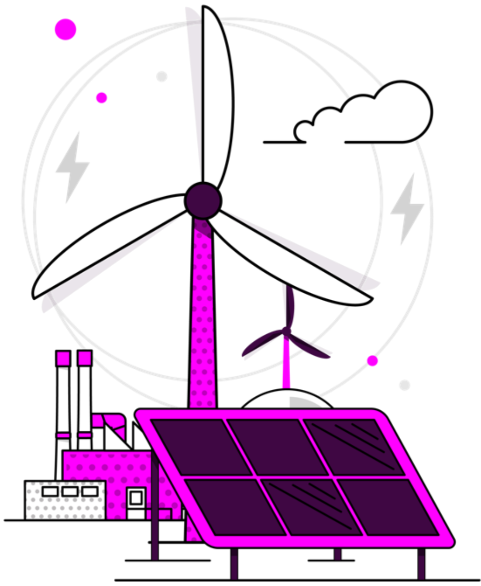
December 2024

Strategic Spatial Energy Plan

Draft methodology

NESO
National Energy System Operator

Contents



1. Introduction

1.1 Executive summary

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

An independent, public corporation at the centre of the energy system, NESO takes a whole system view to create a world where everyone has access to reliable, clean and affordable energy. Our work will be the catalyst for change across the global community, forging the path to a sustainable future for everyone.

Tackling climate change is truly the challenge of our generation; addressing energy security, sustainability and affordability for everyone is at the forefront of the global agenda and drive to meet net zero. It is NESO's job to transform the whole energy system to meet these challenges and transition to a low-carbon future, embracing new technologies and cleaner generation sources, always with the cost to the consumer in mind.

Our three primary duties are:

- **Net zero** - enabling the government to deliver on its legally binding emissions targets.
- **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.

NESO's Strategic Spatial Energy Plan

The concept of a Strategic Spatial Energy Plan (SSEP) for Great Britain (GB) was introduced in August 2023, with the publication of a government-commissioned report on how GB can accelerate the deployment of its electricity transmission infrastructure[1]. The report, produced by the UK's Electricity Network Commissioner, recommended the creation of an SSEP for GB.

The commissioner's report was followed in November 2023 by the UK government's Transmission Acceleration Action Plan[2], which set out a holistic approach to delivering the recommendations. In October 2024, the UK, Scottish and Welsh governments officially commissioned NESO to produce the SSEP[3].

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[1] Nick Winser, Accelerating Electricity Transmission Network Deployment (August 2023) - https://www.gov.uk/government/publications/accelerating-electricity-transmission-network-deployment-electricity-network-commissioners-recommendations

[2] Department for Energy Security and Net Zero, Transmission Acceleration Action Plan (November 2023) - https://www.gov.uk/government/publications/electricity-networks-transmission-acceleration-action-plan

[3] Department for Energy Security and Net Zero, Strategic Spatial Energy Plan: commission to NESO (October 2024) - https://www.gov.uk/government/publications/strategic-spatial-energy-plan-commission-to-neso

The SSEP is part of a wider transition towards more strategic energy planning initiatives. It will forecast for the first-time energy supply and demand characteristics and their likely whereabouts.

The first of its kind in GB, the SSEP is a critical step in accelerating and optimising GB's energy transition. This draft methodology describes how we will deliver the SSEP and, in turn, support the ambitious changes required for GB's energy system on the road to net zero.

The first SSEP will be a GB-wide plan mapping potential locations, quantities and types of electricity and hydrogen generation and storage infrastructure over time, modelled across a range of plausible futures. Future versions of the SSEP may have a broader scope. This first SSEP will achieve the following goals:

- Provide a pathway for electricity and hydrogen supply types, locations, capacities and timings. This will be optimised for cost across demand and high-level network needs, as well as environmental, community and other spatial interests, to support the energy transition efficiently and securely.
- Provide UK, Scottish and Welsh governments and Ofgem with a plan they can endorse. This will:
    - inform government policy and any developments that may be deemed beneficial in legal frameworks in England, Scotland and Wales.
    - enable specific network solutions to be developed and agreed through the Centralised Strategic Network Plan (CSNP).
- Firmly set the context for the nation's energy requirements, which will increase certainty and confidence for industry and investors through having a plan in which community voices and interdependencies are considered in advance.

An overview of this methodology

In this publication, we outline the principles and methods for delivering the SSEP. To produce the methodology, NESO has collaborated with a diverse range of stakeholders to design an iterative process. This process models and assesses options for meeting future demand projections, integrating economic modelling, spatial evaluation and statutory environmental assessments. NESO will work closely with the Scottish and Welsh governments to ensure that devolved planning responsibilities, statutory and non-statutory plans are accounted for, and consider existing project pipelines.

The methodology considers how we assess and combine a range of factors, including security of supply, decarbonisation targets and the needs and operability of the GB energy system. In addition, we consider the needs and views of communities and society, environmental protection, other important uses of the land and sea, national priorities and strategies, practical delivery and economic costs.

All the above are reflected in this draft methodology, together with how we will engage the public, communities, industry representatives and environmental organisations, allowing us to incorporate their feedback and improve the first and future versions of the SSEP. Future iterations could also include other energy vectors, like natural gas.

The methodology is structured through six main chapters (see figure 1), which are preceded by an initial chapter that outlines the foundations underpinning the SSEP. A summary of each chapter is outlined below:

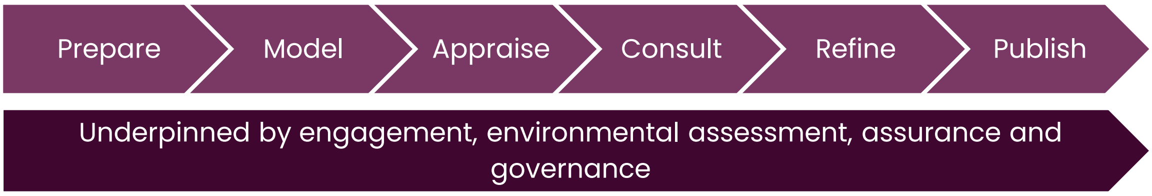

Figure 1: SSEP process

Foundations

Our SSEP process is supported by engagement, environmental assessment, governance and assurance. We set out SSEP pillars that encompass economic, societal, environmental, other spatial uses and technical engineering requirements. These are supported by a governance structure that includes a committee, advisory groups and working groups. Transparent engagement with stakeholders and societal groups is a foundation for the SSEP's development and refinement. We also describe how the SSEP interacts with other strategic plans and policies, enabling coordination, consistency and collaboration in the development of an integrated, sustainable energy system.

Prepare

This chapter outlines two important assumptions that 'start' the modelling process: the SSEP baseline which covers projects we consider 'fixed' in the SSEP background and the SSEP time period covered by our modelling. We then describe which technologies are in scope for SSEP, the modelling tooling and processes we will utilise, as well as the decisions we have made before the modelling begins. To proactively address environmental concerns and facilitate transparent decision-making, the SSEP will include a Strategic Environmental Assessment (SEA) and Habitats Regulations Assessment (HRA).

Model

The next phase is a combination of economic modelling and spatial evaluation. Economic modelling plays a crucial role in simulating and analysing the functioning and evolution of the energy system under various inputs and scenarios. By incorporating inputs mentioned in the prepare chapter with the outputs of the spatial evaluation, we will run simulations to develop pathway options for the SSEP.

The spatial evaluation itself assesses the environmental, societal, other uses of the land and sea and technical engineering design pillars. Through this process, we will identify suitable geographic areas for each of the in-scope technologies. Although we will not recommend project-specific locations, we will understand the potential for the development of energy infrastructure in different GB zones. It will be important to ensure that this approach to modelling is sensibly aligned with established planning methodologies already operating in different parts of GB, such as Scotland.

Appraise

Through this modelling, we will provide a comprehensive appraisal of multiple possible pathways. As part of this, we will create between four and six pathway options, including one 'low regrets' pathway, defined as having the highest probability of success across all plausible futures. Once all the information on the final pathway options has been evaluated, the pathway options should be shared with Welsh and Scottish energy ministers for their views before the Secretary of State for Energy Security and Net Zero (from here on referred to as 'the UK Energy Secretary') makes a final choice on a single pathway option.

Consult

Using structures and forums established during the SSEP's development, we will engage a broad range of political, societal, energy industry and community stakeholders to gather valuable perspectives. Our consultation process is designed to be flexible, open, inclusive and responsive to community and industry needs. This will be supported by opinion surveys, targeted focus groups, outreach to prominent interest and campaign groups and sector-specific briefing packs.

Refine

In this chapter, we explain how we will address potential issues, gather valuable input and adjust our processes in line with feedback and best practice. We will strike a balance between incorporating stakeholder perspectives and maintaining the overall robustness, coherence and consistency of the SSEP.

Publish

The final chapter in the draft methodology explains how we will publish the SSEP and provides an overview of the content and format.

1.2 About this consultation

NESO has published this consultation document to seek feedback on the draft methodology for our first SSEP.

The draft SSEP methodology is set out in detail throughout this document, building on the executive summary above. Each chapter also has its own main messages at the start for ease of reference.

For those who would like more detailed information, additional appendices are available from page 108. A glossary is also included from page 151 to explain more technical terms.

The consultation is open to all members of the public and will close at 11:59pm GMT on Monday 20 January 2025.

To share your views on the methodology, please complete this form:
https://forms.office.com/r/rLN34jFEaC

Please note that we will publish consultation responses unless they are marked as confidential. You will be given the option to make your response confidential at the end of the form.

At the start of the relevant chapters, we have highlighted questions on which we are seeking feedback. We of course welcome any other additional comments or queries.

If you have any questions about the consultation process, please contact us at:
box.sep-portfolio@nationalenergyso.com

Together with the publication of this SSEP draft methodology for consultation, NESO has also published the Centralised Strategic Network Plan (CSNP) and the transitional Centralised Strategic Network Plan 2 refresh (tCSNP2 refresh) methodologies for consultation. These documents are available under projects and publications at our Strategic Planning page: https://www.neso.energy/what-we-do/strategic-planning

What happens next?

The publication of this draft methodology launches a five-week consultation period, after which we will refine the methodology based on stakeholder feedback. The final SSEP methodology will be published in Spring 2025, following approval from the UK Energy Secretary and Ofgem. Later next year, we will produce the pathway options for review by the UK Energy Secretary, whose choice of pathway will form the basis of our public consultation on the draft SSEP in 2026.

SSEP delivery dates

- Final approved methodology published – Q2 2025
- Pathway options presented to UK Energy Secretary - Q4 2025
- Draft SSEP published for consultation – Q2 2026
- Final SSEP published – Q4 2026

2. Foundations

2.1 Foundations: chapter overview

This chapter summarises the principles and cross-functional fundamentals which underpin the whole SSEP methodology. It describes overall SSEP pillars and governance, how the SSEP will align with other strategic plans and policies and our approach to environmental, societal and stakeholder considerations.

Throughout this chapter, you will see how we have taken a holistic approach to the SSEP, characterised by best practice modelling, early engagement with key stakeholders and close collaboration with energy industry and technical experts. Our processes are designed to build trust, confidence and credibility in the SSEP and are reinforced by robust, transparent and inclusive processes.

Main messages

- We have set out SSEP pillars which are key to delivery of the SSEP. These pillars encompass economic, societal, environmental, other spatial uses and technical engineering design requirements.
- To govern the development of the SSEP, a structure has been established, including a committee, advisory groups and working groups.
- The SSEP places a strong emphasis on protecting and enhancing the environment while working towards net zero targets. Environmental principles of prevention, precautionary and integration guide our approach.
- Transparent engagement with stakeholders and societal groups is crucial to the development and refinement of the SSEP.
- For English, Welsh, and Scottish modelling in the marine space, we will be collaborating with The Crown Estate, Crown Estate Scotland and Scottish Government at a strategic planning level.
- The SSEP interacts with other strategic plans and policies, fostering coordination, consistency, and collaboration in the development of an integrated, sustainable energy system.

We would like to know

- **Methodology** - Overall, does the methodology feel appropriate and cover the requirements for the SSEP?
- **Stakeholder engagement** - Do you agree with how we are engaging stakeholders and wider society throughout the development of the plan?
- **Environment** - Do you agree with our environmental approach, including how we have integrated SEA and HRA into the SSEP?
- **Other plans or policies** - Are there any other plans or policies we should consider that could potentially interact with the SSEP?

To share your views, please complete our consultation form:
https://forms.office.com/r/rLN34jFEaC

2.2 SSEP pillars

The SSEP aims to provide a more strategic approach to the energy transition, based on a spatially optimised energy system.

To achieve the SSEP's aims, we need to account for practical considerations that influence the delivery of energy infrastructure. To support this, we have developed a set of SSEP pillars with specific inputs into our analysis. These are economic, societal, environmental, technical engineering requirements and other spatial uses. These differ from the strategic framework objectives in the UK, Scottish and Welsh governments' commission to deliver the SSEP.

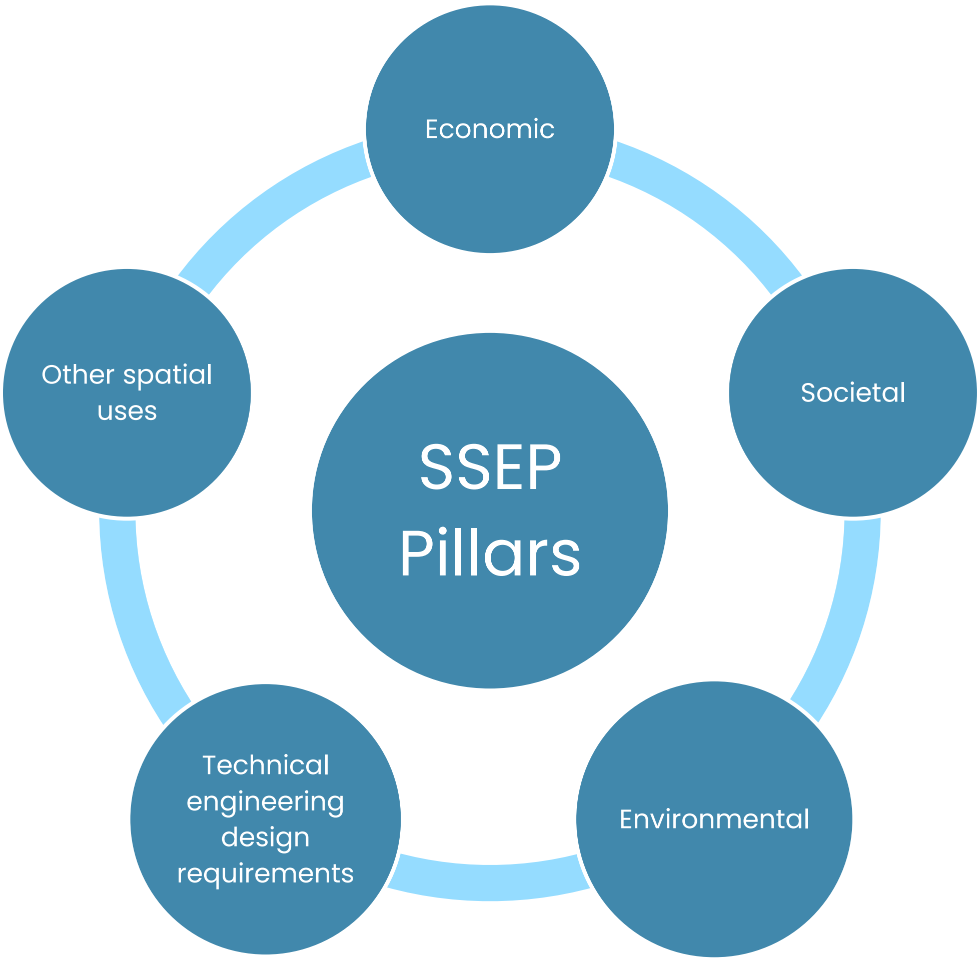

Figure 2: SSEP pillars

Economic

For the SSEP, we will focus on the most relevant economic factors relating to the costs of building and operating the energy system. The aim is therefore to ensure the infrastructure built and operation of the system are efficient, secure and meet carbon emissions targets, all with the aim of minimising costs to the consumer.

Economic modelling will be fundamental to our analysis and will create views of optimum future energy systems under different scenarios and sensitivities.

The other pillars will help the economic modelling reflect real-world practicalities on build capacities and rates in each economic zone, while also focusing on minimising total system costs, such as transport costs between different economic zones.

Societal

Many parts of society will have views on future energy infrastructure relevant to the SSEP. Our modelling will take these views into account through a range of societal indicators, including those relating to recreation and tourism, employment, health and wellbeing, community and visual amenity. We will consider how the views of society could affect the deployment of specific types of technology, and what that means for net zero.

Feedback and data will be used to assess how the SSEP pathways align to public opinion, so we can minimise impacts on different sections of society. This will enable societal views to shape the decision-making process and the pathway that is ultimately approved by the UK Energy Secretary.

Environmental

We will assess the potential environmental interactions, or impacts, associated with delivering the energy infrastructure in scope of the SSEP. The assessment will look to understand how environmental factors may impede, limit or support specific technologies. The assessment will encompass various aspects, including biodiversity, historic environment and the preservation of sensitive habitats.

Generally, the higher the environmental impact, the more challenging it will be to achieve consent and deliver. We will undertake a Strategic Environmental Assessment (SEA) and a Habitats Regulations Assessment (HRA) to evaluate environmental impacts early in the process, as well as to inform decision-making as the plan develops.

An SEA framework will be developed to assess the SSEP options against the current environmental baseline[4] to determine if significant environmental effects are likely to arise and to provide appropriate mitigation. This will be presented in the form of an SEA Options Report, which will accompany the pathway options report to the UK Energy Secretary.

Technical engineering design requirements

This pillar considers how different types of renewable energy technologies have different technical and locational requirements. This involves evaluating factors such as terrain, footprint and seabed conditions, access to relevant resources (wind speed, solar irradiation, water availability) and proximity to necessary infrastructure (for example, access to transport).

This will be reflected in our approach to considering the technical engineering design requirements of in-scope energy generation and storage. By identifying and addressing

[4] The environmental baseline provides the evidence base on which the key issues to be addressed via the SEA are identified, as well as against which impacts of the plan can be assessed.

these issues in the earliest stages of plan development, we can account for potential risks and opportunities, increasing the deliverability of the SSEP.

Other spatial uses

Land and sea areas are finite resources facing increasing demands from different sectors. These demands can be complementary or competing and may change over time to meet evolving government ambitions and colocation opportunities. For example, the utilisation of land and marine areas needs to be assigned appropriately to provide housing for a growing population, protect and enhance the environment and achieve net zero. We will consider factors such as urban development, agricultural land, fisheries, protected areas (for example, defence infrastructure and areas of utilities and services).

We will identify land and sea spatial use demands, considering them alongside societal and environmental factors. This enables us to have a comprehensive view of all land and sea sectors that may compete or complement the potential development of in-scope energy infrastructure.

The SSEP will reflect UK and devolved government policies for agriculture that prioritise and protect the best and most versatile agricultural land. In England, it will reflect the National Planning Policy Framework; in Scotland, National Planning Framework 4, and in Wales, Planning Policy Wales. Similarly, it will reflect marine planning mechanisms already operating and in development in different parts of Great Britain, such as Scotland's existing National Marine Plan and its development of a National Marine Plan 2, as well as the process to review and update the Scottish sectoral marine plan for offshore wind.

Our recommendations for the zonal locations of energy infrastructure will not take precedence over other land uses. Instead, we will take a more strategic approach that allows for more location and project-specific decisions to be made during subsequent processes. As noted above, this work will consider existing planning frameworks (included devolved) across the UK as an input, including spatial policy and requirements already set out.

Summary of SSEP pillars

The SSEP will consider different economic pathways to decarbonisation that are holistically assessed against societal, environmental, technical engineering design requirements and other spatial uses to provide greater confidence that the final SSEP pathway is deliverable. Security of energy supply and achieving net zero are core to NESO's mandate and all pathways will achieve these. We also refer to spatial evaluation pillars as all those listed above apart from the economic pillar.

2.3 SSEP governance

Given the SSEP's scale and potential impact, the SSEP commission outlined the minimum governance structure required to support its development.

This governance will ensure that throughout the process, we have engagement with, and input from, the UK, Scottish and Welsh governments and Ofgem. The governance meetings will provide advice and guidance to NESO, ensure oversight and accountability from government and facilitate key stakeholder feedback.

To ensure the SSEP aligns with the clear purpose outlined by the commission, we have established a governance structure, illustrated in the below figure.

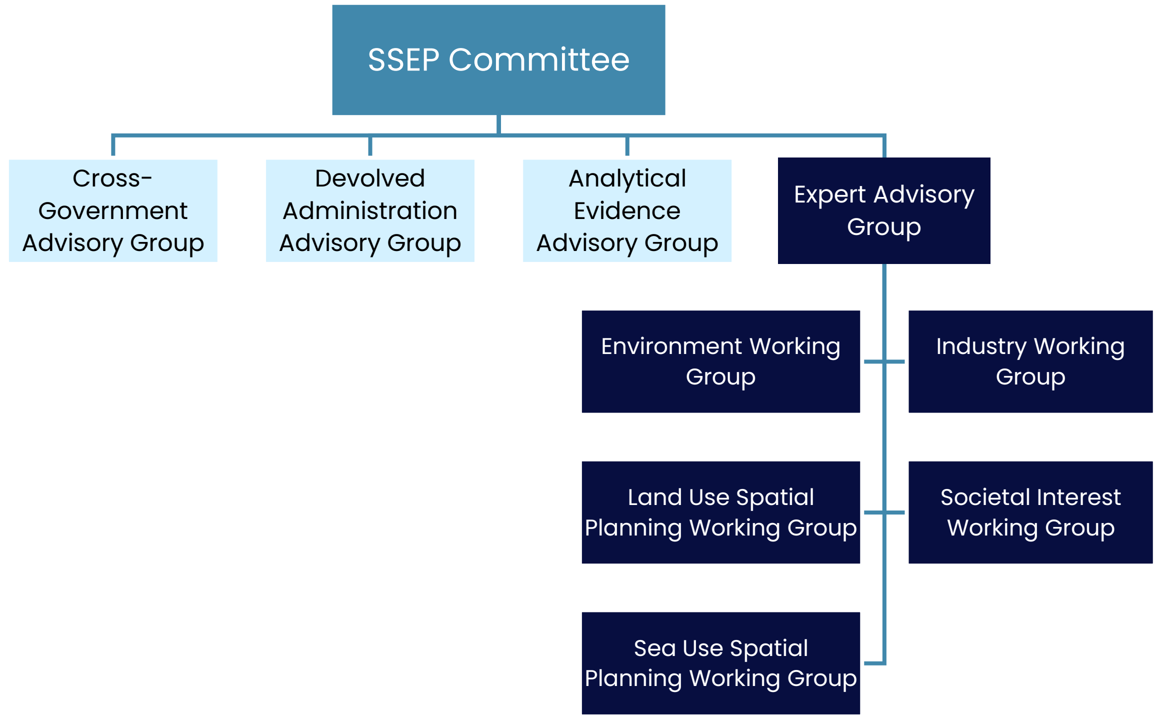

Figure 3: External governance structure

2.3.1 Governance groups

SSEP Committee

A committee chaired by NESO with representatives from NESO, DESNZ, Ofgem, the Scottish Government and the Welsh Government. This group is responsible for providing strategic direction and advice on the development and production of the SSEP. We also have an SSEP Committee Working Group to support the committee which seeks to manage risks and actions for the SSEP Committee, ensuring it interacts effectively with the other governance groups.

Cross-Government Advisory Group (CGAG)

An advisory group chaired by DESNZ with representation from various UK government departments. This group provides strategic direction and advice from representatives on wider sectoral demands on land and sea.

Devolved Administration Advisory Group (DAAG)

An advisory group chaired by NESO with representation from NESO, DESNZ, the Scottish Government and the Welsh Government, ensuring strategic direction and advice relevant to devolved issues.

Analytical Evidence Advisory Group (AEAG)

An advisory group chaired by NESO with representation from NESO, DESNZ, Ofgem, the Scottish Government and the Welsh Government. This group delivers oversight and assurance on the modelling process and analytical issues. In addition to the above, we have also established an Analytical Working Group (AWG) to support the AEAG. The AWG feeds into the AEAG and discusses the detailed modelling topics underpinning the SSEP methodology.

Expert Advisory Group (EAG)

An advisory group chaired by NESO that provides technical insight and advice on the SSEP, based on engagement with environmental, land, marine, energy industry and societal groups. The EAG will challenge, review and weigh up benefits and opportunities across all categories of expertise.

Topics for the governance groups

As we develop the SSEP, we will ensure that crucial outputs and discussion points are taken to the relevant external governance forums as part of our plan. These include:

- **Methodology consultation** – The content of this document and the associated approaches to modelling the SSEP.
- **Completion of initial modelling** - We will prepare supporting advice on pathway options informed by an SEA alternatives assessment, including environmental, community and technical appraisals, as set out in the commission. This will be submitted to the SSEP advisory groups and SSEP Committee for review and feedback.
- **Pathway options** - We will share the pathway options and supporting advice with Ofgem and the Scottish and Welsh Energy Ministers, prior to submission to the UK Energy Secretary.
- **Submission of pathway options** - We will submit the pathway options, together with supporting advice and stakeholder feedback, to the UK Energy Secretary. Separately, Ofgem may provide independent advice to the UK Energy Secretary regarding the impact of the pathways on consumer interests. The SSEP is co-commissioned by the UK, Scottish and Welsh governments and is being developed

on a partnership basis between those governments. In keeping with this approach, the views of the Scottish and Welsh energy ministers and Ofgem will be sought and provided to the UK Energy Secretary ahead of any decision. We will aim for agreement between the parties in advance of submission to the UK Energy Secretary. Where this isn't possible, we will highlight the different perspectives and the reasons behind them in our advice.

- **Pathway selection** - The UK Energy Secretary will confirm to us which pathway to take forward for public consultation and for the HRA.
- **Final SSEP publication** - On completion of the SEA, HRA and public consultation, the final SSEP for publication shall be reviewed by the SSEP Committee prior to publication. The UK, Scottish and Welsh governments and Ofgem will be invited to provide their endorsement alongside its publication.

2.3.2 Stakeholder working groups

Under the EAG referred to in the governance section above, there are several stakeholder workings groups as described below.

Environmental Working Group

This group brings together statutory and non-statutory environmental stakeholders representing GB's land and marine environment to:

- determine the approach and methodology for appraising and assessing the environment for the SSEP
- gather environmental data and feedback from the group to support the environmental appraisals (SEA and HRA) for the SSEP
- demonstrate that the SSEP minimises and mitigates environmental impact
- assist in meeting the statutory consultation requirements for the SEA and the HRA

Land and Sea Use Spatial Planning Working Groups

These groups bring together government stakeholders with planning expertise and data for land or sea use to:

- gather data and feedback from the group to support the development of the land and sea use framework and the technical engineering design requirements for the technologies we are spatially optimising
- support the approach and methodology for appraising and assessing land and sea use
- challenge and review the pathways to prioritise land and sea uses and recommend pathway trade-offs
- provide spatial data modelling expertise

Industry Working Group

Energy industry stakeholders such as transmission owners (TOs), distribution network operators (DNOs), energy infrastructure developer representatives, original equipment manufacturers (OEMs) and academics sit on this group to provide an industry steer and expertise in both electricity and hydrogen. The group will:

- be a central communications channel to ensure the energy industry understands the aims and objectives of NESO's strategic energy planning projects and how they work together
- test understanding and gather data, insights and feedback, showcasing the work of and gathering support for strategic plans

Societal Interest Working Group

The primary way we will engage with societal interests will be through societal forums, each focused on a societal sector. The purpose of the forums is to provide insight on the development of the SSEP and listen and act upon feedback to influence and contribute to its evolution. For more information on societal forums, see appendix 2 societal approach.

Representatives from societal forums will sit on the Societal Interest Working Group. They will:

- collate views from across societal forums, ensuring that members' views and unique perspectives on the energy trilemma are reflected
- listen and feedback on any questions or concerns from societal stakeholders
- suggest ways to enhance the success of our engagement activity
- advise on any changes to the structure of our engagement with societal groups that may be necessary

2.4 Stakeholder approach

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

Through SSEP stakeholder groups we will seek advice from experts and key stakeholders to gather data and opinions. This will be supported by a clear engagement plan which provides feedback opportunities and explains how we have considered and acted on feedback.

Who are our stakeholders?

The SSEP 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 Regional Energy Strategic Plans[5] (RESPs).

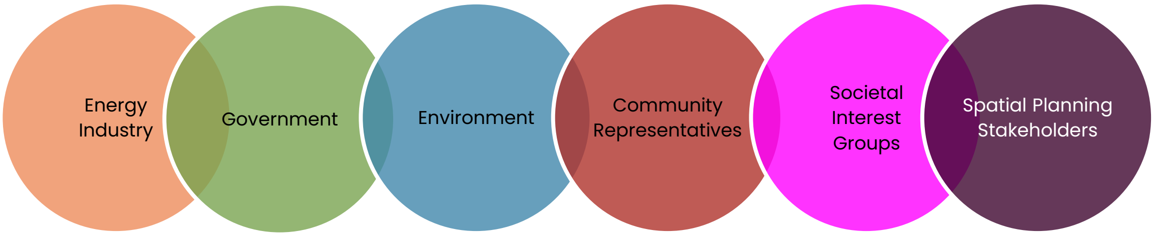

Figure 4: Stakeholder groups that we will be engaging with throughout the SSEP

2.4.1 Engagement principles

The following will define our stakeholder engagement:

- **Timely and transparent** - We will engage early, with a transparent process and 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, and 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. We will group feedback under themes and share how we have considered and addressed these themes. We will manage stakeholders' expectations and explain that 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. Finely balanced trade-offs will need to be made.
- **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

[5] NESO, New Regional Energy Strategic Planner role - https://www.nationalgrideso.com/news/new-regional-energy-strategic-planner-role

stakeholders' time. We will build on relationships formed during other strategic planning activities and explain to stakeholders how the SEP projects all fit together.

- **Tailored engagement** - 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 regularly seek feedback to understand how well the engagement is working for stakeholders so we can enhance our approach.

2.4.2 Timely engagement

Continuous engagement with the working groups throughout the development of the SSEP will help shape, challenge and review its outputs. Alongside this, we will undertake regular bilateral engagement with interested and influential stakeholders and representatives of a wide range of societal and community groups.

We will also provide transparency via regular communications open to all. The public will have the opportunity to respond to our draft SSEP consultation that will be published on our website. Figure 5 shows our high-level engagement milestones:

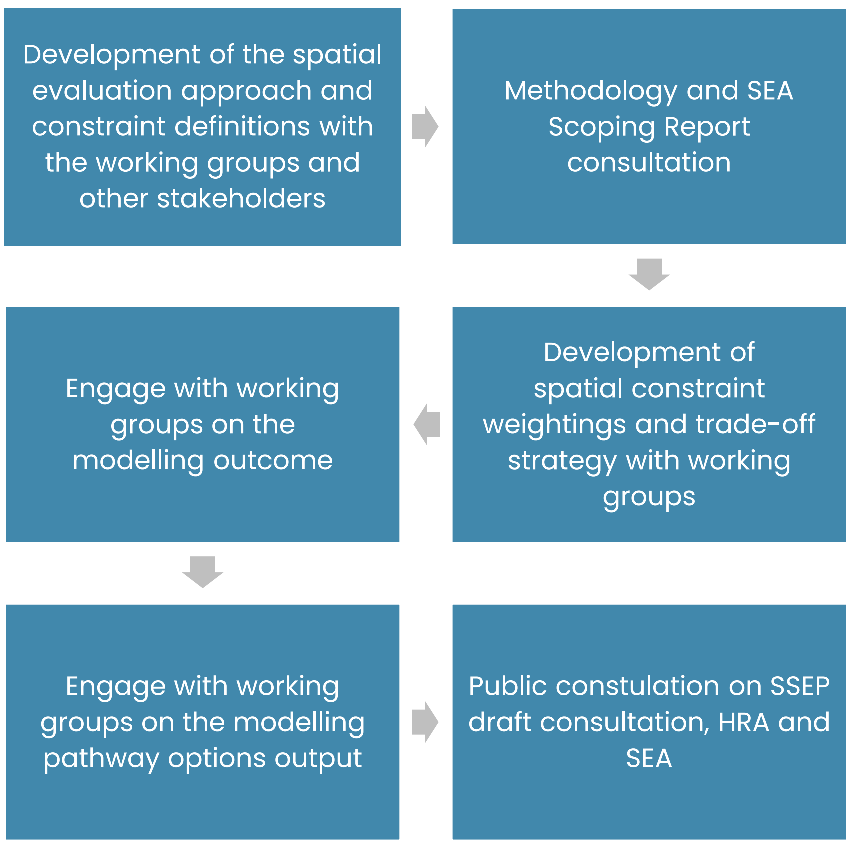

Figure 5: Process flow of high-level engagement milestones

For further information on our engagement activities, please see appendix 1.

2.5 Societal approach

The SSEP is one of the largest strategic energy planning projects ever undertaken in GB, so it is important to listen to the views of the public and interested parties as the plan is developed. Considering these views is key to seeking societal acceptability for the SSEP and GB's transition to clean, secure and affordable energy.

Engaging with a diverse array of stakeholders will ensure the SSEP comprehensively reflects the needs, values and ambitions of society in relation to the energy transition. This inclusive approach will align the SSEP with societal expectations and also contribute to a more equitable and just transition, by considering the perspectives of society as a whole.

Additionally, through this engagement, society can learn about and discuss the options for achieving GB's energy transition, including its potential impacts on, and benefits to, local communities.

Our engagement will use primary research to take feedback and opinions on the transition to net zero and provide engagement channels for a wide range of stakeholders as the SSEP progresses. Participating in these and seeing how inputs from different sectors of society are considered will build public trust in the process and the final plan.

The societal component of the spatial evaluation will underpin our approach. The framework will help identify spatial locations suitable for energy infrastructure so that the societal spatial constraints (alongside environmental and other spatial constraints or exclusions) can be effectively considered alongside the energy and economic modelling being undertaken for the SSEP.

We expect different people and groups to have diverse views on energy infrastructure and its impact on communities and the environment. By analysing their feedback, we will understand what society values and use this evidence to shape our decision-making process. Societal views will be used to develop analysis and metrics that will inform our spatial evaluation and give us a deeper understanding of societal opinion on in-scope infrastructure that will in turn influence plan development. It may also highlight opportunities for infrastructure development with high levels of societal support in certain areas of GB.

