Offshore Co-ordination Project

Technical webinar
4 August 2020

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Agenda

1. Introduction (5 minutes)
2. Offshore coordinated conceptual designs applied to GB network and impact of technology availability and barriers on network designs (60 minutes)
3. Q&A session (25 minutes)
4. Next steps (5 minutes)

Many thanks for joining. Please stay on mute and keep cameras off as we are recording this session. If you have any questions as we present please add them to the chat function – we will cover these in the Q&A sections

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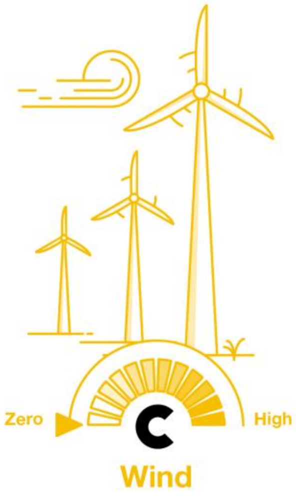
Why are we looking at this?



Government net-zero commitments:
- 40 GW of offshore wind by 2030
- 75 GW of offshore wind by 2050

Department for Business, Energy & Industrial Strategy
- Offshore Transmission Network Review (July 2020)

Ofgem decarbonisation action plan
- “Exploring options a more coordinated offshore transmission system to connect offshore wind generation, to achieve a rapid and economic expansion of the offshore network”
- “As a first step we will work with the ESO to ensure it can take forward an options assessment for offshore transmission”

Potential benefits of a new approach
- Issues now with the impact on coastal communities of the current radial approach
- Questions around cost-effectiveness above current levels

Scope 1 workstreams and what we are speaking to you about today

These are our four phase 1 workstreams that need to take place at the beginning of the larger programme to inform later workstreams and the scale of potential benefits. We will consider our role in areas such as commercial and regulatory barriers as we scope phase 2.

1) Technology readiness and cost for offshore integration

2) Offshore conceptual design, impact on Onshore Network and cost benefit analysis

3) A review of the offshore connections process to encourage more coordination

4) Gap analysis and review of existing work, leading to scope of potential second phase

Plus collaborative stakeholder engagement

Offshore Networks: Enabling the Technology, GB Implementation & Power System Analysis findings

NG ESO Offshore Coordination Project

4 August 2020

Agenda

1. Introduction
2. Technology Availability and Overcoming Barriers
3. Offshore Network Design
   - Method
   - North Scotland & Irish sea case studies
   - Hybrid Interconnection Integration – South
4. Power System Analysis
   - Method
   - North Scotland & Irish Sea Case Studies
   - Overall GB system findings
5. Conclusions and Next Steps

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1. Introduction

2050 Net Zero Emissions Target – A New Scale of Challenge?

Focus for this project:

- ❑ Identifying and assessing approaches for holistic (onshore and offshore) transmission system development
- ❑ Managing change is not new, but the step change in pace required is a new scale of challenge
- ❑ Developing and analysing design options to assess suitability of the proposed structured approach to accommodate onshore and offshore variables and to facilitate delivery of the 2050 challenge

OFFSHORE VARIABLES

- ❑ Offshore development areas identified with defined zonal capacity limits
- ❑ Specific project details are yet to be decided
  - ➢ Who? Where? Size? When?

ONSHORE VARIABLES

- ❑ Existing onshore transmission system continues to evolve:
  - ➢ Strategic developments (NOA, FES)
  - ➢ Customer driven (connections)
  - ➢ Asset replacement

Basis for design options: the conceptual building blocks

HVAC (2 options)	**HVAC** with HVDC (1 option)	**HVDC** (4 options)
• Integrated HVAC and HVAC at lower frequency	• Integrated HVAC with parallel HVDC	• Symmetrical monopole, Bipole HVDC with return cable, multi-ended HVDC and meshed HVDC

Stakeholder Feedback

Key Themes

- HVAC Technology Design Solutions
- Explore possible enhanced HVAC options
- Barriers in SQSS
- Application of technical and non-technical KPIs
  - Assess onshore impact particularly for local communities
- Technology options
  - Immediate future
  - Future developments

Actions we have taken

- Use of radial HVAC design building block as a counterfactual for analysis
- Investigation of integrated HVAC as well as HVAC/HVDC combi design options
- SQSS limitations have been flagged:
  - SQSS governance arrangements allow for specific modification proposals to be raised
- KPIs have been applied and onshore impacts assessed as part of our analysis of region specific design options.

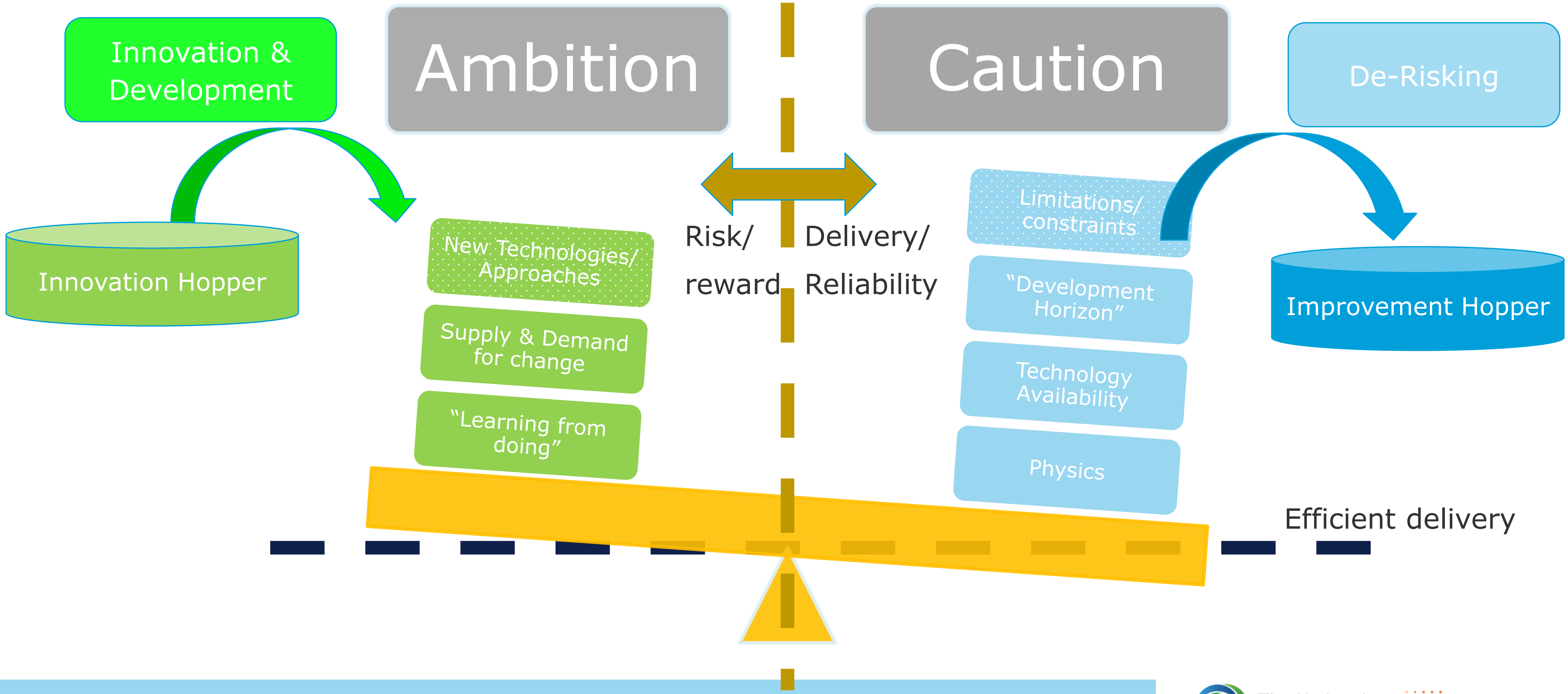
Technology options – expected to be a changing picture

