Public

Strategic Energy Planning (SEP) technical webinar

Economic and geospatial modelling for the Strategic Spatial Energy Plan (SSEP)

3 April 2025

11:00 – 12:30

Sli.do: #SEPTECH

Please ask questions via slido.com using code: **#SEPTECH** or you can scan the QR code

NESO
National Energy System Operator

Sli.do: #SEPTECH

SEP Technical Webinar: SSEP

Please ask questions via slido.com using code: **#SEPTECH** or you can scan the QR code

This session will be recorded

Camera and microphone are disabled for all attendees

You can contact the team by emailing box.sep-engagement@nationalenergyso.com

NESO National Energy System Operator

Agenda

1. Introduction to NESO, Strategic Energy Planning role & SSEP

2. SSEP Modelling Overview

3. Deep Dive into Economic Modelling and Geospatial Evaluation

4. Q&A (approximately 25 minutes)

Please note: all images and charts are for **illustrative purposes only**. Dummy data has been used to create examples, and no insights should be inferred from these.

Introduction

Posy MacRae

Strategic planner role

NESO will act as a body, independent of asset owners, to coordinate system design and planning efforts across the energy system

Strategic planning

For the first time in industry, we will **coordinate system design and planning efforts across the whole energy industry** so planning and investment decisions can be optimised to deliver GB's net zero objectives at the most equitable cost to consumers.

Our three overarching roles are:

- **Strategic Spatial Energy Planning (SSEP)**
- **Centralised Strategic Network Planning (CSNP)**
- **Regional Energy Strategic Planning (RESP)**

Facilitate Net Zero target while ensuring energy security

Deliver regional and national whole energy solutions

Consider the impact on communities

Consider the impact on the environment

Consider costs to consumers and deliver economic strategies

NESO National Energy System Operator

Strategic energy planning overview

Gas network planning

Confirm **gas,** and potentially **hydrogen**, network transmission needs

Offshore coordination

Connect offshore wind in a coordinated way

Zero carbon operations

Ensure a zero carbon energy system can be operated

Strategic spatial energy plan

Map potential **electricity** and **hydrogen generation** and **storage** infrastructure for **GB**

Centralised strategic network plan

Plan to develop and assess **electricity**, **gas,** and potentially **hydrogen**, **transmission networks**

alignment

Regional energy strategic planner

Develop **whole system, cross-vector regional plans** with input from local actors

Clean power 2030

Government **Clean Power Action Plan by 2030**

Future energy scenarios

Credible supply and demand pathways to meet net zero

Connections reform

Ensure ready projects aligned with strategic plans **can connect**

Review of electricity market arrangements

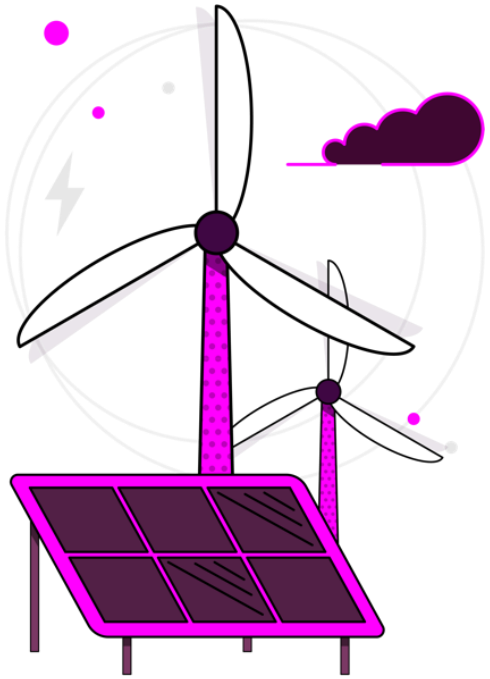
Reform electricity markets to achieve net zero cost-effectively

NESO
National Energy System Operator

SSEP explained

What is the SSEP?

A GB-wide plan that will map potential zonal locations, quantities and types of electricity and hydrogen generation and storage over time, modelled across a range of plausible futures.



Purpose

The SSEP will help accelerate and optimise the transition to **clean**, **affordable** and **secure energy** in Great Britain. It is part of a set of strategic energy plans that will help us achieve **net zero by 2050**. The SSEP was recommended in the Electricity Network Commissioner's 2023 Report.

Commission

We were jointly commissioned by UK, Scottish and Welsh governments in October 2024 to create an SSEP for the energy system, land and sea, across Great Britain.

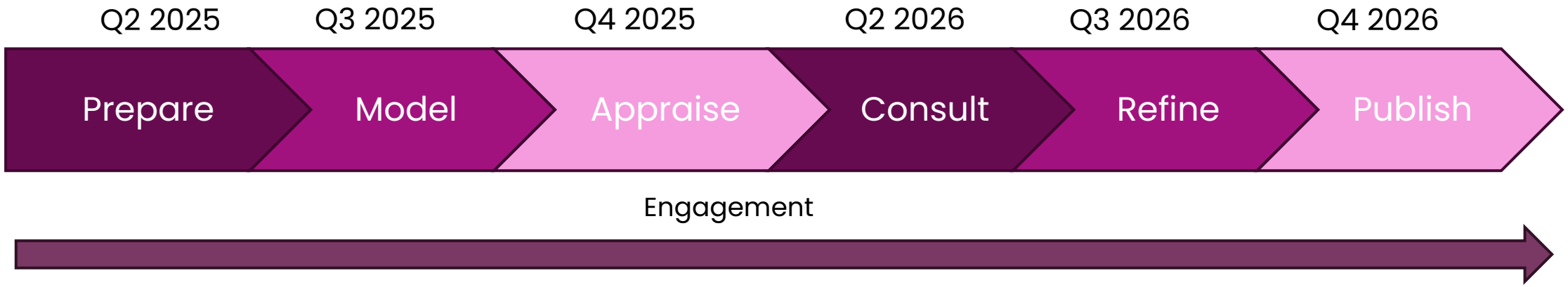
Pathway options

We will develop 4-6 options for how the energy system could look in the future. These will be presented to the UK Secretary of State for Energy Security and Net Zero, who will confirm to NESO which pathway should be taken forward for public consultation.

NESO
National Energy System Operator

How we will deliver the SSEP

The SSEP will be delivered through a phased approach across a two-year period and will be underpinned by our delivery principles to ensure robust and comprehensive engagement, assurance and governance.



Stakeholder engagement

Environment

Assurance

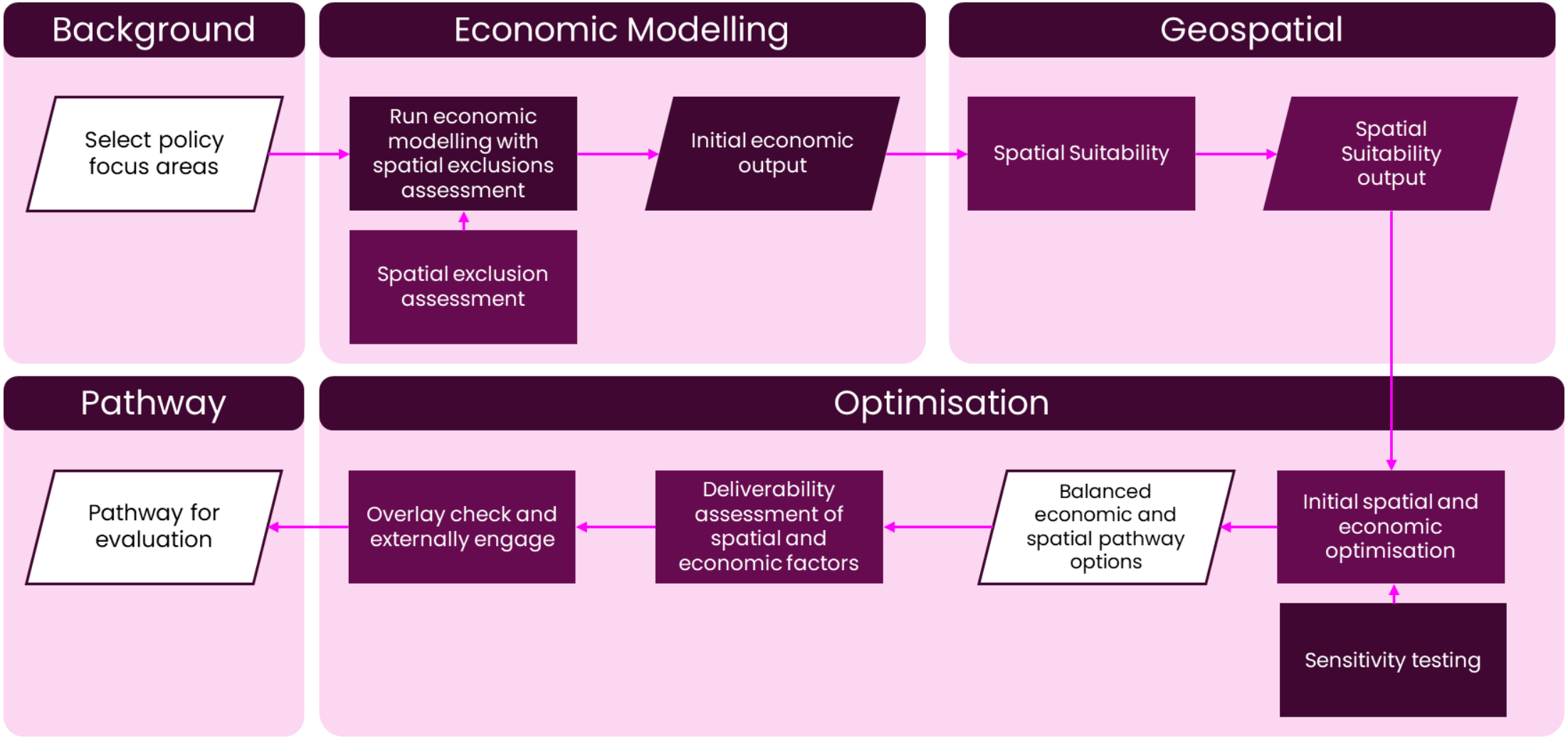
Governance

SSEP Modelling

Tomas Poffley

NESO
National Energy System Operator

Modelling flow



Data, images and charts

All images and charts are for **illustrative purposes only.**

Dummy data has been used to create examples, and no insights should be inferred from these.

Economic Model Setup

Tomas Poffley

NESO
National Energy System Operator

Model Setup

Economic modelling aims

To answer the fundamental questions in the SSEP, we first decided what was in and out of scope of the economic modelling exercise

What we are modelling

- **Future electricity system investment:**
  - Generation
  - Network
  - Storage requirements
  - Interconnection
- **Future hydrogen system investment:**
  - Supply
  - Network
  - Storage requirements

All of the above is co-optimised in the model and spatial recommendations are made for each category

What we are not modelling

- **Natural gas:**
  - Existing network ,storage and supply
  - Asset replacement and decommissioning

While we aren't explicitly modelling the natural gas system, the model still has access to natural gas as a commodity for gas fired power generation

NESO National Energy System Operator

Model Setup

Building the framework

17 economic zones

Chosen to represent major electricity network bottlenecks and potential hydrogen clusters

Existing supply

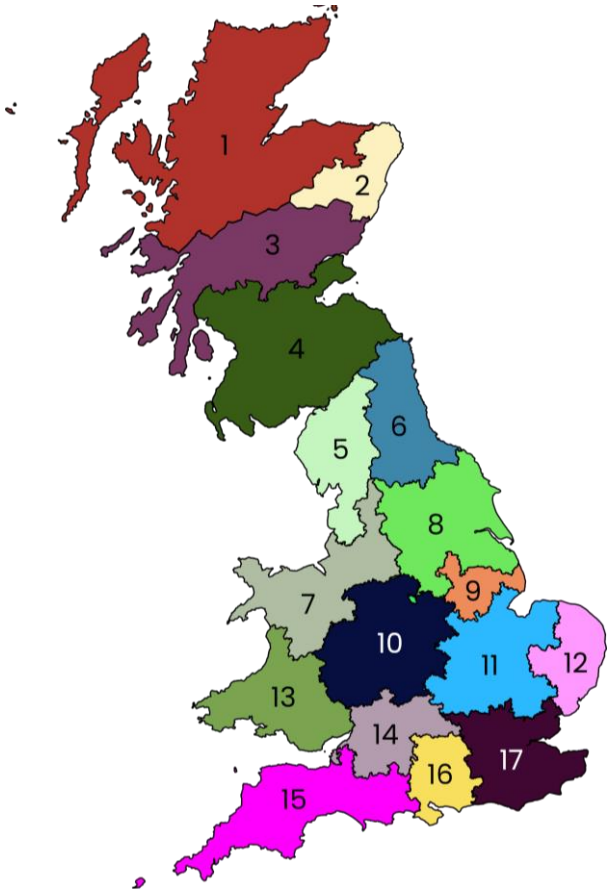
A digital replica of the energy system today with planned closures and connections out to 2030*

Hourly forecasts

50 years of historical weather data, forecast demand growth with hourly profiles

Existing network

Existing network capability with planned investments out to 2030*



NB: these zones are for modelling purposes only, and do not represent final SSEP zones

*to align with Clean Power 2030 recommendations

NESO National Energy System Operator

Model Setup

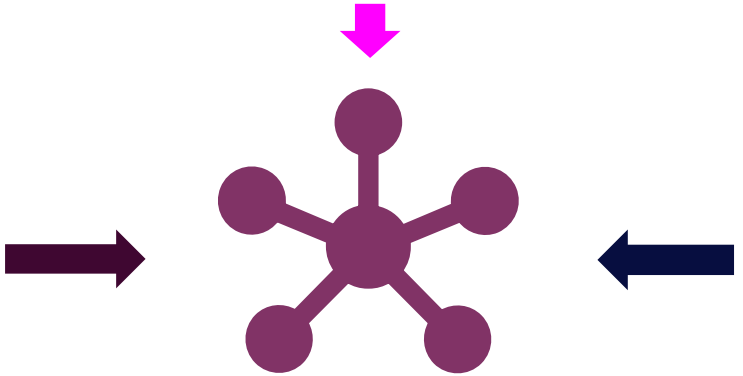
Inputs and dependencies

Demand projections

Geospatial inputs
What can be built where?