Alongside gathering in-depth primary data, we will use high-quality secondary data shared with us by the government, energy and broader stakeholders, such as the DESNZ Public Attitudes Tracker[6]. The data will help inform the spatial evaluation.

[6] Department for Energy Security and Net Zero, DESNZ Public Attitudes Tracker - https://www.gov.uk/government/collections/public-attitudes-tracking-survey

2.5.1 Why we are engaging societal stakeholders

Society will benefit from the development of new infrastructure. However, they will also be impacted, not only through the financial cost associated with it, but also by its potential effects on local communities and any negative environmental impact. In this context, it is crucial to develop and retain societal acceptability for the final plan.

Experience in the development and delivery of large-scale energy projects has shown that policy makers, developers and campaigners use many different data points and narratives to rationalise the trade-offs of benefits and impacts to the public. These can be difficult to understand, so by openly collecting and analysing primary and secondary data, NESO aims to be a trusted provider of information, helping the public focus on the facts and key trade-offs that need to be made.

2.5.2 Our approach

We will conduct societal opinion research and engage a representative cross-section of societal interest groups and political representatives.

How and with whom we engage will be based on stakeholders' interests and how they relate to the SSEP, focusing on the energy trilemma of sustainability, security and affordability. This will enable effective conversations with different stakeholder groups, keeping the discussions relevant to their experience and interest in the plan.

We will consider a wide range of societal opinions, although the SSEP will not be able to reflect the views of every person or group. However, the SSEP will explain how decisions have been made, considering what we have heard in feedback and what we must do as part of our obligation to government and society.

Four broad categories of societal stakeholders will be engaged:

- **The general public** - A GB-wide societal opinion survey will gather the views of different demographics and segments of society across GB. The survey will aim to speak to about 9,000 people. This large sample will reflect society at a GB level and across the nations and allow us to use multi-level regression (MRP) and post stratification methods, to further understand local views. The survey will be supported by a series of focus groups, split both regionally and demographically, allowing us to further analyse and understand findings from the opinion survey.

- **Interest groups** - Some societal groups are interested in the energy trilemma because it impacts or contributes to their purposes or goals. These groups – including energy or infrastructure campaign groups – represent a broad spectrum of society and will bring unique perspectives to the conversation.

- **Political representatives** - Political representatives and groups are important to aid society's understanding of energy infrastructure development. While the UK, Scottish and Welsh governments have a formal role in the SSEP, we will also engage with politicians who represent society at regional, constituency or local government levels.

- **Host areas** - The SSEP will consider all parts of GB and it is likely some areas will see clusters of projects, a high number of projects or host energy infrastructure projects for the first time. The development of the SSEP will provide an early opportunity for communities to have their say on strategic planning that may affect them. We will also help these areas understand the process and signpost them to how they can engage and influence the developments in their area.

For further detail on how we will engage and capture feedback, please see appendix 2.

2.5.3 The Public Sector Equality Duty

In developing and delivering the SSEP, we will comply with the Public Sector Equality Duty, ensuring we think about how our activities can improve society and promote equality in every aspect of our day-to-day business.

2.6 Environmental approach

The UK, Scottish and Welsh governments are committed to the protection and enhancement of the environment and the preservation of the unique natural, cultural and heritage assets it offers. Achieving this and meeting net zero targets go hand in hand. Our development of the SSEP will reflect this, by identifying and addressing environmental risks and opportunities in the earliest stages of plan development.

2.6.1 Guiding principles

Our approach is underpinned by the environmental principles outlined in recent UK, Scottish and Welsh governments' policy statements. As required by the Environment Act 2021[7], the Environmental Principles Policy Statement 2023[8] includes five core principles for England's environmental protection: integration, prevention, rectification at source, polluter pays and the precautionary principle. Similar principles have been set out or proposed in Scotland[9] and Wales[10].

There is no prescribed approach for applying the environmental principles. For the SSEP, the most relevant are prevention, precautionary and integration, where:

[7] Environment Act (2021) - https://www.legislation.gov.uk/ukpga/2021/30/contents
[8] Department for Environment, Food & Rural Affairs, Environmental principles policy statement (2023) - https://www.gov.uk/government/publications/environmental-principles-policy-statement/environmental-principles-policy-statement
[9] Scottish Government, Environment - guiding principles: statutory guidance (August 2023) - https://www.gov.scot/publications/scotlands-guiding-principles-environment-statutory-guidance/
[10] Welsh Government, Environmental principles, governance and biodiversity targets: White Paper (April 2024) - https://www.gov.wales/environmental-principles-governance-and-biodiversity-targets-white-paper

- Prevention promotes policy design options that prevent environmental harm. This is most effective when considered early before any harm occurs.
- Precautionary manages the risk of serious or irreversible environmental harm. It promotes reasonable assessments of likelihood and severity of harm even where there is a lack of scientific certainty.
- Integration guides policymakers to look for opportunities to embed environmental protection and enhancement across all fields of policy, not just those directly related to the environment.

These principles provide a foundation, alongside relevant planning and environmental policy, to embed environmental protection and nature recovery in the development of the SSEP. The mitigation hierarchy as set out in UK planning guidance, will be key to determining how environmental factors are considered and is discussed further in appendix 7.3.

Proposed approach

The SSEP's development will integrate environmental considerations throughout, from conceptualisation to completion, based on three distinct but complementary processes.

Process	Objective
Spatial Evaluation	The environmental component of the spatial evaluation will help identify spatial locations suitable for energy infrastructure. This enables environmental spatial constraints or exclusions (as well as societal, other spatial uses and technical engineering design requirements considerations) to be effectively considered alongside the energy and economic modelling being undertaken for the SSEP. This is discussed further in the prepare and model chapters.
Strategic Environmental Assessment (SEA)	To meet the requirements relating to the SEA in England, Scotland and Wales, the SEA process will inform and influence the SSEP's development, evaluating the likely significant environmental effects of the plan and reasonable alternatives. The SEA approach is discussed below and detailed further throughout the methodology.
Habitats Regulations Assessment (HRA)	The HRA's objective is to determine whether SSEP implementation could adversely affect the integrity of internationally important wildlife sites. Where significant effects are identified, an 'appropriate assessment' will be undertaken to identify the internationally important wildlife sites that could be impacted, what the impacts could be, and how they could be mitigated. The HRA approach is discussed below and detailed further throughout the methodology.

Table 1: Proposed approach

Throughout each of these processes, we will assess the potential environmental interactions, or impacts, of the strategic energy infrastructure options to ensure our plan considers the environment. The SEA and HRA will provide an assessment of the energy infrastructure considered in scope for the SSEP. These environmental assessments will be informed by work already underway or completed on relevant plan-level assessments. These will be identified during the SEA scoping and HRA evidence gathering stages.

2.6.2 SEA overview

The SEA is a systematic process to evaluate the likely significant environmental effects of a draft SSEP and reasonable alternatives in terms of environmental issues. Its purpose is to ensure the plan is sound and reflects sustainable development ambitions. The SEA is a tool to identify the potential environmental impacts of the decisions being made during plan development.

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

- England - Environmental Assessment of Plans and Programmes Regulations 2004[11]
- Wales - Environmental Assessment of Plans and Programmes (Wales) Regulations 2004[12]
- Scotland - Environmental Assessment (Scotland) Act 2005[13]

In addition to complying with the with the relevant legislative requirements, the SEA process is an important opportunity to help SSEP decision makers understand the potential impacts of different spatial approaches. The SEA process also provides the opportunity to explore the relative sustainability merits and trade-offs required for different SSEP options. In response to this, the SEA will be undertaken through a series of phases, as represented in figure 6 and explained throughout this methodology.

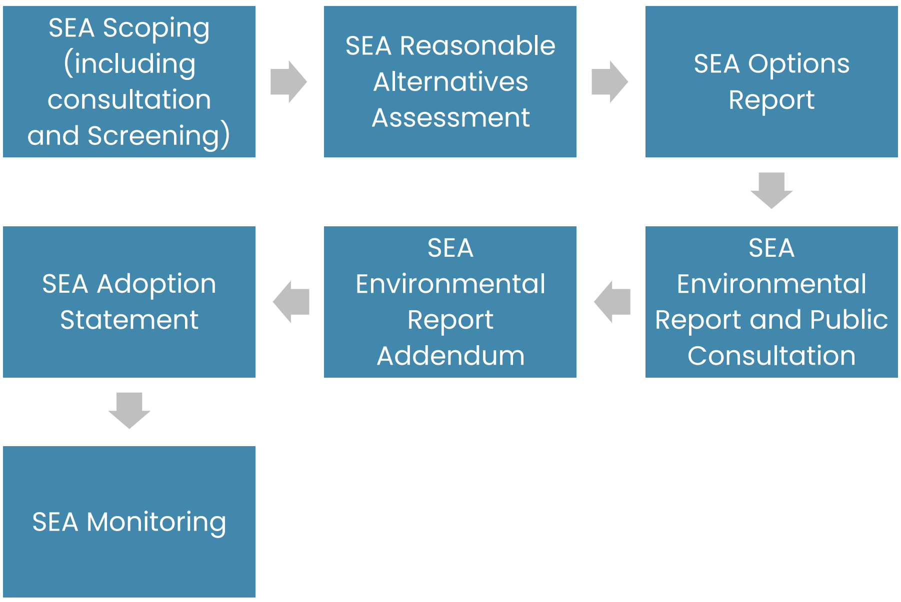

Figure 6: SEA process

[11] Environmental Assessment of Plans and Programmes Regulations (2004) - https://www.legislation.gov.uk/uksi/2004/1633/contents

[12] Environmental Assessment of Plans and Programmes (Wales) Regulations (2004) - https://www.legislation.gov.uk/wsi/2004/1656/contents/made

[13] Environmental Assessment (Scotland) Act (2005) - https://www.legislation.gov.uk/asp/2005/15/pdfs/asp_20050015_en.pdf

2.6.3 HRA overview

In February 2021, the UK government published HRA[14] guidance. HRA is the term used for the process set out in the Conservation of Habitats and Species Regulations 2017[15], the Conservation of Offshore Marine Habitats and Species Regulations 2017[16] for England and Wales, and the Conservation (Natural Habitats, &c.) Regulations 1994[17] as amended for Scotland, collectively referred to as Habitats Regulations.

The HRA is a plan compliance assessment that determines whether the SSEP will cause an adverse effect on the integrity of internationally important wildlife sites either alone or 'in combination' with other plans or projects. These sites include Special Areas of Conservation (SAC), Special Protection Areas (SPA) and, as a matter of government policy, listed or proposed Ramsar sites (wetlands of international importance), potential SPAs, possible SACs and any site required as compensatory measures for adverse effects on sites listed under the Habitats Regulations.

If an adverse effect on integrity will arise, the SSEP must either be amended or it must pass a series of further tests, known as derogations, to establish that:

- there are no feasible alternatives to the harmful proposal that would cause less harm
- there are Imperative Reasons of Overriding Public Interest (IROPI) why the harmful proposal should nonetheless proceed
- all necessary compensatory measures are secured to address the harm to the network of internationally important wildlife sites

For the SSEP to adopt a proposal likely to have an adverse effect on the integrity of an internationally important wildlife sites, all three tests must be passed.

There is value in the HRA process commencing prior to the completion of a draft SSEP, when options will be fixed. Depending on the level of detail available regarding the options, commencing the HRA early will help shape the SSEP by identifying options that pose a risk to internationally important wildlife sites and prove difficult to avoid or mitigate. This will inform the degree to which the SSEP may need to rely on derogations from the regulations. As such, the HRA for SSEP will commence during plan drafting and will support the development of options.

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[14] Department for Environment, Food & Rural Affairs, Natural England, Welsh Government and Natural Resources Wales, Habitats regulations assessments: protecting a European site (February 2021) - https://www.gov.uk/guidance/habitats-regulations-assessments-protecting-a-european-site
[15] The Conservation of Habitats and Species Regulations (2017) - https://www.legislation.gov.uk/uksi/2017/1012/contents
[16] The Conservation of Offshore Marine Habitats and Species Regulations (2017) - https://www.legislation.gov.uk/uksi/2017/1013/contents/made
[17] The Conservation (Natural Habitats, &c.) Regulations (1994) - https://www.legislation.gov.uk/uksi/1994/2716/contents

2.6.4 Statutory consultation requirements for environmental assessments

As part of developing the SEA and HRA, we will engage with the statutory environmental consultees. The outputs will accompany the draft SSEP for public consultation.

SEA requirements

In line with the relevant SEA requirements in England, Scotland and Wales, the SEA Scoping Report will be sent to the SEA statutory environmental bodies for comment over a period of five weeks. These include:

- England - Environment Agency, Historic England and Natural England
- Scotland - Historic Environment Scotland, NatureScot and Scottish Environment Protection Agency
- Wales - Cadw and Natural Resources Wales

We will look to utilise the SSEP's Environmental Working Group (EWG) to undertake the SEA Scoping Report consultation. The members of this group include the SEA statutory environmental bodies and other relevant environmental organisations.

Given potential transboundary effects, it is anticipated statutory consultees for SEA in Northern Ireland and the Republic of Ireland will also be consulted. These include:

- Northern Ireland - Department of Agriculture, Environment and Rural Affairs (DAERA)
- The Republic of Ireland - Environmental Protection Agency (EPA)

Transboundary consultation is not likely to be required with the other nations bordering GB waters given the more limited likelihood of impacts across these maritime boundaries. The appropriateness of engagement with these stakeholders will be reviewed as the SSEP and SEA progress.

In addition, the SEA legislation in England, Scotland and Wales have statutory public consultation requirements for the SEA Environmental Report, which will be undertaken on the pathway selected by the UK Energy Secretary.

HRA requirements

The HRA's first stage will be to produce the HRA Evidence Gathering Report. This report will be shared with the Environmental Working Group, including the relevant Statutory Nature Conservation Bodies (SNBCs), which include:

- Natural England
- Natural Resources Wales
- NatureScot
- Joint Nature Conservation Committee (JNCC)

As with the SEA, this could also include stakeholders in Northern Ireland, the Republic of Ireland and other European countries bordering GB's waters.

There is no strict requirement on when consultation must occur in the HRA process. However, we consider it is essential to involve and consult with the SNCBs throughout the process, so we will be engaging with the SNCBs throughout, starting from the HRA Evidence Gathering stage. This will enable the early identification and testing of options that pose a risk to internationally important wildlife sites, so measures can be taken to reduce the need for derogations under the HRA regulations.

2.6.5 Climate change impacts on availability and suitability of land

Land is a finite resource facing increasing demand and challenges, one of which is climate change. Climate change could result in changes to water availability, leading to drought and flooding forecasts, which affects certain generation technologies like electrolysers that have a dependency on water. As a result, changes in water levels in certain areas could impact the viability of locations for these technologies. If a location is more prone to flooding in the future, this may also mean it is less or no longer suitable as a location for energy infrastructure.

Our assessment of climate change's impact will be considered through available data sources. We will use this information to consider the suitability of locating assets at a zonal level over the lifetime of generation assets. As far as possible, this will mitigate against assets being located in more vulnerable zones.

2.7 Collaborative marine modelling

We will work in close partnership with The Crown Estate, Crown Estate Scotland and the Scottish Government on the offshore component of the SSEP. In addition to collaborating with The Crown Estate in relation to England and Wales, their marine modelling will cover Scotland through collaboration with Crown Estate Scotland and the Scottish Government.

To ensure the independence of NESO in carrying out the SSEP modelling, we will set the modelling and decision parameters underpinning the SSEP. This will also provide transparency of outcomes and consistency between onshore and offshore analysis.

Spatial offshore analysis for the SSEP will be supported by The Crown Estate's Whole of Seabed modelling capability. This will help ensure strategic coherence between SSEP and offshore leasing activities, as well as other initiatives where this capability has been used, for example The Crown Estate's Marine Delivery Routemap and Defra's Marine Spatial Prioritisation Programme (MSPri). The Whole of Seabed modelling will cover Scottish waters as well as English and Welsh waters and joint work is already underway between The Crown Estate, Crown Estate Scotland, and the Scottish Government to ensure that the

Whole of Seabed modelling reflects the marine spatial planning approaches and modelling that already exist in Scotland. Under the partnership, and using its two decades of marine spatial planning experience and insights from its Marine Delivery Routemap, The Crown Estate will work in partnership with NESO to support the development of:

- the treatment of spatial constraints
- opportunities for colocation of offshore renewables with other users, interests and sensitivities within the marine environment
- marine stakeholder perspectives and issues
- Levelised Cost of Energy (LCoE) for offshore renewables
- interpretation of spatial modelling outputs and insights

It is critical that the SSEP and marine leasing and development in English, Scottish and Welsh waters are appropriately aligned. This way, we can maximise the impact that strategic spatial planning will deliver, and respective processes and outputs will be aligned to achieve this. We are exploring with the Crown Estate the most appropriate way to align the SSEP HRA and the Crown Estate's HRA on their prospective leasing plans.

When it comes to utilising the Whole of Seabed evidence base, our collaboration with The Crown Estate, Crown Estate Scotland and Scottish Government will be underpinned by key principles and clear roles and responsibilities. We will draw on our experience in the Virtual Energy System project[18] to adopt a collaborative approach to SSEP data sharing. This will enable us to integrate and interoperate with The Crown Estate and the relevant marine leasing and planning authorities in Scotland on their leasing models, strategies and datasets.

Using this approach requires our organisations to consolidate data and insights in a consistent manner. Both NESO and The Crown Estate will use agreed data standards, classification and categorisation to nurture effective data sharing in support of interoperability, while protecting underlying intellectual property and securing sensitive underlying data. We are also investigating the scope for establishing a similar marine spatial data sharing approach with Crown Estate Scotland and the Scottish Government, where seen as beneficial by all parties.

2.7.1 Principles

- **Alignment** - Developing and working towards a shared strategic vision and direction of travel.
- **Collaboration** - Working together to integrate models and datasets.
- **Ensuring independence** - Creating a governance framework for collaborative marine modelling, formalising roles and responsibilities for realisation of consumer benefits and maintaining independence throughout the approach.

[18] NESO data sharing infrastructure to enable an ecosystem of interconnected digital twins of the entire energy landscape, working in parallel to the physical system.

- **Transparency** - Clearly communicating to stakeholders their roles and responsibilities, ensuring visibility of the federation approach.

2.7.2 Process

- We will use agreed data standards, classifications and categorisation.
- We will engage with stakeholders to develop the spatial evaluation for the marine area. Throughout this process there will be close engagement with The Crown Estate, Scottish Government, Crown Estate Scotland to ensure it is informed by their input.
- We will share our spatial evaluation model and the economic modelling outputs for the marine area with The Crown Estate, Crown Estate Scotland, and the Scottish Government.
- The Crown Estate will use its Whole of Seabed model to run geospatial analysis on marine output in accordance with NESO's methodology for spatial evaluation.
- The Crown Estate will provide NESO with the resulting geospatial outputs and input layers. These layers will contain the applied exclusions and spatial constraints and give insight on the deliverability of marine generation volumes within the defined zones.
- This information will be used to inform modelling runs during the modelling iteration process across both economic and geospatial modelling.

2.8 Interactions with other strategic plans

2.8.1 Other NESO strategic energy plans

The UK government also commissioned NESO to deliver advice on how to achieve a clean power system by 2030. Our advice[19], published on 5 November 2024, focuses on what is required from a generation and network perspective to achieve that ambition. The government will respond to this in their Clean Power 2030 Action Plan, which will form the starting point for the SSEP or the SSEP 'baseline'.

The SSEP objective is to provide greater certainty on the locations of electricity generation and storage, including hydrogen assets which will feed into our CSNP, which will then set out the specific network solutions to meet the additional network requirements. In December 2023, Ofgem published its 'Decision on the framework for the Future System

[19] NESO, Clean Power 2030 – https://www.neso.energy/publications/clean-power-2030

Operator's Centralised Strategic Network Plan[20],' which provides an overview of NESO's role in developing the CSNP and the interactions with the SSEP. The report sets out that, "once a SSEP has been produced it should inform the first longer-term CSNP… covering the transmission network needed to deliver the spatial energy plan."

There will also be interactions with the Regional Energy Strategic Plans (RESPs), fostering coordination, consistency and collaboration in support of an integrated and sustainable energy system.

The SSEP, CSNP and RESPs will need to align and be coherent across different timescales and levels of planning. For example, they will share information, data and insights to inform development. This can include sharing scenario assumptions, modelling results, infrastructure requirements and other relevant information to ensure a comprehensive, coordinated approach over time.

In the long term, the plans will undergo iterative processes, whereby feedback and insights from one plan informs the development or revision of another. For example, insights from the development of the RESPs will inform the development of future iterations of the SSEP, which will in turn provide feedback for follow-on iterations of the CSNP and RESPs respectively. A summary of these interactions can be seen in figure 7.

The respective plans will each analyse and evaluate the shared information to identify areas of alignment, potential conflicts and opportunities for coordination. This may involve comparing scenario assumptions, assessing infrastructure requirements and identifying synergies or trade-offs between different plans.

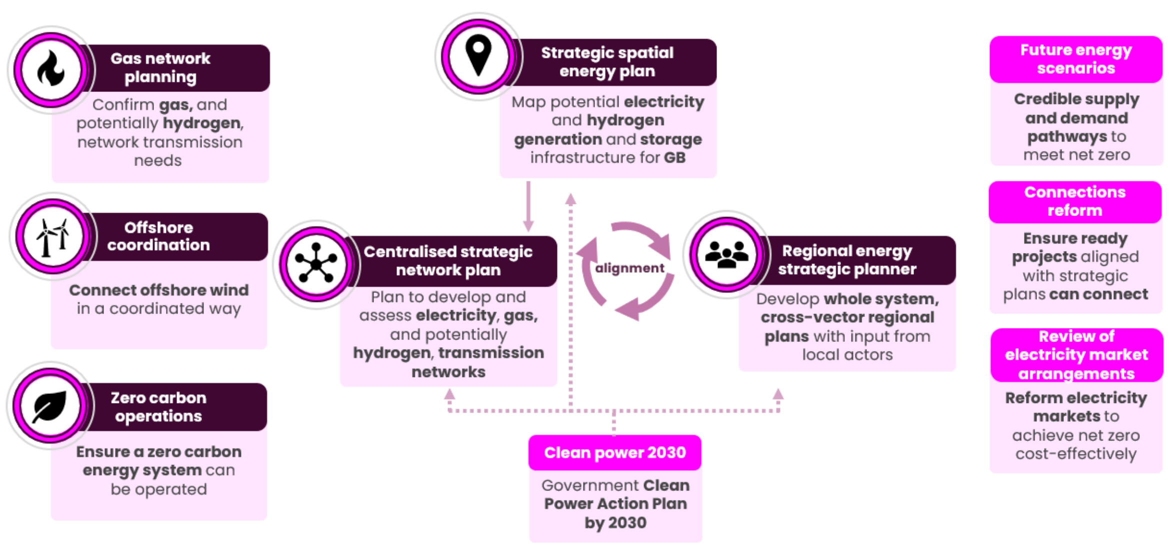

Figure 7: Summary of strategic energy planning interactions

[20] Ofgem, Decision on the framework for the Future System Operator's Centralised Strategic Network Plan (December 2023) - https://www.ofgem.gov.uk/decision/decision-framework-future-system-operators-centralised-strategic-network-plan, p5

2.8.2 Connections reform and interactions with SSEP

It will be important to consider how the SSEP interacts with the current reforms to the electricity transmission connections process. The overall objective for a reformed connections process in GB is to ensure quicker connection to and use of the electricity transmission system, in a more coordinated and efficient way, in order to help meet net zero ambitions[21].

The UK government and Ofgem published their Connections Action Plan (CAP)[22] in November 2023. Action 3.6 of the CAP said we should introduce a connections process that aligns with strategic planning reforms and the Review of Electricity Market Arrangements (REMA).

We published our connections reform consultation[23] on 5 November. In that consultation, we recommend that the new connections queue, determined under the revised connections reform arrangements (currently planned to be implemented from Q2 2025), should be aligned to the government's Clean Power 2030 Action Plan.

In addition, to enable investors of projects seeking to connect to or use the transmission system in the interim period before the SSEP, we recommended to the government that their Action Plan should also include a pathway from 2031 to 2035. If the connections reform proposals are taken forward, this will be used as the basis for issuing connection offers for projects in that period.

Once the first SSEP is in place, it will be used as the basis for offering connection agreements going forward. Where the SSEP pathway sets out a higher capacity than has confirmed connection agreements for the 2031 to 2035 period, additional contracts will be offered. Where the SSEP pathway sets out a lower capacity in a particular technology, the connection agreements in place will remain; no connection contracts will be taken away from developers in light of the SSEP.

2.8.3 Interactions between markets and the SSEP

The delivery of an efficient, secure and decarbonised power system requires an approach that draws upon the strengths of both market mechanisms and strategic plans.

Strategic energy planning and markets each have their own strengths and limitations in sending efficient investment signals to different assets. We are carefully considering the interactions between markets and SSEP to provide greater clarity on the shape of our future energy system.

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[21] NESO, Great Britain's Connections Reform: Overview Document (November 2024) - https://www.neso.energy/document/346816/download

[22] Department for Energy Security & Net Zero and Ofgem, Connections Action Plan (November 2023) - https://assets.publishing.service.gov.uk/media/6581730523b70a000d234bb0/connections-action-plan-desnz-ofgem.pdf

[23] NESO, Connections Reform, Phase 3: Consultation documents - https://www.neso.energy/industry-information/connections/connections-reform

The government is currently considering the market reforms proposed in REMA[24]. The SSEP will sit alongside and grow with future government policy and market-led interventions by providing a more strategic approach to spatial planning.

Any potential market reforms should enable price signals to reveal where generation build is most valuable and encourage efficient dispatch of the existing assets. If the government decides to progress with zonal wholesale market pricing, we encourage alignment between the market zones and the economic zones used to model the SSEP to ensure complementary locational signals.

2.8.4 The planning and consenting system

Planning and consenting plays an important role in the timely, safe, cost-effective, efficient and reliable provision and operation of energy infrastructure, as well as how it interacts with other planned infrastructure. When considering the location of generation and demand, it is essential to understand how this interacts with other strategic plans and policies across UK, Scottish and Welsh governments. Scotland, for example, has a devolved planning system.

In the context of land use, other plans to consider include the National Planning Policy Framework in England, National Planning Framework 4 in Scotland (NPF4), Planning Policy Wales (PPW) and Future Wales: The National Plan 2040, along with other UK government programmes such as the planned Land Use Framework for England. From an offshore perspective, we will account for the UK Marine Policy Statement (MPS), The Marine (Scotland) Act 2010, Scotland's National Marine Plan (2015), the Welsh National Marine Plan and other existing and future UK and devolved government marine plans. For a list of other strategic plans and policies, please refer to appendix 3.

As included in the SSEP commission, the UK, Scottish and Welsh governments intend the SSEP to become part of the framework of planning systems across GB, which NESO supports. The UK, Scottish and Welsh governments will lead on consideration of how the SSEP may be used in planning frameworks across the three GB nations' respective planning regimes, how it can support planning policy and whether it is appropriate to amend the existing planning frameworks to incorporate the SSEP or its spatial outputs. All this will be subject to relevant statutory impact assessment requirements and procedures.

[24] Department for Energy Security & Net Zero, Review of electricity market arrangements (July 2022) - https://www.gov.uk/government/collections/review-of-electricity-market-arrangements-rema

2.9 Assurance

Throughout the development of the SSEP, we will monitor and evaluate our work, carefully controlling risks and continuously learning from experience.

We are developing a monitoring and evaluation process with UK, Scottish and Welsh governments and Ofgem for the SSEP, described in further detail in appendix 4. We will also have a monitoring and implementation plan for the SEA which is described in appendix 9. Technical assurance and programme delivery assurance are delivered by a 'three lines of defence model', described in appendix 5. These will show the boundaries between different roles and responsibilities in the delivery of assurance and risk management. For more information on programme assurance, see appendix 5.

3. Prepare

3.1 Prepare: chapter overview

The purpose of this chapter is to summarise how we will ensure a robust and effective framework is in place prior to starting the SSEP modelling. These activities involve the development of our process, stakeholder engagement, data collection, setting up the economic model and preparing for environmental assessments.

Main messages

- Policy considerations will be crucial to SSEP analysis and can include government ambitions or specific parameters, such as net zero targets and security of supply.
- Two important assumptions 'start' the modelling process: (1) the SSEP baseline (for example, what projects we consider 'fixed' in the SSEP background) and (2) the SSEP timeframe.
- This chapter describes which technologies are in-scope for SSEP spatial optimisation and those that will not be included in this part of the analysis.
- The next stage involves gathering the requisite inputs and data for the SSEP economic modelling. We also identify appropriate modelling tooling and processes and, where necessary, develop and test to ensure their appropriateness for the purpose.
- Before we start modelling, several crucial decisions are needed on how the modelling will consider the energy system, its constituent parts and the potential variables and expansions. These include the zonal economic approach, the use of electrical boundary capabilities to model the transfer of electricity and how network and generation connection data is treated in the economic modelling.
- We also discuss our approach to spatial evaluation, our selected method for evaluating spatial factors (a modified multi-criteria analysis) and our spatial evaluation tool selection (Esri's GIS software ArcGIS Pro).
- To prepare for the Strategic Environmental Assessment (SEA) and Habitats Regulations Assessment (HRA), we will conduct SEA scoping and HRA evidence gathering at an early stage. This means the SSEP can proactively address environmental concerns, facilitate transparent decision-making and reduce the risk of delays during later stages of the plan.

We would like to know

- **Economic modelling** - Do you agree with our economic modelling approach?
- **Data centres** – Out of the options A, B, and C, set out in section 3.4.5, which option do you feel is best for the SSEP?
- **Modelling external markets** - Do you have any views on how we should model external markets? Please provide any views in relation to section 3.4.11 and appendix 6.2.
- **Spatial evaluation** - Do you agree with our spatial evaluation approach?

To share your views, please complete our consultation form:
https://forms.office.com/r/rLN34jFEaC

3.2 Introduction

This chapter covers our overall approach to modelling the SSEP, including economic modelling and spatial evaluation, as shown below.

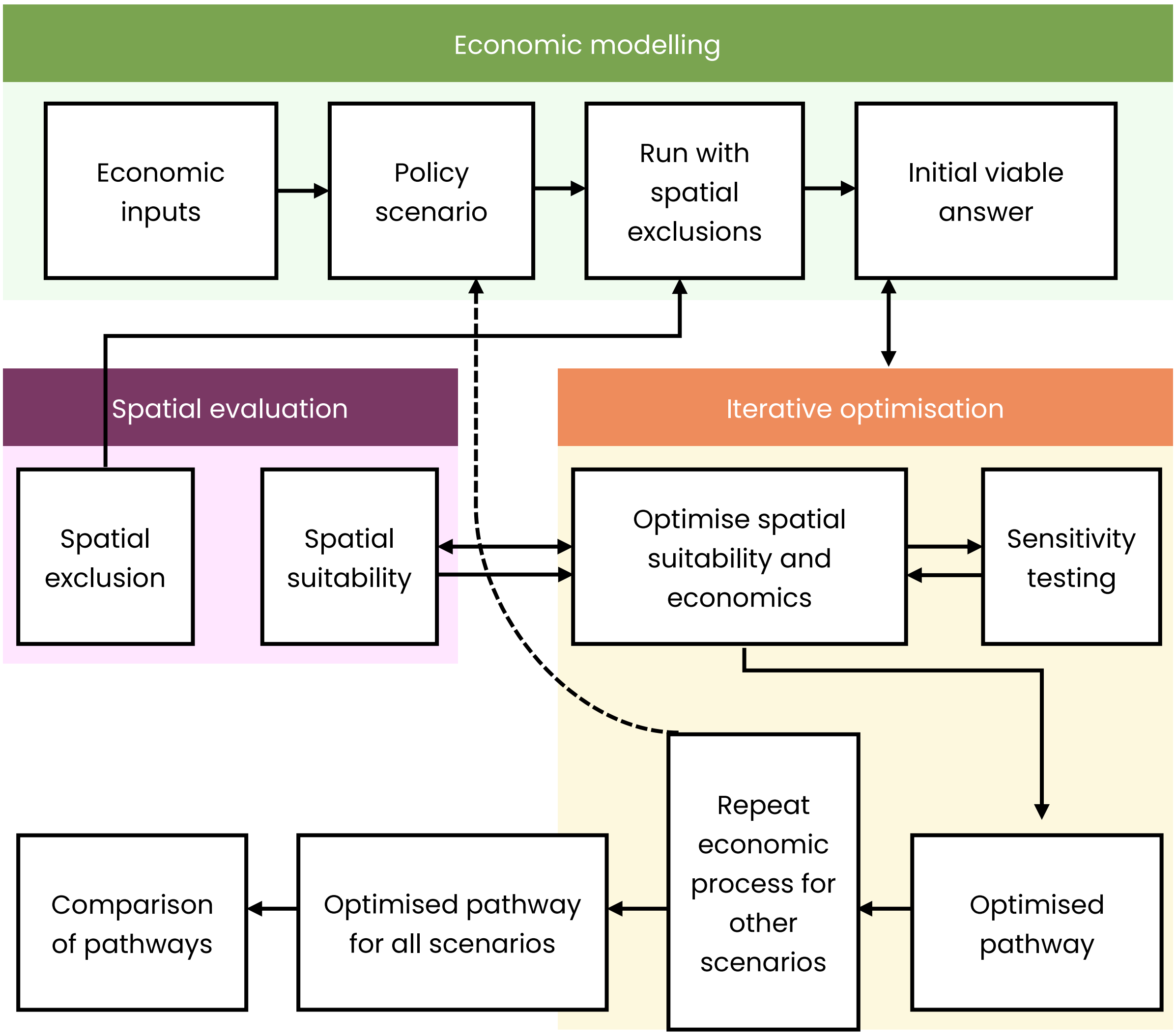

Figure 8: End-to-end modelling process

This chapter uses the following economic modelling terms:

- **Scenario** – A series of inputs to the PLEXOS model (for example, an electricity demand forecast) that form a starting point for our modelling. Some inputs will be determined by assumed policy decisions that form the backbone of the scenario.
- **Sensitivity** – A change or number of changes made to the initial input data of a scenario, which is then re-optimised in PLEXOS to test if it provides a different outcome.

