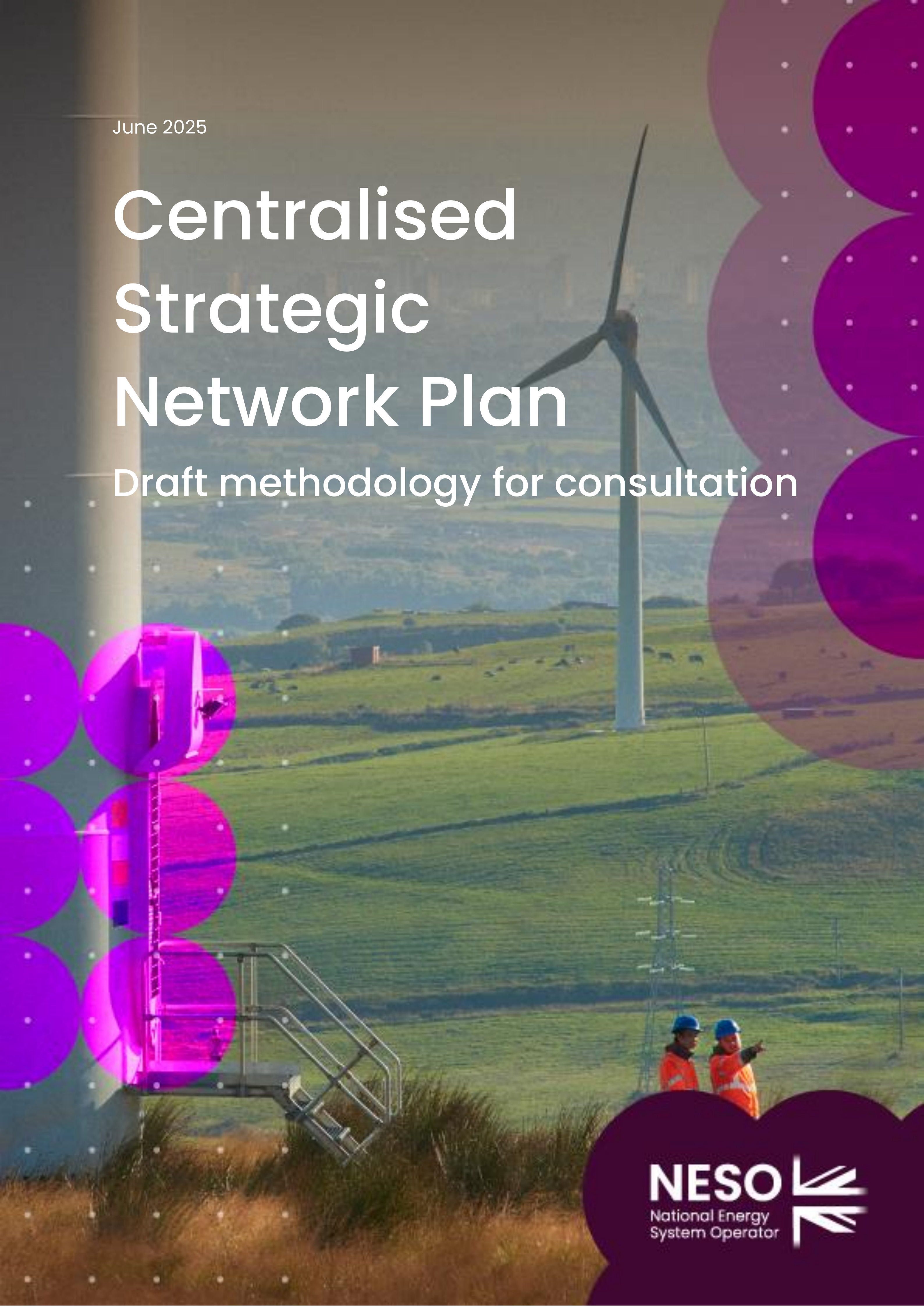


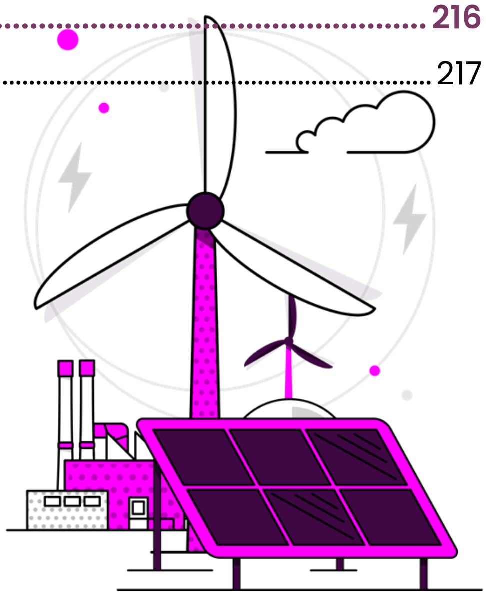
June 2025

Centralised Strategic Network Plan

Draft methodology for consultation

NESO
National Energy System Operator

Contents



1. Introduction

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Executive summary

The Centralised Strategic Network Plan (CSNP) will provide an independent, long-term approach to energy network planning which will support Great Britain (GB) in delivering a safe, secure, resilient, clean system.

This is a groundbreaking approach. For the first time in GB, and perhaps the world, a single framework will propose the energy networks of the future. This is a whole system perspective, one we are uniquely placed to deliver, that considers where energy is being generated and the interactions between gas (methane), hydrogen, and electricity.

Your input is especially important in this new process, which includes numerous innovations, as the methodology will be foundational to our approach in developing and delivering the CSNP.

As GB progresses towards its decarbonisation targets and to enable future economic growth, major investment is needed across its energy networks. The CSNP will ensure our network planning approach is appropriate given the level of change anticipated. It will build on existing plans and provide an independent view of longer-term requirements to and beyond 2050, accelerating delivery of the energy transmission networks that GB requires.

As part of NESO's strategic planning role, the CSNP builds on the plan that is provided by the Strategic Spatial Energy Plan (SSEP). The SSEP provides clarity and certainty on the direction of the energy system by assessing optimal locations, quantities, and types of energy infrastructure. It is the role of the CSNP to identify the energy networks needed.

In this technical methodology document, we present our approach. By its nature it is detailed and uses expert language to explain our proposals accurately and to prompt actionable feedback. However, we have had in mind its accessibility to non-experts, and welcome feedback from all. To help with its readability, elements of the text and information may be repeated to enable sections to be read independently to the rest of the document.

This methodology covers the planning of the wider onshore and offshore electricity transmission networks including cross-border (international) electricity interconnectors, the onshore gas transmission system, and the emergent hydrogen transportation and storage systems.

The consultation document proposes a consistent approach across the three vectors, using the following steps:

- **Drive:** The Strategic Spatial Energy Plan (SSEP) will be used and complimented by the Future Energy Scenarios (FES), by the CSNP to plan the energy networks required for the wider transfer of electricity, gas, and hydrogen.
- **Identify:** The CSNP will provide a view of the current capability and future needs of the networks to inform network options development for each energy vector.
- **Develop:** Considering each vector's system requirements, a range of reinforcement options will be identified and put forward by NESO, Network Owners, and broader parties, as appropriate.
- **Appraise:** Options will then be assessed across multiple assessment criteria to determine the best design across GB. Required reinforcements will progress into the delivery phase.
- **Plan publication:** A draft plan will be published, and a consultation window will provide an opportunity to shape the final CSNP publication. Where required, this will include statutory consultations for environmental assessments.
- **Deliver:** Following publication of the final CSNP, the required reinforcements will progress through detailed design, consenting and delivery. An ongoing change control process will ensure delivery in line with the plan.

Our approach to delivering the CSNP includes extensive stakeholder engagement, as a whole and across the three different energy vectors and subject areas. The CSNP will be overseen by a multi-tiered governance approach including network owners, external experts and stakeholders, governments and the regulator.

We welcome your feedback on this consultation. The consultation runs from 30 June 2025 to 1 August 2025. During this period there will be other opportunities to learn about the CSNP methodology we are proposing, and for engaging with us. Please see our website for further information.

CSNP methodology consultation

This document sets out an overview of the methodology that we will be following to carry out the CSNP. We will deliver it on a three-year cycle.

We are consulting between 30 June 2025 and 1 August 2025. Once the consultation has closed, we will analyse, then consider the feedback and update the methodology where appropriate. We will submit the methodology to Ofgem for approval by 30 September 2025 in accordance with our licence obligations and then publish it on our website.

Details of how to respond to the consultation can be found in the 'next steps' section below.

Structure of this consultation

This methodology is structured into four key parts:

- This section (chapters 1 and 2) outlines the common high-level framework undertaken across our strategic network planning activities. It defines the high-level principles and process that will be applied to generate the CSNP. There are technical reasons why there could be different approaches for each vector, and where this is the case, these differences are highlighted.
- Chapters 3 to 8 outlines the methodology for electricity transmission, builds on the high-level principles previously consulted on to provide more information to stakeholders on the structured framework which will identify, support and enable regulatory approvals to accelerate network deliver.
- Chapter 9 outlines the methodology for planning the gas transmission network, which accommodates our existing gas transmission network planning methodology.
- Chapter 10 outlines the methodology that we propose to adopt for planning the hydrogen system. As the hydrogen industry is less well-developed than gas or electricity, it also sets out how we expect to engage with stakeholders to create a more detailed specification for planning the hydrogen system.

Previous methodology consultations and feedback

In December 2024, we published and consulted on the high-level design principles for the CSNP methodology focusing primarily on electricity transmission, and on the draft methodology for the Strategic Spatial Energy Plan (SSEP), which was cross-vector.

Feedback from our stakeholders highlighted the need for the CSNP to include details for planning of the whole energy system, and for the SSEP to integrate gas assets. We clarified that gas-fuelled generation assets are an integral part of the SSEP although it is assumed that these assets do not have any gas network-related restrictions which might limit their flexibility.

Therefore, while in our previous CSNP consultation we focused on seeking feedback on the high-level principles of the electricity transmission network, this consultation on the CSNP methodology now includes electricity, gas, and hydrogen planning.

The methodology proposed for gas transmission network planning incorporates the methodologies we have developed in accordance with our new roles detailed in our gas system planner licence. These are the Gas Network Capability Needs Report (GNCNR) and the Gas Options Advice (GOA), both of which have been consulted upon in the last twelve months.

Use of artificial intelligence (AI)

The CSNP will engage a broad range of stakeholders to ensure that a diversity of views and opinions are considered during its development. AI will be employed to support summarising of the data and transforming it into actionable insights, facilitating a more efficient and comprehensive understanding of stakeholder perspectives across various sectors of society. All feedback received from stakeholders on the CSNP will be read and reviewed by a human in both its raw and summarised form.

AI's ability to handle diverse data sources and formats enhances our capacity to engage with a wide range of stakeholders. AI can process large volumes of feedback quickly and accurately, ensuring that no valuable insights are overlooked. Additionally, AI can identify patterns and trends within the feedback that might not be immediately apparent to human reviewers alone.

AI will not be used to make decisions autonomously, but serve as a tool to enhance, rather than replace, human judgement and support decision making. AI will help to highlight important issues and common themes, allowing us to include stakeholder feedback in the CSNP more effectively and proactively. This comprehensive approach ensures that stakeholder input into the CSNP is informed by a broad spectrum of perspectives, allowing us to respond in a timely and appropriate manner.

We will regularly review our use of AI in interpreting stakeholder responses, and we will be able to track any stakeholder insight identified by AI to its original source.

We acknowledge the potential for biases in AI platforms. We will incorporate bias mitigation strategies into our AI planning processes. This proactive approach will help us ensure that the actionable insights our AI systems provide are fair, unbiased and reflective of the diverse range of stakeholders' views.

Additionally, we recognise our responsibility to maintain transparency and due diligence in all our AI-related activities. Our AI use will strictly adhere to NESO's relevant policies, including AI, data management, data privacy, data classification and data sharing. These policies ensure that our AI practices are aligned with our commitment to ethical standards and regulatory compliance.

Planning GB's energy networks

The Energy Act 2023 set the legislative framework for an independent system operator and planner to help accelerate GB's energy transition, leading to the establishment of the National Energy System Operator (NESO).

We are an independent public corporation at the centre of the energy system and take a whole system view to create a world where everyone has access to reliable, clean and affordable energy.

Our primary duties are to:

- **Clean energy** - enabling the government to deliver on its legally binding emissions target.
- **Efficiency and economy** - promoting efficient, coordinated, and economic electricity and gas networks.
- **Security of supply** - ensuring security of supply for current and future consumers of electricity and gas.

We also must facilitate competition and innovation and consider impacts on consumers and the whole system.

To successfully undertake these duties, we are moving towards an enduring strategic energy planning (SEP) structure which takes place across three core iterative planning cycles: strategic spatial energy planning (SSEP), regional energy strategic planning (RESP) and centralised strategic network planning (CSNP). Combined, the SEP structure will form a 'cyclical set' of activities each taking place every three years, to create a whole system energy plan for GB, as shown in Figure 1. We will also undertake other activities to support these core planning activities. Fundamentally the three plans will do the following:

- The **Strategic Spatial Energy Plan** will provide more certainty on the location of electricity and hydrogen generation and storage infrastructure, providing certainty on the need for network infrastructure. The SSEP will focus on energy technology capacities on a zonal basis to support the future economic growth and decarbonisation of society and will consider the complex interactions of different components in the future energy system, optimising across the complex trade-offs of location, utility, impact, time and certainty. It will be a primary input into the CSNP which will consider how to transfer energy across GB. As the SSEP will assess the trade-offs between the vectors, the CSNP does not need to consider inter-vector trade-offs.
- The **Centralised Strategic Network Plan**, taking input data on gas, hydrogen and electricity from the SSEP, Future Energy Scenarios (FES) and (once established) RESP, the CSNP will provide an independent, long-term approach to the GB transmission energy networks. The CSNP will be a framework of network planning across electricity, gas, and hydrogen vectors with specific outputs being released

across the three-year cycle. It will plan these networks in the best interests of consumers as GB transitions to net zero. The CSNP will assess the long-term view of what the networks could look like and then working back to make the decisions required today - rather than the previous process which is incremental build from today without that long term plan.

- **Regional Energy Strategic Plans** will develop bottom-up plans of generally smaller energy infrastructure which will be increasingly important as we move to more dispersed forms of energy generation. This process brings local activity driven at a regional level into the broader context. The insights from which can inform the national energy infrastructure requirements, and the national plans can inform the regional plans.

From a broader perspective, the CSNP, SSEP, and RESPs will interact with wider policies, regulations, and planning frameworks. They'll also consider plans, policy objectives and targets set at national, regional and local levels. These include publications such as the Connections Action Plan (CAP), the Reform of Electricity Market Arrangements (REMA) program as well as planning and consenting systems across the UK, Scottish and Welsh governments.

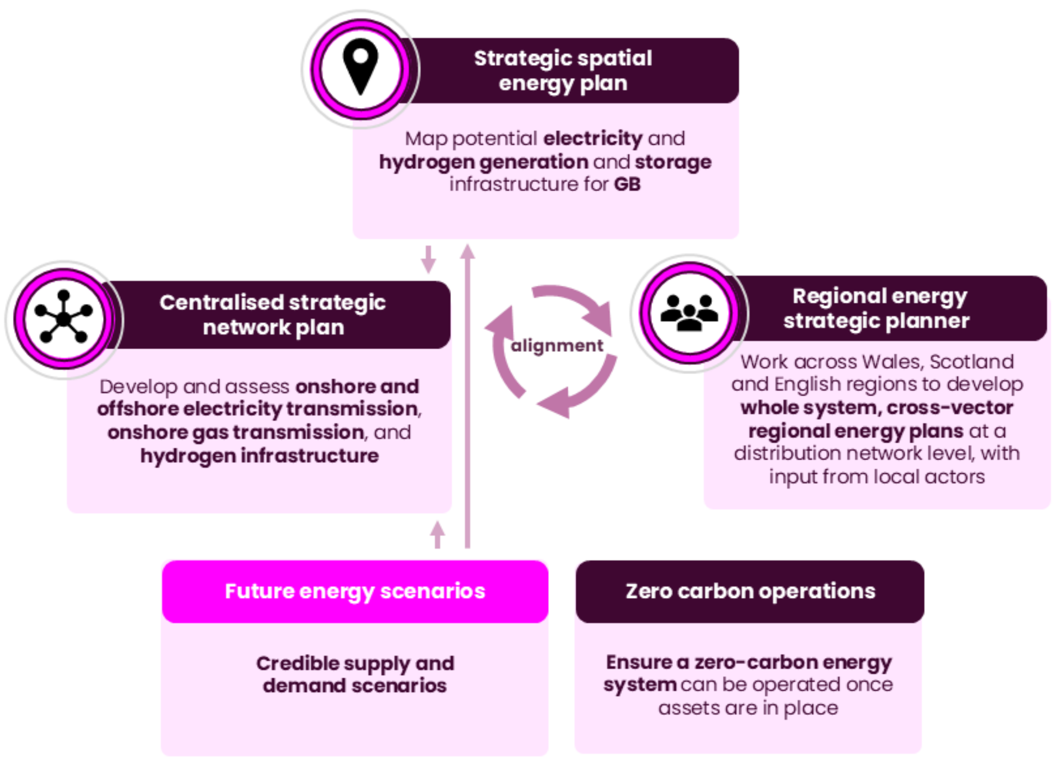


Figure 1: Interactions between NESO's strategic energy planning projects

Stakeholder engagement

Stakeholder approach

Extensive and accessible engagement with a range of stakeholders is critical to ensure the CSNP considers the views of experts, society and of communities across GB.

Our transparent approach will allow stakeholders to understand, shape and feed into the CSNP and see how they have contributed. We will deliver meaningful engagement that instils confidence in the CSNP and considers all stakeholder input, creating a robust plan that encourages advocacy.

We will engage with stakeholders using the established Strategic Energy Planning (SEP) expert working groups. These groups include industry, societal interest, environmental, marine and land spatial planning. They serve as an engagement channel that:

- provides a clear overview of the CSNP
- tests understanding
- gathers data and feedback
- ensures deliverable outputs
- offers opportunities for stakeholder review
- facilitates networking among members

More details of the group aims and members can be found in Appendix A.

Our stakeholders

As a result of the feedback that we received through our CSNP High-Level Principles consultation (published 9 December 2024), we have developed our stakeholder groups to represent the range of stakeholders that can interact with the CSNP at various stages. As the CSNP progresses, we will engage these groups to determine how and when they interact, ensuring targeted and timely communications.

The CSNP is GB-wide, so we will engage across England, Scotland and Wales. Where appropriate, we will engage at a regional level through the structures created by the RESPs.

Our stakeholder groups are shown in Figure 2. These groups overlap and its likely some stakeholders may fit into one or more of the groupings. Appendix A provides our definitions for these stakeholder groups. We will keep these definitions and groups updated, reviewing when required.

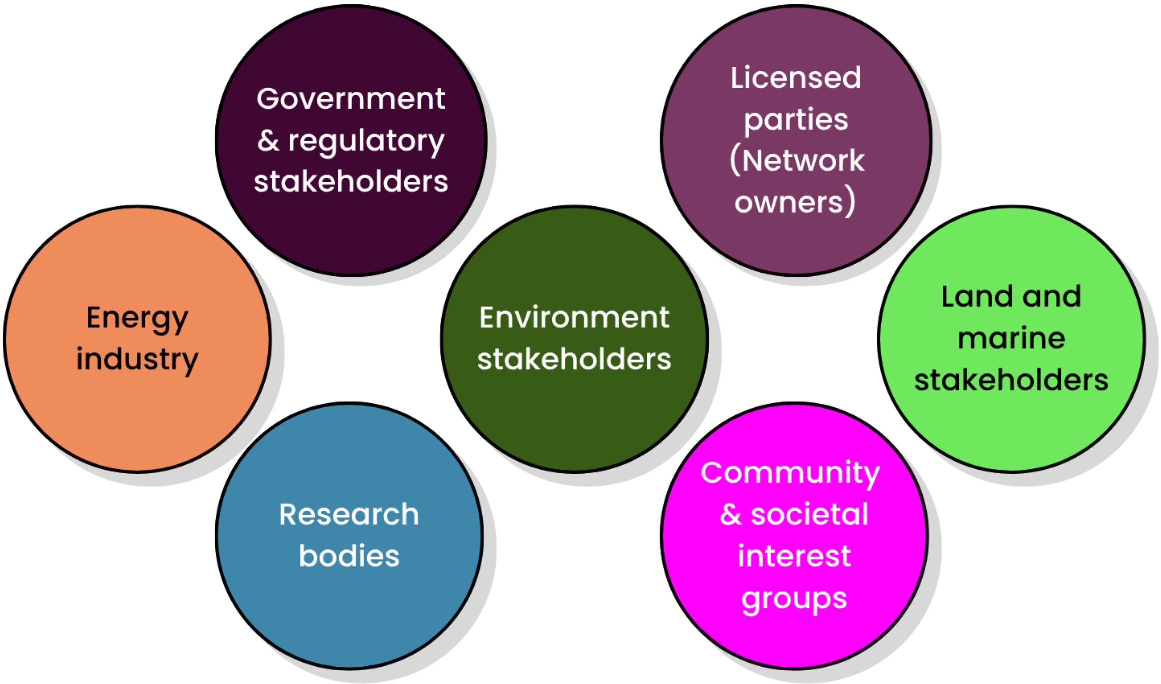


Figure 2: Stakeholder groups

As the three vectors have different licensing requirements, there are some stakeholders that have specific obligations in respect of network planning activities, and these are different across the three vectors. We outline the interaction with stakeholders, for each vector, below.

Stakeholder involvement in electricity network planning

The high-voltage electricity transmission network in GB is owned and maintained by the three licensed onshore Transmission Owners (National Grid Electricity Transmission plc (NGET), Scottish Power Energy Networks plc (SPT) and Scottish and Southern Energy Networks Transmission plc (SSEN-Transmission). Transmission Owners have a license requirement to provide reinforcement options into the network planning process based on the needs provided by SSEP and CSNP.

There will also be opportunities for other stakeholders to submit electricity network proposals into the CSNP. We refer to these stakeholders as 'third parties.' Third parties may come from one or more of the groups as indicated in Figure 3 and will input into the CSNP at various stages of the process.

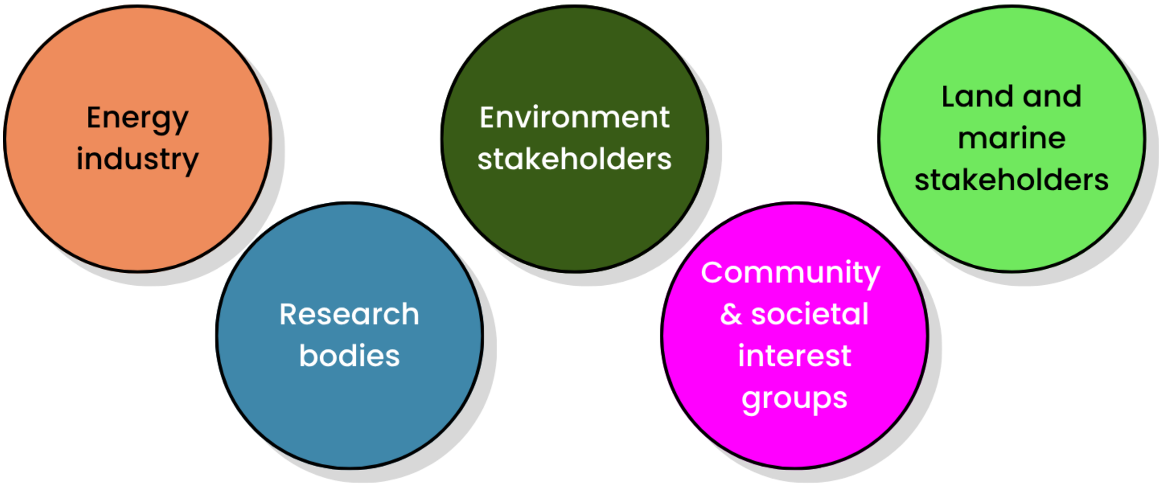


Figure 3: Third party stakeholders

For more details and to understand how third parties will be involved in the various stages of the electricity transmission network planning process, please refer to the develop chapter.

Stakeholder involvement in gas planning

The licensing requirements for the gas system distinguishes between national transmission and regional transmission and distribution operations by specifying a licensed Gas Transporter, (National Gas Transmission, 'NGT'), as the National Transmission System (NTS) System Operator. The license does not contemplate other parties constructing assets that would be included in the NTS.

Under their licence, NGT are required to produce a Strategic Planning Options Proposal (SPOP) that sets out the licensee's best view of any options in response to the system needs that are set out in our Gas Network Capability Needs Report (GNCR). Our gas network planning activities are therefore primarily bilateral in nature, although we will endeavour to involve interested stakeholders throughout the gas network planning process and the development of the CSNP.

Stakeholder involvement in hydrogen network planning

Hydrogen network planning does not currently have an established regulatory structure and is therefore not a licensed activity assigned to a set of organisations. While NESO will deliver the first tangible outputs of its hydrogen strategic planning role in 2026 (with DESNZ remaining the decision maker for awarding business model support to hydrogen transmission and storage projects), it is our expectation that the parameters of this role will reflect the approach we outline in this methodology.

Government support mechanisms currently fund the development against four business models for hydrogen covering its production, transport, storage, and use for power generation. The transport and storage of hydrogen will be considered within the CSNP and as these areas develop, we will seek to engage parties who may also become involved in these planning processes.

We anticipate that regulated energy sector organisations with current interests may be involved in the planning processes in the future and we will engage with these organisations as the regulatory and planning regime develops.

Question: Do you agree that NESO is intending to engage with the right stakeholder categories to successfully deliver the CSNP?

Our engagement principles

The following principles will define our stakeholder engagement approach:

- **Timely and transparent** - We will engage early, with a transparent and open stakeholder approach. We will make it clear to stakeholders how we will consider their feedback and how they can shape the plan, while respecting the confidentiality of the work.
- **Proactive engagement** - We will work with a wide range of stakeholders with interest or expertise in energy planning, and with the representatives of communities that may experience development of energy infrastructure in the future. Their engagement will help us develop and evolve the plan, to make sure it considers a broad range of views of society. We will proactively update our stakeholders on new and changing information via our range of regular stakeholder groups and forums, alongside public communications.
- **Action feedback and inform stakeholders** - We will consider all feedback from our stakeholders during the engagement process. Once all feedback has been reviewed, we will group feedback using themes and share how we have considered and addressed these themes. We will manage stakeholders' expectations and explain why, where relevant, if we will not be able to take on board all views. This could be for a variety of reasons, including that some views will be conflicting, or not aligned with the aims of the plan. Stakeholder feedback will be vital, alongside both policy and supporting information, to inform decisions where there are finely balanced trade-offs.
- **Coordinated engagement** - Where we can, we will align stakeholder engagement activity across NESO's strategic energy planning activities and with other relevant organisations such as The Crown Estate, aiming to be as efficient as possible with stakeholders' time. We will build on relationships formed during other strategic planning activities and explain to stakeholders how the SEP projects all fit together. We recognise that some parts of our CSNP activities will be more important than others to some groups of stakeholders, so we will signpost where things can be found and when different things will be consulted on.
- **Tailored engagement & communication**- We will ensure our engagement is accessible and at the right level for our diverse range of stakeholders, who all have different experiences of the energy sector and spatial planning.

We will use appropriate and various communication methods enabling us to engage with stakeholders in different ways and increase participation, and we endeavour to respond to stakeholders in a timely manner.

Although what we do is technical in nature, we are taking steps to ensure that our communications and publications are as clear and accessible as they can be by presenting information in different ways, such as using diagrams and worked examples to support the technical information and avoiding complex language.

2. CSNP methodology

Context

This section outlines the steps in the CSNP methodology. It defines the principles and process that will be applied to generate the CSNP.

There are technical reasons why there could be different approaches for each vector, and where this is the case, these differences are highlighted. Detailed vector-specific elements of the methodology can be found in chapter 3-8 for electricity, chapter 9 for gas, and chapter 10 for hydrogen.

Expected needs case of the networks

We expect to see a growth in future energy needs both to support economic growth and enable continued decarbonisation, electrifying aspects of our everyday life, such as heating, transport and industry, with an even greater need for clean electricity. To enable this transition, the electricity transmission network will require significant investment to ensure power can get from areas where it is generated to where it is used.

Whilst the electrification of heating will drive lower volumes of gas throughput, the electricity system will continue to have some reliance on gas-fired power generation to ensure security of electricity supply for years to come. New technologies, such as CCS-enabled gas-fired generation and hydrogen production using thermal reformation techniques, will also continue to rely on the gas network to some extent. Whilst it is not expected that we need to grow the gas network to accommodate demand growth, growth of the network may still be required to ensure security of supply for gas supplies to penetrate further into the network where local demand diminishes.

Decarbonisation will require a much greater use of low-carbon hydrogen than today, although the ultimate volumes are still uncertain. There are clear use cases in specific heavy industries and the potential for it to play a role in producing high temperature heat, but beyond this hydrogen may also be an important form of whole system flexibility. Hydrogen can be produced via electrolysis when there is an abundance of renewable power generation, stored, and used to produce electricity flexibly when other sources of clean power generation are unavailable. In this role, particularly where energy storage is required over longer timescales such as inter-seasonally, hydrogen offers significant value to the whole energy system.

These disparate but connected situations require complex, strategic planning across GB to determine how to expand the wider capability of the network and ensure access to reliable, clean and affordable energy for all consumers.

The requirements of the electricity, gas and hydrogen networks will change as we use energy differently to meet future energy needs. Overall, we expect that:

- **Electricity networks will need to continue to grow**. There's a significant increase in the amount of zero-carbon electricity that needs to be generated and transported across the network to reach net zero by 2050, as outlined in our future energy pathways and Climate Change Committee's report. Building on our previous network plans, Pathway to 2030 and Beyond 2030, it is likely that more investment will be required to meet this change.

- **The use on the gas networks will change.** The use of methane gas for electricity, heating and industrial processes is expected to significantly reduce in the future. The priority of this network is one of safe operation whilst it is still required, and then a change in use to potentially hydrogen, biogas or CCUS. Additionally, there may be the potential for non-gaseous uses for the network and where repurposing isn't possible then network decommissioning could be considered.
- **Hydrogen networks may begin to emerge.** There is currently no hydrogen network outside small private industrial examples. Hydrogen has the potential to play a key role in the net zero scenarios of the future, as a store of energy, and as a fuel for industrial processes. The questions being asked of hydrogen-specific planning are how much network and storage is required, when is it needed by, how much of this can be met by repurposing of gas network assets and how much brand-new network is required.

Aim of the CSNP

The aim of the CSNP is to provide an independent, long-term approach to energy network planning across GB providing a single, whole-system plan for GB's energy networks that ensures security and drives efficient solutions across the vectors.

The CSNP will:

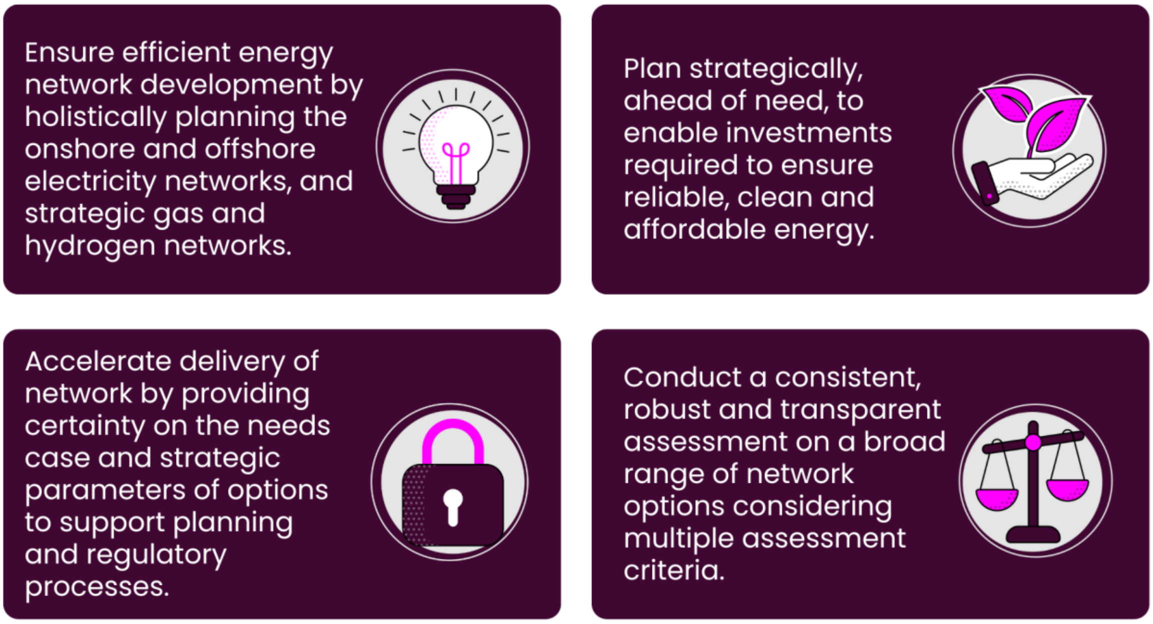


Figure 4: CSNP aims

The CSNP will be a single plan detailing a set of specific projects. Each project in the CSNP will relate to one of the three vectors, or two where there is value in repurposing.

For electricity, the CSNP will holistically plan wider reinforcements on the electricity transmission network alongside the offshore network and opportunities for interconnectors and offshore hybrid assets. In line with Ofgem's Decision Document and the Transmission Acceleration Action Plan (TAAP), the CSNP will provide certainty to streamline regulatory approvals and accelerate network delivery. Timely delivery will help ensure consumer energy costs are efficient and enable generation and demand customers to connect to the network more quickly.

For gas, whilst the gas transmission network is not expected to grow significantly, NGT are required to maintain the network pursuant to their safety case. The CSNP aims to ensure clarity and transparency on relevant asset investment decisions. If there is a need or an opportunity to repurpose gas transmission assets to hydrogen duties, these can be considered in the CSNP.

For hydrogen, the CSNP will provide a clear understanding of the options that deliver the hydrogen infrastructure that might be required by the nascent hydrogen market, mindful of the strategic requirements for the energy sector as a whole. As noted above, the early stages of the development of hydrogen systems in GB will involve specific government support mechanisms across the vertical hydrogen supply chain. Decisions on providing support will be made by government through the relevant hydrogen business models.

Methodology steps

The methodology we use for strategically planning electricity, gas and hydrogen networks within the CSNP follows the same steps. However, the networks are undergoing change differently to one another and require unique approaches in many ways.

These are detailed in the electricity, gas and hydrogen sections. The following sections show the similarities in our planning approach within each step between vectors.

Throughout these steps, stakeholder engagement and opportunities are consistent across all vectors.

Drive

For the CSNP to identify how the electricity transmission, gas transmission and hydrogen system will need to evolve over time. The CSNP will use the energy pathways to set the future requirements of the energy networks.

Strategic Spatial Energy Plan

As described in the Introduction, the SSEP will plan across GB and zonally map capacities of generation and storage of hydrogen and electricity infrastructure. It will establish a single generation and demand pathway to 2050, selected by the Secretary of State, that is co-optimised with high-level network needs. More information on the SSEP is available on our website.

Through efficiently matching the temporal and geospatial needs for energy supply with network and demand, the SSEP will provide important data that can be used to understand where network should be developed. It will also provide governments and the regulator with a plan they can endorse and can be used to inform government policy and planning decisions. Therefore, providing industry with more confidence on the future energy system and anchoring the driver for subsequent plans, including the CSNP, in policy.

The CSNP will plan the network in anticipation of the future customer connections that will be informed by the energy needs identified in the SSEP. The CSNP, driven by the SSEP, can therefore plan the wider network strategically and in anticipation of future customers.

Future Energy Scenarios

The FES explores strategic ways in which energy demand, supply and flexibility can develop out to 2050 to achieve GB's net zero target and enable economic growth. It considers the development of low carbon technologies, exploring the impact on energy demand and supply alongside the role of flexibility and consumer engagement. The FES analysis is underpinned by an extensive programme of stakeholder engagement, incorporated in its outputs alongside analysis and research. It will also consider a wide range of potential high-impact, low-probability (HILP) events.

FES provides four separate views of supply and demand across GB out to 2050 through four datasets, three pathways which meet net zero by 2050 and the counterfactual which does not meet net zero by 2050. The network design will also be tested against the FES. This will stress-test the network design against a range of credible futures to provide confidence on the needs case of required reinforcements. The FES will enable us to model multiple long-term strategic energy pathways that will highlight what must happen across the energy vectors to enable net zero. These will illustrate different routes to expanding the network to meet net zero across the longer-term horizon.

More information on the FES can found on the website.

Pathway usage

For electricity and hydrogen, the SSEP pathway will be the central view that underpins infrastructure development supplemented by the FES. For gas transmission planning, the aspects that will be included from SSEP are modelled gas demand for power generation and for hydrogen production, but with the wider supply and demand inputs driven by the FES.

Identify

Using the energy pathways in the SSEP and FES, we will assess a range of future network requirements for the electricity, gas and hydrogen networks. This will be based on the pathways and will be undertaken through power flow analyses or gaseous hydraulic analyses, as appropriate, of expected future network conditions against different demand and weather conditions.

The analysis we undertake across all three vectors will consider factors including:

- the need for the networks to facilitate the bulk transfer of energy throughout the system,
- the network's requirement to operate securely throughout the year based on different weather, supply, demand and market conditions
- the need to provide additional services such as:
    - stability and voltage needs on the electricity network
    - linepack on gaseous networks to facilitate compliance with the safety cases that are, or might be, required for gas transmission and any hydrogen networks

We will publish our system requirements to signal to stakeholders the future requirements, against which options should be developed and submitted into the CSNP process.

Develop

The CSNP will depend on receiving a variety of options, which may be designed to meet the stated system requirements in different ways. These will then be assessed as part of the options assessment step of the methodology.

Options can be developed and submitted into the CSNP process by licenced network operators (e.g. Transmission Owners for electricity, the NTS system operator for gas), third parties, and by NESO.

There are numerous ways to expand the future capability of the energy networks. A range of options need to be considered, including, but not limited to upgrades to the existing network infrastructure and new infrastructure. A summary of potential option types is outlined in Table 1. These will be identified by NESO, the network owners, and third parties.

Table 1: Potential types of options

Network option type	Description
Network management	Manage energy flows within the existing network, such as with electricity quadrature boosters, reactive compensation or by reconfiguring substations, or by installation of flow control equipment or boundary pressure management systems on the gas system.
Network upgrades	Improve the capability of existing network by replacing existing components or add new assets, increasing the capacity of the system by increasing voltage (electricity) or pipeline uprating and compressor rewheels (gas/hydrogen).
New network	Provide additional capacity, with the development of network routes linking strategic parts of the network. For electricity, this will consider both onshore and offshore strategic routes. For gas and hydrogen this will include new compressors, new compressor motive power, and new pipelines. For hydrogen, this may include the repurposing of existing gas pipelines.

Appraise

The options will be considered against the five assessment criteria outlined in Table 2, from a GB wide perspective. The CSNP will compare the GB-wide network options that deliver the individual energy vector needs as identified in the earlier steps of the CSNP process. As the SSEP will have already assessed the trade-offs between the vectors, the CSNP does not need to consider inter-vector trade-offs.

Table 2: Assessment criteria

Criteria	Description
Economic	The CSNP will assess costs to determine a network design that is economic, efficient and coordinated.
Environment	The plan will consider high-level environmental spatial constraints in considering environmental impacts.
Community	The CSNP will also evaluate community impacts relevant to the strategic plan through desktop appraisals.
Deliverability	The plan will ensure practical delivery, including by considering supply chains and technology readiness.
Operability	To ensure the final plan is operable, the assessment will consider operational needs and complexity.

Plan publications

The CSNP is a three-year planning cycle comprising of several publications that will recommend electricity, gas and hydrogen network infrastructure over the next 25 years. Publications will be released on the strategic planning page of our website.

Environmental assessments

It is proposed to undertake a Strategic Environmental Assessment (SEA), Habitats Regulations Assessment (HRA) and Marine Conservation Zone assessment (MCZ) or Marine Protected Area (MPA) in Scottish waters, for the electricity network.

The environmental assessments will initially focus on the electricity transmission network. It is currently our minded-to position that these will not be extended to cover the gas and hydrogen elements of the plan.

The first scoping and methodology development stage of these assessments will look to set out how they should be undertaken. This includes what assumptions will be made and will be subject to consultations with the relevant Statutory Nature Conservation Bodies (SNCBs). The final strategic results of the environmental report will require public consultation and publication.

Question: Do you agree with our current position that the SEA/HRA assessment should not be extended to cover gas and hydrogen?

Question: If you do not agree, can you provide a reason why?

System requirements publications

We will produce a system requirements publication which will set out what is needed to develop the energy networks and the required reinforcement of options to meet future energy needs and enable us to meet our net zero target. This will allow individual options to be developed and submit to us which fulfil these requirements of the future network.

Options review

For electricity and hydrogen after the options have been received, we will review and publish the options. This will provide stakeholders an opportunity to see what options we will be assessing which meet the system requirements. For gas, the options are assessed before being published in the GOA document.

CSNP submission

After the GB-wide options appraisal has taken place for each vector, we will publish our draft CSNP. Alongside the draft CSNP, other supporting analyses (include statutory environmental assessments where applicable) will be published so that stakeholders will have an opportunity to provide feedback on the proposed GB energy plan. We will then consider the feedback received and make changes to the CSNP and submit to Ofgem for their approval. Following which we will then publish the final, approved CSNP on our website.

Deliver

The energy industry will take forward options included in the CSNP, developing them further, carrying out a detailed design process that includes detailed routing, the consenting process and extensive stakeholder engagement.

For the electricity network, we will provide a clear signal to Transmission Owners on which options we have assessed as favourable to progress through detailed development, and in which order. We will then work with the regulator, Transmission Owners, offshore developers and other third parties to provide the necessary information for further funding to be allocated so that progress against this design can be made.

We will continue to work closely with NGT following the publications of our recommendations of gas network reinforcements. Following agreement to progress recommendations, Ofgem will decide whether and how it is funded under RIIO.

For hydrogen we will evaluate options and identify optimal network solutions as part of our whole energy system planning approach, but we will not include formal recommendations for specific hydrogen projects and delivery timescales. We are working with DESNZ and Ofgem to continue to develop the preferred process in this area.

Question: Do you agree that the methodology steps (drive, identify, develop, appraise, deliver, and plan publications) outlined in the whole system CSNP overview are appropriate for developing a whole system CSNP?

Question: Do you have any comments on the specific assessment steps shared within the whole system CSNP overview?

Question: Do you agree that the 'whole system' approach for centralised strategic network planning has been clearly set out in the CSNP methodology?

Plan timelines

The CSNP will follow the publication of the Spatial Strategic Energy Plan and will be published every three years to support a strategic approach to energy network planning. There will also be a consultation window to enable stakeholders to influence the outputs of the plan.

The proposed timeline for the key deliverables to support the first CSNP are as follows:

- Publish system requirements – by 30 June 2026
- Publish draft CSNP and statutory environmental assessments – by 1 June 2027
- Publish first CSNP – by 31 December 2027

The high-level timelines for the first CSNP are outlined in Figure 5 below.

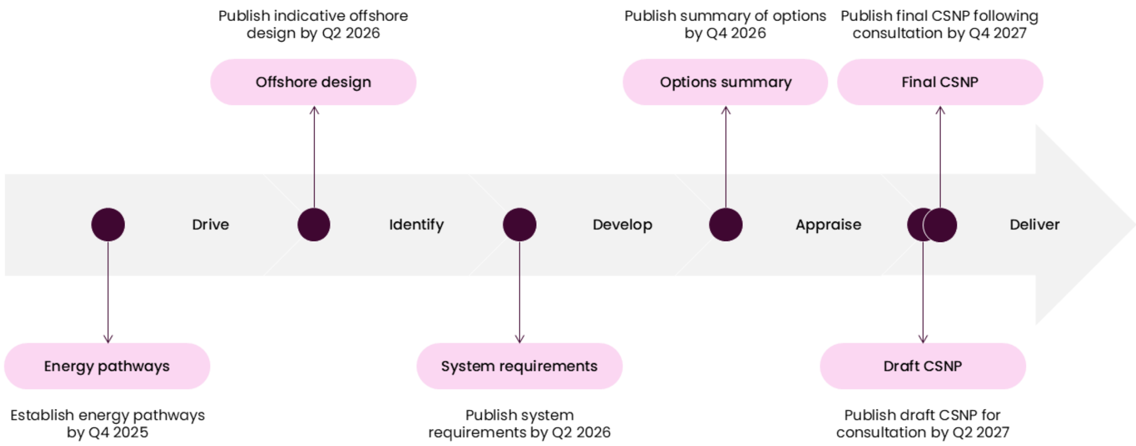


Figure 5: High-level CSNP timeline

Governance of the CSNP

The governance structure for the CSNP has a key role in ensuring accountability and successful delivery of the plan. The governance approach will ensure that throughout the process we will have engagement with governments, the regulator, experts and stakeholders.

CSNP governance structure

NESO have developed a three-tier structure consisting of a committee, a coordination group, and five sub-groups which will together form the CSNP governance structure as outlined in Figure 6:

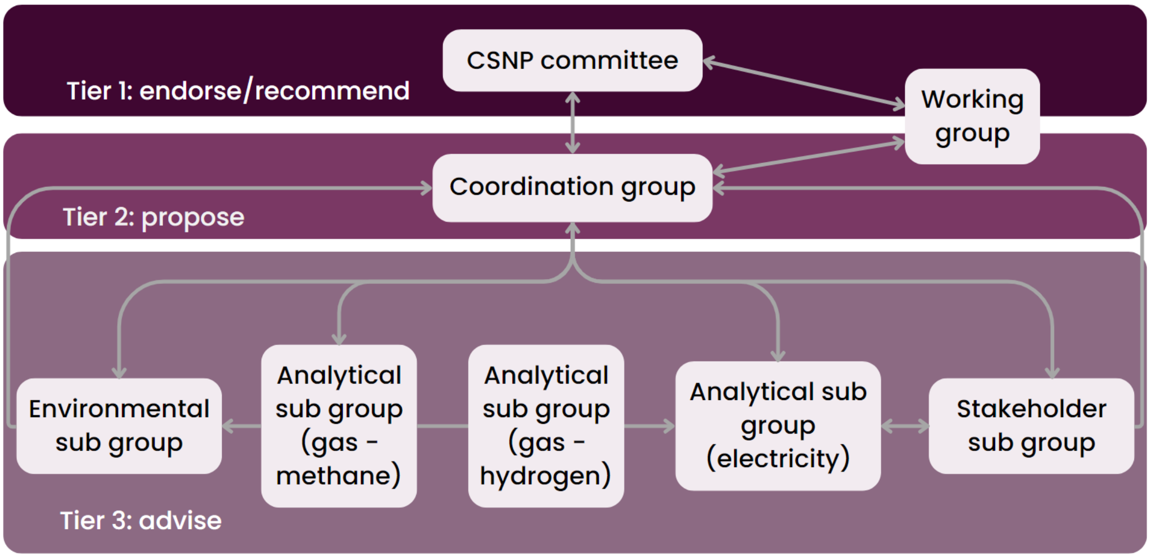


Figure 6: CSNP governance structure

CSNP committee

The committee will be responsible for providing strategic direction and advice on the development and production of the CSNP. The output of the committee will reflect all stages of the CSNP and all key milestones with the final output being the reinforcement options selected and endorsed for electricity and recommended for gas and hydrogen.

The committee will be chaired by NESO with representatives from NESO, DESNZ, Ofgem, and the network owners.

Coordination group

The coordination group is a collaborative forum which will be gathering inputs and outputs from the various sub-groups throughout the entire CSNP process and then presenting to the committee. This approach will ensure oversight and assurance of the CSNP process.