Baseline
What is our starting point?

Deliverability constraints
How quickly can we build?



Economic modelling

Macroeconomic inputs
Demand, commodity prices...

Techno-economic inputs
Build costs, efficiencies...

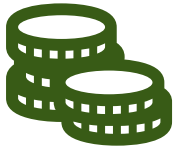
Policy levers
UK/Scottish/Welsh government ambitions

Other SSEP pillars & workstreams
Spatial suitability

NESO National Energy System Operator

Model Setup

Data Sources



Department for Energy Security & Net Zero

Macroeconomic assumptions and technology costs

NESO National Energy System Operator

Technical data

Energy Exemplar

Baringa

Weather and European data

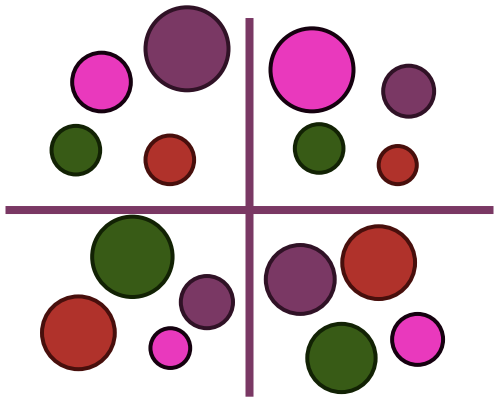
SSEP

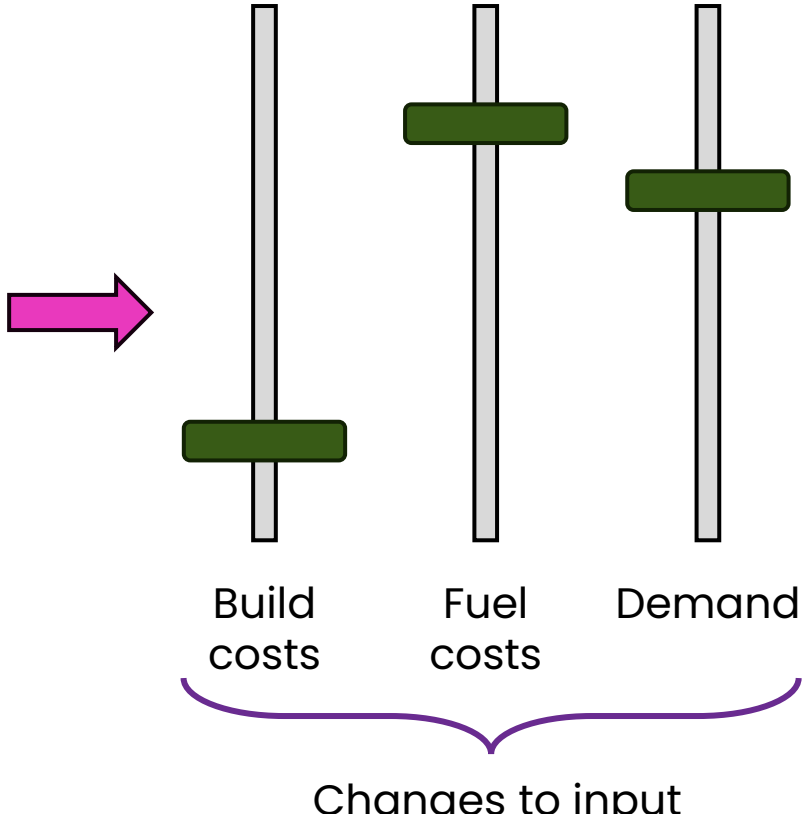
NESO National Energy System Operator

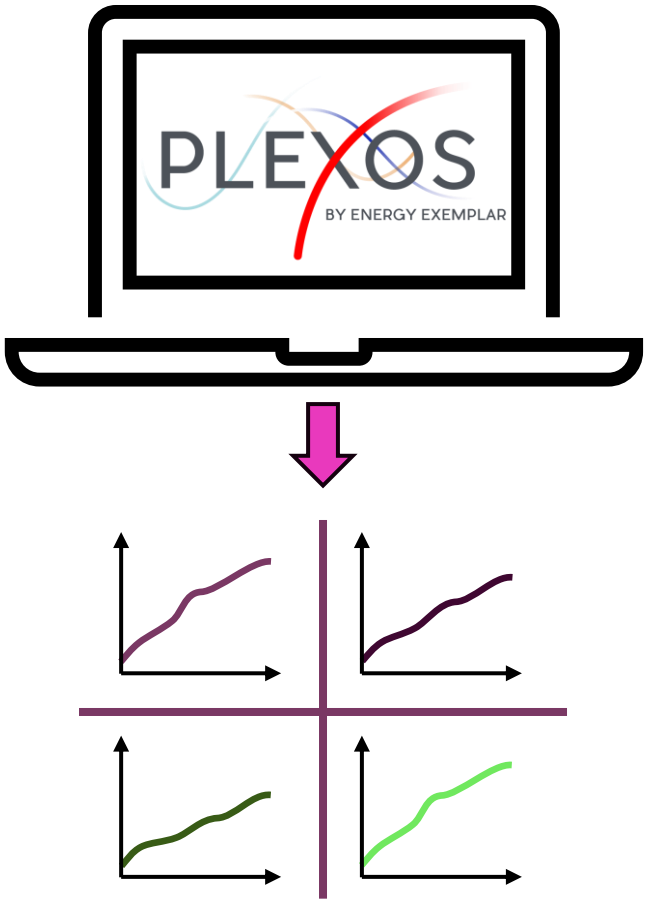
Model Setup

Policy Assumptions

Different modelling scenarios







NESO National Energy System Operator

Model Setup

Example CCGT setup in PLEXOS*

- All objects in PLEXOS are described in as much detail as possible
- The example on the right shows some of the properties describing one of the CCGT objects in PLEXOS
- Similar levels of detail are applied to hydrogen, network and storage assets

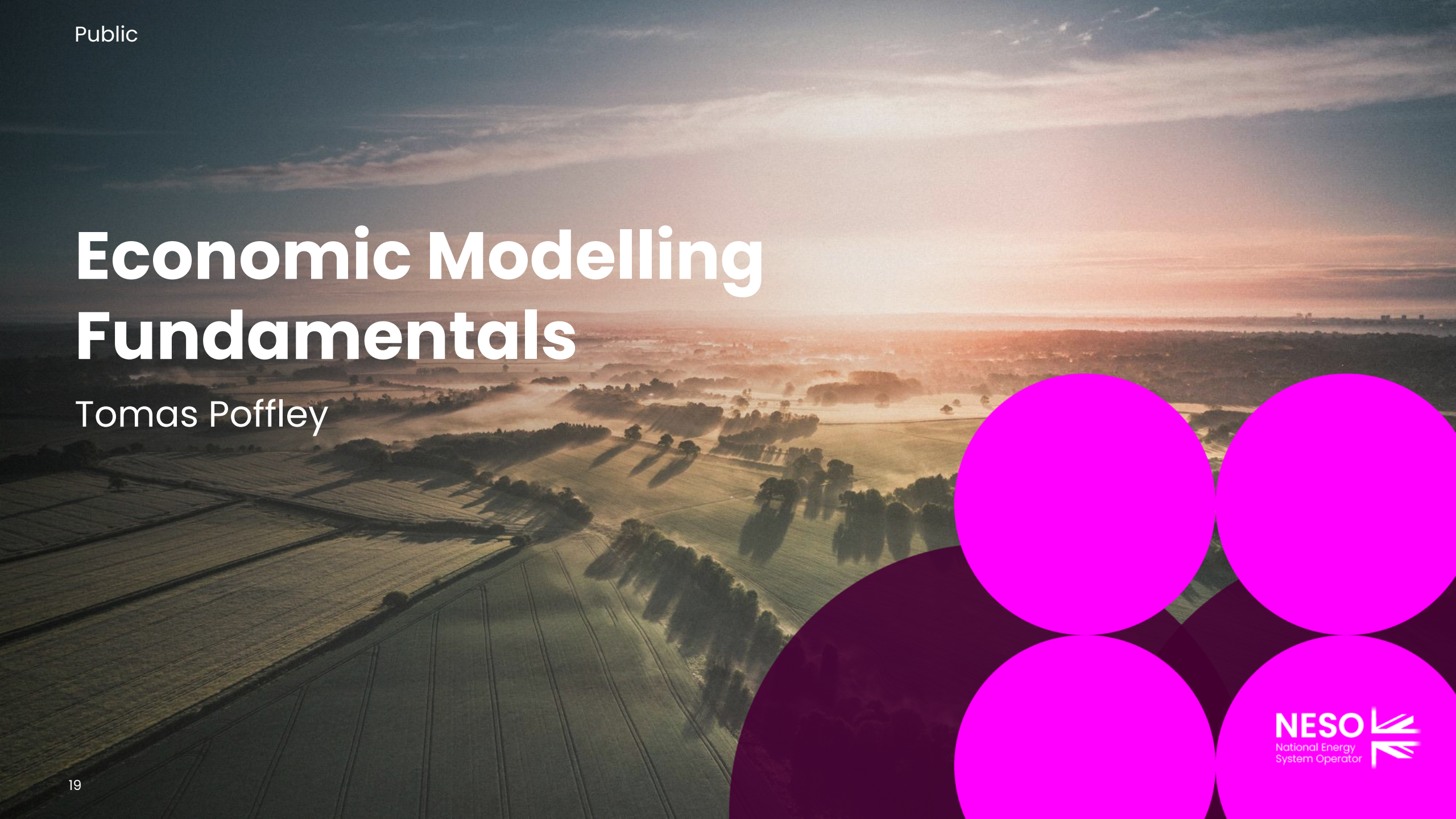
Property	Value	Units
Max Capacity	500	MW
VO&M Charge	2	£/MWh
FO&M Charge	5	£/kW/yr
Heat Rate	6	GJ/MWh
Min Stable Factor	50	%
Start Cost	10000	£
Start Cost Time	4	hours
Min Up Time	3	hours
Min Down Time	3	hours
Forced Outage Rate	3	%
Maintenance Rate	5	%
Max Ramp Up	30	MW/min
Max Ramp Down	35	MW/min

Property	Value	Units
Build Cost	500	£/kW
Technical Life	30	yrs
WACC	10	%
Economic Life	25	yrs
Maximum units built in year	3	
Maximum units built	15	

For new expansion candidates only

**Sample data used for all values*

NESO National Energy System Operator



Economic Modelling Fundamentals

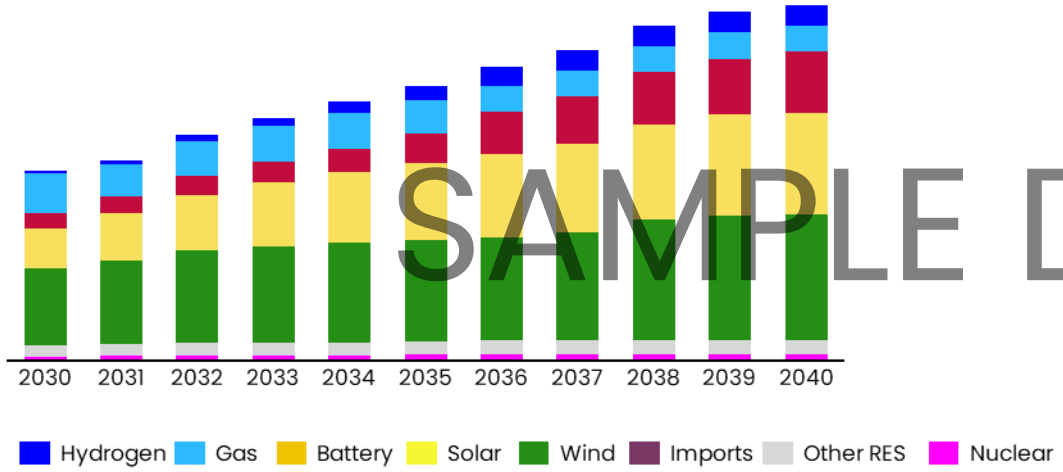
Tomas Poffley

NESO
National Energy System Operator

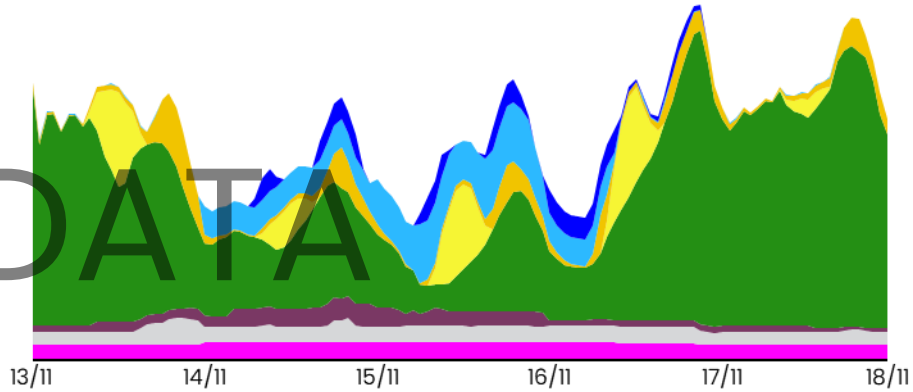
Economic Modelling Phases

Phase	1 - Capacity Expansion	2 - Economic Dispatch
	(LT Plan)	(ST Schedule)
Purpose	Infrastructure planning: to decide what to build, where, and when	Market simulation: to understand how the future system will operate
Key Outputs	Capacity mix by technology and zone	Generation mix by technology and zone, power prices
Key inputs	Construction costs, build constraints, demand	Operational costs, capacity mix, demand

