmca.org.uk/what-we-do/environment-and-energy/home-of-the-green-industrial-revolution/

Beyond 2030 / Regional Blueprints / West Midlands 88

West Midlands

As the region was, historically, home to many energy-intensive industries, electricity demand in the West Midlands used to be significantly higher than other parts of the UK. As such, significant grid infrastructure was developed to meet this level of demand. This means that the electricity transmission network in the West Midlands is already well developed, with large amounts of infrastructure concentrated in the area around Birmingham – with this equipment projected to meet most of the future demand in the region. However, some upgrades will still be needed. Our recommendations in the region are limited but favour upgrading the existing infrastructure (such as by replacing the wires on existing circuits with ones that can carry more electricity) over building new infrastructure which can not only reduce the impact of works on communities but also ensures we utilise existing infrastructure as far as possible, where this is a viable and suitable option.

The map in this section provides a visual summary of the blueprint for the region. While our latest network planning process has not led to any new recommended infrastructure or upgrades in the region, the map shows our recommendations made in previous network planning processes, and other works. More information on these works can be found in our previous *Pathway to 2030 report*.

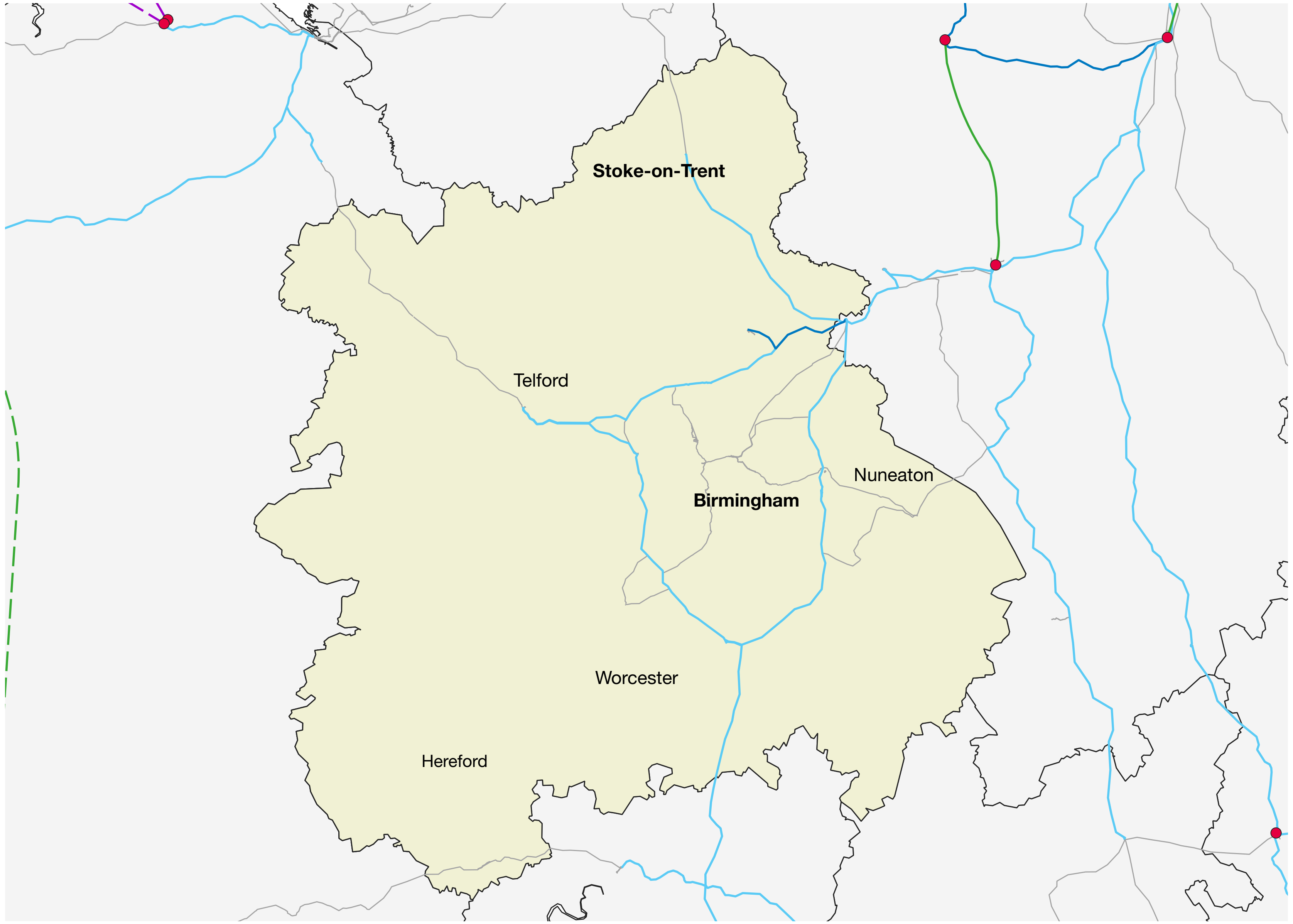


Figure 18. Map of all reinforcements in the West Midlands region

*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

West Midlands

New infrastructure

No new infrastructure is currently required in this region.

New upgrades

No new upgrades are currently required in this region.

The following reinforcements have previously been recommended for this region.
For more information on these options please see the ESO's Pathway to 2030 publication.[18]

Previously recommended

Code	Description	Maturity level
CDP1	Add power control devices to the existing circuit between Cellarhead and Drakelow	■■□□□□
CDP2	Increase rating of power control devices installed on the existing circuit between Cellarhead and Drakelow	■■□□□□
CDP3	Further increase rating of power control devices installed on the existing circuit between Cellarhead and Drakelow	■■□□□□
FHRE	Replace the conductors on the existing circuit between Feckenham and Hams Hall with higher capacity conductors	■□□□□□
FMR2	Replace the conductors on the existing circuit between Feckenham and Minety with higher capacity conductors	■□□□□□
FWRE	Replace the conductors on the existing circuit between Feckenham and Walham with higher capacity conductors	■□□□□□
IFR1	Replace the conductors on the existing circuit between Feckenham and Ironbridge with higher capacity conductors	■□□□□□
PT2030-CW2	Add power control devices to the existing circuit between Rugeley and Drakelow	■■□□□□
PT2030-CW3	Replace the conductors on the existing circuit between Rugeley and Drakelow with higher capacity conductors	■■□□□□
PT2030-CW5	Replace the conductors on the existing circuit between Hams Hall and Drakelow with higher capacity conductors	■■□□□□
PT2030-CW10	Install voltage support equipment at Ironbridge	■■□□□□
PT2030-CW19	Change the configuration of the existing network in the Midlands and increase the voltage of the existing circuit between Drakelow and Rugeley	■■□□□□

18 https://www.nationalgrideso.com/document/264656/download

Beyond 2030 / Regional Blueprints / West Midlands 90

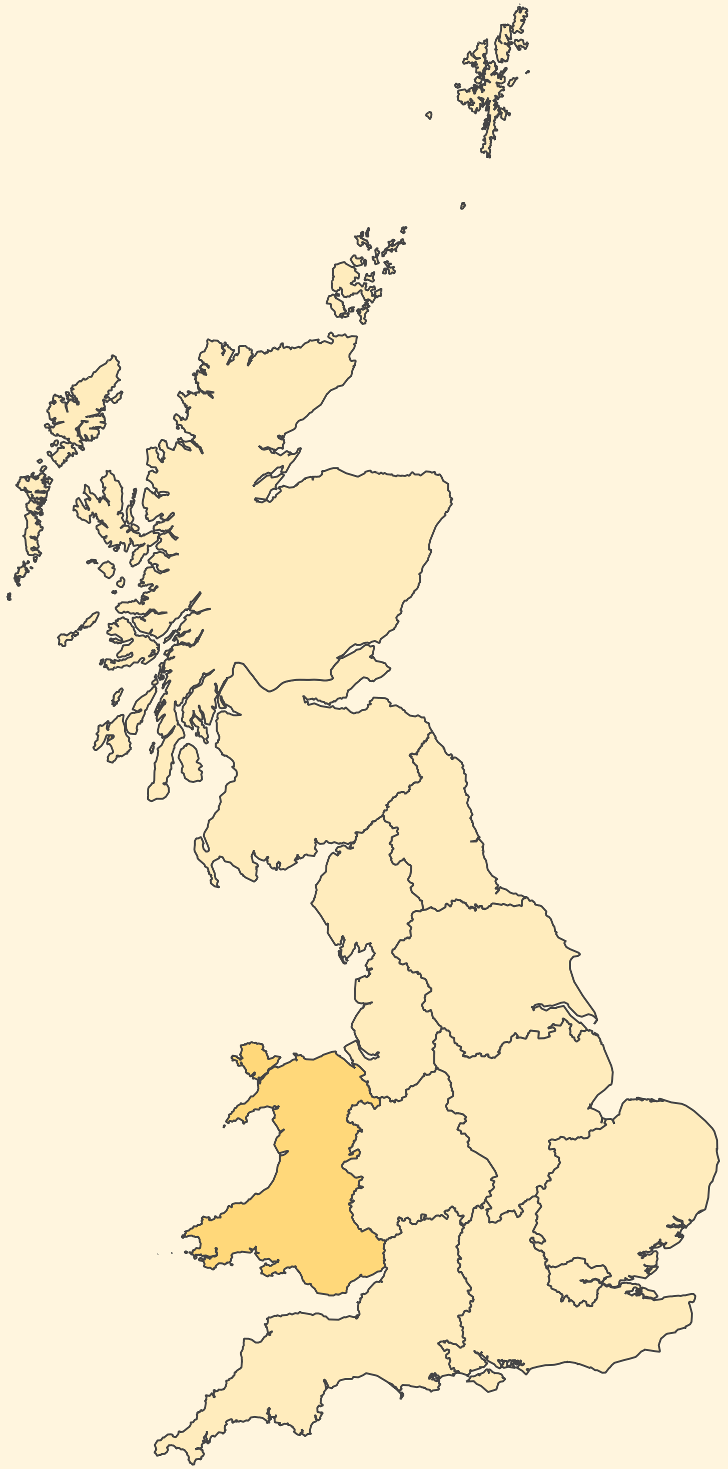
Wales

Famous for exporting materials such as steel, iron, copper, coal and slate - Wales is currently a net exporter of electricity, generating twice as much as it uses. Much like the rest of Great Britain, the Welsh energy mix is undergoing rapid change in its bid to meet net zero.