3.3 Policy scenarios and interactions

3.3.1 Policy scenarios

Defining the SSEP's parameters will provide a structure that ensures our modelling achieves the desired outputs.

Policy scenarios will be created to enable an efficient approach to testing uncertainty and developing evidence relating to decisions the government could make on energy policy, for example, a focus on hydrogen or electrification for domestic heating. This list of questions will form the starting point for our economic modelling and form the initial modelling scenarios, enhanced through the scenario and sensitivity testing set out in the UK, Scottish and Welsh governments' commission to us.

As the modelling progresses, the policy questions may be reviewed to ensure the evidence created through the SSEP reflects the key questions government may want to consider.

Testing economic input sensitivities[25] will be important to refine the scenarios[26]. All input uncertainties will be considered, prioritising those we expect to have the most significant impact on the outputs from the economic modelling. They will be considered from both a locational impact perspective and a total system cost perspective. The final policy scenarios will be generated through investigating modelling sensitivities to understand their relative impacts.

3.3.2 Policy interactions

As the SSEP is a strategic plan, we will consider interactions with UK and devolved governments' targets and ambitions, other strategic spatial plans and policies, network plans and markets. This is important to achieve alignment and coherence and ensure coordinated messaging for future NESO publications and consistent investment signals for the energy market, while also providing the best opportunity for government policies to deliver the outcome set out in the SSEP.

Government decarbonisation targets, affordability, security of supply, operability and deliverability will be incorporated into the modelling process to ensure they are reflected in the recommended SSEP pathways.

3.3.3 Government decarbonisation targets

To develop the economic modelling for the SSEP, we will set certain parameters to ensure recommendations are inclusive of net zero targets and the Sixth Carbon Budget. This budget covers the period 2033 to 2037, detailing the path to a net zero UK economy by 2050 and providing a blueprint for a fully decarbonised UK energy system. It focuses on a

[25] Change(s) made to the input data to test the robustness of the answer.
[26] A series of inputs to the process, primarily linked to assumed policy decisions.

reduction in UK greenhouse gas emissions of 81% by 2035, relative to 1990 and will also account for the Scottish Government target date for net zero emissions of all greenhouse gases by 2045.

Net zero will be considered within our modelling tool PLEXOS by setting the long-term emissions target to zero across the whole economy. A negative target within the co-optimised power and hydrogen system would require the energy sector to offset residual emissions from the economy via deployment of carbon capture and storage (CCS) attached to bioenergy with carbon capture and storage (BECCS).

3.3.4 Technology ambitions

Ambitions for hydrogen production can be incorporated into the economic modelling. Technology-specific ambitions for electricity can also be included within the model, such as those related to offshore wind, restrictions on the building of new unabated generation capacity from a certain year or capping the annual output of unabated plant.

3.3.5 Affordability

In terms of affordability and achieving best consumer value, the economic modelling process will develop the output with the least cost, considering factors such as capital, operating and fuel costs.

3.3.6 Operability

The day-to-day, hour-to-hour, second-to-second ability to run the electricity system safely and deliver the power to where it is needed is a fundamental obligation of NESO. This is what is known as 'operability'. The SSEP will optimise the transition to net zero while protecting system security, reliability and resilience. To consider the operability of the SSEP modelled outputs, we will work closely with relevant expert NESO teams to allow high-level appraisal of these from an operability perspective. This will allow us to identify operability opportunities and risks, then integrate these into our modelling iterations and the narrative on SSEP pathways.

3.3.7 Deliverability

Deliverability, within the context of creating the SSEP, refers to the practical ability of developers to deliver the outcomes of the SSEP. For example, designing, planning and constructing the recommended generation and storage technologies and volumes in the high-level zonal locations, both offshore and onshore. Community views, environmental considerations and cross-sectoral demands on land and sea sit at the heart of the SSEP, which are key elements of deliverability. However, other elements of deliverability, such as practical aspects like supply chains and skills requirements, also need to be considered.

We will consider deliverability of in-scope generation and storage technologies through a variety of different aspects including our SSEP pillars and:

- technology readiness of generation and storage technologies, including innovative technologies

- supply chain (including personnel training and upskilling)
- logistics and associated infrastructure (for example access roads/ports)
- high-level system access (network and connections)
- consideration of planning and consenting regimes

We will consider deliverability of the SSEP optimised technologies by assessing these aspects against the SSEP pillars. Several of these aspects will also be reflected as spatial constraints in the economic modelling (for example, utilising realistic build rates for different technologies).

Through our process, we will consider existing deliverability assessments executed by other NESO strategic energy plans, including the CSNP and the Offshore Coordination Holistic Network Design (HND) exercises, as well as any deliverability considerations in the Clean Power 2030 report. We are engaging with our stakeholder groups on these topics and will consider feedback to help shape the SSEP's deliverability assessment.

3.4 Economic modelling assumptions

This section of the methodology will outline the inputs and activities taken in the economic modelling portion of the SSEP analysis. It includes the choice of simulation tool, key data inputs, a discussion on SSEP assumptions for specific technologies (such as hydrogen and interconnectors) and how we address areas such as security of supply.

3.4.1 SSEP baseline

To develop the economic modelling, a starting point is required for the network, generation and demand, which we refer to as the SSEP baseline. Energy projects in the baseline will be fixed into the background of the model. Projects that are in addition to those in the baseline will be considered against the SSEP pillars (economic, environment, other spatial uses, and society) and take into consideration a number of other factors, including existing seabed leases, lease options and seabed exclusivity agreements.

The SSEP baseline will be the network and generation included in the government's Clean Power 2030 Action Plan. This will build on NESO advice's for achieving clean power by 2030, published on 5 November.

Rationale for approach

Utilising the government's Clean Power Action Plan 2030 (CP2030) as the SSEP baseline enables a natural starting point for the SSEP to continue the progress towards net zero and optimise GB's energy transition. The period between the publication of the government's Clean Power 2030 Action Plan and 2030 will provide certainty to the industry on the investment required for that period, while the SSEP will provide clarity on the future energy requirements and longer-term investment signals to the market.

3.4.2 SSEP time frame

The SSEP will set out a pathway for 2030 to 2050. Starting in 2030 aligns to CP2030, giving the SSEP a natural starting point. The end time frame of 2050 will provide the Centralised Strategic Network Plan (CNSP) a sufficiently long-term outlook, providing confidence for network planning in the anticipated levels of electricity and hydrogen supply and storage. Such a time frame will also help provide longer-term investment signals to the market.

The later years (2040-2050) of the SSEP will be more uncertain, considering the changing market landscape, outstanding policy questions and less certainty on the projects that will be delivered in that period. We will consider how the SSEP accounts for and visually represents the uncertainty in this decade, which will be informed by the modelling output and discussion with our governance groups. The SSEP will be an iterative process with an updated version published every three years.

For transmission-connected power stations, commissioning and decommissioning dates for existing and planned plants have been aligned with DESNZ modelling assumptions. For distribution-connected infrastructure, the Future Energy Scenarios (FES) 2024 Holistic Transition pathway has been used if DESNZ assumptions were not available.

Rationale for approach

An end point of 2050 will provide a longer-term view for the development of the network and help with Final Investment Decisions (FID) for developers, providing the foundation for progress towards net zero. This time frame enables a degree of certainty, building on NESO network plans like Beyond 2030[27] and Pathway to 2030[28].

The SSEP will have specific interactions with the CSNP. The time frame to 2050 will provide a longer-term view to help support Ofgem's regulatory funding mechanisms for transmission networks. This will provide investment signals to the market, aiding developers considering generation projects with longer construction timescales.

3.4.3 Technologies considered

The first SSEP will cover infrastructure for electricity generation and storage, including hydrogen assets. Future iterations could cover other energy vectors, like natural gas. To accurately model the economically optimal future pathways for the GB electricity system, we will model the whole electricity and hydrogen systems, including all expected generation and demand. This allows us to explore how best to match optimal generation and high-level network needs to demand projections under different modelling scenarios.

[27] NESO, Beyond 2030 - https://www.neso.energy/publications/beyond-2030
[28] NESO, Pathway to 2030 - https://www.neso.energy/publications/beyond-2030/holistic-network-design-offshore-wind

Not all technologies included in the economic model will be spatially optimised. In-scope technologies which are spatially optimised are required to meet the overall objective of the SSEP as a strategic plan and be suitable for spatial assessment. These have been selected after assessing them against four key principles, listed below. Technologies not spatially optimised for the pathway will still be modelled in the generation background in our economic modelling, using forecasts of their expected growth and location to ensure a holistic energy system is represented in SSEP modelling.

Technical engineering design requirements will be developed for each of the in-scope technology types as a part of the spatial evaluation. They will then be included for spatial optimisation as technology specific indicators, spatial constraints and opportunities.

Principles

The following key principles have guided the approach to selecting the final list of technologies to be included in SSEP assessments and geospatial optimisation.

- **Consideration of policy ambitions** - The commission requires the UK, Scottish and Welsh governments' ambitions for the level of generation of certain technologies to be considered in the SSEP modelling.
- **Data availability** - The SSEP modelling is based on credible data sources and assumptions that are quality assured. Including technology types in our modelling requires access to reliable data (considering both data availability and data quality) on aspects such as cost and operational properties of the infrastructure type, as well as an understanding of the spatial requirements.
- **Strategic planning** - The SSEP is a strategic plan that will be published on a zonal basis. From a strategic planning perspective, the SSEP will add value by geospatially assessing energy infrastructure to provide confidence and certainty at a zonal level. Certain smaller scale infrastructure would be more challenging to assess in detail geospatially but will be included where it can be aggregated to a zonal level.
- **Provide certainty** - The SSEP aims to provide certainty to stakeholders about the future strategic shape of the energy system, carefully considering any risks associated with technologies in the modelling and recommendations.

Process

The list of technologies to be included in the first iteration of the SSEP was agreed together with the UK government and Ofgem.

Technologies in scope for spatial co-optimisation

Technology	Additional detail
Offshore wind	Both fixed and floating offshore wind included
Onshore wind	N/A
Solar	Network-connected solar (ground mount)
Nuclear	Both traditional nuclear and small modular reactors (SMRs) included
Power/hydrogen carbon capture utilisation and storage	New build and retrofit gas generation
Hydrogen	Hydrogen production, hydrogen to power, electrolysers, transport, storage included.
Long- and short-duration storage	Network-connected storage to be included - pumped hydro power, compressed air energy storage, liquified air energy storage and long- and short-duration batteries
Interconnectors	Landing points for interconnectors in GB to be included
Bioenergy with carbon capture and storage (BECCS)	New build and retrofit BECCS included
Unabated gas	Gas power plants in-scope for security of supply

Table 2: Technologies in-scope for spatial co-optimisation

Technologies NOT in scope for spatial co-optimisation

Technology	Additional detail
Solar - rooftop	Modelled as generation background using forecasts of their expected growth and zonal location
New flexible demand – EV storage	Modelled as demand background using forecasts of their expected growth, price-responsive flexibility and zonal location
Tidal wave and tidal stream	Modelled as generation background using forecasts of their expected growth and zonal location
Energy from waste	Modelled as generation background using forecasts of their expected growth and zonal location
Large-scale demand	Most large-scale demand will not be spatially optimised, SSEP will consider in demand sensitivity analysis

Table 3: Technologies NOT in-scope for spatial co-optimisation

For more detail on the in-scope technologies and those not considered for spatial optimisation, see appendix 6.1.

3.4.4 Innovation

We will need to be responsive to new information as we develop the SSEP. If, for example, new generation technology types emerge in addition to those listed, we will consider how these can be included, alongside other innovations, industry or policy developments. This will be done through our agreed governance processes. Furthermore, the SSEP will be delivered on a three-year cycle, so future iterations can account for new advancements and lessons learnt. We are also seeking feedback through this consultation from stakeholders to ensure other factors or innovation can be considered.

3.4.5 Data centres in SSEP

The input demand profile forecasts demand across all sectors of the economy, including the commercial sector. Demand growth in this sector will include future growth in data centres. The sector is expected to grow significantly due to increases in artificial intelligence (AI) and quantum computing. The level of growth in data centres has the potential to drive a substantial range in energy demand in the future.

As the policy landscape around data centres is evolving, there is an inherent uncertainty around their future growth beyond 2030 and where they will be located. This creates a challenge around robust data available for future growth of data centres. The SSEP risks creating inaccurate recommendations due to uncertainties around assumptions which could result in insufficient network being built and additional network constraints[29], which need to be carefully considered. We are considering how to include data centres in the SSEP and are seeking feedback on the following options:

Option A - The SSEP carries out sensitivity testing around demand growth and measures how that impacts the energy system through economic modelling. As certainty around the locations for data centres emerges, they would be incorporated into the demand profile for the SSEP. The SSEP does not spatially optimise the location of any data centres.

Sensitivity analysis would consider the impact of an increased deployment of data centres on total electricity demand and subsequently build decisions across zones. The analysis may consider locational elements, such as proximity to electricity generators. To enable this analysis, approaches and assumptions would be developed to separate the baseline data centre demand from demand data supplied by DESNZ and refined through engagement with stakeholders. However, by not optimising the location of data centres, the system benefits would be reduced, which could lead to larger network build and increased costs for consumers.

Option B – The SSEP spatially optimises a small volume of demand associated with flexible data centres. The SSEP could spatially optimise a small proportion of data centres (1 to 2 GW) to accrue system benefits of those data centres that are locationally flexible. However, as detailed above, an evolving policy landscape brings challenges to gathering robust data on the assumptions for future growth of data centres.

Proceeding with option B would require extensive stakeholder engagement to refine assumptions around the growth of data centre demand as well as the locational flexibility of new data centres being planned after 2030. Option B also contains risks around creating inaccurate recommendations, which could create additional network constraints as outlined above.

Option C - The SSEP reflects uncertainties around data centre demand in different policy scenarios being considered by varying the scale of demand and spatially optimising data centre demand in one of the policy scenarios.

Varying the scale of demand would mitigate some of the uncertainties around data availability and allow the SSEP to test the input assumptions around data centre demand and locational flexibility. However, this does not fully mitigate the risks around lack of robust data on assumptions for future demand and could create policy scenarios that would inaccurately represent the future. Please see the chapter overview on p 38 for the consultation question relating to these options.

[29] If the flow of electricity across a boundary is at the maximum capability of that boundary, we say that the boundary (or network) is constrained, as no more electricity can flow across the boundary.

3.4.6 Establishment of the SSEP dataset

As set out in the commission, the main source of data inputs into the SSEP economic modelling will be from DESNZ, with other NESO data sources such as FES 2024 used where appropriate.

In early 2024, we collaborated with DESNZ to establish the SSEP economic modelling dataset. We engaged in numerous discussions with DESNZ to create an initial list of input categories and associated parameters, which served as a reference throughout the data collection process.

We agreed that DESNZ would primarily provide cost data for the parameters, while NESO would contribute technical data and fill in any missing information for specific modelling inputs that had not been modelled by DESNZ. Where DESNZ did not provide input data, we followed their guidance to source and utilise NESO data which was subject to DESNZ's agreement prior to use in the modelling. This ensures that the model utilises the most up-to-date data from either NESO or DESNZ.

Where there were discrepancies in the data inputs, these were reviewed, and a decision taken on corrective action. This included, but was not limited to, the correction of inputs and rerunning models to validate the data.

We have collated all the data into a single source that serves as a single version of the truth for all economic inputs. To facilitate transparency of the SSEP process, the economic data inputs (or a list of datasets used in the SSEP) will be published alongside the draft and final SSEP documents, where it is possible to do so.

SSEP data input group	Data provider
Batteries	DESNZ
Commodities	DESNZ
Demand side response (DSR)	DESNZ
Electricity demand	DESNZ
Economic (for example, derating factor)	DESNZ
Electricity plants	DESNZ/NESO
Electrolysis	DESNZ
Emissions	DESNZ
Energy security (minimum capacity reserve margins, capacity shortage price and firm capacity increase)	NESO
Geospatial	NESO
Hydrogen demand	DESNZ
Hydrogen storage	DESNZ
Interconnectors	DESNZ
Modelling zones	NESO
Networks	NESO

Table 4: Table of SSEP data input groups

3.4.7 Economic modelling tools and optimisation

To carry out the SSEP economic modelling, we require a simulation tool that has the capability of optimising the technology, capacity and timing of commissioning and retirement of assets, such as electricity generation and transmission assets. We also will want to consider different time frames, address long-term planning requirements and solve the fundamental problem of ensuring that dispatched generation can meet GB demand.

PLEXOS will be used for our economic modelling. This is an energy market simulation tool that is designed to optimise aspects of the energy market. These aspects include trading strategies, operational management, policy and forecasting.

PLEXOS is designed to minimise the overall system cost for the simulation that it is given, while respecting any economic modelling constraints. These can range from overarching constraints, such as the requirement for energy generation to equal demand or more user-defined economic modelling constraints, such as limits on the build rates for a given technology or limits on how much energy can flow from one point to another. The tool can also model interactive components of the energy system, such as electricity and hydrogen.

PLEXOS can be run in several time frames, ranging from the very short term (almost real time) to the very long term (multi-decade). In addition, PLEXOS allows for flexibility in the spatial resolution of the simulated markets to be varied. For example, the GB energy market can be modelled in greater detail than other European markets. These aspects make PLEXOS an ideal simulation tool for the SSEP, where we want the flexibility to explore a range of approaches to both the time frames considered when optimising and the optionality to model European markets, particularly for interconnectors.

While optimising various aspects (such as capacity and technology), PLEXOS also solves the problem of how to dispatch generation to meet demand. This process is referred to as 'capacity expansion' modelling. PLEXOS can also run the capacity expansion with multiple sets of inputs, for example using multiple historical weather datasets to find the single optimal solution across all the weather datasets.

PLEXOS capacity expansion modelling finds the minimum cost solution, given the modelling constraints placed upon it and the input costs provided. The sources of the following input costs for the SSEP are discussed in section 3.4.6 and include:

- The capital cost of new assets, with the economic life and weighted-average cost of capital (WACC) included to allow calculation of the cost to finance construction of the asset. These assets include:
    - Electricity generation
    - Electricity storage
    - Electricity transmission
    - Hydrogen production
    - Hydrogen storage
    - Hydrogen transmission
    - Interconnectors
- A fixed operation and maintenance cost for each asset, applied each year per unit of capacity.
- The production cost of an electricity generator, which includes:

  - Commodity prices for fuel, such as a natural gas price forecast
  - Carbon price for fossil fuel generators
  - Variable operation and maintenance costs
  - Technical parameters such as the thermal efficiency of a generator type and the carbon intensity of the fuel used
- The cost of unserved energy, that is the value of lost load (VOLL).

Once PLEXOS has found a solution for capacity expansion, we will conduct further analysis on this solution using a more detailed simulation of how the market would dispatch the generation mix. This will be the lowest cost solution, given the inputs and modelling constraints that PLEXOS is given. It will then allow us to simulate market behaviour with significantly more accuracy than is possible in the capacity expansion process due to the size of the problem being optimised.

PLEXOS optimises the cost of building all assets, building supply where renewable resources are greatest, taking into account the cost of transmission assets against the cost of building supply closer to the demand. This results in more supply capacity being required, but fewer transmission assets. It also includes evaluating what balance of electricity and hydrogen assets is optimal.

The natural gas market is not being modelled as part of the capacity expansion in the SSEP. Price forecasts for natural gas are used to determine the cost of production using a gas-fired generator. We will conduct further analysis on potential capacity issues if natural gas plays a part in the outcome of the SSEP (for example, if gas carbon capture utilisation and storage is recommended). This process will be run to test the robustness of the outcome as natural gas assets are phased out in the transition to net zero.

The economic modelling process has layers of modelling. In each layer there are trade-offs that must be made between various aspects of the modelling to keep the problem size manageable. If the problem size becomes too large, either the model will not be able to run or it will take longer to run than is feasible for the number of modelling runs we plan to carry out. The lowest layer is the economic optimisation in PLEXOS. Here, the trade-offs primarily concern the level of detail of the individual modelling parameters. For example, additional historical weather years may be used. However, this will increase the problem size in PLEXOS, requiring either a reduction in the complexity of other modelling parameters or a reduction in the number of PLEXOS simulations that can be run.

3.4.8 Economic zones

A zone in the context of the SSEP is the geographical representation of an area of land, which generation and demand fall within. The SSEP analysis will be conducted on a zonal level to create a high-level overview of the energy system. This will then enable the CSNP to consider network infrastructure in greater detail. Developing a zonal approach also enables strategic analysis of economic, environmental, societal and other space use factors.

17 economic land zones

Our zonal economic approach allows us to consider different analytical and modelling perspectives. The creation of economic zones forms part of the data layers and means PLEXOS can interact with our geospatial tool (ArcGIS). This enables us to optimise the GB energy system by considering capacity needed on a large regional level, within a single model of GB and neighbouring energy markets.

To develop the economic zones, we firstly considered the electricity transmission network constraint boundaries as well as potential constraint boundaries for hydrogen transportation. Network constraint boundaries split the system into multiple parts, crossing critical network paths that carry energy between the areas where flow limitations may be encountered[30]. These determine network congestion and upgrade costs and help us identify high-level network requirements in the overall SSEP. As economic modelling is highly complex, fewer zones enable a more efficient process. Therefore, our approach is to use 17 economic zones to focus on the locational impact of network costs. This has the benefit of providing consistency with the network constraint boundaries to deliver meaningful results. We will also model interconnector flows with neighbouring countries to understand their impact on the GB electricity system.

Electricity and hydrogen demand in each economic zone is derived from DESNZ projections for GB-wide energy demand, combined with NESO analysis of regional load distributions as applied in the FES 2024 pathway modelling.

We will use 17 economic zones in our modelling. However, in presenting the SSEP itself, we will use different zones more aligned to geographical rather than energy system boundaries, which will be configured through our geospatial modelling.

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[30] For further explanation and a description of the key GB electricity boundaries see: NESO, Electricity Ten Year Statement - https://www.neso.energy/document/286591/download

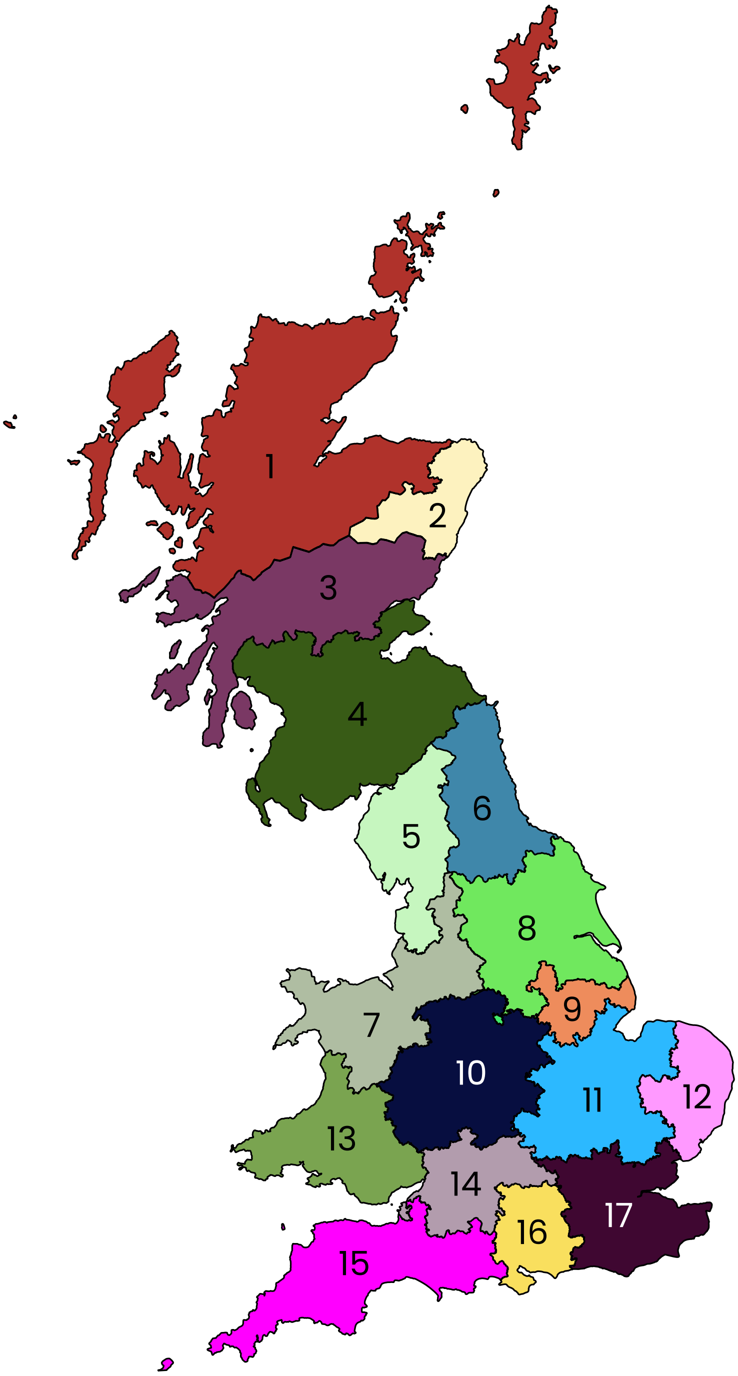

Figure 9: The 17 economic zones

Approach to offshore zones

The 17 land zones (economic zones) will be based on the key network constraints of the electricity transmission network and hydrogen systems. In all land zones that include a coast, offshore technologies already in the baseline will be counted as being in the land zone that they connect to. Furthermore, there will be new build capacity (that is, total generation capacity) for offshore technologies connecting into each of these zones.

To achieve this, environmental, societal, other spatial uses, and technical engineering design requirement considerations will be analysed across connecting marine areas to identify optimal locations of in-scope offshore energy technologies and build limits within each zone. This will be refined through iteration between geospatial analysis and economic modelling to determine the required capacity of offshore technologies and in which of the 17 onshore economic zones capacity should be landed.

Assumptions on market design

As set out above, the SSEP economic model requires a zonal structure to spatially place electricity generation and hydrogen infrastructure and identify network reinforcement requirements. Running the model on a zonal basis will optimise expansion and dispatch simultaneously for all asset types, considering modelled GB network boundary constraints.

The SSEP economic model is intended to be agnostic to market design and trading arrangements. This means that, in running the model on a zonal basis, we are not assuming the implementation of specific market reforms such as the adoption of zonal pricing in the GB electricity market.

Under the current GB market design, the zonal modelling approach can be interpreted as reflecting the outcome of Balancing Mechanism 'bids' and 'offers', a process in which generators and interconnectors are moved away from dispatch positions to mitigate network congestion.

The primary objective of the economic model is to minimise total system costs subject to meeting constraints such as carbon emissions and reliability targets. To move beyond the consideration of system costs and evaluate the commercial viability and profitability of infrastructure investments, it would be necessary to start making assumptions about market design.

Electricity network modelling

The transfer of electricity between SSEP zones in the economic model is limited by a set of electrical boundary capabilities[31]. These boundary capabilities or network constraints are represented in the model by a maximum flow, in MW, for each boundary and a seasonal profile that limits the flow further during certain parts of the year. Further scaling of the maximum flows will be applied to represent generic maintenance outages throughout the year. This means the boundaries will have a dynamic capability throughout the study, which can change year on year.

The economic model has the option to expand boundary capabilities further at a cost, which is explained in the following section.

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[31] The electrical boundary capability is the maximum amount of electricity that can flow through a boundary. As new reinforcements to the network are built, this capability may be increased, allowing more electricity to flow across the boundary.

Electricity network expansion

The electricity transmission network capacity will be allowed to expand from the initial boundary capabilities discussed previously. Each boundary will have a cost per MW of capacity increase. These costs will be derived from forecast boundary reinforcement data taken from the Beyond 2030[27] report. It will be assumed that all practical upgrades to the existing transmission network will already have been made (for example, reconductoring existing lines to increase the amount of electricity they can transport). Therefore, the cost data that will be used to inform the input costs for the SSEP will be taken from the forecast costs for new transmission circuits.

This data will represent an average derived from various options, including overhead lines, underground cables and offshore subsea cables. The output from the SSEP process will be a list of boundary capability increases, the year(s) in which the increases are required and the assumed capital cost of each increase.

The output of the SSEP will go on to inform what level of boundary reinforcement should be considered in other NESO processes; for example, future iterations of the CSNP. The SSEP will not make any recommendations on the form the new asset will take, such as overhead line or offshore subsea cable, or the technology used, such as alternating current (AC) or high-voltage direct current (HVDC), or any indication of routing.

3.4.9 Offshore wind generation

In the SSEP model, we will consider offshore wind as being located in the SSEP land economic zone to which it connects, rather than having its own offshore zone. Each SSEP zone with a coastline will have an offshore wind profile associated with it, distinct from onshore wind profiles.

Expansion

In addition to the baseline, the PLEXOS model in SSEP will include the possibility of building more offshore wind generation, considering both fixed and floating technologies. DESNZ has provided the capital costs for each of these technologies, and as with other types of plant, capital cost of the plant is independent of the zone (see the section below on separate connection costs).

The PLEXOS outcomes of additional offshore wind will be geospatially modelled in collaboration with The Crown Estate and placed in applicable marine zones. These will be mapped back to the 17 economic zones through identifying appropriate landing points. The geospatial analysis will highlight deliverability of offshore wind in these zones, based on the requirement for network connection as well as spatial constraints.

Connection costs

Connecting offshore wind to the onshore transmission network is considerably more complex than connecting onshore. Additionally, in some areas, wind farms are located much further offshore than other areas. Without accounting for these factors, PLEXOS would have to make decisions based solely on aspects like wind conditions and onshore network considerations, ignoring these crucial cost variations and onshore network considerations.

For offshore wind, we will include a cost that represents the connection from the offshore wind farm to an onshore interface point, with a different cost for each zone. This approach involves using data from the Beyond 2030[27] report about future offshore wind locations, cable corridors and connection costs, to give an estimate of the cost of connecting to a specific zone. This data is undergoing updates and further analysis through other NESO offshore planning processes. The cost will reflect an average for the zone, considering that new wind farms might be built with shorter or longer cables and existing wind farms might increase their capacity.

Onshore technologies already have this equivalent cost included in the costs provided by DESNZ.

Radial connections

Offshore wind farms can be connected to onshore interface points either by a radial connection, where the wind farm connects individually and directly to the interface point, or by a shared connection, whereby a wind farm may connect to another wind farm, a tee-point or even have multiple connections (see figure 10 for a diagram with examples of these). There are examples of these in the Pathway to 2030[28] and Beyond 2030 reports.

For SSEP we will use radial connections as the starting assumption for connecting new offshore wind. Shared connections can improve economic, environment and community outcomes in certain circumstances, but it is necessary to limit the complexity of the SSEP modelling process by starting with radial connections. Each wind farm will be considered as connecting to the SSEP zone that is logical, based on NESO's previous experience and publications. This may not necessarily be the closest zone to the offshore wind farm, due to network considerations. However, the results will be investigated, analysed and tests may be conducted to vary the zones that offshore wind farms connect to.

After the SSEP has determined the optimal level and location for future offshore wind, a full offshore design exercise to determine the appropriate level of coordination will be carried out as part of other NESO offshore planning processes.

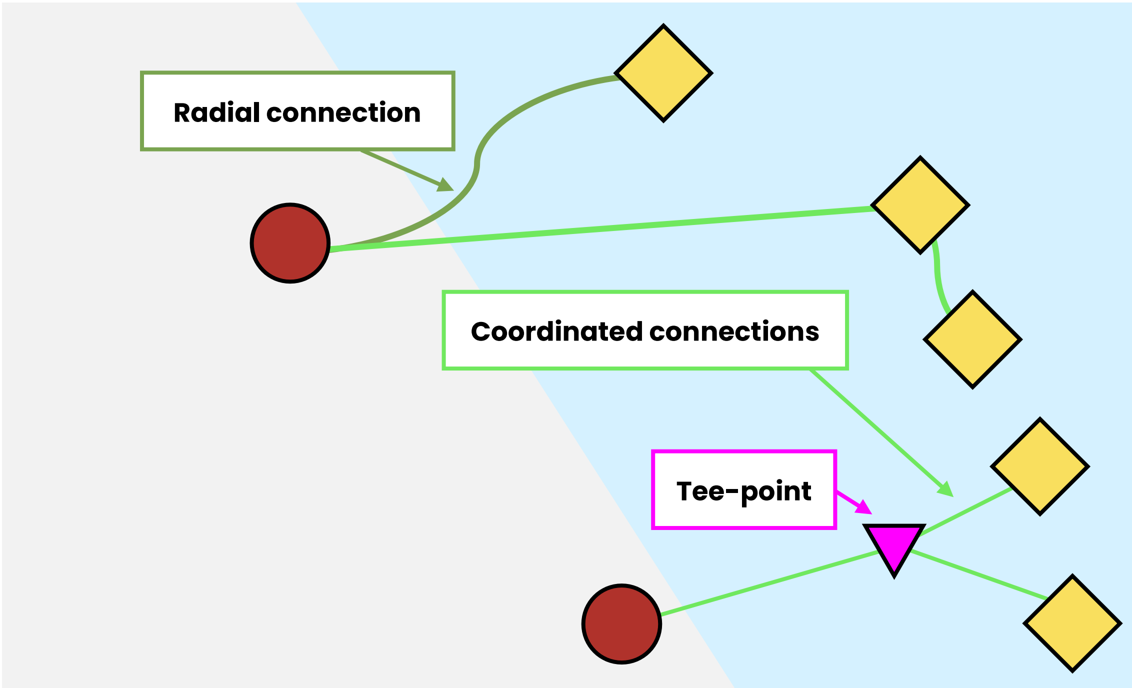

Figure 10: Different types of offshore connections

3.4.10 Interconnector expansion

Interconnectors are links from one country to another which allow the transfer of electricity between them. Like generation, storage and transmission, the starting point for interconnector capacity will be the baseline capacity for the relevant scenario to be modelled. This will include existing interconnectors plus some future interconnectors.

From an economic modelling perspective, it is preferable to optimise generation and interconnector capacity simultaneously, rather than optimising generation first and then interconnectors. This approach aims to reduce total system costs by finding the most economical solution within the given parameters. If generation and interconnectors were optimised separately, the model could provide sub-optimal outcomes by locking in inefficient new builds; potentially leading to overbuilding new generation where new interconnectors could facilitate cheaper imports or underbuilding new generation and missing out on opportunities to export to neighbouring markets.

