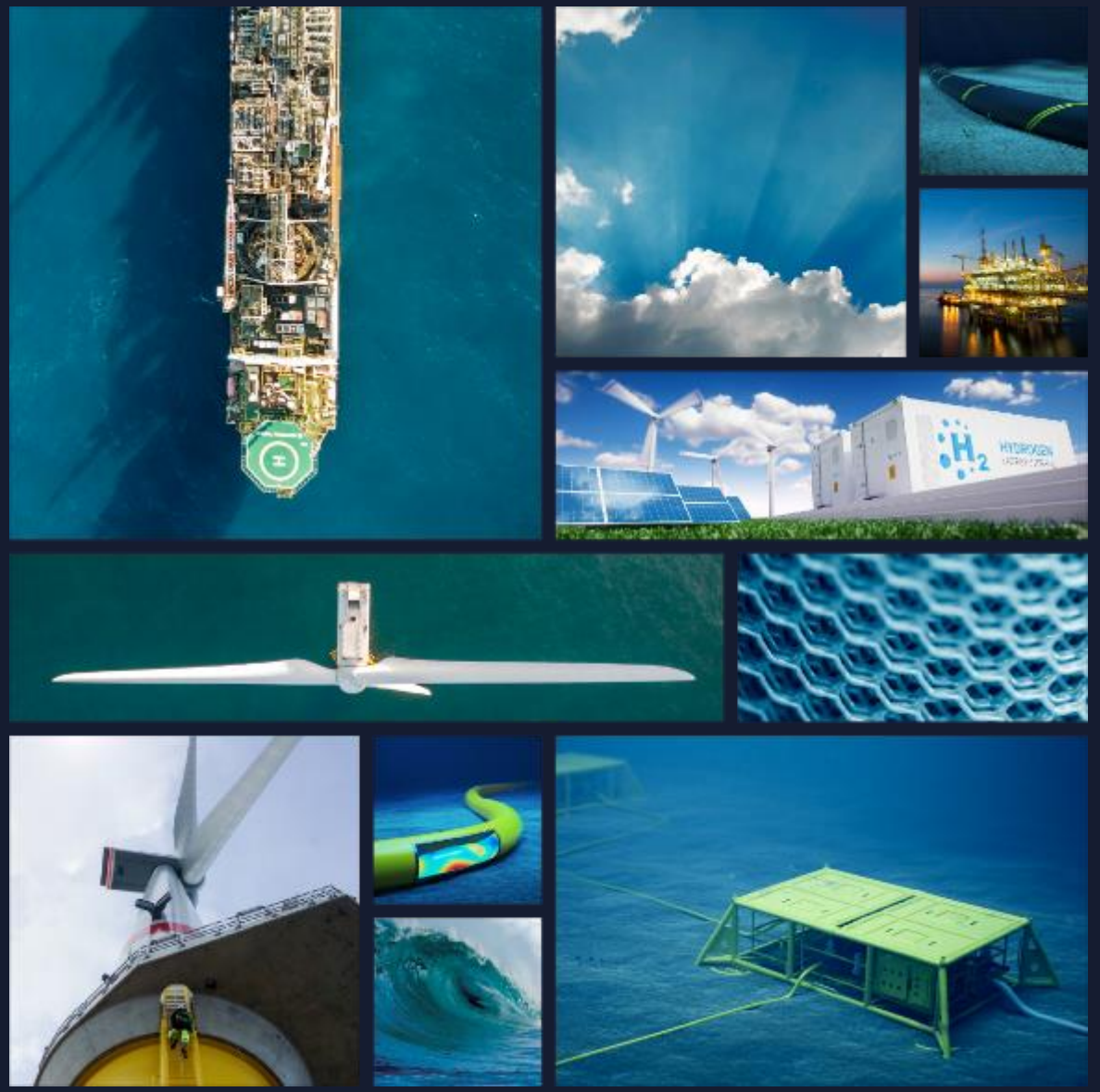
XODUS

Evolution of UK Electricity Transmission

IMarEST Coastal Science & Engineering SIG

Ed Walker



Overview

1. ‘State of Play’
2. Solutions
3. Key Challenges
4. Forward Look
5. Conclusions

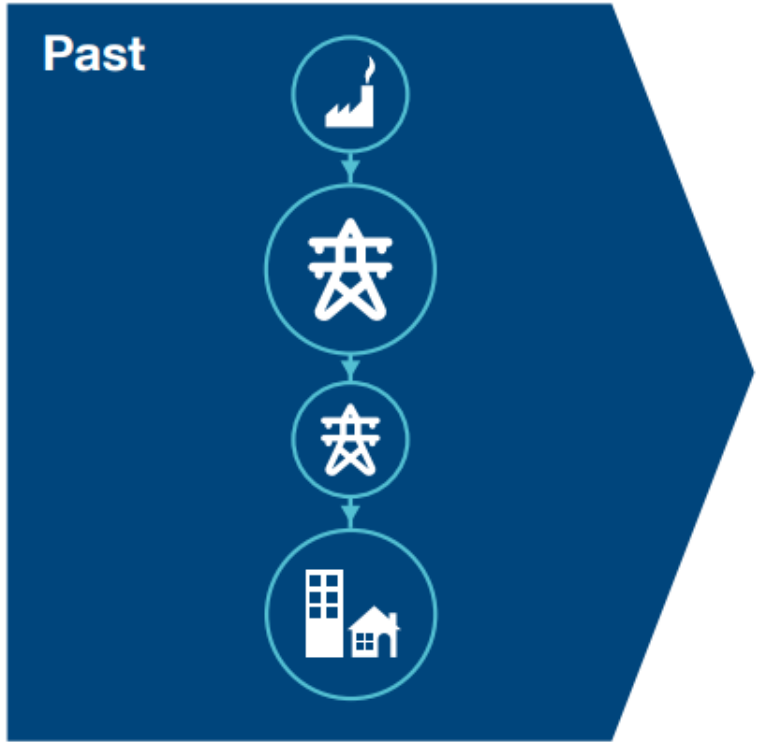
State of Play

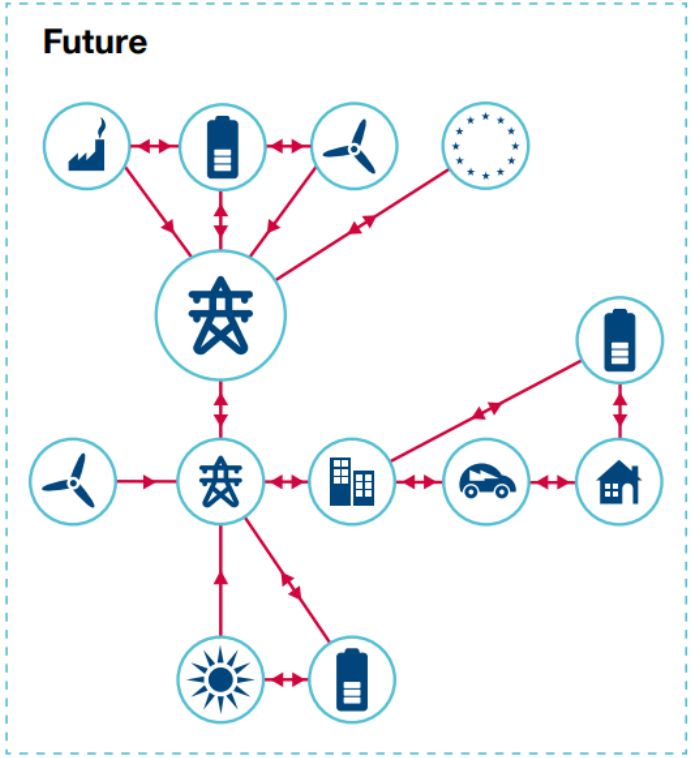
- An aging transmission network - geared toward a “conventional” energy system
- **Urgent** need for decarbonisation
- UK successes in conventional and increasingly floating Offshore Wind
- 50 GW of offshore wind by 2030?
- Greater penetration of renewables on the network
- Changes in consumption (electric vehicles / electrification of heat for e.g.)
- UK Government – full decarbonisation of the electricity system by 2035