Wales has a strong energy heritage. Throughout most of the 20th century, Wales's electricity demand was met, in large part, by a small number of big power stations. Coal predominately powered the south, and the north was home to two large nuclear power stations which provided much of the country's generation capacity. The country's energy mix has changed significantly as it moved into the 21st century. Electricity is no longer supplied from either coal or nuclear sources in Wales as these power stations have now closed. Despite this, Wales still plays a major role in Great Britain's energy landscape.

Wales is home to Dinorwig power station, which is affectionately known as 'Electric Mountain'. It is a pumped hydro facility, which allows cheaper, cleaner electricity to be stored by pumping water from a lower-level reservoir to a higher one (usually at night when electricity is cheaper). The stored energy can be used when needed (usually when there is a peak in demand) by allowing the water to flow from the higher reservoir to the lower one through a turbine (which spins a generator).

Dinorwig is one of the largest pumped storage facilities in Europe and has served Great Britain since 1984. The electricity the power station provides is important to the Electricity National Control Centre as it can be brought online quickly, allowing the grid to handle surges or drops in demand that can happen due to large scale collective behaviour, such as 'TV pickups' caused by the public watching national sporting events. The ability to be able to react quickly, by either taking electricity on or off the system, means that the grid can be kept balanced second by second.



Wales

High voltage transmission lines run from east to west along Wales's north and south coasts. However, there is currently no transmission line connecting the north and south of the country. As such, Mid Wales currently has limited connectivity with no transmission infrastructure in the region. This means that there are limited opportunities in Mid Wales for businesses with high demands for energy to decarbonise by switching to renewable electricity. These 'gaps' in the network will need to be filled to support grid connection opportunities in Mid Wales and achieve the Wales's and the UK's net-zero ambitions. Filling these gaps will allow Mid Wales to meet its own energy needs and the ability to import or export clean electricity from either the Irish or Celtic Seas will be of benefit to all consumers throughout Wales.

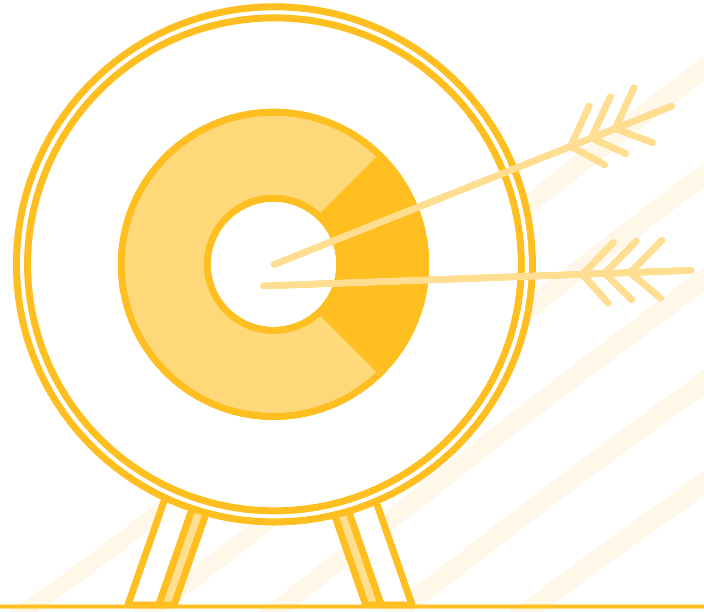
While renewable technologies have expanded rapidly following the closure of coal and nuclear stations, the largest source of the electricity used in Wales is currently gas. Most gas generation is based in Pembrokeshire, whereas there is a spread of wind, solar and biomass generation across all regions of Wales. Onshore wind makes up most of Wales's renewable generation with a significant number of projects being completed throughout the 2010s. In recent years, the amount of renewable energy connecting to the system in Wales has slowed, with a lack of network capacity being one of the key barriers. This lack of capacity can stifle investment and opportunities for local communities.

The Welsh Government also has additional and distinct energy targets, including a target of having 100 per cent of annual electricity consumption coming from renewable sources by 2035. Although energy consumption has trended down across Wales for the last decade, we anticipate that electricity consumption across the country will greatly increase with the electrification of transport and heating.

Significant new generation to help power this transition will come from opportunities offshore. The two areas currently in development are in the Celtic Sea off the south-west coast and in the Irish Sea off the north coast. Technologies exploiting wind resource in deeper waters may enable further opportunities for Wales to capitalise on this vast wealth of green energy which could power the decarbonisation of other sectors.

Managing the flow of this new generation lying on the edges of the electricity network will require major development of the transmission system. Our analysis has not identified further infrastructure requirements on top of our previous recommendations; however, it has reinforced the need for improved connectivity from North Wales to South Wales which will be delivered by the circuit we have previously recommended.

We have also updated our other reinforcement recommendations in North Wales. We are now recommending higher capacity components - this will allow the transmission routes in the area to carry more power whilst maintaining the same footprint.



Beyond 2030 / Regional Blueprints / Wales 92

Wales

This will ensure our recommendations are futureproofed and will reduce the likelihood for more works to be required further down the line. We have also removed a previous recommendation for an offshore circuit between the North West of England and North Wales. This has been superseded by an upgrade to the previously proposed offshore western link from Scotland to North Wales and an upgrade to the existing network around Merseyside. We are recommending that the capacity of the western offshore cable is doubled. This can be done by reconfiguring the cable design which minimises impact to the natural environment and provides significant consumer benefit.

The development of new floating offshore wind capacity in the Celtic Sea has the potential to trigger additional infrastructure in Wales if new connections are made along the coastline. We are considering a number of existing or potential new substations along the South Wales coastline as interface points for the 4.5 GW capacity, due to their proximity to the seabed areas The Crown Estate are leasing as part of their fifth offshore leasing round, as well as considering connections into the South West region. As we have not reached the final recommended design for the 4.5 GW of offshore wind, the new infrastructure that would be required has yet to be defined, however the impacts of the works needed to connect this new renewable energy capacity will be assessed holistically against alternative options within the Celtic Sea area. This could involve developing new substations, upgrading existing infrastructure that currently operates at lower voltages or developing new routes so that this renewable electricity can reach demand centres throughout Wales and beyond.

The map in this section provides a visual summary of the blueprint for the region. It shows our new recommendations, our recommendations made in previous network planning processes, and other works. This section of the report is interactive, providing the opportunity for readers to explore in more detail the specifics of any new recommendations in the region.

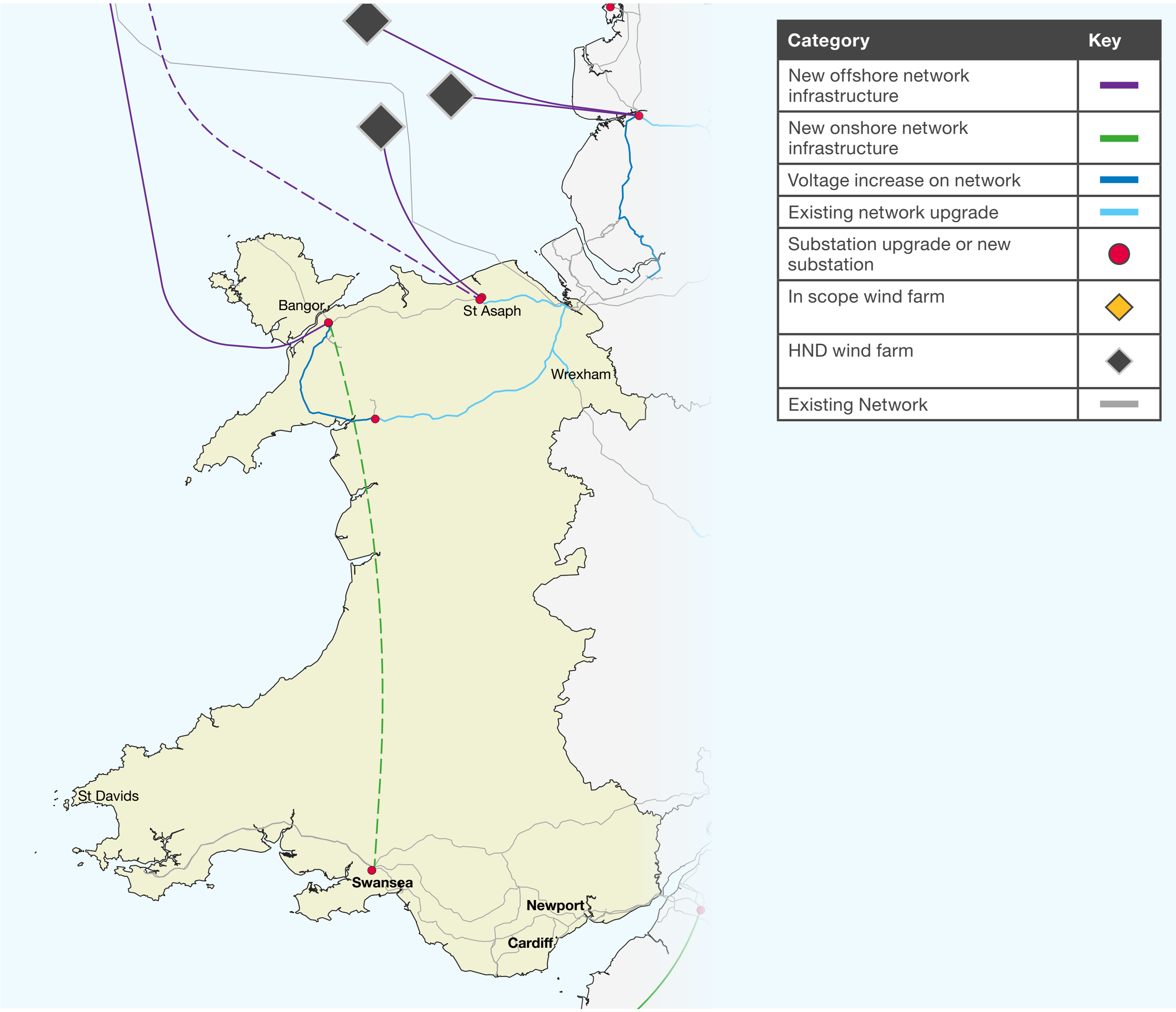


Figure 19. Map of all reinforcements in the Wales region

*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Beyond 2030 / Regional Blueprints / Wales 93