Interconnector capacity expansion will optimise the connecting zone in GB, the connecting overseas market, the capacity of each interconnector and the timing of the commissioning of each interconnector. To reduce the problem size for the model, some limitations will be applied to the GB connection points available. For example, we will not consider an interconnector between Ireland and East Anglia as this would not be practical. From a spatial point of view, we will investigate the potential future landing point capacity of each SSEP zone based on spatial assessments and discussions with relevant stakeholders. This analysis is being conducted as part of a broader investigation into potential future offshore wind locations and connection points.

We will explore the use of caps on the maximum possible capacity of interconnector expansion. This will take the form of a limit on the total amount of interconnector capacity for GB and a limit on the capacity connecting to each overseas market. The use of caps will be tested, and any application will be justified and supporting evidence made transparent. This approach has been adopted because, while allowing unlimited capacity expansion will lead to the most economic solution, it carries the risk of producing an unfeasible solution. For example, the solution could be unfeasible due to a lack of political appetite for interconnection, both in terms of the overseas government(s) and an unwillingness for the UK government to increase reliance on imports for GB energy security.

Offshore Hybrid Assets (OHAs), also called multi-purpose interconnectors, will not explicitly be modelled as part of the SSEP as new expansion candidates. This is due to the significant increase in modelling complexity required to model these assets. However, where offshore generation and interconnector(s) are found to be optimal and relatively closely located, this will be highlighted as an opportunity for integration of the two asset types. CSNP will take the output from SSEP and consider OHAs within the modelling. OHAs may also be a consideration in future iterations of the SSEP.

3.4.11 External markets

Modelling external markets

To model interconnector flows between GB and external markets, we need to account for the other markets to some extent. At a minimum, this requires knowing the electricity price for both markets involved. PLEXOS can simulate European markets with varying levels of complexity, from setting a time-varying market price to explicitly modelling a plant list and deriving the market price for each period. The markets considered in PLEXOS are shown in figure 11.

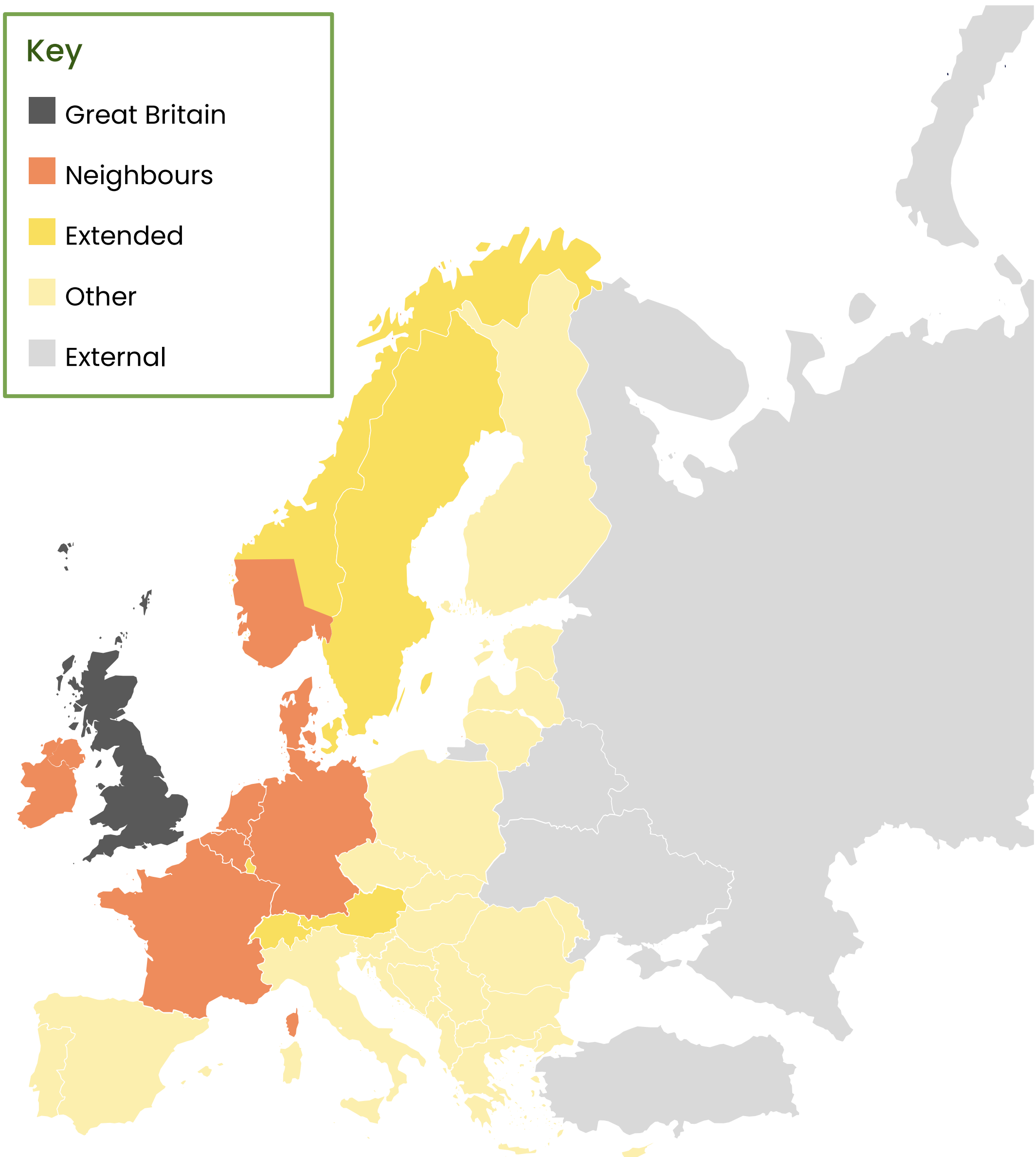

Figure 11: Countries considered in the PLEXOS model

We will investigate different approaches to modelling European markets and retain the option to change our approach during the process if necessary. The decision on which approach to take will be made before the end of January 2025, based on analysis and discussions both internally and through the external governance process. In the final version of the methodology, this section will detail the chosen approach and rationale for choosing it.

Two different approaches from opposite sides of the spectrum are detailed below and summarised in appendix 6.2. We may also use one approach for the main modelling and utilise another for sensitivities.

Explicitly modelling European markets plant list

One approach is to explicitly model the plant list for European markets using NESO's European capacity dataset as the starting point. This dataset considers forecast hydrogen and electricity projections for these markets.

Using this approach, the price for the European markets will be dynamically generated every hour and can react to any changes to the model, such as changes in generation in GB or new interconnector capacity. Furthermore, there will be detailed outputs that we can use for analysis, for example, emissions in these markets.

However, a downside to this approach is that it takes significant computational power and hence an increase in model run time. If this approach is chosen, it would be likely that we would only model the plant list explicitly for markets in the 'neighbours' group (see figure 11), with other markets being modelled by a fixed price, due to diminishing returns for modelling markets further away from GB.

A further step in this approach is to allow PLEXOS to expand the European markets, that is, allow it to build new generators within these markets (table 7, appendix 6.2). This approach avoids a risk that the capacity build assumed in the European markets is based on inconsistent underlying cost assumptions and allows a more accurate identification of trade opportunities. Note that the expansion for these markets could use the FES 2024 pathways as a starting point or it could start from a reduced baseline and provide a different projection. This expansion will be investigated, but has several risks associated with it:

- PLEXOS optimises the whole system, and in this case that would be GB plus the European markets. As such, decisions could be made in the best interest of this whole system, but not necessarily in the interest of GB. Therefore, the results will need to be verified and tested for robustness to see if they are viable and satisfy security of supply requirements for GB.
- Access to European data is limited and not as detailed as GB. For example, we will not be carrying out geospatial analysis for European markets, or separating these markets into zones, as we do for GB.

Predetermined hourly prices

This alternative approach to modelling European markets attempts to simplify the modelling problem, whereby we use a predetermined hourly fixed price set for the European markets, rather than the full plant list.

Here are some details of this approach:

- Each European market will have a predetermined price set for every hour of the day (see details below).
- Flows from GB to these European markets will be optimised by the model, within the interconnector capacities.

- For markets in the 'neighbours' group, this price could be able to vary depending on the interconnector flows to and from this market. This is referred to as a responsive price curve (table 7 in appendix 6.2).

The predetermined prices for European markets will be based on a simulation (short-term phase[32]) where we explicitly model the plant list for the European markets, using the data mentioned in the previous approach. This dataset provides predetermined net zero capacity mix pathways for European markets out to 2050 and historical weather years can also be considered. As part of the SSEP analysis, we would produce different sets of European prices as we vary modelling scenario assumptions (for example, commodity and carbon prices), consistent with those assumed for GB.

The responsive price curve allows a market to react to external changes. For example, if GB imports from France, the price in France will increase and hence the price for GB to import will increase too. This method offers an improved way of modelling European markets over just having a fixed price for every hour.

Despite reducing the computational problem, there are some other downsides to this approach:

- European prices are not fully dynamic and so cannot react to different sensitivities or modelled scenarios, without explicitly producing a different set of European prices. A different set could be made for each modelling scenario, but this is unlikely to be done for each sensitivity.
- We cannot directly model emissions constraints for European markets.

3.4.12 Hydrogen assumptions

Scope of hydrogen supply chain

A co-optimised approach will be adopted to model the SSEP due to the material interaction between hydrogen and power systems. Electrolysers, which use power to extract hydrogen from water, and hydrogen generators, which turn hydrogen into power, are the two types of hydrogen asset that directly link with the power sector. To fully capture their interactions, these two asset types must be considered in the context of the wider hydrogen system. This is because the deployment of electrolysers and hydrogen generators are in turn dependent on the availability of hydrogen transport, storage and alternative sources of hydrogen production. The SSEP, therefore, considers the full hydrogen supply chain in its approach, including transport, storage and the production of hydrogen from electricity, natural gas and biomass.

Scope of demand and supply

GB's existing unabated hydrogen system is not included in the SSEP's scope, and only infrastructure that can contribute to a low-carbon hydrogen system is considered as an

[32] The Short-Term phase in PLEXOS is used after the capacity expansion (Long-Term) phase and looks to model every hour of the year. This phase is used to get detailed outputs, such as market price, generation, interconnector flows, emissions, operation costs and so on.

expansion candidate. Hydrogen demand input assumptions reflect this and exclude hydrogen demand in the power sector. Hydrogen demand in the power sector is not an input assumption because it is a model output, determined by the outcome of the hydrogen and power system co-optimisation.

Exclusion of the existing unabated hydrogen system limits the opportunity to consider existing hydrogen assets as candidates for retrofit. This is because the date at which existing assets will no longer be used to meet unabated hydrogen demand (and therefore become available for retrofit) is uncertain when the unabated system is not modelled. Similarly, the opportunity to include the retrofit of existing natural gas assets to hydrogen as expansion candidates is limited by access to data on their phase-out of the natural gas system.

Expansion candidates

To manage computational run times, the number of technologies selected as expansion candidates at each stage of the hydrogen supply chain will be limited. The selection of technology alternatives for each supply chain stage will be based on data availability, the technical and economic similarity of alternatives and impact on the modelling problem size. For example, if two technologies have similar cost projections and technical characteristics, then only one alternative may be selected if the inclusion of both does not materially add to the model's insight. The selected technology will then represent both alternatives in the model. For example, autothermal reformers (ATR) with CCUS will represent all blue hydrogen production including steam methane reformers.

We recognise that many hydrogen technologies are still in the early stages of commercialisation and that some may not progress to a suitable technology readiness level for deployment at scale. Uncertainty about the availability of hydrogen technologies and their future techno-economics will be an underlying consideration during the selection of expansion candidates.

Hydrogen production	Hydrogen storage	Hydrogen transport
Proton exchange membrane (PEM) electrolysers	Salt caverns	Transmission pipelines
Alkaline electrolysers	Depleted gas fields	Trucking
Autothermal reformers (ATRs) with CCS	Lined rock caverns	
Steam methane reformers (SMRs) with CCS	Above ground bullet tanks	

Table 5: Hydrogen production, storage and transport technologies considered for selection as an expansion candidate

Note that some of these are developing technologies and have low levels of technology readiness.

3.4.13 Weather and security of supply

Weather

The assumptions made on weather patterns used in PLEXOS simulations are an important factor in the solutions PLEXOS creates. The weather assumptions affect both the demand patterns and the available output of weather-dependent renewable generation. Given the increasing capacity of weather-dependent renewables, the weather datasets used also have a significant effect on security of supply considerations for the SSEP. This is discussed in more detail in the following section.

There is a large range of weather datasets available to the SSEP that use historical observations to determine what relative demand levels and weather-dependent renewable generation availability would be on a zonal basis. We can select either a single weather dataset, or multiple datasets, as an input to PLEXOS capacity expansion. The choice of datasets is of particular importance to weather-dependent renewables as it can determine which zones are the most economically attractive to build the technology types.

Sampling is used in the capacity expansion process to reduce the problem size. It is particularly important that sufficient sampling of time periods is used because if the temporal sampling is too small, it can result in solutions that are artificially attractive. This problem can also occur if attempts are made to increase the diversity of the weather datasets used by reducing the number of time periods sampled to maintain the problem size.

Each factor will be considered when determining suitable weather datasets for the PLEXOS simulations, where modelling accuracy will be balanced against computational run-time and resource. While there will be limitations on the number of weather datasets directly considered as inputs to the capacity expansion optimisation, it will be possible to stress test the resulting capacity pathways for resilience and operability during extreme conditions using multiple years of weather data. The decision on which approach to take will be made during the SSEP modelling process.

Increased seasonality of electricity demand is expected as more of GB's heating is electrified over time and so the modelling process will also consider an energy mix that provides secure supply when the potential shifts of demand are linked to the different weather patterns. Derating factors, infeed loss risk and other inputs to the reliability assessment could also be factored in.

Security of supply

Security of supply standards help us determine if GB's demand can be met in a range of situations, particularly where the system is experiencing stress conditions such as low availability of renewable generation resources coinciding with high demand. By meeting security of supply standards, we can ensure that GB has a resilient transmission network.

The security of supply standard set by the UK government for electricity in GB[33] is three hours of loss of load expectation (LOLE) per year. We will ensure that the SSEP economic expansion model is configured to build sufficient generation, storage and interconnection to meet a target derated capacity margin and account for the largest infeed loss. This means maintaining a reserve margin of electricity supply (whether from generation, storage or interconnection) to cover the event of the largest supplier being cut from the system (largest infeed loss). For example, if the largest supplier at a given time was a nuclear power plant with 3 GW output, we ensure we have 3 GW of backup supply in case the nuclear plant suddenly shuts down or a connecting circuit experiences a fault.

The reliability of the resulting capacity expansion pathway is then tested to assess LOLE. Derating factors and other inputs to the reliability assessment are sourced from the NESO Electricity Capacity Report[34].

An equivalent national security standard has yet to be defined for hydrogen. For modelling purposes, we assume a Value of Lost Load, which acts as a penalty on shortages in the capacity expansion process.

There are several approaches that can be used to ensure the output of the modelling has taken security of supply into account. Testing multiple sets of weather data as an input

[33] Department of Energy & Climate Change, Annex C: Reliability Standard Methodology (July 2013) - https://assets.publishing.service.gov.uk/media/5a7c52eaed915d338141e0ce/emr_consultation_annex_c.pdf
[34] Electricity Market Reform Delivery Body, NESO, Electricity Capacity Report - https://emrdeliverybody.nationalenergyso.com/IG/s/article/Electricity-Capacity-Report-ECR

should produce different demand estimates to stress test a system with more electrification of heat. These approaches can be split into three broad categories:

- Using multiple sets of weather data as an input to the optimisation process, resulting in a single optimised answer.
- Using a single set of weather data as an input and testing this post-optimisation against security of supply metrics to subsequently refine the pathway.
- Using a capacity margin constraint to ensure that a specific security of supply metric is met.

The first approach will result in the most efficient solution, assuming the weather datasets considered cover a representative range of cases that will test the solution with regards to security of supply. However, there are several downsides to this approach. Firstly, each weather dataset considered increases the problem size. This requires either additional computational resource or compromises to be made elsewhere in the modelling. Secondly, a set of weather datasets that is sufficient to adequately stress the solution with regards to security of supply may have detrimental effects in other areas. For example, if the set of weather datasets happens to have an annual average wind availability greater than normal, then the solution may contain more wind farms than it should, as wind appears more favourable relative to other technologies.

The second approach is relatively simple from a computational resource perspective. It has the advantage of separating the capacity optimisation and security of supply problems. This allows for more comprehensive security of supply testing to be carried out. However, the final stage of refining the pathway adds an additional iterative stage to the process and will likely require numerous iterations to come to a final answer.

The third approach does not require the iterative stages that the second approach requires. However, it does require an accurate forecast of the contribution to security of supply of each technology type (commonly referred to as the 'de-rating factor'). This is particularly problematic for weather-dependent renewable technologies and less mature technologies.

Each of these three approaches will be assessed as to their suitability for the SSEP datasets, considering computational resource limitations versus the additional efficiencies of solution. The most practical option may be to utilise aspects of all three approaches in a single combined method as follows:

- Use data from a limited set of multiple weather years as inputs to the capacity expansion optimisation.
- Use a capacity margin constraint, calibrated to the desired security of supply target.
- Conduct stress testing post-optimisation with a wider set of weather data.

The approach will be finalised during the SSEP modelling process following extensive testing and considering stakeholder feedback.

3.5 Development of the spatial evaluation approach

To determine the optimal zonal locations for the in-scope technologies and develop the SSEP, it is necessary to evaluate the spatial and economic factors that influence these. By assessing both the spatial and economic considerations, we can identify potentially suitable locations for each of the technologies, helping to ensure an effective and deliverable SSEP.

The spatial evaluation is a crucial part of the process that considers environmental, societal, other spatial uses and technical engineering design requirements for each of the in-scope technologies. This analysis helps identify the optimal zonal locations for the different in-scope technologies within the energy system, considering both the spatial constraints (push factors[35]) and potential spatial opportunities (pull factors[36]) of those locations. This process will maximise the effectiveness and deliverability of the final SSEP pathway, not only within the energy system but also in the broader context of our society.

Our approach to the spatial evaluation will ensure a fair assessment of spatial constraints and opportunities related to in-scope technologies and facilitate stakeholder engagement on these inputs to the SSEP process. Alignment with existing marine and terrestrial planning, including spatial planning policies on the deployment of energy, will support this evaluation. This will allow for the development of an evidence base of spatial constraints and opportunities for each of the technologies, which is validated by stakeholders of the SSEP.

3.5.1 Spatial evaluation pillars

The spatial evaluation is guided by four of our SSEP pillars, which are referred to as 'spatial evaluation pillars' for the purposes of the spatial evaluation. These are environment, societal, other spatial uses and technical engineering design requirements. These are considered as part of spatial evaluation for each technology. Greater detail on how the spatial evaluation pillars are considered in spatial evaluation can be found in appendix 7.4.

A hierarchical classification of spatial factors that sit within the spatial evaluation pillars is illustrated in figure 12. This provides a clear framework for implementing the spatial evaluation as it enables the application of assessment processes (for example, scoring and weighting) at different levels within the hierarchy (see section 4.2.4 – spatial suitability assessment). Its structure was informed by literature, policy reviews and

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[35] Push factors - factors that are considered to negatively impact the feasibility of building energy infrastructure due to spatial constraints/sensitivities in that area.

[36] Pull factors - factors that are considered to positively impact the feasibility of building energy infrastructure due to the provision of more favourable conditions.

stakeholder input completed when identifying relevant spatial factors for the SSEP. These are described in appendix 7.3.

Pillars
Key elements of the spatial evaluation, namely environment, society, technical engineering design requirements and other spatial uses

Categories in each pillar
Landscape and ecology and biodiversity within the environment pillar; health & wellbeing and recreation & tourism within the society pillar

Subcategories in each category
Landscape designations within landscape category, recreational routes within recreation

Indicators in each subcategory

Datasets representing a spatial factor(*)
Datasets scored in relation to each infrastructure type and to each devolved nation where relevant to create metrics and a standardised set of data.

Figure 12: Hierarchical classification representing spatial factors

3.5.2 Development and implementation of approach

To deliver the evaluation, the following components need to be developed and implemented:

Prepare

1 Clearly defined objectives

Clearly articulating the objectives and goals of the spatial evaluation provides a clear direction and purpose for the analysis. Please see appendix 7.1, which sets out the aims and objectives of the evaluation in providing a robust and transparent tool for identifying optimal locations for the in-scope technologies.

2 Identification and selection of relevant spatial factors

We will gather the necessary data for each selected spatial factor. Each of the in-scope technologies will then be evaluated for the spatial factors that may exclude, constrain or favour its development. Their categorisation is described in the next section.

3 Develop criteria that will be used to assess and evaluate spatial suitability

To assess and evaluate the spatial suitability for each of the technologies, it is essential to develop a set of criteria aligned with the objectives and goals of the evaluation. These involve identifying the factors that could potentially impede, limit or support optimal placement and assessing the significance, importance and impact of these factors in identifying optimal areas for the technologies respectively. The criteria used for the suitability assessment is described in the model chapter.

Model

4 Perform evaluation

There are three stages of spatial evaluation: spatial exclusion, spatial suitability and supporting overlays.

5 Aggregation and analysis

This involves aggregating the evaluations for each technology and transposing the results to the GB area. Results will be analysed to identify areas with high or low suitability for each of the technologies based on the aggregated assessments.

6 Interpretation and visualisation

This entails interpreting the results of the analysis and visualising them to better understand the implications of the aggregated scores on energy infrastructure development.

7 Documentation and Communication

The methodology, data sources and results of the spatial evaluation will be documented, followed by communicating the findings and recommendations effectively to stakeholders and decision makers. This is described in appendix 7.2.

Figure 13: Development and implementation

3.5.3 Multi-criteria analysis

Our selected method for evaluating spatial factors is a modified multi-criteria analysis (MCA) approach. MCA assesses multiple criteria (that is, spatial factors) to inform a decision, encompassing constraints and opportunities associated with environmental, social, economic and technical engineering design requirements.

This method is particularly useful in situations where there are conflicting objectives or potential trade-offs between criteria, as it provides a systematic and comprehensive approach to decision making. It is also highly applicable to, and commonly used for the basis of, Geographic Information System (GIS) spatial mapping and analysis tools.

To improve transparency and clarity in the spatial evaluation, we are taking an enhanced, or modified, approach for our MCA. This includes documenting the approach thoroughly, defining clear criteria and employing an evidence-based approach to scoring and weighting with stakeholder involvement via our stakeholder working groups. A more detailed description of this enhanced approach, as well as the process taken to select a modified MCA method, is described in appendix 7.1.

3.5.4 Refining and data collection

To map the spatial factors that influence the suitability of certain technologies across GB, it is crucial to have data pertaining to these factors. However, not all inputs initially identified in the assessment of spatial factors are suitable for inclusion, considering the objectives and scope of the SSEP. To create a refined list of inputs represented by suitable data sets, each input from the comprehensive list will be evaluated against the following data selection criteria:

- **Data is available with national coverage** - Suitable national-scale datasets are available for use as part of the geospatial analysis. Datasets do not need to be created or collated from multiple sources such as combining data held by individual local authorities.
- **Data, or equivalent representation, is available for England, Scotland and Wales** - This criterion aims to minimise bias within the geospatial model by ensuring consistency in the availability of datasets across the devolved nations. If datasets are not available for all nations, equivalent datasets representing similar features are acceptable. For example, Agricultural Land Classification (England), Predictive Agricultural Land Classification (Wales) and national scale land capability for agriculture (Scotland) can be used as equivalent representations. Datasets that are embedded in relevant national planning policies and/or development plans, such as wild land unique to Scotland, are also considered relevant for inclusion in the SSEP.
- **Data is available at a strategic scale** - Point source data is not considered appropriate for inclusion as these data points cannot be accurately represented within the spatial context of the SSEP and are avoidable at a local level. Given the use of hexagon grid cells as part of the geospatial analysis, the inclusion of point source data is not considered appropriate. Point source data representing features

that require a notable buffer zone and cannot be easily avoided at a local level may be included. An example of this is a listed building, where a buffer can be applied to account for potential impacts on the setting of the asset.

- **Data quality is suitable for the purposes of the SSEP** - The suitability of data is assessed based on the dimensions outlined in the UK Government Data Quality Framework[37]. The framework identifies six core data quality dimensions: completeness, uniqueness, consistency, timeliness, validity and accuracy. When evaluating data quality, it is important to consider user needs and make trade-offs when necessary. It may not always be feasible to achieve optimal data quality, but efforts should be made to ensure that it is fit for purpose. This may involve making trade-offs between different dimensions of data quality to ensure it is as suitable as possible for the SSEP.
- **Relevance** - Datasets must be relevant for inclusion in the SSEP. While some spatial factors may be suitable for inclusion in other spatial frameworks or plans, their relevance to the scope of the SSEP needs to be considered. Spatial factors are deemed suitable for inclusion if the presence of the feature could impact the potential acceptability of at least one of the infrastructure types within the scope of the SSEP.

A figure summarising the criteria to develop a refined list of data sets can be found in appendix 7.3.

The data selection criteria are aligned with the requirements from INSPIRE (EU Information for Spatial Information in Europe)[38] and are assessed for inclusion as follows:

- Datasets assessed as 'green' across all five criteria categories are considered suitable for inclusion.
- Datasets that receive at least one 'red' ranking are determined to be unsuitable for consideration in the SSEP.
- Datasets that receive 'amber' rankings against at least one criterion category may still be suitable for inclusion in the spatial evaluation. In such cases, trade-offs and the availability of other information for the spatial evaluation will be considered on a case-by-case basis to determine their suitability for use. The justification for including or excluding datasets that receive 'amber' rankings will be documented.

It is noted that datasets considered unsuitable for inclusion in the spatial evaluation, such as those that have limited spatial coverage, may still be considered within the broader SSEP. For example, as an 'overlay' for information purposes only.

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[37] UK Government, The Government Data Quality Framework (December 2020) - https://www.gov.uk/government/publications/the-government-data-quality-framework/the-government-data-quality-framework

[38] European Commission, INSPIRE Overview - https://knowledge-base.inspire.ec.europa.eu/overview_en#:~:text=The%20INSPIRE%20Directive%20aims%20to,an%20impact%20on%20the%20environment

Once the refined list of datasets is developed, a review is conducted to ensure they fit within the appropriate hierarchy of the MCA structure presented in figure 12.

3.5.5 Spatial evaluation tool

The spatial evaluation process will leverage Esri's GIS[39] software ArcGIS Pro, The Crown Estate's Resource Identification and Optimisation (RIO) tool, and various input spatial data layers to interpret and visualise the spatial evaluation for each of the in-scope technologies. Geospatial data layers will be combined in ArcGIS Pro to help determine areas where generation and storage infrastructure development may be possible. This data may take the form of points, lines, polygons or gradients to represent the indicators spatially.

This approach is in line with the widespread use of GIS in land and sea use planning worldwide. By utilising GIS, we will generate a comprehensive series of maps for GB that depict the identified spatial exclusion areas, suitability areas and informative overlays across each of the technologies. Aggregating these assessments in GIS will provide an overview of the available area across GB for the respective technologies. This information can then be converted into potential energy output per unit area for each technology. The economic model can utilise this information to conduct scenario analyses and optimise technology configurations based on the potential energy output provided and the economic assumptions for testing and sensitivity analysis. A further description of this process is described in section 4.2 in the model chapter.

3.6 Preparation for SEA and HRA

The first step in the SEA and HRA processes will be SEA scoping and HRA evidence gathering. These stages establish the background and context for the whole SEA and HRA process, considering key parameters such as the range and level of environmental issues to consider, how the assessments will be undertaken, and the information needed.

3.6.1 SEA scoping

SEA scoping will involve:

- Reviewing plans, policies and programmes relevant to the SEA process of SSEP.
- Identifying the evidence base for the SEA.
- Identifying the main environmental issues associated with the SSEP.

[39] Geographic Information Systems (GIS) consist of integrated computer hardware and software that store, manage, analyse, edit, output and visualise geographic data.

- Creating the SEA framework of objectives and assessment questions against which the SSEP will be assessed.
- Developing the methodology for the SEA process, in conjunction with the SSEP's wider spatial evaluation.

Outcomes will be presented in the SEA Scoping Report, which is targeted and accessible and sent for statutory consultation, as described in the foundations chapter under our environmental approach (p 28).

Incorporated within the SEA Scoping Report will be an SEA screening opinion. This will explain why the SSEP requires an SEA, in line with the Transmission Acceleration Action Plan (TAAP) and the Electricity Network Commissioner's recommendations.

3.6.2 HRA evidence gathering

Unlike for SEA, scoping is not a formal requirement of HRA. However, we see its value because of the atypical nature of the plan (there is no real precedent for the SSEP) and it is therefore referred to as evidence gathering. The relatively high level of information likely to be available for each option will influence the level of detail possible in the HRA. Outcomes will be presented in the HRA Evidence Gathering Report and will cover:

- the methodology for the HRA, including data sources and impact risk zones based on expected impact pathways
- the geographic scope
- the 'in combination' scope (other projects and plans to be considered)
- how internationally important wildlife sites will be identified for inclusion in the assessment

The HRA Evidence Gathering Report will then be shared for consultation, as described in the foundations chapter under our environmental approach (p 28).

4. Model

4.1 Model: chapter overview

4.2 Integration and iteration of modelling streams

4.1 Model: chapter overview

The model chapter demonstrates how we will use economic modelling and spatial evaluation to identify the optimal zonal distribution of in-scope electricity and hydrogen generation and storage technologies.

Economic modelling focuses on simulating energy system scenarios and optimising costs, while spatial evaluation assesses factors that shape the spatial configuration of the future energy system. Throughout the modelling process, spatial and economic assessments are iterated so that we can optimise the two elements to deliver a plan that balances sustainability, affordability and security of supply as well as interactions with other uses of the land and sea.

Main messages

- The economic model plays a crucial role in simulating and analysing the operation and evolution of the energy system under various inputs and scenarios. It incorporates the inputs described in the prepare chapter and the outputs of the spatial evaluation to run simulations to shape and develop pathway options for the SSEP.
- The spatial evaluation assesses environmental, societal, other spatial uses and technical engineering design requirements that help to identify potentially suitable areas for the development of each of the in-scope technologies. This takes place via three interlinked exercises: identifying areas of exclusion, identifying areas of suitability and overlaying the data with additional insights for each of the in-scope technologies.
- The flow diagram presented in figure 14 illustrates the individual workflows, information flow, interactions and iterative processes that constitute the approach to the modelling in the SSEP.

This chapter uses the following economic modelling terms:

- **Scenario** – A series of inputs to the PLEXOS model (for example, an electricity demand forecast) that form a starting point for our modelling. Some inputs will be determined by assumed policy decisions that form the backbone of the scenario.
- **Sensitivity** – A change, or number of changes, made to the initial input data of a scenario, which is then re-optimised in PLEXOS to test if it gives a different outcome.
- **Component** – A capacity for a given technology, on a zonal (or inter-zonal for transmission assets) level. For example, 5 GW of onshore wind capacity in zone 1. Components can be binary or non-binary, with an example of a binary component being a nuclear power station, which is either built or not built. Most components are non-binary.

- **Outcome** – A list of components that should be built for a given scenario or sensitivity.
- **Pathway** – The final outcome for a scenario. Through sensitivity analysis this outcome will have been determined to be robust.

4.2 Integration and iteration of modelling streams

Integration of and iteration between the spatial evaluation assessments and economic modelling are critical aspects of the SSEP modelling process. By incorporating both spatial evaluation and economic modelling into the analysis, we can capture the complex interplay between spatial exclusions, spatial constraints, spatial opportunities and economic optimisation.

The economic analysis and spatial evaluation run alongside each other to optimise the energy system based on realistic inputs and assumptions and, at various stages, the two processes feed into each other. For example, as the spatial evaluation process progresses, its outputs feed into the economic modelling process, to provide detail on land potentially suitable for generation or storage.

Within the economic modelling, the PLEXOS tool looks for an optimal solution to a range of sensitivities. If this is not reached, there is scope to reassess relevant aspects of the spatial and economic analysis to explore alternative options that could lead to achieving optimised outcomes. The integration and iteration of the modelling processes is illustrated in figure 14 and described in the following sections, where it is presented in the order the processes first appear. Due to the iterative nature of the process, it is not linear, so please refer to the end-to-end modelling process (figure 14) for an overview of the flow and iterations.

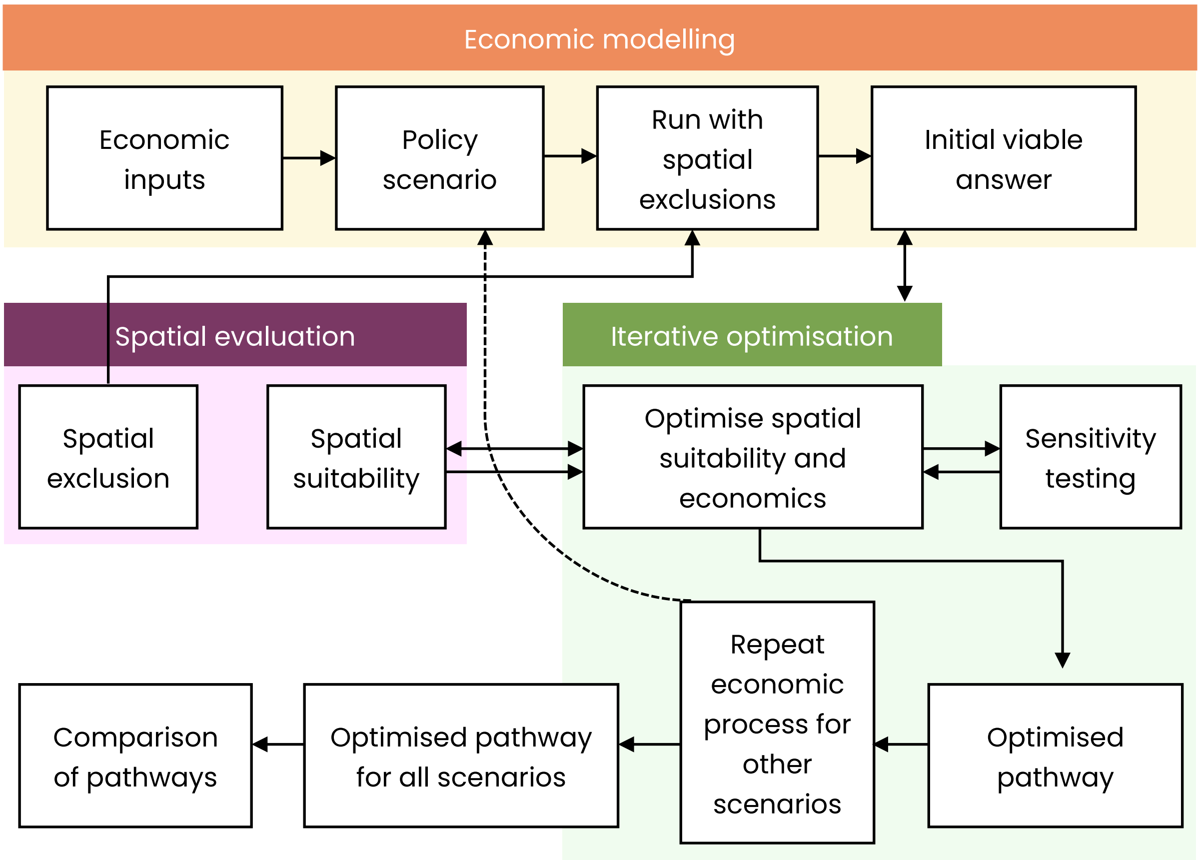

Figure 14: End-to-end modelling process

4.2.1 Scenarios in economic modelling

The SSEP pathways will be developed through scenario testing. Some inputs will be determined by assumed policy decisions that form the backbone of the scenario. For example, we may consider two scenarios: the first assumes that domestic heating is predominantly electric, the second assumes significant use of hydrogen for domestic heating. These two scenarios are mutually exclusive; they are different pathways that GB could take. There could also be further scenarios which consider varying combinations of these two approaches.