Credit: Hywind; National Grid ESO; Hartlepool Power

State of Play

- Past: electricity flows from large transmission-connected generation to the end consumer
- Future: wider range of decentralised, low-carbon energy sources connected in a sophisticated way





Credit: National Grid ESO – FES (2018) (Link)

State of Play

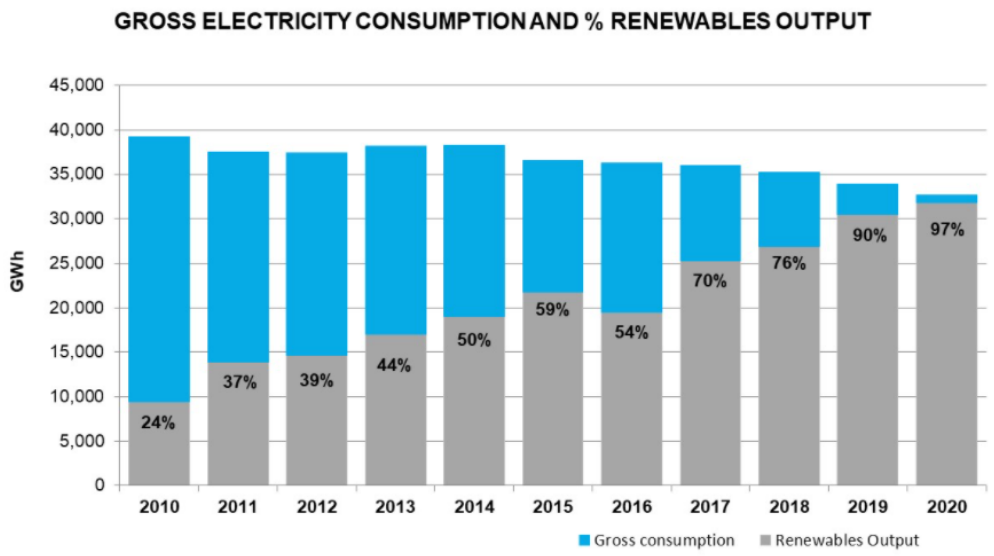
Past

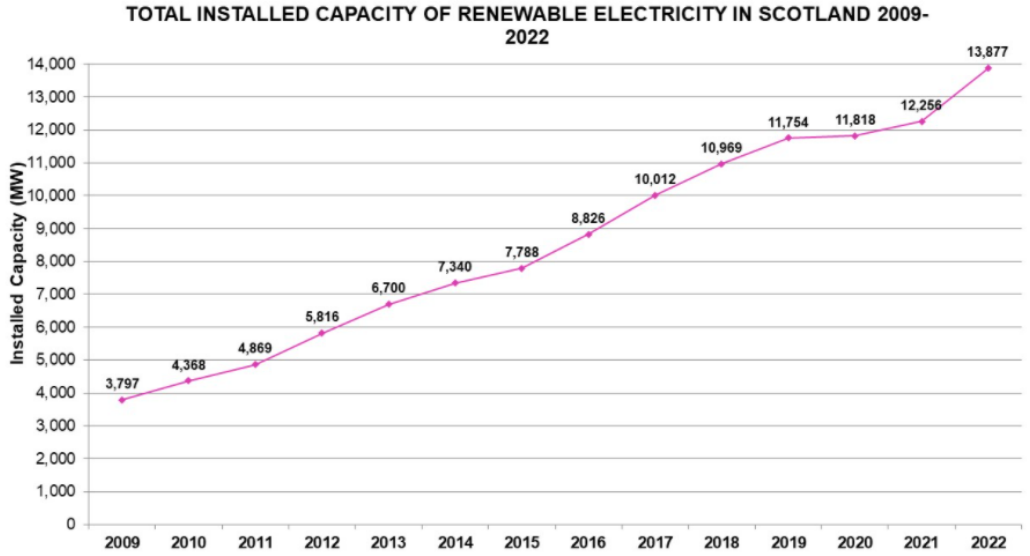
Future

Credit (L to R): UKCA; Drax Power; BBC; Walker, E; Sizewell C / CGN; Narec Dist. Energy [Decerna]; Rolls Royce Group; Xodus Group

State of Play

- Increasing challenges of balancing up renewable and low-carbon generation with the demand centres
- Taking Scotland as an example, frequently on an energy (electricity) surplus
- Renewable electricity = ~97% of Scotland's gross electricity consumption
- However, significant onward planned growth of OWF in Scotland…





Credit: Scottish Renewables (2023) (Link)

Solutions

- Investment in upgrade to the transmission system
- Combination of onshore and offshore reinforcement
- So-called ‘Great Grid Upgrade’
- Wide range of UK HVDC reinforcement

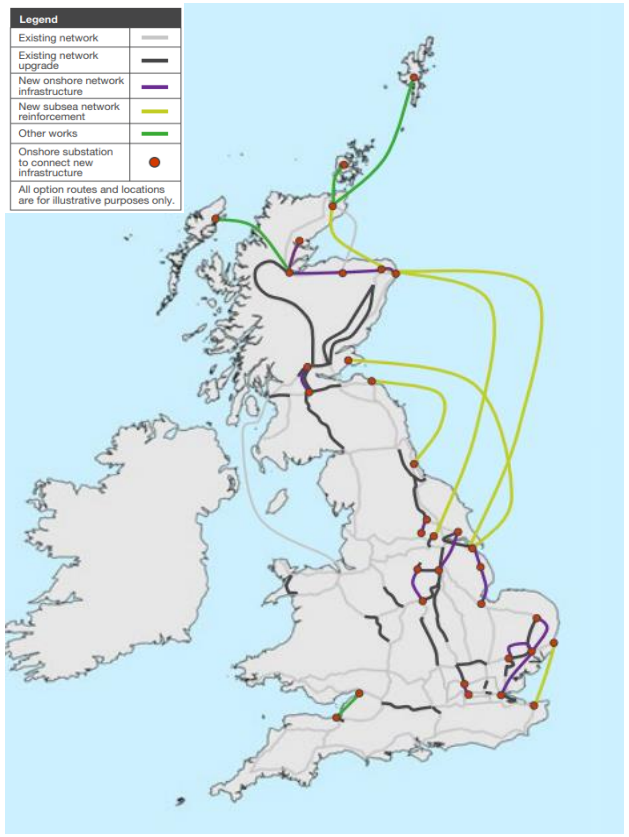
Credit (T – B): National Grid ESO; Xodus Group; Global Offshore; National Grid

Solutions

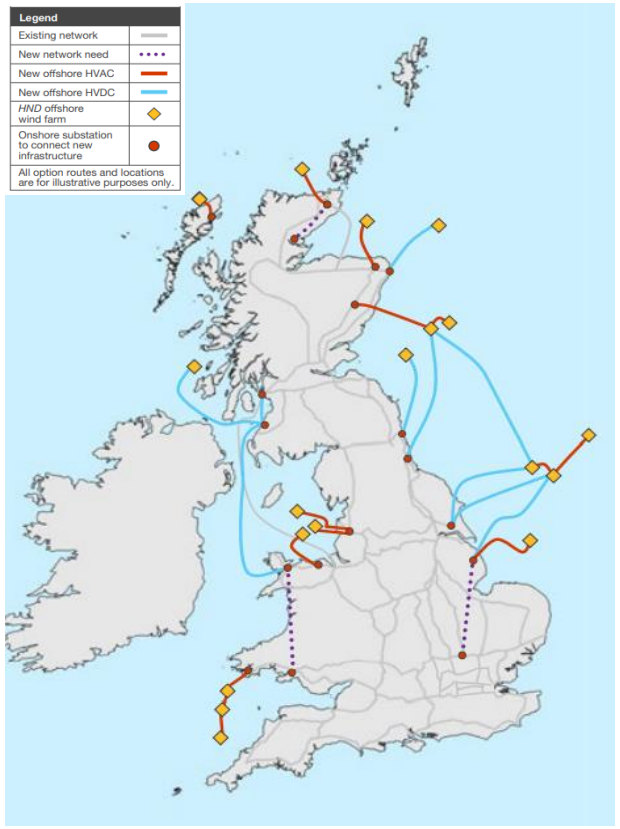
- Onshore reinforcement + offshore
- National Grid ESO ‘Pathway to 2030’ sets out a vision for a new network to support movement toward net zero
- ‘Holistic Network Design’ – onshore and offshore design that can facilitate UK ambitions for offshore wind