The coordination group will be chaired by NESO with representation from the regulator, government, network owners, and a sub-group representative. It will also include an external expert appointed by NESO to provide an independent perspective.

Working group

The CSNP working group is a NESO group to support the committee and coordination group. It will manage risks and actions and ensure the committee and coordination group interact effectively with the other governance groups.

Sub-groups

The sub-groups will comprise of subject matter experts, chaired by NESO and will report to the Coordination Group. The sub-groups will have working level engagement at the appropriate level with network owners, the regulator, and central and devolved government. There will be five of these groups, focusing and providing insight on:

- **Environmental** – demonstrate the CSNP understand environmental impact and overall assurance of the approach and methodology of the CSNP environmental assessments.
- **Analytical** – assurance on the technical (engineering) and economic analysis which the CSNP will use. Challenge and review of all aspects of the CSNP, including offshore, system requirements and the option development and assessment process. There will be three analytical sub-groups: electricity, gas, and hydrogen.
- **Stakeholder** – provide insights and expertise from the energy industry, for example developers and supply chain parties, and wider stakeholder groups including representation from outside the energy industry. This will inform the CSNP outputs while ensuring the energy industry and all interested parties understand the CSNP process and outputs.

Themes to be incorporated

We will ensure that crucial outputs and discussion points are taken to the CSNP governance structure as part of our plan. We intend to use existing NESO working groups to make effective use of stakeholder time where possible.

Discussion points will include:

- **Methodology** – the development of approaches to detail modelling aspects of the CSNP.
- **System requirements** – the development of the system requirements.

- **Options** – we will share the options, together with supporting advice and stakeholder feedback, to Ofgem.
- **GB options assessment** – we will discuss the options assessment progress, sharing results and evidence when appropriate. NESO will aim for agreement between the parties in advance of submission to Ofgem. Where this is not possible, we will highlight the different perspectives and the reasons behind them in our advice.
- **Publication** – on completion of the options development and assessment and public consultation, the final CSNP shall be reviewed by the CSNP committee prior to publication.

It is expected that the CSNP governance structure will be established in the latter half of 2025 to assist with successful delivery of the first CSNP. The timings of the meetings will be established after approval of the methodology.

Question: Do you agree that the outlined governance structure proposed in the methodology is appropriate to support the delivery of the whole system CSNP?

Question: Do you agree that the membership, roles, and responsibilities set out for the governance process will support the delivery of a whole system CSNP?

Next steps

How to respond to the consultation

The consultation runs from 30 June and will close at 17:00 BST on Friday 1 August 2025.

To share your views, please complete our consultation by 17:00 BST on Friday 1 August 2025. Questions have been divided by topic into four surveys, which you can access below:

- Whole system network planning
- Electricity network planning
- Gas network planning
- Hydrogen network planning

You will be given the option to mark your response as confidential at the beginning of the form. For confidential responses, we will not publish your response or your feedback in an identifiable form. All responses will be shared in full with Ofgem even if marked as confidential. If you have any questions about the consultation process, other additional comments or queries, please contact us at Box.SEP-Portfolio@neso.energy.

After the consultation

Once the consultation has closed, we will carefully consider the feedback that we receive. We will amend the methodology where appropriate based on feedback before we formally submit it to Ofgem on 30 September for their approval as detailed in our licence.

The methodology will be published, subject to Ofgem approval, on our website by no later than 31 December 2025.

Question: Do you have any other comments on the overview of the whole system CSNP draft methodology that you would like to share?

Navigation

Read the electricity section of the methodology

Read the gas section of the methodology

Read the hydrogen section of the methodology

Read the methodology’s annexes, including the glossary

Respond to the whole system consultation

3. The CSNP for Electricity

Overview

Scope

Framework

Overview

Key messages

- The CSNP will holistically plan the electricity transmission network, including wider onshore reinforcements, the offshore network and opportunities for interconnectors and offshore hybrid assets.
- The delivery pipeline will provide certainty on required reinforcements ahead of the detailed design and delivery stages and remove the need for such reinforcements to be reassessed in the next CSNP.
- The CSNP will be published every three years to support a strategic approach to electricity network planning and create opportunities to collectively identify and co-ordinate a range of reinforcement options out to 2050.

Electricity

The CSNP will provide an independent, long-term approach to energy network planning across GB, considering gas (methane), hydrogen and electricity. This part of the document outlines the detailed methodology for electricity transmission network planning.

Steps

The CSNP will holistically plan wider reinforcements on the onshore transmission network alongside the offshore network and identify opportunities for interconnectors and offshore hybrid assets. This process will consist of five key steps, each detailed through a subsequent chapter and linked in Figure 7.

1	Drive	Driven by the SSEP, an initial offshore design will be developed. This will then be co-ordinated alongside the onshore network through the following steps. Different resilience scenarios will also be established.
2	Identify	The current capability and future requirements of the network will be assessed to identify when and where investments may be needed.
3	Develop	A range of reinforcement options will be developed by NESO, Transmission Owners, and third parties to satisfy future network requirements.
4	Appraise	Proposed reinforcement options will be appraised considering multiple assessment criteria to determine the preferred GB network design.
5	Deliver	The delivery body will progress reinforcements included in the delivery pipeline through the detailed design and delivery stages. A change control process will monitor delivery.

Figure 7: Framework steps

Scope

Electricity network

Individual **reinforcements options** will be identified through the develop step. Then the preferred **GB network design** will be determined in the appraise step. These terms, used throughout the electricity section are explained below:

- **Reinforcement options** – individual options to increase the capability of the transmission network. They could include, but are not limited to, network management options, upgrades to the existing network as well as new onshore and offshore circuits.
- **GB network design** – a combination of reinforcement options that together form a co-ordinated network design to support flows of electricity across GB.

The CSNP will focus on the development of the electricity transmission network – onshore and offshore- including wider onshore reinforcements on the Main Interconnected Transmission System and the planning of the offshore network to facilitate offshore wind and identify opportunities for interconnectors and offshore hybrid assets.

Wider reinforcements support flows of electricity between different areas across GB to ensure continued access to reliable, clean and affordable electricity. We will also identify residual stability and voltage needs in relation to standards, such as those set out in the Security and Quality of Supply Standard (SQSS).

For wider network reinforcements, the concept of boundaries will be used. Boundaries split the transmission system into multiple parts, crossing critical circuits that carry power between areas where power flow limitations may occur. They enable the assessment of reinforcement options and analysis of bulk power flows across GB to support a strategic, long-term approach to network planning. The plan will also provide insight on thermal loading limitations at specific circuits across the year as part of the identify step.

The plan will determine a GB network design for delivery that is efficient, co-ordinated and economical, which considers impacts on environment and communities, and is deliverable and operable. It will also consider interactions with relevant policy and standards, such as the SQSS.

The network planning process will not plan individual customer connections or cover non-load related investments, such as the replacement of ageing assets. However, these additional drivers may interact and be considered, for example, where a customer connection forms part of a wider network reinforcement option.

The scope of the CSNP for electricity, alongside interactions with other relevant plans, processes and policies, is illustrated in Figure 8.

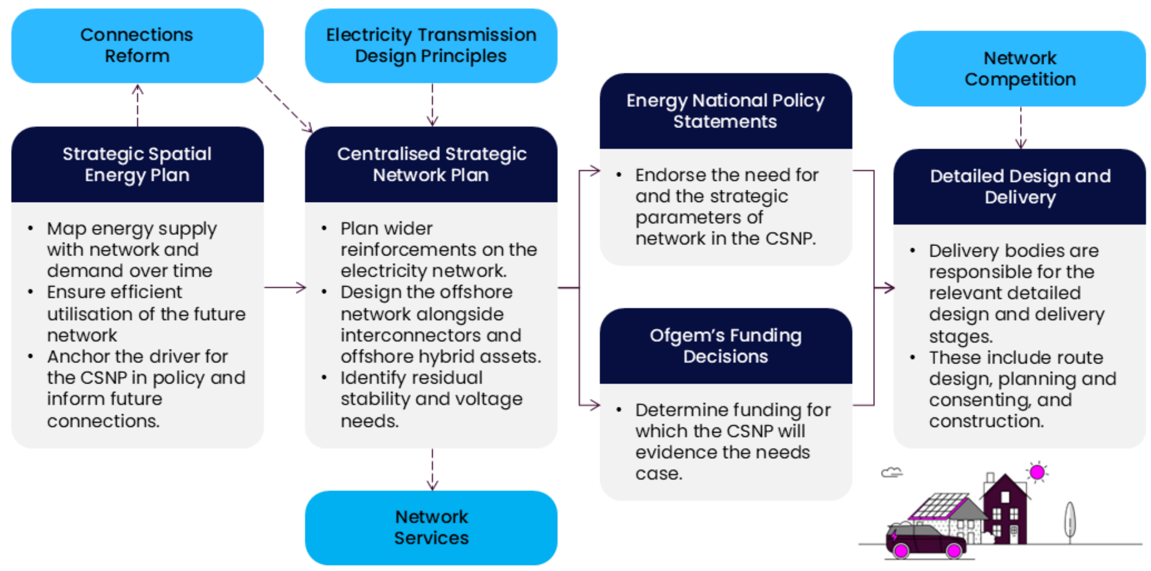


Figure 8: Scope and interactions of the CSNP for electricity

Plan development

As a strategic plan, the CSNP will determine a GB network design through high-level assessments. It will not extend into the detailed design and delivery stages, including route design, planning and consenting, and construction. These stages will be the responsibility of the delivery body. The delivery body could be an incumbent Transmission Owner, competitively appointed party or an offshore developer. The scope of plan development is summarised in Table 3.

Table 3: Scope of plan development

Strategic plan co-ordinated by NESO	Detailed design by the delivery body
The plan will determine the strategic parameters of reinforcements for delivery, such as the technology type and strategic design.	Development of options, within the defined strategic parameters, though the subsequent detailed design and delivery stages.
In determining the strategic parameters, assessments will be conducted on reinforcement options and consider broad spatial envelopes.	In the delivery pipeline, the siting and routeing of options will be decided, such as the siting of new substations or routeing of new circuits.
The plan will be a desktop exercise and may consider strategic mitigation, such as undergrounding, if appropriate to do so.	Local mitigation will be decided as part of detailed design in response to specific environment or community impacts.
The CSNP for electricity will include a Strategic Environmental Assessment (SEA),	The plan will not require on the ground surveys and project-level environmental

Habitats Regulations Assessment (HRA) and Marine Conservation Zone (MCZ) assessment. assessments, such as an Environmental Impact Assessment (EIA).

Timeline

The CSNP will be published every three years. It will provide decisive outcomes and follow the SSEP. This timeline will allow a range of reinforcement options to be collectively identified and co-ordinated, as opposed to incremental decisions, and provide opportunities for consultation. An illustrative timeline is given in Figure 9.

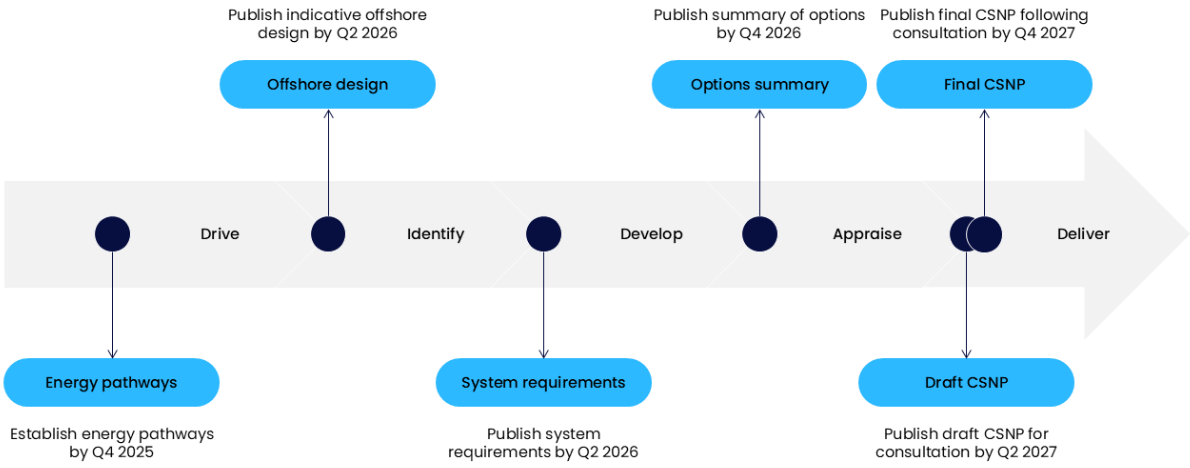


Figure 9: Illustrative timeline for the first CSNP for electricity

The first CSNP will be published by the end of 2027. The key deliverables to facilitate this are listed below:

- **Offshore design** – publication of an indicative offshore design, facilitating offshore wind, interconnectors and offshore hybrid assets, ahead of co-ordination with the onshore network.
- **System requirements** – view of the network capability and requirements to inform the level of boundary reinforcement required through the develop step.
- **Options summary** – summary of the reinforcement options developed by NESO, Transmission Owners and third parties ahead of the analysis step.
- **Draft CSNP** – a draft publication for consultation; this will include the preferred GB network design, SEA draft environmental report which will include input from the HRA and MCZ, and potential future GB network designs.
- **Final CSNP** – the final CSNP publication following consideration of consultation feedback; this will include the final GB network design for delivery.

We will also analyse residual requirements on an annual basis to ensure the safe, reliable operation of the electricity network. These include thermal, stability, and voltage needs. We will engage with Transmission Owners ahead of this analysis. Any residual requirements will be published on an annual basis and may be met through Network Services' tenders. Network Services provide opportunities for third parties to offer solutions to meet system requirements whilst considering counterfactual solutions from Transmission Owners.

Framework

Overview

In planning the transmission network across GB, the CSNP will establish a delivery pipeline of reinforcements and provide certainty on necessary investments. In the long-term, where there is more uncertainty, an options funnel will be formed of potential future reinforcement options. This framework is illustrated in Figure 10.

Options funnel

The long-term funnel of potential reinforcement options will look across a 25-year horizon. It will collate multiple indictive GB network designs to illustrate different routes to reinforce the network in response to system requirements. This will support earlier visibility of future reinforcements to the energy industry and wider stakeholders. The options funnel will also provide opportunities to plan strategically, co-ordinate reinforcement options and ensure timely network delivery to enable the outcomes of the SSEP.

The network planning process will consider a range of options to reinforce the network. These could include, but are not limited to network management options, upgrades to the existing network as well as new onshore and offshore circuits.

The CSNP will have regard to the Electricity Transmission Design Principles as relevant, once these have been established. The principles will provide greater clarity on the type of asset to be used in different environments, how the impact of transmission infrastructure on the environment, landscape, and communities can be mitigated, and set out flexibilities for route and technology design. NESO will consult on the Electricity Transmission Design Principles in due course.

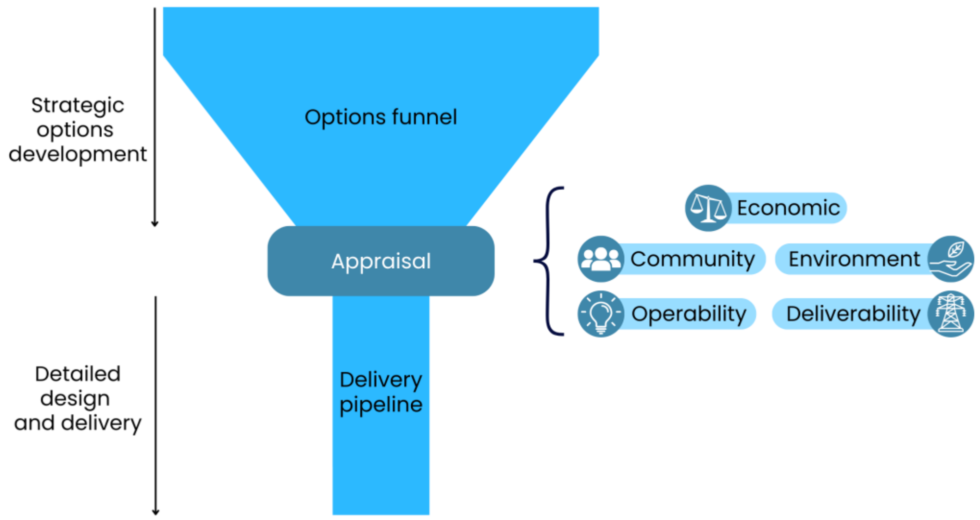


Figure 10: Illustrative options funnel and delivery pipeline

Delivery pipeline

The preferred GB network design will be determined using a consistent, robust and transparent process. Required reinforcements will progress from the options funnel into the delivery pipeline, as shown in Figure 10. The progression of reinforcements into the delivery pipeline will depend on their delivery timescale, maturity and needs case. Reinforcements in the delivery pipeline will not be reassessed, unless there are substantial changes to the reinforcements, or their needs case.

Establishing a delivery pipeline will provide confidence to the energy industry and supply chains to help accelerate delivery. It will also provide greater certainty on the future network and system requirements. The delivery pipeline will be linked to Ofgem's funding decisions, in line with the relevant funding mechanism, for which the CSNP will evidence the needs case. In establishing the needs case, or justification for a reinforcement option, the network planning process will assess a range of options considering multiple assessment criteria including:

- economic
- environment
- community
- deliverability
- operability

The needs case of reinforcements will be driven by the timing and extent of additional boundary capability provided as well as any relevant additional drivers, such as customer connections.

Where appropriate, reinforcement options not progressed into the delivery pipeline will remain in the long-term options funnel and be reassessed in the future.

Strategic parameters

Alongside the needs case, the CSNP will also determine the strategic parameters of the reinforcements that progress into the delivery pipeline. The strategic parameters, as listed in Table 4, define the critical considerations and choices when planning significant electricity transmission network infrastructure.

Proposed updates to the energy National Policy Statements will recognise the need for and accept the strategic parameters for electricity transmission network infrastructure in the CSNP. This will be subject to statutory environmental assessments and only relevant to the reinforcements which will progress into the delivery pipeline. This will help accelerate the consenting process and support the upgrade of the network.

Table 4: Strategic parameters

Parameter	Description
Spatial envelope	The broad geographical area in which a reinforcement is required.

Technology type	The type of reinforcement, such as High Voltage Alternating Current (HVAC) or High Voltage Direct Current (HVDC), as well as upgrades to the existing network.
Strategic design	The high-level design of a reinforcement, including whether it is onshore or offshore, predominantly overhead or underground and any strategic mitigation.
Interface zones	The areas of the transmission system which a reinforcement will connect between.

These parameters will enable flexibility within the spatial envelope and interface zones to support choices though the subsequent detailed design and delivery stages, including refinements in consideration of design development, appropriate surveys, planning and consenting, as well as local engagement. The extent of this flexibility will be evaluated through the appraise step.

Figure 11 illustrates the strategic parameters of an example new circuit.

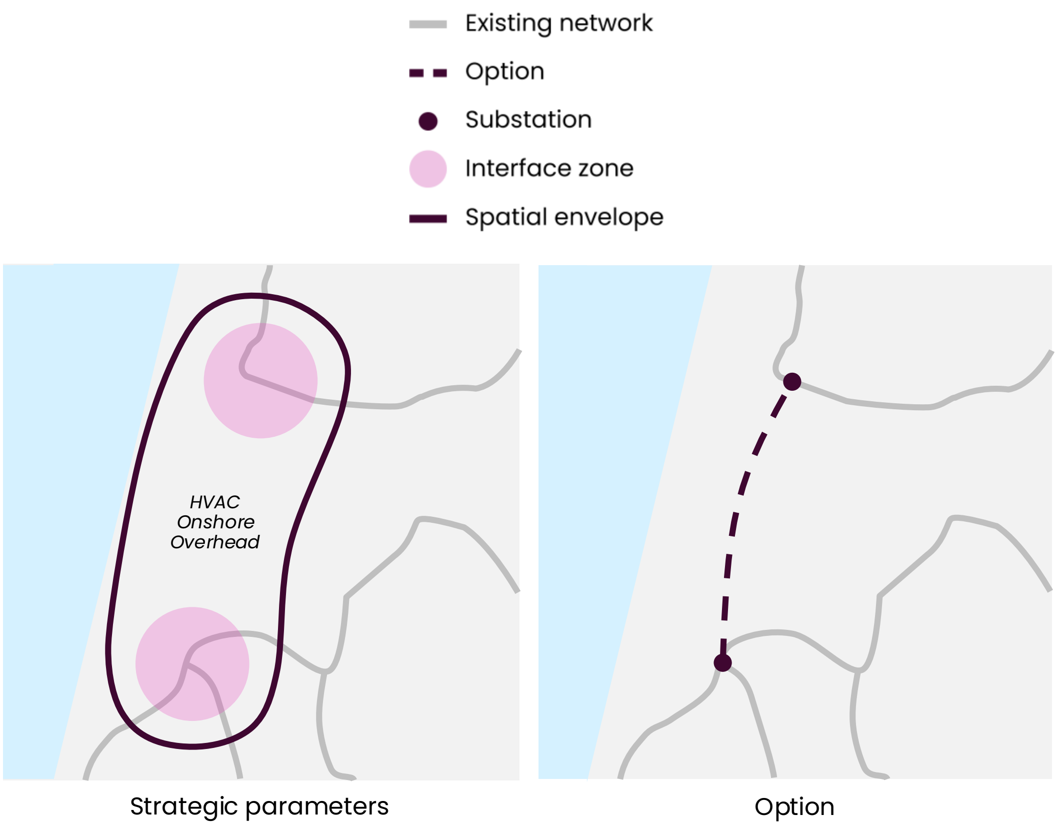


Figure 11: Illustrative strategic parameters of a reinforcement

The strategic parameters could include multiple options where they provide consistent benefits across the assessment criteria. Such options would have the same technology type and strategic design as well as support the same needs case.

The delivery body will progress required reinforcements through the detailed design and delivery stages within the defined strategic parameters. However, the needs case and the strategic parameters of the reinforcements that progress into the delivery pipeline will not be reassessed, unless there are substantial changes to the reinforcements or their needs case. This will provide the certainty required to help accelerate network delivery.

Question: Do you agree with the scope and framework, consisting of the options funnel and delivery pipeline, for electricity transmission network planning?

4. Drive (Electricity)

Overview

Energy pathways

Resilience

Offshore design

Overview

Key messages

- The CSNP will be driven by the Strategic Spatial Energy Plan and the Future Energy Scenarios.
- NESO will design a coordinated offshore network to facilitate offshore wind and identify opportunities for interconnectors and offshore hybrid assets.
- By considering high-impact, low-probability events, along with climate and other resilience scenarios, we will stress test the network plan to ensure it is sufficiently resilient.

Context

The route to clean energy requires fundamental changes to the future energy mix. These changes are illustrated in Figure 12. In this context and to support long-term decision making, it is important to look ahead and consider the possible energy system of the future.

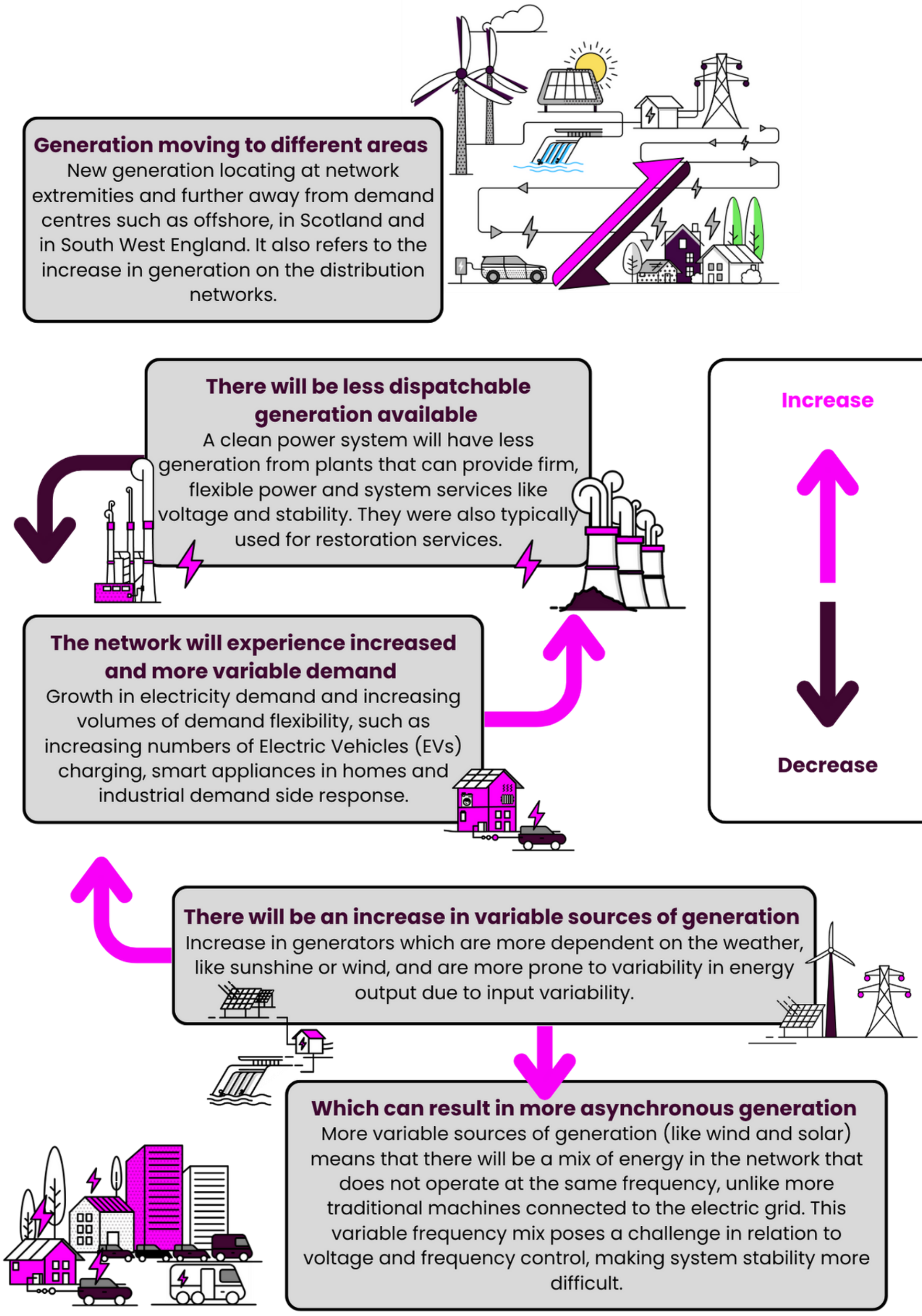


Figure 12: Future energy mix considerations

Planning for the future

The first step will be to consider a range of credible futures, or energy pathways. These pathways, established through the SSEP and the FES, will cover potential future generation mixes, including future offshore infrastructure, and a range of electricity demands.

In addition to these energy pathways, the CSNP will consider high impact, low probability events and establish different resilience scenarios to indicate potential resilience risks as we progress towards the energy system of the future.

To ensure that the CSNP is developing a plan that considers all aspects of the future energy system, NESO will also develop an offshore network design, taking account of offshore wind, interconnection and offshore hybrid assets. This will then be co-ordinated alongside the onshore network.

This offshore design process will take place alongside the wider strategic planning process, covering both the SSEP and CSNP. Due to these interactions with multiple planning exercises, to explain the offshore design process in full requires providing context on these SSEP interactions alongside the CSNP which will be detailed further below.

Energy pathways

Pathway usage

The single SSEP pathway will be used to determine the preferred GB network design and decide the required reinforcements to progress into the delivery pipeline. The GB network design will also be stress-tested against the FES to provide confidence on the needs case of required reinforcements. The FES will also help us illustrate long term indicative designs that represent different routes to reinforcing the network in response to system requirements across the horizon of the long-term options funnel.

The SSEP will use 17 zones in its economic modelling to efficiently match the temporal and geospatial needs for energy supply with network and demand. The transfer of electricity between these economic zones will be limited by a set of boundary capabilities. The economic model may expand boundary capabilities at a cost, so that the outputs are optimised with assumed boundary reinforcement.

For bulk power flows, the CSNP will identify more granular network capability and requirements following input from the single SSEP pathway. It will utilise additional boundaries compared to the SSEP. These boundaries have developed over many years of operating and planning the transmission system. For each boundary, the SQSS required transfers and expected annual unconstrained power flows will be identified. These will inform the level of boundary reinforcement that developed options are expected to satisfy in the CSNP. The concept of boundaries and requirements are outlined in the identify step.

The CSNP will plan the wider network in anticipation of future customer connections that will be informed by the SSEP. This will ensure the CSNP, driven by the SSEP, can plan the wider network strategically.

The range of credible future pathways which the FES will present out to 2050 will provide the background for which the GB network design can be stress-tested against. Additionally, the CSNP will develop resilience scenarios to consider additional risks, the approach to this is detailed below.

Resilience

Context

In addition to multiple energy pathways discussed above, the CSNP will also consider different resilience risks. The GB transmission system has historically demonstrated high levels of resilience. As the system evolves and given the pivotal role that energy systems bring to society and the economy, it is important that a resilient system is maintained.

The energy system is undergoing a rapid transition, integrating more energy resources with more electrified demand, such as domestic heating and transport. In parallel, we are seeing shifts in the operating landscape, with climate change intensifying extreme weather and geopolitical tensions threatening global supply chains. These factors create interconnected challenges and opportunities that can amplify or reduce risks, cause cascading impacts and affect the resilience of the transmission and wider energy system.

In the CSNP, a risk is defined as a potential event which, if it were to materialise, would have a substantial impact on the safety, security and/or resilience of the energy system at a GB level. It is important that the CSNP considers these risks to ensure the reliability, resilience and security of the future electricity transmission network. Failing to address them could lead to a network that is vulnerable and experiences more frequent or more widespread disruptions and subsequently significant socio-economic impacts.

Risks

There are a range of risks that if materialised could cause significant disruption to the electricity transmission network and that are relevant to long term transmission network planning. Risks were considered relevant if they could result in the unavailability or reduced reliability of electricity transmission network infrastructure. A summary of these is provided in Figure 13. More details on these and the mapping exercise that we used to identify these risks, is provided in the resilience appendix.

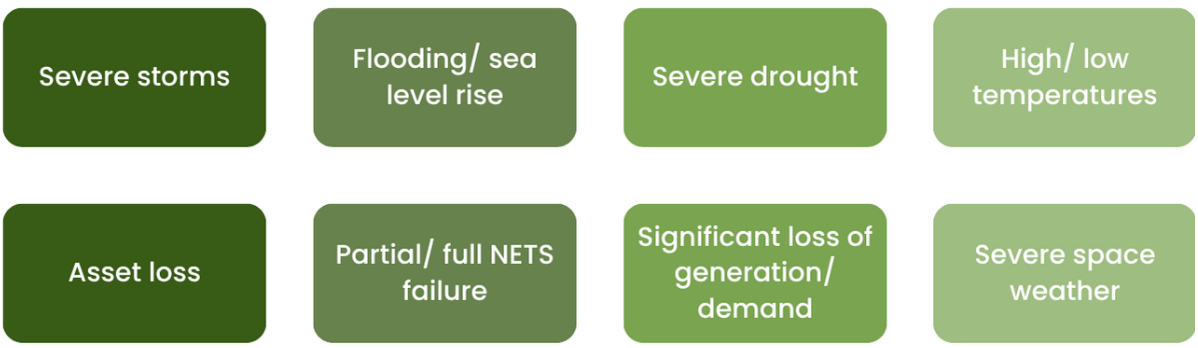


Figure 13: Risks that are relevant to the CSNP

Resilience scenarios

We acknowledge that various industry activities are already underway to address and mitigate some of these risks (e.g. network operators climate adaptation activities). There are also continuous reviews into recent national or international network events so that lessons learned can be identified and implemented. However, stress-testing risks as part of the CSNP process will help us explore how the future transmission network performs in times of system stress and assess whether further investment is appropriate and proportionate to mitigate against potential disruptions.

We propose that, rather than stress-testing individual risks within the CSNP, we will develop adverse scenarios that combine multiple credible risks. This approach would stress-test the transmission network more effectively, providing a more realistic and comprehensive assessment of the electricity network's resilience compared to testing a single risk in isolation. Examples of how several risks could be combined to form a scenario is provided below:

- cold temperatures which lead to high electricity demand, network outages, asset failures, and the unavailability of some generation (e.g. thermal, wind) and interconnection
- loss of critical national infrastructure which leads to a loss of generation or demand
- high temperatures combined with wildfires or severe drought, which lead to high electricity demand, network outages, asset failures and the reduced output of some generation (e.g. wind, hydro), interconnection

Scenario development

NESO has identified four general principles for its approach to developing the resilience scenarios. When designing any stress test, we will balance these principles appropriately.

- **Robust** – the approach for assessing the resilience of the transmission system against adverse scenarios must be robust, repeatable and informed by data, expert judgement and analysis.
- **Proportionate** – stress tests have limitations. Therefore, the time, resource and planning requirements associated with developing, and implementing stress tests need to be proportionate to the benefits.
- **Relevant** – stress tests should be responsive to the changing risk environment and assess emerging or structural trends or risks that are plausible.
- **Transparent** – the approach and findings from scenario testing must be communicated openly with policy makers and the public. This will improve decision-making and understanding of the transmission system.

Developing and implementing stress testing will require robust co-ordination to align methodologies, ensure consistent data sharing and a shared understanding of risks across all entities. Regular engagement with key stakeholders will be necessary throughout the stress testing process. This will involve:

- engagement with the governance stakeholder sub-group which includes the key stakeholders (e.g. DESNZ, Ofgem, Transmission Owners, developer and supply chain representation) in the scenario selection and design phases, and ensure sufficient data is available on asset failures for effective stress testing
- working within our governance framework to ensure transparency and accountability for decision making across the stress testing process, e.g. scenario selection and recommendations

Figure 14 summarises the design process of stress test scenarios which is anticipated to run parallel to the CSNP process and cycle. The design of the scenario should be informed by historical experience, future projections and the current/emerging risk landscape as set out by the NESO's Resilience and Emergency Management directorate.

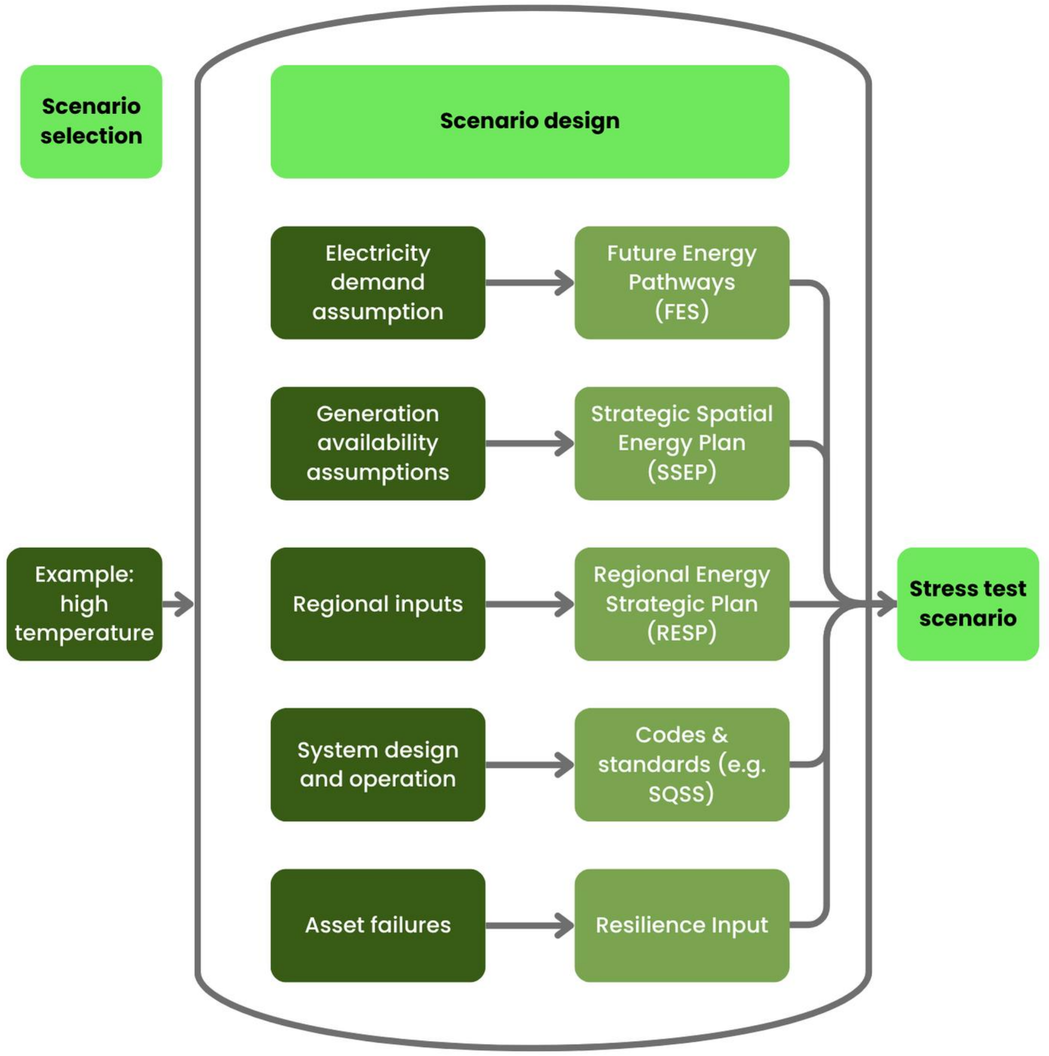


Figure 14: Stress test scenario design process

Some inputs for the stress test scenario may require variations to the background conditions (e.g. weather data, generator availability, electricity demand) of FES or the other strategic energy plans.

While the intention is to ensure consistency and alignment of background conditions (e.g. consistent weather data) across all network plans, there may be some differences initially, due to the different timeframes that they are being developed across. For example, the proposed SSEP and FES methodologies use historical weather data for capacity expansion, stress testing and demand and supply modelling respectively.

However, as the SSEP and FES are already being developed prior to the first CSNP, it will not be possible to update the weather data used in the first cycles of these plans due to timing. The RESP's processes can help identify regional differences in risk events, such as localised flooding risks or prolonged heat events in specific areas. As we develop the RESP methodology, we will aim to incorporate any resilience outputs and integrate them into the SSEP and CSNP processes. We will incorporate any resilience outputs or learnings from these plans into the RESP. However, it is unlikely that these interactions will be fully realised within the first cycle of RESP, SSEP, and CSNP.

For electricity, the CSNP decision making process uses the single SSEP pathway. Resilience scenarios will therefore not directly change any CSNP decision but are to be used to indicate any potential resilience risks. If any risks are identified, they can be taken forward for further analysis. This could lead to review of standards, codes or policy. Asset policy is expected to be managed by the relevant asset owners and developers. The resilience scenarios may include changes in network power flows or capability. Projected power flow changes will be shown by passing the resilience scenarios through the calculation of network requirements, either boundary required transfers or annual power flows. Network capability changes due to asset-based changes (such as de-rating of circuits due to higher temperatures) will be assessed if required. See the appraise step for more details.

Code or policy review

If the conditions of the stress test scenario fall outside of current security standards e.g. the Security and Quality of Supply Standard (SQSS), it may prompt a review of the relevant parts of those standards. Significant changes, such as those to the would undergo investigation and any changes would be made through code review panels. Eventually, any code changes will be integrated into subsequent CSNP cycles. Code review activities are managed by specific code governance arrangements.

Offshore design

Background

The impact of offshore assets on a future network

The SSEP represents a fundamental change to energy network planning. It will inform future optimal connection locations, capacities, and timings for offshore wind and interconnectors to achieve a chosen pathway. As we await the recommendations of the first SSEP, our insights come from NESO's FES. This shows that a significant growth in offshore assets is required to decarbonise the supply of electricity in GB. This includes offshore wind accounting for approximately half of the GB electricity supply in multiple FES pathways. Future interconnection capacity will provide a vital form of flexibility as more intermittent generation sources are integrated into the energy mix. This rapid growth will drive a significant increase in flows on the transmission network requiring a clear plan for offshore generation.

Relative to onshore generation, offshore generation is unique when it comes to planning and assessing its impact on the onshore electricity transmission network. This is due to two key aspects:

- **Capacity:** As offshore technologies mature, higher capacity assets are being used. GB's first pilot offshore wind project in 2000 had a total capacity of 4 MW across all its turbines. Individual modern turbines in a newly developed windfarm may have three times that total capacity. Due to the high amount of power each windfarm produces, connecting these generators to the onshore transmission network requires significant investment.
- **Connection flexibility:** Although the seabed provides complex physical and environmental constraints, there is more opportunity for flexibility and optimisation with regards to connecting to the onshore electricity transmission system. This flexibility for offshore generation means more options are available when planning the network.

The generation capacity of these large-scale generators can cause significant network flows and drive significant network reinforcement need. However, since they have more options for connection locations compared to other types of generators, their connections can be strategically placed in less congested areas of the network to minimise this impact

Figure 15 shows how early consideration of the interface point for an offshore generator can be beneficial to the onshore network.

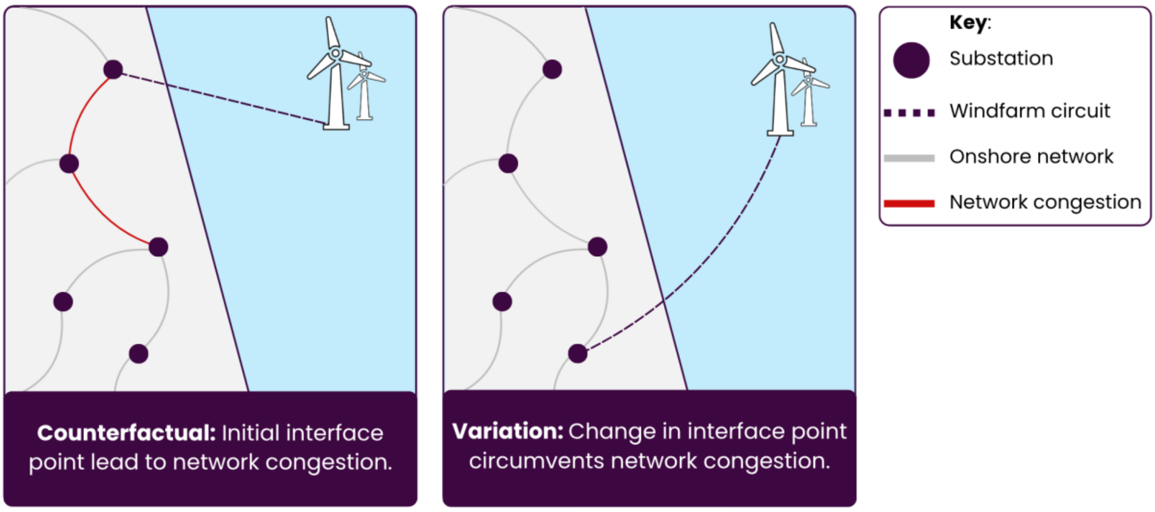


Figure 15: Example of viable routes and leasing areas for connecting the same offshore windfarm to shore

These unique characteristics and the high potential impact on the network mean it is important that offshore wind and other offshore assets are planned holistically. In 2020 the UK Government established the Offshore Transmission Network Review (OTNR) which tasked us with designing an offshore network to ensure that offshore transmission assets for a number of offshore wind projects are delivered in the most appropriate way which minimises environmental, social, and economic costs.

To realise these benefits, we built extensive coordination into our previous offshore network planning processes and will continue to utilise coordination going forward. We have gained significant experience in creating, appraising, and recommending coordinated designs and we aim to embed this expertise into our ongoing work.

The following section explores the varying forms of coordination and their potential to improve performance against the assessment criteria and avoid network congestion and upgrades.

Defining coordination

NESO's previous planning exercises, such as the Holistic Network Design (HND) and Holistic Network Design Follow-Up Exercise (HNDFUE), have recommended high levels of electrical coordination between offshore windfarms, highlighting the value coordination can deliver against our holistic assessment criteria. Having supported the progression of these recommendations through the detailed design stage, several lessons have been learnt.

These have identified ways in which the same holistic benefits can be delivered through different approaches to coordination. This ranges from:

- better collaboration between NESO and leasing authorities developing offshore leasing rounds
- utilising standardised assets to mitigate supply chain challenges
- considering new ways in which electrical coordination can provide wider transmission system benefits

In this section we outline how we will explore coordination in the CSNP process.

Role of seabed leasing

GB has two seabed leasing authorities: The Crown Estate (TCE) who are responsible for seabed leasing In England, Wales and Northern Ireland, and Crown Estate Scotland (CES) who are responsible for seabed leasing in Scotland. The leasing authorities are uniquely positioned in planning and one of their core responsibilities is the identification, assessment, and subsequent leasing of suitable areas for offshore development.

The detailed design and development of seabed leasing is a complex process involving extensive analysis that considers a wide range of factors to determine the most suitable areas of seabed for leasing. Leasing authorities also engage with many stakeholders to ensure that they balance the needs and priorities of all users of the seabed. Figure 16 illustrates a simplified representation of a typical seabed leasing design exercise.

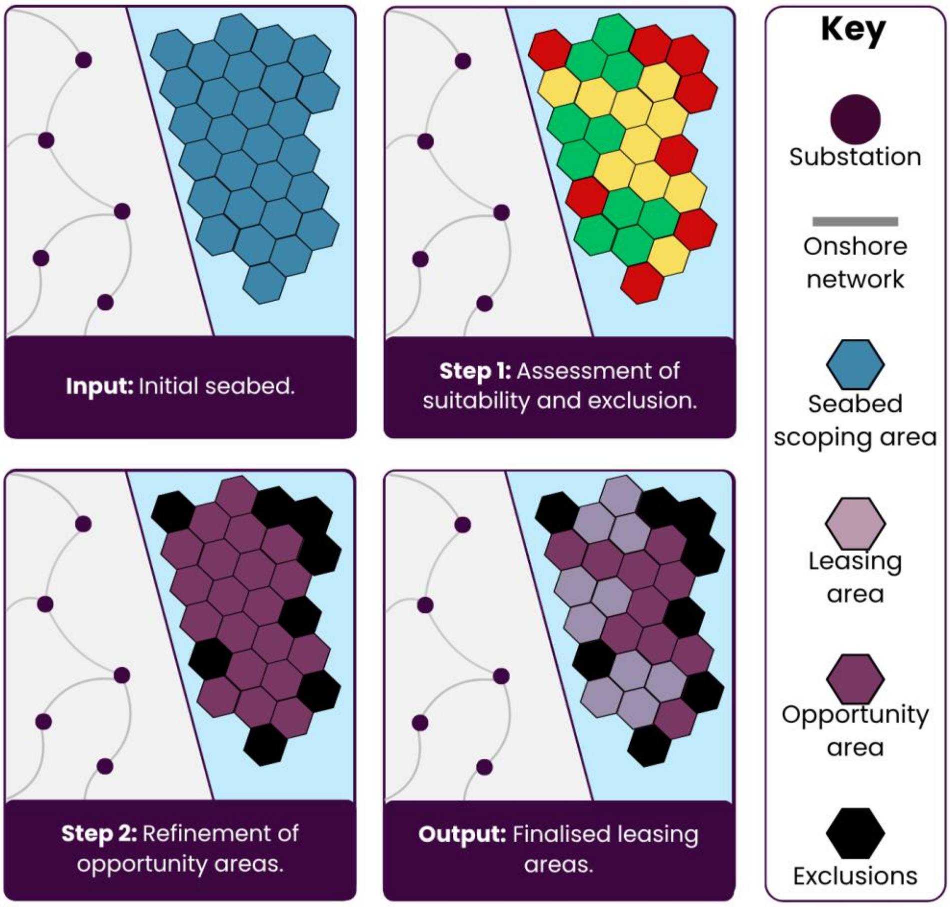


Figure 16: Simplified representation of seabed area assessment and leasing process

There is potential to reduce impacts to the onshore transmission network through early consideration of lease area size and location. Responsibility for selecting and leasing seabed areas sits with the leasing authorities. But early collaboration and coordination with the SSEP process will allow us to provide network planning input and identify opportunities to minimise the impacts of offshore windfarms on the network, the environment, and communities.