Each scenario will be considered independently to determine the optimum outcome (the pathway) for that scenario. Once this has been achieved, comparisons can be made between the pathway developed from each scenario. This will give insight into each scenario and the policy decision(s) that created that scenario.

There are many inputs to a scenario that may not be linked to any specific policy decision. These will include costs, build limits and commodity prices. It is likely that these inputs will be the same across all scenarios, although they may subsequently be varied using sensitivities, which we explain later in this chapter.

4.2.2 Spatial exclusion

The spatial exclusion assessment involves identifying and excluding areas from analysis. The definition for a spatial exclusion is "a spatial factor that precludes the potential siting of in-scope energy infrastructure due to relevant physical, legal and land and sea use restrictions". What classifies as a spatial exclusion may differ from one technology to the next; therefore, the assessment is conducted for each in-scope technology separately. Utilising the GIS tool described in section 3.5.5, areas where these exclusions are present are omitted from the ongoing assessment.

The areas remaining after the spatial exclusion assessment will undergo further filtering to exclude areas that do not meet assumed minimum footprint requirements of each technology type. Key deliverability factors will also be considered, including the shape of the remaining areas, to ensure they meet the specific requirements of each technology type. Once these areas are excluded from the analysis, an initial study area for each in-scope energy infrastructure technology remains. These are referred to as potential developable areas.

The remaining potential developable areas will then be converted into economic modelling inputs. Since the economic model does not read inputs based on spatial parameters such as area, the areas remaining are converted to potential energy output, expressed in GW. The stacked process diagram in figure 15 illustrates the steps in producing spatial exclusion outputs that feed into economic modelling.

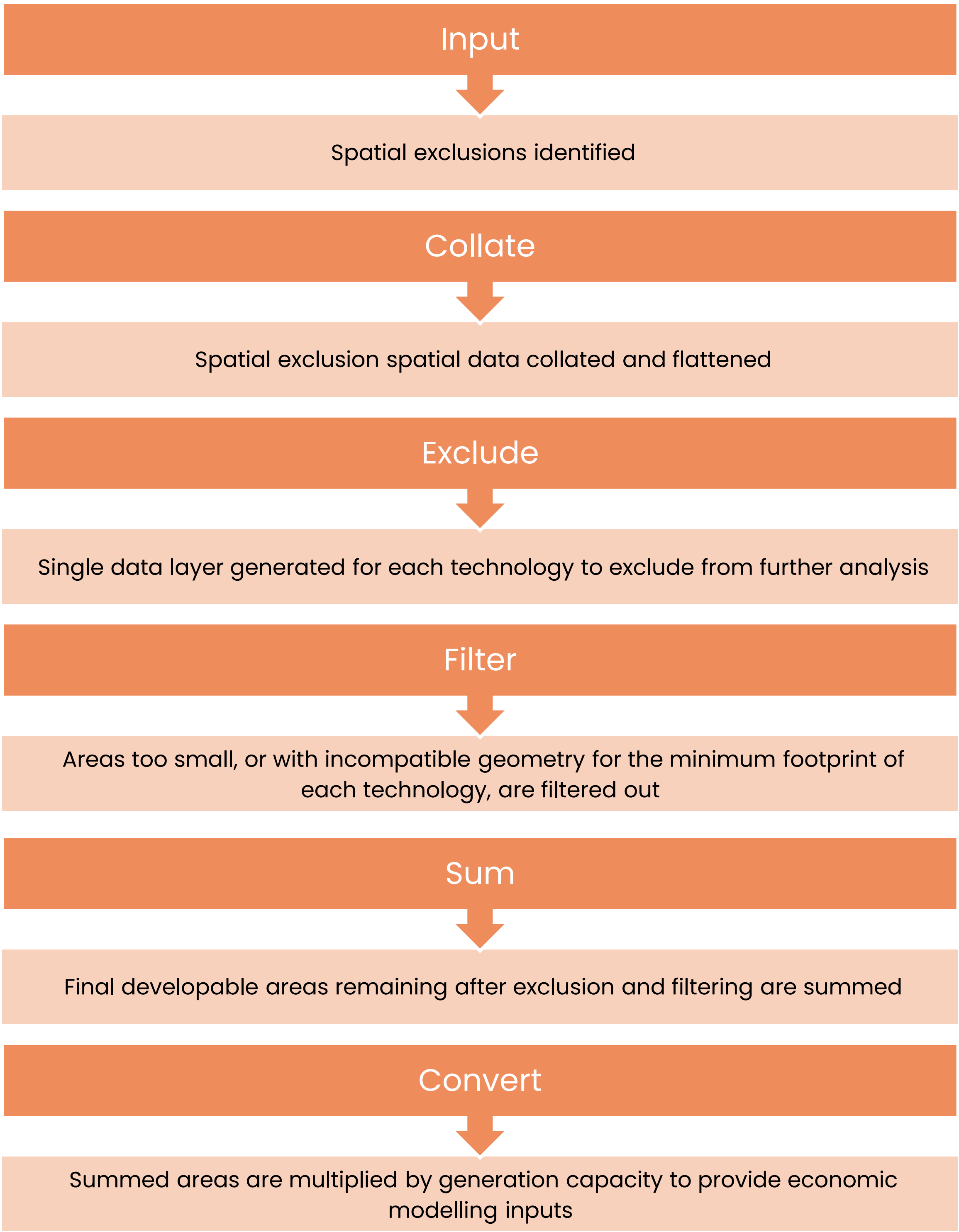

Figure 15: Spatial exclusion flow diagram

A full list of data included in the exclusion assessment will be provided as part of a data register in the final SSEP report.

4.2.3 Integrating economic modelling and spatial exclusion - initial viable answer

The initial phase of co-optimised modelling takes all the inputs and policy scenarios gathered in the modelling assumptions phase and puts them into the economic modelling alongside the outputs of the spatial exclusion. In-scope technologies are modelled on the areas remaining to create an 'initial viable answer' for each scenario.

4.2.4 Spatial suitability assessment

Spatial suitability as part of spatial evaluation involves evaluating and scoring the spatial factors present within the remaining potential developable areas and evaluating their relevance to in-scope energy infrastructure. These factors fall into one of two categories:

A **spatial constraint** is a spatial factor that may, to varying degrees, limit the potential siting of in-scope energy infrastructure. The constraints assessment focuses on evaluating factors related to the environmental, societal and other spatial uses pillars.

A **spatial opportunity** is a spatial factor that may, to varying degrees, support the potential siting of in-scope energy infrastructure. Spatial opportunities are instrumental in highlighting where development is desirable for a given technology, based on its specific requirements. These factors are specifically related to the technical engineering design requirements pillar.

Spatial constraint assessment criteria

To assess spatial constraints, we propose scoring on their evidence-based, individual, substantive importance and their magnitude of effect in relation to the in-scope technology under consideration. The first criterion aims to consider the significance and distinct characteristics of each spatial factor, including its uniqueness, intactness and overall value. The second criterion focuses on the impact that the development of a given type of energy infrastructure could have on the spatial factors. By scoring both the importance and the potential magnitude of the effect, we gain a comprehensive understanding of the significance and relevance of each spatial factor on a given technology. The spatial constraints criteria are negatively scored to reflect these as 'push factors'.

During scoring, the importance of spatial factors is assessed independently. However, there may be instances where it is necessary to assign greater importance to groups of spatial factors, such as whole categories or spatial evaluation pillars. To achieve this, weighting can be applied at the category or spatial evaluation pillar level, dependent on the rationale for doing so. For instance, weighting may be used to normalise, test specific scenarios or to reflect stakeholder sentiment towards different categories or pillars. This method is flexible, remains under evaluation and will be applied with caution and transparency if implemented. The approach taken will also look to align with our principles and incorporate recommendations outlined in the HM Treasury Green Book. To derive the overall weighted scores, the individual scores of each spatial factor are multiplied by their corresponding weights (if weighting is utilised).

Spatial opportunity assessment criteria

As described above, spatial opportunities relate to technical engineering design requirements for a given energy infrastructure type. This assessment aims to capture the level of opportunity provided by a given technical engineering design requirement by evaluating its effect on potential energy output, capital expenditure (CapEx) and operational expenditure (OpEx). These criteria ensure a robust understanding of the criticality of the technical engineering design requirement for siting energy infrastructure and its importance compared to other key drivers. The criteria for this assessment are positively scored to reflect that they are 'pull factors' that enhance the spatial suitability of a given area. The scoring matrix that brings together the criteria for assessing spatial constraints and spatial opportunities is being refined through geospatial testing and stakeholder engagement (figure 16). Neutral scores may also be considered for both spatial constraints and opportunities.

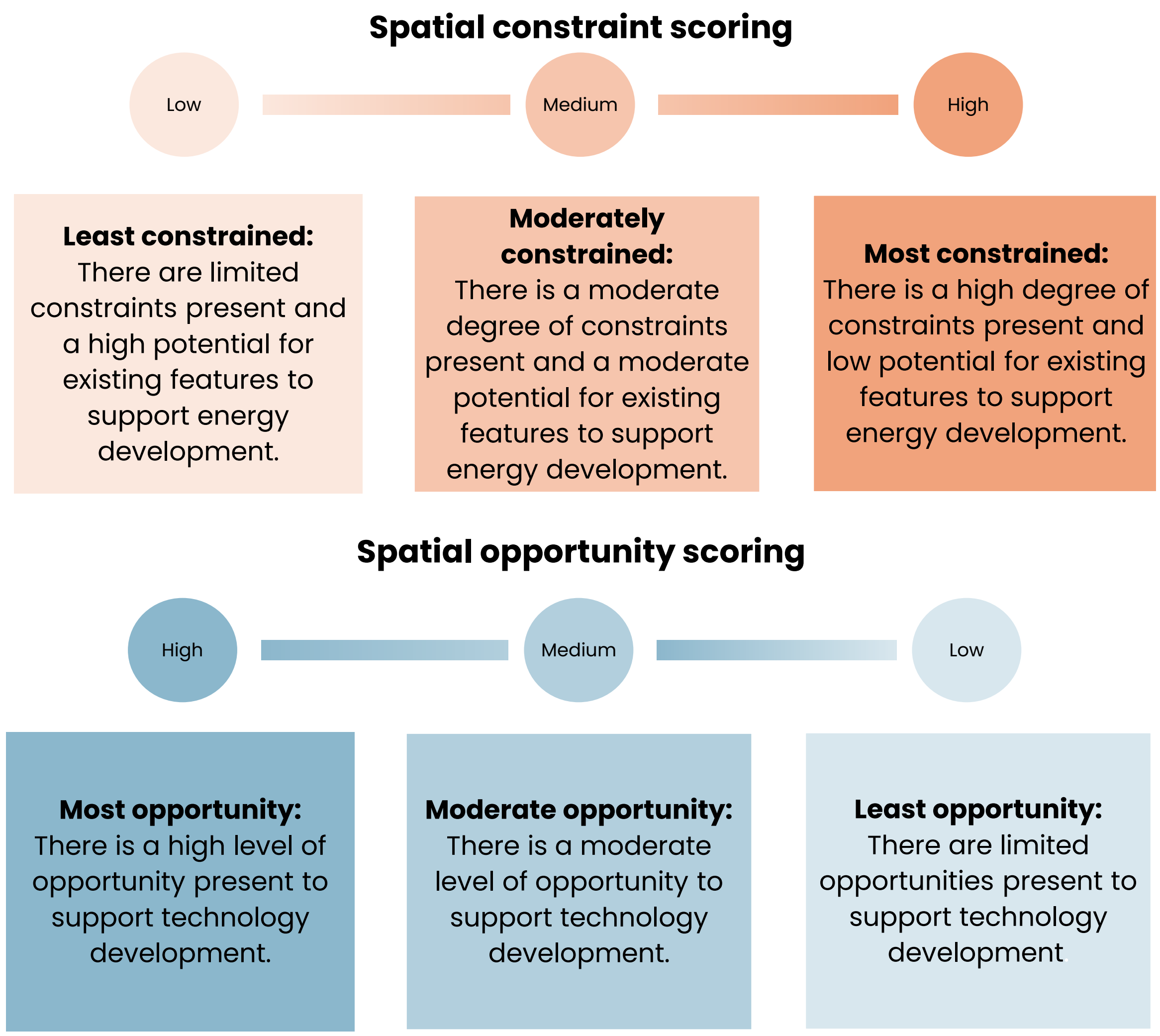

Figure 16: Example of overall scoring approach

Refining spatial suitability

Once the spatial suitability assessment has been conducted, we propose establishing a threshold within the range of scores observed to further prioritise potential developable areas for each technology. Areas that score below this threshold, that is, are less constrained and of highest opportunity, will be considered further, while those scoring higher will be excluded from analysis. This allows us to focus on areas that are potentially more suitable for development, disregarding areas with more constraints or lower opportunity. The threshold may be determined as a percentile of spatial constraint areas or a cut-off in the overall scores. The threshold will be informed by stakeholder and expert review. Areas scoring below the threshold will be converted to potential energy output. This will reduce the initial potential developable area and corresponding potential energy output. The outputs will be used to further constrain the economic model, described in section 4.2.5 below.

4.2.5 Iterative optimisation integrates spatial suitability into economic modelling

Following the spatial suitability assessment described above, the refined potential energy output is combined with the 'initial viable answer' in the economic model. This enables further spatial and economic optimisation.

4.2.6 Iterative optimisation and sensitivity testing

At times, the optimal spatial and economic outcomes could be in conflict. To identify solutions that achieve balanced outcomes across both spatial and economic components we will undertake sensitivity testing. For example, varying the spatial suitability threshold will impact the potential energy output per economic zone available to the economic model, and may result in some generation being moved between economic zones. The economic model, in turn, will demonstrate the effect on cost of this spatial suitability change. Testing these variables facilitates iteration between the spatial suitability assessments and economic modelling, thereby identifying optimal outcomes that align with the SSEP's objectives.

As the economic optimisation process is carried out, economic costs are repeatedly traded off against spatial suitability inputs to reach a balanced outcome that minimises cost and optimises spatial outcomes. Once sufficient sensitivity analysis and expert review have been carried out, an 'optimum pathway for the first scenario will be reached.

Given the size of the optimisation problem in the SSEP, it is not practical to use commonly used statistical methods such as the Monte-Carlo analysis. Therefore, we will use targeted sensitivity analysis. Our current thinking on sensitivity analysis is included here, however we will adjust the process as appropriate once we are carrying it out.

Sensitivity analysis enables a change, or a number of changes, to be made to the initial input data of a scenario, which is then re-optimised in PLEXOS to test if it gives a different outcome. For example, the sensitivity of the recommended capacity of solar farms could be tested by varying their capital cost to understand how sensitive the output is to that cost. As we know that all the input data used by PLEXOS is either a forecast or an assumption, it is not sufficient to optimise the pathway for this scenario with the belief that these inputs are completely accurate.

When considering which inputs to vary and by how much, we will use our own insight, the output of the economic modelling, and stakeholder recommendations. In most cases we will conduct multiple sensitivities on the same input, using a different value each time. This increases our insight into how sensitive an outcome is to variance in the input. Testing a particular sensitivity may affect various components, even those unrelated to the initial input. For instance, higher capital costs for one technology can impact the optimal capacity of another.

The sensitivities we will initially test are those with economic and spatial inputs that are considered to be the most influential for the optimisation of a scenario. It will allow us to gain insight for those sensitivities that may be useful to run in the other scenarios, which will save considerable computational effort in the long run.

By conducting sensitivity analysis and understanding the variance to the input, we can test the robustness of the pathway to key input data forecasts. Employing robust analysis in sensitivity modelling ensures that the results obtained are reliable and not heavily influenced by minor fluctuations or uncertainties. In the SSEP economic analysis, sensitivity testing enables us to gain a more accurate understanding of the relationships between input parameters and model outputs, allowing for better decision-making and risk assessment.

The process by which robustness is measured is described in more detail in appendix 8. Once the robustness level has been chosen for all components, the components are run through PLEXOS for one final optimisation. The outcome of this final PLEXOS optimisation will be a universally optimised outcome, where all the components are within a tolerance around their robustness level, and this will help form the pathway for that scenario.

4.2.7 Repetition of iterative modelling to create additional pathways

Once the pathway has been developed for an initial scenario, the most impactful components that make up this pathway can each be evaluated in other scenarios and remodelled to generate further pathways.

4.2.8 Supporting overlays

We will also use informative overlays to provide essential context to the modelling and spatial evaluation. For instance, overlaying national spatial plans and policies for energy infrastructure, existing energy infrastructure, or visualised results from societal surveys. An example of integrating existing spatial plans to enhance our analysis and contextual understanding is the integration of spatial assessments conducted for offshore wind generation in Scotland, as part of the current sectoral marine plan. We will consider such work in our analysis and update it when new information becomes available.

These overlays may highlight further opportunities for iteration and optimisation in the modelling, in line with the SSEP's objectives. This layered approach enables the SSEP to capture a comprehensive overview that complements the economic and spatial optimisation process.

While the exclusions and suitability assessments remain the core driving force of the SSEP, overlaying contextual information also offers a transparent framework for stakeholder engagement. This enables clear communication of the primary criteria driving the outcomes while showing how additional considerations relate to the optimised outcomes identified throughout our modelling process.

4.2.9 Optimised pathways

During the modelling process, costs are continuously balanced and traded off against spatial assessments to achieve a balanced outcome that minimises costs and maximises the utilisation of potentially developable areas. After conducting thorough sensitivity analysis and review, an optimum pathway for the given scenario is determined. This process is repeated for other scenarios to generate additional pathways. Once the required number of pathways have been generated, they can be transitioned to the appraise phase, which is elaborated upon in the subsequent chapter.

5. Appraise

5.1 Appraise: chapter overview

This chapter explains how we produce a set of carefully chosen pathway options to facilitate the selection of a single pathway by the UK Energy Secretary. It also covers how the environmental impacts of the chosen pathway are assessed.

Our appraisal process for developing suitable pathway options is guided by key principles - minimising economic and spatial impact and the ability to meet future policy ambitions.

This chapter describes the step-by-step pathway options selection process. It is designed to combine analysis, strategic direction by governance committees and stakeholder input, to arrive at a final subset of options that will be presented to the UK Energy Secretary. It also describes how the environmental impact of these options is considered. The chapter concludes by outlining the environmental assessments that will be undertaken on the UK Energy Secretary's chosen pathway.

Main messages

- Economic and spatial modelling will facilitate the comprehensive assessment of multiple possible pathways, including the identification of trade-offs and pending decisions that must be considered, guided by our key principles. A 'low regrets' pathway will be developed, characterised by having the highest probability of success across all plausible futures. 'Higher risk' pathway options may also emerge, which include infrastructure that will be present in some, but not all, plausible futures.
- Pathways will be presented to governance committees, together with a comprehensive explanation of the options, their differences in strategic direction and decisions needed on key points.
- Pathway options will be refined to consider feedback from governance committees and stakeholders. This will produce a subset of pathways for a final decision by the UK Energy Secretary. These options will be accompanied by SEA and HRA pathway options reports.
- Once all the information on the final pathway options has been evaluated, the UK Energy Secretary will choose a single pathway option. This will become the pathway for consultation on the draft SSEP and the draft plan for the SEA Environmental Report and HRA Report to Inform, which together comprehensively assess the environmental impacts of the selected pathway.

5.2 Summary of the appraisal process

Comprehensive evaluation and refinement will be crucial to identifying the SSEP pathway options. The evaluation and selection of these pathways is guided by their ability to minimise costs and spatial impacts and meet future policy scenarios.

The creation of pathway options (described in the model chapter) begins with understanding the key insights and trade-offs. This is initiated by the development of policy scenarios to establish and define the modelling parameters. Sensitivity testing will be undertaken to help determine the economic inputs that have the most significant impacts on economic modelling outputs. Once these outcomes have been assessed, governance committees will provide strategic direction to refine and evaluate the pathway options selected.

The options are presented to internal and external governance committees, accompanied by relevant information such as cost, spatial impacts, alignment with government policies and key differences between pathway options. Feedback and insights from the committees will then be used to evaluate and further refine the pathway options. The environmental impacts of these options will then be assessed through an SEA and HRA pathway options report.

The pathway options will be shared with Welsh and Scottish energy ministers and Ofgem for their views. The UK Energy Secretary then makes the final decision on which pathway is selected. Following this decision, the SEA Environmental Report and Report to Inform HRA will be undertaken on the selected pathway.

5.3 Assessment of pathway options

Pathways will be assessed against their ability to achieve SSEP objectives. The principles guiding the evaluation and selection of pathway options are:

- minimising costs
- minimising spatial impact
- maximising spatial opportunity
- achieving future policy ambitions

These will serve as the foundation for testing and evaluating different outcomes and options within the appraisal process. Using the principles as levers, we will assess the impact of various economic, spatial and policy scenarios and determine to what degree each option fulfils the three principles.

5.3.1 Process

To develop pathway options, we will:

Assess results

Guided by the principles, we will evaluate the outcomes derived from economic and spatial modelling and identify the significant trade-offs and pending decision points.

By conducting tests on a wide range of scenarios and performing sensitivity analysis on model inputs, the modelling process enables a comprehensive assessment of various possibilities. This approach facilitates a thorough evaluation and is expected to identify significant trade-offs and decisions that need to be considered.

These outputs serve as strategic guides, providing insights into the potential pathways for achieving net zero goals while balancing the economic, societal, other land use and environmental considerations. By analysing the results and testing a wide range of scenarios, a clearer understanding of the potential optimal pathways for decarbonisation will emerge. In some cases, pathways presented may be 'higher risk,' meaning they may include infrastructure required in some, but not all, plausible futures.

Aside from scenario-driven outcomes, a 'low regrets' pathway will be created; defined as having the highest probability of success in meeting the policy scenarios across all plausible futures. The identification process for 'low regrets' pathways involves examining the results in detail to select pathway options with substantial margins of viability for meeting the minimum requirements across all plausible futures. This ensures the chosen options can accommodate potential changes or adjustments, reducing the risk of becoming unfeasible if circumstances shift.

Strategic direction by governance committees

Pathways will be presented to governance committees to obtain direction and facilitate decision-making on key decision points.

Once the trade-offs and insights have been understood, these options will be presented for internal and external governance. This is a key element of appraisal that recognises certain decisions require strategic judgment in addition to analysis and cannot be resolved through analytical processes alone.

All the shortlisted options will be accompanied by an explanation of when and where infrastructure should be built across GB on a zonal level, how this differs between pathway options and the key factors driving these differences, such as:

- the overall cost of the pathway option
- what spatial impacts each option represents
- how the pathway options align with UK, Scottish and Welsh government policies, plans and targets

Stakeholder assessment

Information on the outputs of the modelling will be shared with expert working groups and societal and community stakeholders. This will enable us to evaluate the acceptability of pathways among a diverse set of stakeholder groups. By considering a range of perspectives, and the potential impact of pathways on various regions and communities and sectors of society, we can gain an understanding of their potential acceptability. This will help to ensure a comprehensive and inclusive societal appraisal of the pathways.

Evaluation and refinement

Building on the feedback and insights provided by the governance committees and by stakeholders, this stage aims to evaluate and refine further the available options to ensure they align with desired objectives and priorities.

Subset of pathways for final decision

A subset of pathways will be chosen for consideration in the final decision-making, which is ultimately made by the UK Energy Secretary. This will include at least one 'low regrets' option among other pathways, each one selected and refined through the described process, using the principles and objectives as guides. Fundamentally, these options will consist of those most likely to succeed across a range of plausible futures while considering the interests of stakeholder groups.

Our modelling approach is the foundation for this phase of the process, offering invaluable insights into the trade-offs and considerations involved in selecting the most suitable pathways for achieving the desired outcomes. The direction taken in this pathway selection process is contingent upon robust governance mechanisms and effective decision-making structures in line with the objectives and principles outlined above. Through this iterative process between modelling and governance, the SSEP will ensure the selected pathways are well-informed, robust and aligned with the objectives of the energy transition.

5.4 Environmental assessment of options

5.4.1 SEA reasonable alternatives assessment

The SEA legislation applicable to England, Wales and Scotland requires the SEA to identify, describe and evaluate the likely significant environmental effects of the draft SSEP. The legislation also requires the setting of reasonable alternatives which account for the objectives and geographical scope of the SSEP.

The types of alternatives considered can vary, but they need to be relevant to the plan being assessed. It is likely the outputs of the spatial evaluation will help feed into the alternatives assessment. However, the types of alternatives to be considered for the SSEP will be discussed within the SEA Scoping Report.

Each of the selected alternatives will be assessed against the SEA framework of objectives, the assessment questions developed during scoping and the evidence base developed for the SEA. For each alternative, a commentary discussing the findings of the assessment will be presented, providing a clear overview of the relative sustainability merits of each alternative considered.

5.4.2 SEA and HRA Pathway Options Reports

To appropriately inform pathway decision making, we will look to use the SEA and HRA processes to provide relevant environmental information on the options presented. Both SEA and HRA Pathway Options Reports will be submitted as part of the UK Energy Secretary decision on the single pathway.

SEA Pathway Options Report

Once it has been decided which options will be presented UK Energy Secretary, we will produce an SEA Pathway Options Report to provide context on the alternative pathways. The SEA Pathway Options Report will present information in a clear, accessible and concise manner, using visual aids and infographics.

HRA Pathway Options Report

Rather than waiting until the final option has been selected, the HRA process will begin when the pathway options are shortlisted for the UK Energy Secretary.

Each of the short-listed pathway options will be assessed against the HRA criteria developed at the evidence gathering stage. These assessments will draw on the outputs of the spatial evaluation, plus information on the impact of pathways, zones of influence, qualifying features and conservation objectives of internationally important wildlife sites.

Particular focus will be given to identifying whether any options have less of an effect on internationally important wildlife sites and whether there are any options less likely to require reliance on derogations. For each alternative, a commentary discussing the findings of the assessment will be presented, with a view to providing a clear overview of each option’s merits.

5.4.3 SEA Environmental Report

Once the pathway has been chosen, an SEA Environmental Report will be prepared. This will be the main output of the SEA process and will accompany the draft SSEP for public consultation. As such, it will be presented in a clear and concise manner, using simple and clear language and supported by maps and other illustrations where appropriate.

The SEA Environmental Report will present the information required by the relevant SEA legislation for each GB nation. Its purpose is to present readers with an informed assessment of the draft plan, as well as an assessment of the reasonable alternatives identified.

It will detail the likely significant environmental effects of the draft SSEP, covering topics such as biodiversity, water and cultural heritage, which were identified during the scoping stage and considered relevant to the SSEP. The effects identified will include cumulative; short-, medium- and long-term, permanent and temporary and positive and negative effects. Following this, the SEA will identify appropriate mitigation at a level consistent with the assessment.

5.4.4 Report to Inform HRA

The Report to Inform Habitats Regulations Assessment will be produced following the decision on the final pathway. The broad stages of the HRA process are outlined below.

Evidence gathering – collecting information on relevant European sites, their conservation objectives and characteristics and other plans or projects

↓

HRA Task 1: Likely significant effects ('screening') – identifying whether a plan is 'likely to have a significant effect' on a European site

↓

HRA Task 2: Ascertaining the on site integrity – assessing the effects of the plan on the conservation objectives of any European sites 'screened in' during HRA Task 1

↓

HRA Task 3: Mitigation measures and alternative solutions – where adverse effects are identified at HRA Task 2, the plan should be altered until adverse effects are cancelled out fully

Figure 17: Four stage approach to Habitats Regulations Assessment

Test of likely significant effects

Following evidence gathering, the first stage of any Habitats Regulations Assessment will be the Likely Significant Effect (LSE) test. This is essentially a risk assessment to decide whether the full subsequent stage known as appropriate assessment is required. Case law has established that, 'likely' really means 'possible' and a 'significant' effect is one where reasonable scientific doubt remains as to whether it would affect the ability of a habitats site to achieve its conservation objectives. Case law has also established that the assessment must be undertaken without reference to any mitigation measures specifically introduced to protect internationally important wildlife sites.

Appropriate assessment

The second stage of HRA will be the appropriate assessment. Case law has established appropriate assessment is not a technical term; it literally means whatever level of assessment is appropriate to form a conclusion regarding effects on the integrity of internationally important wildlife sites.

As such, it has no set methodology. The steps will be essentially identical to those of the LSE stage but will involve more detail. The methodology will be tailored to the specific impacts requiring investigation and the interest features of the relevant internationally important wildlife sites. It is at this stage that mitigation measures specifically introduced to protect such sites will be considered.

In accordance with the Habitats Regulations, at the test of likely significant effects and appropriate assessment stages, the effects of the plan will be considered both individually and in combination with other relevant plans or projects.

Derogations

If during the appropriate assessment stage, it is identified that the selected pathway would result in adverse effects on the integrity of internationally important wildlife sites (considering qualifying features of a designated site, its sensitivities and conservation objectives), derogation will be required. The legal tests are:

- There are no feasible alternative solutions that would be less damaging or avoid damage
- There are Imperative Reasons of Overriding Public Interest (IROPI)
- The necessary habitat compensation measures can be secured

The Report to Inform HRA will then be shared with statutory stakeholders, including Natural England, Joint Nature Conservation Committee, Natural Resources Wales, NatureScot and the Department of Agriculture, Environment and Rural Affairs in Northern Ireland.

6. Consult

6.1 Consult: chapter overview

This chapter explains how we will carry out a formal consultation on the SSEP and use subsequent feedback to enhance the plan. It also covers the same process for the two statutory environmental reports accompanying the SSEP - the SEA Environmental Report and the Report to Inform HRA.

Our consultation process is designed to be flexible, open, inclusive and responsive to community and industry needs. Using structures and forums established during the SSEP's development, we will engage a broad range of political, societal, industry and community stakeholders, gathering valuable perspectives.

This will be analysed using a wide range of tools, including artificial intelligence (AI), to develop robust and accurate findings that in turn create clear actions for improving the SSEP.

Alongside this, consultation will also be completed for the SEA Environmental Report and the Report to Inform HRA, with responses duly considered, implications evaluated, and updates published via addendums.

Main messages

- We will engage with the same sectors as we have throughout the SSEP's development, including expert working groups on industry and spatial planning.
- This will be supported by societal engagement through opinion surveys or targeted focus groups, outreach to prominent interest and campaign groups and sector-specific briefing packs.
- A range of communication tools and diverse engagement methods will be deployed, including visual representations of the plan, text descriptions and direct engagement such as webinars and stakeholder meetings.
- AI will also be used to summarise the consultation data to help transform it into actionable insights.

6.2 Our approach to stakeholder feedback

Stakeholder feedback is essential to the development of the SSEP. Insights, perspectives and recommendations from stakeholders are built into the development of the plan and will be invaluable as we deliver on the aims of the SSEP. An important element of this will be formal consultations on specific parts of the plan.

To give stakeholders the opportunity to help shape our plan, we are seeking feedback on this draft methodology and, later, the draft SSEP via public consultation. We will explain how we have considered and acted on stakeholder feedback themes to inform the development of the SSEP.

Alongside our draft SSEP, we will publish the SEA Environmental Report in line with our statutory obligations and the Report to Inform HRA to give the public the opportunity to understand and comment on the environmental impacts of the draft plan.

Our consultations will be wide-reaching and inclusive, ensuring everyone can have a say. They will be run in addition to the ongoing stakeholder engagement, which is outlined in the stakeholder approach section. These methods balance broad and meaningful engagement with stakeholders and experts, creating a robust plan and encouraging advocacy for its direction.

6.2.1 Draft SSEP consultation

Once the UK Energy Secretary has selected the pathway, there will be an opportunity for society and a wide range of stakeholders to have their say on the draft SSEP.

We will employ a range of communication tools and diverse engagement methods to explain to the public and stakeholders how the plan has been developed to date and the role that society has played in its creation. Our activities will include visual representations of the plan, text descriptions and direct engagement such as webinars and stakeholder meetings. These efforts aim to provide accessible information and data to various stakeholders interested in the SSEP.

We want to make sure that the SSEP reflects the needs, values and ambitions of society, while delivering on our commission. By providing an overview of engagement to date, we will highlight the journey to the development of the pathway and the significant role that engagement has played.