Credit: National Grid ESO

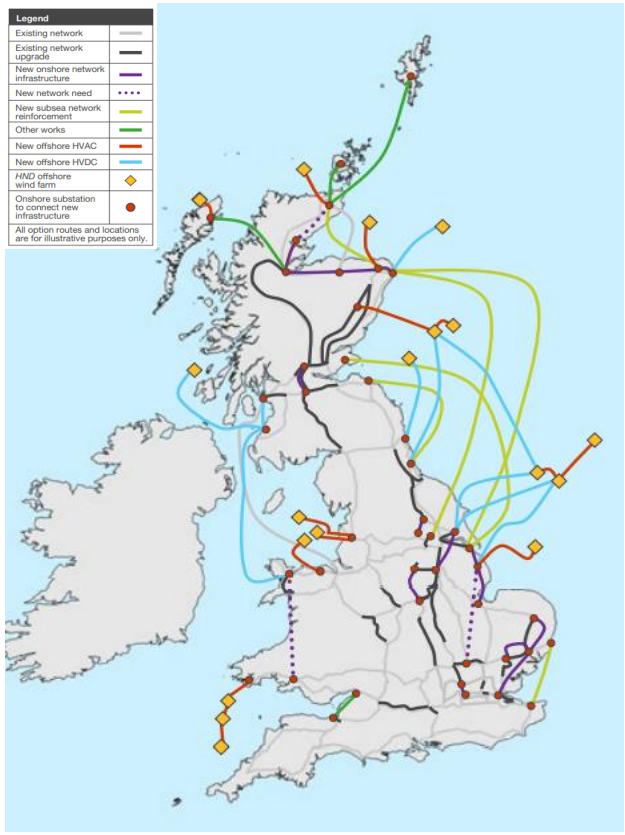
Solutions



HND: Recommendations identified previously



HND: New network needs to be identified

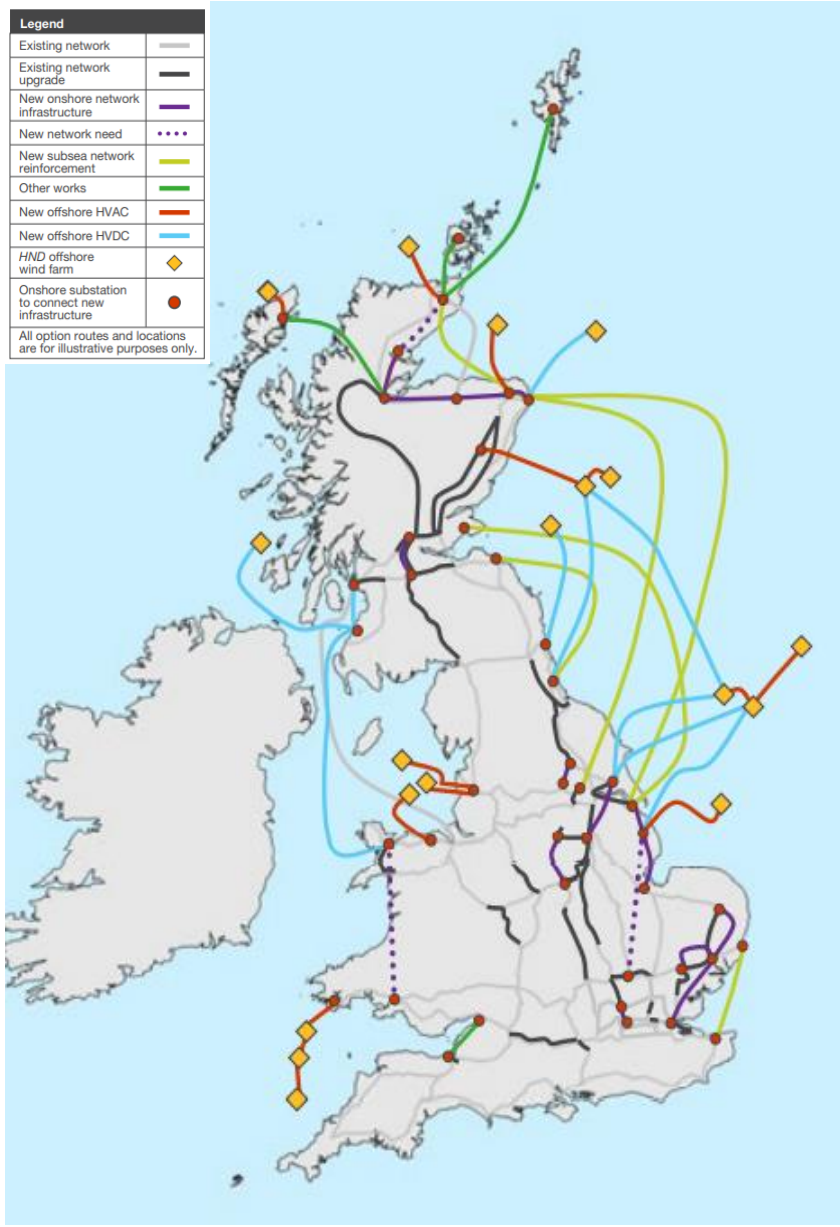


HND: Full set of major network requirements recommended

Credit: National Grid ESO

Solutions

- Network Options Assessment – recommendations for which reinforcement projects should receive investment and ultimately proceed
- Economic recommendations by comparing the cost of managing constraints with reinforcement
- A range of reinforcements from the HND (right) are in varying stages of development…