Annual Capacity Mix



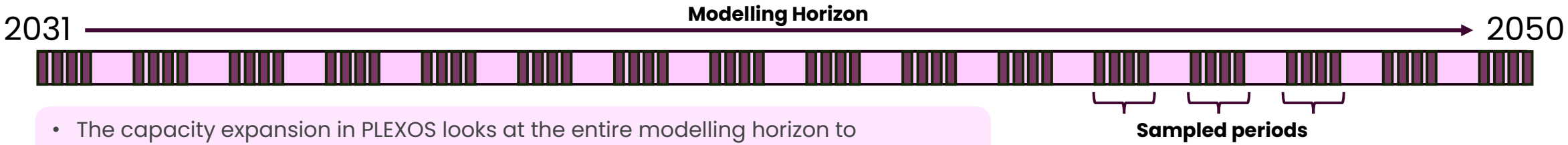
Hourly Generation Mix



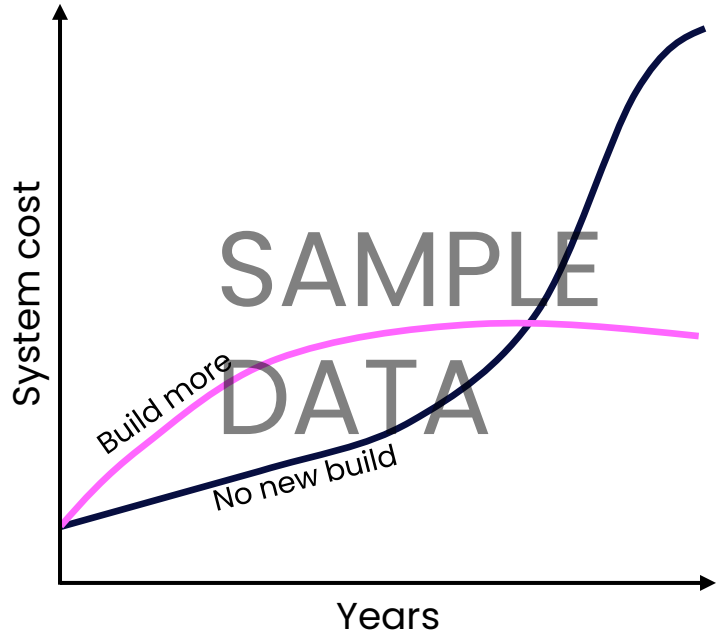
NESO National Energy System Operator

Fundamentals

Capacity Expansion



- The capacity expansion in PLEXOS looks at the entire modelling horizon to determine optimal build decisions.
- Due to the size of the problem being solved, it is necessary to sample data periods to reduce computational complexity while preserving hourly demand/weather dynamics.
- We sample approximately 40% of days across the modelling horizon to achieve a balance between accuracy of results and model run time.
- The remaining 60% of days are mapped to the sampled days to represent the full year.



Objective: Minimise whole system costs

Capital costs

- New supply
- Network expansion
- Asset retirements

Production costs

- Cost of producing energy to meet demand
- Notional cost of unserved energy

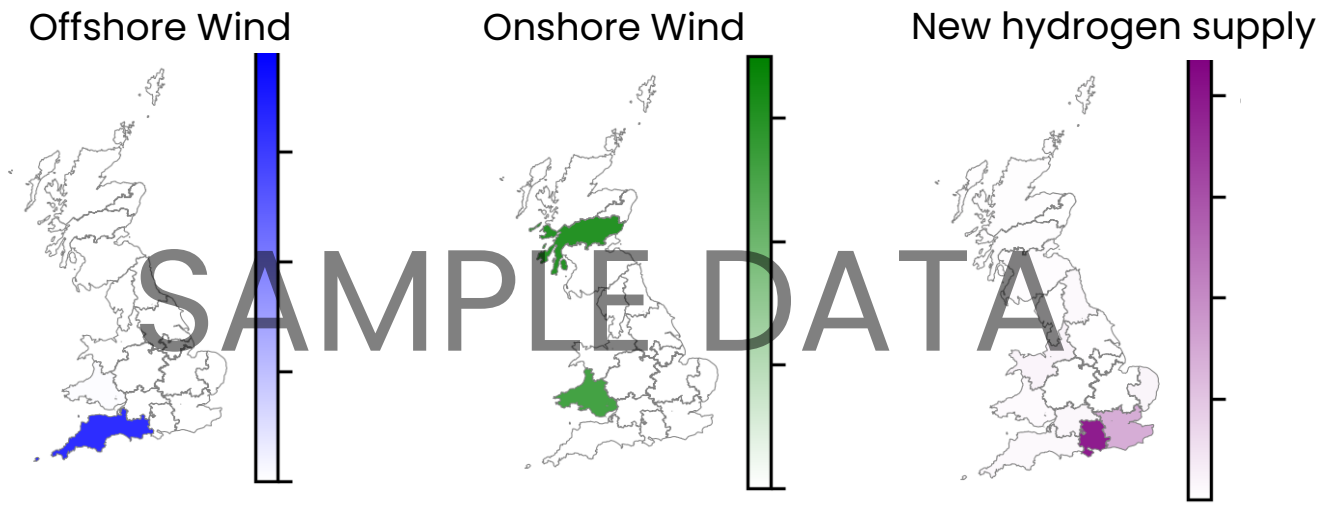
Output: Build plan

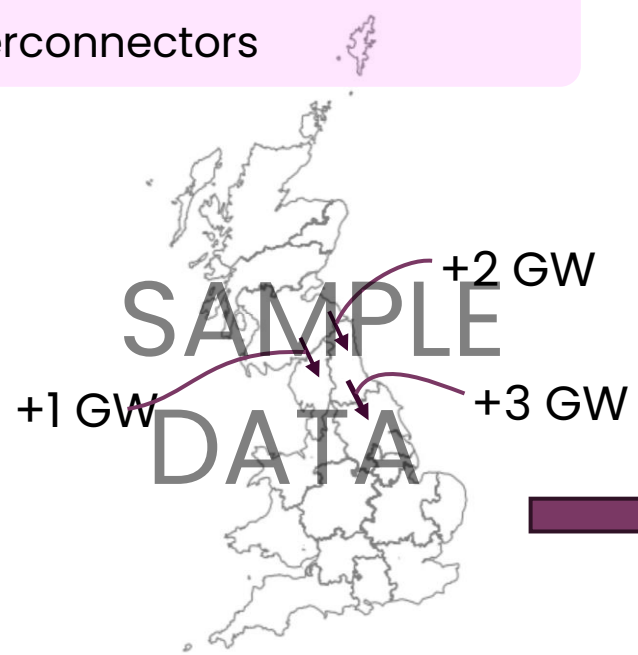
NESO National Energy System Operator

Fundamentals
Capacity Expansion (cont.)

Major Outputs

- Optimal new supply to build in each economic zone (and when)
- Network reinforcement
- Hydrogen infrastructure
- New interconnectors





Economic Dispatch

NESO National Energy System Operator

Fundamentals

Economic Dispatch

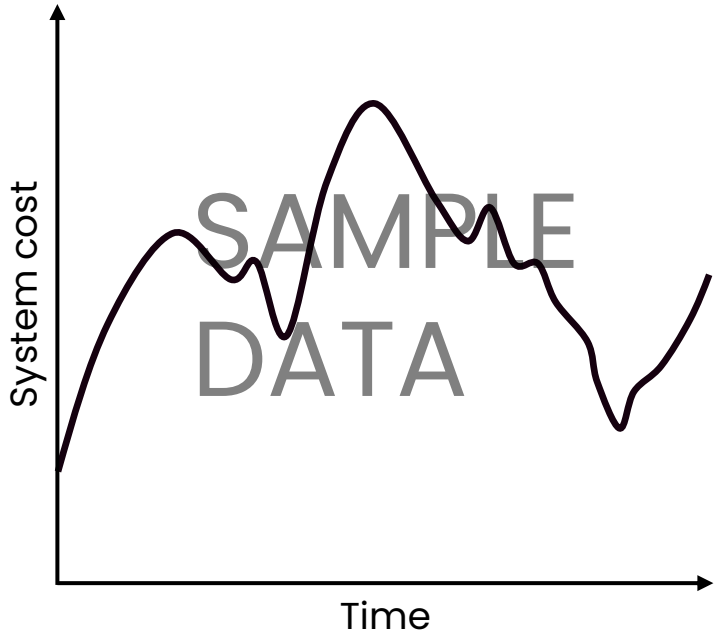
2031 — **Model every hour out to 2050** → 2050

- To ensure the sampling in the capacity expansion results in an operable system, every build plan is tested in an hourly economic dispatch of the energy system
- This is done to study the detailed operating characteristics of the new build plan and test it against security of supply metrics

Objective: Minimise whole system costs

Production costs

- Cost of producing energy to meet demand
- Notional cost of unserved energy



Major Outputs:

- Hourly system prices
- New asset profitability
- Unserved energy
- Flexible demand behaviour

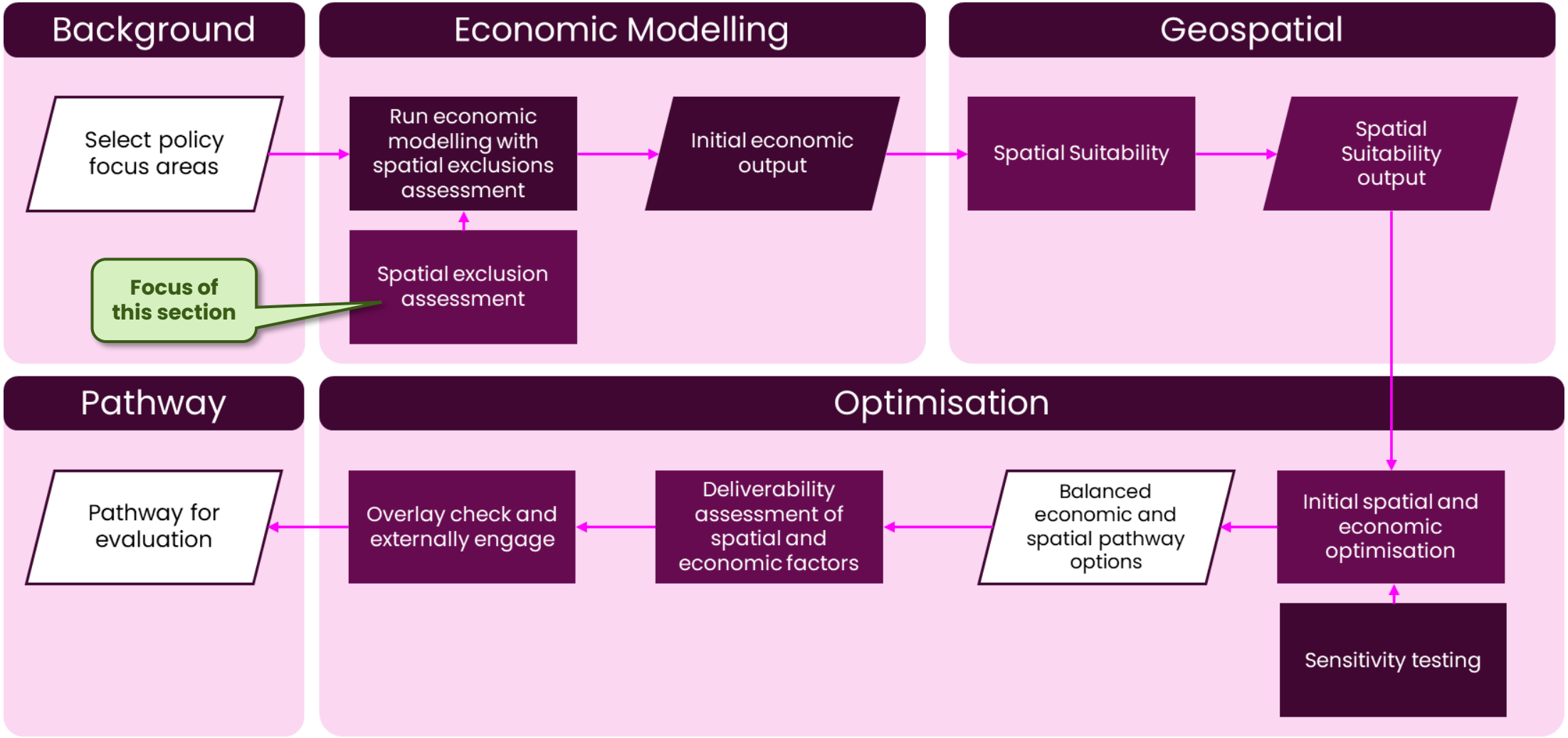
NESO National Energy System Operator

Spatial Exclusions

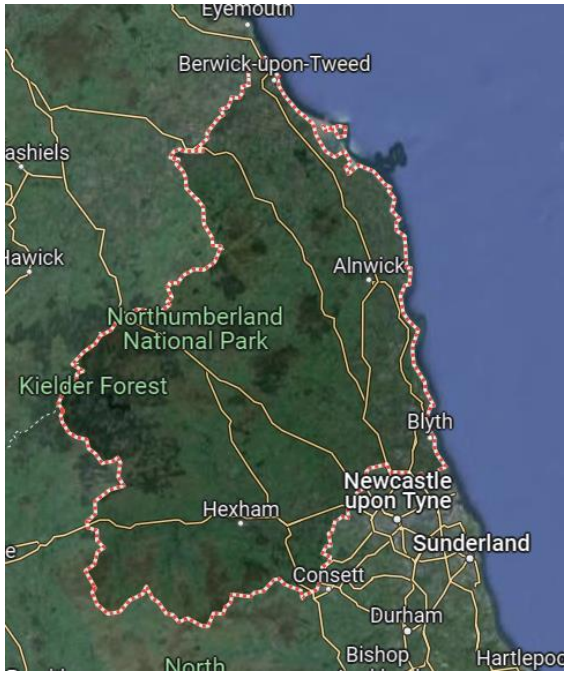
Richard England

NESO
National Energy System Operator

Modelling flow



Identify spatial factors* that preclude the potential development of in-scope infrastructure



REAL WORLD

Technology Design Engineering Requirements	Environmental	Societal	Other Spatial Uses
Spatial Exclusion • 1 • 2 • 3 • 4	Spatial Exclusion • 1 • 2 • 3 • 4	Spatial Exclusion • 1 • 2 • 3 • 4	Spatial Exclusion • 1 • 2 • 3 • 4
Spatial Opportunity • 1 • 2 • 3 • 4 • 5 • 6	Spatial Constraint • 1 • 2 • 3 • 4 • 5 • 6	Spatial Constraint • 1 • 2 • 3 • 4 • 5 • 6	Spatial Constraint • 1 • 2 • 3 • 4 • 5 • 6

CRITERIA > DATA

Spatial Exclusion: a spatial factor* that precludes the potential siting of in-scope energy infrastructure due to relevant physical, legal and land and sea use restrictions.