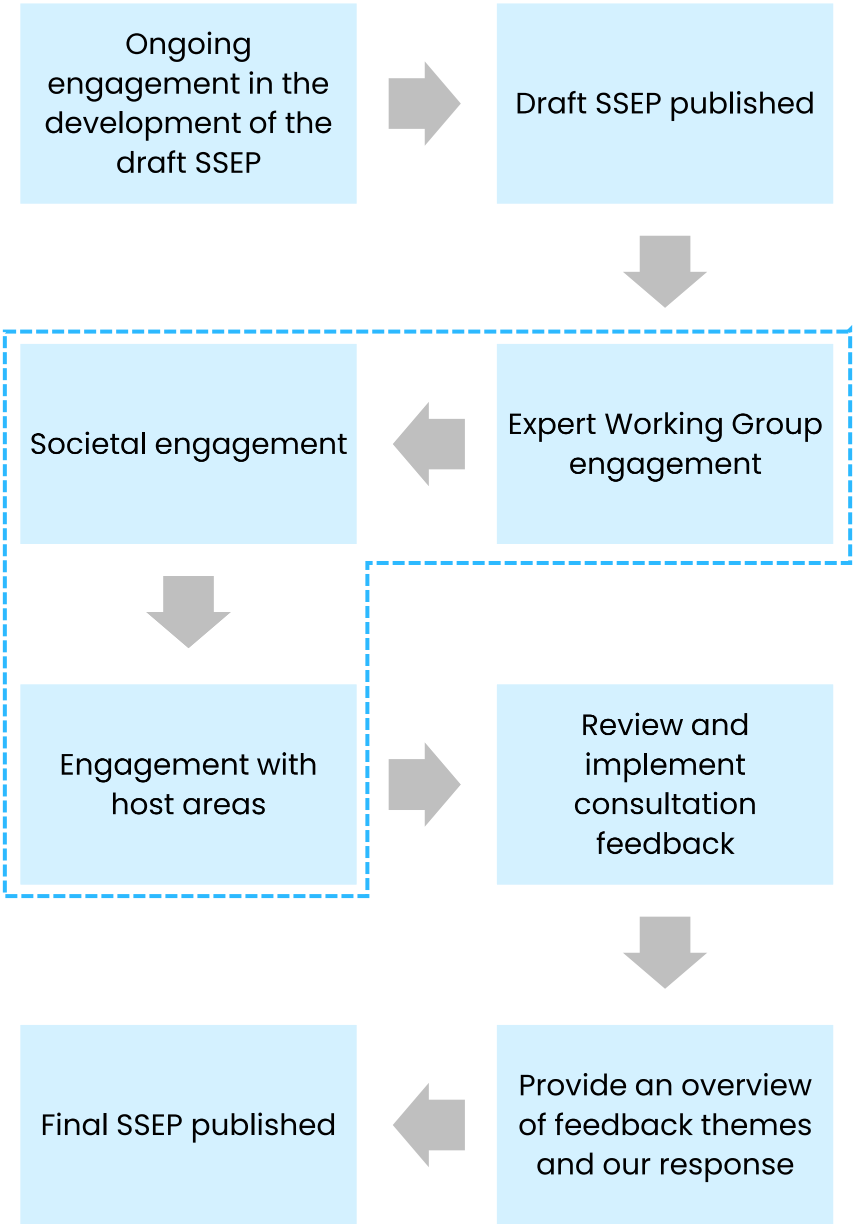

Figure 18: Consultation stakeholder engagement process

We will engage with the same sectors as we have throughout the development of the SSEP, including expert working groups on industry and spatial planning.

This will be supported by societal engagement, which will include re-testing societal acceptance of the necessary trade-offs in the draft SSEP. To better understand these aspects, we will employ various methods, which could include opinion surveys, targeted focus groups, and outreach to prominent interest and campaign groups. Additionally, sector-specific briefing packs will be used to update these groups on the draft SSEP.

Following publication of the draft SSEP, we will continue to engage with the host areas identified as being best suited for energy infrastructure development. Our experience indicates that communities want to participate in the decision-making process. In addition, they want to understand who the key decision-makers for different types of energy infrastructure are and how they can influence outcomes. We will utilise the structures and forums established during the SSEP development to address these points and facilitate conversations among political, societal, industry and community stakeholders about the draft SSEP content and rationale. We will also remain reactive and responsive to community and industry needs, continually evolving our engagement activities accordingly.

6.2.2 SEA Environmental Report and HRA Report to Inform consultation

Public and statutory consultation are legislative requirements for the SEA Environmental Report. This will form the key consultation document in the SEA process, providing an explanation of the environmental effects of the draft plan and reasonable alternatives, along with an opportunity to comment.

For the HRA Report to Inform, we are only required to consult statutory bodies. However, to maintain transparency, it will also be published for public consultation.

The statutory and public consultation for the SEA Environmental Report and HRA Report to Inform will take place alongside the draft plan consultation. For further information on consultees, please refer to the environmental approach section of the foundations chapter (p 28).

6.2.3 Use of artificial intelligence

The SSEP will engage a broad range of societal groups to ensure that a diversity of views and opinions are considered during its development. Artificial intelligence (AI) will be employed to summarise the data and transform 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 SSEP 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. Whether the feedback comes from surveys, meetings, forums, emails or other channels, AI can integrate and analyse this information cohesively. 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.

When we make decisions on the SSEP, AI will help ensure that the voices of all stakeholders are heard and considered. 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.

By summarising and categorising the feedback, AI will help to highlight important issues and common themes, allowing us to include stakeholder feedback in the SSEP more effectively and proactively. This comprehensive approach ensures that stakeholder input into the SSEP is informed by a broad spectrum of perspectives, allowing us to respond in a timely and appropriate manner. 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.

7. Refine

7.1 Refine: chapter overview

The refinement phase is an opportunity to improve the final SSEP through stakeholder feedback and insights, guided by the principles of inclusivity, coherence, continuous learning, transparency and collaboration.

Main messages

- Through ongoing and proactive stakeholder engagement, we will address potential issues, gather valuable input and adjust our plans and processes in line with feedback and emerging best practice.
- The SSEP's processes are designed to be flexible and adaptable in this sense, ensuring the final SSEP achieves its objectives and delivers the best outcomes possible for stakeholders.
- Our refinement process strikes a balance between incorporating stakeholder perspectives and maintaining the overall robustness, coherence and consistency of the SSEP.
- Feedback on this consultation will be shared with stakeholders in the final SSEP methodology document, where we will explain how we've considered and addressed these.

7.2 Principles of refinement

There are several principles that will underpin our approach to the refine process of creating the SSEP.

Inclusivity and engagement - We will continue to prioritise inclusivity and meaningful engagement with stakeholders, valuing the input and perspectives collected in consultation throughout the refinement phase. We will strive to strike a balance between different stakeholder perspectives, considering the weight of feedback based on its representativeness, significance and alignment with project and national planning objectives.

Coherence and consistency - While refining the SSEP, we will strive to maintain overall coherence and consistency. Changes made during the refinement process will be carefully balanced to ensure that the plan remains robust and aligned with its objectives. Changes will be evaluated for their feasibility and practicality, considering technical, economic, environmental and societal aspects to mitigate adverse effects as a result of changes made.

Continuous learning and improvement - Alongside the process of incorporating stakeholder feedback, we will use this period to reflect on lessons learned and actively seek opportunities to refine the SSEP and processes based on emerging best practices and new information. Lessons learned will be incorporated in the process of refining the SSEP should this benefit the overall quality and effectiveness outputs. Feedback received from the consultation will also inform future versions of the SSEP.

Transparency - Throughout the refinement process, we maintain transparency on the modifications made. Explanations will be provided for how consultation feedback has been considered and incorporated, ensuring that stakeholders are informed about the outcomes and the reasons behind them.

Collaboration - We will work closely with governance forums, technical experts and relevant stakeholders to evaluate proposed changes and ensure their effective implementation. This collaborative approach allows us to consider various perspectives and expertise in assessing the feasibility, costs and timelines associated with any refinement that's proposed.

7.3 Proactive refinement

Throughout the SSEP's development, we will encourage ongoing stakeholder engagement and refinement via stakeholder engagement channels.

This approach ensures that development and outputs are consistently aligned with stakeholder interests, address concerns and maintain a balanced and informed approach from the outset.

By involving stakeholders early in the SSEP's creation, potential issues can be proactively addressed, input can be gathered, and adjustments can be made along the way. This proactive involvement strives to reduce the need for significant changes during the public consultation phase and allows for the incorporation of key feedback and perspectives from the beginning. Notwithstanding this, the SSEP process is designed with flexibility in mind, allowing for refinement and adjustments as needed. This flexibility enables us to effectively respond to evolving circumstances based on lessons learned from the public consultation phase and refine the SSEP to achieve optimal outcomes.

In summary, the refinement phase of the SSEP process aims to improve the final SSEP by incorporating stakeholder feedback, lessons learned and best practices. This will be in addition to SSEP incorporating feedback throughout its development via stakeholder groups, however, refinement may incorporate additional considerations if required. As such, this part of the process is designed to ensure the final SSEP aligns with stakeholder interests and achieves the objectives of the SSEP.

7.4 Analysing stakeholder feedback

We greatly value input from our stakeholders as it plays a vital role in shaping and refining the plan.

We are committed to transparency and will clearly communicate which suggestions have been incorporated and the reasons why certain views cannot be implemented. We will explain to stakeholders how we will consider their feedback and how they can inform, influence and improve the plan, while adhering to the confidential nature of the work where appropriate.

We will analyse the feedback from our consultations alongside views from our stakeholder and governance forums. Feedback will be grouped into themes and presented back as part of the final documents. For example, for this consultation, the final SSEP methodology will explain how we have considered feedback and what action we have taken in response.

7.5 SEA Environmental Report Addendum

Once the consultation on the draft SSEP and accompanying SEA Environmental Report has been completed, the responses received will be considered and their implications for the SEA process evaluated.

Where appropriate, assessments in the SEA Environmental Report will be updated to reflect significant changes to the SSEP in light of responses received and new or updated evidence.

The updates to the assessments will be presented in the Environmental Report Addendum, made available alongside the updated plan. If no updates are required, this will be highlighted in the subsequent SEA Adoption Statement.

7.6 Report to Inform HRA Addendum

After the completion of consultation on the draft SSEP and accompanying Report to Inform HRA, responses received will be considered and their implications in relation to the HRA process evaluated.

Where appropriate at this stage, the Report to Inform HRA will be updated to reflect any significant changes to the SSEP made because of the representations received and any new or updated evidence.

Prior to adoption of SSEP by the UK government and Ofgem, the Competent Authority will then use the Report to Inform for their own formal Habitats Regulations Assessment, which will be consulted upon with statutory stakeholders including Natural England, Joint Nature Conservation Committee, Natural Resources Wales, NatureScot and the Northern Ireland Department of Agriculture, Environment and Rural Affairs.

8. Publish

8.1 Publish: chapter overview

This chapter explains what to expect in the final SSEP publication.

Main messages

- We will submit the final SSEP to the UK Energy Secretary, the Scottish and Welsh governments and the energy industry regulator Ofgem for their endorsement. We will also publish it on our website.
- The SSEP will be available in two formats: a digital PDF with interactive navigation, and a downloadable print version. Both formats will contain the same content, with the digital version including additional guidance for navigation.
- The SSEP will feature clear, readable design elements and concise, informative content. It will include an executive summary, context on the SSEP's purpose and its alignment with government strategies.
- The SSEP will incorporate graphs, charts and tables, as well as links to supporting documentation. A glossary will be included to make the document more accessible.
- An SEA Adoption Statement will be published alongside the SSEP, which will detail the SEA process, its influence on the SSEP, consultation feedback and monitoring processes.

We would like to know

- **Accessibility** - We continually look at ways to present information in a more accessible and engaging way. Is there anything we can do to make our future publications more accessible and interactive?

To share your views, please complete our consultation form:
https://forms.office.com/r/rLN34jFEaC

8.2 The final SSEP output

We will submit the final SSEP to the UK Energy Secretary, the Scottish and Welsh governments and the energy industry regulator Ofgem for their endorsement.

The SSEP 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. In addition, NESO will publish a data workbook, which will enable transparency and clarity for the key inputs into the SSEP modelling process.

To ensure the document is accessible for stakeholders, the SSEP will be published in two formats. The first will be a digital e-publication in PDF format with interactive navigation, while the second will be designed for downloading and printing. The content will be the same in both formats, with the digital version housing additional material to guide readers through using the publication's navigation.

Focusing on clarity and readability, the SSEP's design will feature legible fonts at an accessible size, contrasting colours, prominent signposting, appropriate word lengths and content segmentation, to make the document easy to access and understand.

The content itself will follow the same principles, written in a style that is informative and concise, communicating authoritative, strategic advice that is knowledgeable and transparent. All our advice will be supported by clear reasoning and, where necessary, our working assumptions explained and justified.

Throughout the document, we will use graphs, charts and tables to illustrate and expand upon important data and insights. Among these will be a map showing the zonal locations, capacities and timings of electricity and hydrogen generation and storage.

Elsewhere, the digital version will contain links to the documentation for the SEA and HRA, the previously published SSEP final methodology and in-depth supporting information as required. These will also be referenced in the print version of the SSEP, with guidance on how to access this additional material.

To support understanding of the SSEP, it will close with a glossary explaining technical and industry terminology. Important contact information, together with sources of other contextual information relating to the SSEP, will be signposted throughout.

The content items, and the format itself, may change as the SSEP develops. However, we endeavour to stick to the principles set out in this document as closely as possible.

8.3 SEA Adoption Statement

To accompany the published SSEP, an SEA Adoption Statement will be prepared, as required under Part 4 of the English and Welsh SEA Regulations and Part 3 of the Environmental Assessment (Scotland) Act 2005.

Reflecting the requirements of the SEA Regulations and Act, the SEA Adoption Statement will include:

- an overview of the process which has been undertaken for the SEA to date
- how the SEA has informed and influenced the development of the SSEP (including the consideration of reasonable alternatives)
- the consultation that has been undertaken as part of the SEA process and how the feedback has been considered
- a summary of proposed monitoring processes (expanded on through the preparation of a subsequent SEA Monitoring and Implementation Plan, which is described in appendix 9.

9. Appendices

9.1 Appendices overview

The appendices for the SSEP draft methodology expand on previous chapters with relevant contextual information, reasoning and references.

Each appendix is listed below, together with the chapter and page number it relates to in the publication.

For explanations of the technical language in the methodology, please refer to our glossary (p 151).

Number	Chapter	Appendix title
1	Foundations	Stakeholder approach
2	Foundations	Societal approach
3	Foundations	Other strategic plans and policies
4	Foundations	SSEP monitoring and evaluation
5	Foundations	Quality assurance
6.1	Prepare	Technologies considered
6.2	Prepare	Summary of external markets
7.1	Prepare	Identifying an appropriate spatial evaluation approach
7.2	Prepare	Documentation and communication of the spatial evaluation
7.3	Prepare	Identifying and selecting relevant spatial factors for spatial evaluation
7.4	Prepare	How spatial evaluation pillars and categories are considered in the spatial evaluation
8	Model	Robustness testing for sensitivities
9	Publish	SEA monitoring and implementation
10	N/A	Consultation questions

Appendix 1: Stakeholder approach

Engagement activities

We will:

- **Gain expert input into our modelling** engaging stakeholders with experience of spatial plans to inform the SSEP.
- **Meet statutory consultation requirements for the SEA and HRA** as outlined in the government guidance[40] for SEA legislation[11,12,13] and HRA legislation[14].
- **Challenge and review our plan pathways with experts** prioritising spatial elements across land and sea. We will compare trade-offs within the different pathways so that we can ensure our final pathway is robust and tested with stakeholders.
- **Gather specialised data from the stakeholder groups** which could inform and improve the quality of the plan. We will verify the robustness of the data.
- **Align with existing spatial plans,** working with spatial planning stakeholders to facilitate compatibility between the SSEP and other spatial plans, in particular those embedded in planning policy.
- **Have an agreed approach to coordinate sharing and exchange of information with spatial planning stakeholders** - To geospatially model the marine area in the SSEP, we are collaborating with The Crown Estate. By doing this, we will utilise their whole of seabed evidence base to enable us to access the best available data and align on where future offshore wind and other technologies should be located on a zonal basis. In addition to The Crown Estate's usual England and Wales remit, this will cover Scotland through collaboration with The Crown Estate Scotland and the Scottish Government.

Appendix 2: Societal approach

The general public

As part of our engagement planning, we are conducting societal research representative of GB by demographics and location. This is designed to reach a cross-section of those living in GB, to ensure that a broad spectrum of views is considered.

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[40] Ministry of Housing, Communities and Local Government, Ministry of Housing, Communities & Local Government (2018 to 2021) and Department for Levelling Up, Housing and Communities, Strategic environmental assessment and sustainability appraisal - https://www.gov.uk/guidance/strategic-environmental-assessment-and-sustainability-appraisal
Scottish Government, Environmental assessment - https://www.gov.scot/policies/environmental-assessment/
Welsh Government, Strategic Environmental Assessment - https://www.gov.wales/strategic-environmental-assessment

Our engagement with the general public will include:

- **Societal opinion survey** - We will invite a representative sample of society to take part in a GB-wide opinion poll to understand the views of different segments of society in different locations. The poll, which will be delivered by an independent organisation, will ask high level questions on the right balance of developing energy infrastructure based on topics such as financial cost, negative environmental impact, positive economic opportunities and local social value. This data collection will shape our decision-making process and create a context for all other engagement.
- **Focus groups** - We will hold focus groups to gather qualitative views. These focus groups will enable us to further explore and analyse the quantitative information in the opinion survey, ask specific questions and gain participants' views on the trade-offs of developing energy infrastructure. Where we find conflicting views or require a deeper understanding of responses from the survey – either society-wide or in certain parts of GB – we will use focus groups to investigate further.
- **Engagement campaigns** - Where appropriate, we will consider social media and other technologies to engage, inform and educate about the SSEP.

Societal forums

Although not considered as 'energy organisations' in the traditional sense, some societal interest groups are interested in the energy trilemma because it impacts or contributes to their purposes or goals. Such groups bring diverse perspectives to the conversation, so we will ensure our engagement with them represents a broad spectrum of economic, demographic and environmental interests across GB.

Our early work has indicated relevant groups are in the following societal sectors (figure 19):

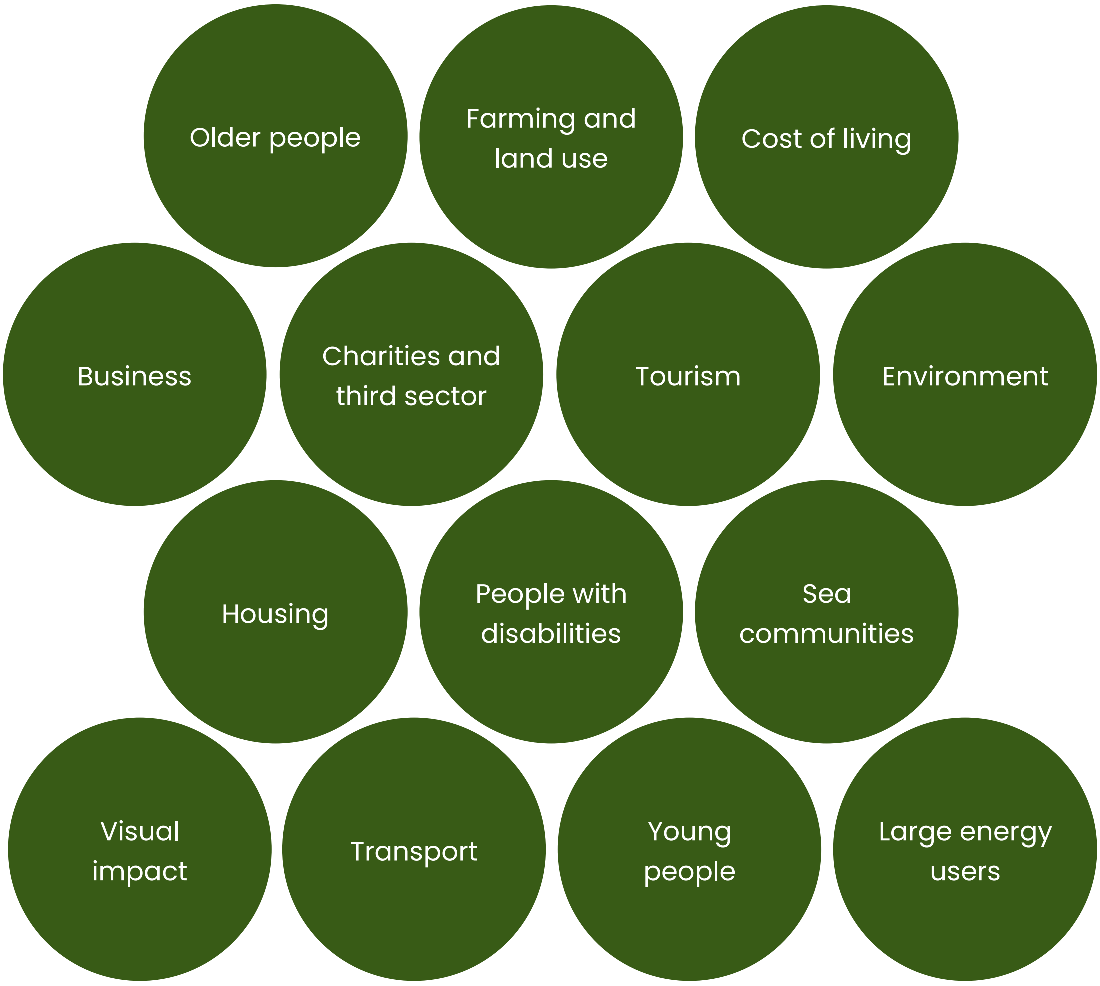

Figure 19: Overview of interest groups

These interest groups can support the SSEP's creation and direction, either through their unique perspectives on the energy sector or by representing a wide cross-section of GB communities who would not typically engage with more traditional engagement methods.

These groups all have an interest in the energy transition and experience it in difference ways, so it is important we give them a voice in the SSEP. We will seek to understand what they perceive to be of most value and consider how that should influence the development of the SSEP.

The following criteria will define the specific societal groups we engage with:

- They have participants/members across more than one geographical region.
- They are non-statutory.
- They are non-decision making.

- They have an interest in the future energy system.
- They have an influence in discussions of the future energy system.

The primary way we will engage with interest groups will be through societal forums, each focused on one of the societal sectors above. The purpose of the forums is to provide insight on the development of the SSEP and listen and act upon feedback to influence and to contribute to the evolution of the SSEP. Depending on how these discussions and the SSEP evolve, we may need to meet certain groups more frequently than others.

Representatives of stakeholders on societal forums will sit on the Societal Interest Working Group, which forms part of the SSEP governance structure.

Our initial view is that the above societal sectors will provide the broad spectrum of societal views that will help achieve the aims of the SSEP. However, we will continue to monitor the success of our engagement activity. The structure of our engagement with societal groups may evolve during the preparation of the SSEP. Additionally, we will look for efficiencies for us and our stakeholders by integrating or combining our engagement with other NESO or industry projects and bodies where appropriate.

Campaign groups

Society, and in particular local communities, often have strong views on the development of specific infrastructure projects. While the SSEP will not consider the benefits or impacts of individual energy projects, we want to engage with people who take an active role in influencing the development of projects across GB.

Through campaign groups we can reach some of the most active groups in GB who will engage in the conversation and share feedback to support the development of the SSEP. A consistent issue raised by campaign groups is that they have not been engaged early enough in the process to have strategic influence. We will engage with a selection of campaign groups so they can voice their concerns and positive arguments for consideration in the SSEP’s development.

These groups will be a mixture of organisations that support or challenge infrastructure projects. They will include groups for or against certain energy sources being developed, as well as groups advocating the energy transition.

Our engagement will include established groups, plus new groups we expect to be formed through the energy transition. Some of these groups are geographically based and have a local interest in where infrastructure is placed, while others support or oppose a particular technology.

We will also engage advocate groups with a strong interest in GB adopting new, sustainable and secure energy sources and which support investment that creates jobs and wealth. Only by hearing a balanced view of campaigning opinions will we be able to reach an accurate understanding of these parts of society.

Due to the nature of the campaign groups, we are not expecting to reach a consensus. For example, a campaign group may be against a particular technology type, while another campaign group will be advocating for it. However, we will listen to these different views, considering them alongside the other stakeholder and technical data as we make decisions. The views of all of society are important to the development of the SSEP, but there are trade-offs and difficult decisions that need to be made. These will be explained in an open and transparent way.

Engagement methods

We plan to engage a selection of these groups via online forums, organised based on the needs of the SSEP. At these forums, we will share updates on our plans and request feedback in both written and verbal form during and after these sessions.

As with the societal groups, we will engage with a selection of campaign groups to ensure a broad representation of perspectives. However, we will continue to monitor the engagement and may amend the groups and groupings during the life cycle of the SSEP. We will also look for efficiencies for both NESO and our stakeholders by combining our engagement with other NESO or industry projects and bodies where appropriate.

Politicians and government

Political representatives and groups are important to aid society's understanding of infrastructure development and articulate local and regional perspectives.

Government already has a formal role in the SSEP, so this section of our engagement plan will focus more on hearing the opinions of politicians who do not hold national government office, but do represent society at regional, constituency or local government levels.

As part of our strategy, we will engage with politicians or their representatives at different levels to ensure they have the important facts available to them and their views, and the views of those they represent, are understood. Hearing from politicians with an expertise or high interest in the energy sector, as well as politicians engaged in regional and local matters, will help ensure a full view of opinions.

We will engage with politicians and government through a series of events such as meetings, presentations, and webinars.

Host areas

Host areas are the areas of GB identified in the SSEP as being best placed for energy infrastructure development. While all parts of GB will be considered, it is likely some areas will see clusters of projects, a high number of projects or have energy infrastructure projects for the first time.

Engagement with host areas will build on our early engagement with regional community representatives, where we will share early outputs from our work and engage in discussions to better understand regional sentiment towards new energy infrastructure. The SSEP will provide the host areas with their first understanding of proposed energy infrastructure in their areas. To support communities, we will develop an engagement framework that will help these areas comprehend the process, guide them on how to participate and influence and ensure ongoing engagement throughout the lifecycle of the developments.

The SSEP will use the information and intelligence it has received from all its sources to understand which areas would most benefit from this engagement. This could include other engagement carried out by NESO and its other strategic projects such as the Regional Energy Strategic Plans (RESP). Because of the nature of the process, we will only be able to confirm these areas and engage with them further into the SSEP's development.

Given the likelihood that many small areas (in the context of a strategic GB plan) will seek this engagement, we plan to work with local, national and regional representatives and stakeholders to prioritise resources to areas of greatest need.

Once this has taken place, we will establish an engagement structure with host areas for them to understand the process, how decisions have been made, and how they can influence developments in their area. The SSEP will establish structures, or work with the networks and structures already in existence, to enable conversations across energy and societal stakeholder groups that could include influencing the SSEP, future developments after the SSEP has been published and future iterations of the SSEP.

As a strategic plan, the SSEP will not be able to give certainty to communities about what projects will be developed and specifically where. However, it will explain GB's likely needs and what this will likely mean for a geographic area.

Our experience from previous infrastructure development projects from different sectors tells us there are key themes host areas like to see throughout the development life cycle. These include:

- **Clarity of developments and who is responsible for their development** - As mentioned above, the SSEP will not be able to give certainty to communities about which projects will be developed in their area. However, as the likely first contact with these communities, the SSEP will develop channels of communications with areas (outlined below).
- **Codesign of the developments** - Host communities often say they would like a voice in the shaping of the proposals. The SSEP will consider the views of society at a strategic level and create a structured conversation for society and developers to build upon. However, this will rely upon developers and community stakeholders actively engaging in the process.
- **An opportunity to outline the trade-offs** – Those which are acceptable to local communities.

We plan to establish two types of forums in areas identified as the best locations for energy infrastructure. The forums will bring together societal representatives who have an interest or influence in the development of projects. The purpose will be to:

- communicate the factors that resulted in these host areas being selected
- prepare host areas to actively contribute to and participate in our consultation
- establish a framework for host areas to understand and engage with the SSEP and the projects that will follow

- give host areas an opportunity to feedback on how plans could be made more acceptable and valuable to them

The forums are:

Host Area - Plans and Projects Forum

A regional forum where political, societal, developer and community stakeholders can hear about and discuss plans in a structured, controlled environment as they progress through their development life cycle.

These will be created where there is a need based on the plans for energy infrastructure or where this is requested by local representatives.

Host Area – Social Value Forum

A forum where political, societal, developer and community representatives can hear about and discuss the local social value benefits will be delivered as well as trade-offs that would make plans and projects acceptable to local communities.

NESO and other energy organisations are developing other strategic plans for GB's energy transition. Ensuring clarity and understanding around these is essential when engaging with communities, so our strategy will consider all these and focus on delivering the best outcome for stakeholders.

Overview of process

The outputs of engagements with each group will differ. For that reason, we will run separate sessions.

Who	Society	Politicians & and government	Interest groups	Campaign groups	Host areas
Who is involved in this group	Society as a whole – which encompasses all people across Great Britain	Parliament, politicians and representatives	Representatives of sectors that represent a societal interest	People who proactively campaign about energy and energy infrastructure and their impacts on the world and its population	Areas where development of infrastructure is optimal
Why we are speaking to them	We want to hear from a cross-section of society to see if there are differences in their views on SSEP	For them to represent their constituents and political views in feedback. We need to provide politicians with the right information, relevant to them, so they can influence the SSEP and support and defend plans as part of the role with constituents	These groups have some direct interest in energy transformation and by proactively engaging with them we hope to hear their view and give them a voice in the debate	We would like to engage with these groups to hear their point of view	By engaging we can explain the reasoning for decisions made and get further local community feedback on plans and what they would like to see developed. Establish a channel and method of communications

Table 6: Overview of engagement with stakeholders

Who	Society	Politicians & and government	Interest groups	Campaign groups	Host areas
What we are telling this group	Information on the plans – the need, the benefits, timelines	Information on the plans, with particular emphasis on security, economic and environmental considerations	Information on the plans, relevant to their interest – the need, the benefits, timelines	General overview of information about the SSEP and how they can shape it	The information of how the SSEP developed. What options they have to cocreate and influence
What we would like to know	Are there any differences in how different parts of society value the elements that SSEP could have an impact on	Get their views as part of feedback. Do they have all the tools they need to engage with constituents? Do they have local vs. UK wide objections/comments?	Sentiment and overall feedback, which will shape our plans. Do they have any concerns relevant to their sector that we should know about?	Sentiment and overall feedback, which will shape our plans	What trade-offs are acceptable? How do they feel about the various costs and benefits offered?
How we capture feedback	Quantitative survey, giving statistically relevant cross-section of the country: Qualitative focus group sessions Public consultation	Feedback during the engagements or in writing: Public consultation	Attendees will feed back in the forum sessions: Pre-engagements to segment interest groups Public consultation	Attendees will feedback in the forum sessions: Public consultation	Attendees will feedback in the forum sessions: Public consultation

Table 6: Overview of engagement with stakeholders

Capturing feedback: How we will input societal feedback into our plans

The views and feedback we receive from societal stakeholders will be used to populate and test the metrics used in the spatial evaluation, described in detail in appendix 7.4. The focus will be on how societal groups perceive financial cost to consumers, environmental impacts, economic impacts and regional social value.

We anticipate that feedback will be wide and varied and individual areas and groups will have their own unique interests, points of view and values. It will be highly unlikely for there to be a single 'societal view' from which the SSEP can be developed. We will, however, take all feedback into consideration and use that to inform our decision-making.

There will be opportunities to input and feedback at different stages of the development of the SSEP. These will include:

- this methodology document, which is being consulted on
- a GB-wide opinion survey
- the societal interest groups and campaign groups, described in section 2.5.2 and in this appendix
- a public consultation held on the draft SSEP (more information in the consult chapter), with stakeholder information provided through webinars, information materials and images

This public feedback will be considered alongside feedback from other stakeholders, plus environmental, technical and spatial use considerations.

To create transparency around the process, the SSEP will publish a summary of the feedback received. It will include supporting evidence of how the plan has incorporated feedback and reasons preventing specific themes of feedback being acted upon.

Once the SSEP has been published, we will continue engagement with the selected host areas as the outputs are understood and delivered by other stakeholders. The structures discussed above will enable host areas to feedback on the parts of the plan that will impact them, influencing how it evolves. The SSEP programme will continue to engage with all groups throughout the period of planning at regular intervals.

Appendix 3: Other strategic plans and policies

A brief overview of the strategic plans and policies is provided below:

- **The National Planning Policy Framework**, published in December 2023, outlines the government planning policies for England and includes a framework for locally prepared plans for housing and other developments in a sustainable manner.

- **National Planning Framework 4 (NPF4)**, published in February 2023, is a national spatial strategy for Scotland tied together with a set of national planning policies. The plan sets out spatial principles, regional priorities and national developments.
- **Planning Policy Wales (PPW)**, published in February 2024, provides an overview of the land use planning policies of the Welsh Government. It considers how the planning system contributes to the delivery of sustainable development and improves the social, economic, environmental and cultural wellbeing of Wales.
- **Sectoral Marine Plan (SMP) for Offshore Wind**, published in 2020, aims to identify sustainable plan options for the future development of commercial-scale offshore wind energy in Scotland, including deep water wind technologies, and covers both Scottish inshore and offshore waters.
- **The Land Use Framework**, which will be published by Defra, will aim to support the delivery of multifunctional, resilient and productive landscapes in England to meet the ambitious targets for enhancing the environment, delivering Net Zero and supporting food security.
- **The UK Marine Policy Statement,** published in March 2011, is a framework for preparing marine plans and considering decisions impacting the marine environment. It will contribute to the progress of sustainable development in the UK marine area and will be integral to the development of the SSEP.
- **The Marine (Scotland) Act 2010,** established a new legislative and management framework for the marine environment, allowing the competing demands on the sea to be managed in a sustainable way across all of Scotland's seas.
- **Scotland's National Marine Plan (2015)** provides a comprehensive overarching framework for all marine activity in Scottish seas. Setting out a policy framework to help determine if a new or existing marine activity is environmentally or economically sustainable and suitable for the area and serves as the primary guide to decision-making on the use of marine space and resources in Scotland.
- **Welsh National Marine Plan (2019**) sets out the Welsh Government policy for the next 20 years for the sustainable use of Welsh seas.

These planning frameworks, government programmes and policy statements must be considered while developing and understanding the spatial constraints. Where possible, we will seek consistency and compatibility between existing spatial plans and policies. Further details on the principles for alignment are outlined in the strategic approach, technical engineering requirements and other spatial uses sections.

Appendix 4: SSEP monitoring and evaluation

In addition to NESO assurance, we will develop a monitoring and evaluation process with DESNZ and Ofgem. Monitoring and evaluation activities will consist of the following:

Monitoring

- Oversight of progress and the key risks to SSEP delivery, primarily achieved through existing reporting and other core processes such as risk management.