RECOMMENDATION
Ongoing review of:

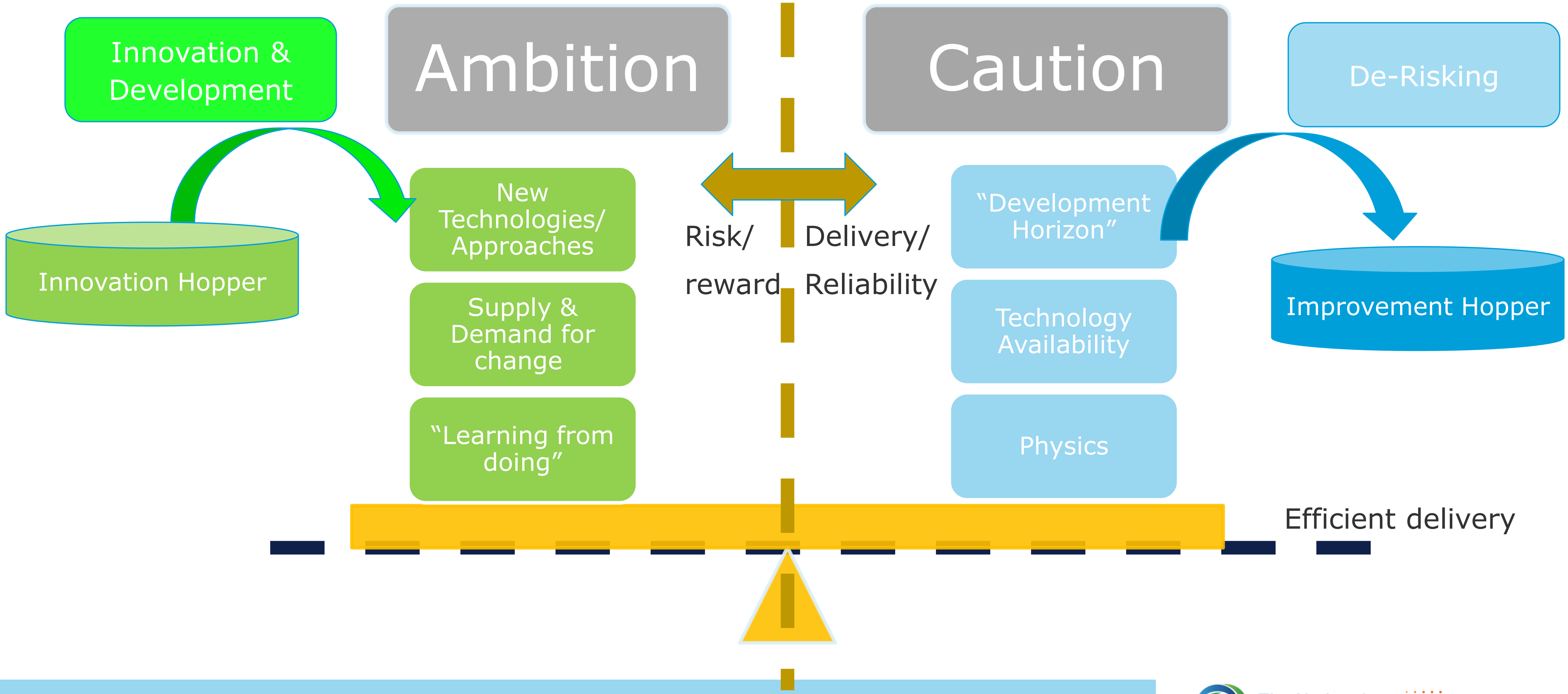
- what is available
- what will come soon
- what is yet uncertain but is expected to offer benefits and solve existing issues.

2. Technology Availability and Barriers

Technology Availability and Barriers – A Balancing Act



Technology Availability and Barriers – A Balancing Act



Conceptual Design TRL Level, Illustrative KPIs, and Levers for Change

Topologies

Illustrative KPIs

	T1. Integrated HVAC at 50Hz	T2. HVAC at lower frequency	T3. HVAC with parallel HVDC	T4. Point-to-point Symmetrical Monopole HVDC	T5. Bipole HVDC with parallel AC	T6. Radial multi-terminal HVDC	T7. Meshed multi-terminal HVDC system
Security of supply	Yes	Due to low TRL	Yes	Yes	Yes	Yes	Yes
Maximum Capacity	About 1.2GW, with cables each rated 400MW at 220kV AC.	Not available at scale	Limited by AC link capacity.	Limited by HVDC cables. Power ratings up to 4GW and ±800kV DC voltage available by 2030. Also, subject to existing SQSS offshore infeed limit of 1.32GW.			
Transmission Distance	Typically, 80-200km. Limited to coastal landings.	Up to 400km	Offshore distance limited by parallel AC link	Typically, up to and beyond 400km		Suitable for interlinking across different offshore zones.	
Boundary Capacity Benefits	No due to limitation of AC power flow control capability	No due to limitation of AC power flow control capability	Possible in one power flow direction	Yes. Bi-directional flows possible.	Yes	No for interconnector with T-design. Yes, for H-design with minimum of two onshore landing points.	
Technology Readiness	Mature	Low	Existing	Existing	Onshore project experience exists	Control, protection and offshore HVDC switchgear developments	
TRL (to 2030)	8-9	2-3	9	9	7-8	5-7	4-6

Overcome through Innovation strategy

Overcome through Development strategy

Overcome through Industry code review

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Overcoming Barriers

Recommendations

Update legislation to allow for integration of offshore assets

Update regulatory framework rules for development of offshore grids

1320MW-> 1800MW maximum infeed loss risk limit increase for offshore

Standardisation of offshore infrastructure

Improve maturity of technology:

- HVDC XLPE cables > 320 kV
- HVDC converters ≥ 1000 MW
- DCCBs
- multi-vendor, multi-terminal solutions
- HVDC GIS

Actions

Engage with relevant stakeholders

Initiate updates to the regulatory framework rules

Co-ordinated Process between industry, end users and standards organizations

Co-ordinated functional specification

Final commercial design and qualification tests against industrial standards and norms for technologies

Identify and support potential pilot projects

Implementing these Integrated Offshore Technologies:

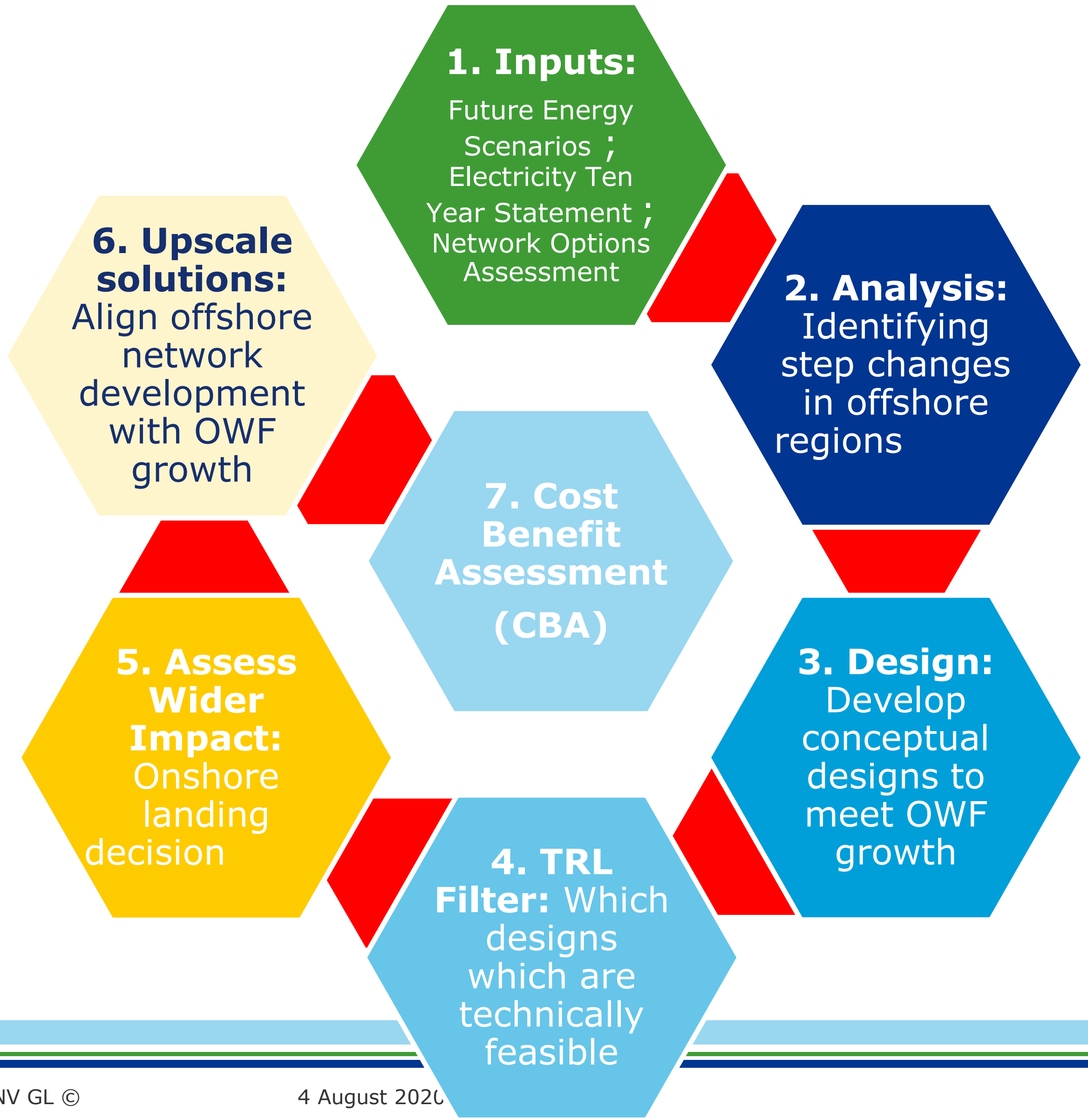
Innovation Strategy	Development Strategy	De-Risking	Outputs
• Identify new conceptual design efficiencies • Focus Research effort	• Develop designs- towards GB application • Identify "quick wins" • Progress interoperability	• Update codes & standards • Enable Composite testing & design	**2020-24: Begin the delivery** Act to remove barriers and adopt further integrated thinking into BAU activities.
• Recommend new areas of development & trial • Implementation review	• New testing of modular technologies & their control • Build supply chain	• In-service Verification of models & plant • Integrated GB operation	**2024-2030: Build and grow the capability** Implement the full opportunities available today, whilst developing the capability to go beyond that.
• Identify new opportunity areas • Monitor Technology status	• Capture innovation and standards opportunities • "Learn from doing" areas of refinement	• Refined testing and design approaches • EU integration	**2030-2035: Enhance the approach** Implement the optimisations envisaged today, demonstrate and review efficiencies.
• Improve focus • Improve development handover	• better capture innovation and "learning from doing"	• Improve code, standards and process clarity from experience	**2035-2050 Sustain Pace** Monitor technology development, realise opportunities for ongoing efficiencies
• Reviewing, identifying and evolving technologies to develop efficient solutions	• Delivery & in service Support of Flexible, efficient and interoperable solutions	• Capabilities, Tools,Techniques and Standards	**2050 realise the goal** Efficient offshore development, integrated into onshore network, limiting community impacts, meeting targets.

3. Offshore Network Design

Key Elements of Developing Offshore Networks

Counterfactual – Project by project transmission build up	Integrated - Transmission asset sharing enabled
▪ Year-on-year requirement individually	▪ Anticipates future requirements
▪ Considers point-to-point offshore network connections only	▪ Includes multi-terminal/meshed HVDC and HVAC options
▪ Individual project optimisation and transmission (HVAC or HVDC) decision	▪ Whole system optimisation and transmission technology decision
▪ Onshore grid and offshore network designs are separate	▪ Considers effect on onshore system in offshore design
▪ Interconnector separately designed and connected	▪ Interconnector / bootstrap capacity shared by OWF
▪ Local community impacts managed project by project	▪ Overall local community impacts considered

Method Statement



Our Approach

- Inputs are changing regularly
- Analyse pace of offshore wind growth for counterfactual & integrated transmission
- Develop 8 conceptual designs using HVAC and HVDC technologies
- Use technology readiness & appropriateness as filter for designs
- Identify wider benefits for onshore system using detailed designs & Power System Analysis
- Determine asset count – and combine with unit costs for Cost Benefit Assessment (CBA).

Design Considerations

Key Inputs

- Installed capacity of OWF per year between 2025 & 2050 (Source: FES2020)
- Transmission distance from offshore zones to shore (Source: Crown Estate & Marine Scotland)
- Offshore wind load factors (Source: FES2020)
- Onshore Reinforcement options (Source: NOA)
- Interconnector load factors (Source: NOA)
- Onshore Boundary Transfer Requirement (Source: ETYS)

FES Scenarios

ETYS

SRF: ESO calculates and circulates Boundary Transfer Requirement

ESO receives options to meet requirements

NOA

OWF growth per zone

Onshore landing decision

Onshore network background

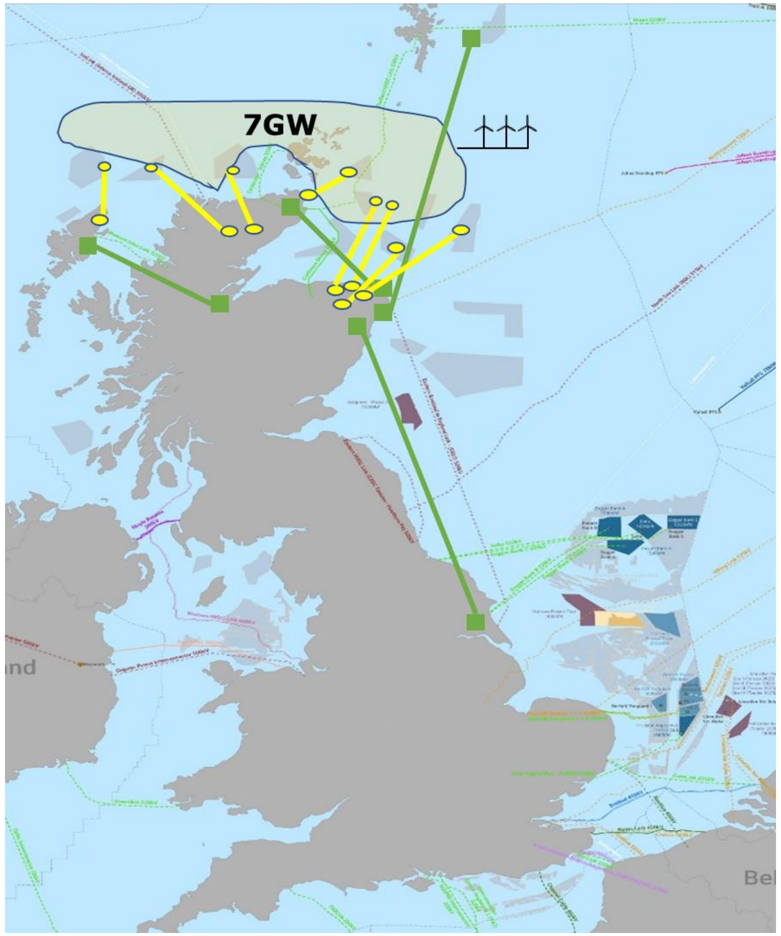
Transmission Distances from OWF to shore → **Transmission Technology decision (HVAC or HVDC)** → **Conceptual Offshore Network Designs & Sequential Build Options**