Deliverable achieved: identification of exclusion areas, where potential siting of in-scope energy infrastructure is not possible.

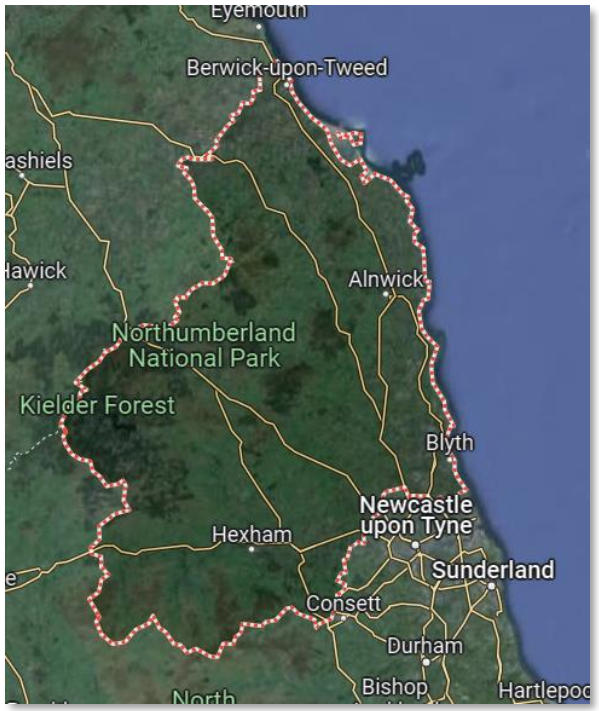
Spatial Constraint: a spatial factor* that may, to varying degrees, limit the potential siting of in-scope energy infrastructure.

Deliverable achieved: identification of 'push' factors, helping to determine optimal spatial location of in-scope energy infrastructure.

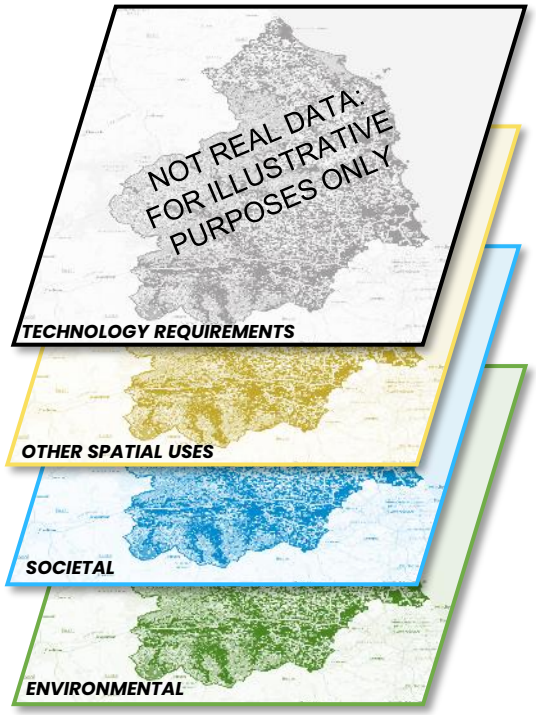
***Spatial factor:** A feature, object, activity or process within a given space or area.*

NESO National Energy System Operator

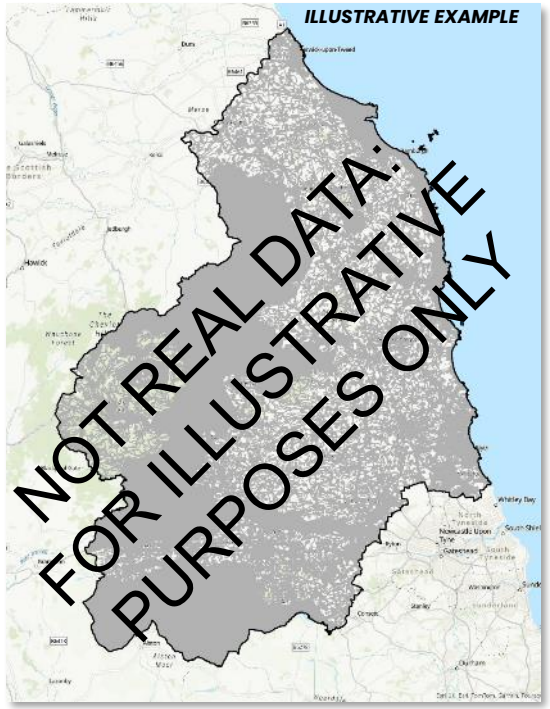
Removing areas of Spatial Exclusion from our analysis



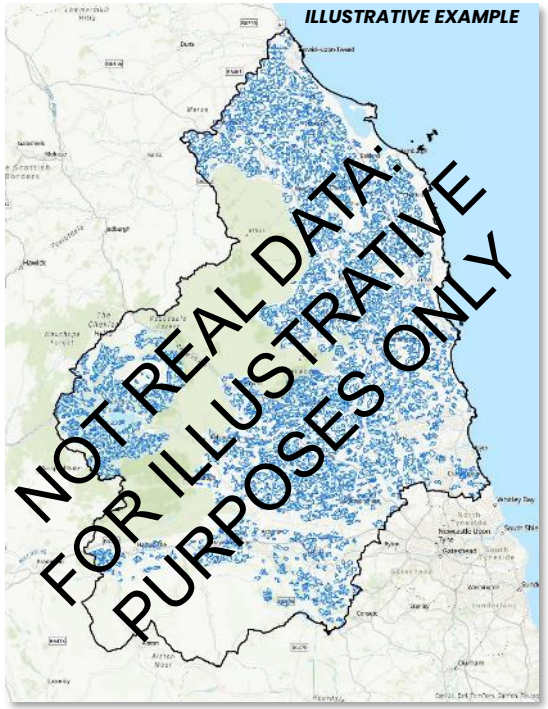
REAL WORLD



SPATIAL DATA LAYERS



SPATIAL EXCLUSION



POTENTIAL DEVELOPABLE AREA

Note: spatial data will be aggregated and analysed at the economic zonal level

NESO National Energy System Operator

Removing areas of Spatial Exclusion from our analysis

POTENTIAL DEVELOPABLE AREA

GEOSPATIAL

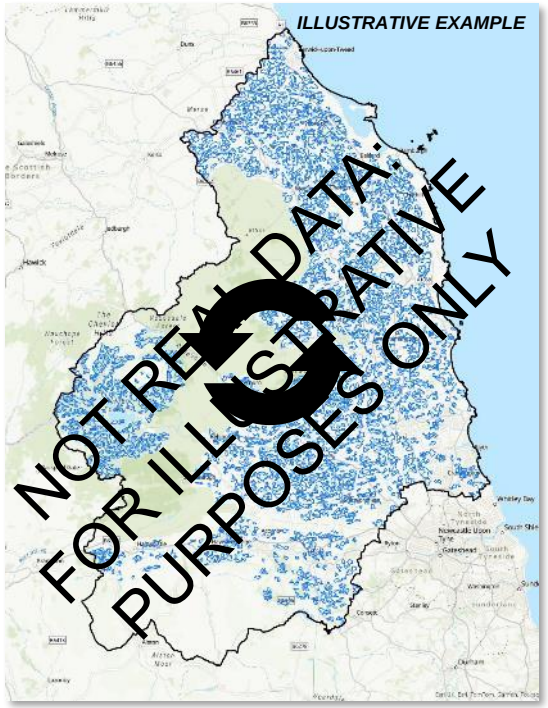
ENVIRONMENTAL

SOCIETAL

OTHER SPATIAL USES

TECHNOLOGY DESIGN ENGINEERING REQUIREMENTS

REVIEW MAPS, ITERATE IF REQUIRED



UPDATED POTENTIAL DEVELOPABLE AREA

Convert "potential developable area" to inputs for Economic Modelling.

(Calculation to convert area into generation yield in GW for each technology, yet to be defined)