Evaluation

- **Identifying and synthesising process lessons** from the design and conduct of the analysis which produces the SSEP, especially important due to the programme's novel nature. We will be responsible for this evaluation and will use it to inform future iterations of the SSEP and other analysis programmes and projects.
- **Evaluating objectives** to understand the outcome or impact of the SSEP against the shared goals in the Commission and whether changes should be made to future iterations of the SSEP to better support those objectives. This will be conducted following the final SSEP publication.

The AEAG, and subsequently the SSEP Committee, will receive the outcomes of the monitoring and evaluation process. The SSEP Committee may authorise changes in delivery strategy because of the findings.

Appendix 5: Quality assurance

Due to its complexity and the potential impact of the results, the SSEP will be subject to the high levels of assurance across all aspects of the programme. This will encompass both programme delivery and technical assurance.

The former covers all aspects of how the SSEP programme is set up and delivered. The latter covers the design, implementation, and usage of the modelling process, drawing principally upon the guidance in the HM Aqua Book[41].

[41] HM Treasury, The Aqua Book: guidance on producing quality analysis (2015) - https://www.gov.uk/government/publications/the-aqua-book-guidance-on-producing-quality-analysis-for-government

The two processes have differing roles and requirements and so are described separately here. However, since there are dependencies between them, both will be covered in a single integrated assurance plan and coordinated collectively.

Our assurance will be conducted using the NESO 'three lines of defence' structure:

- First line of defence - internal programme activity to ensure plans and processes are of a high standard, kept up to date and are adhered to.
- Second line of defence - oversight from the NESO Strategic Energy Planning (SEP) portfolio and other NESO subject matter experts.
- Third line of defence: oversight from an independent third party.

Relationship with other functions

The design and execution of the integrated assurance plan will interface with the SSEP governance model. Assurance activity will form a key part of the programme delivery strategy and activities will be captured in the master schedule, supported by a robust monitoring and evaluation process.

References

The SSEP integrated assurance fully meets the requirements of the following:

- UK Government Functional Standards 002 – Project Delivery[42]
- Government Functional Standards 010 – Analysis[43]
- HM Treasury Aqua Book – Guidance on producing quality analysis[41]
- UK Government Orange Book – Management of Risk – Principles and Concepts[44]
- HM Treasury Green Book – Appraisal and evaluation in central government[45]
- HM Treasury Magenta Book – Guidance on evaluation[46]
- Infrastructure and Projects Authority - Assurance review toolkit[47]

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[42] Infrastructure and Projects Authority and Cabinet Office, Government Functional Standard GovS 002: Project Delivery (2018) - https://www.gov.uk/government/publications/project-delivery-functional-standard
[43] Government Analysis Function, Government Functional Standard GovS 010: Analysis (2021) - https://www.gov.uk/government/publications/government-analysis-functional-standard--2
[44] Government Finance Function and HM Treasury, Orange Book (2013) - https://www.gov.uk/government/publications/orange-book
[45] HM Treasury, The Green Book (2022) - https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government/the-green-book-2020
[46] HM Treasury and Evaluation Task Force, The Magenta Book (2011) - https://www.gov.uk/government/publications/the-magenta-book
[47] Infrastructure and Projects Authority and Cabinet Office, Infrastructure and Projects Authority: assurance review toolkit (July 2021) - https://www.gov.uk/government/collections/infrastructure-and-projects-authority-assurance-review-toolkit

- Infrastructure and Projects Authority - Implementing integrated assurance for major projects[48]
- DESNZ QA College[49]

Programme delivery assurance

First line assurance will be delivered by the SSEP programme team, which will use key programme processes effectively. These include:

- verification processes are designed in accordance with NESO and/or UK Government policy requirements, including:
  - data management
  - risk, assumption, issues, dependencies (RAID)
  - cost control
  - lessons learnt
  - procurement
- health checks to assess maturity across all key functions, conducted biannually as a minimum
- deep dives into areas identified as a concern or identified as treatment plans for risks or issues
- quality checks and review of all products and outputs

Second line assurance will be delivered from outside of the programme team, by other bodies within NESO. The wider SEP Portfolio Office, which is responsible for managing programmes across our strategic energy planning initiatives, will lead and provide assurance of:

- programme controls
- programme reporting
- programme maturity
- status of documents
- recruiting and qualifications
- cost control

This will ensure confidence controls are effective and the SSEP is delivering in line with expectations and agreed specifications.

[48] Infrastructure and Projects Authority and Cabinet Office, Implementing integrated assurance for major projects (June 2011) - https://www.gov.uk/government/publications/implementing-integrated-assurance-for-major-projects

[49] Department for Energy Security and Net Zero, Energy security and net zero modelling: Quality Assurance (QA) tools and guidance (February 2024) - https://www.gov.uk/government/publications/energy-security-and-net-zero-modelling-quality-assurance-qa-tools-and-guidance

As per our governance structure, there will be specified milestones in the programme schedule:

- stage gates in the programme life cycle with defined entry and exit criteria
- assurance checks prior to the release of key deliverables, including quality control of these deliverables

The SEP Portfolio Office has the option to conduct deep dives into areas identified as a concern or develop treatment plans for identified risks or issues. Other NESO functions, such as Internal Audit, may also support.

Third line assurance will be provided by an independent third party, competitively procured, which will assure the programme is being managed as part of the SEP portfolio.

Technical assurance

Technical assurance will be delivered through the three lines of defence structure, providing external peer review and audit, as per the Aqua Book guidance for programmes with the highest degree of risk and complexity.

First line assurance will maintain key documents such as a centralised master data and assumptions list (MDAL). Some of these documents and processes will be assured via programme delivery assurance.

Second line assurance will utilise internal subject matter experts in our assurance team. NESO's Chief Economist will provide process oversight, including chairing our Analytical Evidence Advisory Group (AEAG). This is the external governance forum with UK, Scottish and Welsh governments and Ofgem that oversees the analytical and modelling process, including SSEP quality assurance and reporting. The Chief Economist's office will also review our economic modelling assumptions.

Third line assurance will engage an independent third party. Competitively procured on behalf of the SEP portfolio, this specialist provider will perform an assurance role on SSEP processes, modelling and the resulting analysis. Areas externally assured will be the draft SSEP consultation, economic and spatial modelling (including model verification and validation) and spatial evaluation data.

Appendix 6: Economic modelling assumptions

Appendix 6.1 Technologies considered

In-scope technologies for spatial optimisation

Solar

The SEP will spatially optimise and assess network connected solar energy. Solar energy is a key part of DESNZ's strategy to enhance the UK's energy security and net zero ambitions, and solar will play an increasing role in this. We will consider rooftop solar, mid-scale solar and grid-scale solar separately in SSEP modelling. Geospatially modelling rooftop solar is challenging as it is embedded in the distribution network and interacts with domestic electricity demand. The SSEP will consider rooftop solar in the economic modelling background.

Offshore wind

The SSEP will spatially optimise offshore wind, both fixed and floating, through spatial evaluation. The UK government will significantly increase the deployment of offshore wind to meet our Clean Power 2030 and net zero targets. The Climate Change Committee concluded that the number of new offshore wind installations each year would need to be trebled if the UK was going to meet its net zero target.

Nuclear

New nuclear will play a role in helping the UK achieve energy security and clean power, while securing thousands of good, skilled jobs. The SSEP will spatially optimise nuclear power, both traditional and small modular reactors. Siting of nuclear reactors is currently determined by the National Policy Statement (NPS) EN-6, which identifies pre-assessed nuclear sites for new nuclear power stations expected to be deployed by the end of 2025.

The UK government is developing new criteria for siting nuclear power post-2025 through a new NPS EN-7 to provide more flexibility in the site selection process, including small modular reactors (SMRs) and advanced modular reactors (AMRs) alongside traditional nuclear plants. Previously designated sites identified in EN-6 will be taken into consideration in the next policy statement. The proposed changes in EN-7 aim to provide flexibility while ensuring nuclear power stations are appropriately constrained and sited in suitable locations (considering safety, environmental impact, access to water, waste management and so on).

Onshore wind

Onshore wind is a key part of the GB's energy mix and has a role to play in reaching the UK's net zero target. In 2024, the UK government published a policy statement on onshore wind, revising planning policy to place it on the same footing as other energy developments. It has committed to consulting on bringing large-scale onshore wind into the Nationally Significant Infrastructure Project regime, followed by a revised National Policy Statement for quicker determination of projects. The SSEP will therefore spatially optimise onshore wind and assess against impacts on environmental, society and other spatial uses.

Hydrogen

The SSEP will consider hydrogen production, hydrogen to power, electrolysers, transport, storage and hydrogen generators.

Hydrogen could significantly shape the future of decarbonisation of the energy system and can provide flexible energy. Hydrogen electrolysers could form a large source of demand that could operate flexibly given the right incentives and could help balance the energy system and manage constraints. It is also expected to play an important role in longer-duration energy storage and could support decarbonisation of sectors that are hard to electrify. The role of hydrogen in decarbonising industry, transport and heat has not yet been firmly established. Key policy decisions on the future of hydrogen are outstanding.

The hydrogen strategy published by the government in 2021 (updated in 2023) highlights opportunities around hydrogen for the UK based on its geography, geology, infrastructure and capabilities. The SSEP can provide evidence on spatial opportunities for hydrogen and possible policy options to inform government decision-making.

Energy storage

We will spatially optimise network connected short-term storage and long-duration energy storage (LDES) in the SSEP. Energy storage helps offset the hour-to-hour variability of renewables and facilitate the electrification of transport and heat. Electricity storage can help us balance the system at a lower cost and maximise the usable output from intermittent renewable generation. Use of storage technology will be essential for meeting the government's decarbonisation ambitions. However, uncertainty remains on the form that energy storage will take.

The government is developing a policy framework to enable investment for long-duration storage technologies beyond hydrogen and CCS and has recently published the consultation response designing the policy framework to enable investment in long-duration energy storage. Electricity storage can be provided by a range of technologies like liquid air electricity storage (LAES), compressed air electricity storage and flow batteries, which are still nascent technologies. Most LDES technologies are still considered nascent. Pumped hydropower is one of the most widely used grid-scale storage technologies worldwide and has unique geographical and geological requirements and long lifetime of assets.

Power and hydrogen production with carbon capture, utilisation and storage (CCUS)

The SSEP will spatially optimise hydrogen production and power with CCUS. CCUS will play an important role in providing flexibility to the energy system alongside achieving wider

2050 net zero targets. Beyond 2030, commercial deployment of CCUS is expected to increase to support the Climate Change Committee's Sixth Carbon Budget.

Bioenergy with carbon capture and storage (BECCS)

The SSEP will spatially optimise both retrofit as well as new BECCS infrastructure. BECCS is important for delivering the UK's greenhouse gas removal targets. The net zero strategy set an ambition to deploy at least 5 Mt CO_2/yr of greenhouse gas removal methods by 2030, rising to 23 MtCO_2/yr by 2035.

Interconnectors

Interconnectors can play an important role in providing supply side flexibility by allowing greater integration and coordination of electricity supply across borders with our European neighbours.

As we move towards an energy system more reliant on intermittent sources of generation, interconnectors provide the capacity to import and export energy to help balance the energy system during periods of oversupply or undersupply of energy generation.

Delivering interconnector projects requires countries on both sides to be confident on benefits for consumers, which will be driven by price differentials between both UK and European markets. The UK government's policy ambitions on interconnectors are still evolving. The SSEP modelling and analysis can provide the evidence on potential policy options to inform decision-making by testing multiple scenarios to outline implications of different policy decisions.

Applying the spatial evaluation assessment for interconnector expansion in neighbouring countries will be challenging. The SSEP will therefore spatially optimise the landing points for interconnectors in GB to provide more confidence on the landing locations in GB.

Unabated gas

The SSEP will spatially optimise generation of unabated gas-fired generation. Unabated gas-fired generation is used to provide flexibility and resilience to the energy system. To ensure security of electricity supply, unabated gas capacity will continue to be needed on the system throughout the 2030s, until low-carbon, long-duration flexible technologies have been deployed at scale. There is a need to carefully consider the phase out of gas in a decarbonised energy system beyond 2030, to account for a range of future weather projections where there might be lower-than-expected supply from other sources and the availability of low-carbon alternatives.

Technologies out of scope for spatial optimisation

Small-scale flexible electricity demand

Certain small-scale demand such as electric vehicle storage, smart heat pumps, smart white goods and domestic ion batteries is expected to provide flexible electricity demand in the future. For example, vehicle-to-grid (V2G) technology would deliver power back to the grid, turning EVs into energy storage systems. V2G chargers are small scale. It would be challenging to aggregate and assess them at a strategic level. The SSEP is a strategic plan and therefore would not be able to assess accurately or effectively the location of domestic small-scale flexible demand zonally. We will not be spatially optimising small scale flexible demand such as EV storage as these technologies can be widespread and deployed by consumers anywhere in GB, which brings challenges to effective geospatial modelling. EV storage will be included in the background in the economic modelling. Heat networks will also not be spatially optimised. Heating demand from electricity or hydrogen will be considered in the overall demand projections.

Wave and tidal

Wave and tidal energy are emerging technologies and volumes in development are currently very low. The cost of wave and tidal energy is bespoke to projects and is challenging to consider at a plan level. For this reason, the SSEP will not spatially optimise the location of wave and tidal energy projects in the first iteration. As policy and technology advances, wave and tidal energy could be considered in future iterations of the SSEP.

Energy from waste (EfW)

The principal purpose of EfW plants is to reduce the amount of waste going into landfill and recover energy as electricity, heat or fuel. The government's Net Zero Strategy outlines that emissions from EfW represent a significant part of residual emissions from the power sector. EfW can, however, reduce net emissions compared to disposal in landfill. Utilising the waste heat produced from EfW facilities increases their efficiency and displaces the use of gas for heating, further reducing net emissions. Due to the distinctive drivers for EfW, the SSEP will not be spatially optimising the location of EfW facilities.

Appendix 6.2: Summary of external markets

The choices in how to model European markets can be summarised in the logic tree in figure 20. The advantages and risks of each option are explored in table 7. The options in the table represent broad approaches, although other options could be considered, such as different methods for deriving the responsive price curves or varying the degree of freedom on the expansion. It may also be that different groups of markets in Europe will be modelled using different approaches, most likely based on the proximity to GB.

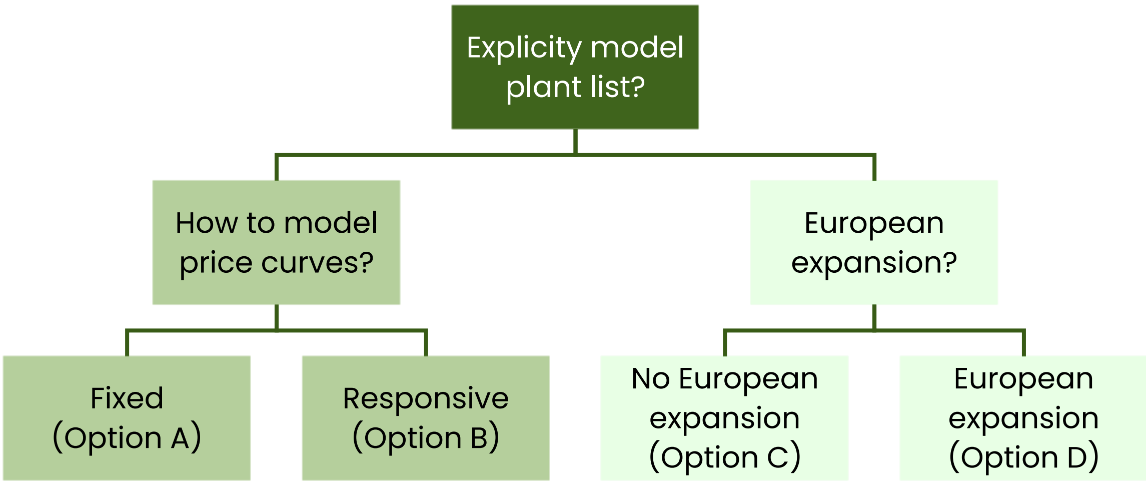

Figure 20: Choices in how to model European Market

	Option A	Option B	Option C	Option D
Summary	**Fixed prices**	**Responsive prices**	**Plant list modelled with <u>no</u> expansion allowed**	**Plant list modelled with expansion allowed**
Details	Have a set value for the market price at every hour.	Have a set value for the market price at every hour that can vary depending on interconnector flows to and from the market.	Plant lists are explicitly modelled using the FES 2024 pathway. Plant lists are explicitly modelled using the FES 2024 pathways. No expansion beyond the plant list.	Same as C but expansion is allowed. The baseline used for European markets could be the FES 2024 pathways or a reduced version of them. The baseline used for European markets could be the FES 2024 pathways or a reduced version of them.
Advantages	Reduced run times for the Long-Term phase (compared to explicitly running the plant list). Optimising GB is the sole objective, PLEXOS does not optimise any European markets in the Long-Term phase.	Same as A. Improved modelling of European prices whilst still being simple to run.	European market prices derived from simulation. Prices can react to scenarios and sensitivities on operational parameters, but not on capex assumptions. Can directly model emission constraints for Europe.	Same as C. Europe can build new plants as a reaction to changes in GB market and with different scenarios/sensitivities. Modelling will consistently apply costs/uncertainties for items which have insignificant geographical variation.

Table 7: Table on choices on options to model European markets

	Option A	Option B	Option C	Option D
Summary	**Fixed prices**	**Responsive prices**	**Plant list modelled with no expansion allowed**	**Plant list modelled with expansion allowed**
Risks	Still requires running a Short-Term phase to get the output, which would need re-running for different scenarios (and potentially sensitivities). Interactions with European markets realistic. Cannot directly model emissions constraints for Europe.	Same risks as A. Method of getting responsive prices needs to be confirmed.	Increased run time and problem size. PLEXOS optimises GB plus these European markets, leading to optimal solutions for the whole system, which are potentially sub-optimal from a GB perspective. European data is limited. Security of Supply could be a concern for GB if results are dependent on new build in European markets and exporting to GB. European assumptions may not be as accurate as GB, for example in respect to flexible demand, hydrogen, transmission boundaries, etc. External markets further afield will still need to be calculated (if they are using fixed prices, they will still need Short-Term runs to be performed).	Same as C, but a larger problem size. Political alignment may be needed for an efficient European-wide solution. Expansion has no geospatial analysis. Outcome of SSEP reliant on limited European dataset.

Table 7: Table on choices on options to model European markets

Appendix 7: Development of the spatial evaluation approach

Appendix 7.1 Identifying an appropriate spatial evaluation approach

Various options for evaluating spatial constraints and opportunities were considered (table 8) along with a brief description of each option. The criteria (figure 22, appendix 7.3) are informed by government guidance and a literature review of examples integrating environmental, societal and/or technical factors into decision-making processes were used to identify these options. When identifying an appropriate spatial evaluation approach, no examples of other organisations or countries preparing a strategic spatial energy plan across both land and sea were located via a desktop search and therefore, no direct comparative resources were available.

The sources reviewed to inform development of the spatial evaluation approach were:

- Government resource - HM Treasury The Green Book (2022)[45]
- Government resource - Multi-Criteria Analysis – a manual (2009)[50]
- Government resource - Supplementary guidance on Multi-Criteria Decision Analysis (2024)[51]
- Academic resource - Project 11: Assessing Energy Pathway Impacts in the UK – Microeconomic Assessment Through Spatially Disaggregated Integrated Assessment Modelling | UKERC | The UK Energy Research Centre[52]
- Academic resource - Exeter University LEEP''s NEVO model (2018)[53]
- Sector guidance - The Crown Estate's Resource and Constraints Assessment for Offshore Wind (2019)[54]
- Case studies of framework applications

[50] Ministry of Housing, Communities & Local Government (2018 to 2021), Multi-criteria analysis manual for making government policy (January 2009) – https://www.gov.uk/government/publications/multi-criteria-analysis-manual-for-making-government-policy
[51] Department for Energy Security and Net Zero and HM Treasury, Green Book supplementary guidance: use of Multi-Criteria Decision Analysis (2024) https://www.gov.uk/government/publications/green-book-supplementary-guidance-use-of-multi-criteria-decision-analysis
[52] The UK Energy Research Centre, Project 11: Assessing Energy Pathway Impacts in the UK – Microeconomic Assessment Through Spatially Disaggregated Integrated Assessment Modelling - https://ukerc.ac.uk/project/assessing-energy-pathway-impacts-in-the-uk-microeconomic-assessment-through-spatially-disaggregated-integrated-assessment-modelling/
[53] University of Exeter, Natural Environment Valuation Online tool (NEVO) - https://www.exeter.ac.uk/research/leep/researchimpact/current-projects/nevo/
[54] The Crown Estate, Offshore Wind Leasing Round 4, Resource and Constraints Assessment for Offshore Wind: Methodology Report (September 2019) - https://www.thecrownestate.co.uk/media/3331/tce-r4-resource-and-constraints-assessment-methodology-report.pdf

Framework Type	Description	Example
Spatial cost-benefit framework	Spatial cost-benefit modelling tools to integrate the analysis of prospective UK energy pathways with considerations relating to the value of the environment and society. Covers both integrated assessment models and independent spatial cost-benefit models for environment and society.	UK ERC, ADVENT, Assessing Energy Pathway Impacts in the UK – Microeconomic Assessment Through Spatially Disaggregated Integrated Assessment Modelling.
MCA (multi-criteria analysis)	Multi-criteria analysis (MCA) establishes preferences between options against measurable criteria using simple scoring and weighting.	DfT (2011). Detailed guidance on social and distributional impacts of transport interventions.
MCDA (multi-criteria decision analysis)	Multi-criteria decision analysis (MCDA) is a form of MCA but with a stronger emphasis on an explicit process for scoring and weighting using stakeholders and experts.	The Crown Estate, Site Selection Methodology, Leasing Rounds 4 and 5.
Impact-based scoring	Impact-based qualitative scoring look to assess and score the potential impacts of different options on environmental and community receptors. An options scorecard can be used to assess impacts based on relevant questions.	Natural England EBN (Environmental Benefits for Nature), 2021.
Constraints mapping with BRAG rating	Spatial constraints mapping seeks to provide an assessment based on avoiding significant environmental, societal and technical spatial constraints. Outputs are qualitative only and based on a ranking system (back-red-amber-green (BRAG) or similar).	ESO, Holistic Network Design (HND) and HND Follow-up Exercise (HNDFUE).

Table 8: List of framework options considered

Each of the options was reviewed in detail. To help with decision-making, a comparison of how each option performed relative to each of the criteria was conducted and performance ranked on a broad scale ranging from highly negative to highly positive.

	Robustness and transparency of approach	Relevance	Resources and data to implement	Acceptability	Applicability in SSEP process
Spatial cost-benefit	++	+	--	?	+ (Env) - (Community)
Multi - criteria analysis	+	++	++	+	++
Multi - criteria decision analysis	++	++	-	++	++
Impact based qualitative	+	+	+	-	--
Constraints mapping with BRAG ratings	-	+	+	-	--

Key:

--	Highly Negative	-	Slightly Negative	?	Unknown/neutral
+	Slightly Positive	++	Highly Positive		

Figure 21: Comparative matrix of framework option performance against criteria

Key assessment outcomes of each option

	Advantages	Limitations	Overall assessment
Spatial cost-benefit framework	Consistent with HM Treasury Green Book and (if feasible) would be able to integrate environmental costs and benefits with energy economic modelling.	Models tend to focus on limited set of environmental impacts. Non-monetised impacts particularly societal would be missed. Significant resources required to develop appropriate models.	Not recommended for first iteration of the SSEP but longer-term potential for consideration.
Multi-criteria analysis	One of most used approaches, can integrate economic, societal and environmental data, quantitative and qualitative. Simple to apply, also very applicable for use in GIS tools.	Lack of transparency around weighting. In its simplest form not recommended by HM Treasury Green Book.	Highly recommended if a modified approach to weighting and criteria selection is introduced.
Multi-criteria decision analysis	Like MCA, but more robust due to approach to weighting used e.g., swing weighting or Analytical Hierarchical Processing (AHP). HM Treasury Green Book recognises MCDA as suitable for where impacts cannot be easily monetised.	Requires significant time and resources for weighting and scoring process. Swing weighting and AHP ultimately are based on expert judgement.	Theoretically recommended if time available for AHP/ swing weighting. However, extensive time and resources required.
Impact based qualitative	Aligns with HM Treasury Green Book as defines impact pathways for environmental and societal outcomes that can be used to assess significance of impact.	Best suited to specific options appraisal where impacts can be qualitatively assessed to provide a comparison against each option.	Not recommended as more targeted to an options appraisal stage and does not provide the required spatial information.
Spatial constraints mapping with BRAG ratings	The approach is based on consistent information using publicly available environment and community spatial data sets.	The BRAG requires subjective judgement for the assessment process which makes this less transparent and replicable.	Not recommended as BRAG ratings can lack transparency and outputs not well aligned with SSEP needs.

Table 9: Summary of assessment of framework options

The selected spatial evaluation approach

Out of the options assessed, the multi-criteria analysis (MCA) emerged as the most favourable option, performing positively against all the evaluation criteria and outperforming other methods. The MCA approach demonstrated strength in the following criteria:

- **Relevance** - The MCA model is widely used for integrating economic, social and environmental data.
- **Resources and data** - The MCA approach is relatively straightforward to apply with no specialist software required.
- **Applicability** - The MCA approach is highly applicable, particularly within GIS spatial mapping and planning tools. It is well-suited for the SSEP's purposes, allowing for the integration of primary data and stakeholder engagement.

While the spatial cost-benefit analysis performed well in terms of robustness, aligning with the HM Treasury Green Book, it faced challenges in integrating complex environmental, societal and technical factors within a cost-benefit framework. The MCDA performed well in terms of acceptability due to its robust approach to weighting, but it requires extensive expert engagement for correct application.

To enhance the MCA approach, modifications are proposed to address the criteria of robustness and transparency. This includes documenting the approach thoroughly, defining clear criteria and employing an evidence-based approach to scoring and weighting with stakeholder involvement. By addressing these modifications, the MCA approach can improve its performance in terms of robustness and acceptability within the SSEP.

Appendix 7.2: Documentation and communication of the spatial evaluation

To ensure transparency throughout the spatial evaluation process, we will focus on maintaining documentation and effective communication throughout. This includes documenting the methodology, data information and evaluation results in a clear, comprehensive manner.

The methodology documentation will outline the steps to be taken in a robust way, criteria used, and specific approaches or techniques employed during the evaluation, providing a clear explanation of the process.

We will also document the sources of data used in the evaluation, including information on data collection methods, data quality assessments and any relevant data limitations. This documentation will help stakeholders and decision-makers understand the foundation of the evaluation and the reliability of the data used.

Furthermore, effective communication of the findings and recommendations will be crucial, particularly in the body of the evaluation. We will strive to present the results in a clear and accessible manner, using visualisations and plain language explanations to enhance understanding. We will tailor the communication to the needs and preferences of different stakeholders, ensuring the information is effectively conveyed to all relevant parties.

By documenting the methodology, data sources results, and by effectively communicating the findings and recommendations, we aim to maintain transparency throughout the spatial evaluation process. This will promote trust, allow for informed decision making and enable stakeholders to understand the basis of the evaluation and its implications.

Appendix 7.3: Identifying and selecting relevant spatial factors for spatial evaluation

To conduct the spatial evaluation, it is essential to identify and consider the relevant spatial factors for assessment.

The process of identifying and selecting spatial factors involved a systematic and comprehensive approach to ensure the inclusion of relevant and reliable information. This needed to be acceptable to a broad range of stakeholders to ensure that consideration has been given to a wide range of factors for each technology in question. Representative, non-exhaustive examples of spatial factors are shown in table 10:

Spatial factors - examples			
Feature	**Object**	**Activity**	**Process**
Woodland	Roads	Mining	Flooding
Slope/topography	Buildings	Fishing	Erosion
Water resources	HV cables	Tourism	Sedimentation

Table 10: Spatial factors example

The first step involves conducting a needs assessment to determine the spatial factors relevant to the optimum placement of in-scope infrastructure. This assessment consists of engaging with stakeholders, consulting experts and reviewing existing literature and reports to identify the critical themes and subcategories of spatial factors that would be required as part of a comprehensive, fair and transparent evaluation. A literature review was conducted into academic publications, industry reports, government publications and other credible sources to identify data sets that would be relevant to situating energy infrastructure. A list of the existing studies, reports, and databases reviewed included those sources listed below:

- National planning policy documents including Scotland's National Planning Framework 4 (2023)[55], Planning Policy Wales (2024)[56], England's National Planning Policy Framework (2023)[57] and the DESNZ National Policy Statements for Nationally Significant Infrastructure Projects (2011-2024)[58]
- HM Government, UK Marine Policy Statement (2011) and guidance from 1 January 2021 (2020)[59], Scottish Government, Scotland's National Marine Plan (2015)[60]
- Government plans, strategies and objectives including HM Government's Environmental Improvement Plan (2023)[61], the Welsh Government's Future Wales: the national plan 2040 (2021)[62] and The Environment Strategy for Scotland (2020)[63]
- Examples of large-scale strategic plans, including the UK Offshore Energy Strategic Environmental Assessment 4 (OESEA4)[64] Environmental Report (Department for Business, Energy & Industrial Strategy, 2022[65])
- Spatial modelling resources and examples, including the Geospatial Commission/DSIT, National Land Data Programme
- Energy sector examples including:
    - The Crown Estate's Celtic Sea Floating Offshore Wind Leasing Round 5 – Site Selection Methodology (2023)[66]
    - The Crown Estate, Marine Approach Information[67]

[55] Scottish Government, Scotland's National Planning Framework 4 (2023) - https://www.gov.scot/publications/national-planning-framework-4/
[56] Welsh Government, Planning Policy Wales (2024) - https://www.gov.wales/sites/default/files/publications/2024-07/planning-policy-wales-edition-12.pdf
[57] Ministry of Housing, Communities and Local Government, National Planning Policy Framework (2023) - https://assets.publishing.service.gov.uk/media/669a25e9a3c2a28abb50d2b4/NPPF_December_2023.pdf
[58] Planning Inspectorate, Nationally Significant Infrastructure Projects: National Policy Statements (2012) - https://www.gov.uk/guidance/nationally-significant-infrastructure-projects-national-policy-statements
[59] Department for Environment, Food & Rural Affairs, UK marine policy statement (2011) and guidance from 1 January 2021 (2020) - https://www.gov.uk/government/publications/uk-marine-policy-statement
[60] Scottish Government, Scotland's National Marine Plan (2015) - https://www.gov.scot/publications/scotlands-national-marine-plan/
[61] Department for Environment, Food & Rural Affairs, Environmental Improvement Plan (2023) - https://www.gov.uk/government/publications/environmental-improvement-plan
[62] Welsh Government, Future Wales: the national plan 2040 (2019) - https://www.gov.wales/future-wales-national-plan-2040
[63] Scottish Government, The Environment Strategy for Scotland - The Environment Strategy for Scotland: vision and outcomes (2020) - https://www.gov.scot/publications/environment-strategy-scotland-vision-outcomes/
[64] Department for Business, Energy & Industrial Strategy, UK Offshore Energy Strategic Environmental Assessment 4 (OESEA4) (2022) - https://www.gov.uk/government/consultations/uk-offshore-energy-strategic-environmental-assessment-4-oesea4
[65] Department for Business, Energy & Industrial Strategy, UK Offshore Energy Strategic Environmental Assessment 4 (OESEA4) (2022) - https://www.gov.uk/government/consultations/uk-offshore-energy-strategic-environmental-assessment-4-oesea4
[66] The Crown Estate, Celtic Sea Floating Offshore Wind Leasing Round 5 - https://www.thecrownestate.co.uk/our-business/marine/round-5
[67] The Crown Estate, Marine Overview - https://www.thecrownestate.co.uk/our-business/marine/marine-overview

- The Crown Estate and the Electricity System Operator mark a new chapter to accelerate journey to net-zero, nature-positive energy future, December 2023[68]
- The Crown Estate, Offshore Wind Leasing Round 4, Summary Stakeholder Feedback Report, September 2019[69]
- The Crown Estate, Offshore Wind Leasing Round 4, Resource and Constraints Assessment for Offshore Wind: Methodology Report, September 2019[54]
- The Crown Estate, Offshore Wind Leasing Round 4: Regions Refinement Report, September 2019[70]
- Future Wales: Assessment of onshore wind and solar energy potential in Wales (2019)[71]
- National Grid ESO's HNDFUE Methodology (2022)[72]

Stakeholder engagement played a crucial role in refining and identifying further data sets for consideration through workshops and meetings. Stakeholders across the four spatial evaluation pillars were invited to provide input on the types of data they deemed important for excluding, constraining or favouring the technologies in question. This engagement helped ensure a wide range of perspectives and expertise were considered in the selection of data sets. Experts in the field of energy planning, environmental assessment, socioeconomic analysis and other relevant domains were also consulted to gain insights into the most appropriate datasets for the assessment. Their expertise and knowledge helped in identifying data sources, datasets and indicators widely recognised and accepted within the field. Through this extensive literature review and consultation process with stakeholders and subject matter experts, a comprehensive list of potential spatial factors was developed.