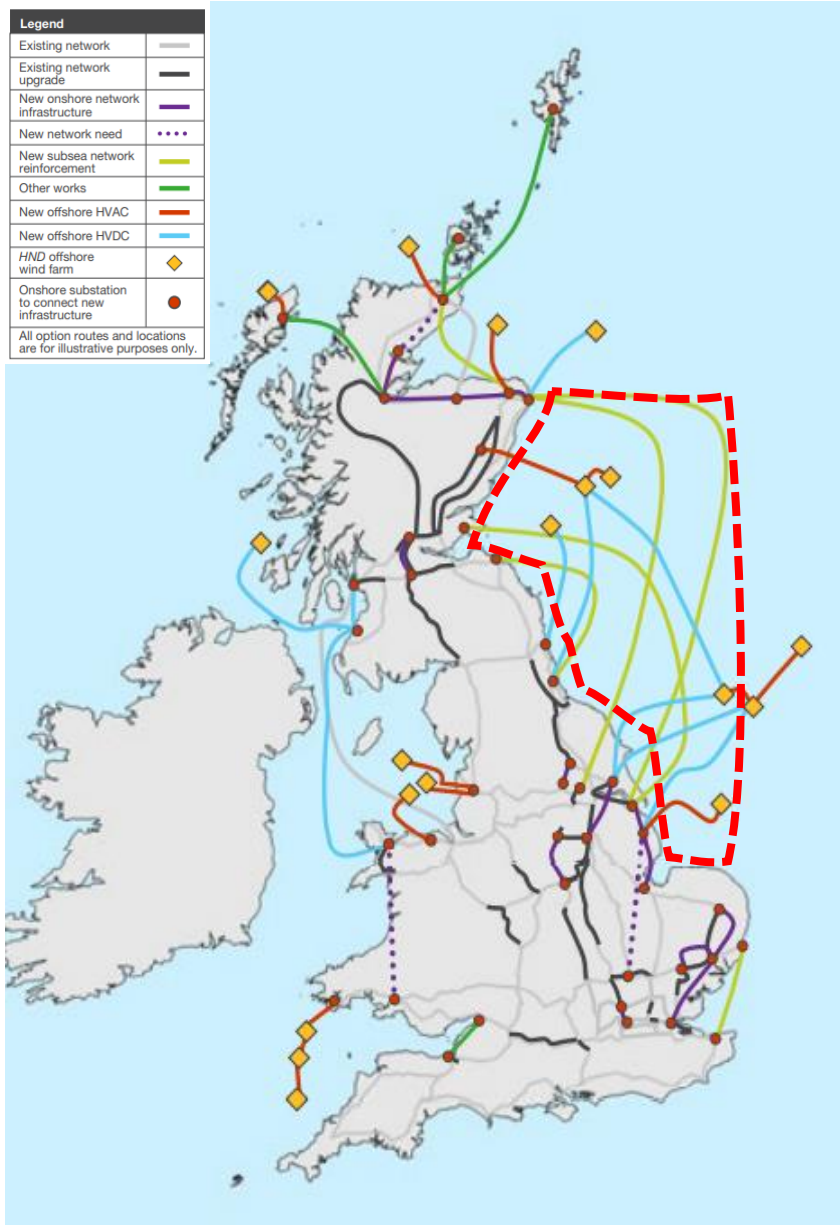


Credit: National Grid ESO

Solutions

East Coast UK transmission reinforcement examples alone...

- E4D3 (Eastern Green Link 2 HVDC) HVDC
- E4L5 (Eastern Scotland to England 3rd HVDC link)
- PSDC Spittal to Peterhead HVDC reinforcement
- E2DC Eastern subsea HVDC link from Torness to Hawthorn Pit
- TGDC Eastern subsea HVDC Link from east Scotland to south Humber area



Credit: National Grid ESO

Solutions

Not just about transmission…

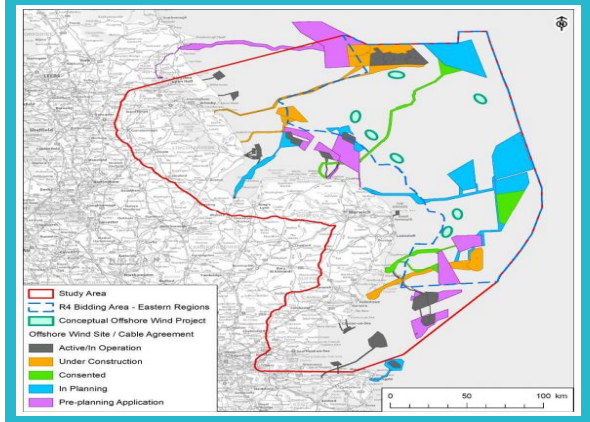
- Multiple generators (offshore wind projects) considered as part of the Holistic Network Design
- Greater coordination in movement of electricity from wind generation
- Options for bringing renewable electricity directly to England from generation in Scottish waters?

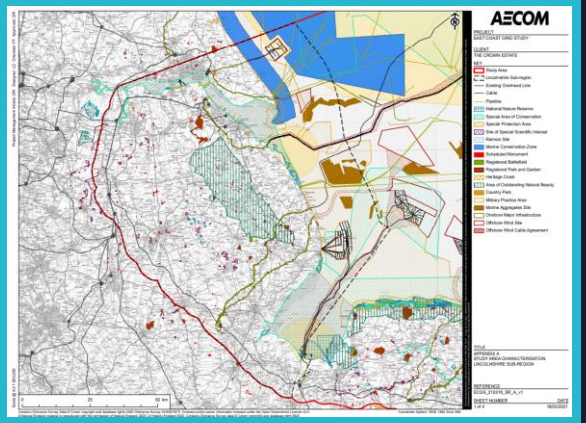
Credit: National Grid ESO

Key Challenges

Congestion

- Increasingly more complex to identify and plan
- Routeing - how to find the best on-balance solution amidst such a ‘busy’ offshore environment?
- Wide range of other sea users – all important to consider…



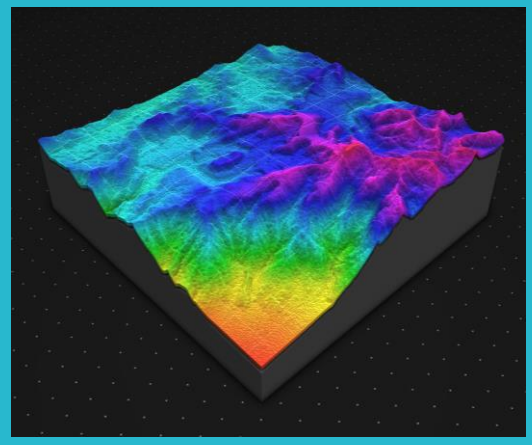


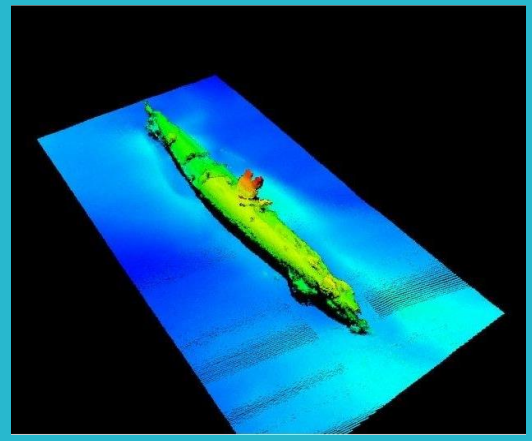
Credit (T – B): AECOM; THD; DNV; MMO; Xodus Group

Key Challenges

Data Acquisition and routeing

- Variable & challenging seabed
- Routeing process can help to avoid many constraints
- Not possible to avoid ‘everything’
- Data used to inform investigation into Burial Assessment
- Best **on-balance** solution from an environmental, technical and commercial perspective





Credit (T – B): Xodus Group; MMS Offshore; Ocean Ecology; Fugro; WesternLink / SPT

Key Challenges

Consenting

- Time to compile Environmental Assessment
- Increasing emphasis on protecting our sensitive marine environment (rightly!) – expanded / additional designated sites
- ‘Regulatory burden’ – UK marine environment increasingly busy
- Proportionality in impact assessment

Marine Management Organisation

Cyfoeth Naturiol Cymru Natural Resources Wales

marinescotland

Scottish Government gov.scot

Credit: MMO; NRW; Marine Scotland; RIBA

Key Challenges

Practical Installation Factors

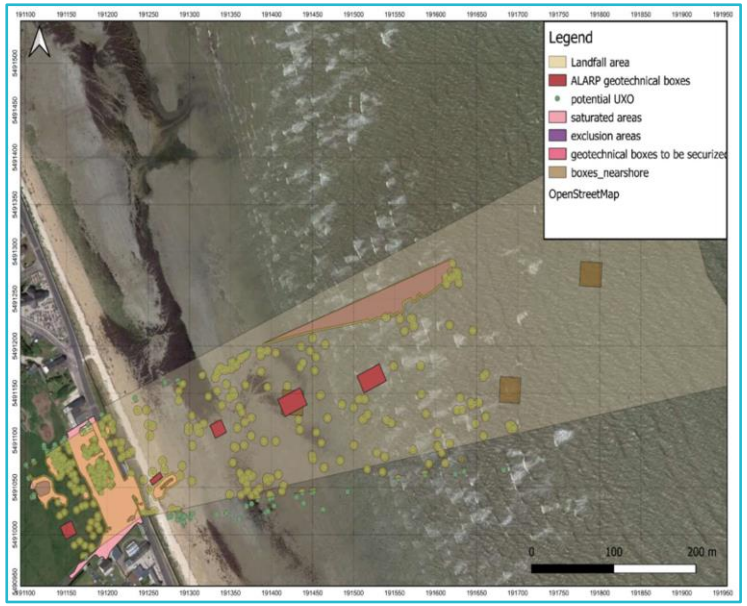
- Physical installation process – highly complex
- Harsh and demanding offshore environment
- Range of installation tools and methodologies to complete