Strategic and spatial coordination

Strategic and spatial coordination focuses on delivering the benefits of coordination through spatial optimisation and strategic foresight. Collaborating more closely with leasing authorities allows us to support the design and development of future leasing rounds by providing valuable insights into transmission network considerations. This contribution to the seabed leasing design process, when aligned with our strategic network plan, will enable the pursuit of highly optimised and strategically integrated future leasing rounds.

Standardising assets

We will explore the benefits of incorporating standardised asset sizes into our future designs. This strategic approach aims to better support the supply chain by reducing the need for bespoke or novel technologies. This should increase industry confidence and the availability of standardised assets and improve the deliverability of our design recommendations. Figure 17 demonstrates how standardising assets can improve utilisation of cable capacity.

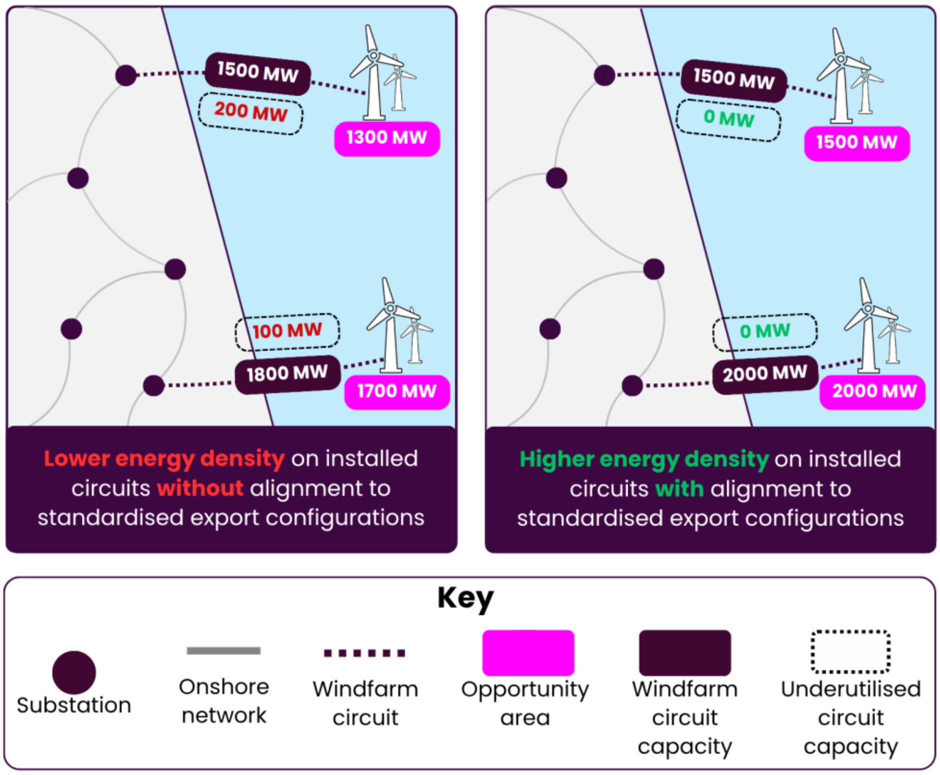


Figure 17: Illustrative visual representation of how standardised export configuration can minimise unutilised cable capacity

Engagement with industry has informed our approach and we have subsequently created a new set of offshore design principles. These principles stipulate rules and guidelines to help us create optimised designs using commercially available assets whilst incorporating known industry constraints and risks. Standardisation within the industry has led to four major technology classifications and these are expected to remain standard into the 2040s. Table 5 outlines these HVAC circuits should be less than 150km total length, with mid-point compensation required for any distances greater than 80km.

Table 5: Offshore technology classifications

Technology	Capacity limit per circuit	Voltage
HVAC	500 MW	132 - 275 kV
HVDC Symmetric Monopole	1500 MW	320 kV
HVDC – Rigid Bipole without dedicated Metallic Return (DMR)	1800 MW	525 kV
HVDC - Bipole with DMR	2000 MW	525 kV

Spatial coordination

Asset standardisation also complements spatial coordination. This can be achieved by supporting the leasing authority's determination of leasing area capacities. Aligning leasing area capacities with standardised cable capacities can reduce the number of cables required for connection, and the number of landfalls made. The leasing authorities will need to balance these efficiencies with the complex dynamics involved with siting potential wind farms such as the local geology, wave heights and potential wake effects. Additionally, an overly prescriptive approach of setting potential lease area capacities to known cable limits may reduce potential opportunities for offshore hybrid assets. To mitigate this, we will consider these opportunities in parallel.

Certain areas of the seabed may not be able to host single large windfarms. There is the potential to cluster smaller leasing areas into a single project lease area. This collection of areas would have a capacity equivalent to a standard cable capacity and is another way to deliver strategic and spatial coordination.

These approaches aim to reduce the need for additional cables to connect offshore generation and reduce the environmental and community impact of our designs. They also look to reduce the complexities of introducing coordination between different projects whilst achieving the same benefits.

Implementation of these standardisation elements must be done with care and in close collaboration with leasing authorities to ensure that these principles can be incorporated appropriately. Figure 18 shows an example of clustering and how it forms a single project lease area.

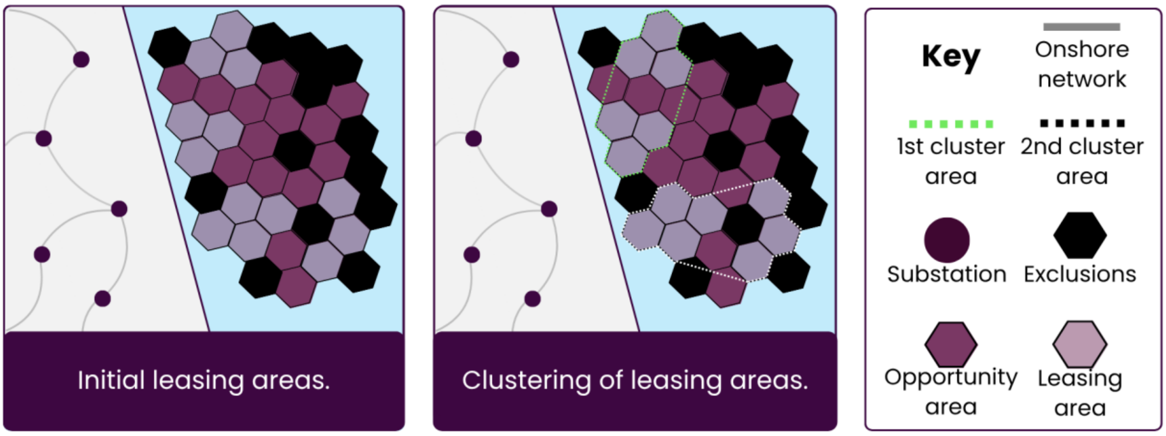


Figure 18: Example showing how clustering can combine leasing areas into a 'single project' lease area

Electrical coordination

Electrical coordination describes the approach in which additional offshore infrastructure can be used to physically link offshore assets together to create an interconnected network. Electrical coordination of offshore assets was first recommended in the HND and continued to be recommended in later design exercises. Subsequently, European Transmission System Operators (TSOs) have taken a similar approach and the first generation of multi-national studies looking at the benefits of incorporating this approach at a sea-basin level have been undertaken. Electrical coordination can range from connections between two windfarms to a more complex "meshed" network, where developers are interconnected with multiple parties, including both GB and European counterparts. Figure 19 is an example of what a future cross-border meshed offshore network could look like.

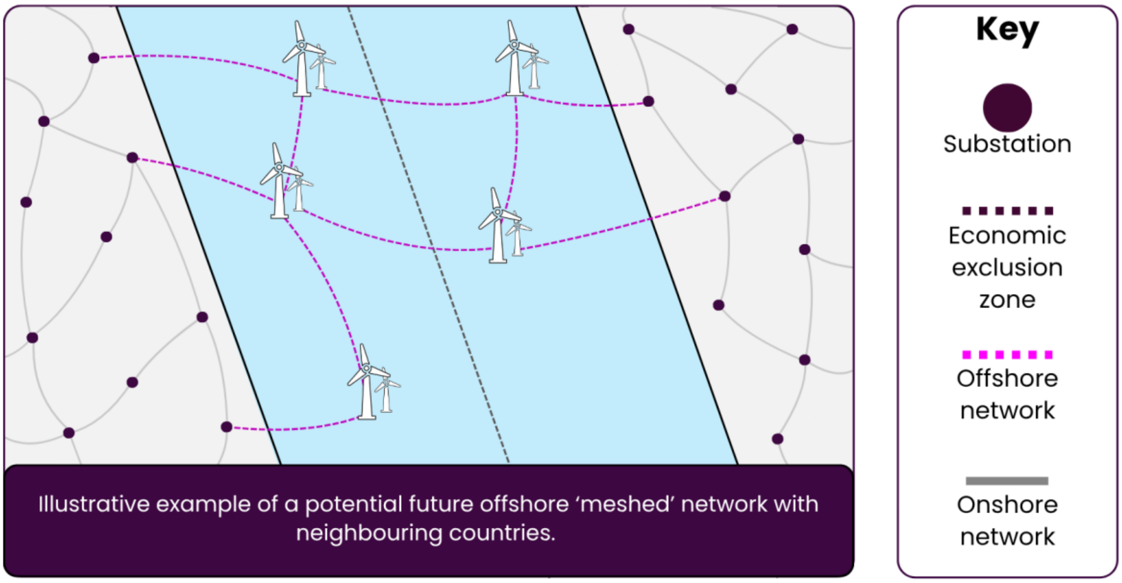


Figure 19: Illustrative example of a potential future meshed offshore network

There are many potential approaches and benefits to introducing electrical coordination such as:

- providing additional redundancy
- increased asset utilisation
- a reduction in the requirement to expand the onshore transmission network
- reducing the impact on the environment and communities
- facilitating efficient trade between neighbouring electricity markets

It is important to consider that as the level of electrical coordination increases, the CAPEX cost increases due to additional design and construction complexities. This can impact the deliverability of meshed grids and the viability of exploring greater levels of electrical coordination. The appropriate extent of electrical coordination needs to be explored and carefully balanced against the assessment criteria within the CSNP. Meshed offshore grids are an important long-term aspiration with innovative solutions currently being investigated such as DC circuit breakers and multi-terminal offshore platforms. These could be available in the future. Figure 20 shows some potential benefits in using offshore coordination to reduce onshore constraints.

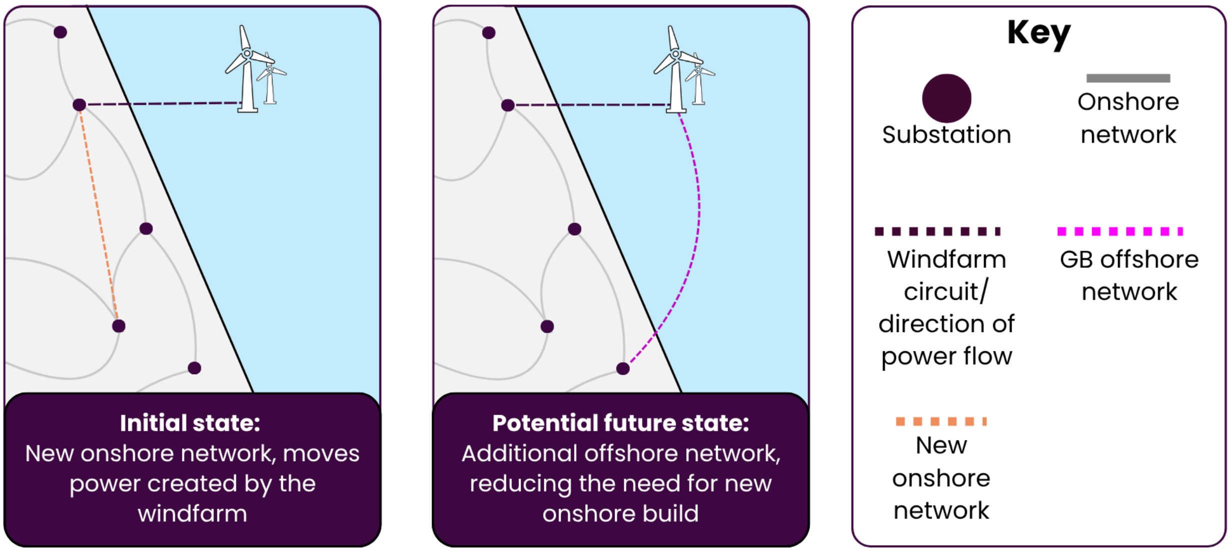


Figure 20: Example of the benefits of offshore electrical coordination reducing need for new onshore network build

The forms of electrical coordination, explained below, will be explored within the CSNP to determine the overall benefit that they can provide.

Project-to-project

This option aims to connect multiple offshore wind farms to reduce the cumulative environment, community, deliverability, and operability (ECDO) impacts of the overall recommended network. Linking wind farms to shore with a shared cable aims to reduce the environmental and community impact by only requiring one interface point. However, the same benefits can be achieved by maximising the cable capacity for a single, higher capacity project, minimising the complexity of the design. With shared cables, the reliance on other projects can create investment uncertainty and risk, making deliverability more challenging. Figure 21 gives a visual example of project-to-project coordination.

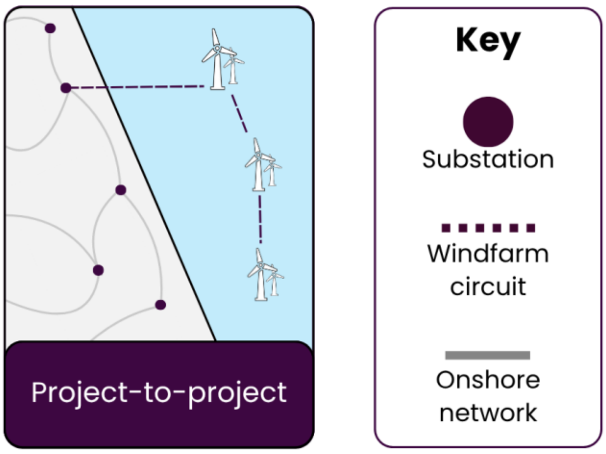


Figure 21: Example of project-to-project coordination

New offshore links

Offshore links seek to give windfarms two electrical routes to the onshore transmission system. This allows for power to be sent to the most beneficial location on the network and allows for power to reroute around congested areas of the onshore network. This can reduce the number of new onshore transmission assets that are required to manage congestion on the network. Linking distinct parts of the onshore network together via offshore routes is a proven approach. However, the combined delivery of generation and transmission assets as recommended by the HND has not yet been delivered. Figure 22 shows an example of this coordination.

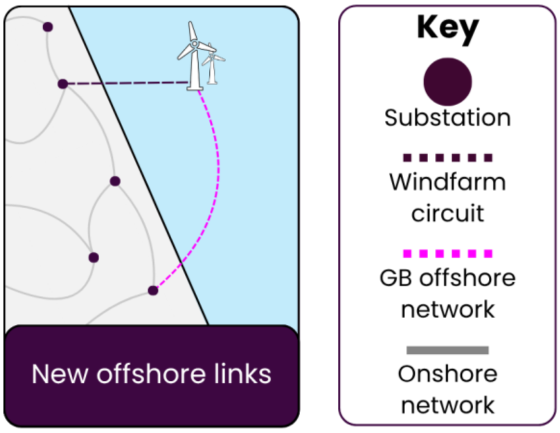


Figure 22: Example of new offshore link coordination

Project-to-project link

This option is an extension of the new offshore link but includes more than one windfarm increasing the meshed nature of the offshore network. The sharing of assets on the network can reduce costs but may increase the investment uncertainty and risk to the project. However, this option can increase the utilisation of the installed cabling and has the potential to reduce the volume of cabling required. This can reduce the impact on the community and the environment. Figure 23 is an example of project-to-project link coordination.

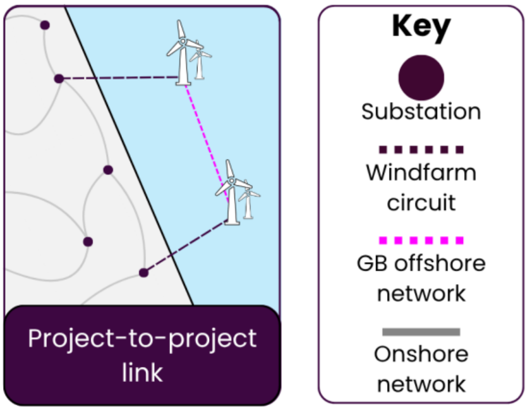


Figure 23: Example of project-to-project link coordination

Offshore hybrid assets

Offshore hybrid assets are a relatively new category of offshore energy infrastructure and have not previously been incorporated into our planning processes These proposals involve connecting offshore wind farms with electrical interconnectors which link together two distinct electricity markets. There are two configurations of offshore hybrid assets. They are:

- multi-purpose interconnectors, where the offshore windfarm is in GB waters
- non-standard interconnectors, where the offshore wind farm is not in GB waters.

Figure 24 shows an example of an offshore hybrid asset.

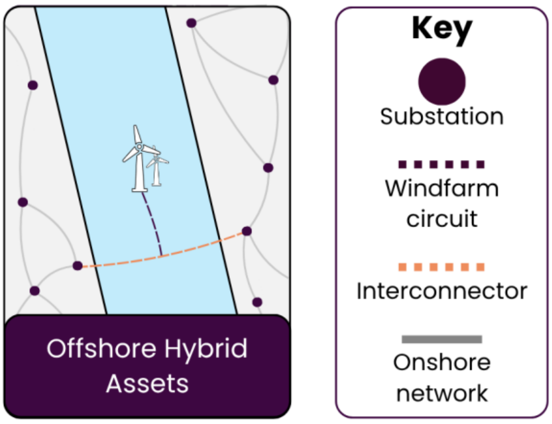


Figure 24: Example offshore hybrid asset coordination

This approach of combining assets is similar to that taken within the HND and HNDFUE where offshore wind farms could have two distinct connections to different parts of GB. In this case spare capacity can be used to trade power with neighbouring countries which can benefit domestic electricity markets and improve the security of supply.

Although Offshore Hybrid Assets are still a relatively new concept, the regulatory framework is being developed with the first dedicated offshore hybrid asset pilot scheme having approved two non-standard interconnection projects. This pilot scheme has demonstrated the interest from industry to develop offshore hybrid assets once an enduring regime is in place. Further to this, European TSOs have also shown extensive interest in advancing such projects, highlighting a shared commitment to collaborative offshore development.

Summarising coordination

In summary, there are various ways in which coordination can be explored. The coordination approaches are not mutually exclusive. It is possible to utilise the aspects of strategic and spatial coordination and deliver a meshed or electrically coordinated offshore network.

Our approach to coordination in the CSNP will focus on establishing a recommended offshore design that is balanced against all the assessment criteria. We will do this by utilising both the benefits delivered through the proactive work of strategic and spatial coordination and finding the optimal level of electrical coordination as we iterate through complex designs.

Question: Do you agree with our approach to utilise both spatial and electrical coordination in developing offshore networks?

Question: Do you agree with our plan to design using current cable standards to provide certainty for connections?

Assessment process

Context

This section explains the approach we will take to develop an offshore network plan that facilitates the connection of offshore generation whilst balancing the impacts on the wider transmission system within the CSNP for electricity.

The unique nature of offshore generation means that planning must begin at an early stage in strategic planning. This process starts during the early part of the SSEP, providing network insight and analysis to support pathway development. It concludes with a final offshore design in the CSNP that facilitates the outputs of the selected SSEP pathway.

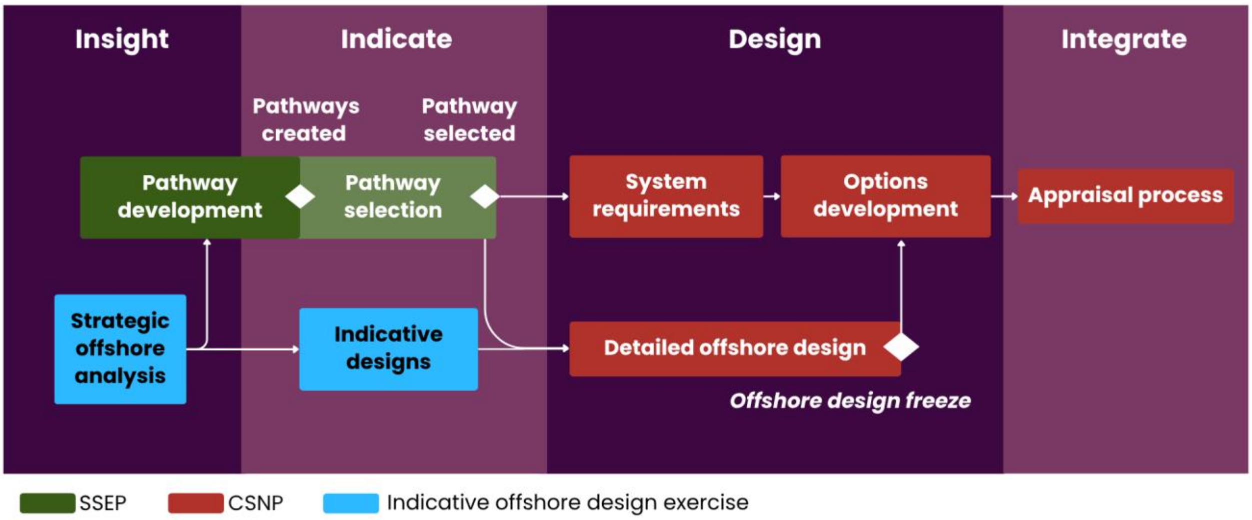


Figure 25: Process map of the four stages

The CSNP's offshore electricity planning process will be comprised of four key stages, as shown above in figure 25. These are as follows:

1. **Insight**: Collect evidence through lessons learnt, NESO analysis, stakeholder engagement and via third party publications.
2. **Indicate**: Our indicative offshore design exercise will develop a design for each draft SSEP pathway ahead of the UK Energy Secretary's final selection. This step ensures we can start the detailed offshore design stage as soon as the final SSEP pathway is selected.
3. **Design**: Our indicative offshore design will move to a detailed design stage, where we will consider different levels of electrical coordination between windfarms, interconnectors and the wider system. This will be followed by an offshore design freeze.
4. **Integrate**: The offshore design freeze will allow time for alternative onshore options to be studied against the offshore design. Further refinement of the offshore design

may take place if onshore reinforcements options suggest a more optimal offshore solution can be found against the assessment criteria.

Assessment stages

Insight

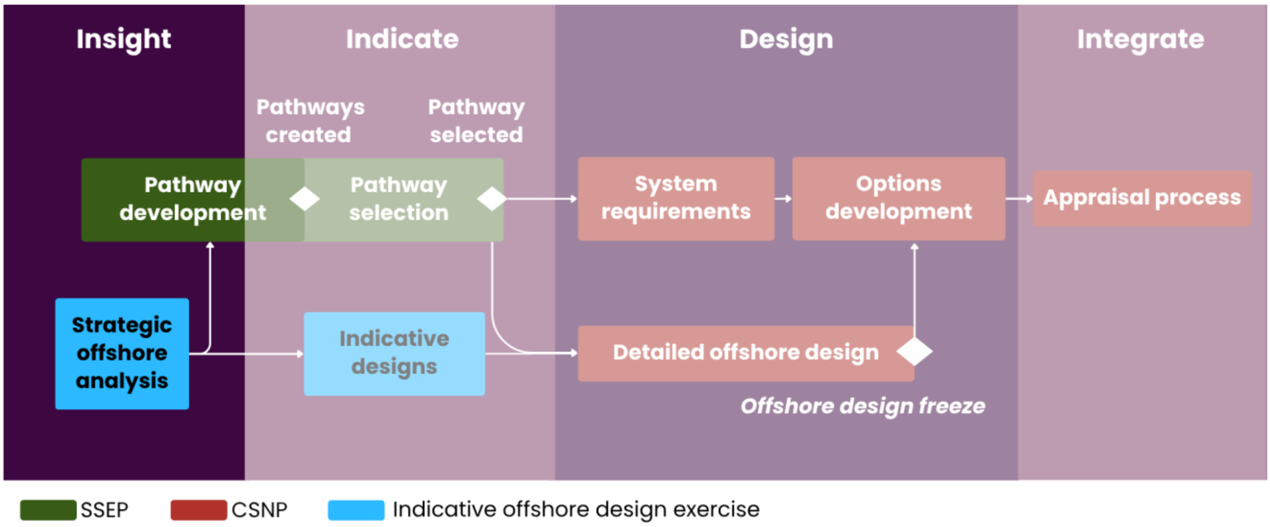


Figure 26: Process map highlighting the insight stage

As shown in figure 26, the strategic planning around future offshore wind and interconnection starts during the early stages of the SSEP. We will carry out strategic offshore analysis that proactively sweeps the coastline of GB to understand where future offshore connections could land onshore. This will build up a complete picture of the current state of the planned network, taking into consideration previous planning processes. We will then extend this picture to focus on the future state, looking to identify existing areas of the network that can facilitate new offshore generation and opportunity areas where new onshore interface points could be established for offshore generation to plug into.

In the insight stage, as illustrated in figure 27, we utilise the lessons learnt from previous planning exercises, extensive stakeholder engagement and research to identify a more strategic approach to offshore planning. This includes the development of the strategic and spatial coordination approach and how we can work collaboratively with leasing authorities and European TSOs to deliver the future plan for offshore electricity, wind, and interconnection.

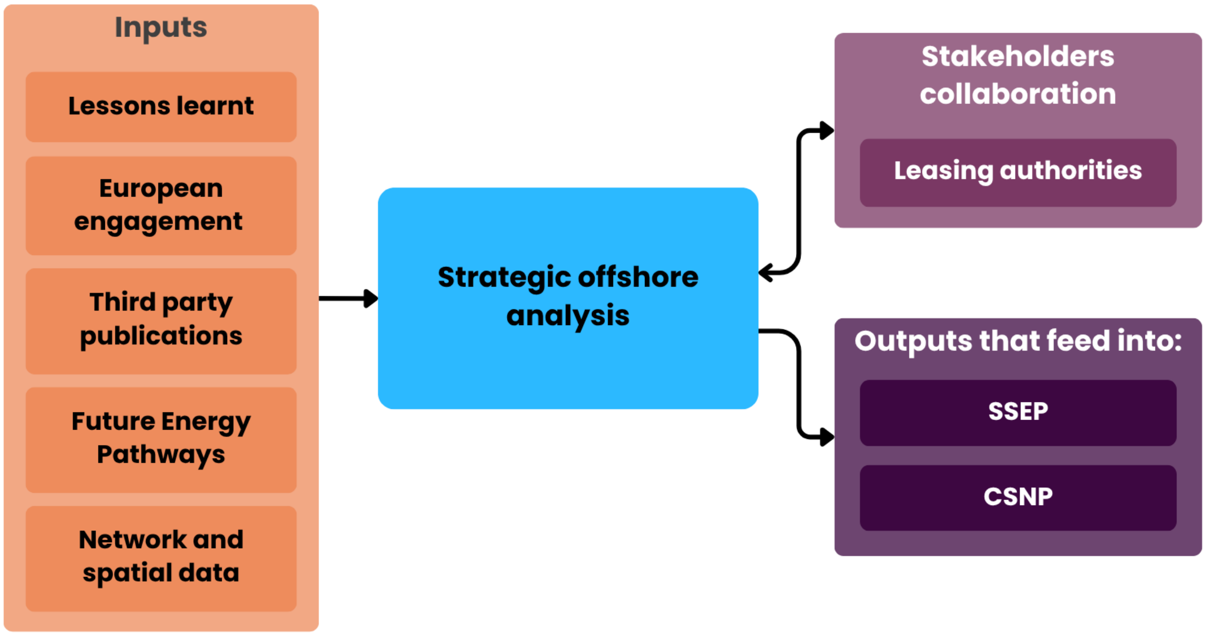


Figure 27: Inputs and outputs of the insight stage

The purpose of the insight stage is to establish a foundation of credible transmission interface points for offshore wind and interconnection, and to gather intelligence into the potential impacts on the onshore transmission system as more offshore connections are developed. This will include a view on:

- the current transmission network capacity and availability of interface points
- potential opportunity areas for new interface points for offshore generation
- the viability of offshore cable routes to these interface points per SSEP zone
- indicative transmission capacities at each interface point
- an indication of any additional indicative transmission works that may be required per SSEP zone
- an overall ranking of interface points per SSEP zone based on their suitability for future offshore connections

Insights from the strategic offshore analysis feed into the SSEP so that known constraints are factored into the pathway development, ensuring a set of credible and robust pathways are produced. Similarly, we will be sharing these insights with leasing authorities to support the development and refinement of future offshore wind leasing rounds. We will also use the insight gained in this stage to inform the development of offshore electricity designs in later stages of the CSNP.

Indicate

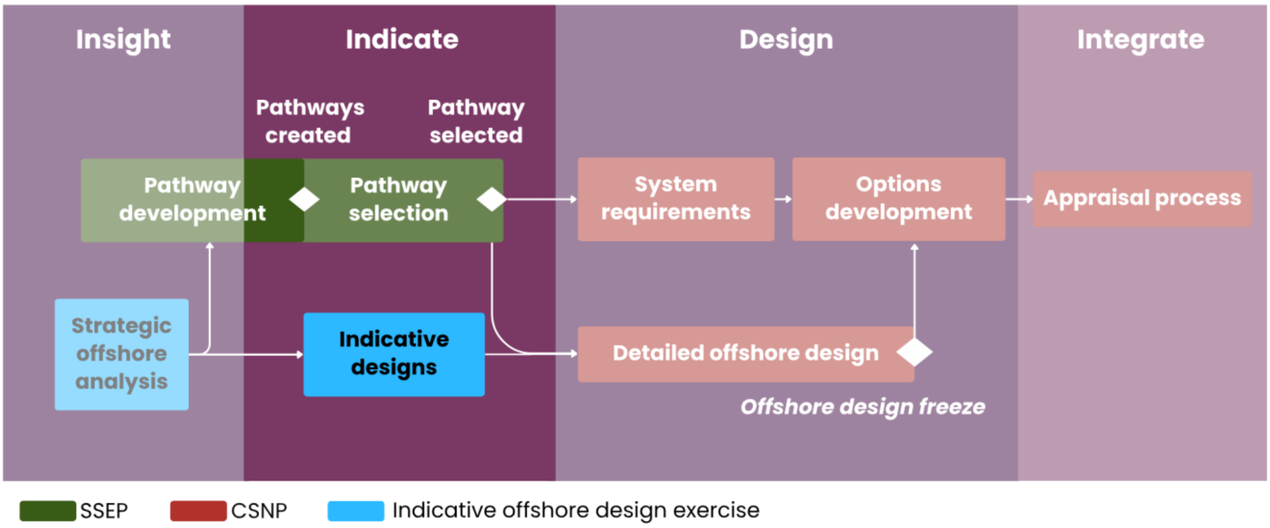


Figure 28: Process map highlighting the indicate stage

The SSEP will create several diverse pathways which each demonstrate different ways in which GB's energy system could be developed in the future. Each pathway will consider a set of policy objectives, complex multi-vector analysis and will have different combinations of energy requirements across technologies, including offshore requirements. These pathways will be presented to the UK Energy Secretary for consideration before the CSNP begins. The indicate stage, as shown in figure 28, will create indicative offshore designs for these pathways.

To ensure that the network system requirements analysis can progress at pace once the UK Energy Secretary chooses a final SSEP pathway, there is a requirement to create a credible and robust indicative offshore design for each potential pathway under consideration. This initial offshore design is essential for the start of the Identify stage to support the calculation of expected flows on the system, and forms part of the network models produced for Transmission Owner studies.

There are lots of different opportunities for developing new offshore wind and interconnection to neighbouring countries. As such, potential offshore designs could look very different between pathways. Figure 29 illustrates how two pathways can differ in offshore wind levels between zones, changing network requirements and flows, and therefore the designs. Note that the capacity figures and regions are for illustrative purposes only.

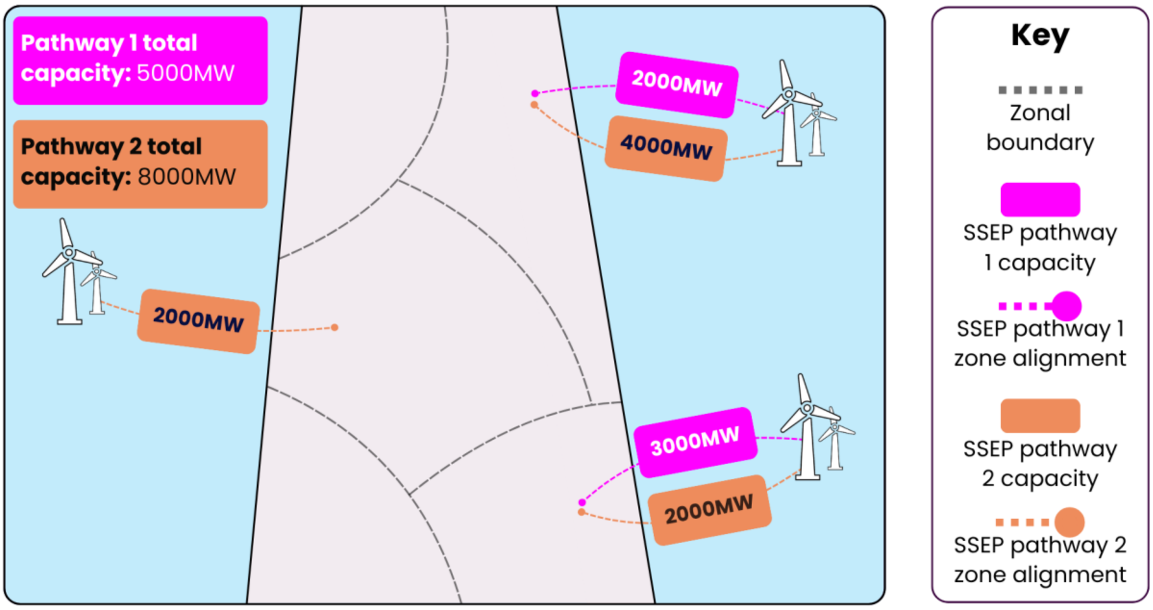


Figure 29: Illustration of potential variance in offshore wind capacity across SSEP pathways

As the SSEP makes capacity recommendations on a zonal basis, it is necessary to attribute the capacity from each SSEP pathway back to specific points on the network. Connections will only be attributed to interface points within the onshore SSEP zone identified within each pathway to ensure parity with the SSEP recommendations.

Each assumed windfarm location (the final locations used for any future leasing process are the responsibility of the leasing authorities) or interconnector will need to be attributed to a specific interface point on the onshore transmission system. The indicative offshore design will do this based on the rankings established for interface points in the insight stage. The order of these connections will be based on the impact of the individual asset and the cumulative impact of the design.

In the indicate stage, we will develop an initial offshore design for each of the SSEP pathways whilst they are under consideration by the UK Energy Secretary. Each design will account for the variation in location, volume and different types of generation technology (e.g. fixed or floating offshore wind) recommended by the respective pathway.

To ensure that a robust set of designs can be established within the short time period between the SSEP pathways being finalised and the UK Energy Secretary's decision, a number of different approaches and assumptions will be taken to streamline the assessment and establish a baseline for each pathway.

- The initial designs will only use point-to-point interconnection and radial offshore wind farm connections to meet the requirements of the shortlisted SSEP pathways. This reflects the SSEP pathways.
- Standardised asset sizes will be used to meet the regional capacity requirements identified by the SSEP. This approach will allow us to quickly establish a robust and

deliverable offshore generation background for the wider network planning process to consider.

- It will be assumed that interconnectors have the same landfall and onshore spatial requirements as offshore wind farms with HVDC connections. At this indicative stage, we will also assume that the electrical requirements for interconnectors and offshore wind are similar.

Additionally, prospective interconnector options will be considered against:

- The high-level electrical limitations of each connecting market, such as the distinct infrequent loss of infeed limits of the Nordics, as identified through the insight stage.
- A spatial map which ensures that interconnection options between each SSEP region and the proposed foreign market is viable. This ensures that highly complex, less viable combinations (such as connections between North Wales and Denmark which would need to be routed long distances around the south coast of England or North Scotland) are not considered.

The initial offshore design developed for each SSEP pathway will then be assessed against the CSNP's assessment criteria when the SSEP's zonal capacity is allocated to individual interface points. This will ensure that a robust, holistic, and detailed assessment is undertaken.

Using the outputs of the insight stage, we will map the offshore capacity to the most suitable identified interface points indicated by their overall ranking. The insight stage ensured that these interface points have been analysed to check that the necessary elements for future connections are spatially and electrically viable.

As illustrated in Figure 30, some SSEP zones may have more than one potential interface point (or no viable interface points). The design will appraise each alternative option against the assessment criteria to determine optimal connection locations in each SSEP zone, which may be one or more of the available interface points.

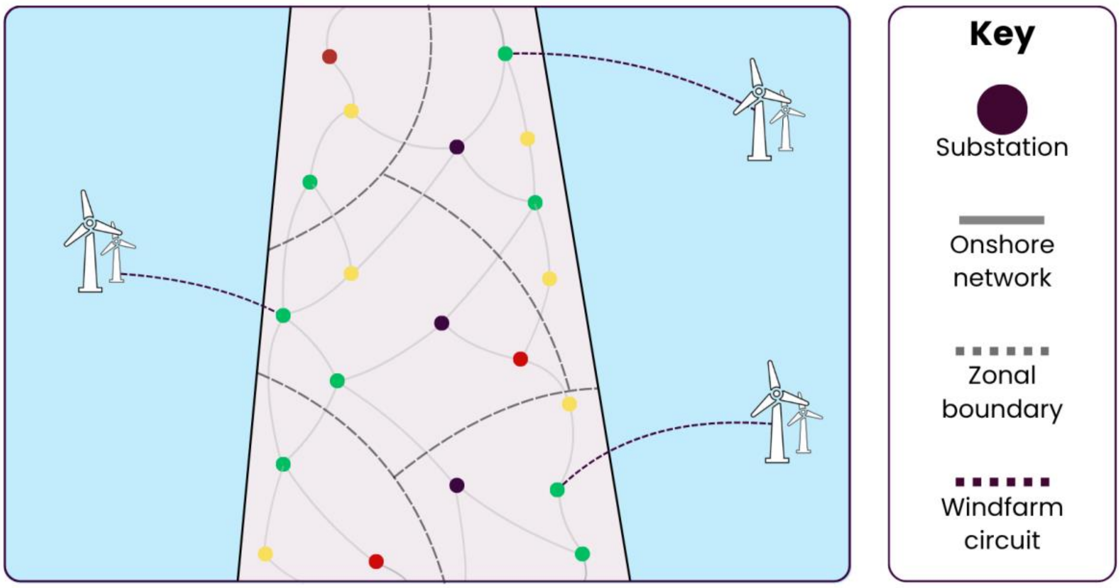


Figure 30: Example of how multiple interface points may be suitable per SSEP zone

The indicate stage will also consider the electrical characteristics at the individual connection and wider transmission levels. This will ensure that both the localised impact of the connection and wider resultant flows of the electricity can be represented within the subsequent system requirements analysis.

This will allow for the process to account for an indicative set of enabling works that may be necessary to connect new capacity to the system and for these to be co-optimised with the development of the wider network. Due to the size of offshore connections, this approach has the potential to drive significant efficiencies in the develop step.

Opportunities for electrical coordination such as offshore hybrid assets will be explored during the indicate stage. However, these will not form part of the set of indicative designs at this stage as more analysis is required to assess all electrical coordination possibilities. This level of detailed offshore design will follow in the design stage.

Design

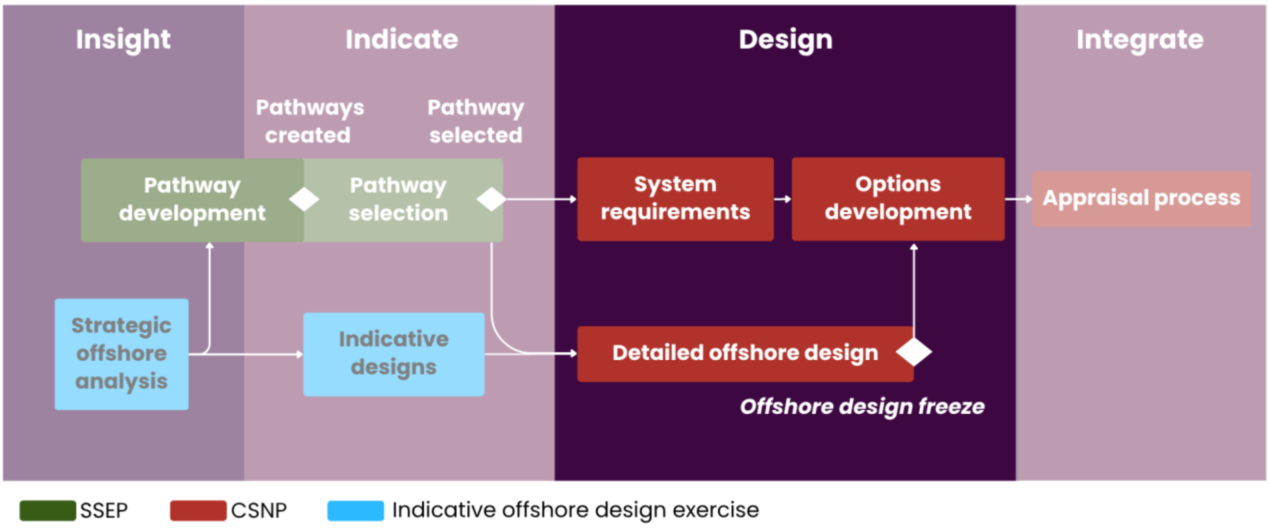


Figure 31: Process map highlighting the design stage

Ahead of the CSNP, the UK Energy Secretary will select the final SSEP pathway. This final pathway will be the basis of the analysis undertaken within the CSNP. The indicative offshore design developed in the indicate stage, will now move into the design stage (highlighted in figure 31). This indicative design will form an integral component of the systems requirement assessment, as described in the identify chapter.

When the CSNP process begins, the indicative offshore design will be used as the starting point by us for further design development and exploration. This will consider and refine design options but the location and capacity of offshore generation will not be changed. This will occur alongside the identification of system requirements and development of network options. To help identify additional opportunities, the indicative design for the final SSEP pathway will be published no later than the publication of the system requirements. Transmission Owners and third parties will then be asked to provide feedback or alternative design proposals which can be considered within the design stage.

By inviting third-party feedback early in the offshore network design process, we will foster a transparent, collaborative, and forward-thinking approach. By engaging stakeholders at the outset, we aim to incorporate diverse perspectives and insights into the design stage before key decisions are made. This early engagement enables us to identify and address potential concerns proactively, reducing the likelihood of change requests later in the development cycle. It also supports the creation of a more strategic and resilient long-term pipeline of network infrastructure that aligns with stakeholder expectations and environmental considerations.

Our design approach builds on the lessons learnt from Offshore Leasing Round five, in the Celtic Sea, where a coordinated offshore network design was developed ahead of the final seabed leasing decision. This was the first time that developers were able to move through the leasing round with an understanding of how new wind farms would be connected to the transmission network (see here for more detail). This demonstrated the value of early design in enabling more integrated, efficient, and adaptable solutions. By applying and evolving that model in the Celtic Sea, we are setting a new standard for how offshore transmission planning can be done with transparency, innovation, and long-term system value at its core.

The design stage will occur in parallel to the identification of system requirements and development of onshore network options. This step is a period of additional design work where we will explore coordination between offshore assets. Coordination, as described earlier in this chapter, can take many forms and all viable opportunities will be explored as the offshore design is further refined within the design stage. Some examples of coordination are shown in figure 32 and include but are not limited to:

- changes to connection interface points
- project to project connections
- offshore links in combination with offshore connections
- combining assets to create offshore hybrid assets
- increasing levels of interconnectivity between windfarms and the transmission system – offshore meshing

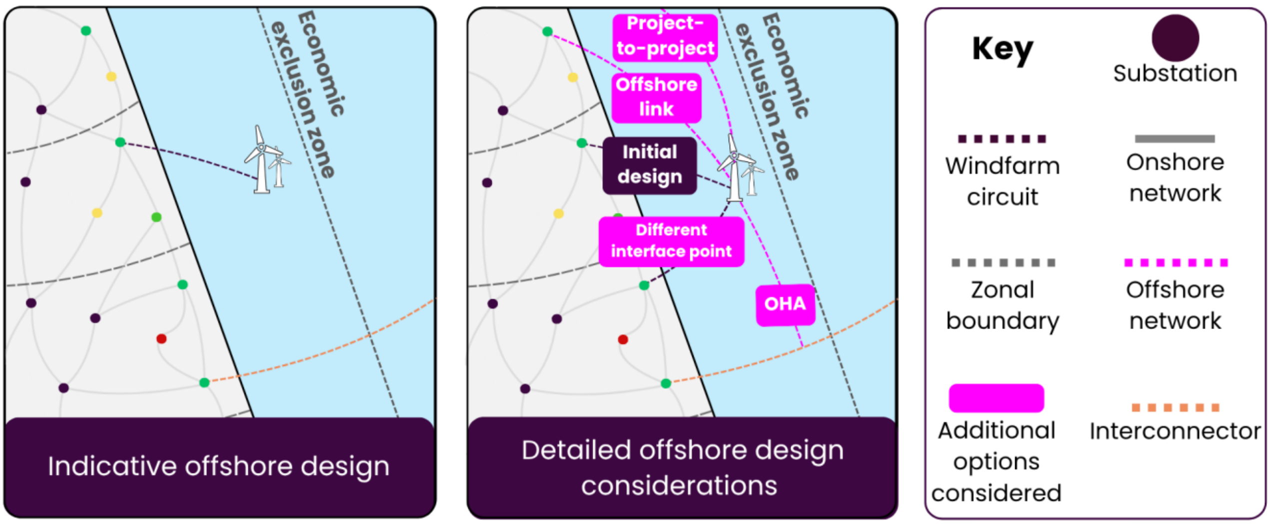


Figure 32: Diagram of the outputs of the indicative offshore design stage and how this will be expanded to explore electrical coordination in the detailed offshore design stage

Alongside the opportunities identified by us, the detailed offshore design process will consider third-party design options which provide sufficient information to compare their benefits to the indicative design. For example, NESO would need to consider whether an option is technically competent for it to be considered within an offshore design.

While the design stage will focus on exploring alternative offshore arrangements, amendments have the potential to significantly impact the onshore transmission network.

The nature of these impacts can vary widely and can be driven by spatial and electrical factors. This can include choice of potential cable routes, a selection of a transmission interface point, or from changing the wider flow of electricity through the transmission network. It is necessary to narrow down the offshore design to allow time for complementary onshore options to be fully developed. This requires the design stage to create a refined offshore design and a set of alternative offshore options which can be mutually assessed within the CSNP appraise step. To do this, the design stage must have a point when offshore options submissions are frozen.

Offshore submission freeze

The offshore submission freeze marks the point at which no further changes should be made to the detailed offshore network design. This includes alternative offshore topologies or arrangements which will be assessed as distinct options within the appraise step. During the develop step of the CSNP, the offshore design (and alternatives to it) are 'frozen' to establish a fixed set of offshore topologies and connection points which will require corresponding onshore studies. These onshore network options can be considered with the detailed offshore network design, and alternatives to it, within the appraise step. This freeze is essential to ensure that a comprehensive set of onshore analysis is available for developing long-term, strategic onshore reinforcement options.

In practice, this means that after the freeze, no new offshore network options should be proposed. However, transmission reinforcement options that involve independent offshore infrastructure can still be considered. This approach enables coordinated development of onshore and offshore options, supporting both the delivery of wider onshore network needs and allowing input from Transmission Owners and third parties into the offshore design.