[68] The Crown Estate, The Crown Estate and the Electricity System Operator mark a new chapter to accelerate journey to net-zero, nature-positive energy future (December 2023) - https://www.thecrownestate.co.uk/news/the-crown-estate-and-the-electricity-system-operator-mark-new-chapter
[69] The Crown Estate, Offshore Wind Leasing Round 4, Summary Stakeholder Feedback Report (September 2019) - https://www.thecrownestate.co.uk/media/3332/tce-r4-summary-stakeholder-feedback-report.pdf
[70] The Crown Estate, Offshore Wind Leasing Round 4: Regions Refinement Report (September 2019) - https://www.thecrownestate.co.uk/media/3330/tce-r4-regions-refinement-report.pdf
[71] Welsh Government, Assessment of on-shore wind and solar energy potential in Wales (2019) - https://www.gov.wales/assessment-shore-wind-and-solar-energy-potential-wales
[72] National Grid ESO, Holistic Network Design Follow-Up Exercise (November 2022) - https://www.neso.energy/document/270851/download

Criteria category	Criteria		
Data available with National coverage	Data currently available with consistent National coverage	Data set has only partial coverage or requires collation from multiple sources	Data set not currently available
Data (or equivalent representation) available for England, Scotland and Wales	Data sets or clear equivalents available for England, Scotland and Wales	Data set limited to England, Scotland and/or Wales, but embedded in relevant national planning policy	Data set limited to England, Scotland and/or Wales, and not embedded in relevant national planning policy
Data available at strategic scale	Polygon / line data available at strategic scale	Point data requiring large buffers	Point data requiring no/limited buffers and therefore likely avoidable at local level
Data quality is suitable for the purposes of the SSEP	Data suitable. For example, official statistics, Government published or widely accepted, valid based on creation date or date of latest update	Data may be suitable. For example, experimental statistics, academic study and so on	Data not suitable. For example, insufficient quality for statistical analysis, considered invalid or inaccurate based on creation date or date of latest update and so on
Relevance to decision-making	Of relevance for decision-making relating to at least one infrastructure type at strategic level	Of relevance for decision-making relating to at least one infrastructure type at local level	Unlikely to influence decision-making for any infrastructure type
Key	**Data suitable**	**Data may be suitable**	**Data not suitable**

Figure 22: Criteria to develop refined list of data sets

Appendix 7.4: How spatial evaluation pillars and categories are considered in the spatial evaluation

Consideration of technical engineering design requirements within the spatial evaluation

For the purposes of the SSEP, technical engineering design requirements can be defined as ‘the operational factors that need to be in place for in-scope energy generation infrastructure to function correctly over time’. This means that they include, for example, adequate wind resource for wind farms, but also access to the strategic road network so turbine components can be transported for construction and maintenance. Other examples include adequate solar radiation levels for network-connected solar panels, and for a minimum viable footprint in terms of land needed for a grid-scale solar farm. These are also ‘spatial opportunities’ described in the development of the spatial evaluation approach section in the prepare chapter. They can, to varying degrees, support the potential siting of in-scope infrastructure.

Our technical engineering design requirements approach is underpinned by the need to consider strategic-scale efficiency and operational factors of in-scope energy infrastructure at a strategic plan level rather than assessing project-scale factors, which are more appropriately considered through the regional and local planning and consenting processes.

The approach will also seek, wherever possible, to account for relevant and emerging technology improvements of in-scope energy infrastructure within the planning period. For example, advancements could improve efficiency and reduce the minimum level of viable land taken for each generation technology. In so doing, the approach seeks to optimise land and sea use. This means maximising compatibility and complementarity with other spatial uses and minimising conflict with them based on a mitigation hierarchy.

Suitable technical engineering indicators for consideration within the geospatial analysis were identified and subdivided into four main categories:

- resources
- terrain and seabed
- resilience to hazards
- access to transport

Consideration of other spatial uses within the spatial evaluation

The SSEP will consider cross-sectoral demand on land and sea so that future decisions can accurately reflect energy requirements and enable effective decision-making. While the SSEP is not intended to be a cross-sectoral plan, assessment of land and sea cannot be carried out in isolation. This must also consider wider government policies on land use including (but not limited to) food production, transport, water supply and fisheries.

The spatial evaluation is part of the evidence base for the SSEP. As such, it informs the objectives of the SSEP and is not intended to be used to assess sectors other than energy.

Key principles for alignment

Wherever possible, we will seek to integrate SSEP marine and terrestrial planning with other spatial plans by:

- ensuring consistency and compatibility where possible between the SSEP and existing spatial plans (single sector and cross-sectoral) in England, Wales and Scotland for energy infrastructure, as well as other government programmes such as Defra's Land Use Framework and Marine Spatial Prioritisation Programme
- adopting a strategic, zonal level approach that does not make site-specific recommendations, nor seek to resolve trade-offs and prioritisation decisions between sectors at an individual project level
- liaising with respective responsible authorities and other sectoral stakeholders for terrestrial and marine spatial planning (including plan development, implementation and review stages) so we can leverage strengths and opportunities and identify emerging challenges early
- ensuring a transparent evidence-base and sharing best practice and available data where relevant and appropriate (including the Crown Estate's Whole of Seabed evidence base) to maximise consistency in planning and decision-making
- considering interactions between land and sea policies to provide a holistic view of spatial demand for energy infrastructure
- considering cumulative environmental effects of multiple sectors through processes such as the Strategic Environmental Assessment (SEA) and Habitats Regulations Assessments (HRA)

Selected spatial uses indicators

Suitable other spatial uses indicators for consideration within the geospatial analysis were identified and subdivided into five main categories:

- utilities and services
- primary production
- urban and transport
- minerals and waste
- defence

Consideration of environmental factors within the spatial evaluation

The spatial evaluation will form the basis of how environmental factors are integrated into the SSEP. The sections below provide a high-level overview of how environmental aspects will be considered.

The mitigation hierarchy, as illustrated in figure 23 and set out in planning guidance across the UK, follows an order for which the impacts of development should be considered and addressed. This aligns with the environmental principles of prevention, precaution and integration. The spatial evaluation will focus on the first two stages of the mitigation hierarchy which are most relevant to the SSEP.

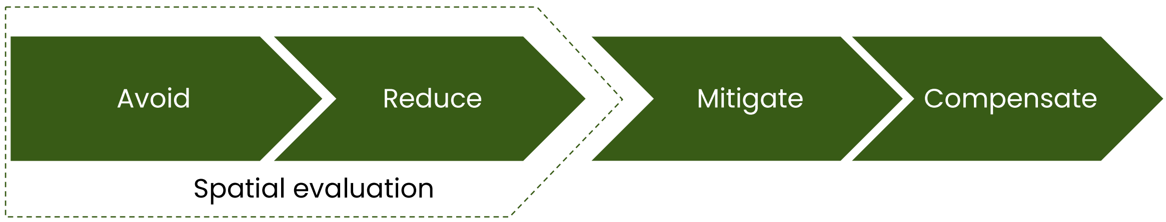

Figure 23: Mitigation hierarchy

We will first use geospatial analysis to verify that key environmental constraints, which we call spatial exclusions, can be avoided. We will then look for suitable developable areas that minimise or reduce risk of harm to environmental features or factors, which will form the spatial constraints.

Due to the strategic nature of the SSEP, the approach to considering mitigation and compensation will also need to be strategic. The SEA and HRA (where required, if likely significant effects are identified or if there is derogation) will look to consider environmental mitigation and compensation on the draft SSEP at a high level and any measures identified will be broad to reflect the strategic nature of the plan. Bespoke mitigation and compensation will be considered, where necessary, at the project level, where impact pathways can be developed in detail as part of the consenting process.

Selected environmental indicators

Suitable environmental indicators for consideration within the geospatial analysis will be subdivided into five main categories:

- ecology and biodiversity
- cultural heritage and historic environment
- geology and soils
- water
- landscape

The environmental indicators will include spatial constraints such as statutory and non-statutory designated sites or features, highly sensitive habitats and areas of environmental risk.

We will also consider sites or features which have been identified as important in meeting the UK, Scottish and Welsh governments' environmental objectives, such as those suitable for habitat restoration and enhancement. These areas will need to be avoided, or the interaction with them minimised, to avoid undermining UK, Scottish and Welsh governments' environmental objectives.

Consideration of societal factors within the spatial evaluation

The views and feedback we receive from societal stakeholders will be used to populate, test, and calibrate the metrics used in the spatial evaluation as described above. The focus will be on how societal groups may perceive potential infrastructure in non-specific settings or references.

We anticipate that feedback will be wide and varied and individual areas and groups will have their own unique interests, points of view and values. It will be impossible for there to be a single 'societal view' from which the SSEP can be developed. We will, however, take all feedback into consideration, weighting the views we hear, and use that to inform our spatial evaluation and decision-making.

Selected societal indicators

Suitable societal indicators for consideration within the geospatial analysis were identified and subdivided into four main categories:

- recreation and tourism
- employment
- health and wellbeing
- community and visual amenity

For all spatial evaluation pillars, metrics related to each indicator will be included within the geospatial analysis. Specific metrics will also be developed specific to each technology type to reflect their individual risk profiles – for example, each technology will have different environmental and engineering risks.

Our metrics will also consider any differences in policy and data availability between the devolved administrations and between marine and terrestrial environments. To prevent unjustifiable prioritisation of one area over another, consistency is an important factor in the selection of metrics and has been carefully considered in the spatial evaluation. Please see appendix 7.3, and the development of the spatial evaluation approach section in the prepare chapter for more detail.

Appendix 8: Robustness testing for sensitivities

This section provides more detail behind the process of testing robustness, as described in the model chapter.

If, for example, the initial output recommends a significant volume of a certain type of generation, then this will be the first focus of our sensitivity analysis. In this case, there are several options (although the list below is not exhaustive) for how we could carry out sensitivity analysis:

- Limit the maximum capacity or maximum build rate that is allowed for the given technology. This is useful in determining what the alternative(s) are.
- Increase the cost of the given technology. The magnitude of the increase required to cause a decrease in the capacity of the given technology by a certain amount is a very good measure of the robustness of the original recommendation.
- Decrease the cost of other technologies until they displace the given technology. This is a good measure of the robustness of the cost assumptions of the given technology.

In each case we may use any or a combination of any of these options. Each time a sensitivity is run, PLEXOS will find the optimum outcome for the sensitivity that has been run. Therefore, once we have run all the sensitivities that we wish to test for the scenario, we will have many outcomes.

The method shown in figure 24 will be used to combine the components (zonal capacity of a given technology) of these outcomes into a single pathway.

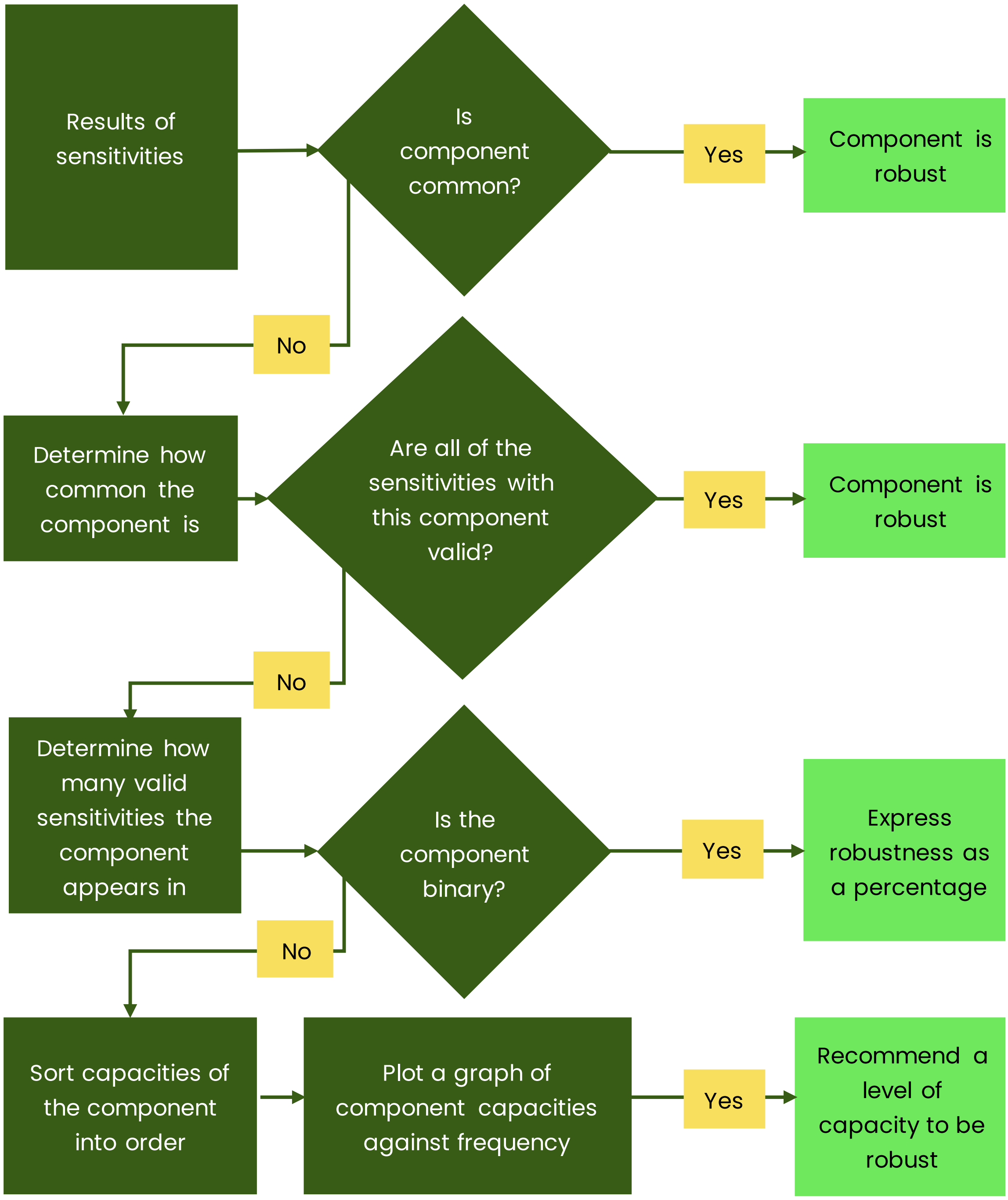

Figure 24: Determining the robustness of components

The input to the process is the results of all the sensitivities for the scenario (that is, the outcomes). If the component appears in all the sensitivities that have been considered, then it will be considered robust. However, this is a very unlikely situation that will probably only occur in a very small number of binary components (for example, large nuclear stations). If the component is not common to all sensitivities, then the next step is to determine how common the component is.

At this point, the validity of each sensitivity will be considered. It is likely that some of the sensitivities that have been considered will be too extreme: these sensitivities should be excluded from this analysis as they would skew the results if they were included.

The validity of a sensitivity may also be questioned if a number of sensitivities have been conducted with very similar changes. For example, if sensitivities investigating an increase in the capital cost of solar generators where the cost was increased by 19%, 20% and 21% had been run, it would be inappropriate to include all three as valid sensitivities as the difference between them is very small and they would likely have very similar outcomes. The categorisation of whether a sensitivity is valid or not is inherently subjective; however, the reason that this method has been chosen is that it removes the requirement to assign probabilities to sensitivities, reducing the problem to a simpler question of binary validity.

In most cases, not all sensitivities will be considered valid. In these cases, the next step is to filter out the invalid sensitivities. The final stage depends upon whether the component is binary or not. An example of a binary component is a large nuclear station, which can be either built or not built. Most components could have any capacity (within certain minimum and maximum build limits) and will therefore be non-binary.

If the component is binary, then it will either appear or not appear in each sensitivity outcome. The robustness of the component will then be expressed as the percentage of sensitivities in which it appears.

If the component is non-binary, then the capacities of the component built in each sensitivity will be sort into order. They will then be plotted on a graph against the frequency that a given capacity is equalled or exceeded.

Once this has been done the robustness level for the component needs to be determined. This will be done in a similar way to how the validity of sensitivities is determined. A frequency level that is deemed credible will be chosen and the associated capacity increase will become the 'robust' level.

Once the 'robust' level has been chosen for all components, this must be run through PLEXOS for one final optimisation. This is because simply summing all the 'robust' level capacities for all components will not necessarily combine into a fully optimised pathway.

The minimum and maximum build limits in PLEXOS for each non-binary component will be adjusted according to the frequency graph. With the 'robust' level as a mid-point, the slope of the frequency curve as capacity is increased and decreased will be used to determine the new minimum and maximum build limits. The outcome of this final PLEXOS optimisation will be a universally optimised outcome where all of the components are within a tolerance around their 'robust' level (that is, the pathway for that scenario).

Comparing components across pathways

Once a pathway has been developed for all scenarios, the components that make up these pathways can each be evaluated in the other scenarios. This allows stakeholders to see where there is and is not risk involved in making decisions on investing in assets. As there will be a large number of components that comprise a pathway, only the components that have the largest impact on the modelling outcome will be evaluated in this stage.

The component being evaluated will be forced in an optimisation, the outcome will be sub-optimal and therefore will have a higher total cost. The risk will be quantified as the regret of pursuing an optimal component of a pathway for one scenario in another scenario. The regret value is the difference in total cost between the optimum pathway for the scenario and the total cost of the revised outcome. This approach must be used with care as there may be cases where the policy decisions that formed two scenarios are so divergent that applying an optimum component from one scenario in the other scenario may not be credible. The process flowchart is outlined in figure 25.

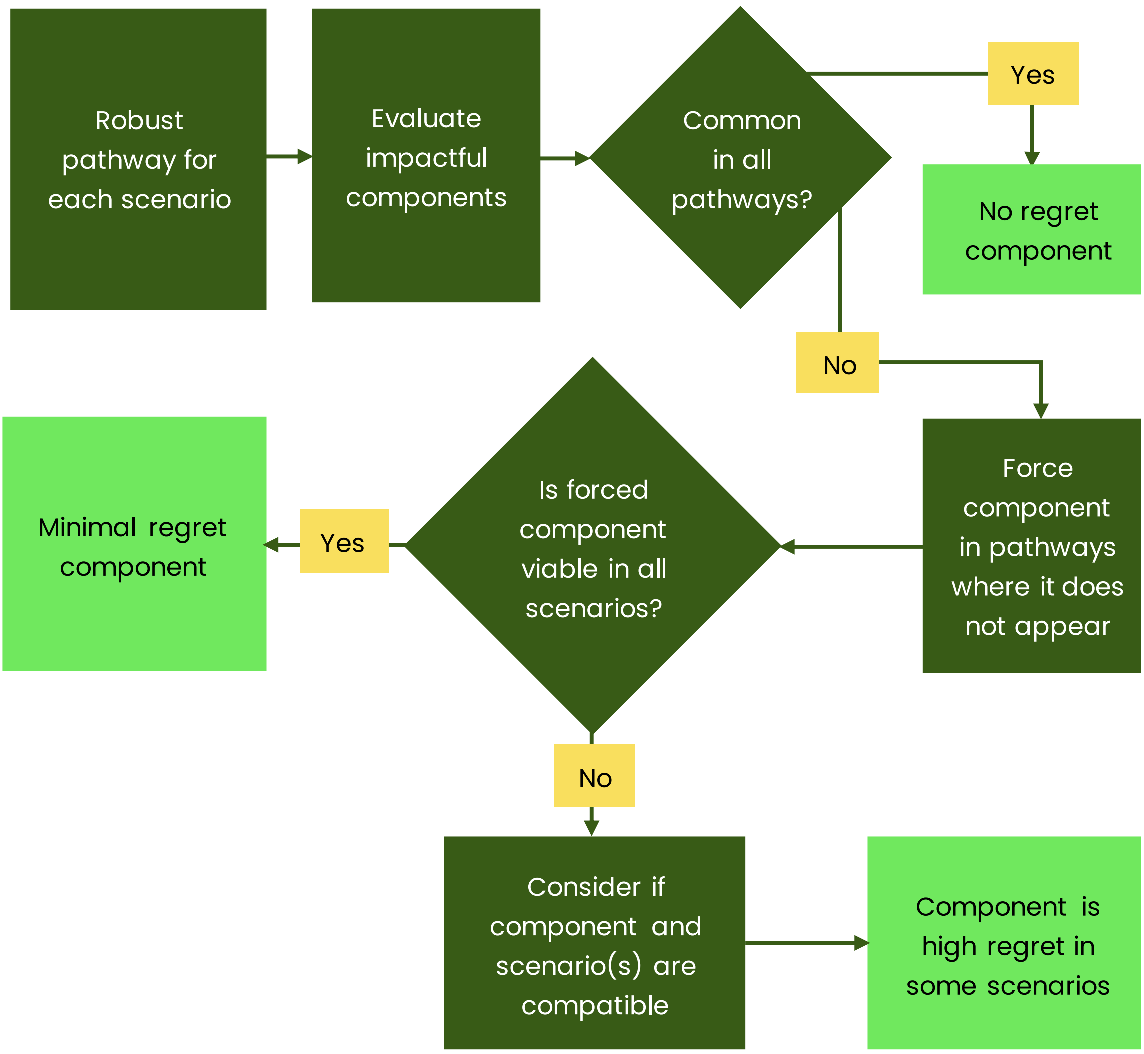

Figure 25: Comparing components across pathways

Appendix 9: SEA monitoring and implementation plan

Schedule 17 of the English and Welsh SEA Regulations and Schedule 19 of the Environmental Assessment (Scotland) Act 2005 require the responsible authority to monitor the significant environmental effects of the implementation of the plan.

The purpose of this is to identify unforeseen adverse effects at an early stage so remedial action can be taken.

SEA monitoring evaluates the sustainability performance of the plan and its compliance through its implementation. It also checks whether the effects predicted in the SEA occur as envisaged or whether unforeseen issues arise.

Monitoring can help evaluate whether the SSEP is fulfilling its core objectives of delivering sustainable development and providing a high level of protection of the environment. The information gathered through monitoring will inform the review and preparation of subsequent iterations of SSEP and the plans and projects that sit within them, thus better influencing future planning decisions.

In response to this, an SEA Monitoring and Implementation Plan will be prepared at adoption of the SSEP. The document will set out an approach to monitoring, which will:

- prioritise monitoring requirements
- set clear roles and responsibilities for monitoring
- develop specific thresholds and key performance indicators where monitoring shows intervention is required
- suggest how preferred environmental outcomes can be cascaded down to other plans associated with the SSEP (including, for example, the CSNP), as well as individual projects
- set out the approach to adaptive management which ensures the plan can be reviewed where appropriate, including through later iterations of the SSEP

Appendix 10: Consultation questions

- **Methodology** - Overall, does the methodology feel appropriate and cover the requirements for the SSEP?
- **Stakeholder engagement** - Do you agree with how we are engaging stakeholders and wider society throughout the development of the plan?
- **Environment** – Do you agree with our environmental approach, including how we have integrated SEA and HRA into the SSEP?
- **Other plans or policies** - Are there any other plans or policies we should consider that could potentially interact with the SSEP?
- **Economic modelling** - Do you agree with our economic modelling approach?
- **Data centres** - Out of the options A, B, and C, set out in section 3.4.5, which option do you feel is best for the SSEP?
- **Modelling external markets** - Do you have any views on how we should model external markets? Please provide any views in relation to section 3.4.11 and appendix 6.2.
- **Spatial evaluation** - Do you agree with our spatial evaluation approach?
- **Accessibility** - We continually look at ways to present information in a more accessible and engaging way. Is there anything we can do to make our future publications more accessible and interactive?

10. Glossary

Term	Definition
Alternating current	Electricity transmission in which the voltage varies, resulting in a current flow that periodically reverses direction. In Great Britain (GB), the direction is reversed 50 times each second, which is known as a frequency of 50 Hz.
Bioenergy with carbon capture and storage (BECCS)	Bioenergy with carbon capture and storage entails capturing and permanently storing carbon dioxide (CO_2) from processes where biomass is either converted into fuels or directly burned to produce energy. Since plants absorb CO_2 during their growth, this method removes CO_2 from the atmosphere.
Boundary	The transmission system is split by boundaries that cross important power-flow paths where there are limitations in capability or where we expect additional bulk power transfer capability will be needed.
Capacity	The maximum rated power output of an electricity generation technology, usually measured in kilowatts (kW), megawatts (MW), gigawatts (GW) or terawatts (TW).
Capital expenditure (CapEx)	Funds used by a company to acquire and upgrade assets. For example, energy infrastructure technology and equipment, engineering, procurement and construction (EPC), and site acquisition.
Centralised Strategic Network Plan (CSNP)	A review of the existing electricity transmission network planning processes across GB that is onshore and offshore. The CSNP considers the need for improvements that will enable GB's electricity transmission network to efficiently meet anticipated future needs of the changing energy system.
Component	A capacity for a given technology, on a zonal (or inter-zonal for transmission assets) level. For example, 5 GW of onshore wind capacity in zone 1. Components can be binary or non-binary, with an example of a binary component being a nuclear power station, which is either built or not built. Most components are non-binary.
Crown Estate Scotland (CES)	An independent commercial business, created by an Act of Parliament, with a diverse portfolio buildings, shoreline, seabed, forestry, agriculture and common land. They are responsible for the leasing of seabed offshore in Scotland. The Crown Estate (TCE) is responsible for England and Wales.
Decarbonisation	The process of removing carbon emissions, such as those generated by fossil fuels, from our economic and social activities.

Demand	The amount of electrical power that has to be generated at any given time to supply homes and businesses.
Department for Energy Security and Net Zero (DESNZ)	UK government department focused on the energy portfolio, formerly part of the Department for Business, Energy and Industrial Strategy (BEIS). DESNZ is responsible for delivering security of energy supply, ensuring properly functioning energy markets, encouraging greater energy efficiency and seizing the opportunities of net zero to lead the world in new green industries.
Derating factors	De-rating factors measure the reliability of a given technology during stress events.
Distribution network operators (DNOs)	A company licensed to distribute electricity in the UK. These companies own and operate the system of cables and towers that bring electricity to our homes and businesses.
Economic zones	The geographical representation of an area of land which generation and demand fall within for the purposes of economic modelling.
Electrical boundary capability	The electrical boundary capability is the maximum amount of electricity that can flow through a boundary. As new reinforcements to the network are built, this capability may be increased, allowing more electricity to flow across the boundary.
Electricity Ten Year Statement (ETYS)	An annual NESO publication that shows the likely future transmission requirements of bulk power transfer capability of the national electricity transmission system, based on the Future Energy Scenarios (known as FES).
Electrolysis	Electrolysis is the process of using electricity to split water into hydrogen and oxygen. This reaction takes place in a unit called an electrolyser.
Energy infrastructure	Electricity generation and storage infrastructure, including hydrogen assets, which will be spatially co-optimised in the first iteration of the SSEP.
Energy network	This refers to all interconnected infrastructure used for transmission and distribution of energy and/or energy sources.
Environmental baseline	The environmental baseline provides the evidence base on which the key issues to be addressed via the Strategic Environmental Assessment are identified, as well as against which impacts of the plan can be assessed.

Future Energy Scenarios (FES)	The FES is a range of credible pathways for the future of energy out to 2050. They form the starting point for our transmission network and investment planning and are used to identify future operability challenges and potential solutions.
Generation	The process of generating electric power from sources of primary energy.
Geographic information system (GIS)	A GIS consists of integrated computer hardware and software that store, manage, analyse, edit, output and visualise geographic data.
Gigawatt (GW)	A unit of power. 1 GW = 1,000,000,000 watts.
Greenhouse gases	A gas in the atmosphere that absorbs and emits radiation within the thermal infrared range.
Grid connection	The linking of an electrical generation or energy storage system to the main electrical grid.
Habitats Regulations Assessment (HRA)	A process that determines whether development plans could negatively impact local plans on a recognised protected European site beyond reasonable scientific doubt.
High voltage alternating current (HVAC)	AC power transmission at voltages above 110 kilovolts (kV).
High voltage direct current (HVDC)	DC power transmission at voltages above 110 kilovolts (kV).
Holistic Network Design (HND)	The purpose of the HND is to provide a recommended onshore and offshore design that can facilitate the UK government ambition for 50 GW of offshore wind in GB by 2030.
Infeed	The provision of power from generators onto the National Electricity Transmission System.
Infeed loss risk	The level of power loss the electricity transmission system must be able to sustain for an unexpected loss of power infeed to the transmission system, which, for example, could be due to a power station suddenly disconnecting. This helps prevent an imbalance between the supply and demand of electricity.
Interconnector	A high-voltage cable that connects the electricity systems of neighbouring countries. In GB an interconnector may typically consist of undersea cables to a neighbouring European country, which allows for the trading and sharing of surplus electricity between the two.
Landing point	The location where a submarine or other underwater cable makes landfall.

Long-term phase (LT)	Long-term (or LT) is the module in PLEXOS we call Capacity Expansion. While optimising various components (such as capacity and technology), PLEXOS also solves the problem of how to dispatch generation to meet demand. This process is referred to as 'capacity expansion' modelling.
Loss of load expectation (LOLE)	The number of hours a year where there is a shortage of generation relative to demand and the system operator must take extraordinary measures to keep the system operating normally.
Megawatt (MW)	A measure of power. 1 MW = 1,000,000 watts.
Multi-criteria analysis (MCA)	Our approach for evaluating spatial factors. It is a method used to assess multiple criteria to inform a decision, encompassing constraints and opportunities associated with environmental, social, economic and technical engineering design factors.
National Electricity Transmission System (NETS)	The NETS is otherwise known as the electricity transmission network which spans across the GB. The network comprises a mixture of overhead cables, underground cabling and subsea cables. The size of these assets is 400kV, 275kV and 132kV. These are all linked together via substations across the country that then connect separately owned generators, interconnectors, large demands and distribution systems.
National Energy System Operator (NESO)	A public corporation that plans and operates Britain's electricity and gas networks and drives the transition to net zero.
National Policy Statements (NPS)	Statutory documents published in accordance with the Planning Act 2008.
Network constraint	A situation where energy is restricted in its ability to flow between two points, for example, due to capacity or voltage limitations.
Network constraint costs	The cost of taking balancing actions to redispatch generation to prevent unacceptable network flows across parts of the network that have limited capacity. These consist of actions to decrease generation output in one part of the country and actions to increase generation output in a different part of the country.
Offshore Hybrid Assets (OHA)	A connection between two countries which also connects in another form of offshore generation. For example, instead of individual wind farms connecting one by one to the shore, offshore hybrid assets will allow clusters of offshore wind farms to connect all in one go, plugging into the energy systems of neighbouring countries. OHAs are also referred to as multi-purpose interconnectors.
Ofgem	The UK's independent National Regulatory Authority, a non-ministerial government department. Its principal objective is to

	protect the interests of existing and future electricity and gas consumers.
Operational Expenditure (OpEx)	Costs directly related to the normal, everyday running of a company. They include things that are essential to keep core operations going, such as employee salaries, asset maintenance, monitoring and control systems, energy and utility costs, and land and site costs.
Optimum pathway	A favourable or preferred pathway identified through the iterated modelling process, considering factors such as cost, spatial suitability and other constraints.
Outcome	A list of components that should be built for a given scenario or sensitivity.
Overhead lines	Electrical cables used for transmitting electrical power that are strung high above the ground between towers or pylons.
Pathway	The final outcome for a given scenario, determined to be robust through sensitivity testing.
Pillar categories	A subset of a spatial evaluation pillar representing a key theme or topic. For example, within the 'environment' pillar, categories include ecology and biodiversity, landscape and cultural heritage and historic environment.
Pillar indicators	A feature or characteristic, the presence or scale of which can be measured using a metric. For the SSEP, indicators relate to spatial constraints (negative) and opportunities (positive) for developing generation and storage infrastructure. For example, a national nature reserve (constraint) or a grid connection point (opportunity).
Pillar subcategories	Subdivisions of categories that group together indicators with common features.
PLEXOS	A powerful energy market simulation engine used for economic modelling in the SSEP.
Potential energy output	An estimate of how much energy can be produced by a system in its operating environment.
Pull factor	Factor considered to positively impact the feasibility of building energy infrastructure owing to more favourable conditions.
Push factor	Factor considered to negatively impact the feasibility of building energy infrastructure due to spatial constraints/sensitivities in that area.
Radial	Direct single connection of an offshore wind farm to the onshore transmission network without connection to other points.

Ramsar sites	Wetlands of international importance that have been designated under the criteria of the Ramsar Convention on Wetlands for containing representative, rare or unique wetland types or for their importance in conserving biological diversity.
Regional Energy Strategic Planning (RESPs)	Activity to ensure energy networks are regionally coordinated across different fuel sources and between geographies, with the right level of local input into the process as well as regional democratic oversight.
Reinforcements	Additional grid infrastructure implemented to ensure the NETS can accommodate existing and future generation and demand.
Renewable generation	Production of electricity from sources that are naturally replenished and do not run out.
Review of Electricity Markets Arrangement (REMA)	A government programme to review electricity markets as part of its plan to deliver a fully decarbonised electricity system.
Scenario	A series of inputs to the economic modelling process, primarily linked to assumed policy decisions. For example, favouring heat pumps or hydrogen for domestic heating.
Sensitivity	A change, or number of changes, made to the initial input data of a scenario.
Sensitivity analysis	The process of systematically varying input parameters or assumptions to evaluate the impact on the outcomes or results of a model or analysis.
Short-term phase (ST)	Phase used in PLEXOS after the capacity expansion (Long-Term) phase and looks to model every hour of the year. This phase is used to get detailed outputs, such as market price, generation, interconnector flows, emissions, operation costs and so on.
Spatial constraint	A spatial factor that may, to varying degrees, limit the potential siting of in-scope energy infrastructure.
Spatial evaluation	Analysis that considers environmental, societal, other spatial use and technological design engineering factors for each of the in-scope technologies to identify their optimal zonal location.
Spatial evaluation pillars	Key elements of the spatial evaluation, namely environment, society, technical engineering design requirements and other spatial uses.
Spatial exclusion	A spatial factor that precludes the potential for development of in-scope energy infrastructure due to relevant physical, legal and land and sea use restrictions.

Spatial factor	A feature, object, activity or process within a given space or area.
Spatial opportunity	A spatial factor that may, to varying degrees, support the potential siting of in-scope energy infrastructure. Spatial opportunities are instrumental in highlighting where development is desirable for a given technology, based on its specific requirements.
Spatial suitability	An assessment of evaluating and scoring spatial factors present for their impact and importance in relation to in-scope energy infrastructure.
Strategic Environmental Assessment (SEA)	A tool that contributes to informed sustainable development decisions by incorporating environmental considerations into public policies, plans and programmes.
Strategic Spatial Energy Plan (SSEP)	A holistic approach to national planning for electricity and hydrogen in GB to identify optimal zonal locations for these assets.
The Crown Estate (TCE)	An independent commercial business, created by an Act of Parliament, with a diverse portfolio of buildings, shoreline, seabed, forestry, agriculture and common land. It is responsible for the leasing of seabed offshore in England and Wales. Crown Estate Scotland (CES) is responsible for Scotland.
Transmission Acceleration Action Plan (TAAP)	A UK government plan setting out a holistic approach to the design and delivery of transmission infrastructure, seeking to reduce timelines to a minimum, while engaging communities effectively and providing community benefits for those hosting transmission infrastructure.
Transmission Owner (TO)	A collective term used to describe the three electricity transmission asset owners within GB, namely National Grid Electricity Transmission, Scottish & Southern Electricity Networks Transmission and SP Transmission plc.
Virtual energy system project	NESO data-sharing infrastructure to enable an ecosystem of interconnected digital twins of the entire energy landscape, working in parallel to the physical system.
Whole energy system	The interaction between electricity, gas and liquid fuels and how these energy sources best contribute to delivering net zero greenhouse gas emission energy for technology, communications, transport, heat and water.
Wind farm	A group of wind turbines within a region that transforms wind to generate electricity.

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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