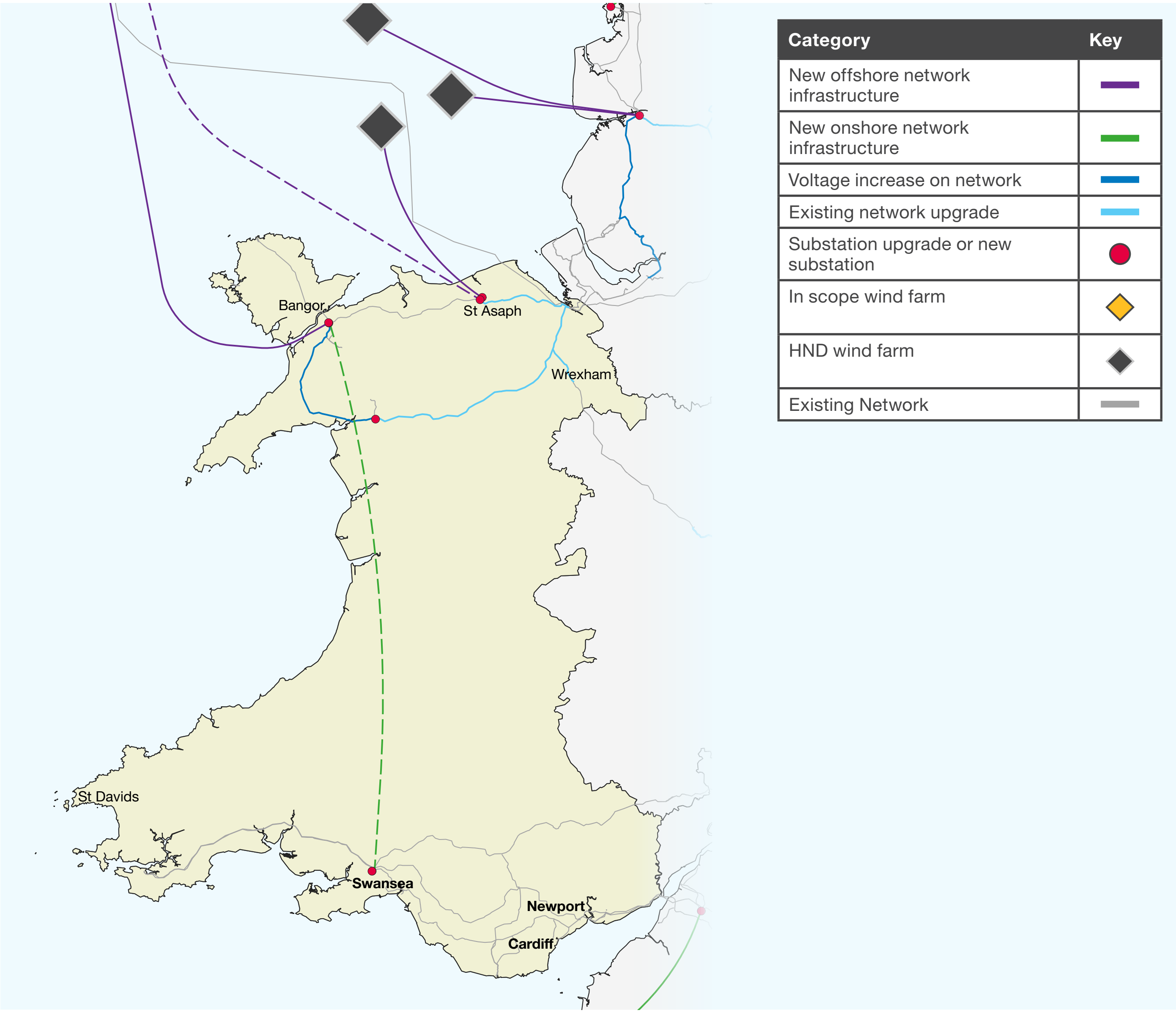
Wales

New infrastructure

Code	Description	Maturity Level
PTN2	New circuit in North Wales with a higher capacity then was previously recommended	■□□□□□

New upgrades

Code	Description	Maturity Level
PTC2	Replace the conductors on the existing circuit between Pentir and Trawsfynydd with a higher capacity then was previously recommended	■□□□□□
WCD4	Increase the capacity of the proposed HND1 West Coast offshore HVDC link between Scotland and Wales	■□□□□□



*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Click code for further information

Beyond 2030 / Regional Blueprints / Wales 94

Wales

The following reinforcements have previously been recommended for this region.
For more information on these options please see the ESO's Pathway to 2030 publication.[19]

Previously recommended

Code	Description	Maturity level
PSNC	New circuit between North Wales and South Wales	■□□□□□
R4_4	Offshore network cable from a single wind farm connecting to Bodelwyddan	■■□□□□
PT2030-CW1	Connect the existing circuit between Connah's Quay and Pentir directly into Bodelwyddan	■■□□□□
PT2030-CW6	Replace the conductors on the existing circuit between Bodelwyddan and Connah's Quay with higher capacity conductors	■■□□□□
PT2030-CW9	Replace the conductors on the existing circuit between Connah's Quay, Legacy and Trawsfynydd with higher capacity conductors	■■□□□□
PT2030-CW14	Add power control devices to the existing circuit between Bodelwyddan and Connah's Quay	■■□□□□

19 https://www.nationalgrideso.com/document/264656/download

Beyond 2030 / Regional Blueprints / Wales 95

East of England

As a world leading trail blazer in offshore wind, thanks to its shallow waters that are well suited to offshore wind farms, the East of England will be key in supporting the UK in meeting its decarbonisation targets.

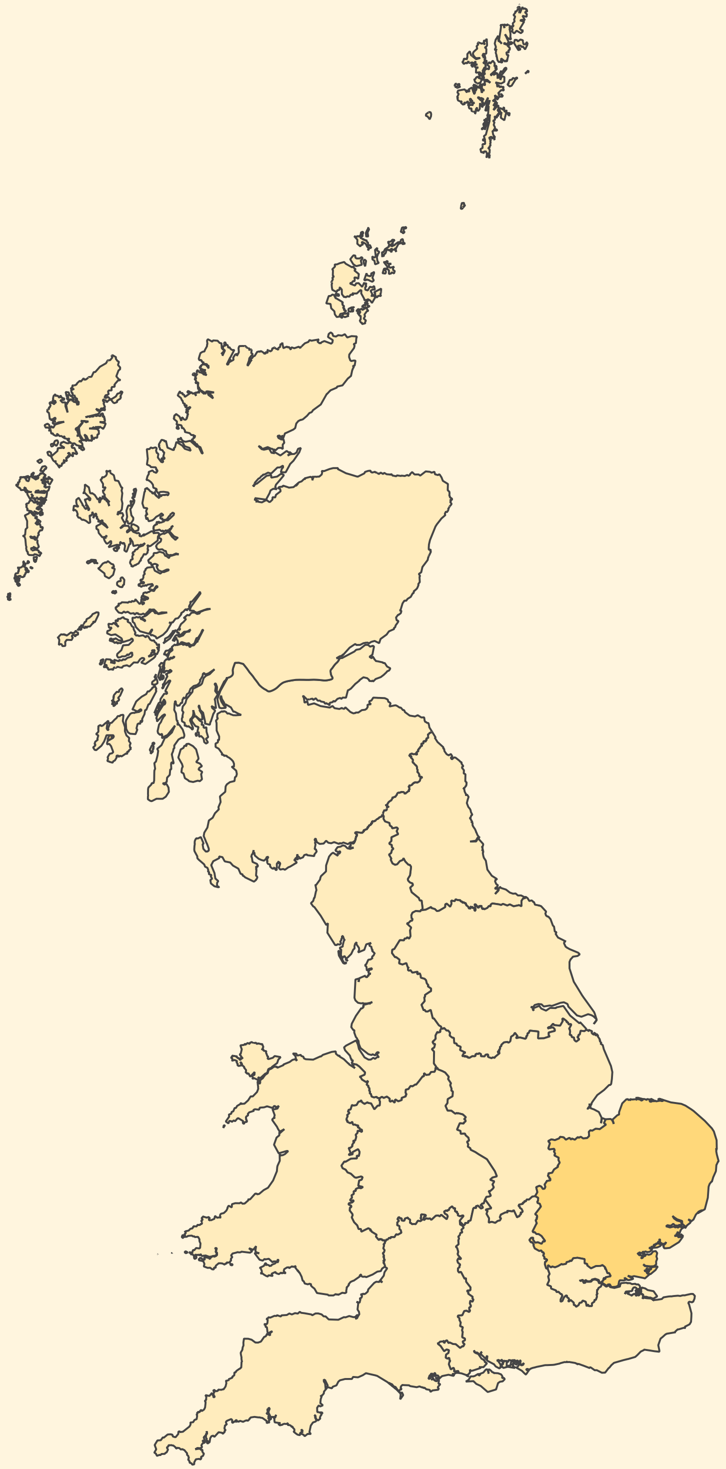
Home to some of the UK's fastest-growing areas, the East of England is a region with high levels of economic ambition. This ambition will mean a growing demand for clean, reliable energy from both homes and businesses in addition to the new requirements presented by zero-carbon heating and transport.

The region will therefore play a critical role in enabling the energy transition by providing the conduit for renewable energy from offshore wind farms to homes and businesses. To do this we need to ensure the electricity network can support this requirement, but in a way that is designed to minimise impact on communities.