The freeze is necessary to manage the complexity of developing strategic onshore reinforcements, which must account for the broader electrical impacts of the highly meshed onshore network. To do this effectively, a fixed set of potential onshore/offshore interface points is required, ensuring that a comprehensive and complementary set of onshore options can be developed.

Integrate

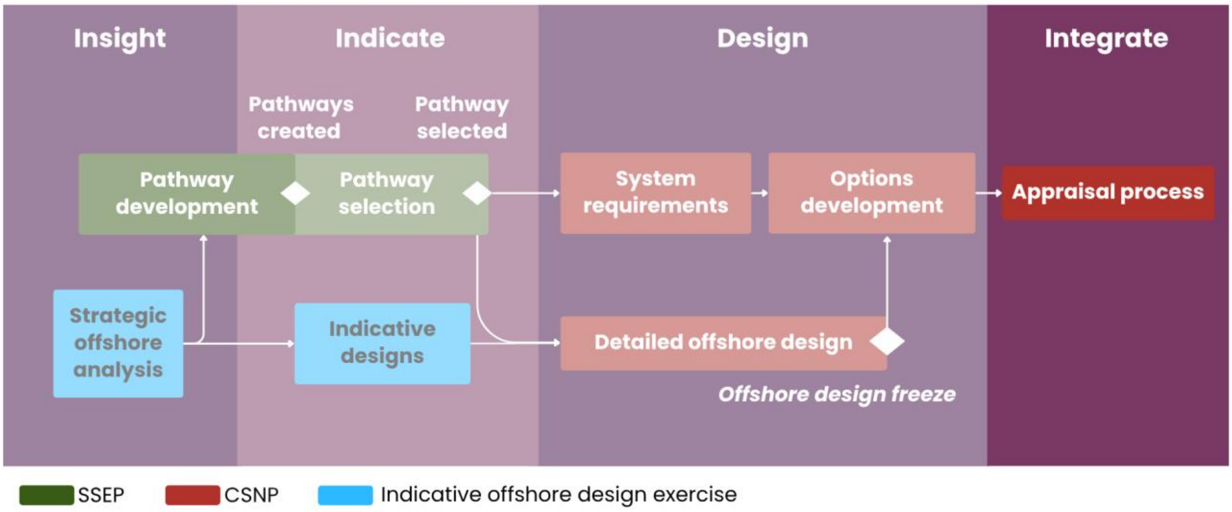


Figure 33: Process map highlighting the integrate stage

At the integrate stage, all detailed offshore design proposals will have been finalised. This step, highlighted in figure 33, will explain how these proposals are integrated into the appraise step following the offshore submission freeze.

As previously explained, the offshore submission freeze provides a stable basis for assessing alternative onshore and offshore options. While a preferred offshore design will be taken forwards at the beginning of this process, it will not be finalised until it has been robustly tested alongside and against the onshore and offshore options which are taken through to the appraise step.

This will be the first time that variations to offshore designs can be appraised alongside onshore options. The CSNP is able to do this by taking the longer term, strategic view as described earlier. This allows for the development of more incremental approaches to both the onshore and offshore networks.

Figure 34 below shows a way in which the preferred offshore design can work with incremental changes within the CSNP. The second pane shows a situation in which a new transmission circuit can be developed from the offshore interface point, whereas the third shows a case in which the offshore landing point can be varied to achieve the same result.

By taking this approach of considering alternative options which can achieve similar benefits, the CSNP appraisal process will identify the best-performing combination of onshore and offshore options based on all the assessment criteria.

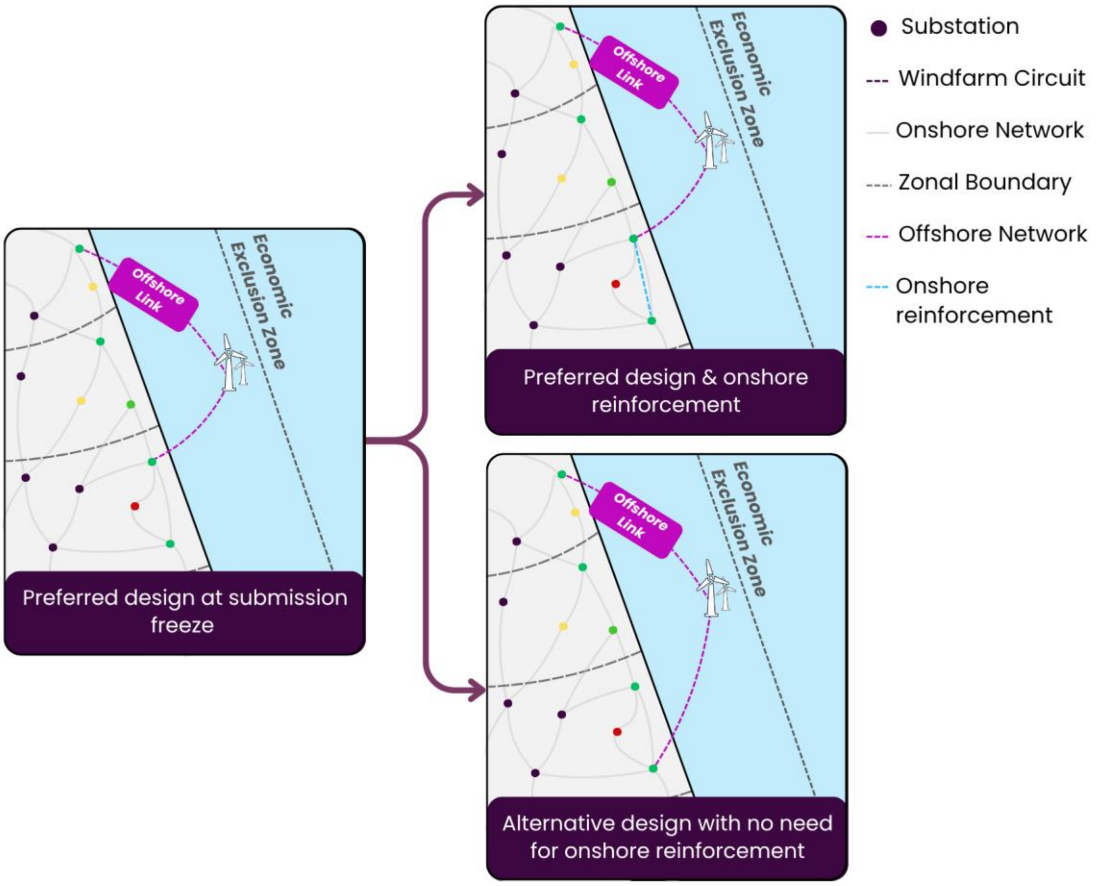


Figure 34: Preferred offshore design and alternative reinforcement pathways

Question: Would it be helpful to see the indicative offshore design before the system requirements publication?

Question: Do you have any additional comments regarding the offshore design process?

5. Identify (Electricity)

Overview

Key messages

- The CSNP will identify electricity network requirements out to 2050 to support a strategic approach to network planning and the development of reinforcement options.
- Alongside boundaries, additional analysis will be undertaken to provide insight at a circuit-level and consider a wide range of system conditions.
- The CSNP for electricity will also identify residual stability and voltage needs to ensure the safe, reliable operation of the electricity network.

System requirements

The electricity transmission network will require significant investment to ensure continued access to reliable, clean and affordable electricity. This step will identify where additional network capability may be needed in the future to facilitate the SSEP pathway, FES and different resilience scenarios. This will inform the development of reinforcement options through to 2050.

We will also identify residual network operability requirements annually, including stability and voltage needs. Residual requirements remain following the assessment of bulk power flows and are important to identify annually due to their dependence on changing system conditions. An overview of the scope of system requirements in the CSNP is shown in Figure 35.

Bulk power flows

The concept of boundaries, which can consider thermal circuit rating, voltage constraints and dynamic stability, will be used to identify future network capability and requirements every three-years. This will be supported by additional insight from circuit-level, year-round thermal loading analysis.

Residual stability

Stability is the ability of the system to maintain and return to stable operation following disturbance. The CSNP will analyse inertia and system strength needs annually.

Residual voltage

Voltage must be kept within set limits to maintain safe and efficient operation. The CSNP will identify high and low voltage needs on an annual basis.

Figure 35: Scope of system requirements

Boundaries

Overview

The transmission network allows electricity to get from areas where it is generated to where it is used. Boundaries split the transmission system into multiple parts, crossing critical circuits that carry power between areas where power flow limitations may occur. NESO will use the concept of boundaries to publish future network requirements for different energy pathways, including the SSEP pathway, FES and different resilience scenarios. These requirements will help inform the development of reinforcement options. NESO and Transmission Owners will then undertake power system analysis to determine future boundary capabilities.

The boundary capability is the maximum power flow that can be securely transferred across the boundary while maintaining compliance with the SQSS. Limiting factors on capability can include:

- thermal circuit rating
- voltage constraints
- dynamic stability

Boundaries are useful for showing network capability and long-term power flow requirements. They have developed over many years of operating and planning the transmission system and enable requirements between different energy pathways to be compared to previous publications, such as the Electricity Ten Year Statement.

Two types of boundaries will be used in the CSNP:

- **Local boundaries** – encompass small areas of the network containing a high concentration of generation. These power export areas can present a high probability of overloading the local transmission network.
- **Wider boundaries** – split the network into large areas containing significant amounts of generation and demand. The SQSS required transfers for these boundaries will be determined by the economy criterion and security criterion set out in the SQSS.

When significant changes occur, new boundaries may be defined and some either removed or amended. Any changes will be considered through relevant engagement.

Analysis

Network requirements will be determined from a regional allocation of generation and demand according to the SQSS planning criteria and our economic modelling tool. The economic modelling tool will prioritise the cheapest available generation to minimise operating costs. It will utilise demand data, weather profiles, and representation of the European markets to determine interconnector flows.

Through the develop step, NESO and Transmission Owners will undertake power system analysis on network models to determine future boundary capabilities. The analysis will be carried out on the SSEP pathway at winter peak demand to stress the transmission system to its capacity. The analysis will extend from 2030 and consider reinforcements already in the delivery pipeline in the background.

An off-peak analysis will also be conducted to capture different system conditions from winter peak demand. This analysis will inform the scaling of boundary capabilities across the year. Additional sensitivities representing wider system conditions, such as interconnector flows, generation patterns or time of the year that may cause critical changes in boundary capability, may be assessed separately.

Where there are no significant changes in generation and demand, some boundaries may not be studied, and the same capability as previous analysis will be assumed.

Publication

For each boundary and different energy pathways, a chart and accompanying data will be published showing:

- SQSS required transfers
- annual unconstrained power flows
- future boundary capabilities

The charts, as illustrated in Figure 36 will indicate where the expected future needs could be in comparison with expected power flows and future boundary capabilities. Each chart will indicate the confidence of power flows across each boundary by showing areas reflecting 50%, between the 25th and 75th percentile, and 90%, bound by the 5th and 95th percentile, of the expected annual power flows. For example, the 95th percentile reflects that 95% of annual power flows across the boundary are lower than this level. The horizon covered by the charts will extend to 2050.

To enable the timely development of reinforcement options, the published charts will initially use boundary capabilities from NESO's latest network plan to reflect where additional reinforcement may be required. These will be updated after the boundary analysis to reflect the new reinforcements following the appraise step.

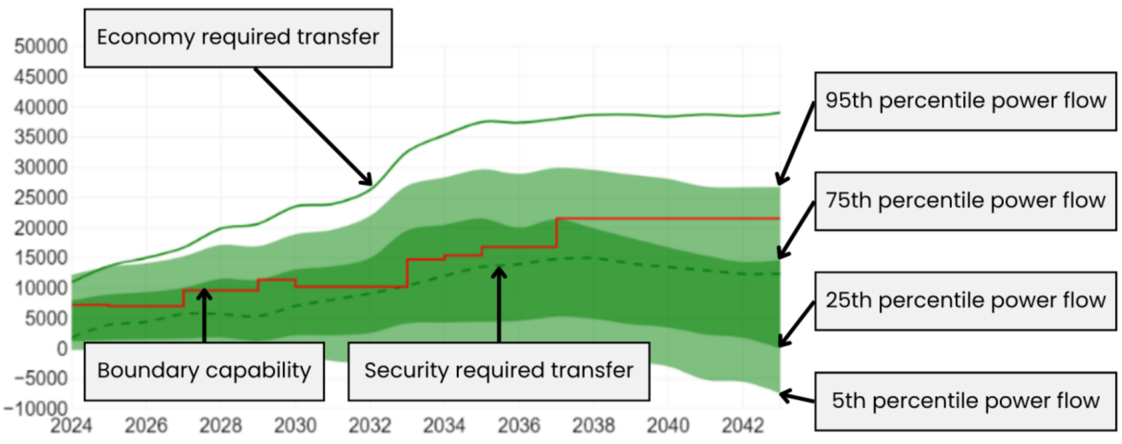


Figure 36: Example boundary charts

Through the develop step, multiple reinforcements must be identified, that when combined, at a minimum, satisfy the greater of either the SQSS required transfer levels or the 95th percentile of annual power flows. This will ensure a breadth of reinforcement options are identified. A summary heatmap, as in Figure 37, will also be provided. This will indicate which boundaries require additional capability. Reinforcement options will be evaluated through the appraise step to determine an efficient, co-ordinated and economical level of reinforcement.

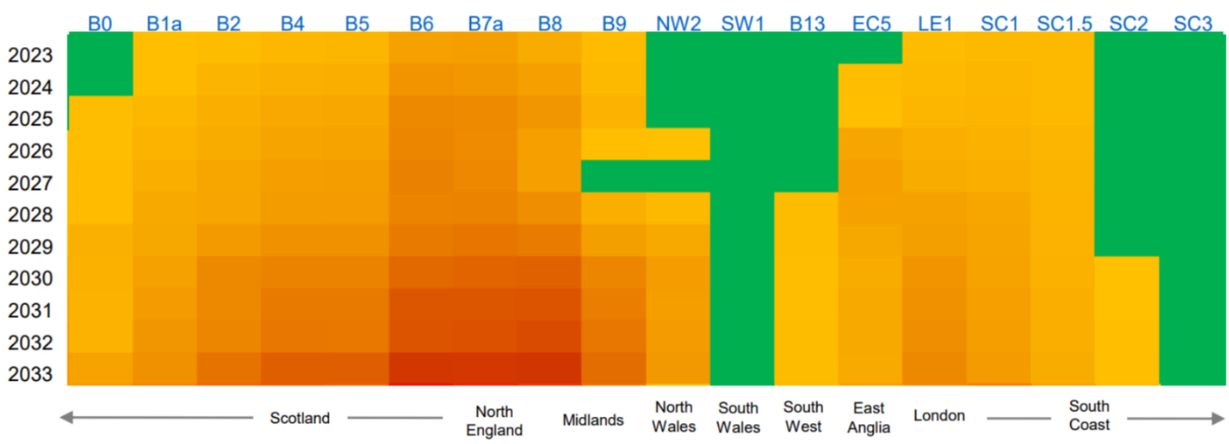


Figure 37: Example heatmap of capability deficit

Thermal analysis

Overview

Alongside boundary analysis, NESO will also conduct year-round thermal loading analysis using the SSEP pathway. This will provide insight on thermal overloads at a circuit-level and consider a wide range of system conditions. This innovative analysis will provide additional insight ahead of the develop step to support more targeted reinforcement options and opportunities for commercial solutions.

While the boundary concept is a useful representation of network requirements and capability, it cannot fully reflect the variation in capability that might arise under different system conditions across the year. Additional thermal analysis at a circuit-level, rather than at boundaries, and across the year will provide insight on which individual circuits and assets experience thermal overloads, driven by credible conditions that may not be considered through the boundary analysis.

Analysis

The thermal analysis will be conducted on network models with year-round dispatch of generation and demand applied from our economic modelling tool. Unlike the winter peak boundary analysis, which doesn't consider planned network outages, the year-round analysis can include these outages to understand potential impacts on the transmission network.

To capture the variations in system conditions throughout the year, each year will be divided into time blocks of a minimum of three-hours. The network conditions for each time block will be analysed considering varying demand, generation, secured faults and anticipated outages. At a three-hour time block duration, each year would be split into, and analysed across, 2920 individual blocks. From analysing the data from all the time blocks, the magnitude and frequency of individual circuit and asset overloads will be identified to inform an overload severity index for each year studied.

As well as providing insight on individual circuits and assets, the analysis will provide more understanding of boundary capabilities. By studying a wide range of network conditions, the analysis will indicate a credible range of boundary capabilities across the year. For each time block analysed, and by considering whether individual circuits and assets are overloaded, the study can define the boundary transfer state as either overloaded or not overloaded. This may be used to inform additional sensitivity analysis for boundary capabilities.

Publication

For each boundary, charts such as Figure 38, will be published, showing transfers as either overloaded or not overloaded. This is an example of summarised data produced from modelling a full year's unconstrainted network operation and evaluating the network loading and boundary transfers.

Large periods of overloading indicate possible high constraints and the need for network reinforcement options. No overloading indicates where less reinforcement is needed. The vertical line between the overloaded and not overloaded areas is the boundary capability. There may be an overlap between the overloaded and not overloaded states, which indicates that the boundary capability is variable over this range. In the example shown, the boundary capability could range between the start of the overloaded area (near 5 GW) and the end of the not overloaded area (near 7 GW).

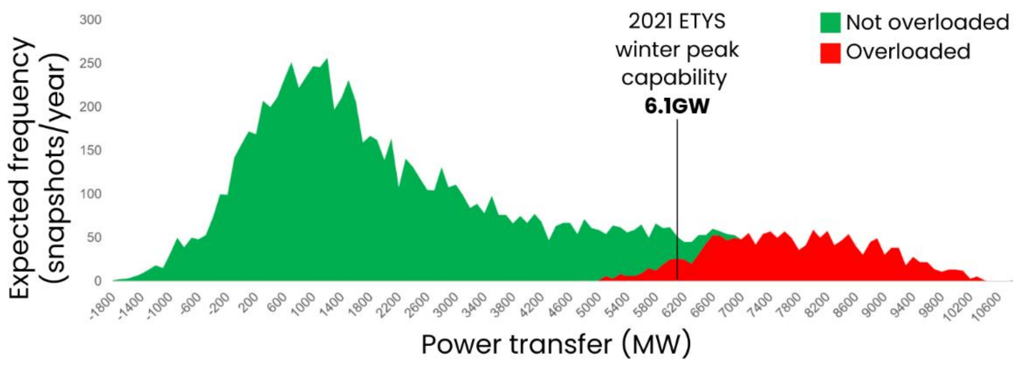
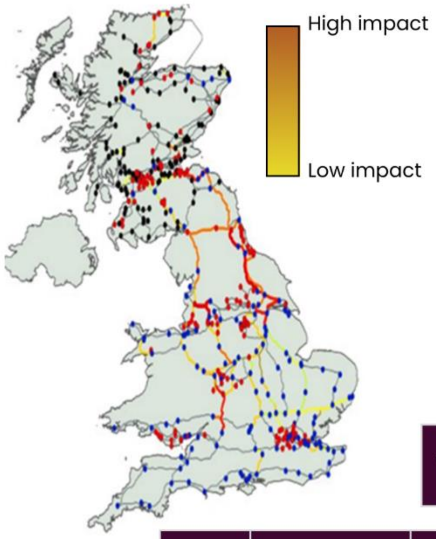


Figure 38: Example boundary transfer chart

Figure 39 is an example of how network modelling at an individual circuit and asset level may be presented. Alongside a geographical representation of the network, data will be provided on:

- overload frequency
- overload magnitude
- corresponding network conditions

This will highlight the circuits and assets that may have the highest impact on future network operation across the year.



Year ▼	Season ▼	Level ▼

Asset name	Frequency (%)	Avg. magnitude (%)	Critical cont.	Avg. wind (%)	Avg. solar (%)	Avg. thermal (%)	Avg. hydro (%)	Avg. inte. (%)

Figure 39: Example presentation of thermal analysis

Residual stability

Overview

NESO will conduct residual stability analysis on an annual basis to ensure the safe, reliable operation of the electricity network. This will include inertia and system strength studies which are described below.

We will collaborate with Transmission Owners ahead of analysis to establish guidelines and required inputs on network models. We will welcome any independent analysis conducted by Transmission Owners. Where we choose to meet any residual requirements through a Network Services' tender, requirements will be shared with Transmission Owners and third parties concurrently to allow all interested parties to develop and propose solutions.

Inertia

Inertia is the sum of the kinetic energy stored in the rotating parts of synchronous machines, and some industrial motors, connected to the system as well as similar energy provided by grid-forming (GFM) inverter-based resources (IBR). In the case of system frequency changes, like a disturbance caused by a generator or demand tripping, this stored energy can temporarily reduce the rate of change of frequency (RoCoF) helping to maintain frequency stability.

With the increasing displacement of synchronous generators with IBRs, traditional sources of inertia are reducing. Alternative sources must be found to ensure the safe and secure operation of a clean power system.

The purpose of the inertia study is to assess available inertia in the future and to identify potential deficits in meeting minimum system inertia requirements.

System strength

System strength is the power system's ability to maintain stable voltage in response to system disturbances. At NESO, system strength needs are categorised in the context of minimum short circuit level (SCL). SCL is the amount of current that flows on the system during a fault. The faults can be caused by events such as a lightning strike, adverse weather conditions or equipment failure. High levels of SCL help maintain system voltage stability and enable quicker recovery from disturbances. In a weak system, characterised by low system strength, a small injection of current typically brings about a large change in voltage. In a strong system, characterised by high system strength, a small injection of current typically causes a small change in voltage.

SCL in the network varies throughout the year depending on generation and demand. In winter, more generators and synchronous plants are running to meet the high levels of demand. In summer, less generators and synchronous plants are running due to the low levels of demand. SCL in the network typically reaches a peak value during winter and a minimum value during summer.

Peak and minimum SCLs have different implications for power system operation. Upper thresholds for peak SCL values are subject to the ratings of power system protection equipment and the maximum fault current they can withstand. Other power system parameters, such as ratings for mechanical loading of busbar systems, also depend on upper thresholds for peak SCL values. Lower thresholds for minimum SCL are important for transient voltage stability in the power system.

In general, SCL in the network has been decreasing due to the shift from synchronous plants to inverter-based renewable sources, like wind and solar, which produce lower fault currents compared to synchronous machines. This decrease is more prominent during system minimum conditions when low levels of synchronous plants are running. Synchronous machines are generally more expensive to run, so they are used only when demand is high, or they need to run to satisfy operational constraints in the system.

The focus of the system strength study as part of the stability analysis is on a system minimum SCL condition only, usually seen during the summer.

Phased locked loop stability

Most IBRs connected to the system today were designed using grid following (GFL) technology meaning that they need a strong system for stable operation. GFL plants rely on phase locked loop (PLL) controllers to track system voltage to remain synchronised to the system and maintain stable operation.

With low levels of system strength, network voltage waveforms are more volatile during a network disturbance which increases the risk for PLL to lose track of system voltage waveform and phase, leading to desynchronisation or instability. Newer IBR converter designs with GFM technology behave similarly to a synchronous machine and do not rely on PLL to remain synchronised to the system. As a result, GFM plants can work in a weaker system without PLL restrictions. This can provide SCL and inertia support to the system during times of need with suitable design and control strategy.

The purpose of the system strength study under PLL stability is to identify potential deficits in meeting future minimum SCL needs in different regions of the network. In doing so, consideration is given to potential support available from new IBR connections that conform with the more recent GFM technology.

Transient voltage stability

Another important measure of system strength is based on the transient voltage performance of the system during and immediately after a fault or a disturbance. The fault ride through (FRT) capability of equipment, such as a generator, is the ability of the plant to stay connected to the power system during and immediately after a power system disturbance, such as after a transmission circuit fault. For a weak network, there are more risks that power system parameters might fall outside the minimum standards set out in the SQSS and the Grid Code during faults and/or after fault clearance. This in turn might cause the connected generators, such as IBRs, to either disconnect from the system or experience oscillations in their outputs.

The purpose of the system strength study for transient voltage stability is to identify potential risks associated with disconnection of generators from the network during faults and/or after fault clearance. This may occur due to non-compliance of busbar transient voltage profiles, as specified in SQSS and Grid Code.

Analysis

The annual stability analysis will use the latest energy pathway and redispatch of generation and demand, considering network constraints, from our economic modelling tool. The phased locked loop and transient voltage stability analysis will be conducted using the latest network model.

Inertia

The inertia analysis will identify the total available system inertia in the future, including contributions from:

- synchronous generators
- grid forming plants
- procured stability services
- approximations from demand

The available system inertia will then be compared against system inertia thresholds to compute the deficit on an hourly basis across the year, using the following equation:

Inertia requirement = system inertia threshold − total available inertia

In the equation, the system inertia threshold is the minimum inertia the system needs to hold to cover the largest loss of generation or demand and maintain the RoCoF within operational limits. The threshold used in assessments for future years will be in accordance with the Frequency Risk and Control Report and Operability Strategy Report guidance.

System strength

Phased locked loop stability

At NESO, PLL stability is currently investigated using the short circuit ratio (SCR) index. The aim is to maintain a minimum SCR in different regions of the network to ensure acceptable system strength levels during minimum SCL conditions.

The SCR is the ratio of the SCL, or system strength, at a transmission substation to the rated capacities of the grid-following IBRs connected to that substation. SCR values will be calculated at a nodal-level and assuming intact network conditions. The resultant values will be compared against pre-set thresholds to identify worst-case minimum SCL needs in the future.

Minimum SCL requirements will be derived by checking the gap between the calculated SCR values against pre-set minimum SCR thresholds required for maintaining minimum system strength. Additional SCL sources will be incrementally inserted into the network model to work out the least SCL requirement needed to cover the SCR gap.

Transient voltage stability

Transient voltage stability studies will be carried out at summer minimum to test a credible worst-case system condition and identify potential transient voltage stability support requirements in the future network. A contingency analysis will be conducted to study several critical circuit faults, with simulations performed in the root mean square (RMS) domain. The results will be recorded and compared against Grid Code definitions of FRT obligations.

To identify requirements for transient voltage stability, we will monitor and review voltage profiles at relevant transmission busbars against FRT obligations. These profiles will come from RMS simulations with critical contingencies. If any issues are identified, we will propose and test strategies in the RMS simulation to ensure compliant FRT performance.

Publication

The inertia and system strength needs identified through the stability analysis will be published. Peak inertia requirements in the future will be graphically presented as exampled in Figure 40.

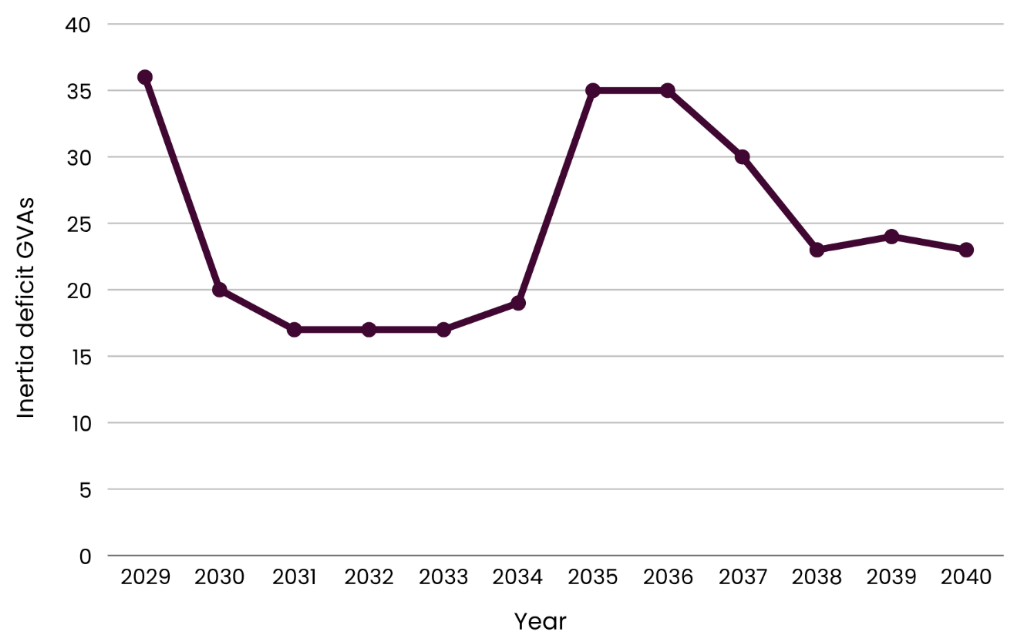


Figure 40: Example peak inertia requirements in future years

Future system strength needs will be graphically presented using regional heatmaps, as shown in Figure 41, ahead of any Network Services' tenders. These regions have been formed by existing system boundaries and system operability issues.

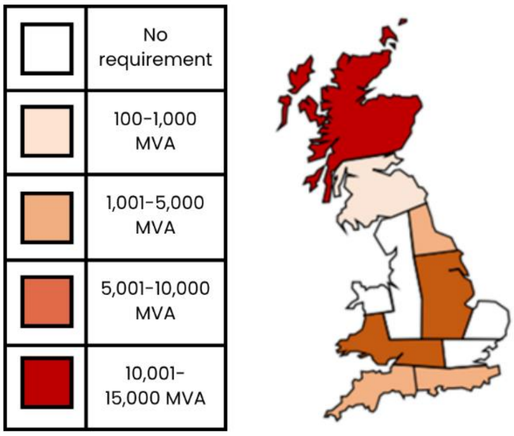


Figure 41: Example heatmap of SCL requirements

Residual voltage

Overview

Using the latest energy pathway, NESO will conduct annual voltage analysis to identify reactive power requirements. These requirements may be met through Network Services' tenders to manage identified high and low voltage issues in the future. NESO and Transmission Owners are responsible for managing voltage levels across the transmission system. To comply with the SQSS, voltage must be kept within set limits across the transmission system to ensure safe and efficient operation.

We will collaborate with Transmission Owners to establish analysis guidelines and required inputs to network models. We will welcome any insights from independent analysis conducted by Transmission Owners. Any residual requirements that NESO choose to meet through a Network Services' tender will be shared concurrently with Transmission Owners and third parties.

Generally, voltage levels are related to reactive power injecting to and absorbing from the system. Absorbing (consuming) reactive power helps lower the voltage, while injecting (providing) reactive power helps raise the voltage. Voltage management can be broadly categorised into low voltage and high voltage control under various system conditions.

During summer minimum conditions, voltages are raised due to less reactive power consumption and reduced power flows across the network due to low demand. During winter peak conditions, voltages are usually lower due to higher reactive power consumption and increased power flows across the network for high demand.

Analysis

The voltage analysis will be conducted using the latest network model under various system conditions to assess power flows and voltage levels. An intact network will be used, except for equipment agreed to be in long-term outages. All reactive providers will have their reactive range scaled down based on an agreed factor from their original capacity to account for any planned short-term outages. The reactive capabilities from HVDC converter stations are considered in the background to support voltage control based on assets availabilities and system conditions.

High voltage

High voltage analysis focuses on studying the requirements for reactive power absorption. This analysis will identify potential high voltage issues in the system and determine the necessary reactive power absorption compensations for the identified issues.

Different system conditions will be set up for high voltage analysis based on generation and demand during summer minimum conditions. This includes sensitivities reflecting different generation mixes, running patterns, interconnector flows, and network power flows in the system.

The high voltage analysis will include both pre-fault and post-fault (contingency) assessments. The contingency analysis will evaluate system voltages under credible fault conditions, with contingency faults defined in SQSS. The total reactive power needed to address high voltage excursions will include both pre-fault and post-fault requirements.

The pre-fault requirement refers to the reactive power absorption compensation needed to reduce voltage to the pre-fault voltage limit set by SQSS before any secured fault event occurs. This is achieved by connecting additional reactive power absorption compensation at transmission substations to bring voltage excursions back within SQSS limits. The total pre-fault requirements are determined by combining these additional compensations through an iterative process to resolve all voltage issues in the network.

The post-fault requirement refers to the reactive power compensation needed to bring voltage down to the post-fault voltage limit set by SQSS following a secured fault. With pre-fault compensation already in place, the post-fault requirements are derived by connecting extra reactive compensation to the network to bring voltages back within SQSS limits. This process is applied to each contingency to calculate the minimum total reactive power absorption volumes (in MVAr) necessary to ensure network compliance for all secured events.

Voltage step change analysis will be conducted to determine if the newly added compensation can exacerbate any existing voltage step issues or create new excursions.

When the pre-fault and post-fault requirements are derived, the corresponding reactive power compensation for each area of network will be added into the model. An overall analysis will adjust the final volumes of requirements and determine the type of compensation needed. This will consider any voltage step change issues and any interacting reactive power requirements identified through low voltage analysis.

Low voltage

Low voltage analysis focuses on requirements for reactive power injection. In GB, the winter peak demand combined with a windy condition is a suitable system condition to test for low voltage issues. These conditions are challenging but credible. This is a similar set of conditions as defined for network planning in the SQSS and used for boundary analysis.

The power flow conditions used for the analysis will be set to levels that are close to their known capability limits across the network. Boundary power flows will not exceed their capability limits as this would not represent a credible state. Additional sensitivity studies may be conducted to ensure all areas of the transmission network are studied at their local capability limits. This process will utilise a similar approach to the scaling of generation and demand used to determine boundary capabilities.

The low voltage studies will be conducted in a similar manner to the high voltage studies. The analysis will identify pre-fault and post-fault requirements in line with the SQSS limits and securable fault events. Voltage step change will also be checked.

Publication

The regional reactive power requirements will be presented on a geographic heatmap, as shown in Figure 42, ahead of any Network Services' tenders.

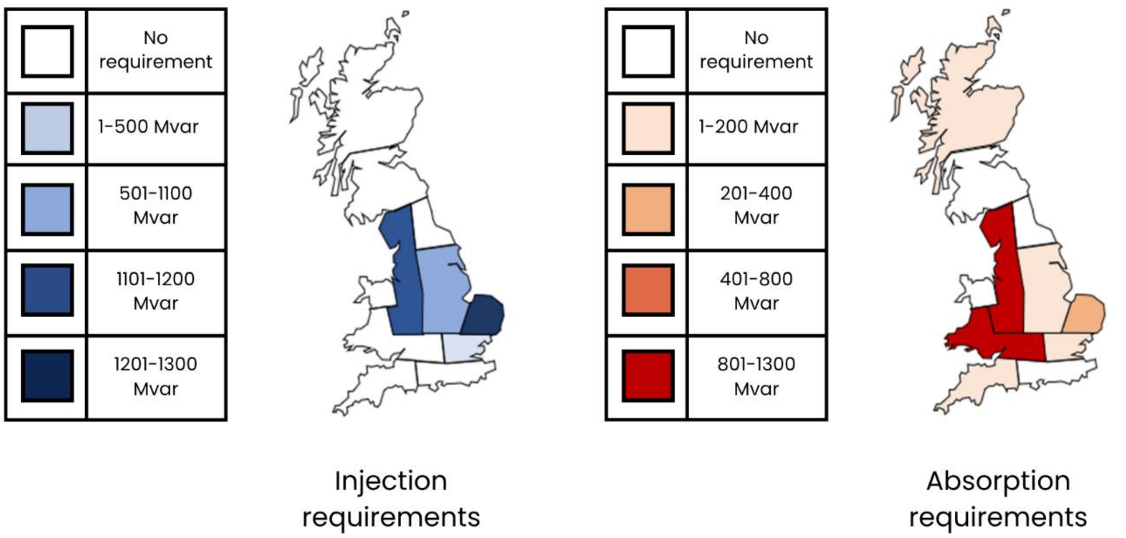


Figure 42: Example heatmap of reactive power requirements

Analysis framework

Interactions

Reinforcement options will be identified to satisfy boundary requirements, including if capability is limited by voltage constraints or dynamic stability. This will be supported with additional insight from the circuit-level, year-round thermal analysis. It is important that operability requirements, such as reactive compensation, are factored into reinforcement options and that these consider the impact on future operations as well as relevant standards, such as the SQSS.

The annual residual stability and voltage analysis will then identify any remaining requirements or those driven by changing system conditions as well as needs that do not interact with bulk power flows. Identified needs may be resolved through Network Services' tenders. This is subject to the context of the requirements and Network Services being the most appropriate route to resolving the need. In some circumstances, solutions to residual needs, particularly for low voltage, may overlap with boundaries. Amongst other factors and ahead of resolving requirements through Network Services, NESO will:

- Seek to progress low voltage needs through the develop step of the CSNP, where appropriate.
- Prioritise potential opportunities to resolve multiple needs concurrently through Network Services.
- Evaluate the longevity and timing of any need as well as engagement with Transmission Owners regarding the local planning of their networks.
- Identify potentially interacting reinforcement options that are part of the develop step.
- Consider counterfactual solutions from Transmission Owner within Network Services.

Network services

Network Services provides new opportunities for industry to offer solutions to meet system requirements, including for thermal, stability and voltage needs. More information on the stability and voltage markets outlined in Table 6 are available in the Markets Roadmap. Through these markets, NESO will seek to widen market access, enhance competition, bring costs down and where possible, facilitate the stacking of services to resolve concurrent issues.

Table 6: Stability and voltage markets

Network Services	Description
Long-term (Y-4) stability and voltage markets	The long-term stability and voltage markets will procure services with a lead time of up to four years from contract award and offer contract lengths in the region of ten years.
Mid-term (Y-1) voltage and stability markets	The mid-term markets will procure services with a lead time of up to one year from contract award with contract lengths of up to one year.

Transmission owners

NESO and Transmission Owners will both undertake analysis to determine future boundary capabilities. When conducting residual stability and voltage analysis, NESO will collaborate with Transmission Owners, as illustrated in Figure 43.

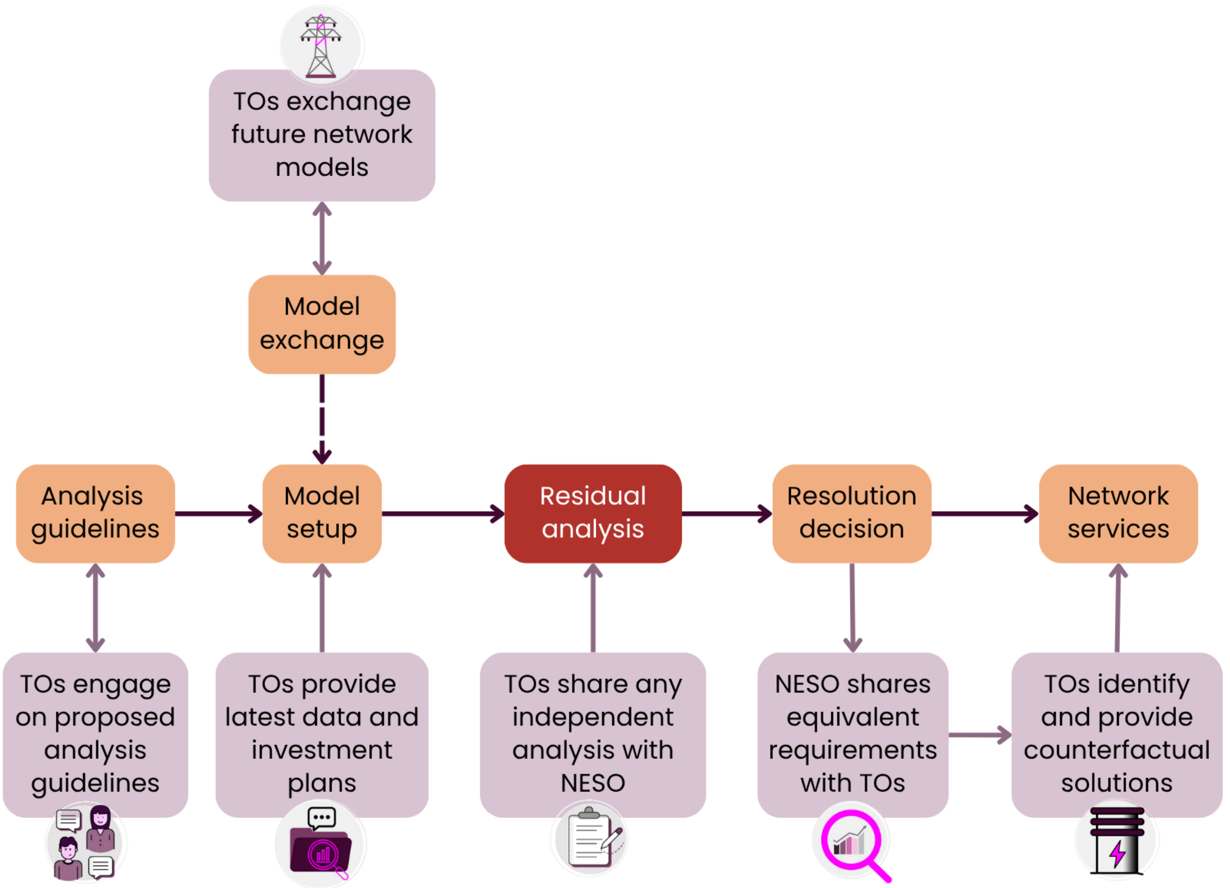


Figure 43: Residual analysis process

Model exchange

NESO and Transmission Owners will exchange annual network models to enable the detailed power systems analysis under the CSNP. These network models will facilitate the complex studies required to identify residual requirements, including stability and voltage needs. NESO will work with Transmission Owners to establish a new model exchange process whilst ensuring the needs of wider model dependencies.

The identify step will use the latest network models available. A new model exchange will then facilitate the develop step and the undertaking of power system analysis to determine future boundary capabilities. For residual needs, detailed power system analysis will be conducted within a ten-year horizon. For boundary and thermal studies, boundary charts will be published out to 2050, but analysis will be conducted on network models within a 15-year horizon. Where analysis is conducted for long-term reinforcement options, future dispatch data will be applied to the latest network models.

Future trends

Beyond the horizon of detailed power system analysis, the CSNP will also indicate long-term system insights and future trends to suggest how the anticipated energy mix may influence the future system. This will support the earlier indication of any needs and potential future challenges. Trends will be established from analysis and engineering insight applied across different energy pathways to evaluate potential impacts on network flows, stability and voltage.

Question: Do you agree with the scope of analysis under the identify step?

Question: Do you have any feedback to improve the presentation of system requirements, as shown in this chapter?

6. Develop (Electricity)

Overview

Licensed parties

Third parties

Required information

Overview

Key messages

- For electricity, the CSNP will consider a range of options, including network management options, upgrades to the existing network and new circuits.
- Different technology types and strategic designs will be considered early in the network planning process to enable a robust assessment.
- We will establish a structured framework to support the development of reinforcement options proposed by third parties.

Context

Where additional capability is needed across boundaries, a range of options need to be developed to ensure a robust assessment in the appraise step. Reinforcement options could include, but are not limited to, those listed in Figure 44 and new, innovative options. These could be identified and developed by NESO, Transmission Owners or third parties.

Transmission Owners have a duty to develop and maintain an efficient, co-ordinated and economical system of electricity transmission. Therefore, Transmission Owners are expected to provide most of the reinforcement options and must develop sufficient options to satisfy identified requirements.

Network management	Manage power flows on the existing network with innovative equipment, commercial solutions, or network reconfigurations.
Network upgrades	Improve the capability of the current network through replacing conductors or increasing the voltage of circuits.
New circuits	Provide significantly more boundary capability with new onshore or offshore circuits.

Figure 44: Potential reinforcement options

Third parties

A third party in this context is any organisation that has an interest in the development of the electricity transmission network. As these parties may have different capabilities and experience, we will establish a separate, structured framework to support the identification and development of reinforcement options proposed by them. This will ensure a range of reinforcement options are considered and compared to a variety of alternatives.

Licensed parties

Development outline

The develop step will ensure a consistent, robust and transparent approach to developing reinforcement options, considering different strategic parameters across Transmission Owners and NESO as outlined in Figure 45.

Figure 45: Approach to the develop step

Options definition

Following the identify step, Transmission Owners and NESO will develop a range of reinforcement options that provide additional capability across boundaries requiring reinforcement. Transmission Owners must develop multiple reinforcements, that when combined, at a minimum, satisfy the greater of either the SQSS required transfer levels or the 95th percentile of annual power flows. This will ensure a breadth of reinforcement options are identified.

Network management options and upgrades to the existing network should be considered ahead of identifying more significant reinforcement options, such as new circuits, to satisfy identified requirements.

A range of reinforcement options will be developed for each boundary. This should include those with different delivery timescales and providing different levels of additional capability. This will allow the appraise step to consider combinations of reinforcement options that, individually, may only partially meet requirements. In addition to new reinforcement options, options developed in previous plans, but not progressed into the delivery pipeline, will be reassessed where appropriate.

To support the development of new reinforcement options, NESO will collaborate with Transmission Owners and may suggest reinforcement concepts. This will utilise insights from our power system and economic modelling capabilities and our view across the assessment criteria.

To ensure co-ordination between Transmission Owners and NESO, a technical description of reinforcement options that are under development is expected to be shared regularly through the relevant CSNP governance forum. More information on the reinforcement options may be requested to allow NESO and Transmission Owners to:

- review reinforcement options under development
- ensure sufficient options to satisfy boundary requirements
- understand interactions between reinforcement options

Similarly, we will work with Transmission Owners to explore commercial options. These solutions use operational measures from commercial providers to increase the volume of power that can be securely transferred across a boundary. If recommended, these solutions would be progressed through Network Services.

NESO may also develop reinforcement options on behalf of third parties. The framework for facilitating options from third parties is detailed later in this chapter.

Ahead of the appraise step, it is important that parties consider relevant strategic parameters for each need, as listed in Table 7. For network management options or upgrades to the existing network, some parameters may be less relevant.

Table 7: Strategic parameters

Parameter	Description
Spatial envelope	The broad geographical area in which a reinforcement could be required.
Technology type	The potential type of reinforcement, such as High Voltage Alternating Current (HVAC) or High Voltage Direct Current (HVDC) as well as upgrades to the existing network.
Strategic design	The high-level design of a reinforcement, including whether it could be onshore or offshore, predominantly overhead or underground and any strategic mitigation.
Interface zones	The areas of the transmission system which a reinforcement could connect between.

When considering these parameters, parties should have regard to the Electricity Transmission Design Principles. The principles will provide greater clarity on the type of asset to be used in different environments. Identifying the strategic parameters upfront will enable resulting differences across the assessment criteria to be evaluated in the appraise step, particularly in terms of their impacts on capability, cost and interactivity with other reinforcement options.

The range of reinforcement options and the extent of strategic parameters identified will depend on the boundary, system requirements and potential additional drivers, such as customer connections or non-load related investments. When developing long-term reinforcements, the full extent of strategic parameters may still need to be considered.

As part of Connections Reform, new connection applications will be assessed through regular gated application windows. Through these, the relevant Transmission Owner will identify reinforcements required to facilitate new connections. These reinforcements may also provide additional boundary capability and therefore be considered in the CSNP. To ensure an efficient, co-ordinated and economical system, Transmission Owners should consider customer connections when developing wider reinforcement options. A range of reinforcement options and different strategic parameters should still be identified, while meeting relevant additional drivers and contracted connection dates. Where optionality is limited, context and justification should be provided to NESO. In advance of the first CSNP, most customer connections in the reformed queue will be connecting prior to 2035. Therefore, beyond this horizon, an extensive range of reinforcement options and strategic parameters are expected to be developed. The CSNP, driven by the SSEP, will then plan the wider network in anticipation of future customer connections.

Initial filtering

The different strategic parameters identified, especially potential interface zones, may generate multiple similar reinforcement options. Where this is the case, and to enable focus on the most viable options, Transmission Owners and NESO will apply an initial filter. This will ensure that only feasible options and those that have benefits over others progress to the appraise step.