MAXIMUM GENERATION PER TECH PER ZONE

Note: spatial data will be aggregated and analysed at the economic zonal level

NESO National Energy System Operator

Modelling pathways co-optimisation

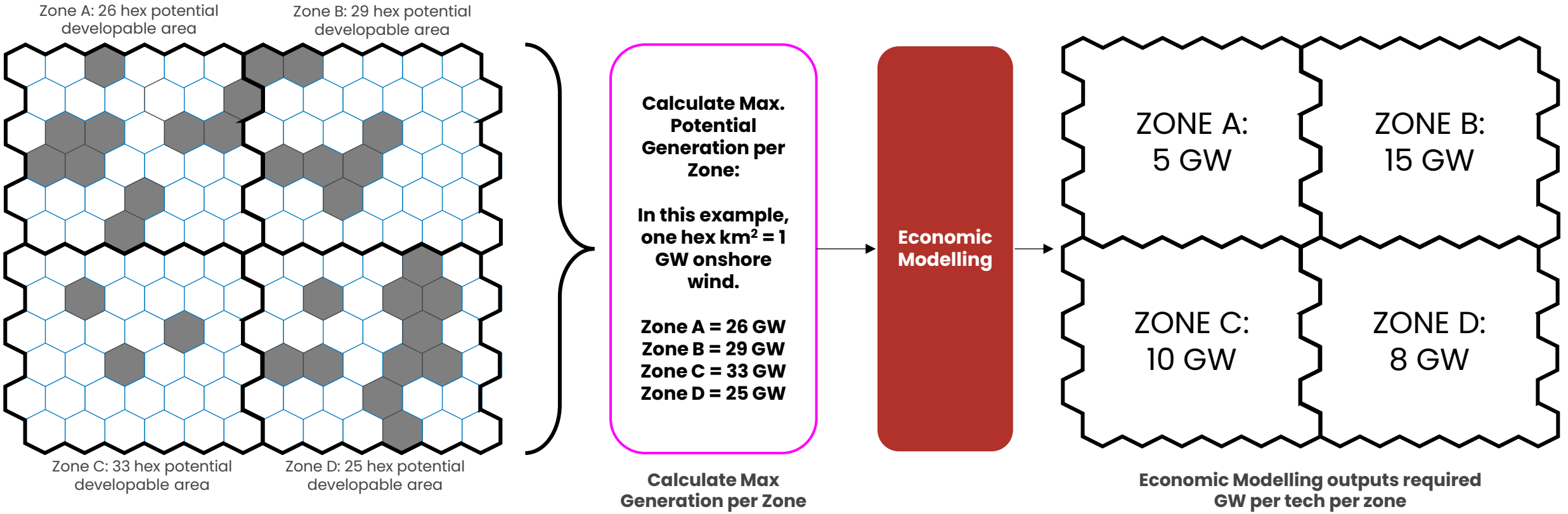


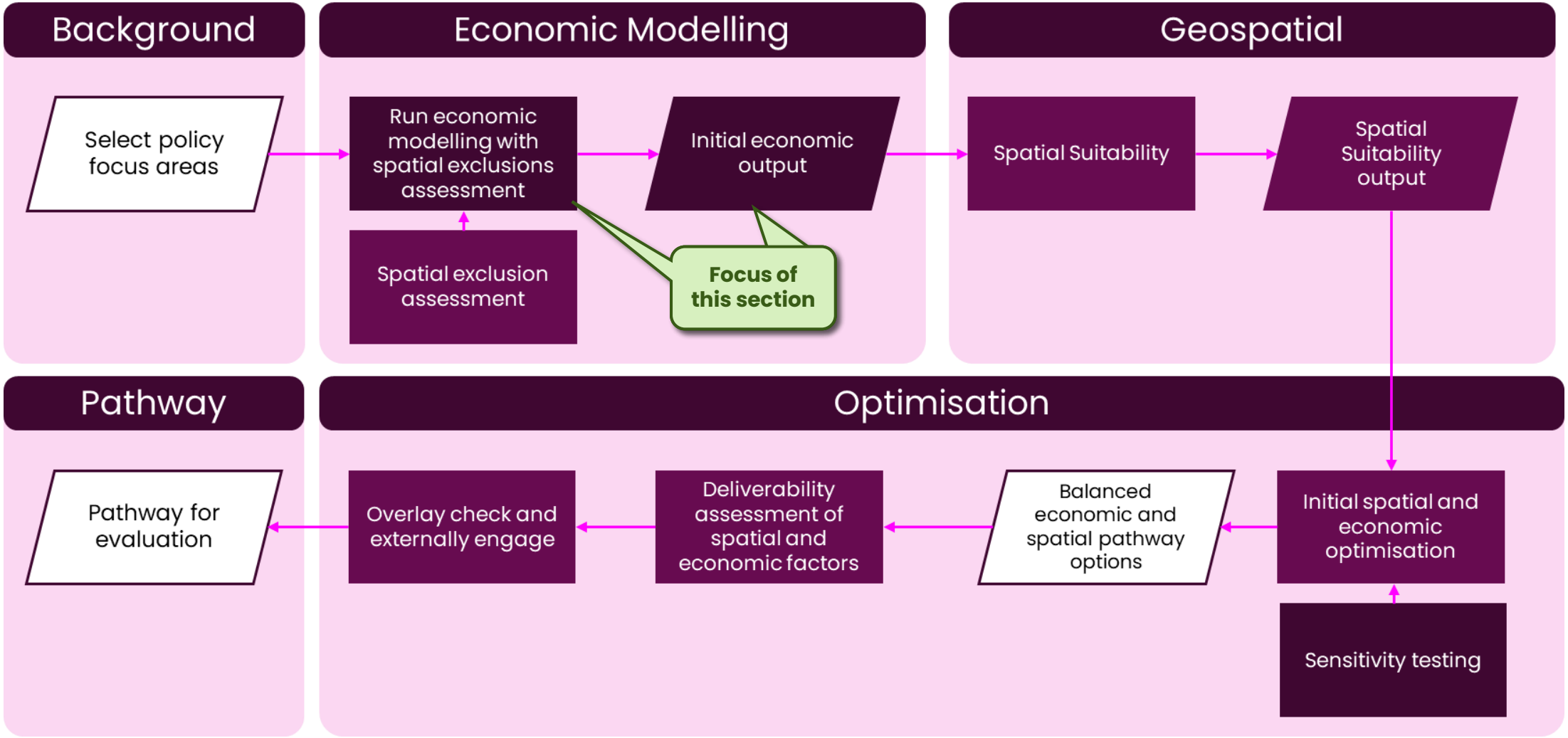
Diagram for Illustrative purposes

Initial economic modelling

Tomas Poffley

NESO
National Energy System Operator

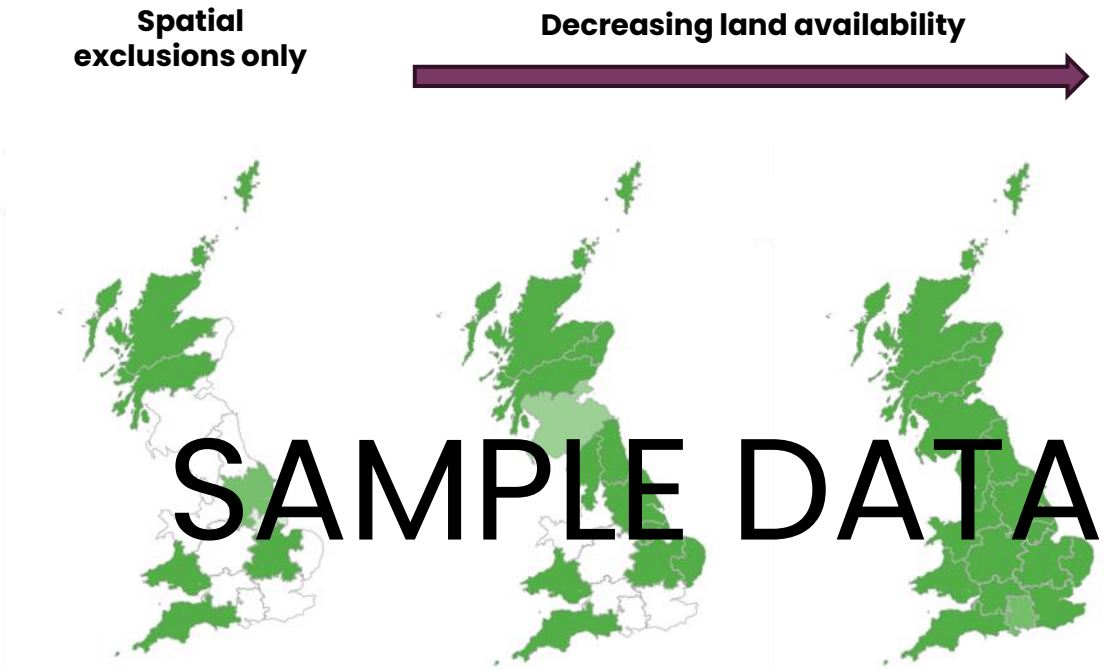
Modelling flow



Initial Economic Outputs

- With only spatial exclusions included, the initial 17 zone results are expected to be “blocky” in their spatial allocation of new assets
- The results are however still useful as they show the preferred location for new infrastructure prior to layering in more geospatial data
- The figure to the right shows example outputs and how they’re expected to change further into the process once we have factored in geospatial constraints and opportunities

Simplified example: Spatial allocation



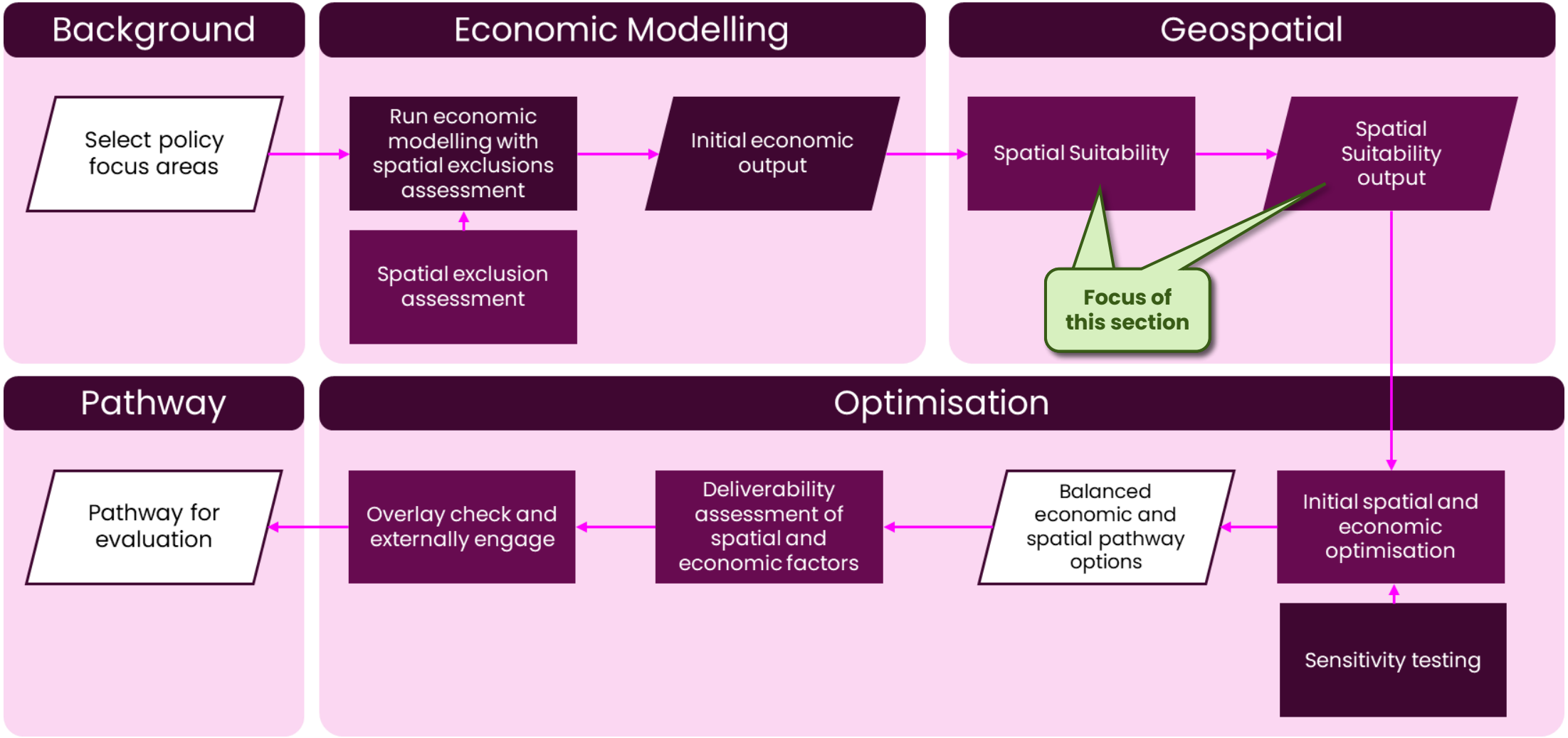
Final outputs will be dependant on the balance struck between optimising for geospatial opportunities and total system costs. This is discussed in the next section.

NESO National Energy System Operator

Spatial Suitability

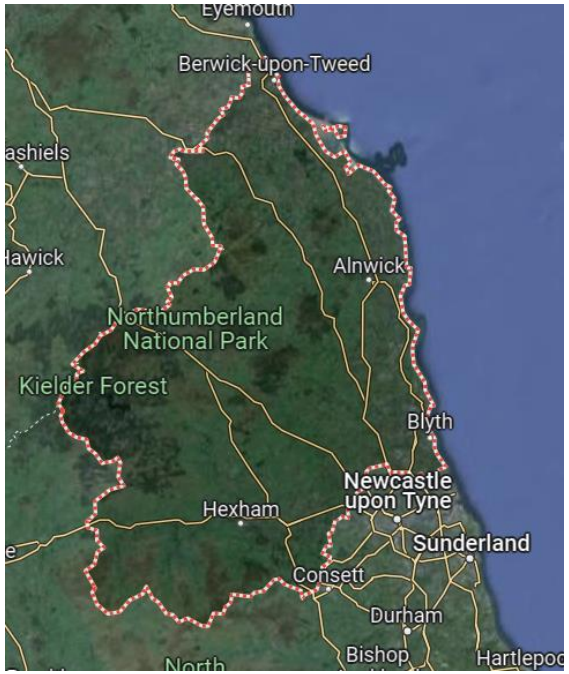
Richard England

Modelling flow



NESO National Energy System Operator

Identify spatial factors* that preclude the potential development of in-scope infrastructure



REAL WORLD

***Spatial factors:** A feature, object, activity or process within a given space or area.*

Technology Design Engineering Requirements	Environmental	Societal	Other Spatial Uses
Spatial Exclusion • 1 • 2 • 3 • 4	Spatial Exclusion • 1 • 2 • 3 • 4	Spatial Exclusion • 1 • 2 • 3 • 4	Spatial Exclusion • 1 • 2 • 3 • 4
Spatial Opportunity • 1 • 2 • 3 • 4 • 5 • 6	Spatial Constraint • 1 • 2 • 3 • 4 • 5 • 6	Spatial Constraint • 1 • 2 • 3 • 4 • 5 • 6	Spatial Constraint • 1 • 2 • 3 • 4 • 5 • 6

Spatial Exclusion: a spatial factor* that precludes the potential siting of in-scope energy infrastructure due to relevant physical, legal and land and sea use restrictions.

Deliverable achieved: identification of exclusion areas, where potential siting of in-scope energy infrastructure is not possible.

Spatial Constraint: a spatial factor* that may, to varying degrees, limit the potential siting of in-scope energy infrastructure.

Deliverable achieved: identification of 'push' factors, helping to determine optimal spatial location of in-scope energy infrastructure.

Spatial Opportunity: A spatial factor* that may, to varying degrees, support the potential siting of in-scope energy infrastructure.

Deliverable achieved: identification of 'pull' factors, helping to determine optimal spatial location of in-scope energy infrastructure.

NESO National Energy System Operator

SSEP Spatial Evaluation Framework Multi-Criteria Analysis

The SSEP Spatial Evaluation Framework will use a modified-Multi-Criteria Analysis (MCA) method to identify, compare and combine spatial factors across the 4 main pillars.

MCA hierarchy for conceptualising scoring and weighting

Pillars
(environment, society, technical engineering design requirements and other spatial uses)

Categories in each pillar
(e.g. landscape, and ecology and biodiversity, within environment pillar, health & wellbeing and recreation & tourism within society pillar)

Subcategories in each category
(e.g. landscape designations within landscape category, recreational routes within recreation category)

Indicators in each subcategory

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

Scoring Applied

Descriptors in the **MCA hierarchy** aid with communication, and serve to support **categorisation** (e.g. Pillars, Categories).

Pillars/Categories can be **weighted** as required, to support with data normalisation and consider stakeholder views.

Indicators describe the corresponding metrics.
E.g. Agricultural Land Class
An indicator is a representative of any one spatial factor.

Datasets will be **scored** according to a standardised scoring approach. The **scored dataset** is an SSEP MCA "**Metric**", a fundamental component which enables the MCA process.

A simple yet comprehensive MCA hierarchy enables effective scoring, weighting and communication in support of a transparent and robust SSEP MCA process.

NESO National Energy System Operator

SSEP Spatial Evaluation Framework: Multi-Criteria Analysis

The SSEP Spatial Evaluation Framework will use a **modified-Multi-Criteria Analysis (MCA)** method to identify, compare and combine a vast number of spatial factors across the four main pillars. Scores will be collated and scrutinised through **policy reviews, literature review** and **stakeholder engagement**.

Spatial Constraint "PUSH" factors

Magnitude of Effect

Importance	High (-3)	Medium (-2)	Low (-1)	Negligible (0)
Very high (4)	*Very Large (-12)*	*Large (-8)*	*Moderate (-4)*	*Neutral (0)*
High (3)	*Large (-9)*	*Moderate (-6)*	*Slight (-3)*	*Neutral (0)*
Medium (2)	*Moderate (-6)*	*Moderate (-4)*	*Slight (-2)*	*Neutral (0)*
Low (1)	*Slight (-3)*	*Slight (-2)*	*Low (-1)*	*Neutral (0)*

[1] **Spatial Constraint:** A spatial factor* that may, to varying degrees, limit the potential siting of in-scope energy infrastructure.