Load factors: Offshore Wind Farms ; Interconnectors & Onshore Reinforcements

Offshore & Onshore Network Coordination

North Scotland Case Study: 2030 view to support installed offshore wind capacity between 2025 to 2031

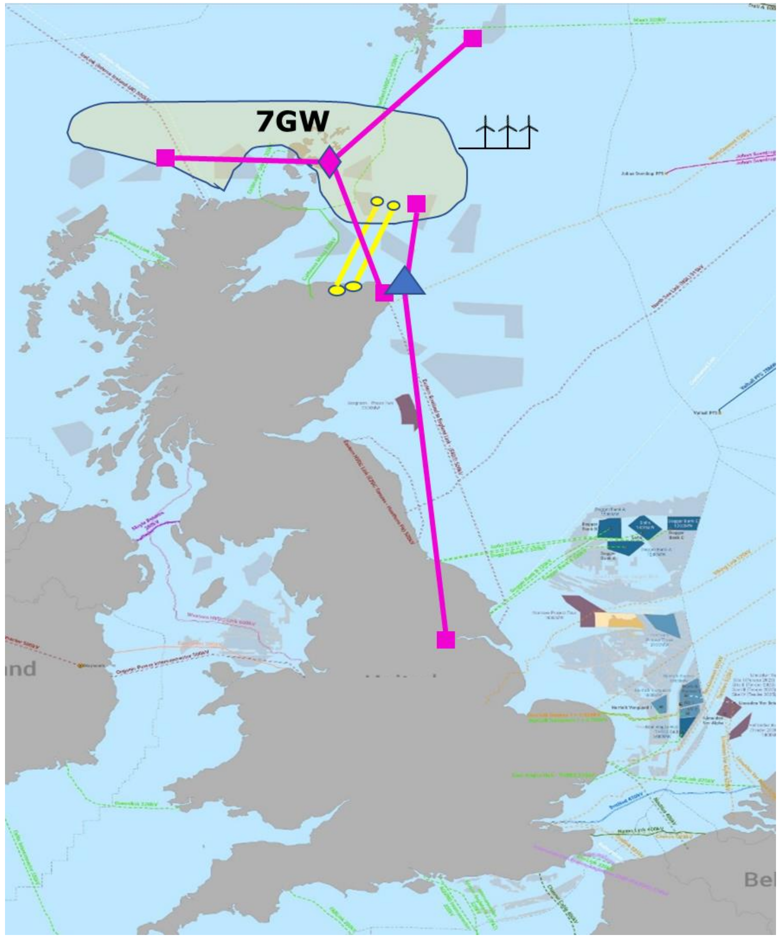
Counterfactual



Legend

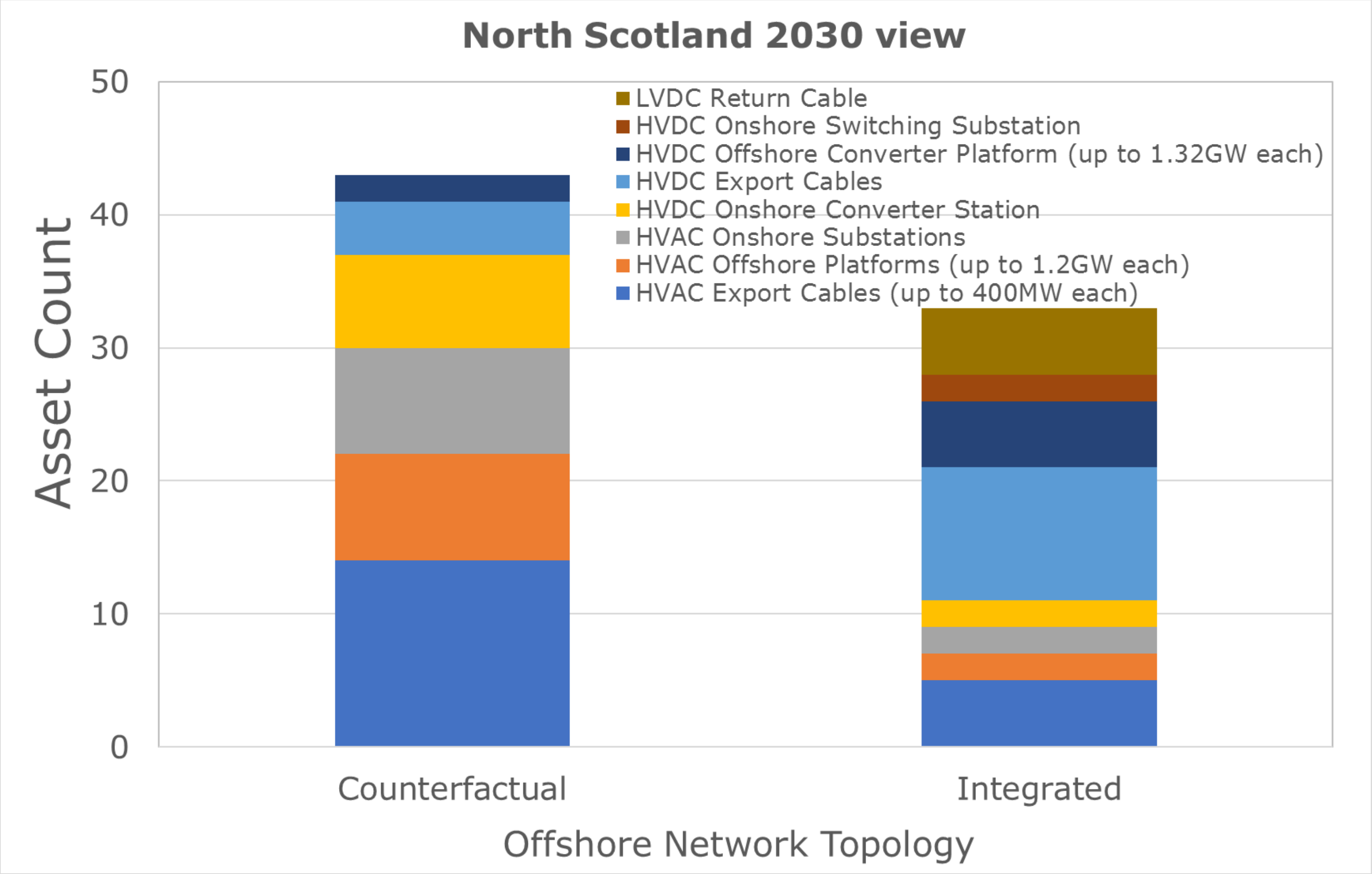
- HVDC Point-to-Point Link
- HVAC Integrated
- Multiple Windfarms
- HVDC Multi-terminal
- Meshed HVDC Substation
- HVDC Island Switching Station

Integrated



13 onshore landings for counterfactual reduced to 5 onshore landings in integrated network option.

Asset Count: North Scotland 2030 View



Key Outputs

- ❑ Integrated offers up to 60% reduction in number of onshore cable landings & substations than counterfactual.

Assumptions for Asset Count

- ❑ Turbine to collector hub infrastructure are same for both integrated and counterfactual option

General Comments

- ❑ Asset shown for illustration – full scale of asset requirements is provided for CBA assessment of savings.