The initial filter will be applied to discount any reinforcement options that are not feasible to deliver or operate. It may also be used to progress reinforcement options that provide comparable benefits over others. Reinforcement options are considered comparable if they are similar and may be progressed over other options if they:

- impact the same boundary or boundaries
- reinforce a similar part of the transmission network
- are clearly distinguishable across all the assessment criteria
- provide comparable benefits in terms of boundary capability, cost and delivery

If it is difficult to distinguish between reinforcement options or they are not considered comparable, these options should progress to the appraise step for further assessment.

To ensure consistency, the initial filter will consider the multiple assessment criteria and where relevant, sub-criteria. Table 8 provides an overview of relevant considerations.

Table 8 – Filtering considerations

Criteria	Considerations	Evidence
Economic	Comparable options will have most benefit if they have shorter circuit lengths and lower costs.	Evidence for economic filtering may include circuit length data and cost breakdowns.
Environment and community	Comparable options will be progressed that seek to minimise environment and community impacts.	NESO will establish a constraints list that will be used to undertake filtering through geographic information systems (GIS) modelling.
Deliverability and operability	The filter will ensure progressed options are considered feasible, either individually or in combination with others, to deliver and operate per relevant standards. Comparable options that meet additions drivers or provide wider system benefits may also be progressed over others.	Evidence may include substation data, relevant sub-criteria and standards, and regional boundary analysis.

Alongside the assessment criteria, relevant policy and principles are expected to be used to justify filtering. This will include the National Policy Statements and the National Planning Framework, as relevant across GB, and the Electricity Transmission Design Principles. This will ensure that any progressed reinforcement options align with relevant policy.

Any options that are not progressed will be transparently documented, including a technical description of the reinforcement option, justification for filtering and corresponding evidence. We will establish standardised documentation and templates to ensure the filter is applied consistently. NESO may request additional information or decide to progress filtered options if it sees benefit. Any reinforcement options progressed to the appraise step are expected to be developed in line with the required information outlined later in this chapter.

Third parties

Overview

A third party is defined in the CSNP as any organisation that has an interest in the development of the transmission network that is not a licensee. This definition comprises a range of stakeholder groups including:

- other parties in the energy industry
- research bodies
- community and societal interest
- environment
- land and marine

For more details on our stakeholder definitions and how we can engage with them please refer to our stakeholder appendix.

Third parties can engage with the network planning process through a wide range of opportunities. Figure 46 highlights these various touchpoints. This section will focus on reinforcement options. This will take place within the develop step of the wider process, with options being detailed in the option summary prior to the appraisal stage.

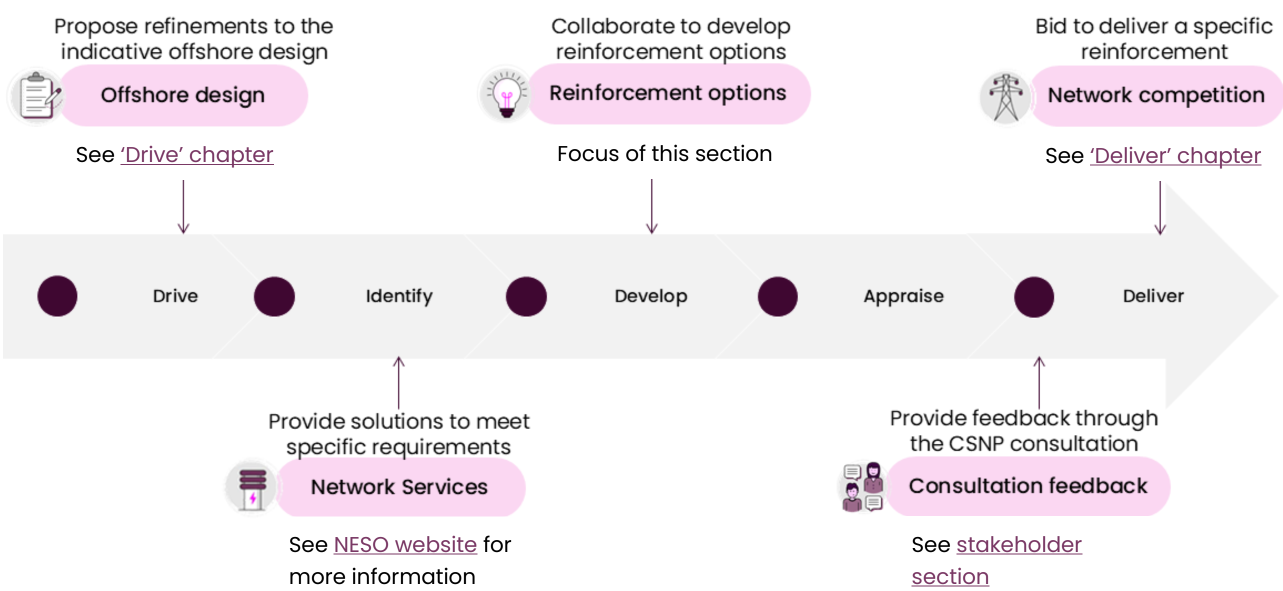


Figure 46: Key touchpoints for third parties

Storage technologies, such as pumped hydro power and batteries, will be considered in the SSEP. The SSEP will produce a pathway including an optimal regional capacity of these technologies built on their economic analysis.

Process

Figure 47 is a process map that shows how third parties can submit reinforcement options, how they will be considered by NESO, and where support would be offered. The process consists of three sections:

- **Option identification** – this is the initial stage of the process. It includes a window where parties can submit their options for consideration and a filtering process where suitable options are progressed for further development.
- **Development support** – this considers how reinforcement options that are viewed as sufficiently detailed and potentially beneficial can receive support to be fully developed for inclusion within the appraisal process.
- **Future cycle options** - this considers innovative reinforcement options which are unable to be progressed within the current cycle of the CSNP but are seen as bringing potential long-term benefit to the system and with further development could be seen to meet future needs.

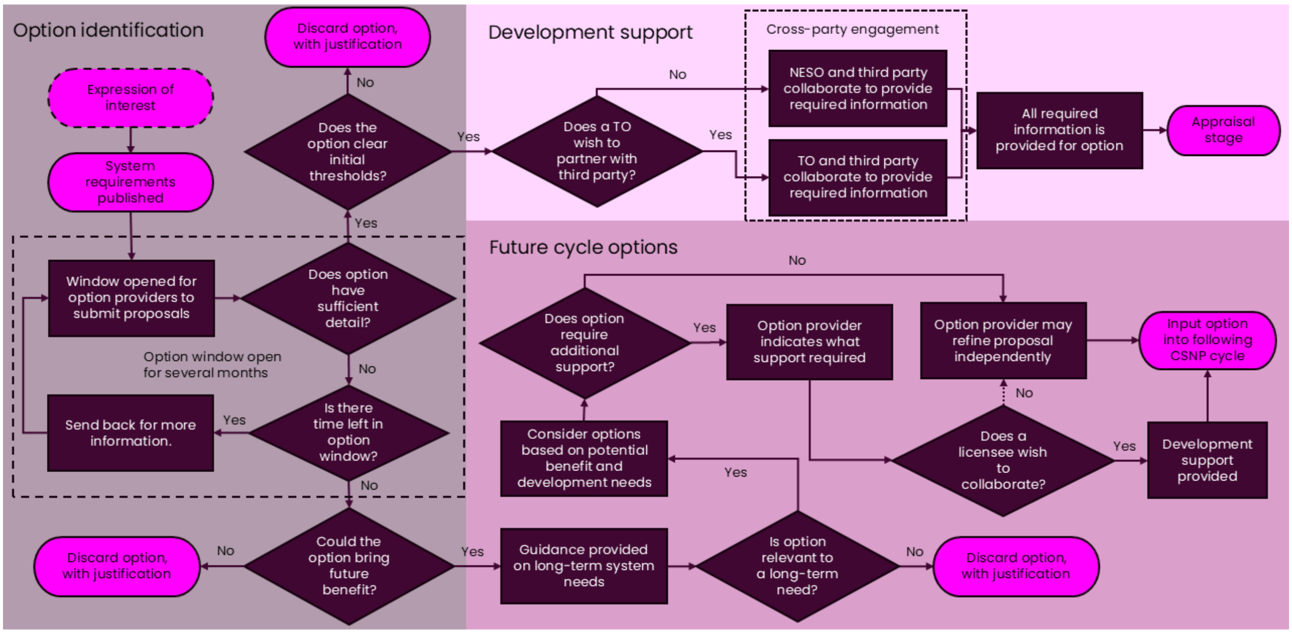


Figure 47: Process map presenting overview of the third party framework

Option identification

Expression of interest

Option identification begins with an expression of interest (EOI) process from parties who wish to engage. This will open several months before system requirements are published to allow parties to complete any required steps prior to the system requirements publication. This will give third parties as much time as possible to develop their proposals.

The purpose of the EOI is to give third parties an opportunity to understand what information will be required to submit for reinforcement options. This will enable NESO to indicate which parts of the system would benefit from new options and allow for initial work to be done before the option submission period begins.

The EOI will consist of several parts, including but not limited to:

- Detail on what information will need to be provided for an option to be considered. For instance, what categories of information must be provided, to what level of detail and how parties can provide this information.
- Guidance on where new reinforcement options may provide the most benefit to consumers. This may include identifying system needs from prior network planning cycles that have seen limited options or highlighting any previously highly constrained area of the network. This guidance will not include any information regarding the current cycles' system requirements as these will still be developing during this period. This would not serve as a shortlist for the only needs which we would consider new solutions for. Options may be provided to meet any need indicated within the system requirements.
- Information on how support can be provided for further option development. This will detail how parties can collaborate with licensees once an option has passed filtering and is progressed for development.
- A process to ensure parties have the capability to contribute options.

This will include NESO detailing what information a third party must provide for an option to be considered in the process and verifying the capability of the third party to provide this. This process will ensure that any party planning to participate in option submission can understand what the requirements will be and whether they have the means to provide potentially beneficial options.

We'll publish the start of this expression of interest process on our website, where you can find all the necessary information. As this process will be open for several months prior to the publication of system requirements, we are considering the most effective methods to inform parties when this process is open.

After a party has successfully completed the EOI, they will be able to submit options into the CSNP process. As shown in Figure 48, an option submission window will be open for a fixed period starting from the point system requirements are published. For the avoidance of doubt, third parties can submit a range of reinforcement options, including proposals for new circuits, upgrades to existing network infrastructure, or network management solutions.

Third parties will be required to submit information on their reinforcement option across a range of categories. Detail on what information would be required can be found below in the 'Required information for third parties' section. This would be submitted online. Information on how this can be included within a submission will be provided within the expression of interest process. Options would also need to differ from previously received proposals.

After submission, reinforcement options will be reviewed to ensure that the third party has provide all required information for further development. If the option is missing information, then it will be returned to the third party highlighting what additional information is required. The third party can resubmit the reinforcement option, providing the submission window is still open. This review will not consider whether the reinforcement option provides benefit or compares favourably to alternative options, only whether enough information is available. Options will be filtered on their benefits when the submission window closes. The submission window will have a fixed deadline. This is necessary to finalise any reinforcement options in time for the appraisal process.

Reinforcement options that do not include sufficient details before the window closes but may be able to meet a long-term requirement on the network can be reconsidered in a future planning cycle. More detail on this process can be found in the 'future cycle options' section.

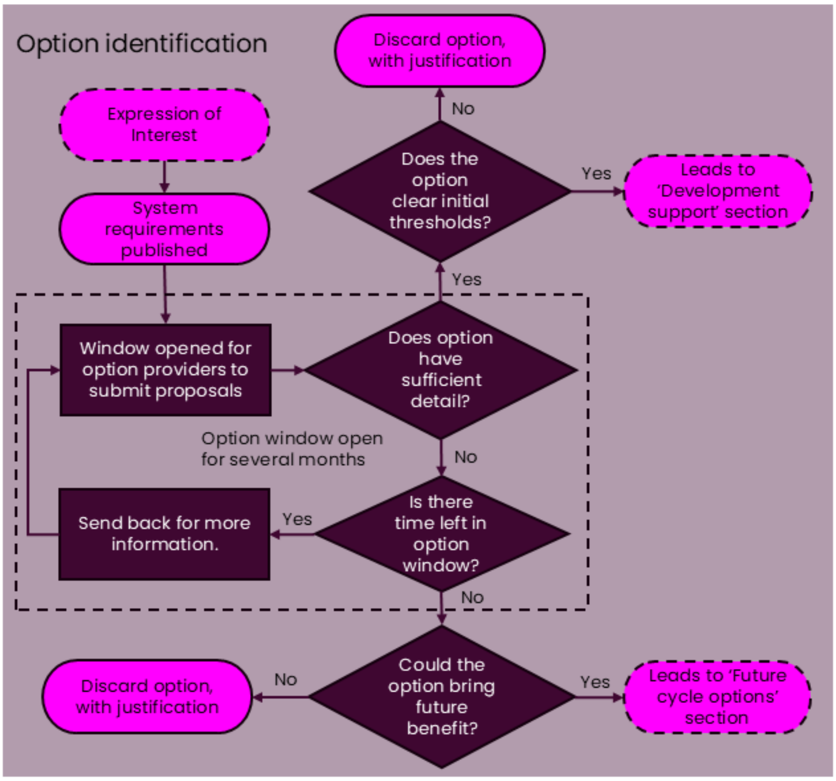


Figure 48: Option identification section of wider third party process map

Option filtering

When the submission window closes, reinforcement options that have included necessary information will be considered against a set of impact thresholds. The aim of this is to ensure that any options progressed for development are feasible and do not have any clear, unavoidable impacts that would prevent the delivery of the option.

These thresholds will primarily consider the deliverability of the asset. It will also make use of the information provided to consider environmental impacts. This filtering would make use of the initial information provided by the third party in their proposal and would not require more details at this stage.

The full detail of what the thresholds are and what impacts can be considered will be detailed as part of the information within the EOI process. Areas that will need to be considered would include (but are not limited to):

- **Technological readiness level:** For an option to be considered it needs to have proof that it is based on sufficiently developed technology for delivery.
- **Delivery risks:** An option will need proof that the supply chain is able to provide the necessary components for delivery as well as a deliverable programme breakdown. This would also need to consider the complexity of design and potential construction.
- **Environmental factors:** If the option requires a physical footprint, then it would need to consider the environmental impact of the option and possible mitigations.

Options will not be compared to one another at this point of the process. This stage functions as a filter. Options would be compared on their merits within the options appraise step. This stage would identify if an option would be undeliverable in the timescales of the system need. For example, if an option is proposed to meet a need in five years but is reliant on technology that has not been physically demonstrated, then it would likely be filtered. Or if an option would be deliverable but would have a large environmental impact that could not be mitigated, then it would be filtered.

Note that deliverability at this point would be considered in isolation. It would consider whether the option as proposed could be delivered but not whether the transmission network in the region proposed had the capacity for it. For example, whether substations in the option area would have suitable available bays in the timeframe presented. This would be understood by developing the option.

This filtering will leave a set of options that, based on current information, are feasible and could bring benefit. These options can then be developed further and may receive support.

Question: What information would be useful to enable you to submit an option in the expression of interest window?

Question: How would you like that information to be communicated?

Development support

After the options have been filtered, we would then look to address any gaps in information between that which has been provided by the third party and what's required for the appraisal process, as detailed in the 'required information' section.

The expectation is that most third parties would not be able to provide information independently on matters such as:

- What operability impacts the proposed reinforcement option has when incorporated into the transmission network, considering points such as outage requirements.
- If the option is deliverable as presented within the wider network. For example, is there capacity on the network in the locations proposed?
- Are there additional drivers that may interact with the proposed reinforcement option?
- How does the option function when considered within a wider GB design?

Licensees, such as NESO and Transmission Owners, would have the required capability to gather information on these points. Through combining this capability with feasible third party proposals, all necessary information can be pulled together to allow for the reinforcement option to be taken forward to the appraisal process. This could take the form of a partnership arrangement between involved parties, where a licensee may provide reasonable technical support to a third party.

For example, a third party proposes a reinforcement option that if delivered, would enhance the capability of a network without needing to build new infrastructure. If a licensee feels this option could benefit their network, then they may choose to partner with this third party and develop the option together. If this reinforcement option is included in the preferred GB design, these parties then already have working arrangements in place to deliver the option.

These partnership arrangements would typically be needed as licensees would have access to information on their own networks necessary to complete the information required for the appraisal process. This includes, substation information, detail on necessary sequencing of new reinforcements and outage requirements.

NESO would serve as a facilitator for partnerships, identifying opportunities for collaboration. Any partnership arrangements would be voluntary for both the Transmission Owner and third party. As is shown in Figure 49 NESO can also serve as the partner to a third party where appropriate, with NESO's role like that of a Transmission Owner, providing necessary information and expertise to ensure complete information for the appraisal process. However, NESO would not be involved in the delivery of any solutions. Options with interactions with the transmission network need to be delivered alongside a licensee.

Support would primarily consist of subject matter expert support or access to relevant network information. Transmission Owners would have the opportunity to make partnership agreements with third party options who they wish to support. Depending on the type of option, this may lead to shared delivery of the asset if progressed for delivery.

As laid out in the System Owner – Transmission Owner Code (STC), certain network planning data can only be shared between licensees and agreed parties who are working alongside licensees in specific cases. This is driven by security, regulatory and confidentiality constraints. This means that third parties providing options independently who may require network planning information to finalise option development would not be able to without a partnership arrangement with a licensee.

If a third party wants to, they can continue to develop their option independently. For the option to be considered further they would be expected to provide all required information before the appraise step. For alternative network build proposals, such as new circuits, if a third party no longer wishes to be involved in the development process, then this would be undertaken by either NESO or a Transmission Owner. This option would then become a NESO-led or Transmission Owner option.

As this support would be provided in parallel alongside licensees developing additional options, there will not be unlimited availability from licensees. The filtering of options prior to this stage should ensure that only options that are credible and could bring benefit would progress. Once an option has been developed with no remaining gaps in information, it would then be moved into the appraisal process.

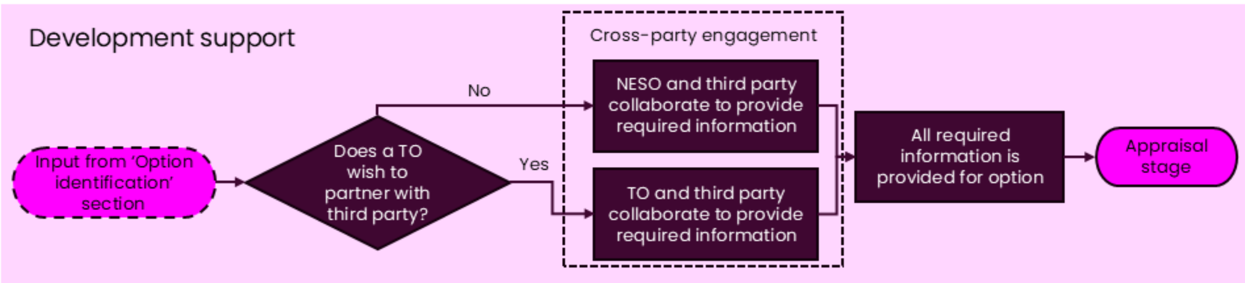


Figure 49: Development support section of wider third party process map

Question: What additional support would you need to develop options?

Future cycle options

Options that do not include all required information for appraisal will not advance within the current CSNP cycle. We need to ensure that new opportunities to meet long-term needs are not overlooked.

Our focus when considering innovation is to identify any potential opportunities to support the CSNP objectives of planning an economic and efficient network, whilst minimising the impact to communities and the environment. To do this we would encourage any new ideas that can either provide new capability or enhance the capability of the current transmission network.

Third parties can choose to develop any proposal independently based on the feedback they've received during the submission window to include in the following CSNP cycle. Options can be reconsidered in a subsequent cycle providing they can give necessary information and are suitable to meet a need identified in that cycle.

If a third party feels that their option requires additional support to get a suitable proposal together for inclusion in a future cycle, then this can be requested. NESO or another licensee, if they wish to, can work with the third party to get an option in a suitable place for a future submission. For an option to be eligible for such support they would need to be the following:

- The option must have the potential to bring benefits to the transmission network. As information would be limited at this point, options would be reviewed based on the capability proposed as well as the current development level (considering technological readiness level etc).
- The third party must provide information on what support they feel is needed to put forward a complete option proposal in a future cycle.

This would take place following the close of the option submission window and is expected to apply mainly to innovative options that have already gone through significant development. For example, there is already evidence of a proposed new technology being demonstrated in a relevant environment. This would most likely apply to options at or beyond technological readiness level 6.

Providing these conditions are met, NESO or Transmission Owners can then choose to provide the requested support or engage with third parties to reach agreements to develop option further. One approach, as shown in Figure 50, may be that a Transmission Owner and third party agree to work together on developing a new technology, with this then being brought forward as an option in the following CSNP cycle.

If an option does not meet the above conditions, then feedback will be provided as to why the option would not be considered for further support within this process. For options that are in earlier stages of development we may instead direct the third party towards a relevant innovation framework such as the Strategic Innovation Fund (SIF) to receive more targeted support and funding.

Providing development support to options will be based on the available capacity of NESO or other licensees, what level of support an option requires and the potential benefit of the option. The support available may include subject matter expert support, access to information, or may also include the means to be able to more robustly demonstrate and test a new technology. All agreements for support at this stage would be voluntary between the licensee and a third party.

After an agreement is in place between relevant parties, they can then work through developing the option and then may be submitted into next CSNP cycle. The option would then be considered against the same criteria as all others and progressed if sufficiently developed.

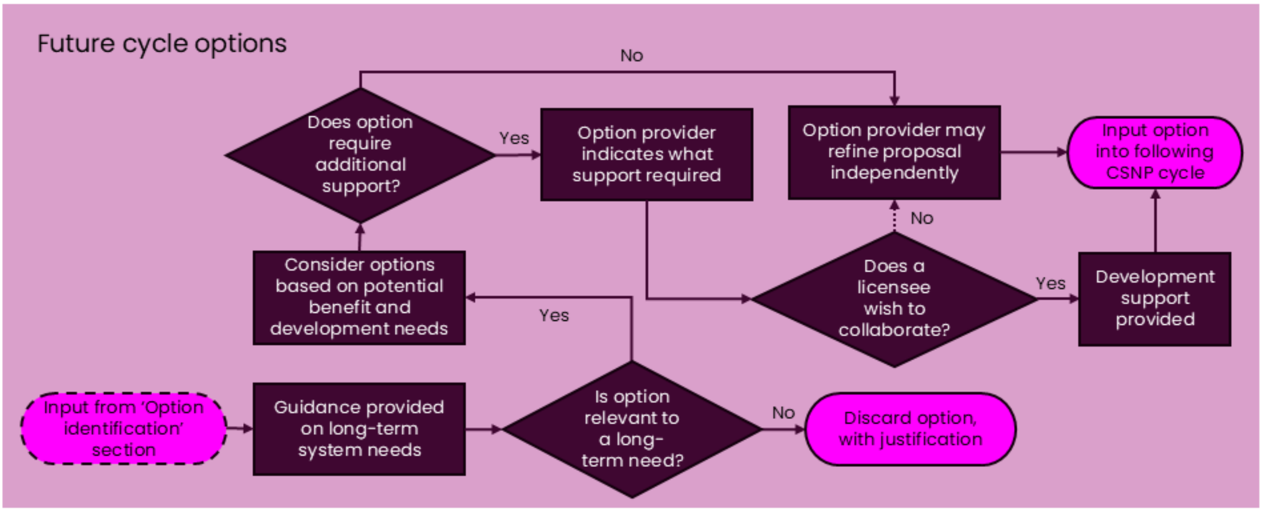


Figure 50: Future cycle options section of wider third party process map

Required information

Progressed options

Reinforcement options must be developed in line with the requirements outlined in Table 9 to be eligible for the appraise step. We will establish standardised documentation and submission forms to ensure consistency in and assurance of provided information. We will review the submission forms and may request specific additional information, if required. Any commercially sensitive information will be treated accordingly.

Similar information is required for long-term reinforcement options to enable equivalent consideration. We note that this information will be more uncertain. Requirements not necessarily needed for long-term reinforcement options but required for reinforcements to be included in the delivery pipeline, are marked with an asterisk.

Table 9: Required information

Information	Description
Additional drivers*	Details of any additional drivers and the extent that these interact with the proposed reinforcement option, including: • customer connections • non-load related investments This information will be used to support the needs case of reinforcements.
Additional boundary capability	The impact of the reinforcement option on boundaries, for which NESO will perform concurrent studies to cross-check capabilities, including: • additional boundary capability provided • where relevant, in combination with other options This information is required to inform the economic modelling in the appraise step.
Cost breakdown	Capital and lifetime costs in the form requested by NESO and including: • price base • cancelation and delay costs, where relevant for options in a later stage of development • annual expenditure profile • costs for separable works

	• weighted average cost of capital (WACC) This information is required to conduct the economic modelling in the appraise step.
Criteria scoring	Scoring of the reinforcement to inform deliverability and operability assessments, as outlined in the appraise step, and including the following respective sub-criteria: • technology readiness, system access, design and construction complexity, supply chain, and interactivity • protection and controls integration complexity, network operation complexity, and scalability and adaptability This is needed to ensure the determination of a GB network design that is deliverable and operable in the appraise step.
Modelling information	Sufficient information to enable power system modelling. NESO will work with Transmission Owners to establish a new model exchange process and required information, under the STC conditions. This should include: • single line electrical schematic • specification of the required asset ratings and electrical parameters • operability requirements, such as reactive compensation, considering relevant standards This information is required to cross-check capabilities and enable power system analysis.
Outages and interactions*	Where available, indicative outage requirements, including: • impacted assets and required duration in weeks, or other duration as appropriate, for each year if delivered on its EISD • sequencing and restrictions with other reinforcements This information will enable the impact of outages to be considered in the economic modelling in the appraise step.
Programme breakdown	A breakdown of the anticipated programme in the form requested by NESO and including: • earliest in service date (EISD) and justification • dependencies with other reinforcement options • opportunities for staged delivery

	• assessment of the potential to advance and the risks of delay This information is required to conduct the economic modelling in the appraise step.
Spatial information	A strategic envelope for new circuits, substations or assets and network upgrades. This should be provided with: • a shapefile to enable GIS modelling • locations of environment and community constraints within the envelope with supporting narrative for context • any strategic mitigation • circuit length data This is required for scoring and considering impacts on environment and communities in the appraise step.
Substation information*	Sufficient information to demonstrate substation feasibility while noting that this may change through the detailed design and delivery stages. Information should include: • bay and land availability • indicative view of the connection of any proposed asset • substation extension requirements This information is required to demonstrate feasibility and due diligence ahead of the delivery pipeline.
Technical description	A technical description of the reinforcement option, including its: • name and stage of development • whether it is new or has been previously proposed • physical description, including its strategic parameters, involved assets, voltage, and capacity • relevance to system requirements This will enable further understanding and context on the proposed reinforcement option

As far as possible from desktop considerations, options will be developed with strategic mitigation included. This could include undergrounding in certain designated areas. Mitigation may be different in Scotland from those in England and Wales depending on policy. The assigned delivery body will decide local mitigation in response to specific environmental or community impacts through the detailed design and delivery stages.

Required information for third parties

All options, regardless of provider or type, will need to provide all the information detailed above to be progressed through to the appraise step. It is not expected that third parties would be able to provide all this information independently, for example it would be unreasonable to expect a third party to provide substation data or modelling information.

Therefore, at the option submission stage a third-party option would be expected to provide the following subset of information:

- cost breakdown
- programme breakdown
- spatial information
- technical description

Third parties would also need to provide supporting evidence with their technical description to aid criteria scoring. This would need to include information on the technological readiness level, supply chain availability and design complexity of their proposal. The technical description would need to provide information on how the option is relevant to a system need and how it would meet that need.

After this information is provided, a third party can then choose to work with a licensee to gather required information across the full range of categories to progress into the appraise step.

These information requirements are a minimum requirement. If a third party can provide robust information covering additional categories, then this will be considered and used to develop that option.

Question: Do you agree with the options development process and the required information?

7. Appraise (Electricity)

Overview

Economic efficiency

Environment and community

Deliverability and operability

Decision-making framework

Overview

Key messages

- During the appraise step, NESO will combine various reinforcement options identified in the develop step to create multiple GB network designs, ensuring a comprehensive exploration of potential combinations.
- The cumulative impact of these reinforcement option combinations will be evaluated using a range of assessment criteria, including economic efficiency, environmental and community impacts, deliverability, and operability, to ensure a balanced assessment of potential impacts and benefits of the GB network designs.
- The goal is to identify NESO's preferred GB network design and ensure stakeholders clearly understand how the recommendations are made by transparently and robustly demonstrating the application of assessment criteria in the decision-making process.

This chapter outlines how NESO will develop multiple GB network designs by combining various reinforcement options identified in the develop step. It details how the GB designs will be assessed across a range of assessment criteria to identify NESO's preferred GB design.

Throughout this step, we will adhere to the principles of transparency, robustness, consistency, and reproducibility.

The appraisal methodology is developed acknowledging NESO's and Ofgem's statutory duties to promote economy and efficiency, as well as the Transmission Owners' licence obligations (Electricity Act 1989) to develop and maintain an efficient, co-ordinated and economical system of electricity transmission. These responsibilities also include:

- having regard to and mitigating environmental impacts
- considering the interests of GB consumers
- investing as needed in new network to ensure consumer energy costs are minimised

As NESO, we are also responsible for ensuring the operability and deliverability of the network, now and in the future, while continuing to prioritise cost-effectiveness.

Table 10 provides a high-level summary of the criteria we will consider for assessing the GB network designs.

Table 10: Assessment criteria

Criteria	Description
Economic efficiency	Use economic assessment tools to identify efficient designs which create consumer value.
Environmental impact	Use geospatial data and information across multiple impact themes to assess impact on the environment.
Community impact	Use geospatial data and information across multiple impact themes to assess community impact.
Deliverability	Consider supply chain factors, construction timelines, technology readiness, and complexities, including challenges from multi-project interactions, to ensure practical delivery.
Operability	Consider real-time operability challenges associated with the GB network design options.

Note that the five criteria in Table 10 are assessed in a multi-stage process that is explained in the 'framework for GB network design appraisal' section. The non-economic assessment criteria (environment, community, deliverability, and operability) are referenced as ECDO in this chapter.

Assessment criteria

Economic efficiency

This section details the economic assessment that will be undertaken as part of the GB network design appraisal. The Net Present Value (NPV) of each design will be calculated by quantifying benefits, such as the forecast reduction in constraint costs due to the inclusion of reinforcements, as well as quantifying costs, such as the forecast capital expenditure (CAPEX) costs of the reinforcements.

The NPV calculation will exclude any potential subsidy payments within constraint costs, such as a Contract for Difference (CfD) which are classed as a transfer payment. The constraint costs arise when there is insufficient capacity on the network to allow the flow of electricity from the original generation mix. This requires us to ensure the system operates within its limits. Some generation may be reduced in certain parts of the network and other generation will be increased in other areas to ensure supply meets demand.

Other costs and benefits will be included in the economic assessment. For example, the forecast reduction in the societal cost of carbon as increasing levels of renewable generation are connected to the system, and changes in wholesale energy costs. In addition to CAPEX, operational expenditure (OPEX) will be a cost that we will consider as the variations in OPEX across various strategic options may be material.

Each GB network design will consist of a range of reinforcement options and commercial solutions. These are analysed within our pan-European market modelling tool. Our analysts will analyse many combinations of reinforcement options. The process will be iterative, as individual reinforcements are added one at a time and we are able to model the impact on constraints and other costs of a particular reinforcement. We will construct combinations of multiple reinforcements. The outputs from each iteration are compared to determine whether each additional reinforcement option provides economic benefit and to identify the combination of options that provide the maximum economic benefit. By repeating this process many times, we will be able to construct a diverse range of viable GB network designs that maximise the potential optionality within the strategic variations provided by Transmission Owners, NESO, and third parties.

Our assessment will assume the appropriate asset life for each reinforcement, typically between 40 and 50 years. The modelling of constraint costs with our pan-European market modelling tool will extend out to 2050. The forecast costs beyond year 2050 are assumed to be the same as year 2050. The impact of this assumption is reduced as forecast costs are discounted using HM Treasury Green Book's[1] Social Time Preferential Rate (STPR)[2] to convert the forecast costs into present values. The capital cost for each reinforcement option selected is amortised over the asset life by applying the Spackman

[1] gov.uk/government/collections/the-green-book-and-accompanying-guidance-and-documents

[2] https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government/the-green-book-2020

methodology[3], using the appropriate weighted average cost of capital that is also discounted using the STPR.

To identify the preferred GB network design, we will undertake a cost-benefit analysis (CBA) for each of the shortlisted GB designs, monetising as many ECDO sub-criteria as possible to identify the preferred GB design. During this stage we will also be able to consider a range of dates that an individual reinforcement may become operational. This will be in accordance with HM Treasury Green Book principles which recommends conducting a CBA to move from the shortlist to a preferred final solution.

Question: Are there any other elements that we should include within the economic assessment?

Sensitivities and stress testing

The options assessment process will be undertaken using the chosen SSEP pathway. The single SSEP pathway will be used to determine the preferred GB network design in the CSNP and decide which reinforcements to progress into the delivery pipeline. The single pathway will be used through the decision-making framework throughout the process, establishing multiple credible GB network designs through to the final CBA to identify the preferred GB design.

Establishing the network design against the single SSEP pathway will:

- Enable the CSNP to plan the network in anticipation of future connections that will be informed by the SSEP. This will ensure the CSNP, driven by the SSEP, can plan the wider network strategically and in anticipation of future generation and demand customers.
- Align the network design with the SSEP, a plan that UK government and devolved administrations and the regulator can endorse, to anchor the driver for the CSNP in policy.
- Ensure the offshore design and the wider network are holistically planned against a single energy pathway.

We recognise that with the need for significant network expansion, stress-testing the decisions by considering different pathways and sensitivities becomes crucial. Evidence to back the recommendation decisions is necessary to give decision makers confidence in approving the network plans. The chosen GB network design will be tested against NESO's FES. The FES will enable us to model multiple long-term strategic energy pathways that will highlight what must Are there any other elements that we should include within the economic assessment?

[3] https://www.ofgem.gov.uk/sites/default/files/docs/2011/10/discounting-for-cost-benefit-analysis-involving-private-investment-but-public-benefit.pdf

happen across the energy vectors to enable clean energy.

The chosen GB network will be tested against the resilience scenarios described in the drive step. These stress-tests will ensure that the final GB network design is tested against a range of credible futures to provide confidence in the needs case of required reinforcements. Understanding the impact of uncertainty on the chosen network design will provide evidence to support Ofgem's funding decisions.

These sensitivities will also enable us to explore a wide range of long-term network designs. These will illustrate different routes to expanding the network across the horizon of the long-term options funnel.

Question: Do you agree with our approach regarding sensitivities?

Question: Are there any other specific sensitivities you think we should consider?

Societal costs and benefits

The CSNP will incorporate a range of economic components in the economic assessment.

We recognise that it is important to consider carbon emissions reductions through proposed projects and to factor these into the economic assessment methodology of the CSNP. To align our economic assessment with the HM Treasury Green Book, we have incorporated a calculation of the societal value of carbon resulting from network reinforcement into our cost benefit analysis. This allows the impact on CO_2 emissions to be a key consideration in our recommendations, with the definition of "consumer benefits" widened to include the benefit of lower emissions.

Balancing mechanism (BM) costs accrued from plants with CfDs will not be included in the final BM costs used for investment recommendations. This is because these costs will be borne by consumers regardless of whether the plant is re-dispatched or not (through the Low Carbon Contracts Company (LCCC) if they generate, or NESO if they are re-dispatched).

This summer (2025) the government plans to provide an update on the Review of Electricity Market Arrangements (REMA) which commenced in 2022. This will detail how it intends to progress wholesale market reform. The government believes that reforming electricity markets through the REMA programme is vital to the delivery of a fully decarbonised electricity system by 2035, subject to security of supply.

After two rounds of consultation, the government has selected two potential approaches to wholesale market reform. The first approach is to implement zonal pricing. Under this approach the current national wholesale electricity price would be replaced by regional pricing zones where the prices in individual zones will be based on the costs of producing and supplying energy in that area. This approach could reduce the need for network reinforcements. The second approach is a reformed national pricing regime.

We will consider the most appropriate range of cost calculations to be included, for example calculating consumer costs and total system costs, to ensure the economic analysis is robust. For national or zonal pricing, we may consider:

- consumer costs, the costs paid by consumers for their energy
- other services provided by producers and networks
- system costs (the underlying costs of building, maintaining and operating infrastructure to provide energy and services)

In-service date and delivery date ranges

The in-service date, that is the date a network option commences operation, is currently determined by Transmission Owners based on their experience of delivering comparable projects and the latest insights including supply chain, consenting and capital cost assessments. As the owner of the national strategic network investment plan, NESO is well-positioned to review regional investment planning, and will develop its capability to scrutinise delivery plans including delivery dates and capital cost forecasts from a GB-wide perspective.

Previous economic analysis has assessed the economic benefit of delivering projects on the in-service date submitted by Transmission Owners, compared to later delivery. However, the analysis does not quantify the potential benefit of delivering projects earlier than the in-service date. This information regarding the optimal delivery date (ODD) could help determine the advantages of accelerating project delivery. Earlier delivery of reinforcement options may support more rapid renewable generation integration.

In-service date assessment can be complex because of the level of detail available. Certainty will evolve over time with a lack of granularity during the early development of a project. It can also be derived in multiple ways. We will work with Transmission Owners and Ofgem to ensure a structured, consistent and transparent approach regarding definitions, asset types, project costings and delivery date ranges. This will ensure all options can be compared fairly. These will be agreed and documented through the relevant CSNP governance forum. Once agreed, they will be published on our website.

We will conduct a pre-assessment to identify a selected set of options which are most likely to provide additional benefit with an in-service date advancement and/or where one option is critical for the delivery of other projects. Modelling will then be undertaken with revised delivery dates, CAPEX and outages.

We will use the reinforcement option developers' estimated in-service date to create the first GB designs. This estimate will be created from probability risk analysis at the 50th percentile. Once we have shortlisted the GB designs, different delivery years of reinforcement options can be considered. At this stage, we will simulate EISD advancement and delay sensitivities on a selected set of projects, focusing on interactions and dependencies with other projects. These projects will be chosen based on their importance and significance to the GB design. After determining the optimal timings through EISD and delay sensitivity analysis for selected options in the shortlisted

GB designs, we will consult with reinforcement option developers. Developers can then provide evidence to show whether EISDs may be suitable for advancement or not. Finally, we will apply the final CBA based on agreed dates to identify NESO's preferred GB design.

Benefit-cost ratio

Ofgem will be making decisions to fund and maintain the assets over their lifetime. Benefit-cost ratios (BCRs) will provide additional information and context regarding reinforcements included within the delivery pipeline. BCR may be a useful additional economic metric to be used within the CSNP economic assessment alongside NPV for demonstrating value for money, and for identifying options that may be marginal, or sensitive to a change in inputs such as capital costs.

Environment and community

This section outlines the assessment of potential environmental and community impacts and interactions onshore and offshore across GB.

Environment and community are two separate criteria and will each be considered independently. For this document, the criteria are presented together as they adopt the same methodological approach.

The assessment for environment and community will incorporate a two-stage process.

The first stage would involve carrying out high level geospatial mapping to identify reinforcement options which may have an impact on environmental or community constraints and could be difficult to mitigate. This stage forms part of the initial filter outlined in the develop step.

We suggest this is undertaken by those proposing network reinforcement solutions. The focus of this stage would be firstly to avoid, and if not possible, minimise impacts on environmental or community constraints based on a geographic information system (GIS) with overlayed constraints. It is recommended that this approach is standardised and formalised for consistency across all parties proposing solutions.

The second stage would be undertaken by NESO and will use an impact-based appraisal risk matrix. It will use the data output from the first stage, supplied by the reinforcement option's developer and use a structured method with clear criteria for assessing the risk impact of each option. This approach will consist of a qualitative and quantitative assessment. Table 11 outlines the key terms used within the risk matrix approach.

Stage 1 data output will consist of:

- a spatial envelope (the broad geographical area in which a reinforcement is required)
- identified environmental and community constraints within the spatial envelope
- strategic parameters i.e. onshore/offshore, overhead, or underground
- a narrative to provide context and additional information

This approach would use well defined environmental data sets and indicators to assess the impact of different solutions and options on the environment. The outputs of the assessment would comprise a graded matrix with a rating against each impact category to highlight the comparative potential risk of impact.

Table 11: Glossary of key terms in impact assessment risk matrix

Key terms	
Sub-criteria (impact category)	A subset of the environmental or community categories representing a key topic (e.g. ecology)
Impact Pathway	A sequence of events through which an activity could potentially affect a receptor*. In this context, this includes a description of the potential impact arising from an activity, who/what the receptors are and how the receptors could be affected.
Indicators	A feature or characteristic whose presence or scale can be measured.

An assessment of technology types which are to be included in the CSNP was undertaken to assess what environmental and community factors could be affected for each solution type for both construction and operation. Informed by discussions with NESO and Transmission Owners, consultants conducted a review of solution typologies to assess whether they adequately covered the range of solutions that are currently proposed or that may be proposed in the future. These included solutions such as developing new circuits (overhead lines, underground or offshore cables), new substations, re-configuring substations, convertor stations and upgrading existing circuits, for example.

An impact screening exercise was undertaken to identify which of the environment and community impact categories were most common and relevant across multiple solution types. This has informed the proposed environment and community categories, shown in Table 12.

Table 12: Proposed environmental and community impact categories with potential example of indicators.

	Sub-criteria (impact category)	Potential examples of indicators
Environment	Ecology and biodiversity	Special Areas of Conservation (SACs) Special Protection Areas (SPAs) Sites of Special Scientific Interest (SSSIs) Ancient woodland
	Flood risk	Flood Zones 2 and 3 (England and Wales) Medium / High flood risk areas (Scotland)
	Global climate regulation	UK Peatland National Forest Inventory Woodland GB wide
	Historic environment	World Heritage Sites UK Scheduled Monuments Listed buildings Conservation areas
	Landscape/seascape	National parks National Landscapes (formerly AONBs) Wild Land Areas (Scotland)
Community	Local economy	Fishing activity Agricultural Land Classification (England and Wales) National scale land capability for agriculture (Scotland)
	Air quality	UK Air Quality Management Areas (AQMAs)
	Recreation and tourism	Designated bathing water sites National Trails / Scotland's Great trails
	Community amenities	Urban Data Zones/Lower Super Output Areas (LSOAs)

Note: This list is not exhaustive and will need to be agreed and finalised through the relevant CSNP governance forum.

Each impact category will contain a number of indicators whose presence can be measured via relevant questions and criteria.

The impact categories will also align with the *identification of key issues* which needs to be completed as part of the scoping stage for the SEA process. This will increase the robustness of the SEA scoping. The matrix impact categories have also been mapped against typical SEA themes.

The scoring approach for the risk matrix will use the following factors to calculate a risk response score (Figure 51):

- Sensitivity – based on 'significance' of each environment and community indicator, including uniqueness, adaptability, replacement and recovery potential. Justification for ratings by indicator is based on policy review and wider evidence on value (e.g. natural capital values).

- Scale factor - (at high-level information) based on presence of feature in the spatial envelope (study area) and risk adjusted for solution features. Metrics are estimated for features as a percentage of total study area or number per km^2.
- Solution feature factor – to adjust scores based on the likelihood that a solution feature (e.g. overhead line) will impact an indicator (e.g. bird populations).

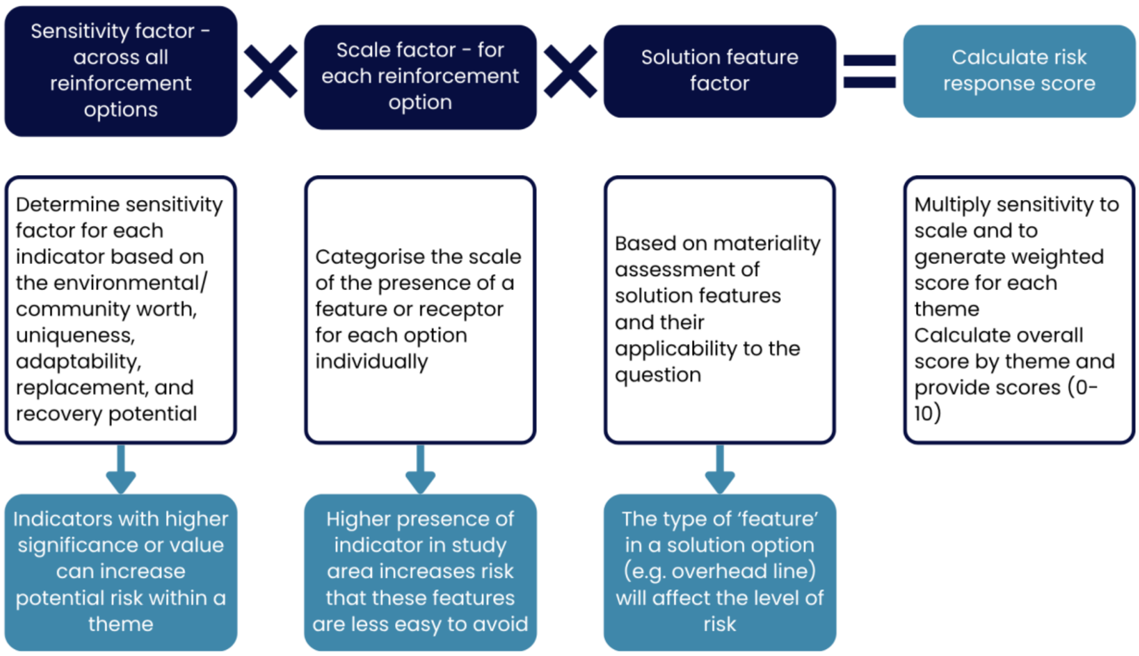


Figure 51: Scoring approach

Question: Do you agree with the proposed scoring approach for environmental and community?

The outputs of the assessment would comprise a matrix with a score or rating against each impact theme to highlight potential risks in Figure 52. The risk matrix would be considered alongside the other criteria outputs to inform decision making. To address the issue of potential masking of a high score, a 'red flag' symbol will be used to highlight where an individual indicator category has reached a maximum possible risk score. The flags reflect that there are high-risk indicators within certain categories, and the underlying scores should be further scrutinised to better understand the risk drivers.

	EXAMPLE A	Risk Score	
	Phase	Construction	Operation
Environment	Ecology	🚩 6	5
	Flood Risk	2	2
	Global Climate	🚩 6	🚩 6
	Heritage	5	5
	Landscape	🚩 5	🚩 5
Community	Recreation and Tourism	5	5
	Community Amenities	2	2
	Local Economy	3	2
	Air Quality	1	0

🚩 *Indicates that an indicator within the impact category has reached the maximum risk score*

Figure 52: Example table for a single reinforcement option (for illustration only)

Question: Do you agree with the proposed flag system for highlighting when an individual indicator within an impact category has reached the maximum possible score?

To be effective, this approach will require a minimum level of information. This will be provided by the reinforcement option developer to inform the environmental and community appraisal, including a spatial envelope, connection points, indications of infrastructure solution, technology type, and a supporting narrative.

The risk matrix is currently in development and will require stakeholder consultation to rank the input data associated with each indicator, finalise the calculation factors and refine the tool. This will be developed through the relevant CSNP governance forum.

We are proposing that the quantitative outputs are supplemented with a substantial qualitative narrative. This will capture additional information that may be available for options but is not reflected in the quantitative output. This would facilitate balancing the standardised and replicable quantitative outputs with the ability to provide context-specific qualitative information which will provide context and support the Strategic Environmental Assessment (SEA), Habitat Regulation Assessment (HRA), Marine Conservation Zone (MCZ), and Marine Protected Area (MPA) assessments and help sense check the ranking of network designs.