The offshore wind capacity in the region is complemented with existing and new zero-carbon nuclear generation at Sizewell, and the region may also see greater interconnection with countries across the North Sea.

This new renewable generation will ensure that technology hubs surrounding Cambridge and Norwich, and manufacturing and agricultural businesses stretching across the region can be supplied with greener and cheaper electricity, supporting regional economic growth.

The current high voltage electricity transmission network in East of England was developed in the 1960s, with the regional network centred around Norwich and Ipswich, along with several major north-south circuits hosted by Hertfordshire, Bedfordshire and Cambridgeshire. Until now, the existing high voltage electricity network has been sufficient to meet demand, however, as electricity needs grow, the capacity of the electricity transmission network will need to grow to meet this.



Beyond 2030 / Regional Blueprints / East of England 96

East of England

Cambridgeshire, Bedfordshire and Hertfordshire

Our most recent network assessments have found that the recommendations we have previously set out for this area are sufficient to meet the future needs of the transmission network in these three counties and beyond. As such, we are not proposing any major new infrastructure in Cambridgeshire, Bedfordshire or Hertfordshire on top of our previous recommendations.

Previously, our recommendations in Cambridgeshire, Bedfordshire and Hertfordshire included a mixture of new infrastructure, alongside upgrades to the (already well developed) existing network in these three counties.

One of these previously recommended projects is a mixture of a new circuit and upgrades to existing circuits – a new circuit between Wymondley and Waltham Cross, alongside upgrading the voltage of surrounding circuits to increase their capacity.

We continue to recommend that the wires on some existing circuits are replaced (reconductored) with higher capacity ones that can carry more electricity – increasing the capability of these circuits, with minimal long-term impact on surrounding communities and at a lower cost to consumers. Two of the circuits we have recommended to be reconductored are between Grendon and Sundon, and between Sundon and Elstree. These circuits form parts of a major north-south electrical corridor which is vital to the transmission network in the region and the whole system.

During detailed network design of a previously recommended circuit from Lincolnshire through Cambridgeshire and Bedfordshire and on to Hertfordshire, the relevant Transmission Owner is currently reviewing and optimising this circuit to be shorter in length. The starting point for this circuit will be along an electrical boundary that borders the outskirts of South Lincolnshire, Cambridgeshire and North West Norfolk. The routing of this circuit will follow the same trajectory as previously recommended and likely pass directly into and through Cambridgeshire on the way to Hertfordshire.

Beyond 2030 / Regional Blueprints / East of England 97

East of England

Norfolk, Suffolk and Essex

As set out previously, the shores around East Anglia were one of the first seabed areas to be leased by The Crown Estate. As a result, there are many offshore wind farms either built or starting construction off its coast and subsequently the region was deemed in scope of the 'Early Opportunities' workstream led by the UK Government which incentivised voluntary offshore coordination.

As confirmed by the Department for Energy Security and Net Zero on 5th December 2023, the output of the early opportunities workstream (known as the Offshore Coordination Support Scheme – OCSS) has seen a proposal being put forward by North Falls offshore wind farm, Five Estuaries offshore wind farm and National Grid Electricity Transmission (NGET) for their Sea Link project to explore voluntary offshore coordination.

Following the OCSS announcement, the ESO have studied whether this proposed change in connection location (from the coordination proposed through the OCSS) would change the underlying power flows within the region and therefore the need and location of network transmission infrastructure.

We provided a side-by-side comparison of ten different electricity network configuration options that transfer power across or around the region. The link to this report and our findings can be found here.

At the time of writing this report, no decision had been made from the UK Government and relevant developers as to whether they would continue exploring voluntary offshore coordination through the OCSS. If this process progresses to the next stage, as set out in our study, there are multiple network configuration options for the Transmission Owner and other relevant parties to progress further.

Beyond 2030 / Regional Blueprints / East of England 98

East of England

Looking out into the 2030s, the ESO is not recommending any further wider electricity transmission network reinforcements running through the counties or landing within them, aside from the network capacity already proposed and explained on the previous page.

The map in this section provides a visual summary of the blueprint for the region. It shows our new recommendations, our recommendations made in previous network planning processes, and other works. This section of the report is interactive, providing the opportunity for readers to explore in more detail the specifics of any new recommendations in the region. Our previous recommendations have been through a recent review as part of the *East Anglia Network Study* due to the change in power flows brought on because of the OCSS, although the outcome of this review is not covered within this document.