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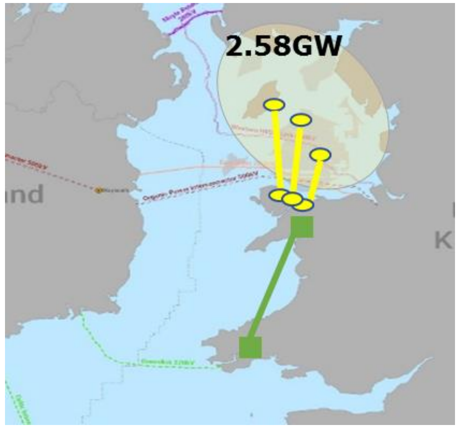
North Wales & Irish Sea Case Study: 2030 view to support installed offshore wind capacity between 2025 to 2032

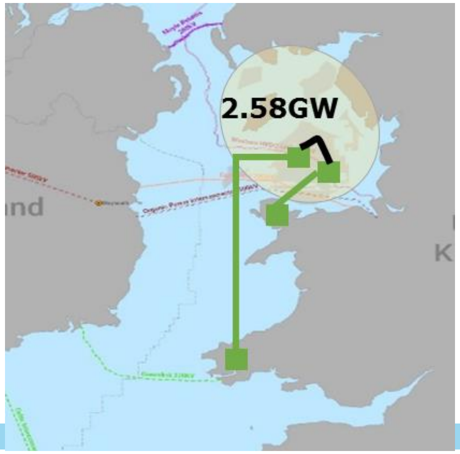
Counterfactual



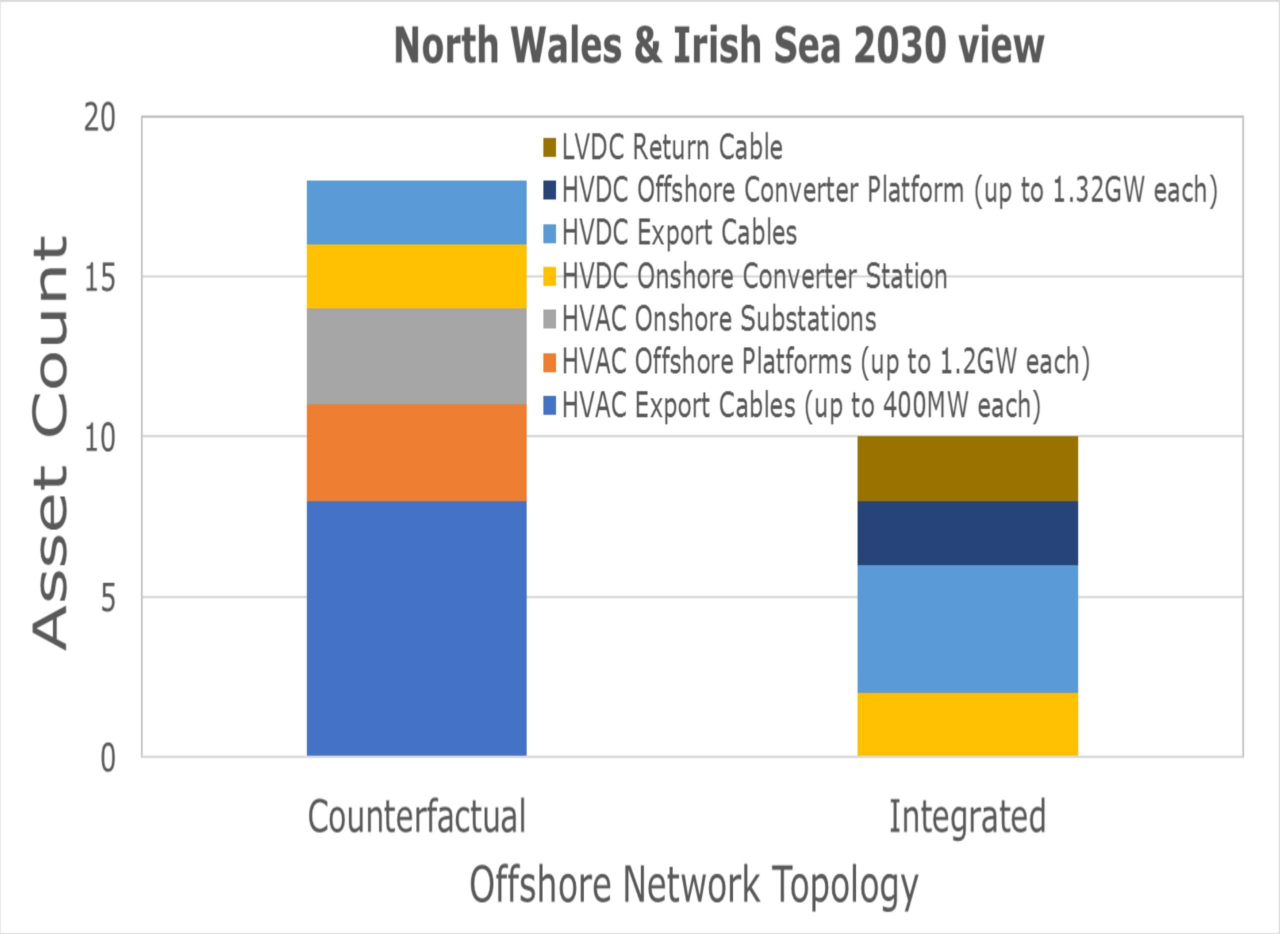
Key

- HVDC Point-to-Point Link
- HVAC Integrated
- Multiple Windfarms
- HVAC Interlink

Integrated



More onshore landings required for counterfactual (5) compared to integrated (2).



4. Power System Analysis

Impact of Coordinated Offshore Design on the Onshore Network?

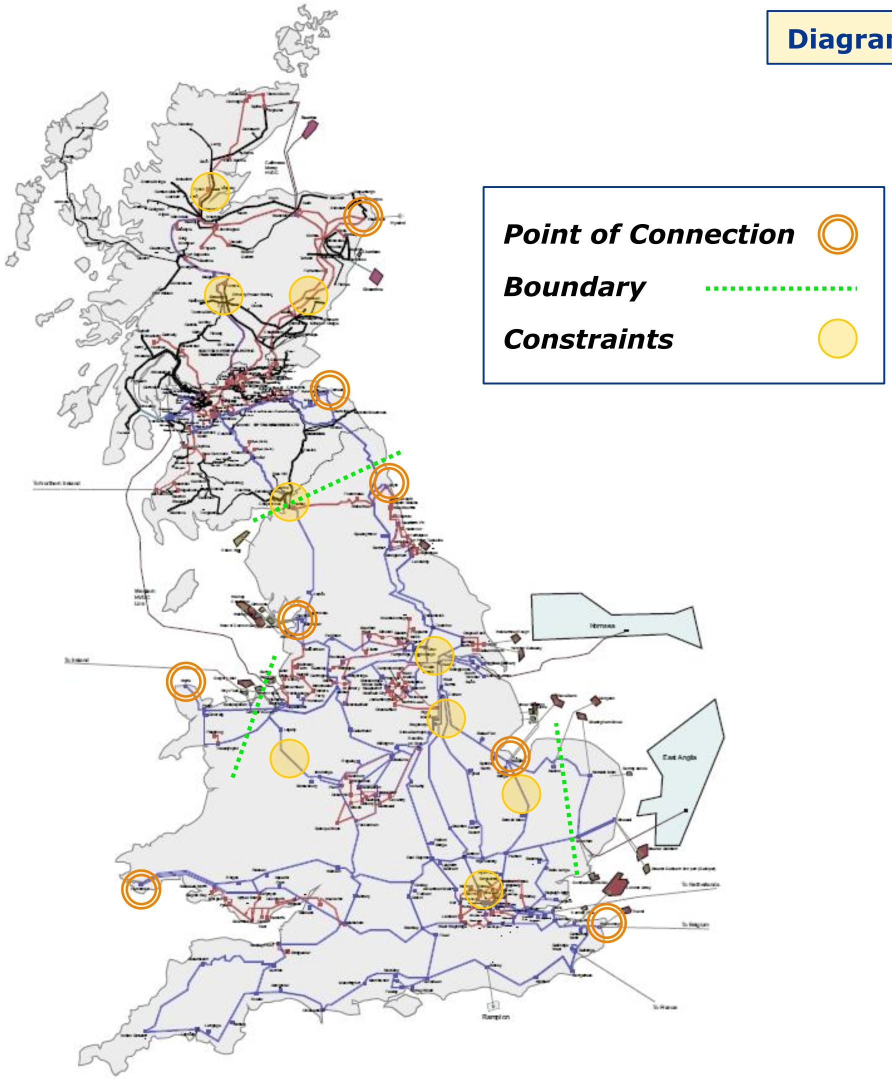
Diagram provided for illustration purposes only

Onshore Boundaries

- Power flows onshore?
- Network constraints?
- Reinforcements required?