Providing additional qualitative information is crucial to overcome any issues due to lack of data or specificity of the solutions at the time of appraisal. The narrative can be used to capture:

- knowledge of whether constraints are avoidable or not (e.g. a national park at the edge of a study area that is highly likely to be avoided, versus a world heritage site crossing the study area which is unavoidable)
- knowledge of mitigation measures, particularly for more mature options, that may remove or reduce the risk of impact (e.g. proposed undergrounding of cables to avoid specific features)
- knowledge gained through previous option development that could suggest that the risk of impacts are higher than the quantitative outputs suggest.

NESO will need to define the approach to obtain aggregated scores for the GB designs for Environment and Community. This will require stakeholder consultation to assess the most appropriate approach and combining option level scores and accompanying narratives.

Environment assessments

An integral part of the CSNP for electricity will be the following plan-level assessments:

- SEA
- HRA
- MCZ and MPA assessments

These plan-level environmental assessments will comply with the relevant legislative requirements to assess the potential environmental impacts of proposed policies, plans and programmes, such as the CSNP. They are required to ensure that plans are designed and implemented in a way that minimises negative environmental effects, promotes sustainability, provides opportunity for stakeholder and public consultation, and provides necessary information for NESO to make informed choices. The diagram (Figure 53) shows how we propose the various stages of these environmental assessments to integrate into CSNP process.

We will work with environmental stakeholders to define the scope and develop the methodology for these consultations; to help ensure key issues are identified and environmental considerations underpin the process. The information used to undertake these assessments i.e. spatial envelopes, environmental and community constraint maps and narratives, will be produced during the reinforcement options development process by the options developer.

Due to the strategic, GB wide nature of the CSNP, the plan-level assessments considered relevant for consideration will be at the national level. The requirements will be identified during the SEA scoping and HRA and MCZ/MPA assessment evidence gathering stages. We will co-ordinate with other plan-level assessment owners within NESO such as SSEP during the early stages of the CSNP to make sure our approaches are coordinated and consistent.

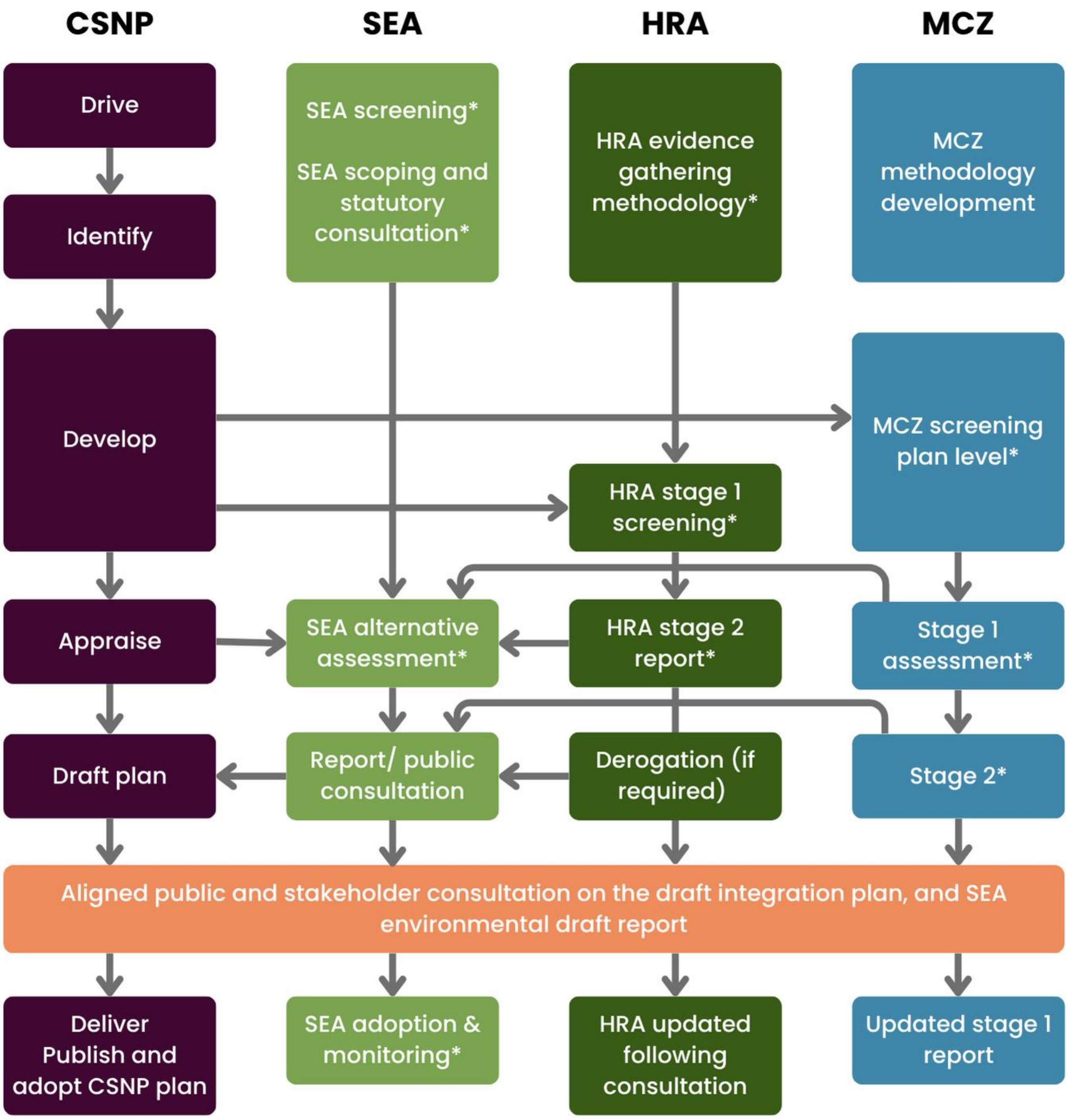


Figure 53: Draft overview of the environmental assessment processes with the CSNP

(* indicates further context in Table 13 below.)

Table 13: Expanded definitions of steps in figure 52.

SEA	HRA	MCZ
SEA screening: determine the need for an SEA SEA scoping and statutory consultation: set out baseline, identify issues, develop framework, prepare scoping report.	HRA evidence gathering methodology: sets out methodology for HRA and approach to use of zones of influence in assessment	MCZ screening plan level: identify sites that could have their conservation objectives hindered by the impact pathways associated with CSNP developments, and need to be taken forward to stage 1 assessment.
SEA alternative assessment: identify and assess reasonable alternatives of GB design.	HRA stage 1 screening: likely significant effects on short-listed options to identify any of particular concern (if any).	Stage 1 assessment: statutory nature conservation consultation.
SEA adoption & monitoring: monitor the significant effects of the plan.	HRA stage 2: Appropriate assessment, develop report and undertake Statutory Nature Conservation Bodies (SNCB) consultation.	Stage 2: consider if public benefit outweighs the risk of damage to the environment.

Strategic environmental assessment (SEA)

The SEA is a systematic process for evaluating the environmental implications of a proposed plan such as the CSNP. It provides a means for looking at the cumulative effect and appropriately mitigating at the earliest stage of decision-making alongside economic and social considerations.

The SEA will assess the extent to which the CSNP will:

- provide a response to environmental and climate change-related challenges
- may adversely affect the environment and climate resilience

Compared with a project level environmental impact assessment (EIA), a SEA provides recommendations at a strategic level and considers the cumulative effects of multiple and combined options. It also allows for monitoring of environmental effects and that any mitigation measures are effective.

The aim of a SEA is to ensure that environmental considerations are integrated into the outputs of the CSNP. The SEA process implicitly operates to prevent the selection of projects or policies without sufficient information about alternatives being appropriately considered and assessed.

The SEA for the CSNP will meet SEA requirements in England, Scotland, and Wales. These comprise:

- England - Environmental Assessment of Plans and Programmes Regulations 2004
- Wales - Environmental Assessment of Plans and Programmes (Wales) Regulations 2004
- Scotland - Environmental Assessment (Scotland) Act 2005

Where applicable, NESO will also consult with other administrations such as those in Northern Island, the Republic of Ireland or the Isle of Man.

Habitats regulations assessment (HRA)

The HRA refers to the several distinct stages of assessment which must be undertaken to determine if the CSNP is likely to have a significant effect on a European site or a European offshore marine site also known as the National Site Network (either alone or in combination with other plans or projects) before deciding whether to undertake, permit, or authorise it.

European sites are protected by the Conservation of Habitats and Species Regulations 2017 as amended (England and Wales) and Conservation (Natural Habitats, &c.) Regulations 1994 (Regulation 48) (Scotland) known as the Habitats Regulations.

All plans and projects (including planning applications) which are not directly connected with, or necessary for, the conservation management of a habitat site, require consideration of whether the plan or project is likely to have significant effects on that site.

The 'habitats regulations assessment screening' should consider the potential effects both of the CSNP proposals and in combination with other non-electrical plans or projects. Where an adverse effect on the site's integrity cannot be ruled out, and where there are no alternative solutions, the plan or project can only proceed if there are imperative reasons of over-riding public interest and if necessary compensatory measures can be secured.

If a proposed plan or project is considered likely to have a significant effect on a protected habitats site, then an appropriate assessment of the implications for the site, in view of the site's conservation objectives, must be undertaken. If an adverse effect on the site integrity cannot be ruled out, then the derogation route should be followed (if required).

Marine conservation zone (MCZ)

An MCZ assessment (or Marine Protected Area (MPA) in Scottish waters) will consider the potential for the CSNP to impact the conservation objectives of these sites in GB waters. Assessing MCZs in the formulation of the CSNP will allow the plan to demonstrate how the CSNP will avoid or compensate (where necessary) for effects on nationally designated marine conservation sites. The process and methods are similar to HRA, but a separate and parallel process that considers different designated sites and designated features, underpinned by different legislation.

MCZs in English, Welsh, and Northern Irish territorial and offshore waters, are designated under the Marine and Coastal Access Act 2009 (MCAA); they provide protection for a range of important marine habitats, species and geological formations. In conjunction with other existing international and national designations, these sites contribute to an ecologically coherent network of Marine Protected Areas (MPA) in the North East Atlantic and North Sea. MPAs in Scottish territorial waters are designated under Section 1 of the Marine (Scotland) Act 2010 and under the MCAA 2009. Highly Protected Marine Areas (HPMAs) have also been designated under the Marine and Coastal Access Act 2009 (HM Government, 2023). These sites provide ecosystem wide protection and recovery of all species, habitats and processes within their boundaries. In particular, these sites intend to prevent all activities considered damaging, depositional, or extractive.

Deliverability and operability

Deliverability and operability are distinct criteria that will be considered independently. However, for the purposes of this document, they are presented together because they adopt the same methodological approach.

Deliverability refers to the ability to successfully deliver network reinforcement options within the given timeframes while meeting their original objectives and system requirements. It involves assessing various factors that could impact the successful delivery of a network reinforcement, such as supply chain availability, technological readiness, design and construction complexity and interactions with other projects.

Operability refers to the practical and safe operability of the future network infrastructure considering real-time operability challenges associated with GB network designs. It involves assessing factors such as protection and control integration complexity, complexity in integration into existing planning and operational analysis systems and scalability and adaptability of reinforcement options.

In the assessment stage, NESO will conduct deliverability and operability assessments of the GB designs. Details of the GB design assessments are provided below.

Deliverability and operability assessment of GB network designs by NESO

Deliverability and Operability sub-criteria along with their definitions, are provided in Tables 14 and 15 respectively.

As specified in the develop step, progressed reinforcement options will have scores provided for deliverability and operability following the specified scoring characteristics under the deliverability and operability sub-criteria provided in Appendix C.2 and C.3. The scores from reinforcement option developers are necessary at the individual option level, which is why the definitions in Tables 14 and 15 and in Appendix C2 and C3 refer to reinforcement options. Option developers are also required to provide supporting information, in the form of narratives, to accompany the reinforcement option scores to aid NESO's GB wide assessment.

NESO will conduct the GB network design level assessment for the same sub-criteria using the scores and narratives provided by the option developers. The aim is to differentiate the designs by evaluating them directly at the GB design level, considering their overall deliverability and operability. This approach allows for a tailored evaluation, considering the interactions and dependencies between options within each GB design.

Deliverability sub-criteria

Table 14: Deliverability sub-criteria and their definitions

Sub-criteria	Definition
Technology readiness level	Technology readiness refers to the maturity of technologies used in transmission network reinforcement, assessing their industry familiarity, operational experience, and deployment track record to determine their feasibility for large-scale implementation.
System access	System access evaluates both the direct impact of outages on thermal limits, voltage limits and grid stability and the effectiveness of mitigation strategies in minimising disruptions.
Design and construction complexity	Design and construction complexity refers to the challenges associated with both the design and construction of transmission network reinforcement options. For design, it includes factors such as the capacity and scale of the reinforcement option, the interdependence of components, network configuration, and the requirements for consenting and planning while considering the proposed delivery date. For construction, it involves challenges related to site accessibility, managing multi-phased projects, and coordinating concurrent construction activities while considering the proposed delivery date.
Supply chain	Supply chain considers the known availability of critical components, supplier capacity, and logistical challenges influencing the timely and efficient delivery of materials for transmission network reinforcements.
Interactivity	Interactivity refers to inter-scheme dependencies and coordination required across multiple schemes, considering shared infrastructure requirements, cascading delays, and simultaneous constructions.

Some deliverability sub-criteria listed in Table 14 may have already influenced the determination of risk-adjusted delivery dates or date ranges for options submitted to NESO. If these sub-criteria have influenced the delivery date assumptions, the scores provided to NESO should reflect the risk associated with the new delivery date to avoid double counting. For example, a sub-criteria score might have been high before adjusting for risk, but after delaying or adjusting the delivery date, the score should reflect an improvement.

As outlined in the framework for GB network design appraisal section later in this chapter, NESO expects transparency regarding the assumptions behind delivery date calculations.

Operability sub-criteria

Table 15: Operability sub-criteria and their definitions

Sub-criteria	Definition
Protection and control integration complexity	Assessment of an option's complexity of integration into protection, control, monitoring or other physical systems. Scoring to be conducted through knowledge-based assessment.
Network operation complexity	Assessment of an option's real-time operation needs associated with analysis tool requirements and business process, in order to operate the transmission system safely and securely, conducted through knowledge-based assessment.
Scalability and adaptability	Scalability and adaptability refer to the future expansion and flexibility considering the ability to expand for future capacity needs, integrate additional energy sources, and adapt to emerging technologies or innovations, and the risk of obsolescence.

We recognise that it is normal for all GB designs to have certain operability challenges, which could be addressed through various approaches, such as advanced control and protection systems, new tools, additional network services, or changes to business procedures. While some of these solutions may involve additional costs and complexity, the purpose of this GB design level operability assessment is to proactively identify these challenges through engineering judgement, enabling us to plan for a cost-efficient and safe future GB system.

Question: Do you agree with the deliverability and operability sub-criteria listed and their scoring characteristics (Appendix C2 and C3)?

Question: Are there any new criteria you believe should be included, or any existing criteria that you think could be removed?

Framework for GB network design appraisal

This section outlines the process NESO will follow to decide the GB network design that will be put forward for regulatory approval.

It is crucial to consider the cumulative impact of various reinforcement option combinations across GB, as the future network's performance depends on how these individual options work together against all the assessment criteria.

As NESO, we recognise the importance of justifying decisions by comparing progressed and discounted options, presenting alternatives, and providing consistent, transparent, evidence-based rationale for elimination. Through the GB network design assessment framework, we aim to achieve this. NESO evaluated a range of decision-making frameworks, these are explored in Appendix C.1.

In this process, NESO placed special emphasis on considering both quantitative and qualitative factors, reducing subjectivity, and ensuring a comprehensive evaluation of individual reinforcement options and option combinations that form GB network designs. The aim is not only to identify NESO's preferred GB network design but also to provide transparency so that our stakeholders will have a clear understanding of how the decision-making was conducted. Figure 54 summarises how NESO selects the preferred GB network design.

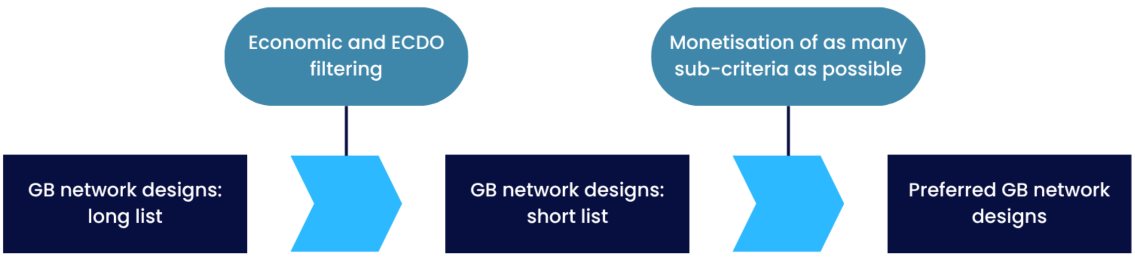


Figure 54: The GB design appraisal – filtering from a long list to the preferred GB design

Initially, NESO will create a range of different credible GB network designs to form a long list prioritising the economic efficiency of the designs. To be credible, the GB designs must be technically feasible and economically viable. This credible range of designs at this stage is not a maximum combination of all reinforcement options, but as broad a range as possible of GB designs that utilise as many of the network reinforcement options and that provide the identified system requirements and meet ECDO objectives. Also, the term 'long list' should not be interpreted as a large number: the objective is to maximise the range of GB network designs, which will be filtered down to a short list. All options within the 25-year horizon will be included within the GB network design assessment.

Key steps of GB network design appraisal

This section explains the key steps of the framework NESO has developed to select the preferred GB network design. The framework has three steps, outlined in Figure 55.

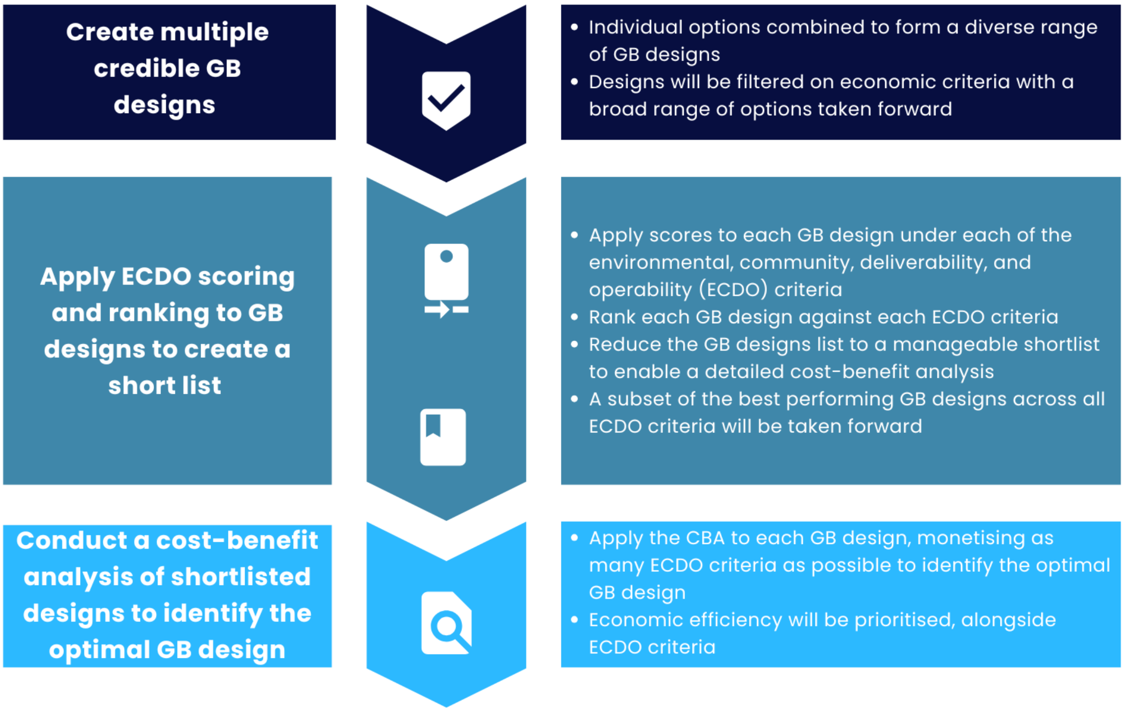


Figure 55: Key steps of the decision-making framework

The three steps of the options assessment decision-making framework are explained in more detail below.

Create multiple credible GB designs

The reinforcement options received from option developers will be combined to form a pool of technically feasible and economically viable GB network designs. This process will involve the following steps:

- The SSEP energy pathway chosen by the UK Energy Secretary will provide the demand and generation background for our modelling. NESO will use our pan-European economic market modelling tool to prioritise the most economically viable GB designs. The assessment involves comparing the boundary capabilities of a range of combinations of reinforcement options to the boundary capabilities of the existing network. This process enables us to calculate a range of costs, including network constraint costs due to NESO undertaking balancing actions and costs of emissions. Alongside these costs, we also consider the capital expenditure (CAPEX) of the different reinforcement options. By evaluating these factors, we can determine the Net Present Values (NPV) of each of the GB network design, effectively comparing the CAPEX against the savings from reduced constraints and emissions.

- In this process, the pool of GB network designs will be continuously reviewed to ensure a diverse selection that addresses not only economic efficiency but also a broad spectrum of ECDO criteria. The evaluation will be guided by engineering judgement and the information available at the outset of the process.
- The spread of total NPV for GB network designs will be analysed to identify clusters and outliers.
- An initial economic filter will be applied to select the most economically efficient subset of GB network designs. Figure 56 illustrates this concept by varying the NPV threshold as an economic filter.

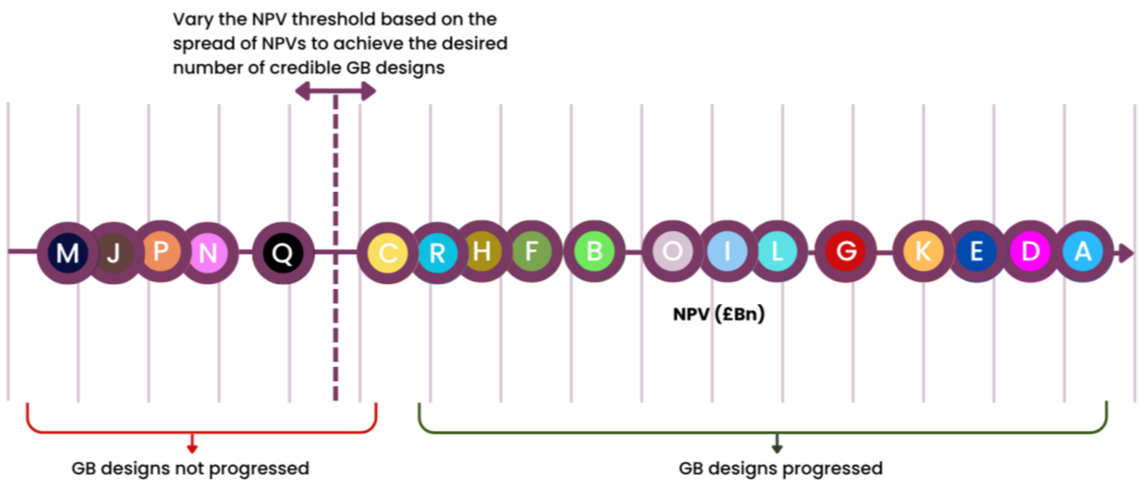


Figure 56: Applying an initial economic filter

Apply ECDO scoring and ranking to GB designs to create a shortlist of GB designs

Reinforcement options that progress to the appraise step will be accompanied by scores, supporting narrative, and spatial information. This will support NESO's environmental and community impact assessment of these reinforcement options. The scoring characteristics and scoring mechanism for the ECDO sub-criteria of individual reinforcement options are detailed later in this chapter.

NESO will perform the GB network design level assessment for the ECDO sub-criteria using the available scores and narratives of each reinforcement option within each GB network design. The objective is to conduct a tailored evaluation, considering the interactions and dependencies between options within each GB design across all ECDO sub-criteria which can then be aggregated per criteria.

The GB network design level scoring system will ensure:

- Capturing the most important ECDO sub-criteria for differentiation between GB designs, while considering the availability of information needed for a credible assessment.
- Aggregating ECDO sub-criteria level scores to ECDO criteria level robustly.
- Clearly defining score characteristics to minimise subjectivity.
- Enabling ranking of GB network designs at the ECDO level.

This scoring approach will facilitate the application of engineering and other multidisciplinary professional judgement in a robust, consistent, and reproducible manner. It will help minimise subjectivity in narrative approaches and will be especially useful when comparing a large number of reinforcement options and multiple GB network designs involving multiple assessment criteria. NESO will then be able to rank the performance of each GB design against each individual ECDO criteria. Figure 57 provides an example of ranking GB network designs at the main ECDO criteria level.

GB design	ECDO Rank			
	E	C	D	O
A	1	5	4	2
B	12	13	13	11
C	13	12	11	12
D	4	7	6	9
E	11	11	12	13
F	2	4	5	1
G	7	2	7	6
H	8	8	2	10
I	9	9	9	5
K	6	6	8	8
L	5	10	1	7
O	3	1	3	4
R	10	3	10	3

Figure 57: ECDO ranking of the GB designs

We will narrow down the GB designs list to a manageable shortlist for the subsequent CBA.

Analyse score distributions:

- NESO will evaluate the score distributions across all ECDO criteria to establish thresholds for selection of top designs and eliminating non-feasible GB designs. This step can be carried out at both ECDO sub- criteria and assessment criteria levels.

No preference to any ECDO criteria:

- NESO will assign no preference to any specific ECDO criteria.

Selection of top designs:

- There are several approaches that could be applied, based on the score distributions and ranking. The preferred and simplest would be to select the top 'X' of GB designs that perform well across all ECDO criteria (Figure 58). Alternatively, a compound approach would select the designs ranked in the top 'Y' in every criteria, or those ranked in the top 'Z' in any single criteria. Another approach would be to select the top 'X' of GB designs ranked at the sub-criteria level for all ECDO.

Key considerations:

- **Review and adjust**: We will allow flexibility to review and adjust the selection criteria. If the shortlist contains too many or too few GB designs, the thresholds will be modified to achieve a manageable number.
- **Document for transparency**: We will clearly document the thresholds and processes used for filtering to maintain transparency. This information will be made available to our stakeholders.

GB design	ECDO rank				Top 5 by rank				Shortlist	
	E	C	D	O	E	C	D	O		
A	1	5	4	2	Y	Y	Y	Y	Y	A
D	4	7	6	9	Y	N	N	N	N	
F	2	4	5	1	Y	Y	Y	Y	Y	F
G	7	2	7	6	N	Y	N	N	N	
H	8	8	2	10	N	N	Y	N	N	
I	9	9	9	5	N	N	N	Y	N	
K	6	6	8	8	N	N	N	N	N	
L	5	10	1	7	Y	N	Y	N	N	
O	3	1	3	4	Y	Y	Y	Y	Y	O
R	10	3	10	3	N	Y	N	Y	N	

7 GB designs eliminated: 3 GB designs progress to stage 4

Figure 58: Shortlist of GB designs based on ECDO rank

Conduct a CBA of shortlisted designs to identify the preferred GB design

According to the HM Treasury Green Book, multi-criteria decision analysis (MCDA) techniques can be used to create a short list from a long list. Since we are already at the short list stage, the Green Book recommends applying a CBA to move from the short list to a preferred final solution.

NESO will identify the preferred GB design from the short list of GB designs by considering economic costs calculated in the initial step while taking into account additional costs associated with the ECDO criteria and monetising as many factors as possible under the ECDO sub-criteria.

If, after conducting the CBA, several designs exhibit similar economic performance and it is difficult to determine a final preferred design, we will use the remaining ECDO sub-criteria that could not be monetised in the CBA to make the final decision.

Question: Do you agree with our approach to the GB design decision-making framework?

The preferred GB design will recommend which network reinforcements enter the delivery pipeline. The next chapter explores how these reinforcements are developed and how progress is monitored

8. Deliver (Electricity)

Overview

Key messages

- When reinforcements progress into the delivery pipeline will depend on their delivery timescale, maturity and needs case.
- Reinforcements in the delivery pipeline will not be reassessed, unless there are substantial changes to the reinforcements or their needs case.
- NESO will identify reinforcements that meet the relevant criteria and are eligible for network competition.

Context

The CSNP will evidence the needs case and determine the strategic parameters of required reinforcements and progress these options into the delivery pipeline. The delivery body will be responsible for the relevant detailed design and delivery stages, as outlined in Figure 59. The delivery body will either be an incumbent Transmission Owner or a Competitively Appointed Transmission Owner (CATO).

Route design	For new circuits, appraise a range of routeing and siting options to form a preferred corridor through engagement.
Design development	Undergo further design, supply chain engagement and assessment considering site surveys and land access.
Planning & consenting	Where relevant, prepare for planning and consenting and conduct consultation.
Application approval	Gain planning approval and undergo a full project funding assessment with Ofgem.
Asset construction	Procure and complete construction ahead of the asset being commissioned.

Figure 59: Detailed design and delivery stages Figure 59: Detailed design and delivery

Accelerating delivery

The government's Transmission Acceleration Action Plan seeks to halve the delivery timeframe of electricity transmission network infrastructure, including the stages listed in Figure 59. To help realise this, the CSNP will support quicker regulatory funding and provide greater confidence to industry and supply chains to help accelerate delivery.

Delivery progression

Delivery horizon

The appraise step will determine the preferred GB network design. A subset of the reinforcements within the preferred GB network design will progress into the delivery pipeline. This will depend on their delivery timescale, maturity, needs case and whether delivery is required to begin in the following three years.

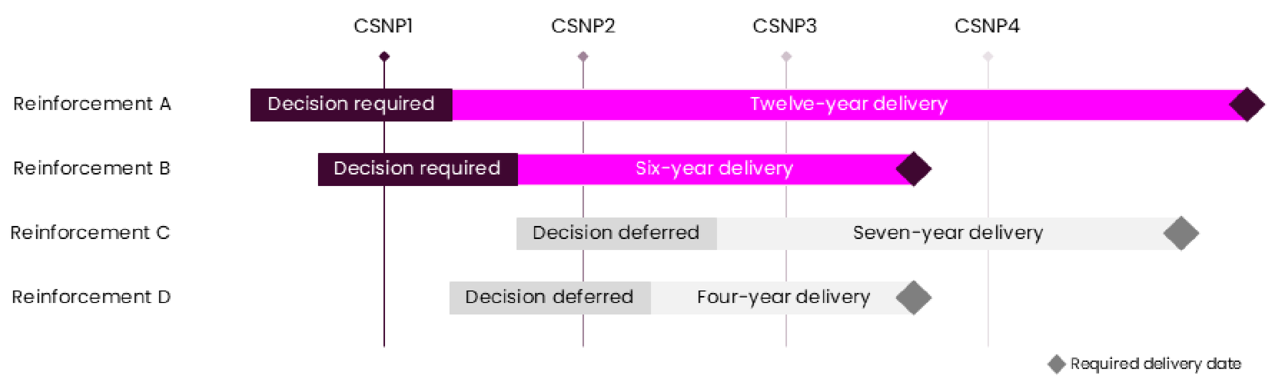


Figure 60: Illustrative timeline of reinforcements

In Figure 60, Reinforcement A and Reinforcement B would progress into the delivery pipeline to ensure the timely fulfilment of their needs case. The progression of Reinforcement C and Reinforcement D would be deferred to the following CSNP, where they will be reassessed. This is because delivery is not required to begin in the three years prior to the next CSNP. This approach will ensure timely delivery by balancing anticipatory decisions with the flexibility to defer decisions when delivery is not yet required. Where relevant, network competition may also need to be factored into delivery timescales.

Dependent reinforcements

In specific circumstances, it may be beneficial to progress reinforcements into the delivery pipeline together, even if a decision can be deferred for one reinforcement. This may be appropriate where the benefit provided by one reinforcement is dependent on the delivery of another. This will be subject to CSNP governance and consider the criteria in Table 16 as well as any interactions with network competition.

Table 16: Dependent criteria

Criterion	Description
Effective	The reinforcement provides significant benefit in combination with another reinforcement relative to its cost.
Certain	The needs case and system interactions are not expected to change, and the reinforcement is clearly favourable compared to alternatives.
Proximate	The reinforcement is in a similar area of the network to the other reinforcement.

For example, the criteria could be met where a network upgrade, with a shorter delivery timescale, unlocks the benefit provided by a more significant reinforcement, with a longer delivery timescale. In this circumstance, it may be advantageous to progress the network upgrade into the delivery pipeline alongside the more significant reinforcement. This approach will provide greater certainty on the future network and system requirements.

Delivery decision tree

Required reinforcements that progress into the delivery pipeline will be subject to Ofgem funding, in line with the relevant funding mechanism, and will be removed from the cyclical process. Reinforcements that are not included in the preferred GB network design or are not yet required to progress into the delivery pipeline will remain in the options funnel and be reassessed in the next CSNP. This is illustrated in Figure 61.

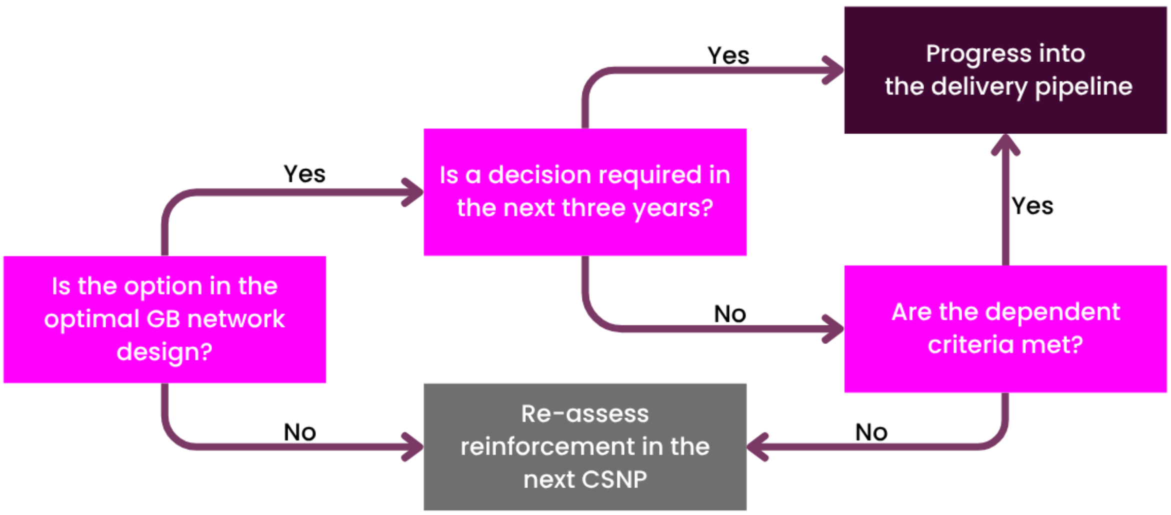


Figure 61: High-level decision tree

Where long-term reinforcement options do not progress into the delivery pipeline, these may form part of indictive GB network designs to illustrate different routes to reinforcing the future network.

Option selection

If the strategic parameters include multiple options, the delivery body will select the final option and progress through the detailed design and delivery stages within the defined strategic parameters. This will enable flexibility to support choices through the subsequent detailed design and delivery stages, including refinements in consideration of design development, appropriate surveys, planning and consenting as well as local engagement. The plan will have determined and evidenced the needs case and strategic parameters of reinforcements, ensuring any selected option provides consistent benefit and supports the wider GB network design.

Ahead of progression into the delivery pipeline and to support Ofgem's funding decisions, reinforcement options may require further development within the defined strategic parameters. If, through this development, a reinforcement option substantially changes, the change control process will be initiated.

Network competition

Competition

NESO will identify required reinforcements that could be put out to tender so that other parties as well as incumbent Transmission Owners can own, operate and maintain parts of the electricity transmission system. There are two types of competition known as early and late. These refer to the point in the development process at which the competition is run. At time of writing, only Early Competition has a mechanism for delivery via The Electricity Regulations 2025.

Early Competition is a competitive process to select a bidder to deliver a specific reinforcement on GB's electricity transmission system. The process begins prior to the detailed design and delivery stages. This means organisations could compete for the design, build and ownership of onshore transmission solutions. Early Competition will help encourage new ways of working and aims to seek the best delivery at a fair cost for consumers. Early Competition will not facilitate solutions relating to system operation which will be identified through Network Services.

Eligibility criteria

Required reinforcements progressing into the delivery pipeline will be eligible for competition where they meet the criteria listed in Table 17 as per The Electricity Regulations 2024.

Table 17: Eligibility criteria for competition

Criterion	Early	Late	Description
Network need	✓	✓	The reinforcement must be capable, with reasonable certainty, of addressing a network need.
Novelty	✓	✓	The reinforcement is a completely new asset or is a complete replacement of an existing asset.
Separability	✓	✓	The boundaries of ownership between the reinforcement and other assets are clearly delineated.
High value		✓	The reinforcement has an expected capital expenditure of £100m or above.
Consumer benefit	✓		The reinforcement is economic to tender in consideration of associated benefits and disbenefits.

NESO will publish reinforcements that meet eligibility criteria for both late and early competition as part of the draft CSNP publication. The outcome of the consumer benefit assessment may be published later as part of the final CSNP publication and NESO will then make requests to Ofgem for any tender as in The Electricity Regulations 2025. This is illustrated in Figure 62. Whilst required reinforcements may meet the eligibility criteria when published, it is not guaranteed these will be taken forward for competition.

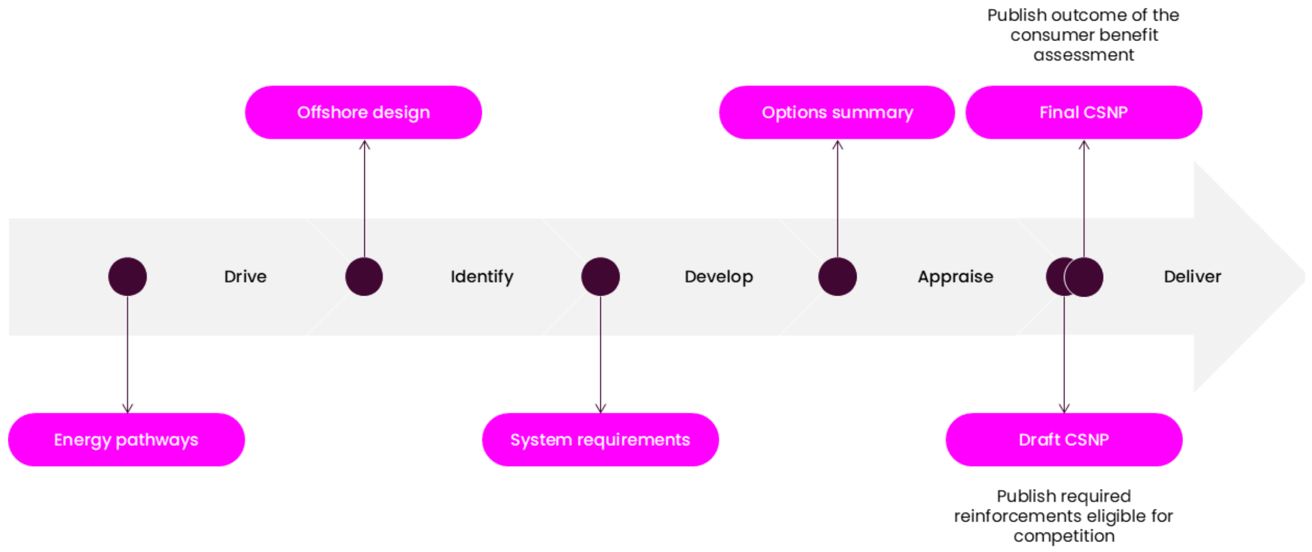


Figure 62: Interactions with network competition

Process

The process to test reinforcements against the eligibility criteria is outlined in Table 18. Some reinforcements that initially fail the separable criterion, in stage five, might pass this criterion if elements can be split away from the rest of the project in stage six.

Table 18: Eligibility process

Stage	Activity	Description
1	Gather all project costs for an area or region that meet the network need criterion. Can the projects be bundled or split?	The stage checks bundling or splitting, for example, because of the similarity of works, location, and timeframes.
2	**Late only** – Is the value over £100m?	The first of a two-stage process, of which the second is stage four (in this table). The trigger threshold is set at £90m to highlight projects that are marginally below the £100m figure. This produces a yes/no output.
3	Is this a new asset or complete replacement?	If a project delivers completely new assets or complete replacement assets that fulfil the same function as the assets

		to be removed or replaced. This produces a yes/no output.
4	**Late only** – Are the new or complete replacement assets over £100m capex?	The second part of a two-stage process, of which the first is stage two (in this table). If the reinforcement has a very high proportion of new assets and high value, the reinforcement will pass this stage. For more marginal projects, NESO uses provided cost breakdowns to calculate the value of the new assets. This produces a yes/no output.
5	Are the new assets separable?	Check if the reinforcement already has points of connection to existing assets that can be clearly delineated. Disconnectors are an example and other points, such as clamps on busbars, would also be acceptable if the point can be clearly identified. This produces a yes/no output.
6	Can the projects be bundled or split?	As for stage one, above. Note that projects that are split must have component parts that meet or exceed the £100m value threshold for late competition. Splitting might be needed to meet the separability criteria.
7	Evaluate if further electrical separation is needed.	If this stage is required, NESO treats any such instances on a case-by-case basis for options that pass the earlier stages and look likely to go to tender. NESO will consider factors such as safety and operability as well as cost and record outcomes along with the method used.
8	**Early only** – Is there a net benefit to run a tender?	Checks if the benefits of tendering outweigh the disbenefits of tendering. This assessment process is described in our Consumer Benefit Assessment Methodology. This produces a recommendation for Ofgem on whether to run a competition. Ofgem then have the final decision of whether this is taken to competition or not.

Cost bands will be used which give industry an indication of the value of reinforcements while maintaining confidentiality. The assumptions are that land costs are included in the costs, but the cost of consents is excluded. The costs apply for new and separable elements only. Table 19 lists the agreed cost bands.

Table 19: Cost bands

Cost band
£100m - £500m
£500m – £1,000m
£1,000m - £1,500m
£1,500m - £2,000m
Greater than £2,000m

Change control

Scope

The needs case and strategic parameters of the reinforcements in the delivery pipeline will not be reassessed, unless there are substantial changes to the reinforcements or their needs case. In such cases, a change control process will be initiated. This process will assess the impact of any changes on the strategic plan but not evaluate specific developments through the detailed design and delivery stages.

Independently of the change control process, delivery bodies will be subject to delivery incentives and a full project funding assessment with Ofgem. As part of Early Competition, CATOs will be subject to change control measures, incentives and funding arrangements as per the Commercial Framework. The change control process will not apply to solutions identified through Network Services.

Materiality triggers

The process will be initiated under a limited set of materiality triggers. These are outlined in Table 20 and apply to any wider reinforcements determined in the CSNP.

Table 20: Materiality triggers

Change	Trigger	Description
Strategic parameters	Any change to the strategic parameters of reinforcements.	The plan will determine the strategic parameters of reinforcements. Any change to these parameters will require a reassessment.
Electrical configuration	A material change to the electrical configuration, including to the interface zones or the additional boundary capability provided.	A change to the selected interface zones may impact future interacting reinforcements or additional drivers; this will only be applicable if the strategic parameters include multiple options. A material change to the additional boundary capability provided will also necessitate reassessment.
Capital cost	A 50% increase to the total capital cost of the reinforcement.	A material change to the cost of a required reinforcement will prompt reassessment.
Delivery year	A delay to the delivery year of the reinforcement.	A material delay to the delivery of a reinforcement will trigger the change control process. Where a delivery range is

defined, this trigger will be redefined accordingly.

The change control process may also be initiated where there are material changes to the needs case of reinforcements. The needs case of required reinforcements, including any additional drivers, will be regularly monitored in the delivery pipeline by NESO as well as against the latest energy pathways every three years. Alongside the needs case, changes to interacting reinforcements, including to the offshore design, may also initiate the change control process.

Delivery monitoring

To ensure network delivery in line with the CSNP, NESO will monitor the delivery of electricity transmission network reinforcements in the delivery pipeline. This will build upon the electricity network delivery and monitoring group established as part of Clean Power 2030. The group will support the timely identification of change and the mitigation risks through the detailed design and delivery stages. The group is anticipated to meet every three months with representation from NESO, Ofgem, DESNZ, and delivery bodies.

As part of the electricity network delivery and monitoring group, delivery bodies will be expected to submit the latest data and status of reinforcements in the delivery pipeline as well as raise any risks on a regular basis. A reporting dashboard will log and assure any updates through the detailed design and delivery stages which will be flagged in accordance with the triggers outlined in Table 20. Updates may also be provided by NESO, where relevant. The electricity network delivery and monitoring group will be responsible for governing next steps following any updates, including whether and when a reassessment is required as well as the outputs of any impact assessments.

The high-level change control process is outlined in Figure 63.

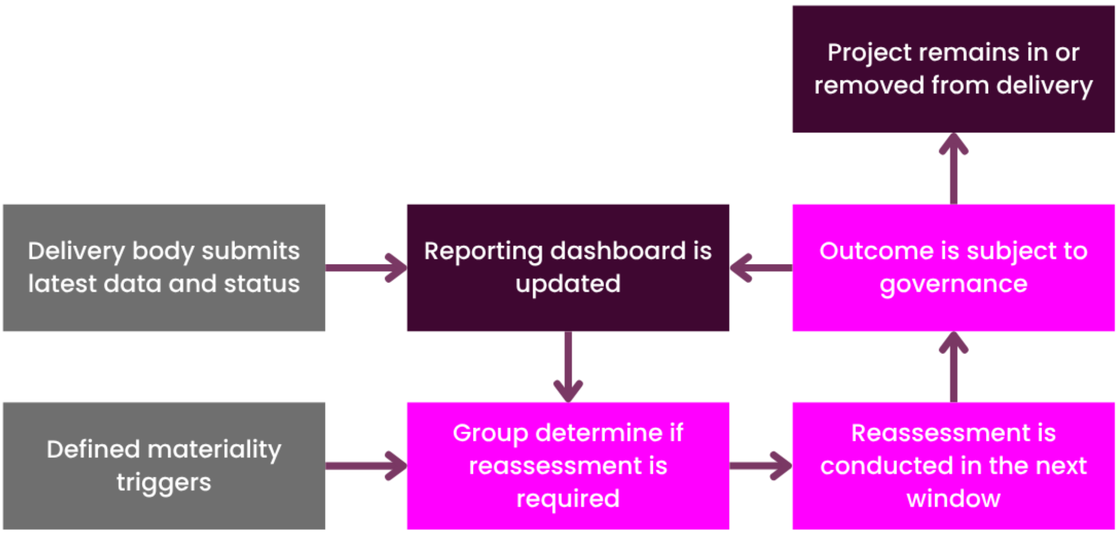


Figure 63: Change control process

Where a reinforcement triggers the change control process, it will be reassessed through a six-monthly change control window. The windows will provide opportunity to collectively coordinate and assess any substantial changes to reinforcements or to the offshore design. NESO will reserve the right to extend or run the process outside of windows where there are potential benefits or opportunities. Depending upon the outcome of the process, the reinforcement will either remain in or be removed from the delivery pipeline.

Reinforcements will only be in-scope of the change control process up to the completion of the full project funding assessment with Ofgem. Where a change has potential for significant impact, such as across multiple boundaries or reinforcements, NESO may decide it needs to be reassessed alongside broader alternatives in the next CSNP. The six-monthly windows may also be adjusted to ensure the robustness of the appraise step in any parallel CSNP.

Reassessment

To ensure an efficient, timely process, an initial evaluation will be conducted on reinforcements that initiate the change control process. This will consider the impact of change and determine whether a full impact assessment is required.

If a full impact assessment is required, an in-depth assessment will be conducted. This will follow a similar approach to the appraise step, including consideration of the multiple assessment criteria. As appropriate to the impact of change, the impact assessment may focus on a particular area of the network. The outcome of any impact assessment will be subject to governance. The delivery body will be responsible for providing NESO with sufficient information on the context, details and justification for change to enable reassessment. If there is a change to the strategic parameters of a reinforcement, this may require amendments to statutory environmental assessments. NESO will consider whether to conduct amendments within the window or as part of the next CSNP depending upon the significance and timing of the change.