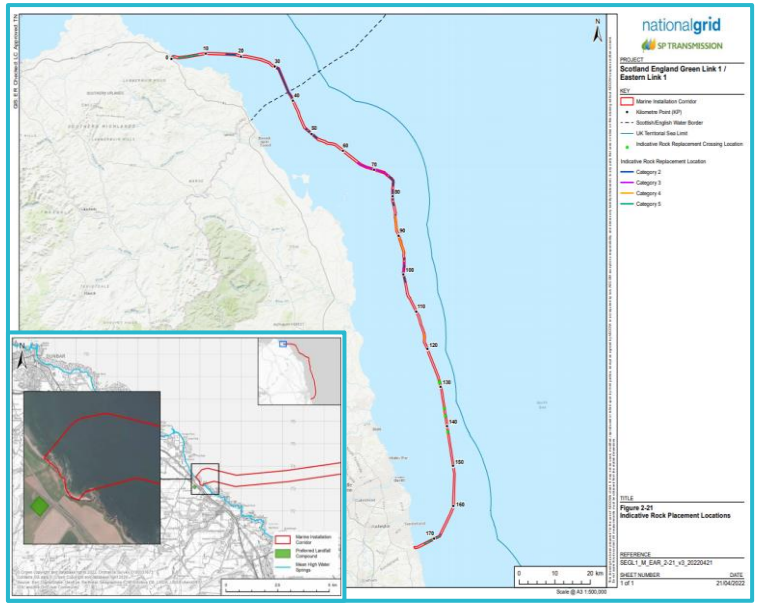
Credit: NKT; Soil Machine Dynamics; IHC International

Key Challenges

Landfalling

- Transmission links require landfalls (i.e. the point where offshore meets onshore)
- How to locate a landfall in complex, often sensitive environments?
- Wide range of criteria which need to be considered…



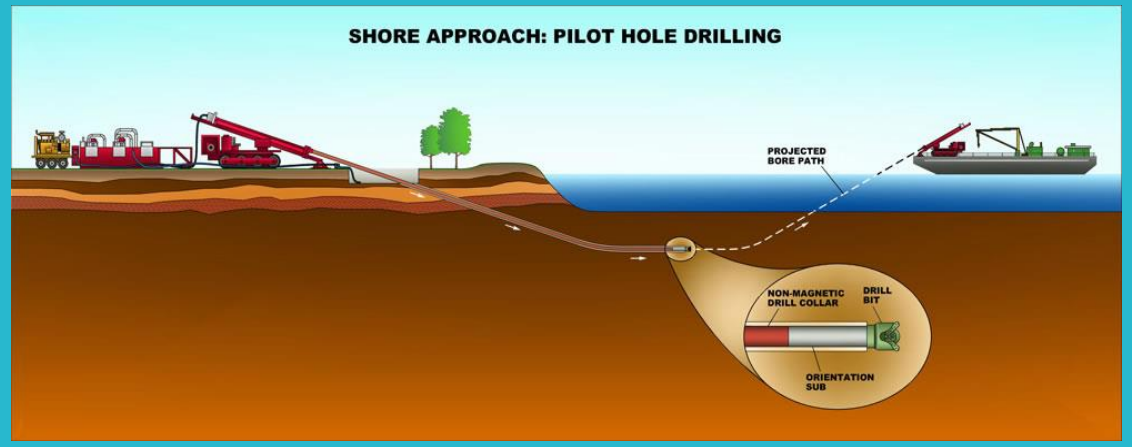


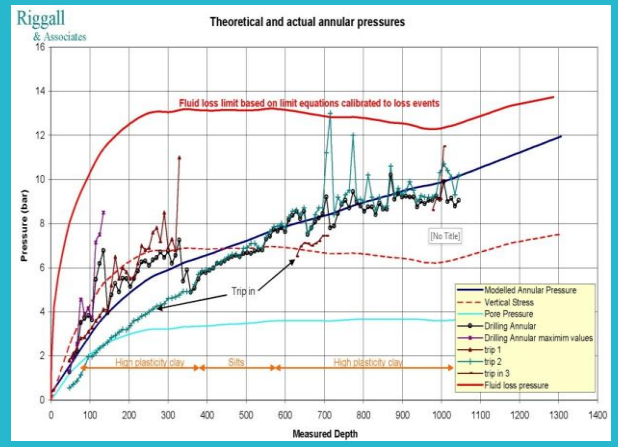
Credit (L – R): Xodus Group; Eastern Green Link 1 / AECOM

Key Challenges

Landfalling

- Selecting a landfall which is technically, commercially and environmentally viable?
- “Consentability”
- Locally acceptable
- Competition (volume of connections vs available space)
- Resilience for lifetime of the project





Credit: FCC Industrial; Flowtex; Riggall & Associates

Key Challenges

Logistical Factors

- Securing vessel availability - “competing” for availability
- Subsea cable manufacturing
- Constrained cable production & installation market

Credit: Prysmian Power Cables; JDR; HDC-Cables Limited

Key Challenges

Pace

- Scale of these and other challenges significant but need to reinforce at pace
- For example, see below (and this is only one geographical section from the NOA!)

Table 3.1: *HND* essential options for North Scotland

Code	Option description	EISD*	RISD**	Earliest optimal delivery date	Eligible for competition?
BBNC	Beauly to Blackhillock 400 kV double circuit addition	2030		2030	✓
BLN4	Beauly to Loch Buidhe 400 kV reinforcement	2031	2030	2030	✓
BPNC	A new 400 kV double circuit between Blackhillock and Peterhead	2031	2030	2030	✓
E4D3	Eastern Scotland to England link: Peterhead to Drax subsea HVDC Link	2029		2029	✓
E4L5	Eastern Scotland to England 3rd link: Peterhead to the south Humber subsea HVDC Link	2031	2030	2030	✓
PSDC	Spittal to Peterhead HVDC reinforcement	2030		2030	✓
SLU4	New network need between Loch Buidhe and Spittal	2030		2030	✓
TKUP	East Coast Onshore 400 kV Phase 2 reinforcement	2032	2030	2030	✓ (Part)

Table 3.2: List of options and their recommendations for North Scotland

Code	Option description	EISD*	Earliest optimal delivery date	Recommendation	Eligible for competition?
BDUP	Uprate the Beauly to Denny 275 kV circuit to 400 kV	2029	2030	Hold	
DLUP	Windyhill-Lambhill-Denny North 400 kV reinforcement	2029	2029	Proceed	
DNEU	Denny North 400/275 kV second supergrid transformer	2025	2026	Hold	
DWNO	Denny to Wishaw 400 kV reinforcement	2028	2028	Proceed	
DWUP	Kincardine - Wishaw 400 kV reinforcement	2026	2026	Proceed	
LWUP	Kincardine 400 kV reinforcement	2027	2027	Proceed	
TFPC	Power flow control device along Tealing to Westfield	2025	2027	Hold	

* EISD is currently based on the current regulatory and consenting process and acceleration

Forward Look

Transmission System

- UK transmission reinforcement – ‘Great Grid Upgrade’
- Several ‘leading’ schemes (watch this space for schemes such as Eastern Green Link 1 and 2 which have all primary consents)
- Further emerging schemes, as recommended by the NOA

Forward Look

Innovation

- Emerging solutions, such as Multi-Point Interconnectors
- Growth of Floating Offshore Wind – how can this integrate into the evolving transmission system?
- Role of other technologies, such as Hydrogen and CCUS – relationship with transmission system?
- Use of data to help speed up development (more on this later…)

Forward Look

Resource Demands

- Existing and future demand for skilled individuals
- Complex infrastructure projects = significant and varied demands for people
- Major opportunity for those considering marine careers…

Forward Look

Pace

- Urgency of required upgrades
- In order to tackle the challenge at hand, urgent need for coordination
- More coordinated network? Shared landfalls?
- Whilst working at pace, need to do so whilst maintaining **safety as the top priority**

WHAT WE DO

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Integrating our diverse technical and commercial expertise

ENGINEERING

Using experience and knowledge to maximise performance

ENVIRONMENT

Delivering a sustainable and responsible energy future

SUPPLY CHAIN

Adding value to projects, communities and consumers

With specialist engineers, consultants and scientists across multiple disciplines we combine our skills to deliver a **truly integrated** offering.