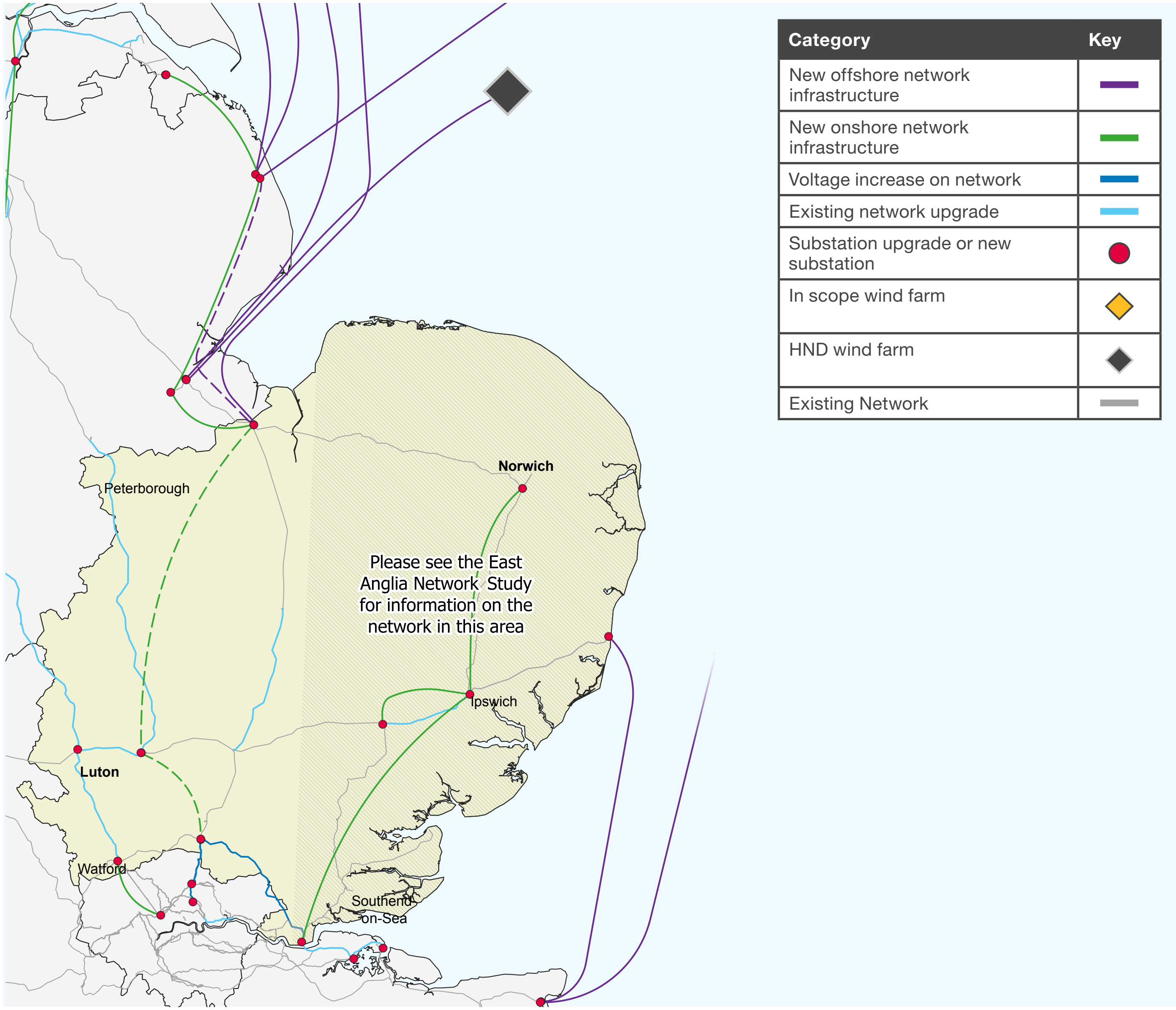


Figure 20. Map of all reinforcements in the East of England region

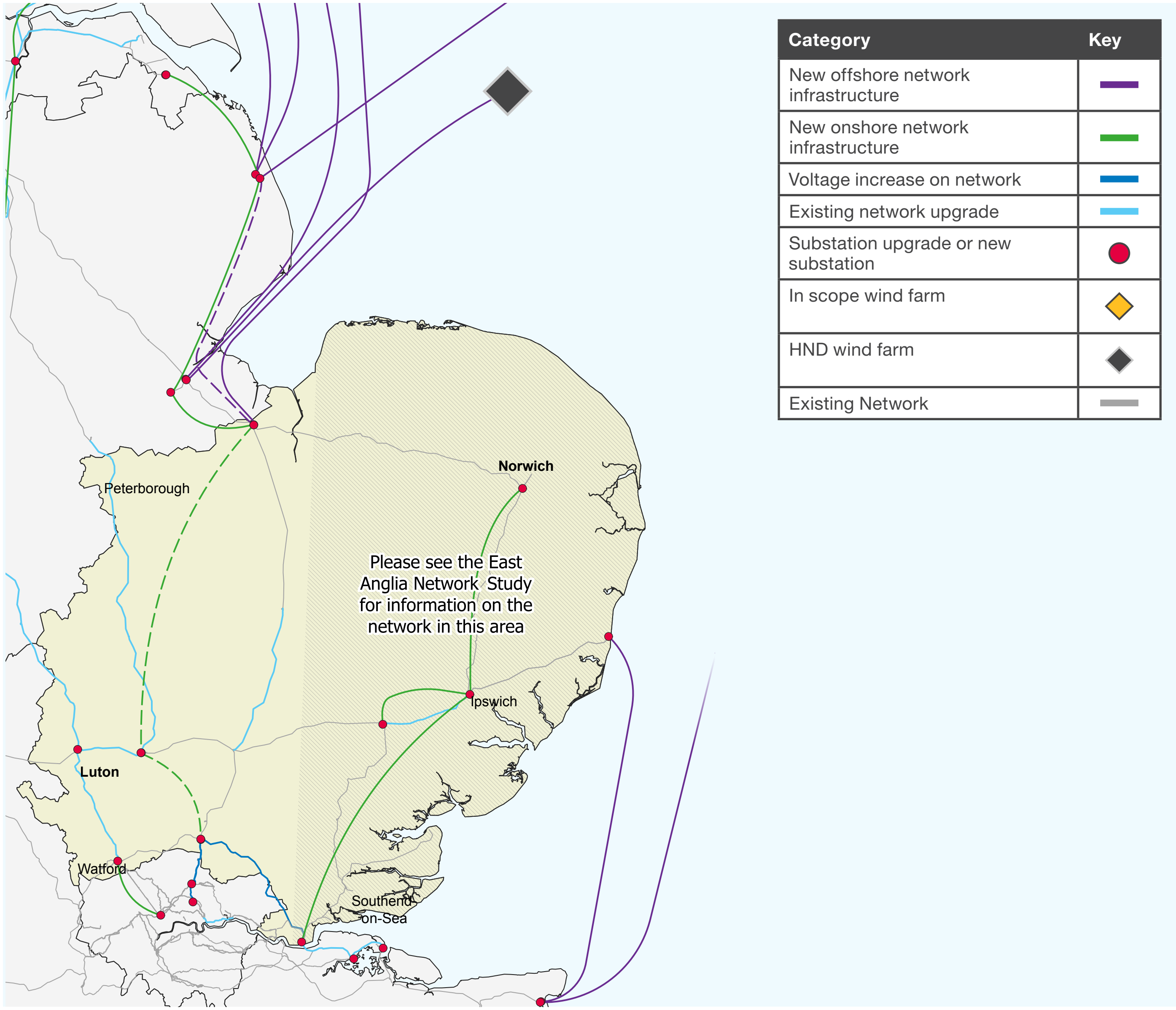
*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Beyond 2030 / Regional Blueprints / East of England 99

East of England

New infrastructure

Code	Description	Maturity Level
E4L6	Refine one of the proposed offshore HVDC link planned between Scotland and Eastern England with a third connection into Lincolnshire	■□□□□□
LRN6	New transmission capacity between the South Lincolnshire, Cambridgeshire and North West Norfolk boundary to Hertfordshire	■□□□□□
TWNC	New circuit between Wymondley and Waltham Cross and increase operating voltage of the network within the area	■□□□□□



*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Click code for further information

Beyond 2030 / Regional Blueprints / East of England 100

Beyond 2030 / Regional Blueprints / East of England 101

East of England

New upgrades

No new upgrades are currently required in this region.

The following reinforcements have previously been recommended for this region.
For more information on these options please see the ESO's Pathway to 2030 publication.[20]

Previously recommended

Code	Description	Maturity Level
AENC	New circuit in north East Anglia	■■■□□□
ATNC	New circuit in south East Anglia	■■■□□□
BTNO	New circuit between Bramford and Twinstead	■■■■□□
ESC1	New circuit between Elstree and St John's Wood	■■□□□□
HWUP	Upgrade the existing network to a higher voltage between Waltham Cross to Hackney	■■□□□□
GWNC	New circuit between North Lincolnshire and the South Lincolnshire border	■■□□□□
NBEU	Carry out thermal upgrading to Bramford and Norwich substations	■■□□□□
NTP1	Add power control devices to the existing circuit to the north of Tilbury	■■□□□□
PEM1	Install further voltage support equipment at Pelham	■■□□□□
PEM2	Install voltage support equipment at Pelham	■■□□□□
RHM1	Install voltage support equipment at Rye House	■■□□□□

20 https://www.nationalgrideso.com/document/264656/download

East of England

Previously recommended continued

Code	Description	Maturity Level
RHM2	Install further voltage support equipment at Rye House	■■□□□□
SER1	Replace the conductors on the existing circuit between Elstree and Sundon with higher capacity conductors	■■□□□□
SER2	Replace the conductors on the existing circuit between Elstree and Sundon with higher capacity conductors and connect into the Elstree Substation	■■□□□□
TGDC	New offshore HVDC link between East Scotland and the East of England (Eastern Green Link 4)	■■□□□□
TGP1	Add power control devices to the existing circuit between Tilbury and Grain	■■□□□□
TKP1	Add power control devices to the existing circuit between Tilbury and Kingsnorth	■■□□□□
TKRE	Carry out thermal upgrading on the existing circuits between Tilbury to Grain and Tilbury to Kingsnorth	■■□□□□
WAM1	Install voltage support equipment at Walpole	■■□□□□
WAM2	Install further voltage support equipment at Walpole	■■□□□□
WYTI	Connect the existing circuit between Pelham and Sundon that passes Wymondley substation into the substation	■■□□□□
PT2030-CW23	Replace the conductors on the existing circuit between Sundon and Wymondley with higher capacity conductors	■■□□□□
PT2030-CW34	Replace the conductors on the existing circuit between Grendon and Sundon with higher capacity conductors	■■□□□□
PT2030-CW35	Replace the conductors on the existing circuit between Ryhall, Eaton Socon and Wymondley with higher capacity conductors	■■□□□□
PT2030-CW37	Carry out thermal upgrading on the existing circuit between Burwell Main and Pelham	■■□□□□

Beyond 2030 / Regional Blueprints / East of England 102

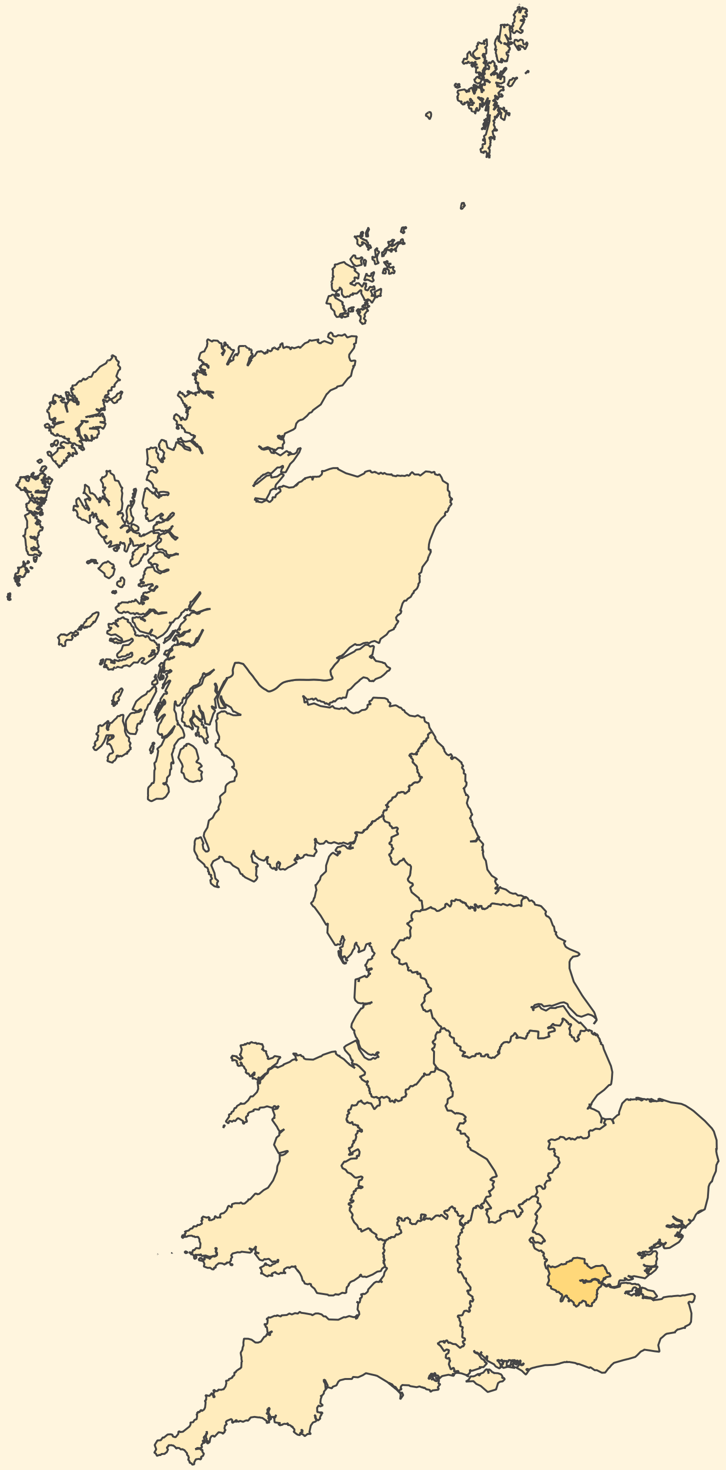
London

It takes a lot of energy to keep the biggest city in Western Europe running. As an economic, transportation and cultural centre, London's energy needs are due to grow as the UK decarbonises.

London is a pioneering city. It had a significant role in Great Britain's industrialisation, and it is the home of the world's first underground passenger railway. The city also hosts multiple early and iconic power stations which have left a lasting legacy. Today, London is often seen as a 'green investment capital', with a reputation for supporting and investing in initiatives and enterprises that promote sustainability and social responsibility. However, the city's early advancement and significant population growth means that upgraded infrastructure is required to support its ever-growing energy needs.

With a population of around nine million, London is a large source of electricity demand. The sources of these needs can be varied – from London's role as a public service and business hub to the huge electricity needs of the local technology and computing sector.

In addition, London's energy needs are growing due to both population growth and the increasing decarbonisation of heat and transport (with London being the region with the most electric vehicle (EV) charging points in the UK as of January 2024).



Beyond 2030 / Regional Blueprints / London 103

London

As a densely populated urban area, the city does not have the space for large-scale renewable electricity generation projects. Instead, it needs a robust electricity network to meet its energy needs. To ensure that the electricity network can meet changing and increasing demand, the existing infrastructure in and around London must be upgraded to meet the needs of the future.