System operation

- Network losses?
- Voltage profiles?
- Dynamic behaviour?
- Fault response?



Study Approach

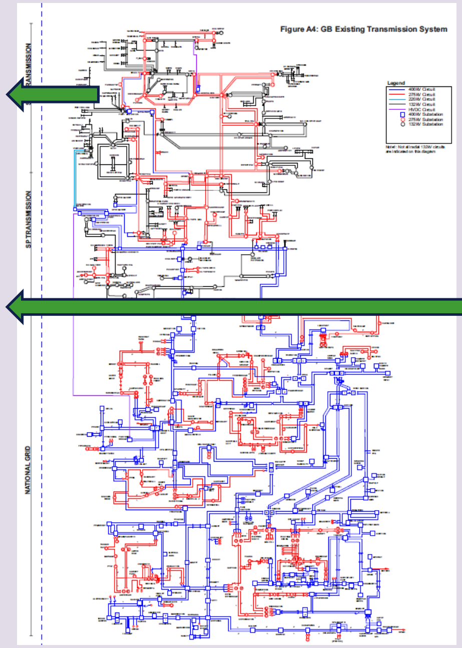
- Offshore wind capacity
- Interconnector load factors

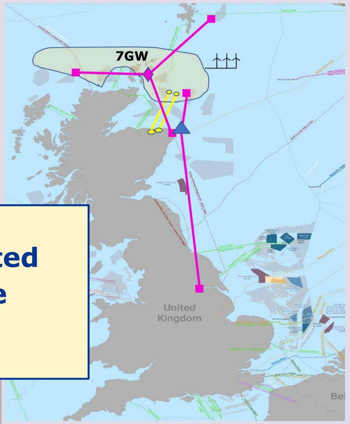
- Planned reinforcements

- GB’s simulation model

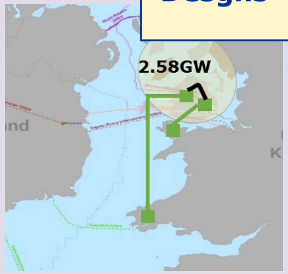
- Points of connection
- Power injection [MW]

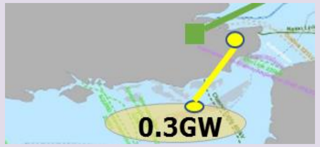
Inputs





Integrated
Offshore
Desgns





Simulations

- Power flows
  (i.e. steady-state)
- Dynamics only qualitatively

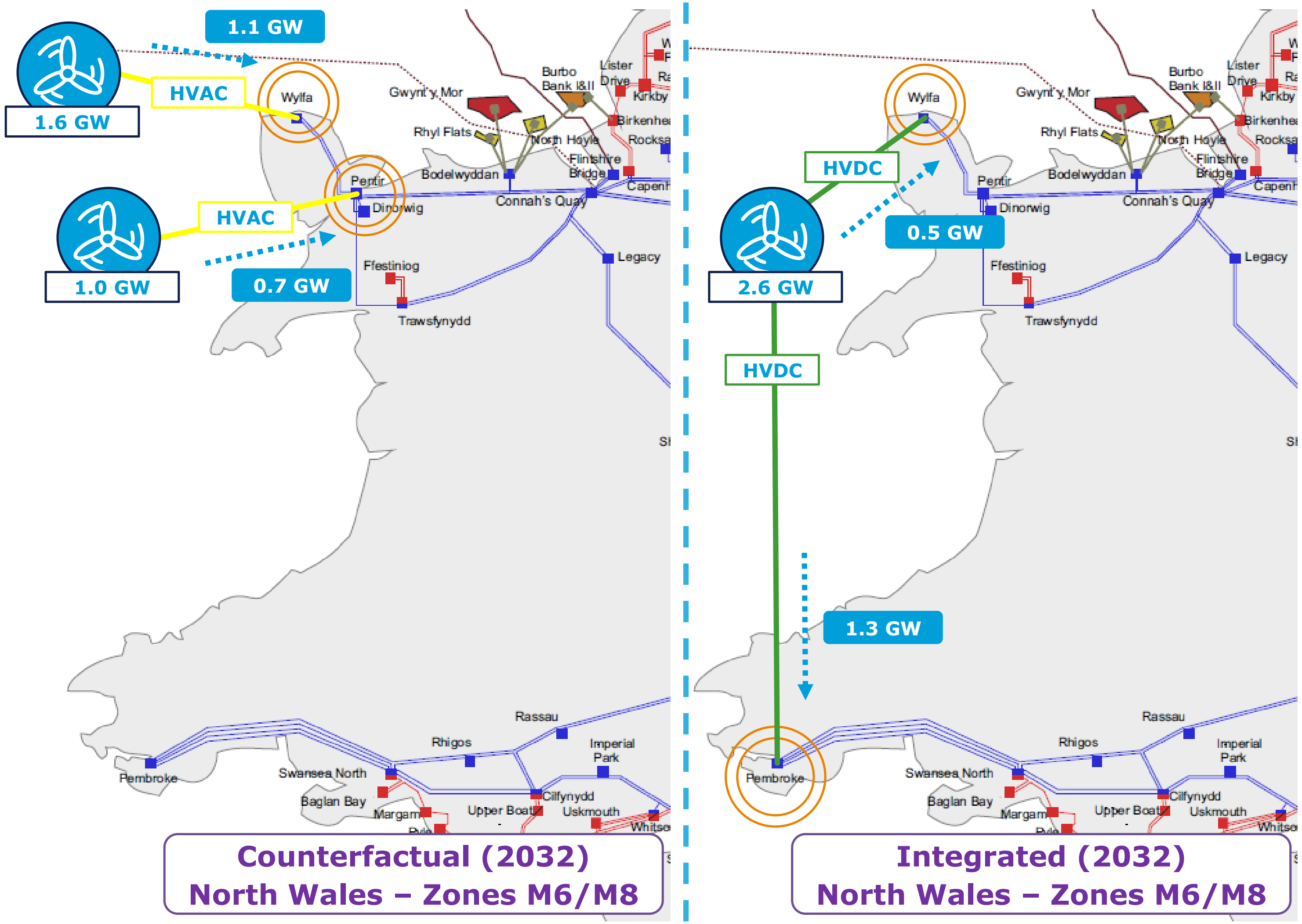
Analysis

- Onshore boundaries
- System operation (limited)