Our Offices and Sample of Existing Clients

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Scottish & Southern Electricity Networks

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JAPAN RENEWABLE ENERGY

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TOTAL

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SSE Renewables

equitix

Ørsted

Simply Blue Energy

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1 UK . 2 Boston . 3 Houston . 4 Egypt . 5 UAE
6 Japan . 7 Perth . 8 Melbourne

What does the I&C team deliver?

Development	Engineering	Construction	Operations
1 Desktop Route Engineering	1 Cable Burial Risk Assessment (CBRA)	1 EPCI Procurement and Negotiation Support	1 Cable Integrity Risk Assessment (CIRA)
2 Landfall Assessment	2 Burial Assessment Studies (BAS)	2 Contract Management	2 Asset Integrity Management (including XAMIN)
3 IAC Layout Design and Optimization	3 Installation Engineering & Analysis	3 Package Management	3 Emergency Response Planning & Cable Repair Management
4 Survey Specification, Procurement, Management, Client Representation & QAQC	4 In-Place Engineering & Analysis – Static Cables	4 Owner's Engineer	4 Specialist Engineering Studies, e.g., hydrodynamic modelling, Cable thermal analysis, VIV modelling, etc
5 EIA & Consenting	5 Seabed Morphology & Future Span Analysis	5 Client Representation	5 Decommissioning Planning
6 Cost Estimation	6 In-Place Engineering & Analysis – Dynamic Cables	6 Consent Compliance	6 Inspection Survey Specification, Procurement, Management, Client Representation & QAQC or Principal Contractor

Specialist Advisory – *Technical Advisory, Due Diligence, Expert Witness*

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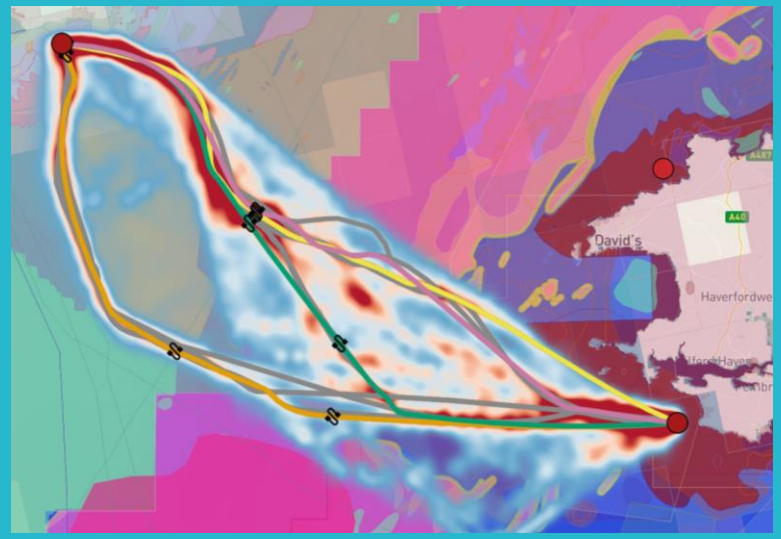
Specialist Advisory – *Technical Advisory, Due Diligence, Expert Witness*

optioneer

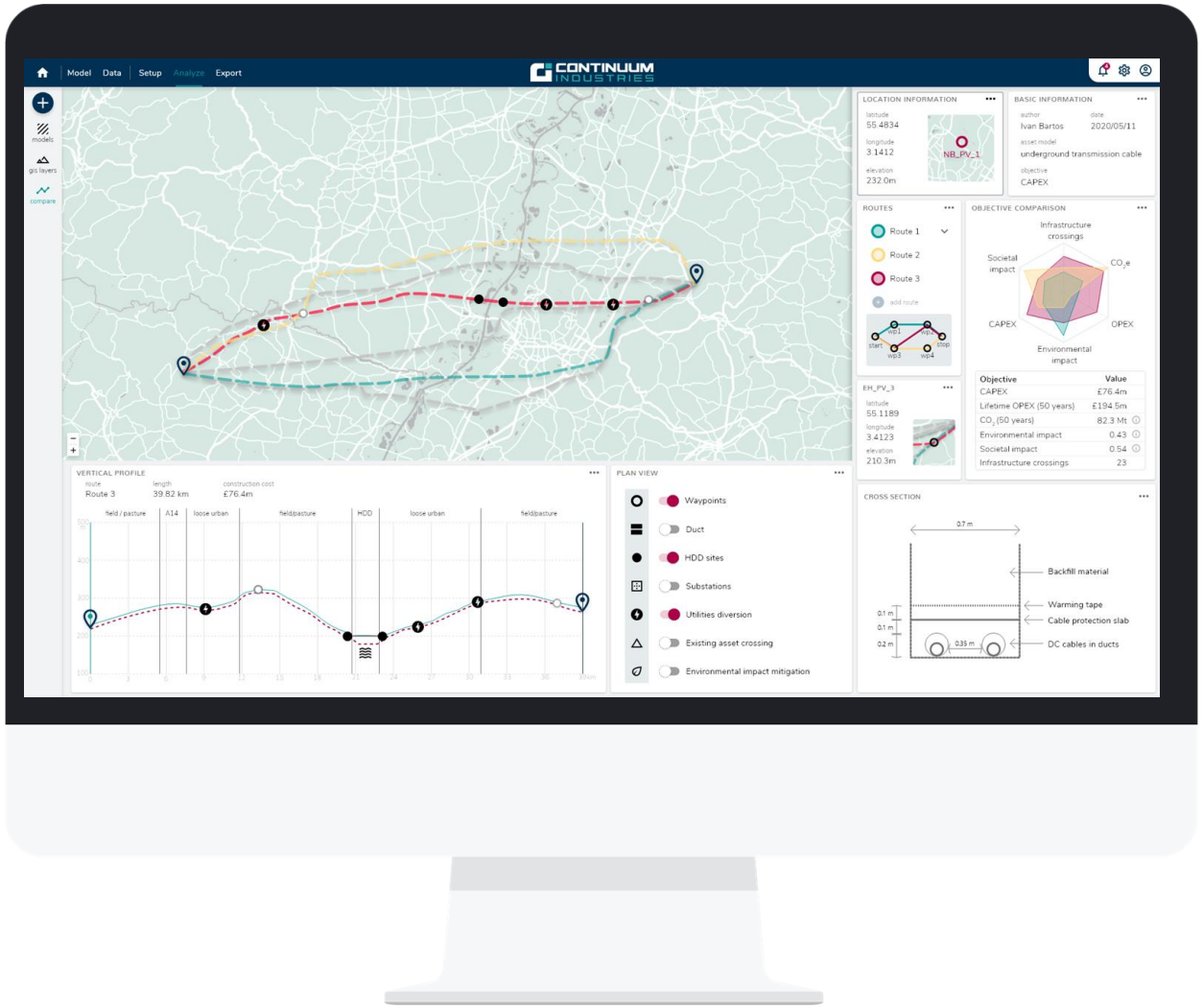


Routing with Artificial Intelligence

Evolutionary Algorithms | Millions of Routes | Rapid Optioneering

CONTINUUM INDUSTRIES

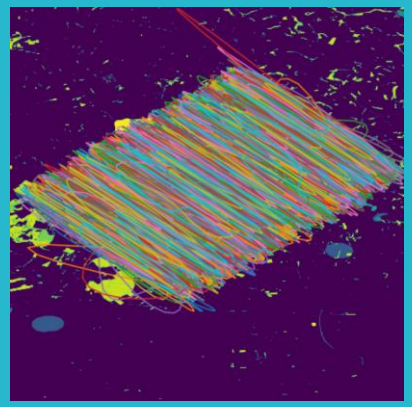
What is optioneer?