Spatial Opportunity[2] "PULL" factors

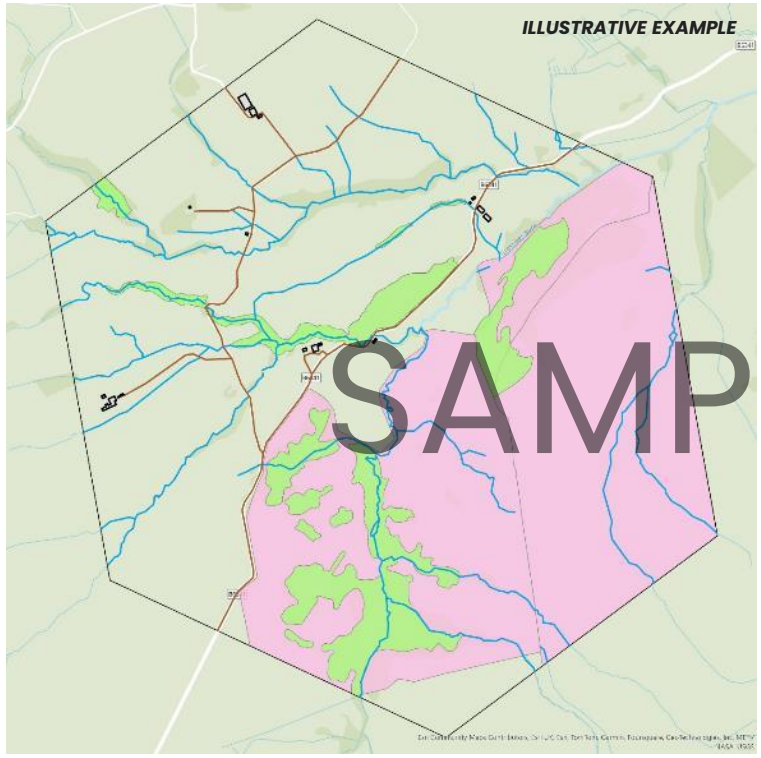
Magnitude of Effect

Significance	Negligible (0)	Low (1)	Medium (2)	High (3)
Very high (4)	*Neutral (0)*	*Moderate (4)*	*Large (8)*	*Very Large (12)*
High (3)	*Neutral (0)*	*Slight (3)*	*Moderate (6)*	*Large (9)*
Medium (2)	*Neutral (0)*	*Slight (2)*	*Moderate (4)*	*Moderate (6)*
Low (1)	*Neutral (0)*	*Low (1)*	*Slight (2)*	*Slight (3)*

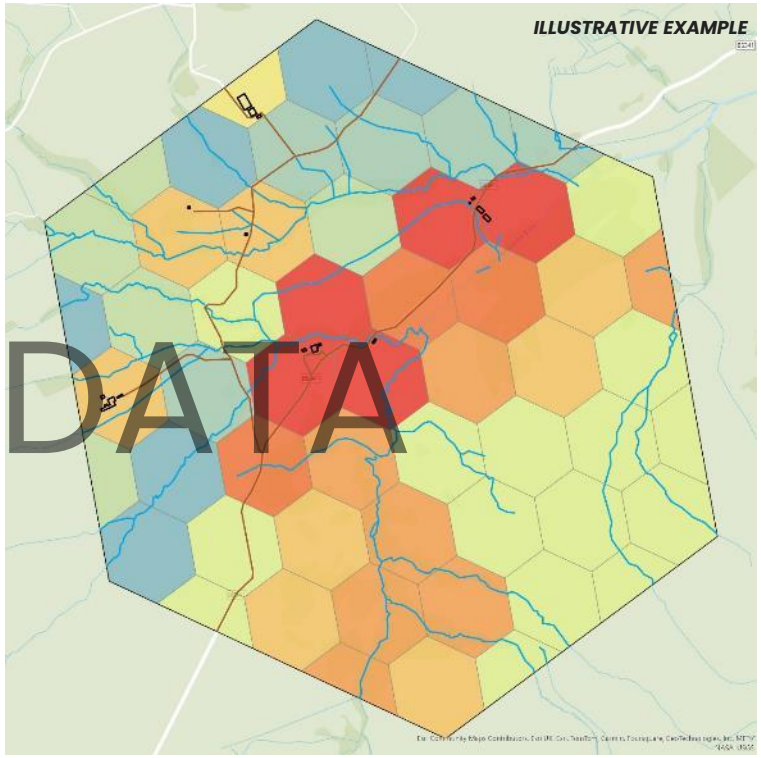
[2] **Spatial Opportunity:** A spatial factor* that may, to varying degrees, support the potential siting of in-scope energy infrastructure.

NESO National Energy System Operator

Geospatial Analysis of Spatial Constraints

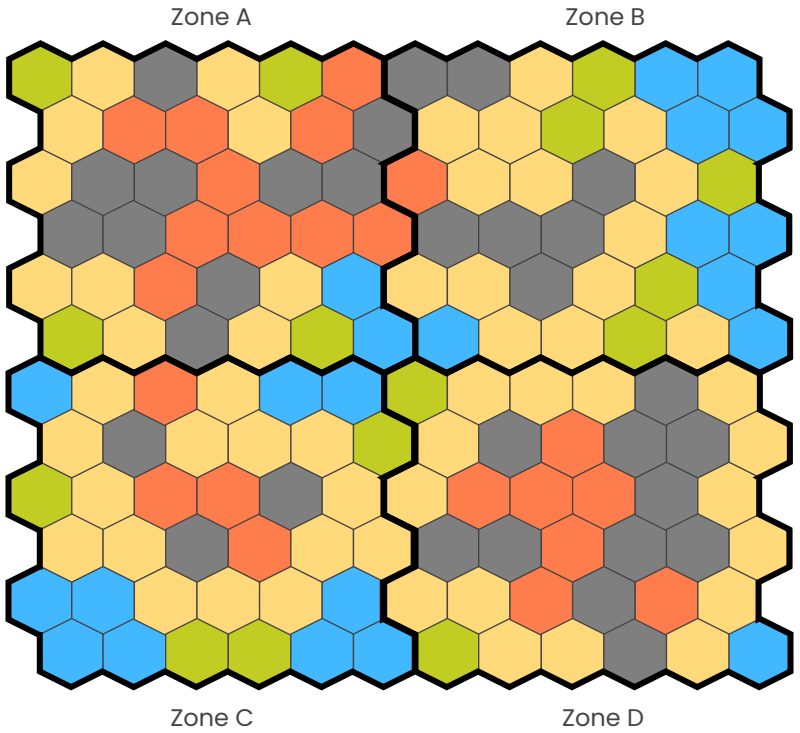


INPUT DATA
POLYGONS / LINES / GRADIENTS



EVALUATION FRAMEWORK OUTPUT AGGREGATED IN HEXAGONAL MESH

Spatial Constraint heatmap outputs to Economic Modelling options



Geospatial Outputs

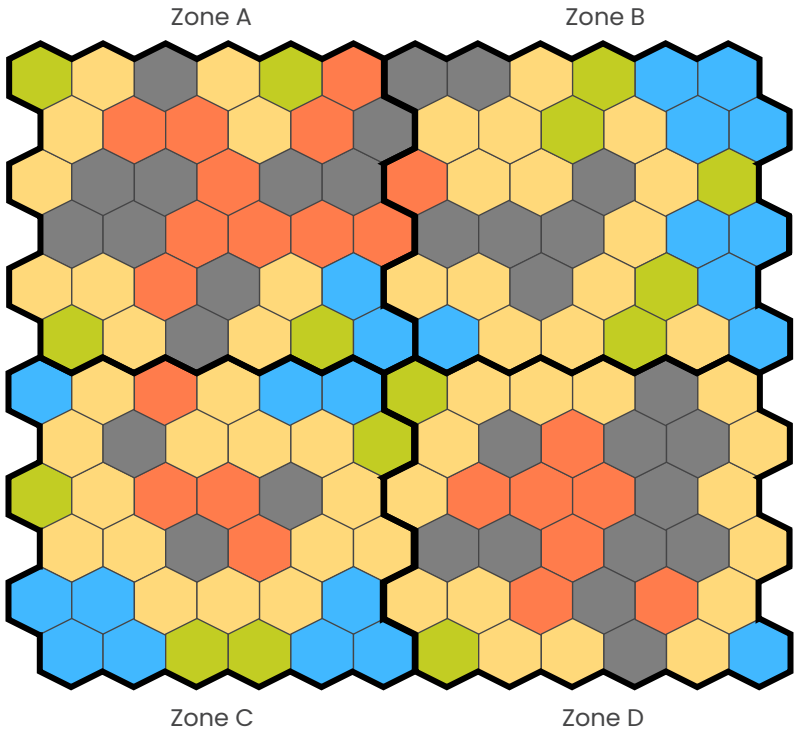
How do we go from heat maps and areas to Economic Modelling inputs?

Option	Description	Uses Excl Economic Modelling outputs?	Facilitates trade-offs	Robust and transparent
1	**50% least constrained areas** Arbitrary cut-off based on constraints	✗	✗	✗
2	**Stochastic model** e.g. Monte Carlo, which uses all Spatial Constraints but doesn't exclude any areas	✗	✗	✓
3	**Balanced soft constraint cut-off** balancing "what the Economic Model wants" against Spatial Constraint heat maps to inform qualitative or quantitative Spatial Constraint cut-off	✓	✓	✓

Diagram for Illustrative purposes

NESO National Energy System Operator

Spatial Constraint heatmap outputs to Economic Modelling options



Geospatial Outputs

How do we go from heat maps and areas to Economic Modelling inputs?

Option	Description	Uses Excl Economic Modelling outputs?	Facilitates trade-offs	Robust and transparent
1	**50% least constrained areas** Arbitrary cut-off based on constraints	✗	✗	✗
2	**Stochastic model** e.g. Monte Carlo, which uses all Spatial Constraints but doesn't exclude any areas	✗	✗	✓
3	**Balanced soft constraint cut-off** balancing "what the Economic Model wants" against Spatial Constraint heat maps to inform qualitative or quantitative Spatial Constraint cut-off	✓	✓	✓