Question: Do you agree with the approach to progressing required reinforcements into the delivery pipeline

Question: Do you agree with the change control process?

Navigation

Return to the whole system overview

Read the gas section of the methodology

Read the hydrogen section of the methodology

Read the methodology’s annexes, including the glossary

Respond to the electricity consultation

9. The CSNP for Gas

Introduction

Drive

Identify

Develop

Appraise

Plan publication

Deliver

Introduction

This section sets out our proposals for how we plan the gas transmission system elements of the CSNP.

Our gas system planner licence[4] sets out specific obligations in respect of planning the gas transmission network. These obligations are set out in condition C8. Our gas system planner licence also requires the creation of the CSNP to provide an independent view out for 25 years across electricity, gas, and hydrogen. We will deliver our C8 licence obligations as part of delivering the CSNP.

To ensure consistency and clarity, we will reference the existing processes that meet our C8 licence condition: the Gas Network Capability Needs Report (GNCNR) and the Gas Options Advice (GOA). This section seeks feedback so that our existing methodologies can be further developed and integrated into the CSNP.

Key messages

- The gas transmission network is owned and operated by National Gas (commonly referred to as NGT: National Gas Transmission). NESO has strategic planning responsibilities of the NTS.
- The gas processes within CSNP will be carried out through the existing deliverables set out in the gas system planner licence.
- The GNCNR and GOA methodologies form the basis of this document, with feedback needed to integrate them within a whole-system CSNP.

Our gas-specific obligations form part of a two-year gas network planning cycle, which identifies gas transmission network needs and drives the development and assessment of network reinforcement options. Gas network planning is carried out in collaboration with National Gas Transmission (NGT). NGT is the System operator and owner of GB's gas transmission system, the National Transmission System (NTS).

The NTS is made up of over 7,660 km of pipeline, 24 compressor sites, eight gas terminals, and over 350 above ground installations, and is owned by NGT.

The planning cycle begins with us identifying the NTS system physical capability needs through the GNCNR. Based on these findings, NGT will develop the Strategic Planning Options Proposal (SPOP) to propose network reinforcement options. The GOA completes the gas planning cycles, by providing an independent assessment of the proposed reinforcement options. The outputs from this cycle support Ofgem in making decisions on funding and progression of asset interventions for the NTS.

[4] NESO's Gas System Planner licence condition

Although we provide recommendations for the options to meet the NTS's needs, Ofgem or other relevant parties will ultimately decide on the investments made.

Question: Are there any additional processes or analyses you believe should be considered in gas network planning?

Figure 64 illustrates the gas network planning cycle:

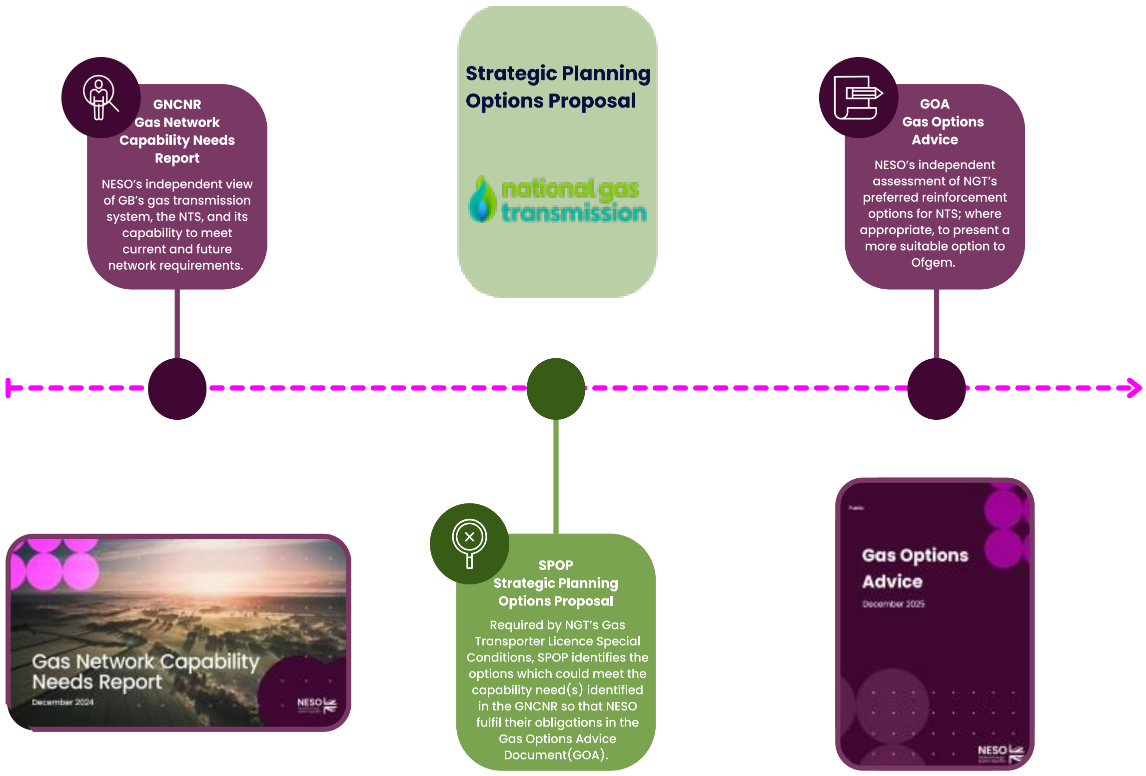


Figure 64: Gas network planning cycle

In December 2024, we published the GNCNR which was our first gas publication based on these new licence conditions. The GNCNR 's purpose is to offer an independent view of GB's gas transmission system, the NTS, and its capability to meet current and future network requirements.

If you want to see more detail on the GNCNR 2024 report and its associated documents, you can access them on our website at: neso.energy/what-we-do/strategic-planning/gas-network-capability-needs-report-gncnr

The SPOP is NGT's response to the capability needs identified by NESO in the GNCNR. This is required as per Special Condition 9.10 of NGT's Gas Transporter Licence. NGT is obligated to share the SPOP with NESO and Ofgem.

Once these options are proposed, NESO will analyse them to recommend a preferred option that is either an option presented in SPOP or a new option that NESO believes is a preferred option. The outcomes of this will be published in the GOA document.

Question: Should gas network planning align with electricity and hydrogen by publishing proposed options before assessment?

Drive

Overview

Key messages

- The gas processes within CSNP will be informed by the Strategic Spatial Energy Plan and NESO's Future Energy Scenarios.
- CSNP is underpinned by the outputs of the SSEP, which provide the capacity requirements for the hydrogen and electricity network infrastructure but also has a base assumption that the gas network is capable of meeting gas demand.
- By considering a wide range of possible supplies and demands based on the FES net zero pathways and the counterfactual, the gas network will be able to maintain appropriate levels of safety and security.

Context

The primary element of establishing gas transmission network needs is forecasting future customer-led flows of gas into and from the NTS. It is these flows against which the capability of the NTS is assessed.

Predicting market behaviour has long been challenging, making it difficult to forecast with certainty the sources from which GB will import its gas -the future supply and demand of gas is uncertain.

Planning for the future

As we transition and progress towards a future powered by clean energy, the role of a resilient and secure gas network will continue to be important into the foreseeable future.

The gas network needs to maintain appropriate levels of safety and security despite wide and growing uncertainty. The network needs to be adequately sized and reliable to meet customer demands under a variety of conditions while supporting continued economic growth.

Future energy pathways

Strategic Spatial Energy Plan

The SSEP assumes a level of gas network capability is retained to ensure that gas is available as a fuel for power generation and a feedstock for hydrogen production.

CSNP uses SSEP as an input. It provides the capacity requirements for hydrogen and electricity network infrastructure but also assumes the gas network is capable of supplying gas demand. Such demand covers fuel for power, feedstock for hydrogen production, residual heating load in housing and industry.

We will continue to develop our processes to ensure future alignment and cohesion of strategic plans. For more information on the SSEP, you can review the latest methodology documents on our website.

Future Energy Scenarios

The FES net zero pathways and the counterfactual provide four separate views of supply and demand across GB for each year from now until 2050. The next FES iteration will also provide a 10-year forecast.

We model each of these datasets separately to identify the different NTS capability needs by creating a range of possible supplies and demands. This range considers uncertainties such as weather, the day of the week, and historical data.

The GNCNR considers the FES net zero pathways and the Counterfactual out to 2050 for its assessment of the NTS capability needs. Consequently, NGT's SPOP deliverable and the GOA publication also use the FES net zero pathways and the Counterfactual to assess the NTS investment options out to 2050 to reflect future uncertainty, identify system requirements, meeting future energy needs and supporting economic growth.

For this reason, we propose that the CSNP considers FES inputs also ensuring consistency with gas generation profiles from SSEP data, for its gas network planning processes, aligning to future FES ten-year forecasts.

Pathway usage

The SSEP will determine the NTS system needs for gas-fired power generation. The CSNP gas-specific analysis is supported by the FES, which enables NESO to analyse different long-term strategic energy pathways that outline the system requirements for enabling net zero.

Question: Do you agree with our approach to base gas planning activities within the CSNP on needs from the SSEP, supplemented by FES net zero pathways and the counterfactual?

Identify

Key messages

- The CSNP gas-specific system requirement analysis will be carried out using the GNCNR methodology, ensuring that any current or future system needs identified on the gas transmission network are clearly communicated to our stakeholders.
- We will use a zonal approach to assessing the gas transmission network's capability needs.
- In order to accurately carry out strategic planning for the NTS, physical entry and exit capabilities are assessed using a range of demand and supply data.

Overview

In order to deliver the gas-specific system requirement analysis within the CSNP, we are proposing to use the GNCNR methodology. This will enable us to identify any current or future system needs identified on the gas transmission network.

'Network capability' is a defined term used by the gas industry to mean the maximum flow of gas that the network can physically transport to or from specific locations or zones. This is to be done without exceeding high pressure safety limits or compromising any equipment safe operational tolerances whilst still meeting pressure obligations at offtakes. Network capability can be influenced by various factors, such as supply and demand fluctuations and the availability of network assets.

Where the network capability is insufficient to provide the pressures or flows needed by customers, this can lead to a constraint. These are either an entry or exit constraint depending on whether it is impact gas flowing into or from the network. Where a constraint materialises, NGT may choose to manage these situations commercially and through other constraint management tools[5].

Zones

To simplify communication of the capability of the network, the NTS is divided into seven 'zones'.

Both the zonal concept and the construction of the zones were introduced by Ofgem and NGT as part of the 'Revenue = Incentives + Innovation + Outputs' (RIIO) business planning process and were used in historical publications of NGT's Annual Network Capability Assessment Report (ANCAR). Each zone has distinctive gas flow requirements and characteristics.

[5] Constraint management | National Gas

The geographic descriptions, for instance South East, are provided as indicative explanations for each zone. For example, Zone 4, commonly known as South Wales, covers not only South Wales but also part of the Midlands.

The zones are referred to as:

- Zone 1 – Scotland and the North
- Zone 2 – North West (including North Wales)
- Zone 3 – North East
- Zone 4 – South Wales
- Zone 5 – South West
- Zone 6 – East Midlands
- Zone 7 – South East

Gas is delivered to the NTS via entry points which comprise terminals and storage sites. Exit points are above ground installations known as offtakes, they are connected to the NTS where the gas leaves the network. These are mostly lower pressure gas distribution networks that supply mainly homes and businesses. However, there are some large industrial users directly connected to the NTS such as power stations, energy-intensive industry, gas storage sites and interconnectors. Figure 65 illustrates how the NTS is split into the zones.

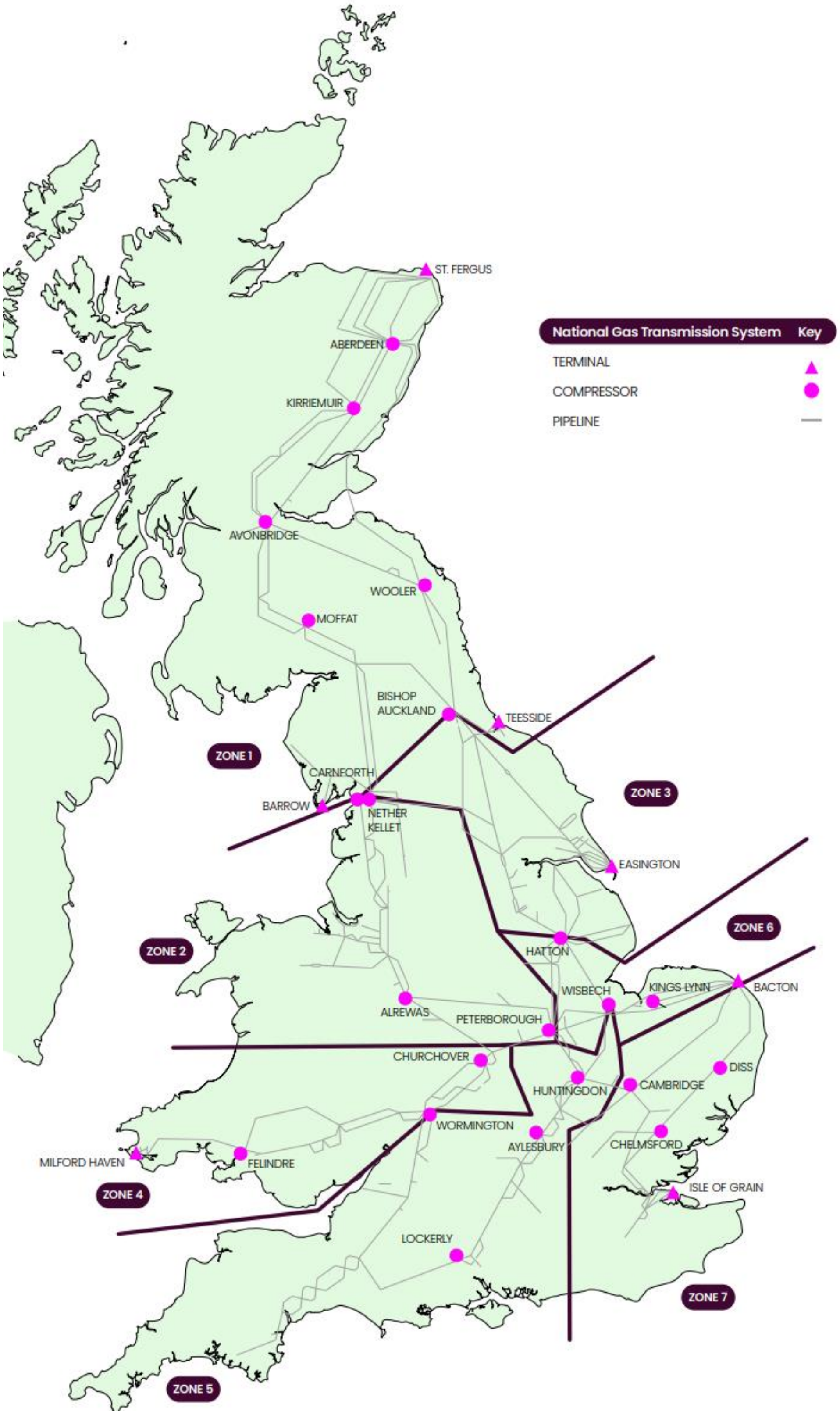


Figure 65: NTS map split into zones

Network analysis

At NESO, we use specialist gas network analysis software to simulate gas transmission networks under a variety of conditions. We consider both steady state conditions (which assumes perfect balance between time-invariant supply and demand) and transient conditions (where supplies and demands can independently change over time, creating temporal imbalances). The analysis helps us understand how the network performs. This analysis is crucial for planning the current and future needs of the gas network.

NTS capability is defined as either:

- Physical entry capability, representing the amount of gas that can be supplied into the NTS at a point or into a zone
- Exit capability, representing the amount of gas that can be delivered from the NTS to customers

There is a requirement for NGT to design the NTS as stated in the Transmission Planning Code (TPC) [6]. Where entry and exit capability gaps on the NTS are highlighted in the GNCNR these will be further assessed as part of the GOA process via NGT's SPOP submission.

Entry capability

The methodology to analyse entry capability of the NTS process is summarised below:

- A base case model is first created in the gas network simulation software by importing supply and demand data from our FES data having considered gas generation profiles from SSEP data.
- To determine the entry capability of the selected zone, the supply in the zone is increased gradually from the base case supply forecast ensuring there are no network constraints.
- As the supplies in the selected zone are increased, the supplies in other zones should be rebalanced, starting with the supply point of least interaction (determined by pipeline distance). Each supply point is reduced to minimum forecast supply before moving on to the next nearest balancing point. In all cases NTS supply in the model will remain the same after rebalancing.
- The step-size increment of the model will continue until the scenario or network reaches a constraint. The last supply volume into the zone before the constraint is reached is the maximum entry capability. The model is solved in the simulation software to ensure all pressures and network conditions are met and the network can be operated in an efficient manner.
- Entry capability models are generated to cover a range of selected demand levels and the results used to plot the entry capability boundary line for the selected zone.

[6] https://www.nationalgas.com/sites/default/files/documents/TPC%202023%20v0.4.pdf

Creating the base case model

The base case derives its inputs from the FES forecasts which are assessed against the SSEP gas profiles. We create forecasts for a range of demand levels, covering summer, typical winter, and more extreme winter conditions. These forecasts are created for each FES pathway and the FES counterfactual, in line with the TPC.

Additional information is considered to model within-day variation: for demand this is taken from Gas Distribution Networks' forecasts of requirements and from power station analysis; and for supplies, we consider historical information.

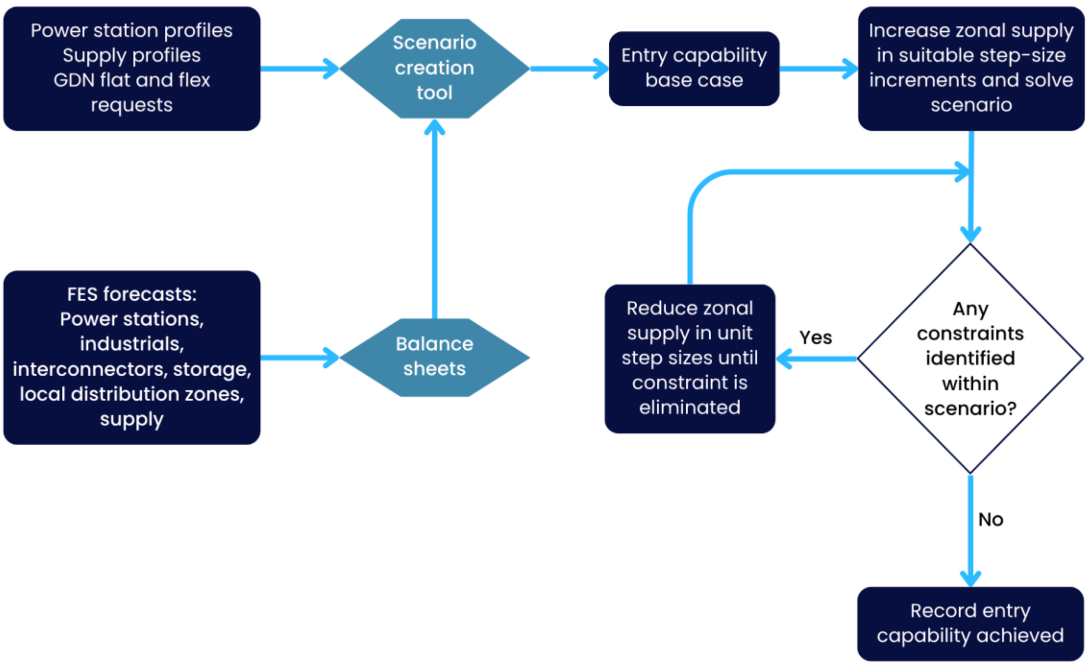


Figure 66: Entry capability assessment process

Zonal supply adjustment

Entry capability assessment is done for each zone by increasing the supply in the zone from the forecast in the base case model gradually in suitable step size increments. The increase in supply for each supply node in the zone is rebalanced by reducing an equivalent amount from the least interacting point determined by pipeline distance. Each balancing node is reduced to forecast minimum supply as per FES forecasts before moving on to the next balancing node.

The rebalancing of supply flows ensures that total supply remains in balance and same as demand.

The entry capability is the maximum supply into the zone that can be effectively solved within the scenario without reaching a constraint.

Network assessment

Each entry capability model is created from the base case steady state model and finally a transient model is solved to ensure that the capability can be achieved when within-day supply profiling, power station profiling and Gas Distribution Network (GDN) requirements are taken into consideration. Within-day and geographical balance between supply and demand is examined within the transient analysis to ensure the network operates within safe limits.

An entry capability model is defined as solved when all exit point and other pressure requirements are met, and that compressors and other equipment are operating within their design limits. Further details of network analysis and assumptions can be found in section 6 of the TPC.

Creating the entry capability boundary curve

The results from the entry capability assessments for each modelled demand level are plotted and a curve is fitted to predict the entry capability in the zone at any demand level. The capability curve can also be used together with the flame charts for constraint analysis[7]. A sample of the boundary capability line plot is shown below:

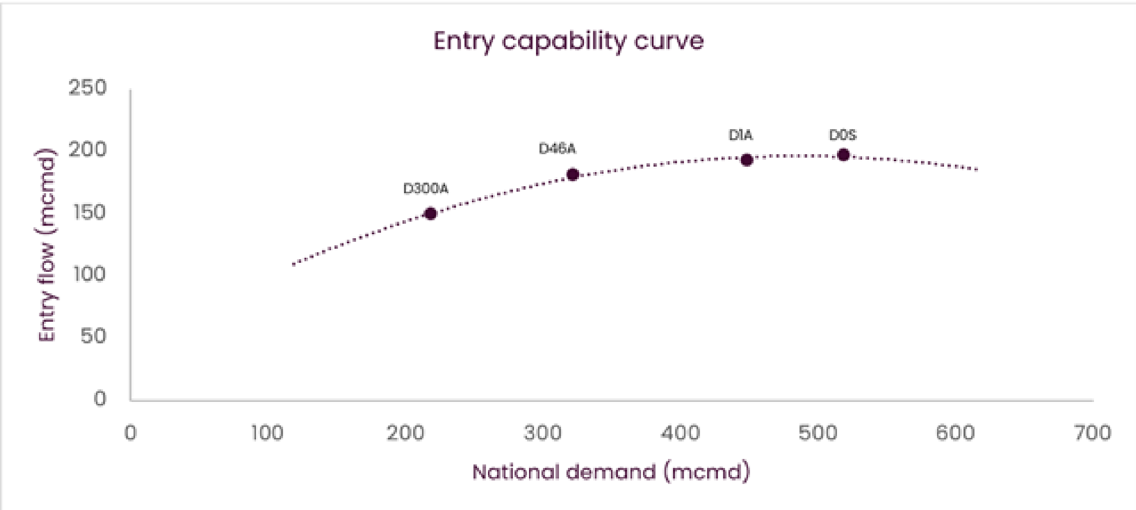


Figure 67: NTS entry capability curve

Note:

- D30DA = forecast 300th highest daily demand from an average weather year

[7] See GNCNR Methodology

- D46A = forecast 46th highest daily demand from an average weather year
- D1A = forecast highest daily demand from an average weather year
- D0S = forecast peak day demand from a severe weather year

Exit capability

The methodology to analyse exit capability of the NTS process is summarised below:

- A base case model is first created in the gas network simulation software by importing supply and demand data from our FES data having considered gas generation profiles from SSEP data.
- To determine the exit capability of the selected zone, the supply in the zone is decreased gradually from base supply forecast ensuring there are no network constraints.
- As the supplies in the selected zone are decreased, the supplies in other zones should be rebalanced starting with the supply point of least interaction (determined by pipeline distance). Each supply point is reduced to minimum forecast supply before moving on to the next nearest balancing point. In all cases NTS supply in the model will remain the same after rebalancing.

Creating the base case model

The base case derives its inputs from the FES supply and demand forecasts[8] and SSEP pathway. Network analysis is carried across a range of demand conditions.

Additional inputs required to create the base case include GDN's capacity requests for the relevant gas year, supply profiles for supply terminals as well as power station profiles for use in transient analysis. Exit capability is assessed using both static and transient analysis in line with section 6 of NGT's TPC.

[8] See Gas Demand Forecasting Methodology

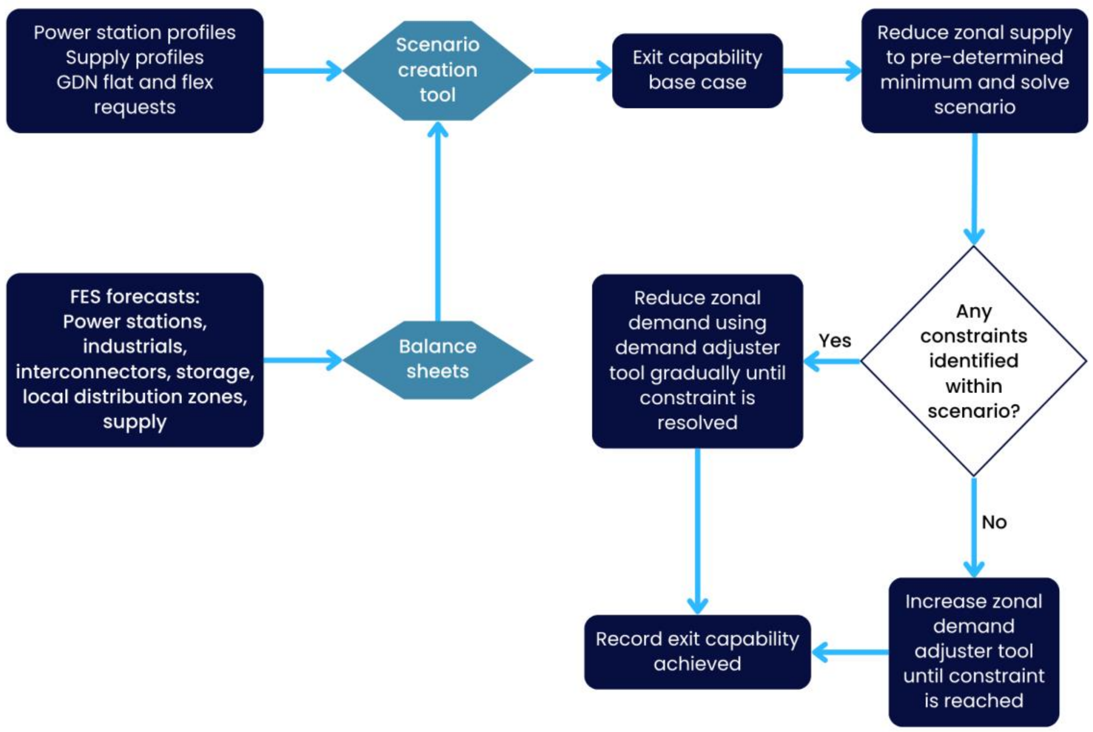


Figure 68: Exit capability process

Exit capability assessment is done in each zone with a minimum supply assumption, creating a reasonable worst-case scenario for assessing the exit capability. The minimum supply assumption in each zone is influenced by forecasted minimum flows as per FES pathways, physical network minimum operational requirement, as well historical minimum flows. This approach allows for the comparative assessment of the ability to utilise compression to move gas from high supply regions of the NTS to lower supply regions or the zone of interest.

The adjustment of flows at supply points within the zone of interest is rebalanced at the supply point of least interaction (determined by pipeline distance) to keep total supply in balance and same as demand. The requirement for balance between demand and supply is in line with long term planning analysis requirement under the TPC.

Once the minimum supply assumption is met and network can be solved without constraints or pressure breaches, the demand in the zone of interest is increased gradually until a constraint is reached. The increase in demand in each zone is rebalanced in other zones. The rebalancing methodology adjusts the demand from three or four least interacting zones to the zone of interest. The demand in the zone can also be reduced to assess the exit capability in the zone if there are constraints or pressure breaches resulting from reducing supply in the zone to minimum supply.

Network assessment

Each exit capability model is created from the base case static model. A transient model is solved to ensure that the capability can be achieved when within-day supply profiling, where within-day power station and GDN offtake profiles are taken into consideration. Linepack balance across the gas day must also be maintained and this is assessed in the transient models.

An exit capability model is defined as solved when all exit point pressure requirements are met, Pipeline Maximum Operating Pressures (MOPs) are within limits, and compressors and valves are operating within design limits. further details of network analysis and assumptions can be found in section 6 of the TPC.

Creating the exit capability boundary curve

The results from the exit capability assessment across different days is plotted to create the boundary curve for the zone. The curve can be used to predict exit capability in the zone at any demand level. The capability curve can also be used together with the flame charts for constraint analysis[9]. A sample of the boundary capability line plot is shown below (Figure 69):

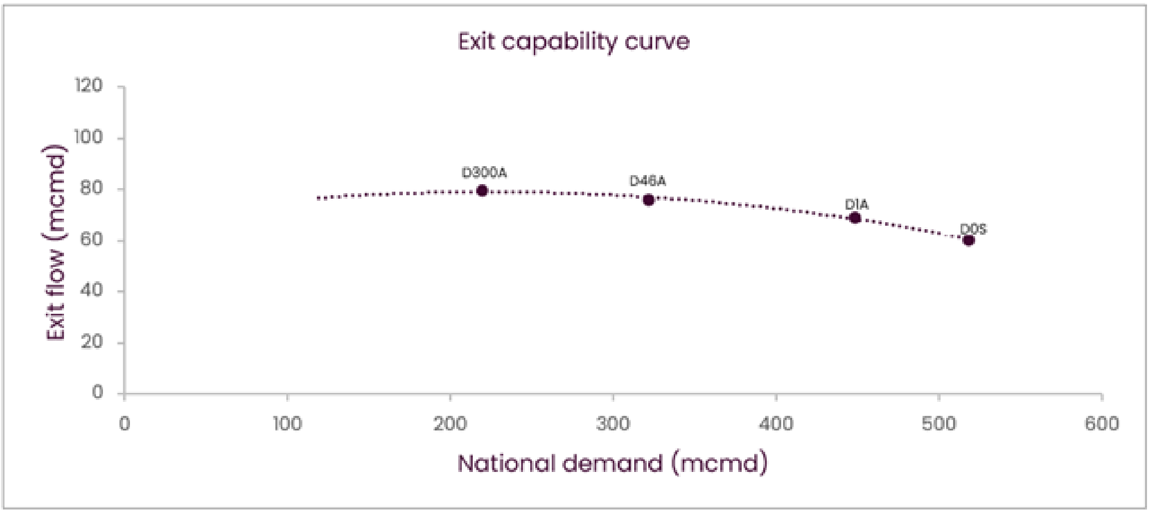


Figure 69: NTS exit capability curve

Note on figure 69:

- D30DA = forecast 300th highest daily demand from an average weather year
- D46A = forecast 46th highest daily demand from an average weather year
- D1A = forecast highest daily demand from an average weather year
- D0S = forecast peak day demand from a severe weather year

[9] See GNCNR Methodology

Network capability flame charts

To visualise the capability of the NTS we include different sets of information on a figure referred to as a 'flame chart'. The information includes a large series of supply and demand forecasts (shown as individual points with different colours representing the density of points), two curves that describe the physical capability of the network, a line which represents 'baseline entry' or 'baseline exit' capacity[10], and a point representing a peak day demand forecast.

Looking at the flame chart in Figure 70 there are several data points which are above the capability line. The number of data points above the line compared to the total number of data points in the chart shows the probability of the constraint.

NGT is also required to plan and develop the NTS such that it meets the 1-in-20 peak day. The 1-in-20 peak day demand is the demand, in a long series of winters, at connected loads held at the levels appropriate to the winter in question that would be exceeded in one out of 20 winters, each winter being counted only once. It is more specifically defined in NGT's licence and described in the Gas Demand Forecasting Methodology[11].

The flame charts illustrate our analysis of the capability needs under two different sets of assumptions: an 'intact network' – which assumes all compressors are available, and a 'high resilience' condition, where some compressors are unavailable. This is described in more detail in the next section. A capability curve for each zone is derived from network analysis undertaken across a range of different national demand levels.

[10] Capacity 'baselines' are specified In NGT's gas transmission licence
[11] National Grid, Gas Demand Forecasting Methodology, 2020, pp 38 - 39, available at: nationalgas.com/sites/default/files/documents/Gas%20Demand%20Forecasting%20Methodology%202020_v1.pdf.

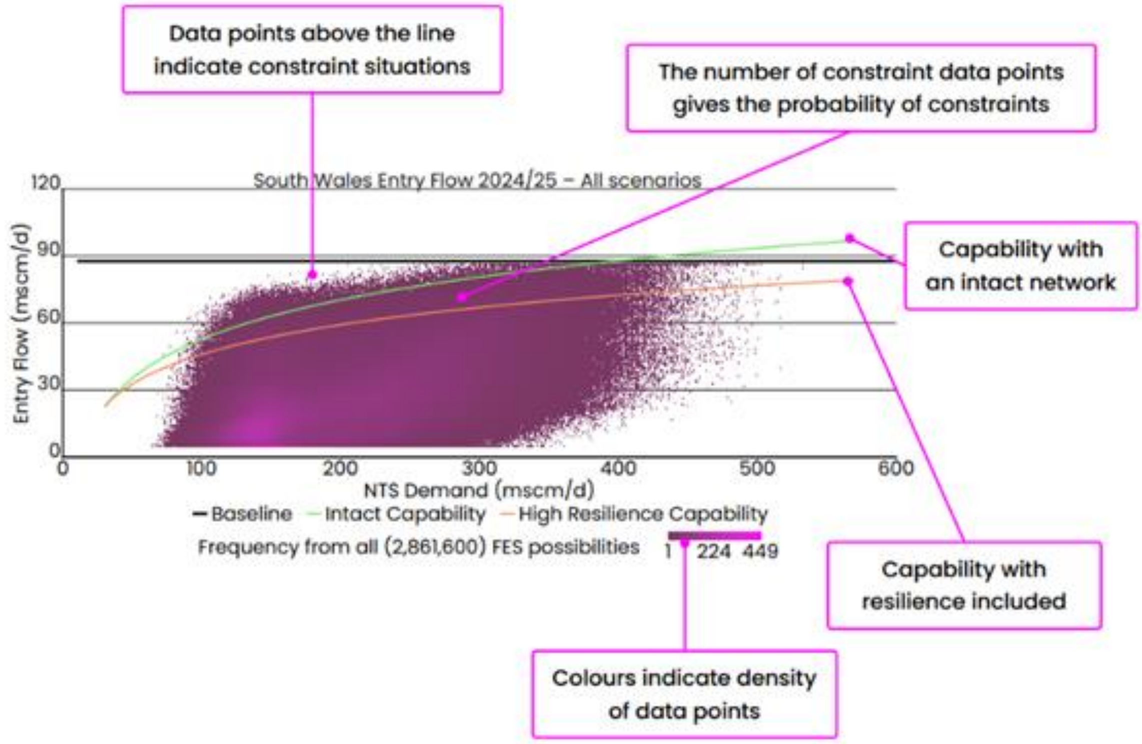


Figure 70: Network capability flame chart explanation

Resilience

In order to deliver a resilient transmission infrastructure, we will undertake a resilience assessment within the CSNP. For both gas and electricity, resilience analysis will consider the impact of a N-1 standard for security of supply.

The gas security of supply regulation requires the United Kingdom to ensure that, in the event of a disruption of the single largest piece of infrastructure, the remaining infrastructure has sufficient capacity to satisfy the total demand occurring during a day of exceptionally high gas demand occurring with a statistical probability of once in 20 years[12]. This requirement is measured through the N-1 infrastructure resilience standard.

As per the definition available in section 9.6 of the TPC, the N-1 standard facilitates the following:

- ensuring the provision of gas to protected customers,
- ensuring a minimum standard of infrastructure resilience,
- ensuring there are adequate preparations for a gas supply emergency,

[12] nationalgas.com/sites/default/files/documents/TPC%202023%20v0.4.pdf

- improving coordination between markets to enable regional cooperation and support, and
- ensuring the gas market functions for as long as possible in the event of an emergency.

It is important that the CSNP considers all factors that impact resilience to ensure that the gas transmission network remains reliable and resilient.

The way this is achieved is by assessing the physical capability of the NTS and how it compares with future network requirements. An intact capability is calculated based on an assumption that all compressor stations and other operational equipment are fully available for use. It is not always possible to achieve intact capability because one or more compressor units may be unavailable at any given time. There are a variety of reasons for this, which could include planned and unplanned maintenance or other asset health-based interventions. To understand the impact of lowered availability, 'high resilience' capability analysis is carried out to reassess the network's capabilities.

High resilience capability analysis involves assessing the maximum physical entry and exit capacity a zone can deliver for each forecast supply/demand day, using a subset of compressors needed for full availability. The subset is calculated using the mathematical combinations technique and probability theory with the availability of station and unit availability assessed for each zone.

The subset of compressors required to achieve the resilient capability, is calculated such that the probability of unavailable compressor units is less than or equal to 1% i.e. the theoretical likelihood of available compressors is at least 99%.

The subset of units is selected based on the following rules in the stated order:

1. All units at compressor stations with overall station availability less than 50% will be considered unavailable. The subset will thus be selected from the remaining compressor stations.
2. High availability (or reliability) units are selected first up until subset total is reached.
3. Priority will be given to units in compressor stations with higher availabilities where a choice is to be made between two units of the same availability.
4. Units that can be run in parallel or series with higher availability units in the same compressor station will be prioritised where a further choice is to be made between units of the same availability.

At least one unit from each compressor station should be selected where possible to ensure this is consistent with maintenance outage planning strategies. This may not be possible all the time in the following circumstances:

- If the subset number is reached by selecting high availability units from other stations or
- Intact station availability is lower than the target value at one of the sites

The resilience capability curve was analysed in the same entry or exit capability flame chart that can assess the potential amount of constraint days, where a constraint was determined as a supply/demand day that is above the physical NTS capability.

Resilience calculation example

The subset is calculated using the mathematical combination technique. Using this technique, the number of units that can be selected out of the 8 units with at least 99% likelihood is determined. The probability of selecting 4 out of the 8 units is calculated as:

$$8c4 = \frac{4}{8} \times \frac{3}{7} \times \frac{2}{6} \times \frac{1}{5} = 0.01 = 1\%$$

By selecting 4 units, it means 4 units are not selected (unavailable) thus the probability of unavailable compressors is similarly 0.01 (1%). If 5 units were selected, this would be same as the probability of 3 compressor units not selected. The probability of having the 4 units available, from the South Wales example, can alternatively be calculated from probability theory (complementary events and mirror probability rule) as:

$$Probablility\ of\ having\ 4\ of\ 8\ units = 1 - probability\ of\ not\ having\ 4\ units$$

$$P(4\ units) = 1 - 0.01 \times P(4\ units) = 0.99 = 99\%$$

The GNCNR methodology consultation will be open in early 2026 where we anticipate consulting on how we:

- calculate resilience and consider asset reliability and availability, and
- assess proposals for repurposing gas transmission assets.

Additionally, there is currently a NGT consultation to review TPC which could lead to changes in the way we do GNCNR.

Question: Do you agree with using the GNCNR methodology for CSNP system requirements analysis in gas transmission network planning?

Develop

Key messages

- The options assessed as part of the gas-specific CSNP process can be developed and put forward either by NGT or NESO.
- NGT use the system needs identified in the GNCNR to develop and propose appropriate network reinforcement options. These form the Strategic Planning Options Proposal (SPOP) publication, which are assessed as part of the GOA.

Overview

The CSNP process will be able to receive network reinforcement options from licenced network operators. In the context of gas network planning, this is essentially limited to NGT, in their capacity as the owner and operator of the NTS, although may include the use of third-party actions, for example from GDNs. NESO can also propose options, where deemed appropriate.

The GNCNR identifies the NTS system physical capability needs for the next five and ten years with a view out to 2050, highlighting if the NTS has sufficient or insufficient capability (known as constraints) for each relevant entry and exit zone.

NGT then uses the findings from the published GNCNR to develop options where NTS capability needs are identified, with the view for these to be assessed as part of the GOA publication.

Development process

SPOP overview

The SPOP is NGT's response to the capability needs identified by NESO in the GNCNR. This is required as per special condition 9.10 of NGT's Gas Transporter Licence [13].

The purpose of the document is to identify the options that could meet the capability needs identified in the GNCNR. Such options may involve construction, expansion, reinforcement, repurposing, replacement or decommissioning. NGT will present a range of options with a cost estimate, physical specifications, technical criteria, and estimated deliverability for each option. NGT will also calculate the impact on the physical network capability that each option creates once implemented.

Decommissioning or repurposing

In addition to NGT's response in the SPOP, the potential of decommissioning or removal of the NTS will be reviewed to support the long-term coordinated approach of long-term

[13] 'National Grid Gas plc Special Conditions

network planning across GB. This will be especially relevant where repurposing options are presented to meet hydrogen network needs.

Any recommendations for asset decommission, removal or repurpose to hydrogen, CCUS or other energy vector assets will be assessed during the options assessment process with the GOA publication.

Question: Do you agree with using the GOA methodology for CSNP options development in gas transmission network planning?

Appraise

Key messages

- In the options assessment stage, we will use specific criteria to evaluate the impacts and benefits of proposed network reinforcement options. Assessment criteria will include economic, environmental, and community impacts and deliverability.
- Our assessment framework for the gas-specific processes within the CSNP will use the Gas Options Advice (GOA) methodology.
- The purpose of the assessment is to develop our view of the suitability of proposed investment options that could meet any needs identified in the GNCNR, ensuring that any findings and recommendations put forward are clearly understood by our stakeholders.
- Our assessment of environmental impacts includes key factors with defined costs, such as emissions (including CO2), and a general view of potential environmental issues and their consequences for viability. Additionally, we assess the location of new assets, considering both environmental and social impacts.

Overview

The options assessment part of the gas processes within the CSNP looks to evaluate the network reinforcement options identified from NGT and NESO. We will do so in a fair, robust, and transparent manner so that we can inform investment decisions needed to address NTS system needs.

Our assessment framework uses the existing Gas Options Advice (GOA) methodology, considering both quantifiable and non-quantifiable factors, and therefore reducing subjectivity and increasing transparency of any asset investment decisions.

The GOA methodology was consulted during May 2025 to seek input from stakeholders on a detailed options assessment process as part of the gas network planning process for 2025 GOA. A detailed GOA methodology will be published in summer 2025, considering the stakeholder feedback received.

We are intending to include the same methodology into the 2027 CSNP methodology.

Question: Do you agree with using the current GOA methodology for the 2027 CSNP, or should there be another consultation for the next GOA cycle?

GOA's purpose

The purpose of GOA is to set out, as far as is reasonably practicable:

- Our view of the drivers for change to the NTS, considering security standards, gas supply and demand requirements, deliverability, and entry and exit capacity obligations.
- Our view of the suitability of proposed investment options that could meet any needs identified in the GNCNR.

The options assessed in the GOA could be proposed either by NGT in the SPOP or be put forward by NESO. Such options can involve no or minimal construction, expansion, reinforcement or replacement of the NTS. In addition, options that relate to rules, codes, and legislation that underpin the regulatory framework or operation of pipeline systems may be considered, as well as options related to the practices, services and commercial arrangements within the energy market.

The assessment can be carried out on either a single option or a combination of options and will support the NTS capability requirements for entry capability, exit capability, or a combination of both. The output of this assessment offers recommendations along with an explanation of how the conclusions were reached.

Should our view of the physical capability needs of the NTS have changed or updated since the publication of the GNCNR, these changes will be clearly stated in the GOA. Focus will be placed on any significant system needs changes that could impact NESO's view of the options and the recommendations put forward.

Our analysis will also consider other arrangements or agreements with other parties regarding the development of the NTS, where there is a long-term impact on the NTS.

The GOA will provide a detailed analysis of each investment proposal based on the economic, environmental, social, and deliverability aspects. NESO and NGT might hold different views on the proposals put forward; those material differences will be identified along with their implications.

Due to the sensitive nature of the commercial proposals, we will take due care to exclude any information that may affect relevant commercial interests. All relevant information will be shared with the regulator to enable them to make the necessary decisions.

Decision-making framework

We will carry out an unbiased assessment of all investment options put forward by NGT. Those proposals are created to meet each identified shortfall in capability. This evaluation will result in the recommendation of the preferred solution.

We consider each option by assessing the following aspects:

- direct economic impacts (capital and operational costs)

- environmental impacts
- social impacts
- deliverability

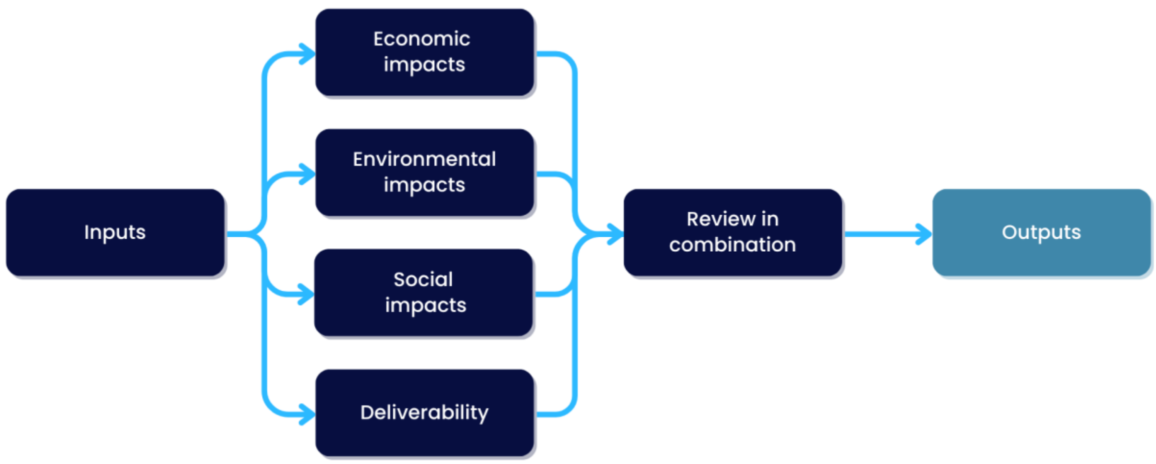


Figure 71: Decision-making framework

The listed items are currently the criteria in-scope to be included in our assessment. The following sections provide a detailed explanation of each criteria.

Table 21: In-scope criteria to be included in the GOA assessment

Assessment categories	Description
Capital costs	Costs associated with the design, planning, building and decommissioning (at the end of the assumed operational life) of the investment options
Operating costs	Costs associated with the operation and maintenance of the investment options
Network constraint costs	Costs that NGT incur when gas flows on the NTS are constrained
Environmental impacts	Environmental cost of emissions that are incurred as part of an investment option
Social impacts	Consider to what extent can these options ensure network security of supply, promote and maintain safety for the consumer
Deliverability	Consider the likely complexity in implementing the option, together with any known challenges concerning the proposal's geographical location and whether it is reliant on any unproven technology

Comparing options against the baseline

Changes in the gas transmission network are driven by either a shortfall or excess in network capability in a particular zone (in the present and into the future). In general, a shortfall may be offset via construction of new assets, whereas an excess may present opportunities to decommission assets and thereby reduce operational expenditure.

To assess options that are designed to meet the network capability needs, we begin by establishing our reference (baseline case) where we assume there is no intervention planned to change network capability (i.e. a 'do-nothing' option). Constraints in the relevant zone can be found in the GNCNR 2024.

For the baseline and for each option we calculate the cost of any constraints. The constraint cost for each option is compared with the baseline value, and any reduction is defined as a **benefit**. The increase in total expenditure versus the baseline case is also calculated for each option and this is defined as the **cost** of the option. For the baseline and each option, the costs and benefits will be discounted at a social discount rate/social time preference rate, over the period to 2050. The resultant net value for each option and the baseline is defined as the NPV in each case.