The electricity network around the city was one of the first parts of the electricity transmission network to be built in Great Britain and was created by joining up previously existing network infrastructure. As such, large amounts of London's transmission infrastructure use a lower voltage compared to most of the grid in England and Wales – meaning the cables and lines can carry less electricity compared to other circuits.

Before the start of recent major projects, the majority of London's electricity transmission network was a ring around the outskirts of the city – like the M25. Also like the M25, this ring is now heavily congested and is no longer suitable for present day needs.

Over the past 10 years, and unknown to many, tunnels have been dug under the capital to carry high capacity 400 kV cables to the heart of London. Just as people move across the city below surface level, London's electricity is also transported deep underground. The first phase of these tunnels and cables has been commissioned and are now a vital part of the transmission network. The second phase of the London Power Tunnels is currently being built, connecting more of the city, and giving new life to the old network.

Beyond 2030 / Regional Blueprints / London 104

London

Map key

Our recommendations include new infrastructure and network upgrades to provide the required capacity for electricity to flow in to and out of London – including a new circuit from Hertfordshire into London and associated upgrades to existing circuits and infrastructure around the border of the capital.

This investment will ensure that London has the reliable and green electricity network it needs. Helping to make sure people and businesses across the city continue to have the infrastructure they need to develop growing sectors of industry and commerce – protecting jobs and increasing the number job opportunities across the city.

The map in this section provides a visual summary of the blueprint for the region. It shows our new recommendations, our recommendations made in previous network planning processes, and other works. This section of the report is interactive, providing the opportunity for readers to explore in more detail the specifics of any new recommendations in the region.

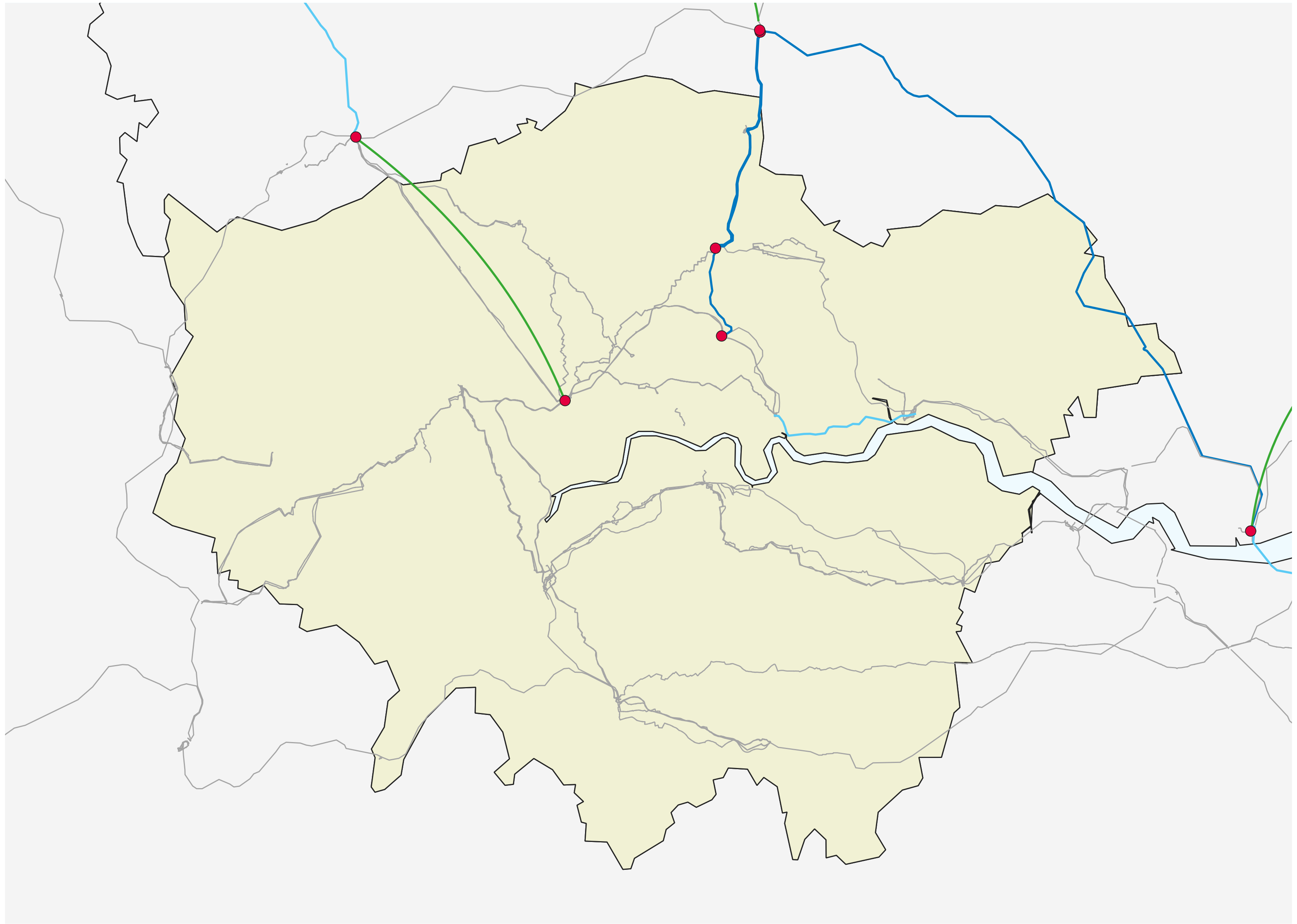


Figure 21. Map of all reinforcements in the London region

*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Beyond 2030 / Regional Blueprints / London 105

London

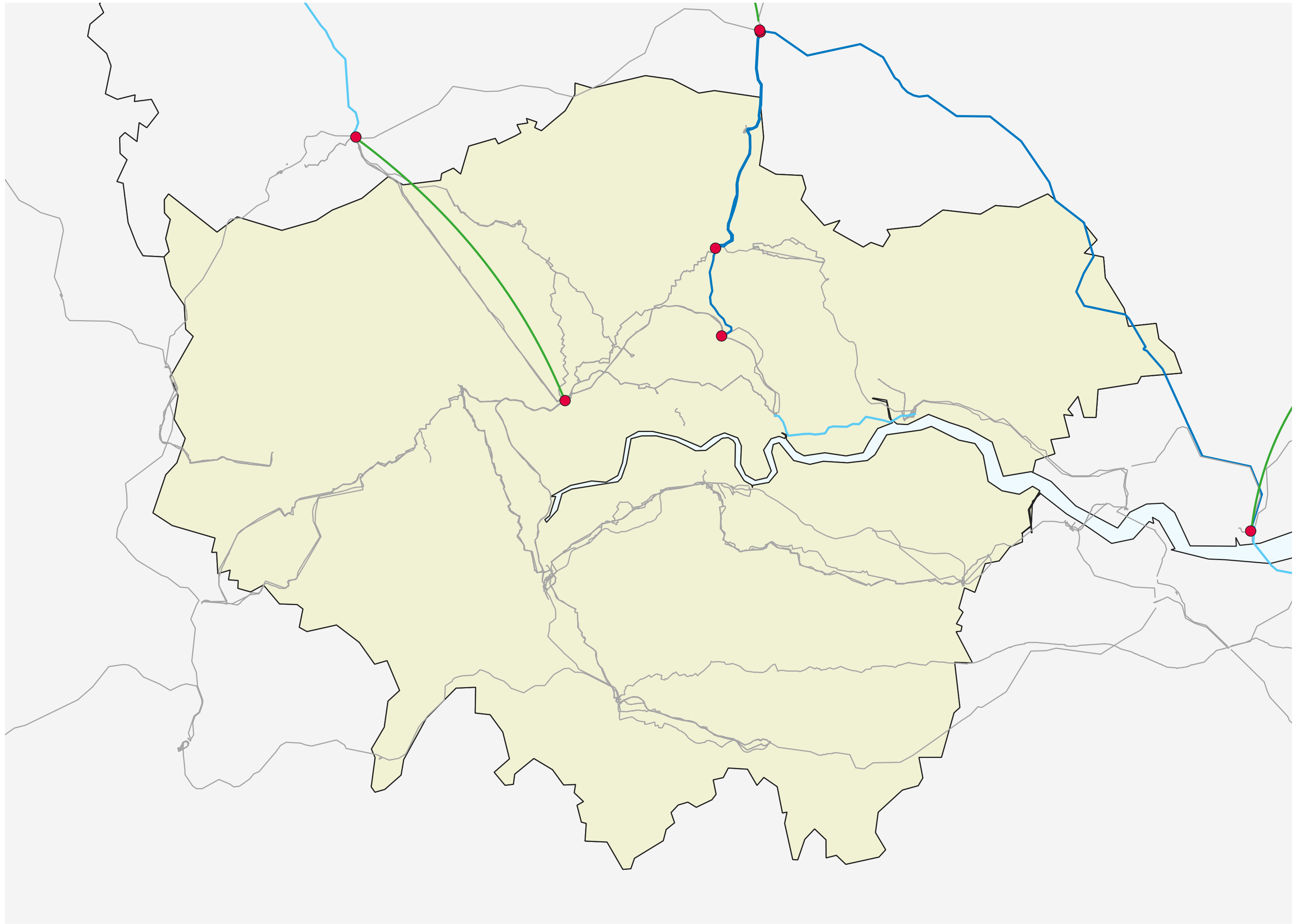
Map key

New infrastructure

No new infrastructure is currently required in this region.

New upgrades

Code	Description	Maturity Level
TWNC	New circuit between Wymondley and Waltham Cross and increase operating voltage of the network within the area	■□□□□□



*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Beyond 2030 / Regional Blueprints / London 106

Beyond 2030 / Regional Blueprints / London 107

London

The following reinforcements have previously been recommended for this region.
For more information on these options please see the ESO's Pathway to 2030 publication.[21]

Previously recommended

Code	Description	Maturity level
BWRE	Replace the conductors on the existing circuit between Barking and West Ham with higher capacity conductors	■■□□□□
ESC1	New circuit between Elstree and St John's Wood	■■□□□□
HWUP	Upgrade the existing network to a higher voltage between Waltham Cross to Hackney	■■□□□□

21 https://www.nationalgrideso.com/document/264656/download

South East

The energy needs of the South East are already the highest in the country and are expected to continue to grow. It is therefore key that the area's infrastructure can cope with this rise in demand.