Example follows

Diagram for Illustrative purposes

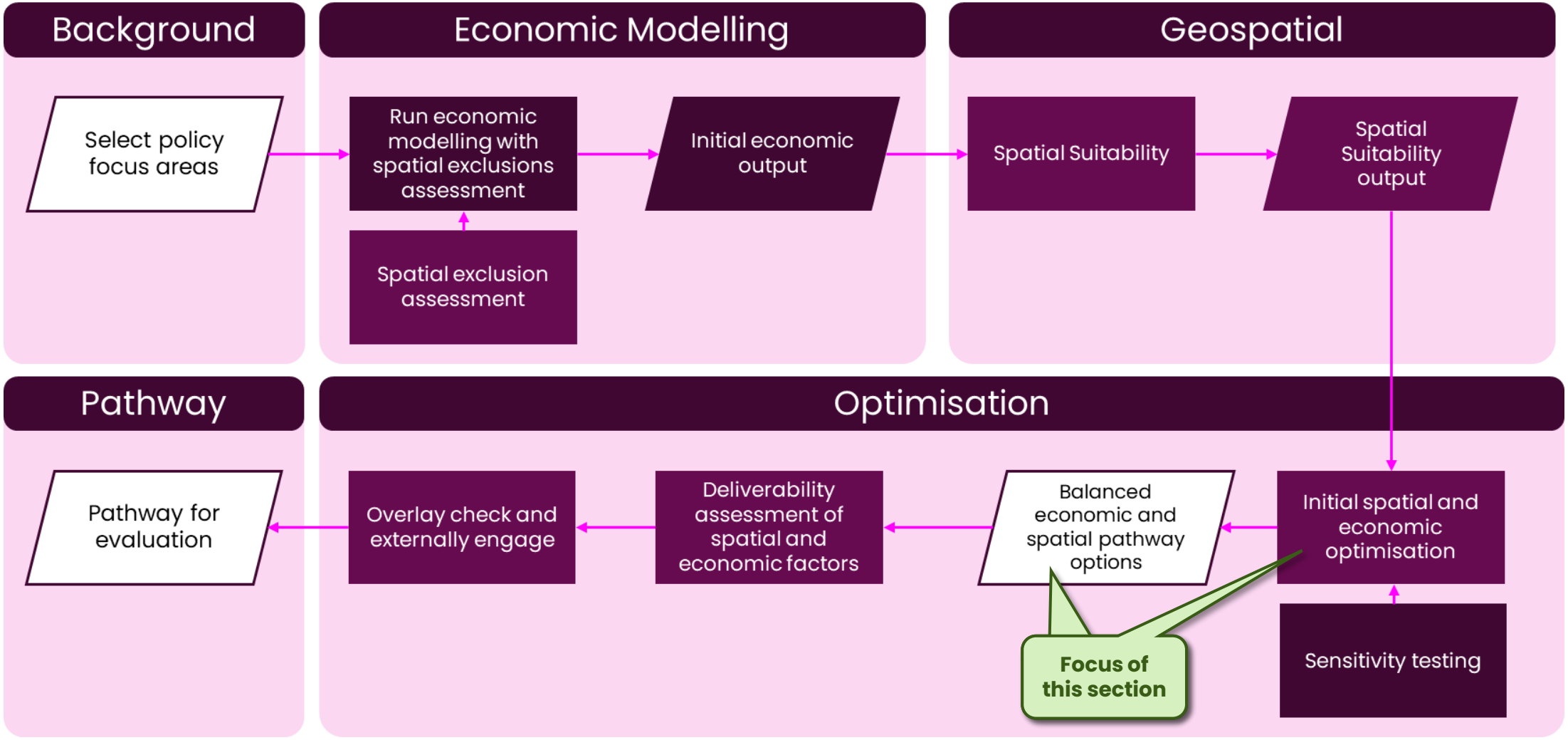
NESO National Energy System Operator

Integrated Modelling

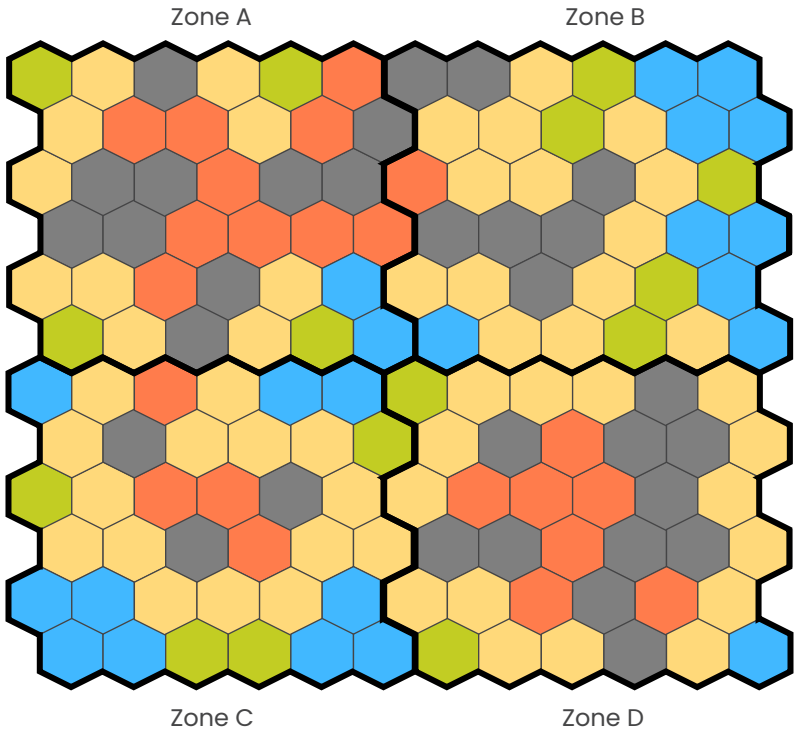
Richard England

NESO
National Energy System Operator

Modelling flow



Balancing Spatial Constraint cut-off against required generation per zone



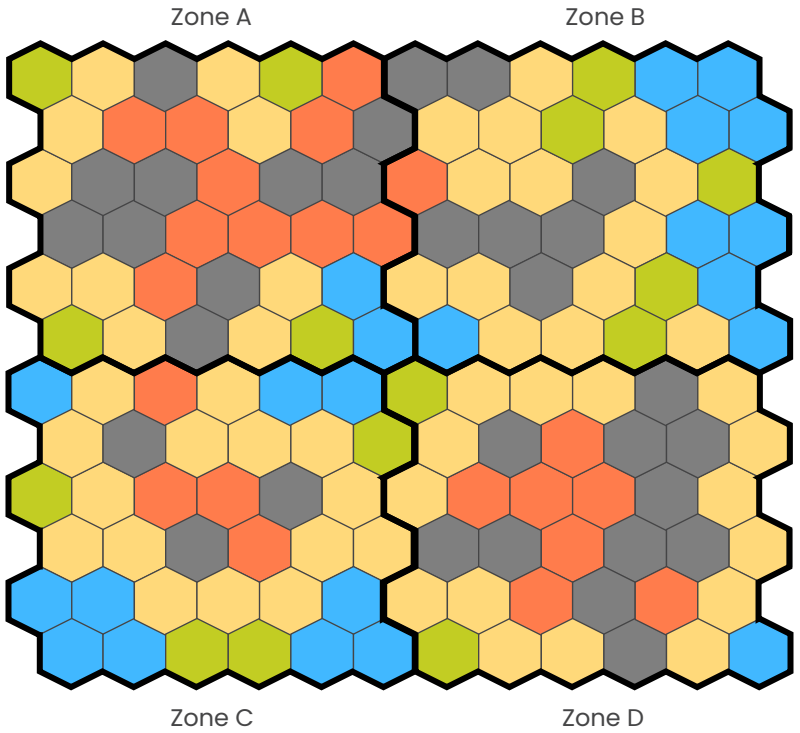
Geospatial Outputs

Impact on Spatial Constraints	Zone A (5 GW req)	Zone B (15 GW req)	Zone C (10 GW req)	Zone D (8 GW req)	Trade-offs required?
Low impact ⬢	2 GW	10 GW	9 GW	1 GW	✓
Medium impact ⬢ + ⬢	6 GW	14 GW	14 GW	3 GW	✓
High impact ⬢ + ⬢ + ⬢	16 GW	28 GW	29 GW	18 GW	✗
Full impact ⬢ + ⬢ + ⬢ + ⬢	26 GW	29 GW	33 GW	25 GW	✗

Diagram for Illustrative purposes

NESO National Energy System Operator

Balancing Spatial Constraint cut-off against required generation per zone



Geospatial Outputs

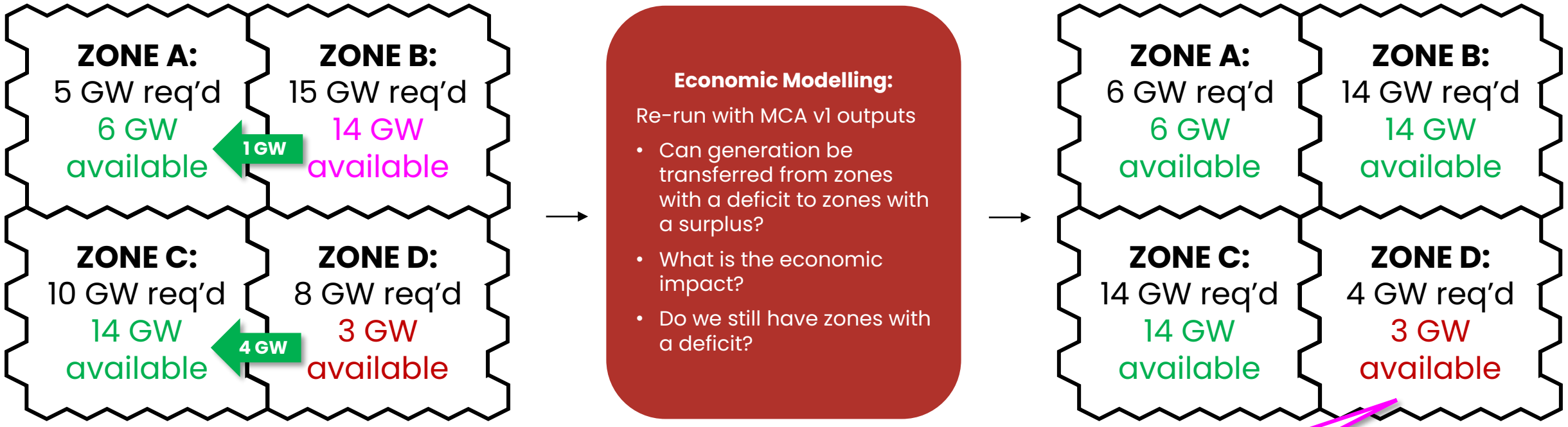
Impact on Spatial Constraints	Zone A (5 GW req)	Zone B (15 GW req)	Zone C (10 GW req)	Zone D (8 GW req)	Trade-offs required?
Low impact	2 GW	10 GW	9 GW	1 GW	✓
Medium impact	6 GW	14 GW	14 GW	3 GW	✓
High impact	16 GW	28 GW	29 GW	18 GW	✗
Full impact	26 GW	29 GW	33 GW	25 GW	✗

Balance impact on Spatial Constraints vs outputs from Economic Modelling hard constraint runs

Diagram for Illustrative purposes

NESO National Energy System Operator

Economic model impacts of transferring generation between zones

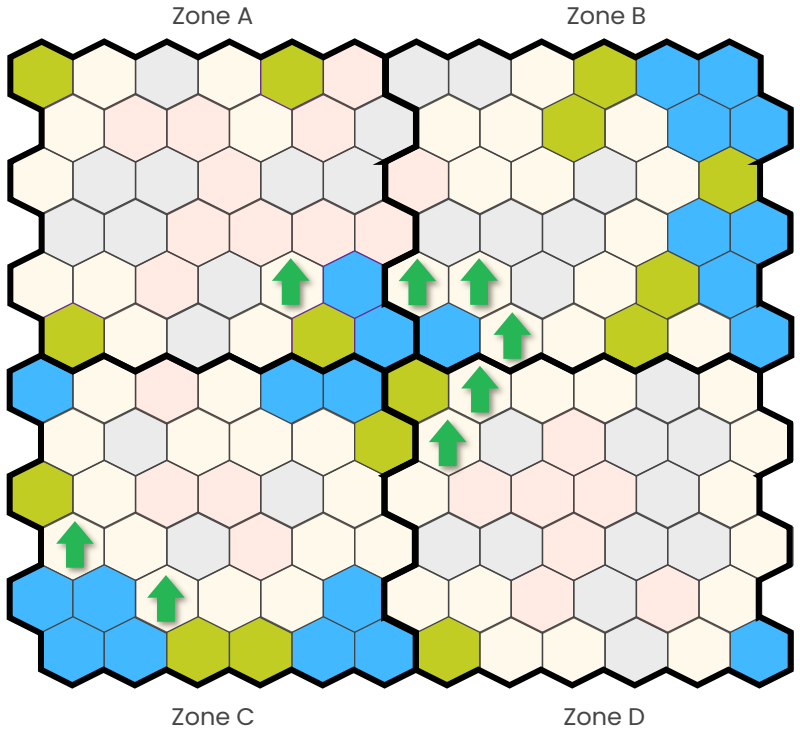


Spatial Suitability Cut-Off Outputs

Diagram for Illustrative purposes

NESO National Energy System Operator

Iterate geospatial analysis of Spatial Constraints – MCAv2



Spatial Suitability cut-off adjusted GB wide

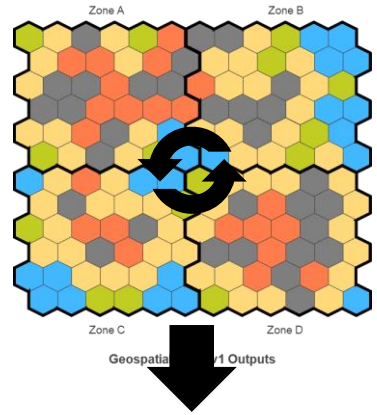
ZONE A:
6 GW req'd
6 GW available

ZONE B:
14 GW req'd
14 GW available

ZONE C:
14 GW req'd
14 GW available

ZONE D:
4 GW req'd
3 GW available

Integrate Economic Modelling outputs after Spatial Suitability (what we can and can't move between zones with deficit vs surplus)



Impact on soft constraints	Zone A (5 GW req)	Zone B (15 GW req)	Zone C (10 GW req)	Zone D (8 GW req)	Trade-offs required?
Low impact	2 GW	10 GW	9 GW	1 GW	✓
Medium impact	6 GW	[illegible] GW	14 GW	3 GW	✓
High impact	16 GW	28 GW	29 GW	18 GW	✗
Full impact	26 GW	29 GW	33 GW	25 GW	✗