The following summarises the elements used in the NPV calculation:

- **Option costs** – this includes any build costs, operating costs, decommissioning costs, environmental, social costs, or the cost of commercial contracts with third parties that will reduce constraints.
- **Constraint costs from each option** – they are calculated by determining the network capability impact of each option under the FES pathways and the counterfactual.
- **Baseline constraint costs** – It is the situation where there is no intervention on the NTS (the 'do nothing' option).
- **Constraint cost savings** – they are calculated by comparing the constraint costs from one option to the baseline constraint costs
- **Option costs compared to the baseline** – they are calculated by comparing options costs to the baseline costs (which equals zero due to no interventions)

The recommended option(s) will have the highest NPV across the FES pathways or the counterfactual considered.

If you want to see more detail on the GOA 2025 methodology consultation and its associated documents, you can access them on our website at neso.energy/what-we-do/strategic-planning/gas-options-advice-goa

Question: Do you agree with using the GOA methodology for carrying out the CSNP options assessment for planning of the gas transmission network?

Economic impacts

Capital and operational costs associated with an option are assessed to further understand the financial costs of an option over its expected life (the direct economic impacts of a given proposal).

When assessing the direct costs of an investment option, we will consider:

- capital investment costs for installing any new assets on the NTS,
- capital investment costs for removing (decommissioning) redundant assets on the NTS, and
- expenditure associated with operating and maintaining both new and existing assets – this could include changes to both fixed operational costs as well as variable costs, such as fuel.

To be consistent with the recommendations included in the HM Treasury's Green Book, where an option requires installing new assets, we propose to include the cost of decommissioning the assets from the NTS at the end of their assumed operational life. At the time of investment assessment these costs are uncertain in both magnitude and time, although they are expected to be relatively small once discounted.

Economic assessment: general NPV method

The NPV of each option is assessed over a set period, and its value is influenced by factors ranging from economic, environmental, social to deliverability.

Subject to the FES pathway or counterfactual used in the assessment, the NPV of the same option could be different. We believe both FES net zero pathway(s) and counterfactual need to be considered in our assessment to minimise the impact to security of supply.

For example, if we only consider the net zero pathways by excluding the counterfactual, it introduces an uncertainty associated with the decarbonisation of heat demand should electrification of heating not happen where and when it is expected. This risk could mean that the gas network is inadequately sized or insufficiently reliable to provide appropriate levels of safety and security.

Operational life

The 'operational life' is a crucial factor within the calculations of the economic assessment to understand the whole life cost of an investment in new assets. Key assets installed on the NTS (e.g. compressors, pipes and valves) are usually assumed to have a design life of 45 years. However, given the commitment of net zero by 2050, there is some uncertainty in how to assess any value to the consumer beyond this point. The FES data does not extend beyond 2050, so assessment of constraint risk beyond this point would require extrapolation and trend-based analysis. There is likely to be a significant discrepancy in the apparent economic between the counterfactual – where economic life extends well beyond 2050, and the net-zero compliant pathways where gas demand is very low. We will consider a range of operational life assumptions in undertaking our assessment.

Constraint costs

These investment proposals and other intervention options are developed to reduce current and probable future network constraints[14]. Constraint costs will occur if NGT cannot meet its contractual obligations at supply and demand points on the NTS. If they occur, those costs could impact consumer bills.

Some intervention options could favourably counterbalance the constraint costs. Those options may include commercial contracts to manage the location of supplies and demands, code changes, or physical changes to the makeup of the network.

By recommending suitable solutions to ease network constraints, GOA will reduce the incidence and cost of constraints on the NTS, delivering consumer benefits.

We will compare two sets of costs against the baseline: option costs and constraint cost savings. The baseline is the "do nothing" option, where there is no asset change or other intervention to mitigate constraints. The desirable option(s) will have low overall costs and high constraint cost savings against the baseline.

Deliverability

To carry out the deliverability assessment, we qualitatively assess each option against the framework, considering a range of factors including the supply chain of technologies, construction complexity and consenting challenges (geographical considerations). Assessing the proposal's deliverability at a strategic level allows us to recommend options that could be delivered in a timely and practical way.

Qualitatively assessing each option using the deliverability framework below provides and overview of approach used to compare the feasibility of each proposal.

[14] More details on constraints can be found in the GNCNR 2024, where we identify constraint scenarios using our network modelling and probabilistic tools, based on the FES data

Table 22: Deliverability framework

Complexity	Geographical considerations	Technology
Highly complex design unlikely to be deliverable. The design is subject to a high likelihood of constraints and risks affecting the construction to such a degree that the option should not be considered further.	The option would be unlikely to be implemented without incurring significant extra costs and delays due to very large areas of population or multiple sensitive areas (AONB/SSSI) located in proximity.	New technology that has not been used before beyond testing. Would need further justification to ensure compliance with safety legislation.
Design that features some complex elements that may be challenging to deliver. The design is subject to constraints that are likely to affect construction to such a degree that the option should not be included without potential solutions identified.	The option would be very difficult to implement or incur significant extra costs or delays, due to large areas of population or sensitive areas (AONB/SSSI) located in proximity.	Emerging complex technology, with uncertainty on longevity.
Design of moderate to significant complexity, with constraints or risks which may impact some construction. Design is likely to be achievable and issues are capable of resolution.	The option may be implemented with some challenges to avoid significant areas of population or sensitive areas (AONB/SSSI etc.) located in proximity.	Proven mature technology that is used by equivalent Gas Transmission System Operators, but not on the NTS.
Design of low to moderate complexity. The design is subject to a low likelihood of constraints affecting construction. Option very likely to be achievable in the time stated.	The option should be achievable, with minimal or no areas of population or sensitive areas (AONB/SSSI etc.) located in proximity.	Proven mature technology already used on the NTS.

Environment

Any investment option that involves a change to the physical makeup of the NTS could have some local and wider environmental impacts, as a result of the construction itself and of longer-term effects from installed assets and changes to the operation of the network.

NESO is committed in its advisory role to providing its best view of the relative merits of each proposed option, while minimising any detrimental effects on the environment. We are aligned with the Government's commitment to the protection and enhancement of the environment.

Environmental assessments enable us to evaluate the potential impact that investment proposals could have on the environment, and to compare options based on their relative impact.

It should be acknowledged that at the early appraisal stage, options under consideration are defined at a broad level. We expect decisions on the required location and detailed design will come at a later stage of the investment cycle.

We do not consider that the GNCNR or the GOA will impose an obligation on any other party, and they are not intended to have any status in planning[15]. We therefore do not consider it necessary to undertake a Strategic Environmental Assessment (SEA) or a Habitats Regulation Assessment (HRA), although we note that these are expected to be integral components of our electricity network planning covered CSNP.

Our assessment of environmental impacts therefore encompasses:

- key environmental factors that have a tangible and/or quantifiable cost, namely the categories of emissions (including CO_2) that we will detail later in this section, and
- a general view of the likely scale of environmental issues that may arise and their potential consequences for the viability of an option.

The second assessment relates to the potential location of new assets, which includes considering both environmental and social impacts. We will develop a scoring matrix to weigh up those factors and review them in combination with other aspects. This review method is presented in the Deliverability section.

In-scope

We propose the following elements to be included in our environmental assessment:

- **CO_2 equivalent emissions** (CO_{2e}) – this is a metric used to compare the emissions of greenhouses gases based on their global warming potential (GWP). It has been designed to standardise the effects of different greenhouse gases on climate change. CO_{2e} represents the amount of CO_2 that would have the same warming effect as a given amount of another greenhouse gas. On the NTS, gas turbine compressors release CO_2 during operation.
- **Fugitive methane emissions** – should these not be included as CO_2e or in the social cost of carbon, they will be captured separately in our assessment. Fugitive methane emissions are the unintentional release of methane in the atmosphere from equipment over time; this can happen during the production, processing, storage, and transportation of natural gas and other hydrocarbons.
- **NO_x emissions** – these represent a group of chemical compounds known as nitrogen oxides which are significant air pollutants and are considered greenhouse gases.

We will use the HM Treasury's Green Book guidance to quantify the cost of environmental impacts, particularly with regard to the cost of carbon emissions or NOx emissions.

As noted above in the Deliverability section, we will also consider how known features in the geographical area of proposed assets may create challenges for the implementation

[15] 'Planning' in the sense of the Planning Act 2008 or the Town and Country Planning Act 2015

of the option, and this consideration will take account of environmental factors such as Areas of Outstanding Natural Beauty (AONBs), Site of Special Scientific Interest (SSSI), and larger protected habitats that could pose a significant restriction on siting or routeing of assets.

Community (social impacts)

Social impact assessments include the process of analysing and appraising the consequences of investment proposals on communities or society. This considers both the positive and negative impacts that result from these options.

The NTS provides an ongoing benefit to the consumer by enabling a safe and secure supply to homes and businesses. For our social impact assessment, we will consider whether proposals ensure that NGT maintains a resilient and secure gas supply.

We recognise there could be a social cost of carbon emissions. They will be considered in our environmental impact assessment.

As we discussed in the environmental impacts section, the geographical area of a proposed option could also lead to certain social impacts that make the option challenging to implement. Our deliverability matrix seeks to cover the social impact assessment as such.

NESO is subject to the Public Sector Equality Duty[16]. It is incumbent on us to consider the impact of any options on protected characteristics – age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, including ethnic or national origins, colour or nationality, religion or belief, and sexual orientation. While we do not expect any significant impacts on any of the protected characteristics, we will carefully consider them.

Question: Are there other elements of social impact we should consider?

[16] https://www.gov.uk/government/publications/public-sector-equality-duty

Plan publication

Publication

We will submit the draft methodology for the CSNP to Ofgem for their endorsement. The approved methodology will be published on a dedicated page on the NESO website, the link to which will be shared on all NESO social media channels. This will be supported by wider stakeholder communication in the form of a public webinar and externally through a NESO digital newsletter.

Gas network planning will be developed in line with the overall CSNP timeline.

Deliver

Overview

The GOA publication will offer NTS recommendations along with an explanation of how the conclusions were reached to the regulator that makes the relevant decisions. The GOA will be published by 31 December 2025 and then on every two years.

We intend to provide updates on the progress of options that are recommended in the GOA document in subsequent GOA documents.

For gas transmission network reinforcements, the CSNP will put forward recommendations for reinforcement options to meet the NTS's needs. For gas the transmission network, it will be Ofgem that ultimately decides which options are progressed.

As NESO is not the decision-maker in this process, we will not be determining a formal delivery phase for the options proposed for the gas transmission network. Nonetheless, we expect that any reinforcement options that are being developed will follow the design and delivery stages outlined below (Figure 72).

Option selection	Where relevant, select the final option variation to progress through the detailed design and delivery stages.
Route design	Appraise a range of routeing and siting options to form a preferred corridor through engagement
Design development	Undergo further design, supply chain engagement and assessment considering site surveys and land access.
Planning & consenting	Prepare for planning and consenting and conduct statutory consultation.
Application approval	Gain planning approval and undergo the regulator's full project funding assessment.
Asset construction	Procure and complete construction ahead of the asset being commissioned.

Figure 72: Detailed design and delivery stages

Review of previous proposals

We will review all outcomes of previous GOA publications, updating on progress and status of each project to ensure that advice is still relevant. Where advice changes through each iteration, this will be communicated to the regulator, who makes the relevant NTS funding decisions.

Navigation

Return to the whole system overview

Read the electricity section of the methodology

Read the hydrogen section of the methodology

Read the methodology’s annexes, including the glossary

Respond to the gas consultation

10. The CSNP for Hydrogen

Introduction

Drive

Identify

Develop

Appraise

Plan publication

Deliver

Introduction

This section sets out our proposals for how we plan the hydrogen system elements of the Centralised Strategic Network Plan (CSNP).

NESO's primary duty under the Energy Act 2023 is focused on decarbonising the energy system, cost effectively and securely. **Condition C12** of NESO's Gas System Planner licence requires us to produce the CSNP, which is defined (in Condition A1) as being "the coordinated strategic plan for long term development of the electricity transmission and natural gas transmission systems, accounting for hydrogen and other energy vectors." In December 2023, Ofgem's decision on the framework for the Future System Operator's Centralised Strategic Network Plan reaffirmed a goal for the CSNP to include analysis of proposed hydrogen networks.

Key messages

- The CSNP will mostly focus on developing national strategic view models, which will informed by Strategic Spatial Energy Plan (SSEP) outputs. These will be able to inform decisions on Hydrogen Transport Business Model (HTBM) allocations.
- One key aspect of the early stages of hydrogen network development will be the development of hydrogen supply and demand within industrial clusters. This will be followed by the need to consider expansion beyond these clusters and how they could be connected over time.
- There is no clear distinction between transmission and distribution in hydrogen as there is in gas and electricity networks. To address this uncertainty, a proposed three-tier approach is put forward for hydrogen network planning, developing national strategic view models, industrial cluster systems models and broader industrial view models.
- Industrial cluster system models will provide a place-based analysis to inform early strategic direction for hydrogen for the buildout of regional hydrogen infrastructure within clusters. We will further develop our approach and the interactions between the NESO's strategic plans.
- The CSNP hydrogen processes will be further developed using this consultation feedback. Future policy development related to hydrogen will also be used to create a more detailed methodology, which we propose to consult on in due course.

This section of the consultation document sets out the high-level principles on how the CSNP will deliver hydrogen network planning.

Approach to hydrogen network planning

Hydrogen network planning will require consideration of hydrogen supply, demand and infrastructure at different scales. There is no clear distinction between transmission and distribution in hydrogen as there is in gas and electricity networks, and hence there is not necessarily a natural split of hydrogen network planning as there is within other vectors.

The early stages of the development of hydrogen systems in GB will involve specific and particular government support mechanisms known as the hydrogen business models – comprising of production (HPBM), transport (HTBM), storage (HSBM), and power generation (H2PBM).

Under the production business model, there are likely to be early hydrogen 'point to point' pipelines above-ground storage, connecting isolated hydrogen production to demand. Where these do not have any impact beyond the specific projects they connect to, they will not need to be strategically planned.

We consider that the primary purpose of NESO's strategic planning of hydrogen transport and storage infrastructure is to help inform DESNZ decisions relating to the HTBM and HSBM, noting that this may also be relevant for other hydrogen business models. As such, we propose that the CSNP focuses primarily on the infrastructure that is of sufficient capacity and significance to be considered for support under current or future rounds of the HTBM and HSBM. Where projects supported through early hydrogen allocation rounds (HARs) could also have important systemic impacts they should also be included, most notably those relating to hydrogen network development in and around the industrial clusters.

We propose to split hydrogen network planning into three scales:

- **National strategic view models**: national-level hydraulic models to determine hydrogen network statement of needs. These should be informed by the hydrogen flows between zones from the SSEP outputs.
- **Industrial cluster systems models** considering initial hydrogen supply and demand projects. These assess physical and performance characteristics of the proposed system and test against various usage scenarios.
- **Broader industrial view models**: these will be informed by both of the previous two approaches and will consider the buildout of hydrogen networks beyond initial supply and demand connections within clusters, and how they can be connected together with strategic storage sites and a wider national network.

National strategic view models

The SSEP will provide the primary view as to whether there is a strategic need for a national hydrogen transmission network. It will also consider the need for hydrogen storage within each modelled zone, subject to geographic constraints on where this can be developed. We will build hydraulic models informed by the hydrogen flows between zones from the SSEP outputs which will allow us to provide greater precision on potential connection points, diameters, operating pressures and other physical characteristics.

These models will also allow us to consider more detailed representations of supply and demand characteristics and, through linepack studies, the need for the network to provide balancing services, the need or opportunity for using compression to improve network efficiency, and to consider interactions with storage facilities.

As outlined in our methodology overview, we propose that CSNP for hydrogen network planning purposes should be delivered using an approach consistent with the CSNP methodology used for gas and electricity. The process will identify system needs and develop network reinforcement options, which will then be assessed to identify optimal network solutions. Whilst we will follow the same framework across the vectors when delivering CSNP, due to the greater uncertainty associated with emerging hydrogen networks, some differences may arise.

The models will be able to inform decisions on HTBM allocations, although might also be relevant for other hydrogen business models.

Question: Do you agree that the hydrogen CSNP should follow an approach consistent with the gas and electricity transmission network planning process where possible?

Industrial cluster system models

Models of the emerging hydrogen- and CCS-enabled and funded industrial cluster systems[17] are to be developed in order to create hydraulic models of the proposed hydrogen networks. Some of these clusters will also include local hydrogen storage development. These models will provide insights into the initial hydrogen networks emerging out of industrial clusters. The models can be used to assess physical and performance characteristics of the proposed system such as diameters, operating pressure regimes, capacities and linepack. The models can also test against various usage scenarios and be used to study the impact of load and system growth.

All SEP network plans currently developed by NESO are continuously refined so that their outputs can be aligned and utilised effectively, ensuring that regional context is aligned to national views.

Question: Do you agree that the modelling of initial hydrogen networks growing out of industrial clusters should be included within the CSNP?

Broader industrial view models

There is a need to consider the buildout of hydrogen networks beyond initial supply and demand connections within clusters, and how and when they might be integrated within

[17] Industrial clusters are often defined as geographically concentrated areas of co-located energy intensive industry.

a wider strategic national network. This will need to be underpinned by both the broader strategic view emerging from the SSEP and the development of initial hydrogen supply and demand projects within industrial clusters. The outputs of the SSEP will determine the scale of any required national hydrogen network and therefore help shape the scope of this level of hydrogen network planning, whether it includes connections of clusters to a national network or considers the potential for connection together of specific clusters.

We will need to consider projects under development in and around clusters, led by both existing gas network companies or others. These projects are those whose characteristics will have an impact on the wider strategic hydrogen network and are likely to seek business model funding in future.

Question: Do you agree that the modelling of this broader industrial view should be included within the CSNP?

Question: Do you agree with our three-tiered approach for hydrogen network planning?

Interaction with transport and storage business models

DESNZ first set out its intent for NESO to take on formal strategic planning responsibilities for hydrogen transport and storage infrastructure in August 2023[18]. In December 2023, DESNZ's Hydrogen Transport and Storage Networks Pathway[19] set a further ambition for this to happen from 2026, subject to further policy work. This was further reinforced in the Hydrogen Strategy Update to the Market in December 2024[20]. In line with this we have been working on the inclusion of hydrogen across our Strategic Energy Planning outputs, including the SSEP, Regional Energy Strategic Plans (RESP), and the CSNP.

The early stages of the development of hydrogen systems in GB will involve specific and particular government support mechanisms across the vertical hydrogen supply chain. Decisions on providing support will be made by government through the relevant hydrogen business models. When additional detail on the HTBM and HSBM is published, we may further engage with DESNZ on the specific interactions between our strategic hydrogen planning and this business model support. If needed, we may consult further with industry.

Similarly, as DESNZ develops and refines strategies, plans, and policies for the hydrogen sector, creating greater certainty on early hydrogen network evolution and government's strategic objectives beyond that, we intend to engage with industry. This engagement will ensure that industry feedback is considered in the development of a nascent network planning process.

[18] Hydrogen Strategy: Update to the market, August 2023
[19] Hydrogen transport and storage networks pathway
[20] Hydrogen strategy update to the market: December 2024

Question: Do you agree with the need to limit the scope of hydrogen network planning within the CSNP primarily to projects supported under the hydrogen transport and storage business models?

Question: Do you agree with our approach to engage further with industry on the detail of the hydrogen network planning methodology in winter 2025/2026 subsequent to further policy detail being set out?

Treatment of hydrogen storage

Background – storage in the gas (methane) market

In the GB gas market, there are two broad categories of storage:

- the storage embedded within the gas network and controlled by the licensed gas transporters – typically this is linepack (gas stored within the pipelines by virtue of its pressure) but can also include low-pressure gas holders
- commercial storage, which comprises geological storage facilities that are controlled by storage operators (sometimes owned by specific gas shippers) that provide flexibility services to gas market participants – liquefied natural gas (LNG) facilities also provide similar flexibility services

Storage within the network is assessed and designed by gas transporters and is typically used to provide within-day flexibility to allow for a difference in the rate of flow into and out of the gas network over the course of a gas day. Storage within the network also provides the network operators with operational flexibility. This storage is typically not available to the market, nor the need for it addressable by the market.

While it is reasonable to think of commercial storage as being used to store gas in the summer for use in the winter, or to store gas at the weekend when demand is relatively low for withdrawal mid-week when demand is higher, the actual operation of commercial storage facilities is driven more by the expected price of gas day-to-day and season-to-season. Commercial storage provides a range of services to the gas market, allowing the gas market to respond to a variety of situations, for example day-to-day variation in weather and consumption, and supply outages. Commercial gas storage is used by shippers to both balance their own physical position and also to provide services to the traded gas market more broadly. Additionally, the NTS System Operator, National Gas Transmission (NGT), may procure some commercial storage for operational or emergency management reasons.

The value of gas storage in a liquid, traded market can be characterized by two dimensions: the total amount of gas that can be stored in the facility, and the rate at which gas that can be injected into and withdrawn from the facility during the market's balancing period. The former of these characteristics is of primary importance when considering long-duration factors such as seasonality, the latter is of primary importance when considering shorter-duration factors such as the difference between weekend and weekday demand levels, the impact of weather and the ability to respond to unforeseen supply or demand shocks.

In other gas markets, a third category of gas storage is sometimes present which is centrally planned and controlled and used to cover extreme circumstances. This is often referred to 'strategic storage'. We note whilst gas storage in the GB gas market was originally centrally planned (prior to vertical separation in 1996), it is not centrally planned or coordinated and is currently left entirely to the gas market participants through normal market activity. Gas (methane) storage planning therefore does not form part of the CSNP.

Application of these concepts to the hydrogen system

No hydrogen market exists, but hydrogen storage is likely to be a vital part of a hydrogen system at some point in the future, providing common good services to the low carbon hydrogen market as it expands from its current very low base. Initially therefore it appears reasonable that hydrogen storage should be centrally planned, and hence we propose to include it in the CSNP.

This section sets out our proposals for assessing the needs and options for delivering hydrogen storage infrastructure.

Initial industrial clusters

The initial evolution of the hydrogen system is likely to be based around vertically arranged structures designed to connect a small number of specific production facilities with a small number of industrial consumers and potentially power generation. It is unlikely that a liquid traded market will materialise in these situations.

NESO expects that the characteristics of each user – typical and extreme production/consumption patterns, sensitivity to external stimulus such as weather or market prices, etc. – will be considered by the project developer(s) in developing the vertical structure. This means that matters which in the gas market are covered by both storage in the network and commercial storage will be considered when designing both the transport and storage requirements for the system.

Noting that the initial industrial consumers are likely to initially retain gas (methane) back-up supply, and assuming that hydrogen production could be turned down or off should the need arise, it may be that the need for hydrogen storage in these systems is somewhat limited initially.

We are expecting to review the developers' plans and to construct simple models of the vertically arranged structures to test the potential characteristics of each user in that system. We will use these models to consider the performance of any alternative facilities that may have been proposed, either by third parties or by NESO. The purpose of this analysis will be to ascertain the extent to which the physical system may need to rely on the gas (methane) network facilities, to compare developers' plans against alternatives, and to identify any other issues that may be highlighted. We intend to consider situations where gas back-up may not be available, for example because it has not appeared in developers' plans, and consider whether, under a variety of circumstances there is a need for physical storage.

National strategic view

The SSEP will be considering the trade-offs between different types of storage across electricity, gas (via gas-fired power generation and hydrogen produced from methane reformation), and the hydrogen systems. The SSEP will also produce views on the location and capacities for both electrolysis and hydrogen-fuelled power generation, to maximise whole energy system value. The SSEP will therefore identify a requirement for hydrogen storage that is strategic in nature and designed to cope with seasonality and the variation due to weather. Moreover, the SSEP might suggest a size of market whereby liquid, traded hubs emerge.

We will consider the results of the SSEP and assess any options proposed internally or by third parties by considering both the longer- and shorter-durational factors. Options might include above-ground steel containment or geological storage. It might be that we need to consider combinations of options so that the underlying need can be met.

We will not conduct a more detailed commercial evaluation of proposed options. Our assessment will aim at identifying the most economically effective option or combination of options that meet the needs identified.

Broader industrial view

For the broader industrial view analysis, similarly to the initial industrial cluster analysis, we will consider developers' (and any other) proposals and assess them against anticipated production and consumption profiles. However, the analysis will be supplemented by national strategic view analysis, and we will consider whether there are synergies in aligning needs and/or options.

At this stage it is difficult to state precisely how we are going to assess options that exist in this category, and we may need to rely on qualitative analytical techniques.

Operability and strategic options

Noting that as the hydrogen system develops and a market emerges, there could be opportunities for providing additional security of supply or growing additional demand where there is additional storage available to the nascent market. We will therefore seek to identify opportunities for bringing forward options for delivering hydrogen storage where there is an apparent strategic benefit.

Question: Do you agree with our treatment of hydrogen storage within the CSNP?

Drive

Overview

Key messages

- Hydrogen network planning within the CSNP will be driven by the Strategic Spatial Energy Plan alongside NESO's Future Energy Scenarios.
- The Strategic Spatial Energy Plan, due to be published in 2026, will set out the need for hydrogen transport within GB.

Context

The extent of the future role of hydrogen in energy system is uncertain, as is the future level and makeup of supply and demand. The level of hydrogen infrastructure required across different pathways may vary, as could the spatial distribution of it to deliver the optimal whole energy network.

Economic analysis conducted within the input energy pathways will help optimise the location of hydrogen supply and demand. This will then inform the requirement for hydrogen transfer between different areas of the country.

Supply and demand

Strategic Spatial Energy Plan

The SSEP will plan across GB and map potential locations, quantities and types of electricity and hydrogen production and storage infrastructure over time. It will consider interactions between hydrogen and electricity systems, including electrolytic hydrogen production and hydrogen to power, as well as hydrogen transport and storage developments. These technologies will be spatially optimised on a zonal basis. It will also consider natural gas demand as a feedstock for hydrogen production from methane reformation.

The SSEP will establish a single pathway covering hydrogen production, storage and flows across boundaries. The modelling outputs will include required hydrogen transport between zones for the pathway, which will be used to inform the core hydrogen transport needs for the national strategic view.

Future Energy Pathways

The Future Energy Pathways (FES) net zero pathways and the Counterfactual provide four separate views of supply and demand across GB for each year from now until 2050. The next FES iteration will also provide a 10-year forecast. The FES therefore sets out a range of outcomes for future hydrogen supply and demand, underpinned by an extensive programme of stakeholder engagement. This will allow us to supplement the use of the SSEP pathway to explore network needs against higher or lower hydrogen demands where appropriate.

Natural gas network planning is primarily underpinned by FES alongside natural gas demand for power generation and hydrogen production within the SSEP. The use of the FES will allow the hydrogen and natural gas systems to be planned on a coordinated basis, accounting for the potential repurposing of gas network assets to transport hydrogen.

Other supply and demand inputs

To inform our industrial cluster systems models and broader industrial view modelling we may need to consider other data inputs at a more granular level than FES and the SSEP. The Ofgem 'Hydrogen Likely Areas' tool is one such input we may consider here. Initial hydrogen network development within industrial clusters will be based around specific hydrogen supply projects and demand customers, and network routes connecting specific locations of these sites. We will engage with stakeholders to understand the details involved in these projects and how we should consider them within our modelling.

Resilience

We are developing our approach to assessing resilience of hydrogen networks and considering whether this should be included within the CSNP. NESO also produces a gas security of supply assessment; we will consider how best to incorporate hydrogen resilience and security of supply into our outputs.

Question: Do you agree with our proposal to use the outputs from the SSEP and the Future Energy Scenarios to model a potential national strategic hydrogen network?

Question: Are there any other data sources or pathways that we should consider?

Identify

Overview

Key messages

- The CSNP will model SSEP zones and the flows across boundaries of these zones to identify the hydrogen network capacity needed
- SSEP zones are considered more appropriate for hydrogen due to the interaction with the electricity system of hydrogen and its effect on electricity network constraints, however consideration will need to be given to impacts on boundary flows on the gas network RIIO zones

Context

As GB decarbonises there will be a role for hydrogen to meet future demands in some sectors. The distribution of hydrogen supply, demand and storage sites will drive the need for some level of network needed to connect these various locations.

Unlike the gas and electricity transmission systems, there is no existing hydrogen network to consider against a set of future network requirements. We will need to define future system requirements for hydrogen based on input from the energy pathways we are considering from the SSEP and the Future Energy Scenarios. To get hydrogen from where it is produced to where it is used, a hydrogen network will require sufficient transfer capability to move this energy.

We will establish suitable software for this process and carry out analysis of potential hydrogen network needs.

Boundary zones

A hydrogen network will allow the transport of hydrogen between locations for production, demand, and storage. On the gas and electricity transmission systems we analyse the available capacity to move energy across network boundaries. Boundaries split the network into multiple parts that enable the assessment of network capacity between areas where limitations may be encountered. These boundaries are established based on existing network conditions and where constraints occur today and in the future. For hydrogen there are no existing network constraints, making boundary definitions challenging.

Hydrogen network flows will be influenced by both existing gas and electricity network capability. Using electrolysis to produce hydrogen and transporting it using a hydrogen network provides an alternative way to move energy within GB compared to using the electricity transmission network. This means that it is important to be able to analyse hydrogen flows across electricity network boundaries in order to compare whole system options for GB energy networks. The potential for the repurposing of portions of the gas transmission network mean that boundaries and constraints on the gas network will also be important to the development of hydrogen network options. The boundary zones used for gas transmission network analysis are known as RIIO Zones; these do not align with the zones used to model the electricity network.

The SSEP is based on 17 economic modelling zones primarily designed to reflect existing boundaries on the electricity system, but which has split northern England into two zones to test whether a trans-Pennine hydrogen pipeline might be required. We propose to use the same boundary zones used within the SSEP for hydrogen network analysis, specifically to inform our national strategic view models. The boundaries used may evolve over time depending on future network needs.

Figure 73: Map of SSEP economic zones within GB

Initial industrial clusters are developed in specific locations around existing industrial demands. While these might form the initial kernel of a zone, with growth out beyond this, we would expect the bulk of network development associated with each of these clusters to take place within a single SSEP economic zone. For our consideration of industrial cluster systems views a zonal definition is not helpful at this stage of hydrogen network planning. We will identify boundaries and constraints as we develop our analysis in this area.

Question: Do you agree that boundary zones for hydrogen network analysis should be initially based on SSEP boundaries?

Network analysis

We intend to carry out network analysis using gaseous network modelling software to analyse potential hydrogen network configurations and simulate hydrogen networks under different conditions. We will likely develop both steady state models (where the flows of hydrogen are constant over a reference timeframe) and transient models (where anticipated production and consumption profiles are considered). This will help us understand how the modelled network performs and help establish the capability requirements for a future hydrogen network. Initial hydrogen network analysis is likely to be simpler than methane network analysis, as the initial hydrogen network models will be less complex than the current gas network configuration.

Using the SSEP outputs of the hydrogen flows between zones, we will:

- Develop hydraulic models which will provide us with a better definition of physical characteristics such as diameters and operating pressures.
- Consider more detailed representations of supply and demand characteristics and, through linepack studies, the need or ability for the network to provide balancing services, the need or opportunity for using compression to improve network efficiency, and to consider interactions with storage facilities.
- Evaluate potential donor pipelines from the natural gas networks for suitability (i.e. given pressure, diameter, linepack cycling constraints).

These models will set the basis for the analysis that will identify the hydrogen network system needs.

Question: Do you have any other comments or feedback on our approach to establishing hydrogen network needs?

Develop

Overview

Key messages

- The plan will consider a range of options for meeting the identified hydrogen network capability and storage needs.
- Options for both repurposing of existing gas network assets and new build hydrogen assets will need to be developed. We will consider repurposing and new build options, dependent on SSEP outputs.
- The options assessed could be proposed by regulated energy system participants, or be put forward by NESO or other third parties.

The hydrogen network capability needs identified as part of our system requirements analysis will identify the physical capability needs for a future strategic national hydrogen network. Following the system requirements step, parties can identify a range of network and storage options that could meet this need, for NESO to subsequently consider. Those able to present options could include licensed parties such as gas network owners and NESO, as well as third parties. Options developed could include new build hydrogen network or storage assets or the repurposing of existing gas network assets to transport or store hydrogen.

We will collaborate with stakeholders to design a suitable options development process to ensure a consistent, robust and transparent approach to identifying suitable options and strategic choices such as new build or repurposed assets and different routing considerations can be coherently assessed.

High-level approaches

To support the identification of sufficient and credible network development options, NESO will collaborate with parties to identify a range of options. As this is a new area of development, there may be a range of parties able to present options that could help meet the capability needs of the future hydrogen network. We will work with stakeholders on the process for development and submission of these options. Suitable options to deliver hydrogen network capability could include the development of new build hydrogen pipelines or repurposing of existing gas network assets. Storage options might include above-ground steel containment, geological storage, or a combination of options to meet underlying needs.

To ensure the most cost-effective approach can be identified we propose allowing options to be submitted by a range of parties. All options will need to meet minimum requirements for their technical design before they can be considered in the methodology, and it may be necessary to undertake pre-filtering of options whilst ensuring we still have a representative range. We will work with stakeholders to define these minimum requirements.

In the absence of a pre-existing defined safety regime for hydrogen, we propose producing a set of minimum technical requirements that options would need to meet, and to convene engineering working groups to deliver this with representation from relevant organisations with expertise in gas networks.

Repurposing or new build

Where options are identified that include repurposing of gas network assets, we intend to consider the impact of the removal of these assets from the existing gas network, to ensure that network development is done on a coordinated, whole-system basis.

Options based on repurposing of existing gas network assets may need to be economically evaluated against new build assets. Asset owners of existing gas network assets suitable for repurposing, i.e. National Gas Transmission (NGT) and the Gas Distribution Networks (GDNs) would be expected to identify these options and bring them forward.

Question: Do you think there should be any restrictions on who should be able to propose options to meet hydrogen network needs?

Question: Should NESO undertake pre-filtering of proposed hydrogen network options?

Question: Do you agree with our approach outlined above to establish suitable technical requirements?

Question: Should we always consider new build asset options as an alternative to proposed repurposed assets?

Question: Do you have any other comments or feedback on the approach to hydrogen network options development?

Appraise

Overview

Key messages

- The appraisal of options for hydrogen will set out our view of the suitability of proposed investment options that could meet the identified hydrogen network needs.
- Our options assessment process will follow a consistent approach to that used for gas and electricity, where possible, while taking into consideration the greater level of uncertainty associated with an emerging hydrogen network.
- For hydrogen, we intend to provide analysis of hydrogen network options to identify optimal solutions. Decisions on which hydrogen projects to fund will be taken through the government's Hydrogen Transport and Storage Business Model allocations.

Our options assessment will appraise options that meet the hydrogen network needs outlined in our system requirements document. Because the SSEP will already have assessed the trade-offs between the level of electricity and hydrogen infrastructure required, the hydrogen options assessment will not consider cross-vector solutions to meet these needs.

Decision-making framework

We propose to undertake analysis of the proposed hydrogen network options and provide a detailed analysis of each option. We consider each option by assessing the following aspects:

- direct economic impacts (capital and operational costs)
- environmental impacts
- social impacts
- deliverability

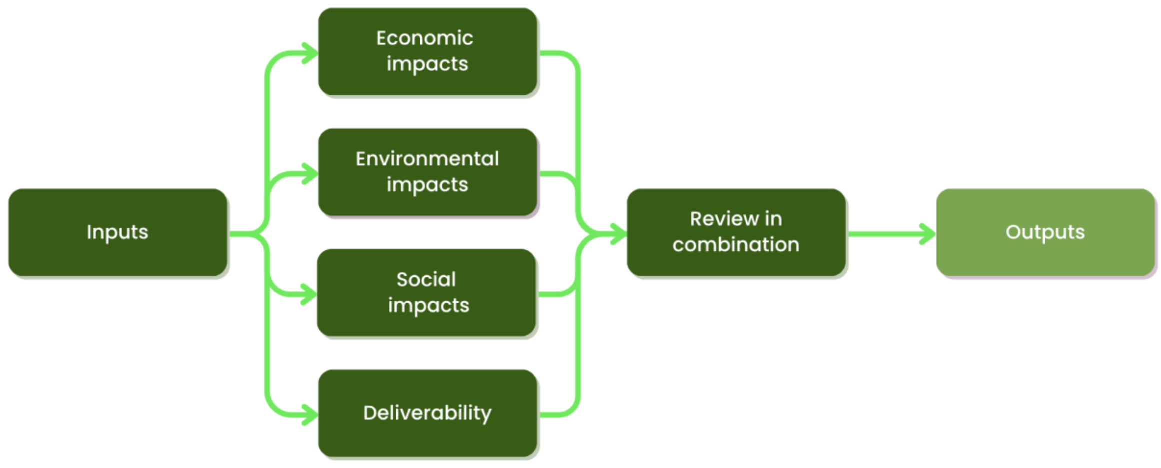


Figure 74: High-level view of the options assessment process

The listed items are currently the criteria in-scope to be included in our assessment. The following sections provide a detailed explanation for each of the criteria.

Table 23: In-scope criteria to be included in the CSNP assessment for hydrogen processes

Assessment categories	Description
Capital costs	Costs associated with the design, planning, building and decommissioning (at the end of the assumed operational life) of the investment options
Operating costs	Costs associated with the operation and maintenance of the investment options
Other costs	Economic factors associated with managing imbalance.
Environmental impacts	Environmental cost of emissions that are incurred as part of an investment option
Social impacts	Consider to what extent can these options ensure network security of supply, promote and maintain safety for the consumer
Deliverability	Consider the likely complexity in implementing the option, together with any known challenges concerning the proposal's geographical location, whether it is reliant on any unproven technology and whether repurposed network options are able to be removed from the natural gas network

Whereas improvements to electricity and natural gas networks will be taken forward primarily through the RIIO price control, hydrogen projects are currently mostly ineligible via RIIO[21]. Initial development of hydrogen network and storage infrastructure will be supported by the government's Hydrogen Transport and Storage Business Models. NESO's outputs will be able to inform future business model allocations, however DESNZ may also consider other factors. With this in mind we propose to provide analysis of hydrogen network options to identify optimal network solutions.

The options assessment may look different for each of the three levels of hydrogen network assessment outlined in this document.

Question: Do you agree with our proposed decision-making framework?

Economic

Capital and operational costs associated with an option are assessed to further understand the financial costs of an option over its expected life (the direct economic impacts of a given proposal).

When assessing the direct costs of an investment option, we will consider:

- capital investment costs for any new-build hydrogen network assets
- capital investment costs for conversion of gas network pipeline or storage assets to transport hydrogen
- additional capital investment costs incurred on the gas network due to the removal of an asset from the gas network for repurposing
- expenditure associated with operating and maintaining both new and repurposed assets – this could include changes to both fixed operational costs as well as variable costs, such as fuel
- economic factors associated with managing imbalance on the hydrogen network

We will also consider decommissioning costs for hydrogen assets at the end of operational life where appropriate in line with our approach to assessing new gas assets. The time when such a decommissioning could occur (the end of asset life) is currently uncertain, however reflecting best practice as recommended in the Treasury Green Book cost benefit assessment this cost should be included.

We will develop our economic modelling approach further and consult on it subsequently.

[21] ofgem.gov.uk/decision/riio-3-sector-specific-methodology-decision-gas-distribution-gas-transmission-and-electricity-transmission-sectors

Question: Given the lack of a market framework within which to quantify the commercial impact of a network that is too small, are there other economic factors or costs that you consider we should be including in the economic assessment?

Question: Do you have any other questions on the hydrogen network options assessment?

Deliverability

To carry out the deliverability assessment, we apply a framework against each option, considering a range of factors including:

- the supply chain of technologies
- construction complexity and consenting challenges (geographical considerations)
- whether repurposed network options are able to be removed from the natural gas network, and if so under what timescales

Assessing the proposal's deliverability at a strategic level allows us to consider options that could be delivered in a timely and practical way.

We will develop this approach further and consult on it in due course.

Environment

In our methodology overview we outline broad principles for how the CSNP will consider high-level environmental spatial constraints in considering environmental impacts.

Any investment option that proposes new build hydrogen network infrastructure or repurposing of existing gas network infrastructure could have some local and wider environmental impacts, as a result of the construction itself and of wider effects from installed assets or changes to the operation of the existing gas network.

NESO will identify and select optimal network projects required for delivery in the near term and provide its best view of the relative merits of each proposed option, whilst minimising any detrimental effects on the environment. We are aligned with the Government's commitment to the protection and enhancement of the environment.

Environmental assessments enable us to evaluate the potential impact that investment proposals could have on the environment, and to compare options based on their relative impact. The SSEP already includes environmental assessment of potential options, so in some instances this may meet our obligations here, however a more detailed assessment of potential options will likely be needed in other instances.

It should be acknowledged that at the early appraisal stage, options under consideration are defined at a broad level. We expect decisions on the precise location and detailed design of any option will come at a later stage of the investment cycle.

The environmental assessment may look different for each of the three levels of hydrogen network assessment outlined in this document. For example, within industrial clusters some initial pipeline proposals may already have their environmental assessments included within their submissions for DCO.

Community (social impacts)

Social impact assessments include the process of analysing and appraising the consequences of investment proposals on communities or society. This considers both the positive and negative impacts that result from these options.

We recognise there could be a social cost of carbon emissions. They will be considered in our environmental impact assessment.

As we discussed in the environmental Impacts section, the geographical area of a proposed option could also lead to certain social impacts that make the option challenging to implement. Our deliverability assessment will seek to cover the social impact assessment as such.

NESO is subject to the Public Sector Equality Duty. It is incumbent on us to consider the impact of any options on protected characteristics – age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, including ethnic or national origins, colour or nationality, religion or belief, and sexual orientation. Whilst we do not expect any significant impacts on any of the protected characteristics, we will carefully consider them.

For environment and community impacts we propose to follow the same approach set out for our gas network planning processes within the CSNP.

Question: Do you agree with taking a consistent approach to environmental and community assessment to that followed for gas network planning?

Question: Do you have any other comments or feedback on our approach to environmental and community assessment?

Plan publication

Publication

We will submit the draft high-level principles methodology for the CSNP to Ofgem for their endorsement. The approved methodology will be published on a dedicated page on the NESO website, the link to which will be shared on all NESO social media channels. This will be supported by wider stakeholder communication in the form of a public webinar and externally through a NESO digital newsletter.

Hydrogen network planning will be developed in line with the overall CSNP timeline set out below. For hydrogen we intend to continue developing our detailed methodology further after the high-level methodology has been published in December 2025 and engaging with appropriate stakeholders to do ensure that it is robust.

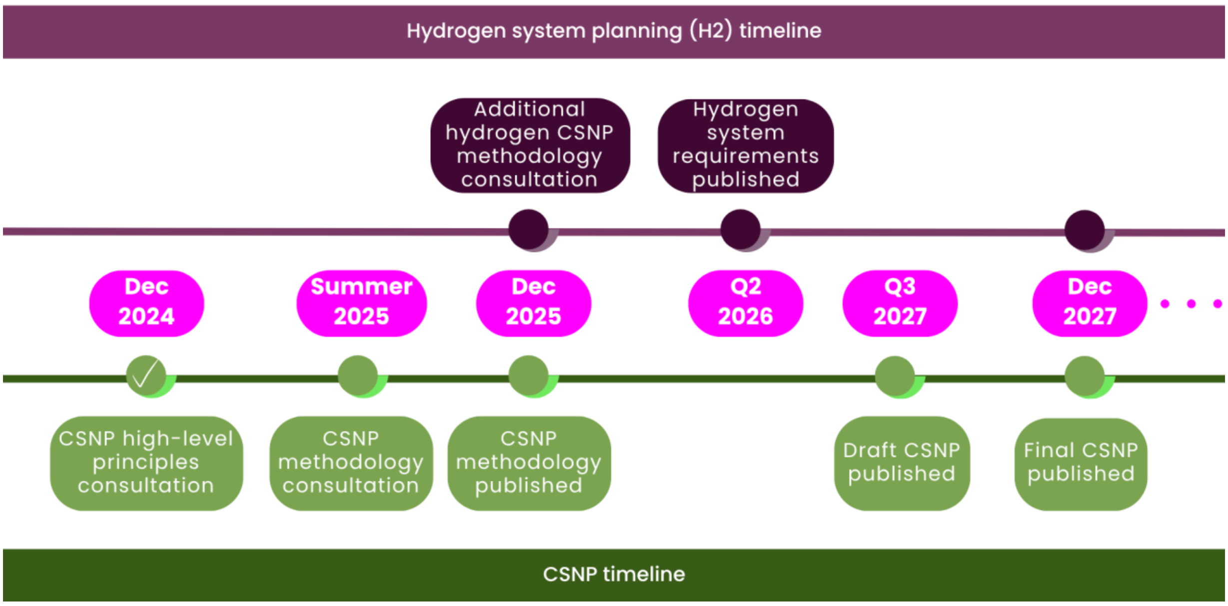


Figure 75: High-level CSNP timeline

The first CSNP will be published at the end of 2027. In relation to hydrogen, this will focus on strategic national hydrogen infrastructure requirements by 2050 and the short to medium term projects to grow a hydrogen network from initial projects.

The key deliverables to support the first CSNP are as follows:

- Publish hydrogen system requirements – Q2 2026
- Publish draft CSNP and statutory environmental assessments – Q3 2027
- Publish final CSNP – Q4 2027

Ongoing engagement and call for interest

Hydrogen is a nascent sector, without established network planning processes. We intend to work with stakeholders to develop our methodology in greater detail for hydrogen and will be engaging with stakeholders to identify interested parties to be involved in developing the hydrogen network planning process.

Subsequent to further hydrogen policy development, we propose that we continue our engagement to ensure that industry feedback is considered in the development of the network planning process.

Question: Do you have a view on how we should engage stakeholders when further developing our methodology and approach to hydrogen network planning?

Deliver

Overview

Our Options Assessment publication will set out our analysis of the submitted options to meet hydrogen network needs. Once a decision is made by government on which options to support, we will publish updates in future iterations of the document on the delivery schedule and progress of the hydrogen network proposals based on updates from the option developer, the regulator and DESNZ.

For hydrogen network proposals, both new-build and repurposed, the CSNP will analyse the options which could meet the identified network needs.

NESO is not the decision maker on which options to take forward as they will be supported via the DESNZ Hydrogen Transport and Storage Business Models and as such require a decision from the Secretary of State. We therefore will not be setting out a formal delivery pipeline. We expect developed options to follow a similar process to that followed for gas and electricity, as outlined in figure 76 below.

Option selection	Where relevant, select the final option variation to progress through the detailed design and delivery stages.
Route design	Appraise a range of routeing and siting options to form a preferred corridor through engagement
Design development	Undergo further design, supply chain engagement and assessment considering site surveys and land access.
Planning & consenting	Prepare for planning and consenting and conduct statutory consultation.
Application approval	Gain planning approval and undergo the regulator's full project funding assessment.
Asset construction	Procure and complete construction ahead of the asset being commissioned.

Figure 76: Detailed design and delivery stages

Review of previous proposals

We will review all outcomes of previous hydrogen options assessment publications, updating on progress and status of each project to ensure that advice is still relevant. Where advice changes through each iteration, this will be communicated to the regulator and to DESNZ, who make the relevant funding decisions through the business model support.

Navigation

Return to the whole system overview

Read the electricity section of the methodology

Read the gas section of the methodology

Read the methodology's annexes, including the glossary

Respond to the hydrogen consultation

11. Legal notice

Legal notice

For the purposes of this report, the terms "NESO", "we", "our", "us" etc. are used to refer to National Energy System Operator Limited (company number 11014226).

NESO has prepared this report pursuant to its statutory duties in good faith and has endeavoured to prepare the report in a manner which is, as far as reasonably possible, objective, using information collected and compiled from users of the gas and electricity systems in Great Britain, together with its own forecasts of the future development of those systems.

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