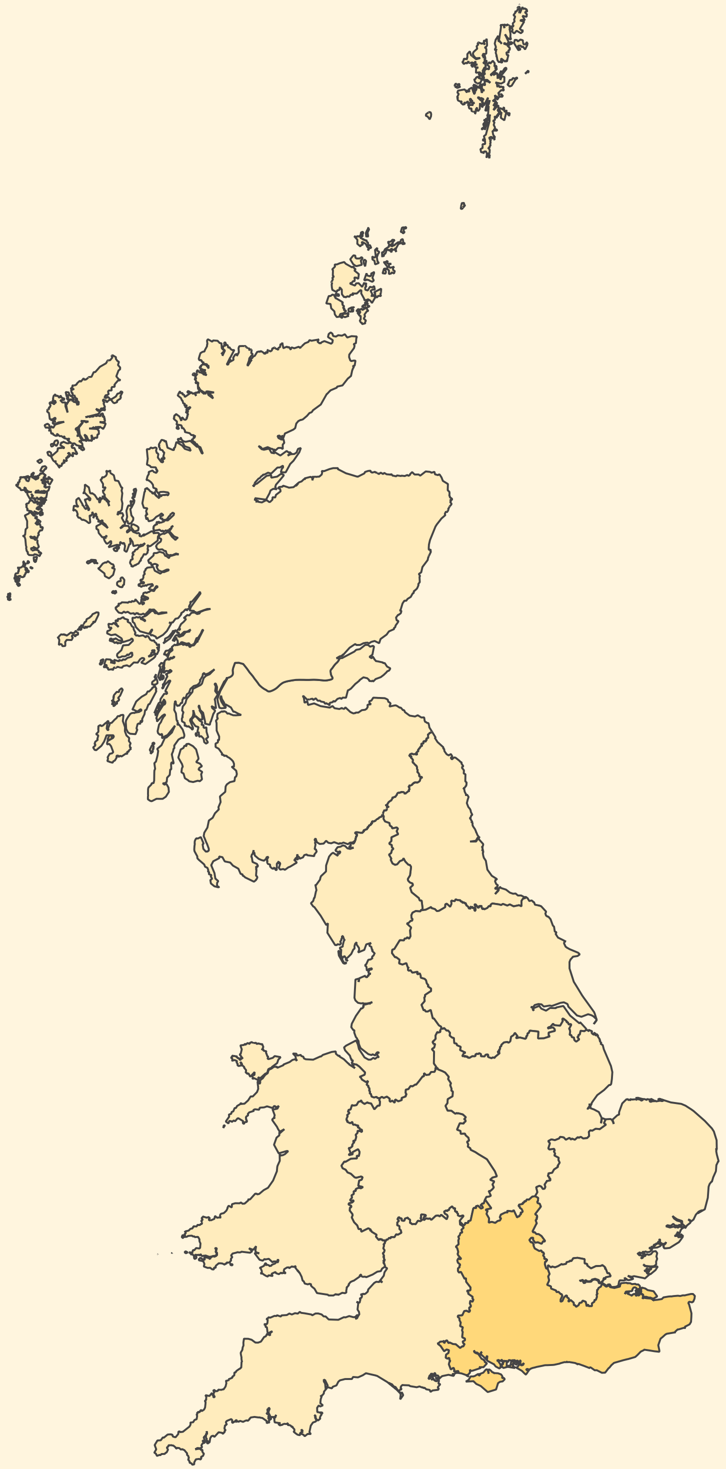
The South East is the home of the Electricity National Control Centre, the brain of Great Britain's electricity system. Located in Wokingham, Berkshire, for over thirty years, engineers work to balance the grid second-by-second, 24 hours a day, 365 days a year. They send commands to power stations and interconnectors across the country to move electricity from where it is generated to where it is needed.

The South East's energy needs will continue to rise in the coming years, as more things which are currently powered by fossil fuel sources of energy (such as cars and heating) are transitioning to electricity.

The area also has a comparatively small amount of generation capacity in relation to its size, population, and energy needs. As such, the electricity used in the region needs to come from elsewhere, and therefore the region's network needs to be able to provide this, reliably and safely.

Kent is the gateway to Europe and Britain is not just connected to Europe by the Channel Tunnel; it is also connected to the continent by a series of high voltage electricity interconnectors, many of which are located in the South East. These interconnectors allow us to import electricity from France, Belgium, and the Netherlands when there is a shortfall of electricity in Great Britain and allow the UK to export and sell electricity to these countries when there is a surplus.

The electricity network in the region experiences times of very high congestion, especially around the North Kent area. We are therefore recommending upgrades that increase the number of connections within the region and improve upon the existing network capability.



Beyond 2030 / Regional Blueprints / South East 108

South East

These upgrades will help make sure that the South East has the infrastructure it needs to ensure a resilient grid for the region and while also providing access to cheaper, cleaner, electricity sources from elsewhere on the network.

The improvements in the region maximise the upgrading of existing infrastructure between the East of England and the South West. This includes replacing the existing Thames cable tunnel and replacing the cables with newer, higher capacity ones. This will allow more electricity to flow in either direction depending on network conditions. Reusing and upgrading existing infrastructure minimises the impact of these upgrades on local communities and means these upgrades can be delivered in a quick timeframe, bringing this vital infrastructure online sooner.

This required investment in the transmission network will make sure that the South East's infrastructure can handle the region's growth and provide Great Britain the opportunity to export clean, electricity to the continent – continuing Great Britain's journey as Europe's leader in offshore wind.

One of the upgrades we are recommending is a high-capacity offshore link from Scotland to the South East. This will diversify the renewable electricity supply into the region and make it easier to export surplus electricity to the continent. Our current design also sees a requirement for a new onshore circuit to be delivered from near Richborough to near Sellindge to facilitate the injection of additional power from offshore wind landing in the region. This circuit is in its early stage of development and is required due to the environmental challenges bringing the offshore cable further south. Further detailed design development will now be undertaken by the relevant Transmission Owner (TO) to understand and reappraise all viable solutions, both onshore and offshore, in a greater level of detail.

Beyond 2030 / Regional Blueprints / South East 109

South East

Map key

Lastly, we continue to recommend an offshore link between Suffolk and Kent – known as Sea Link – with proposals being progressed, and a statutory consultation having been undertaken by the relevant TO at the end of 2023. This link will help bring clean and affordable energy from East Anglian wind farms into the South East.

The map in this section provides a visual summary of the blueprint for the region. It shows our new recommendations, our recommendations made in previous network planning processes, and other works. This section of the report is interactive, providing the opportunity for readers to explore in more detail the specifics of any new recommendations in the region.

Figure 22. Map of all reinforcements in the South East region

*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Beyond 2030 / Regional Blueprints / South East 110

South East

Map key

New infrastructure

Code	Description	Maturity Level
RANC	New circuit within south east England	■□□□□□
SW_E2a_2	Offshore network cable from a coordinated series of wind farms connecting to Richborough	■■□□□□

*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Click code for further information

Beyond 2030 / Regional Blueprints / South East 111

Beyond 2030 / Regional Blueprints / South East 112

South East

New upgrades

No new upgrades are currently required in this region.

The following reinforcements have previously been recommended for this region.
For more information on these options please see the ESO's Pathway to 2030 publication.[22]

Previously recommended

Code	Description	Maturity level
BFRE	Replace the conductors on the existing circuit between Bramley and Fleet with higher capacity conductors	
EBRE	Replace the conductors on the existing circuit between Enderby and Patford Bridge and East Claydon with higher capacity conductors	
MBHW	Carry out thermal upgrading on the existing circuit between Bramley and Melksham	
MBRE	Replace the conductors on the existing circuit between Bramley and Melksham with higher capacity conductors	
SCD1	New offshore circuit between Suffolk and Kent	
TGP1	Add power control devices to the existing circuit between Tilbury and Grain	
TKP1	Add power control devices to the existing circuit between Tilbury and Kingsnorth	
TKRE	Carry out thermal upgrading on the existing circuits between Tilbury to Grain and Tilbury to Kingsnorth	
PT2030-CW33	Replace the conductors on the existing circuit between Cowley and East Claydon with higher capacity conductors	