Iterate geospatial analysis by applying new cut-offs

Diagram for Illustrative purposes

NESO National Energy System Operator

Finding a balanced outcome that minimises impact on cost and Spatial Constraints

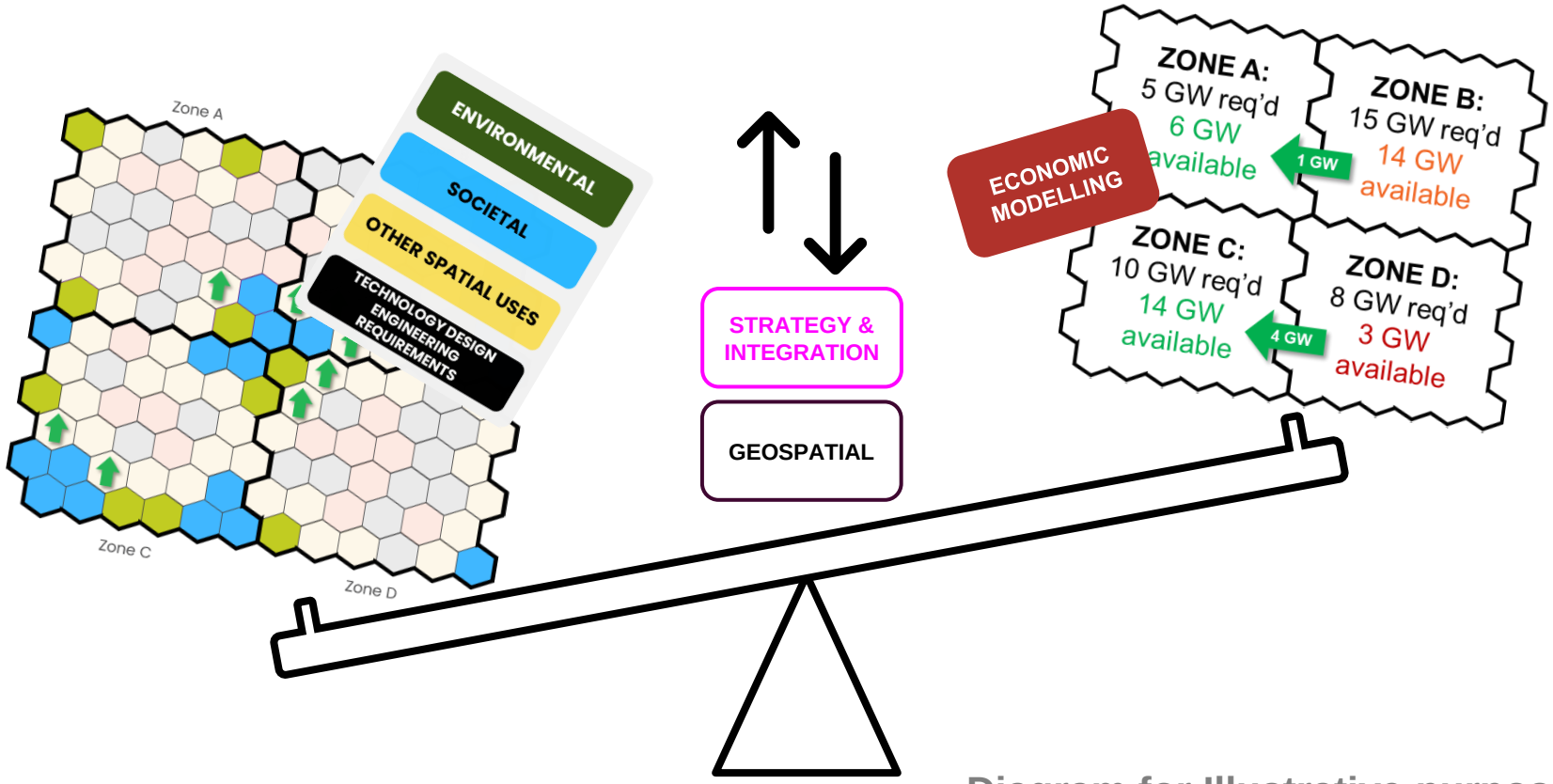


Diagram for Illustrative purposes

NESO National Energy System Operator

Finding a balanced outcome that minimises impact on cost and Spatial Constraints

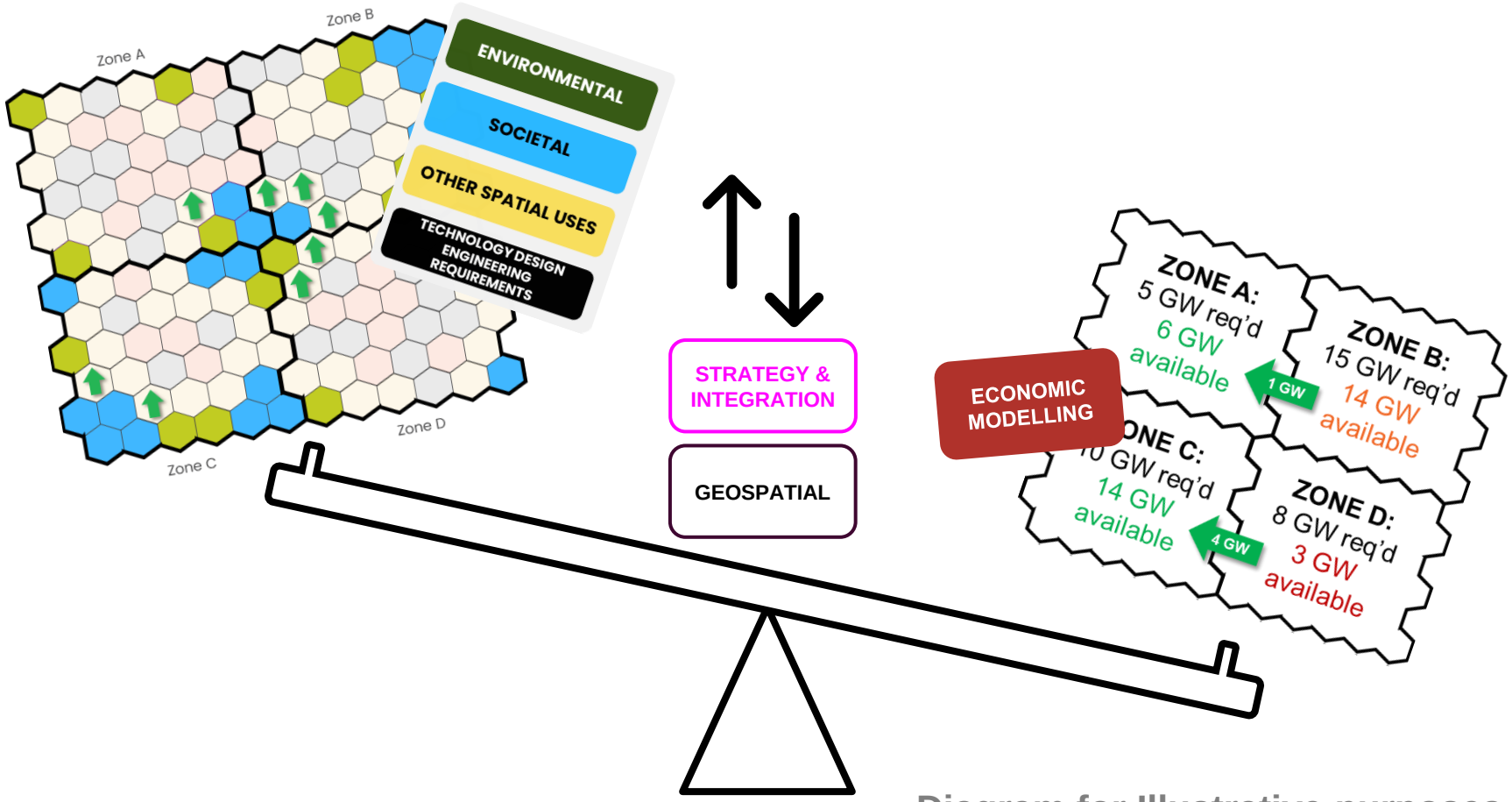


Diagram for Illustrative purposes

NESO National Energy System Operator

Finding a balanced outcome that minimises impact on cost and Spatial Constraints

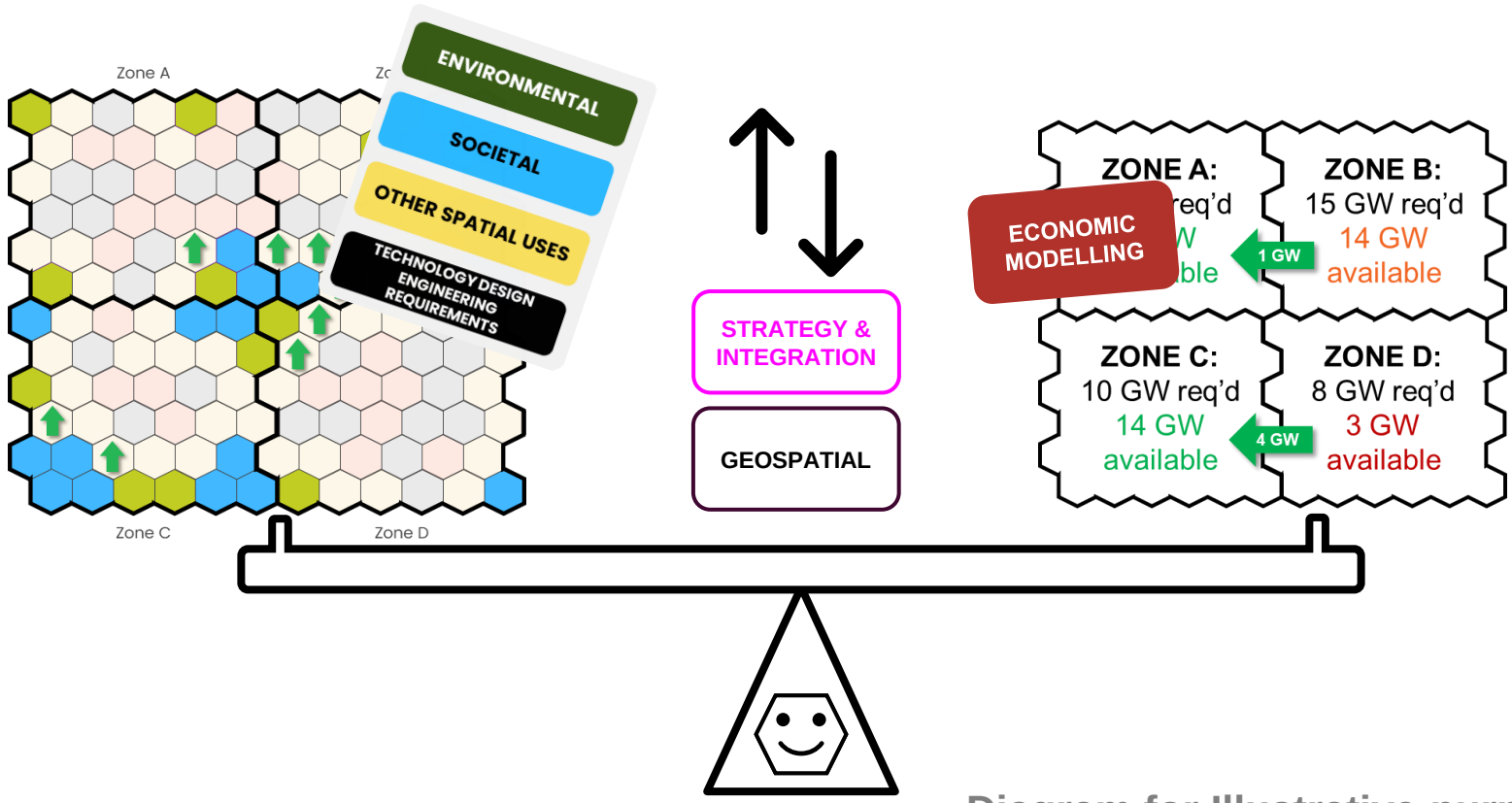


Diagram for Illustrative purposes

NESO National Energy System Operator

SSEP Modelling Outputs

Tomas Poffley

NESO
National Energy System Operator

SSEP Modelling Outputs

Once modelling is complete, NESO will present 4-6 pathway options to the UK Energy Secretary for selection of one for consultation

Outputs will include:

- Maps of a spatial energy pathway
- Projected optimal locations for future electricity generation and storage
- Projected optimal locations for future hydrogen production and storage
- Key narratives on the factors driving the results

These will differ against the different demand growth and major policy assumptions assumed in the inputs

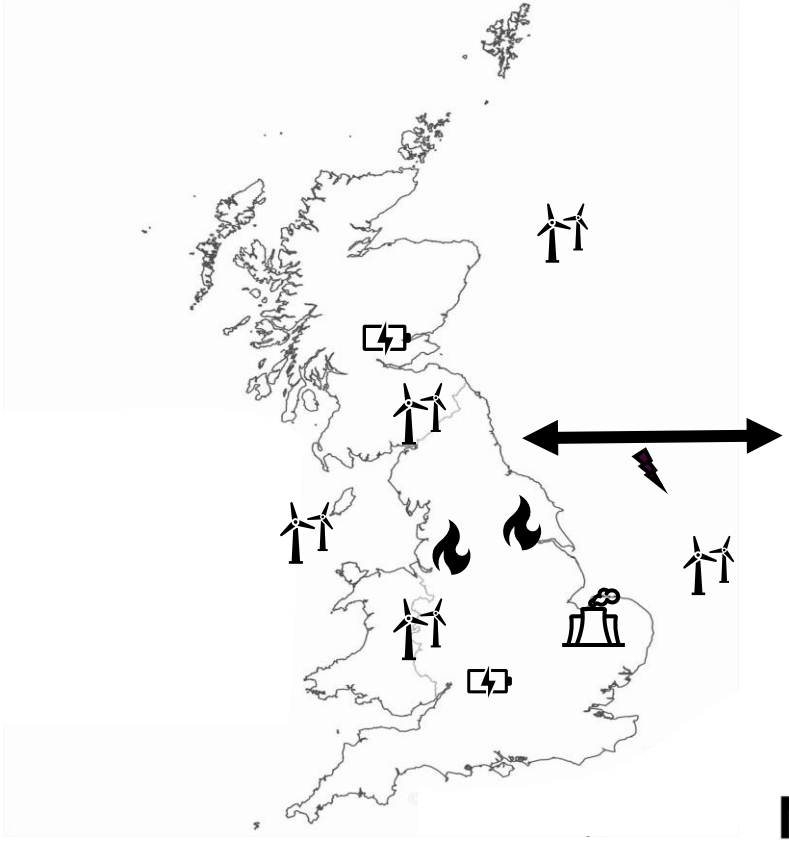
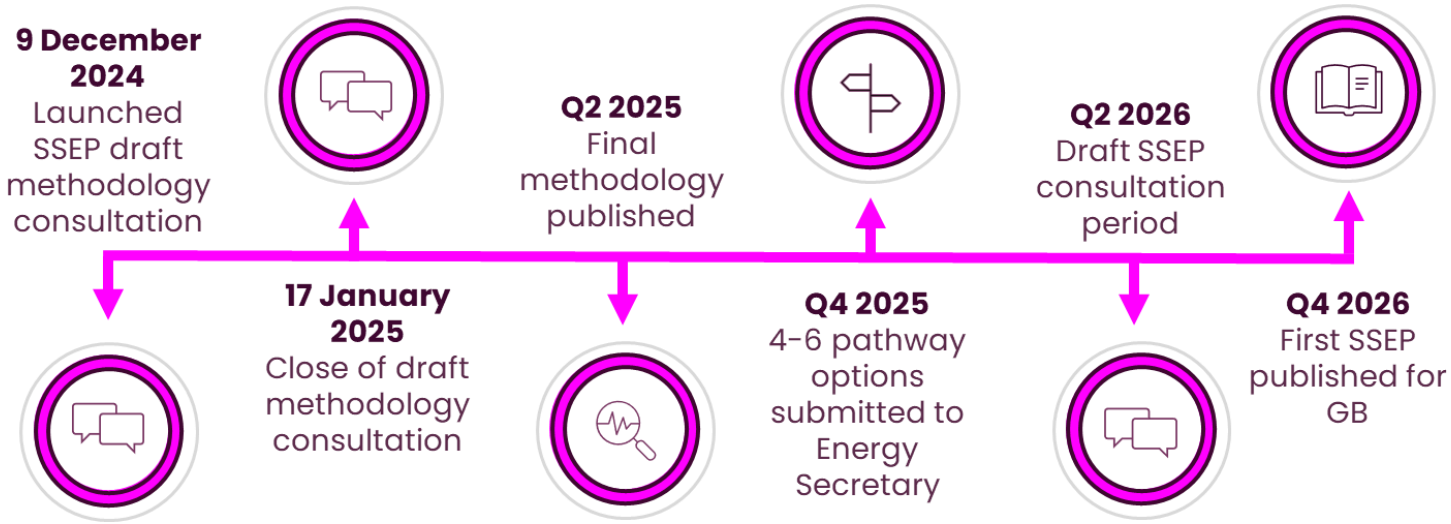


Diagram for Illustrative purposes

NESO National Energy System Operator

Next steps



Stay informed

box.ssep@nationalenergyso.com

www.neso.energy/what-we-do/strategic-planning

Subscribe to our newsletter

NESO National Energy System Operator

Public

Q&A

Please ask questions about the technical webinar via sli.do code: **#SEPTECH**

NESO
National Energy System Operator

Thank you

You can contact the team by emailing box.SEP-engagement@nationalenergyso.com