Modelling the Offshore Network Designs

Assumptions

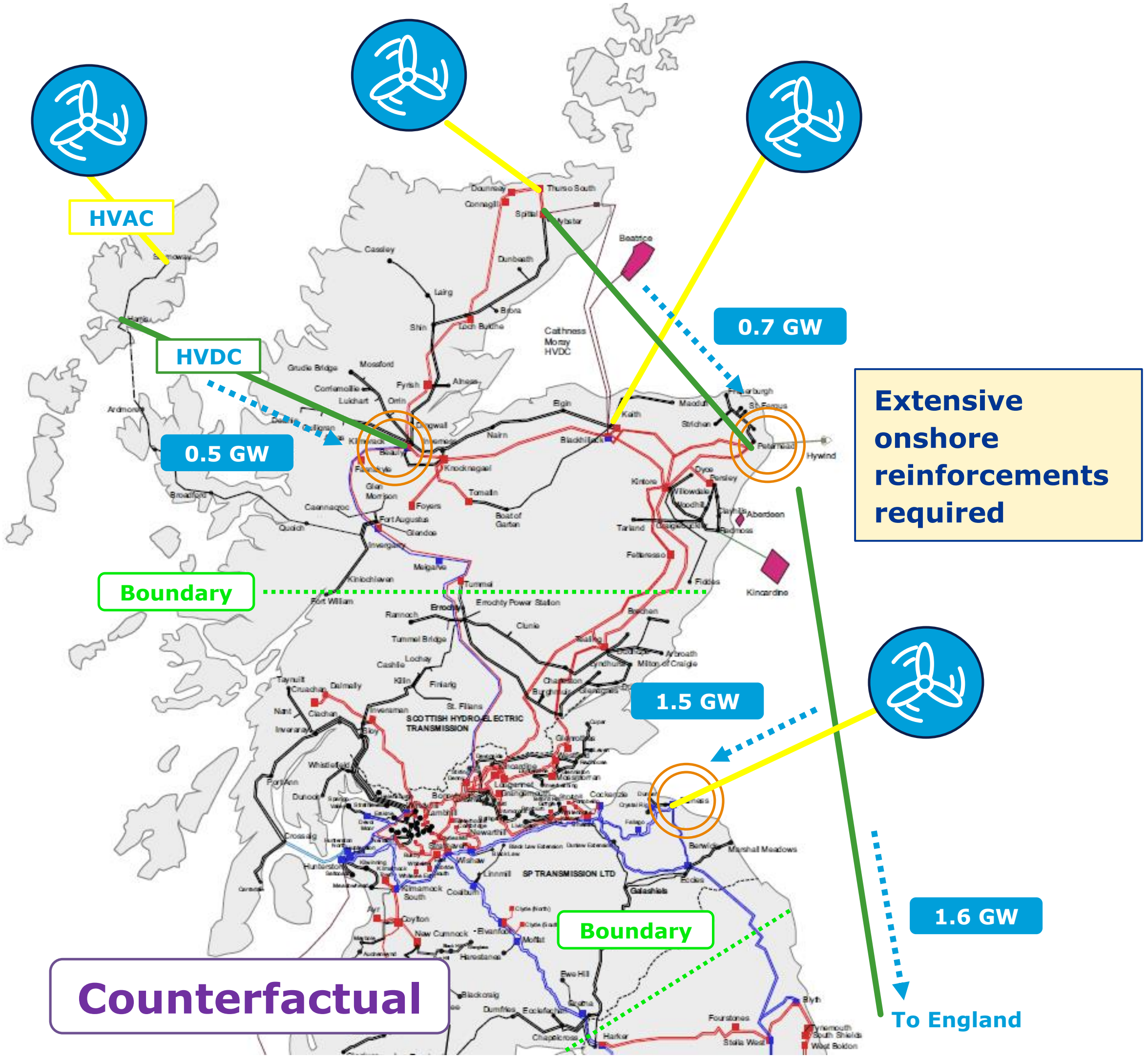
- New wind capacity 2030-2050
- Modelled as active power injections
- Economy dispatch, i.e. 70% of capacity
- Power flow distribution for HVDC loops

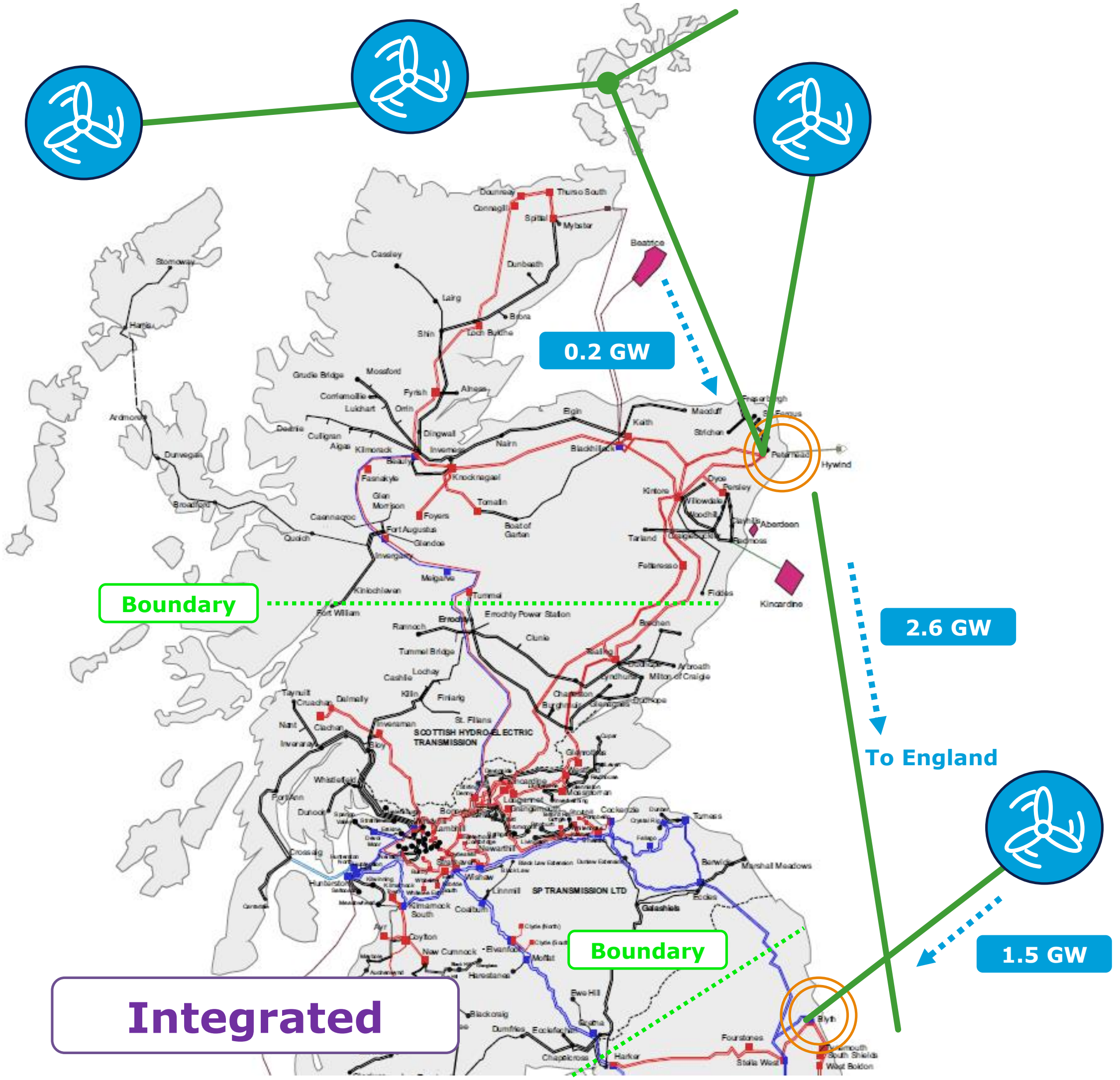


Diagrams provided for illustration purposes only.

Not representative of the actual location of the offshore wind capacity nor the complete offshore infrastructure.