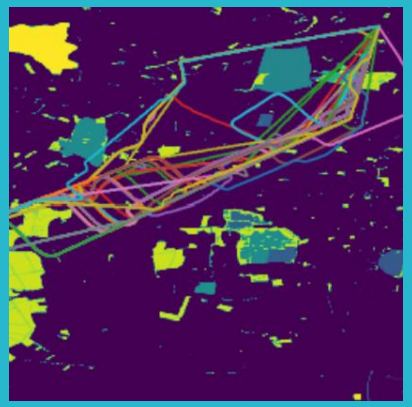
- A routing software which combines engineering requirements (e.g. route geometry, crossing requirements, protection / installation methods) and environmental constraints (e.g. no-go zones, hard / soft constraints)
- Quickly generates feasible route options
- Allows visualisation of large amounts of data for quantities, costs and other important considerations along each route profile

How it Works

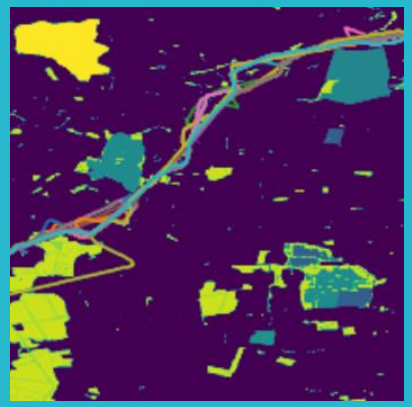
- The software generates route options using evolutionary algorithms
- The algorithm identifies favoured route solutions for short and long distance power cable routes



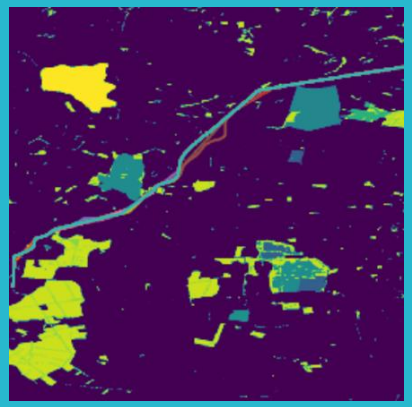
1st generation



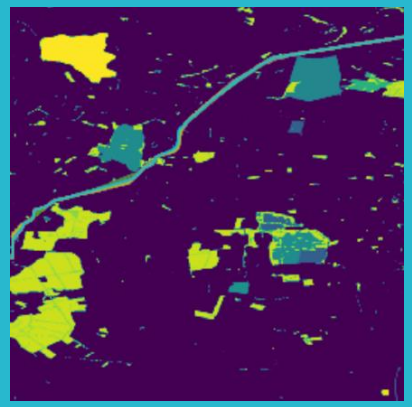
10th generation



30th generation



100th generation



150th generation

Geospatial Data

Environmental Constraints

- Designated Sites (SPAs, SACs, MPAs, MCZs, SSSIs)
- Protected Habitats

Installation Constraints

- Turning radii and run-in lengths (crossings, landfalls)
- Crossing linear infrastructure (cables, pipelines)
- Installation methods (trenching, protection)
- Distance to critical features

Technical Constraints

- Seabed Sediment
- Shallow Geology
- Bathymetry
- Local Seabed Slopes
- Exposed Rock/Reef

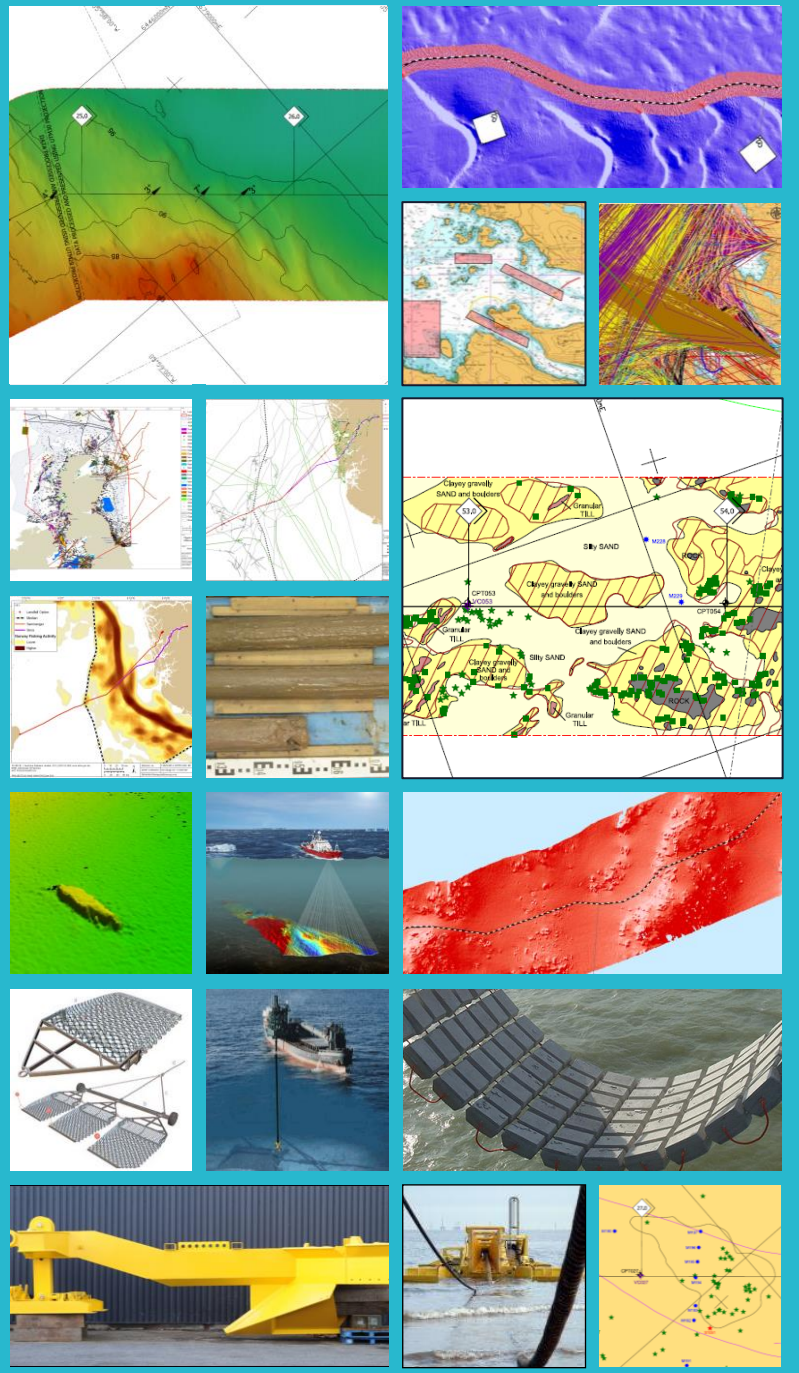
What parameter is required and what data do we have?