22 https://www.nationalgrideso.com/document/264656/download

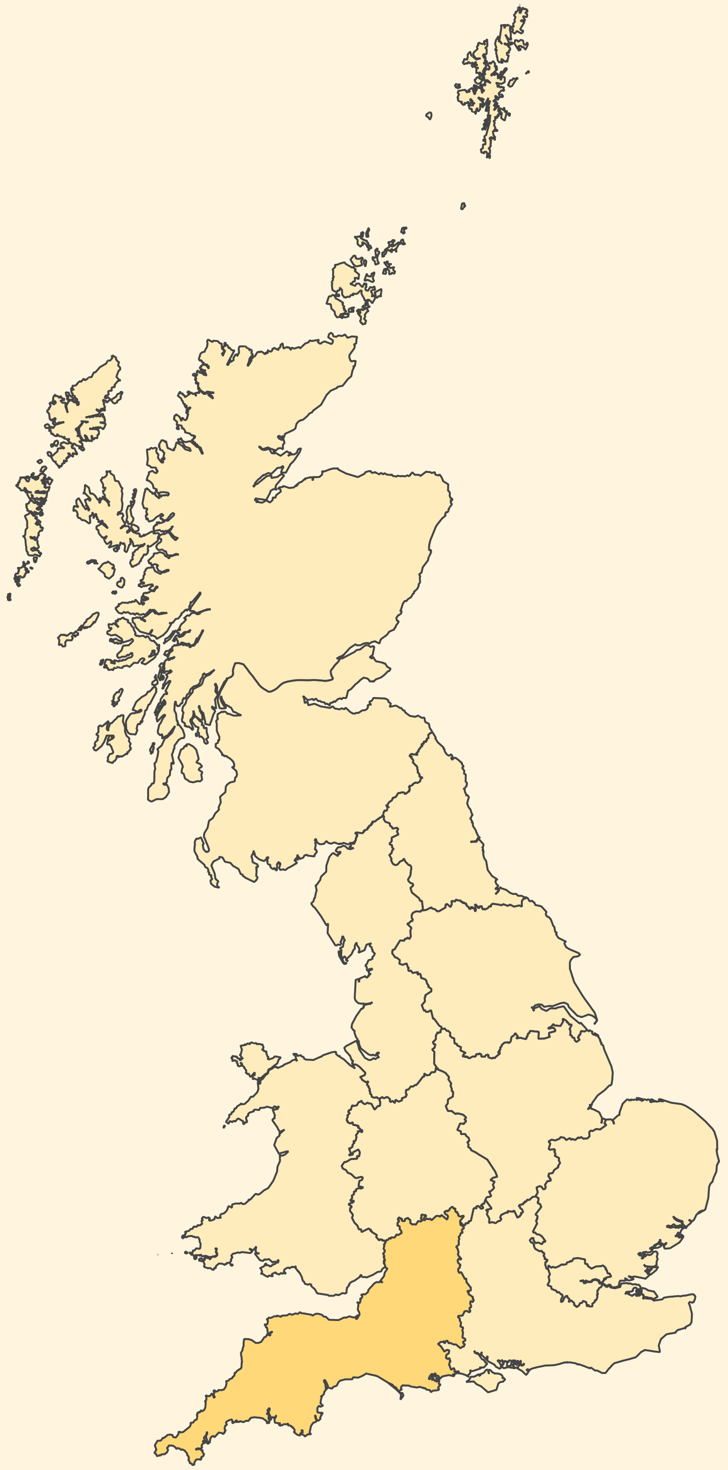
South West

The South West has been the frontrunner in the deployment of commercial scale solar with 4 GW now connected in the region. It is also home to the first new pylon design for nearly 100 years, connecting the region to new sources of home generated, low carbon energy and helping the UK reach net zero by 2050.

The South West has the conditions to support a wide range of renewable generation types, including solar and wind (both onshore and offshore). Being one of the sunniest regions in Great Britain, with some of the highest numbers of sunlight hours per year, means it is particularly well suited to solar farms.

The region also has and continues to host innovative energy projects – including the former Wave Hub project, which was developed to test wave energy machines off the coast of Hayle. The site is now being redeveloped, with a wind farm developer looking to use the site to test an innovative floating wind turbine foundation – building on the technologies which were put to commercial use in Scotland for the first time in the world.

The South West doesn't just host generation, it is also home to innovative projects – with the new connection to Hinkley Point C showcasing a brand new design of electricity pylon. The final T-pylon design was the winner of a competition run by the Royal Institute of British Architects and the UK Government in 2011, with construction starting on the first line using these pylons 10 years later. The new circuit between Bridgwater and Loxton is the first time the T-pylons have been used on the transmission system. These new pylons have a smaller footprint and are around a third of the height of traditional designs, reducing the visual impact to local communities and landscapes whilst also enabling the connection of high volumes of low carbon nuclear energy.



Beyond 2030 / Regional Blueprints / South West 113

South West

These innovations will be built upon by future large scale floating wind farms which will bring many opportunities to the marine and energy sectors in the South West. In late 2023, The Crown Estate announced a leasing round for 4.5 GW of floating offshore wind capacity in the Celtic Sea. We are currently working with The Crown Estate and the Transmission Owner (TO) to develop a holistic design to connect this additional wind into the South West and South Wales regions.

Because of the location of the three project development areas, our designs connecting into the South West consider connections to a range of existing and new substations. We are continuing to assess the impact of connecting varying capacities of the 4.5 GW of capacity into this region. Depending on our final design and how much of the 4.5 GW capacity is connected to the South West, additional onshore reinforcement may be required to export generation from the South West to other areas of the country.

Despite this transition and future potential, the region does not currently have a significant amount of existing transmission infrastructure. For example, while many solar farms have been able to connect to the grid in the region and are producing greener, cheaper electricity, other projects are seeing delays, with one of the causes being a lack of network capacity. This is limiting the ability to integrate new generation into the grid and has the potential to stifle growth in these sectors which will prove crucial to meeting net zero.

Beyond 2030 / Regional Blueprints / South West 114

South West

Map key

Our recommendations for the South West are primarily focussed on upgrading the existing assets within the region. This will be done through a variety of ways. The route between Hinkley Point and Bridgwater will see a voltage increase meaning that significantly more electricity can flow on the existing route. Capacity upgrades are also made to the wires along the existing circuits running south from the Midlands, across the M4 corridor, and from Somerset to Hinkley Point.

Due to ongoing design work for the Celtic Sea leasing round, further infrastructure may be necessary and recommended in future for the region.

The map in this section provides a visual summary of the blueprint for the region. While our latest network planning process has not led to any new recommended infrastructure or upgrades in the region, the map shows our recommendations made in previous network planning processes, and other works. More information on these works can be found in our previous *Pathway to 2030 report.*

Figure 23. Map of all reinforcements in the South West region

*Dashed lines represent low maturity options
Note: all routes and options shown on this map are for illustrative purposes only

Beyond 2030 / Regional Blueprints / South West 115

South West

New infrastructure

No new infrastructure is currently required in this region.

New upgrades

No new upgrades are currently required in this region.

The following reinforcements have previously been recommended for this region.
For more information on these options please see the ESO's Pathway to 2030 publication.[23]

Previously recommended

Code	Description	Maturity level
FMR2	Replace the conductors on the existing circuit between Feckenham and Minety with higher capacity conductors	■□□□□□
FWRE	Replace the conductors on the existing circuit between Feckenham and Walham with higher capacity conductors	■□□□□□
HBUP	Upgrade the existing network to a higher voltage at Bridgewater and replace the conductors on the existing circuit to Hinkley with higher capacity conductors	■□□□□□
MBHW	Carry out thermal upgrading on the existing circuit between Bramley and Melksham	■■□□□□
MBRE	Replace the conductors on the existing circuit between Bramley and Melksham with higher capacity conductors	■■□□□□
THRE	Replace the conductors on the existing circuits between Hinkley Point, Taunton and Exeter with higher capacity conductors	■□□□□□

23 https://www.nationalgrideso.com/document/264656/download

Beyond 2030 / Regional Blueprints / South West 116

Way Forward

Way Forward

Building on the *Holistic Network Design (HND)* published in 2022, which signified the first major move towards a more centralised and strategic approach to network planning, this publication is another key step towards the effort to upgrade electricity transmission infrastructure across Great Britain and to our first centralised strategic network plan due in 2026. The first HND laid the foundations to facilitate the UK Government ambitions of connecting 50 GW of offshore wind by 2030. This second report goes further, and together both reports support the connection of 86 GW of offshore wind as well as an array of other low-carbon technology.

Through maximising and repurposing existing network infrastructure as well as the delivery of new assets, this plan has the potential to add up to £15 billion to Great Britain's economy. It also has the ability to result in large supply chain benefits for Great Britain with electricity cables, substations and network infrastructure all required at a level not seen since the 1960s. Such benefits, if secured in the UK, could result in significant economic opportunities including job growth and reskilling for those transitioning from other industries (such as oil and gas). Just as crucially, it will facilitate greater energy security.

To achieve this transformative plan, industry, guided by governments and regulators, must progress at pace the recommendations in the Government's *Transmission Acceleration Action Plan (TAAP)*. Published in November 2023 it recommends a series of activities to both reduce network delivery times (set out in this chapter) and secure societal consent for the transformational change that we must see to our electricity infrastructure to become more self-sufficient in our electricity supply and meet net-zero targets.

As the Electricity System Operator (ESO) we are clear that impacted environments and communities must be supported as the delivery of network infrastructure takes place. Core to this is implementing the substantive community benefits package announced by the UK Government as quickly as possible.

This is a period of significant change, not just for network infrastructure but across the whole energy industry and the work in this publication sits alongside interlinked policy changes and industry reforms that aim to facilitate and accelerate the decarbonisation of the electricity system across Great Britain. In particular, and as this publication sets out, we see a key role for strategic demand, the efficient placement for which has the potential to negate some infrastructure needs in the future. We have set out information on some of the other key areas of policy work and reform at the end of this section.

Following this publication and the conclusion of the initial high-level network planning phase, the Transmission Owners (TOs) will commence the Detailed Network Design (DND) phase. This will involve optimising the designs proposed in this publication further, determining routeing, technology choices and where other onshore and offshore assets should be located. Continued coordination between project developers across engagement, planning and construction will be key to minimise impacts to communities and the environment and this should be supported as far as possible.

More widely, in the context of these industry and policy developments we will continue to work with industry parties to evolve the way the electricity network is designed. We look forward to progressing our holistic approach and in the future transitioning to whole energy system planning to accommodate new technologies and meet Great Britain's rising energy needs.

Beyond 2030 / Way Forward 118

Way Forward

Energy Act and creation of the National Energy System Operator (NESO)

Strategic Spatial Energy Plan (SSEP)

Centralised Strategic Network Plan (CSNP)

Regional Energy Strategic Planners (RESP)

Connections Reform

Network Competition

Net Zero Market Reform (NZMR)

Further information on policy and industry reforms

In this part of the document, we have set out information on various policies and proposals that are either being currently considered or will be taken forward. While these have been set out as individual projects and programmes (for ease of reading) they should not be viewed in isolation and are part of holistic changes to the design and operation of the energy system.

Click ⊕ for further information

Beyond 2030 / Way Forward 119

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29 These documents are: *Beyond 2030 Technical Report*, *Competition in electricity transmission*, *Comprehensive List of the Onshore and Offshore Network*, *Interconnector Analysis Report* and the *Stakeholder Approach, Engagement and Feedback Report*

30 https://www.ofgem.gov.uk/sites/default/files/2023-11/Direction%20to%20ESO%20relating%20to%20ETYS%20C11%281%29%20and%20NOA%20C27%2812%29%28b%291700759577058.pdf

31 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1181581/otnr-hnd-fue-tor.pdf

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