Example: Scotland (2030)





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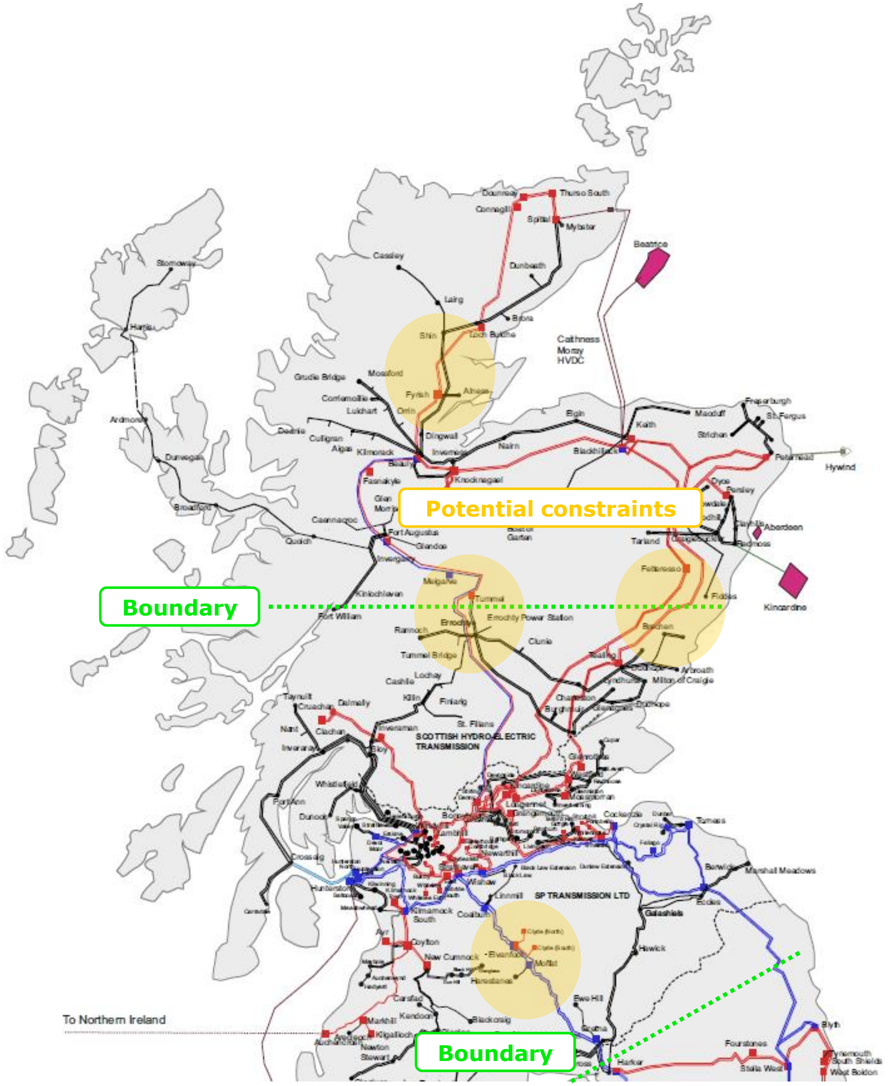
Example: Scotland (2030)

Benefits of Counterfactual Design for the Onshore System

- Lower number of shared connections
- Lesser impact onshore for a single component failure offshore

Benefits of Integrated Design for the Onshore System

- Lower boundary power transfer from North-South (≈20-30%)
- Lower chance of network constraints and onshore reinforcements
- Lower network losses due to balanced power flow



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Not representative of the actual location of the offshore wind capacity nor the complete offshore infrastructure.

Benefits of Integrated Design at System Level

Boundary Power Transfer

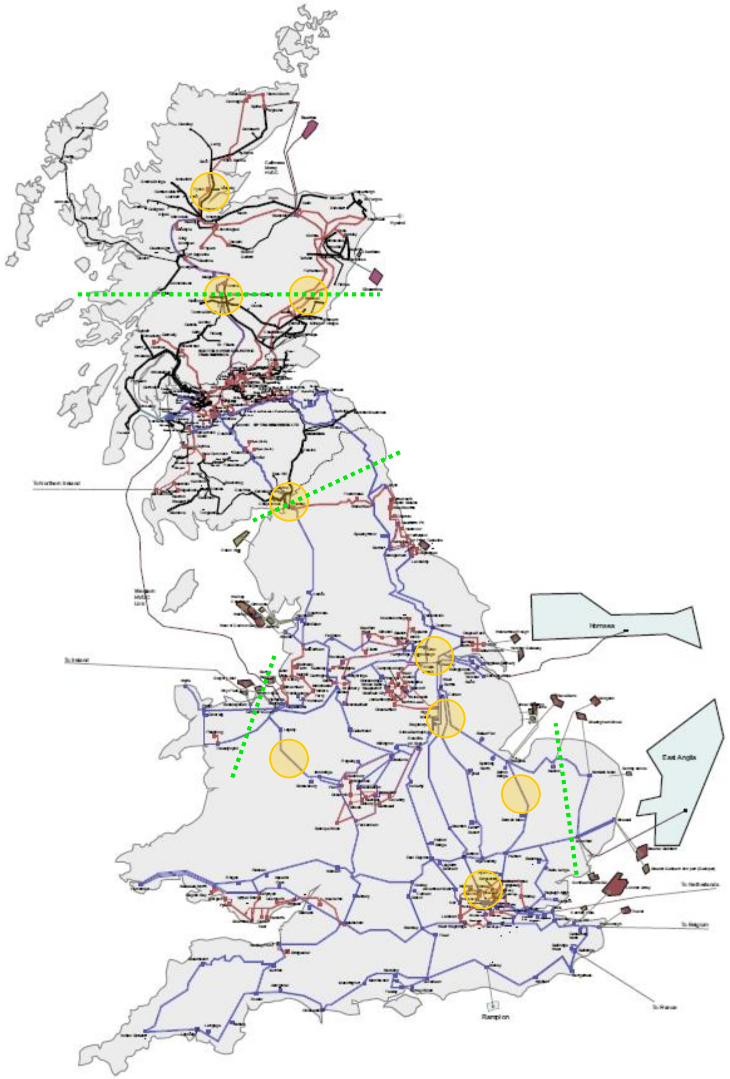
- Lower transfer, especially from Scotland to England and within Wales
- Increased flexibility due to interlinked HVDC connections

Constraints and Reinforcements

- Lower chance of constraints onshore
- Less grid reinforcements required

Losses and Voltages

- More balanced power flow due to distribution of offshore power
- Lower active power losses (up to 20%)
- Improved voltage profiles



5. Conclusions and Next Steps

Key Benefits: Integrated Design compared to Counterfactual

Deliverability

- modular approach
- standardised “building blocks”
- can be built up incrementally
- flexibility to support growth
- asset sharing benefits

Efficiency

- lower volume of assets offshore and onshore
- opportunities for integrating a range of different connection types
- anticipated cost and build benefits
  - CBA assessment report later today

Transmission System Operability

- additional options for onshore network capacity; power flow control and voltage support
- lower losses
- potential for enhanced stability support

Amenity impact

- reduced number of assets through increased asset sharing
- fewer number of onshore locations impacted
- increases choice for the location of onshore sites
- potentially lower overall impact to communities

How this feeds in the Cost-Benefit Analysis?

INPUTS → **VALUING** → **SCORING**

INPUTS

Conceptual Designs of GB network
- Grid topology
- Connection points
- Asset count

Unit Costs
- CAPEX
- OPEX

Power System Analysis
- Reinforcement needs
- Security events

Stakeholder Engagement
- Survey (Local councils)
- Consultations

VALUING

Market model
- Benefits
  - 2030
  - 2040
  - 2050

Expenditure model
- Costs
  - 2030
  - 2040
  - 2050

SCORING

- NPV calculation
- Quantitative comparison
- Environmental impacts
- Risks
- Stakeholder views

→ **Preferred alternative**

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Thanks for listening!
Any questions, please?

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Questions & answers

Next steps

- Thank you for listening today! and we look forward to speaking to those of you who are joining us on our commercial webinar starting at 12.30
- Feedback on anything presented today is welcome, please send to: box.OffshoreCoord@nationalgridESO.com
- Questions we are seeking feedback on by **12 August 2020** to be circulated later today along with the slides and recording
- Document on Q&A to be published along with all feedback received during and following webinars this week

Any feedback on this session is welcome, please feed in to help shape further sessions in the project