Other User Constraints

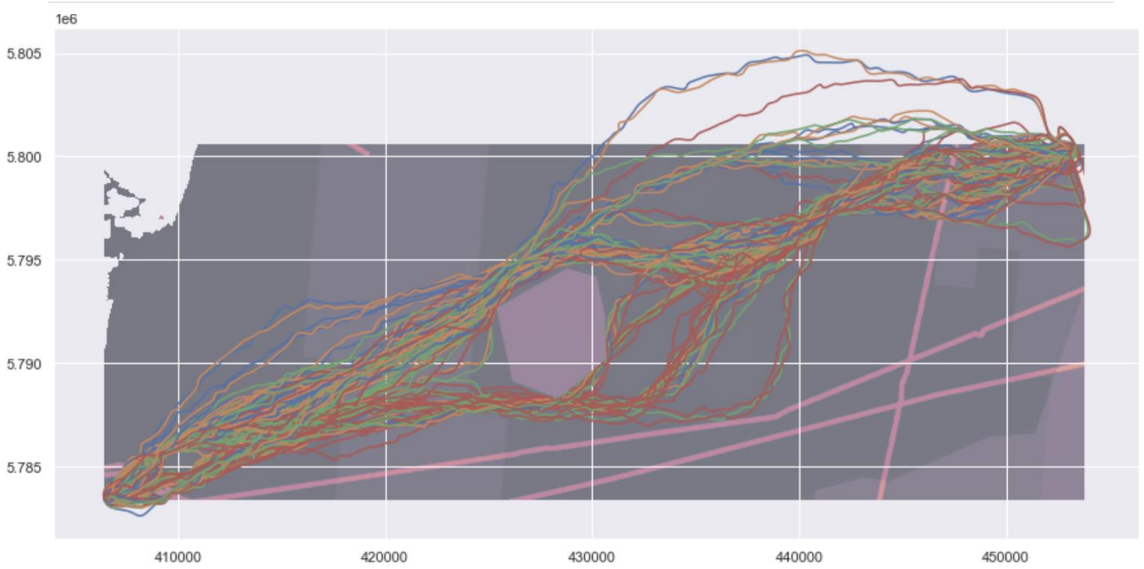
- Harbours, Marinas, Anchorages
- Shipping Density
- Fishing Density
- Dredging/Disposal
- Aggregates/Mining
- Oil and Gas
- Renewable Sites

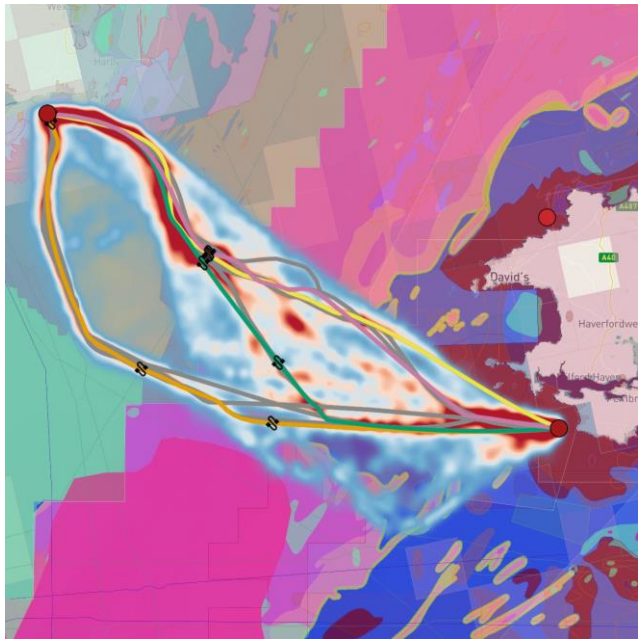
Cultural Heritage and Military

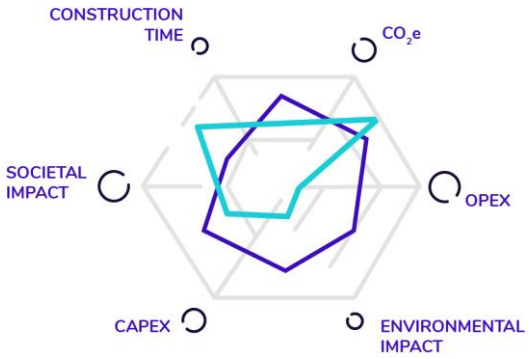
- Wrecks and Protected Remains
- Battlefields
- UXO
- PEXA
- Munitions Dumps



INTERCONNECTORS & CABLES



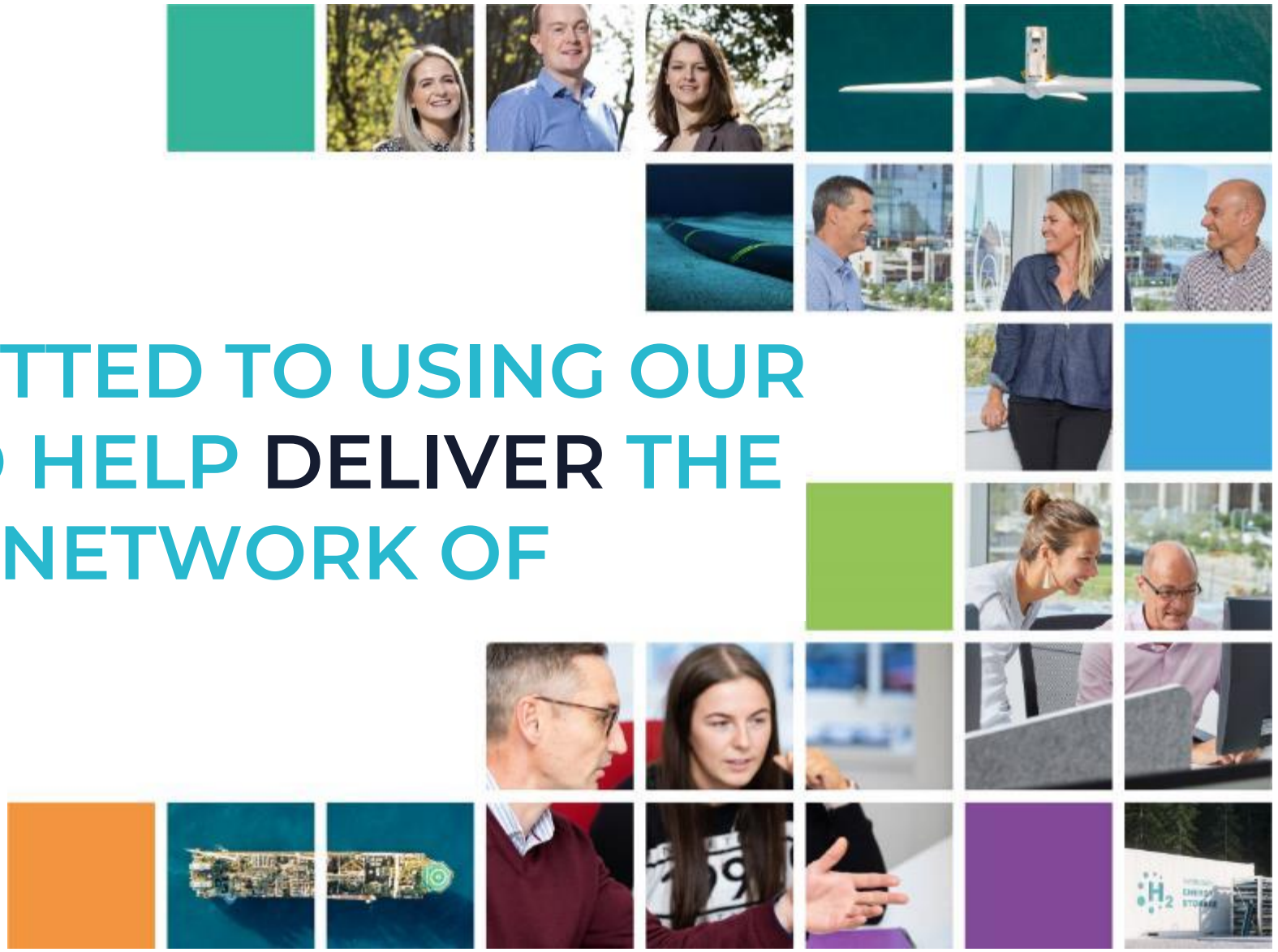




Explore the Options

Understand the Trade-Offs

WE ARE COMMITTED TO USING OUR EXPERIENCE TO HELP DELIVER THE TRANSMISSION NETWORK OF TOMORROW.



Conclusions & Key Takeaways

1. Embracing Challenge
2. Collaboration with Regulator
3. Pace
4. Opportunity
5. Ongoing Industry Actions

Further Reading

- Future Energy Scenarios ('FES') – National Grid ESO (Link)
- East Coast Study – The Crown Estate (Link)
- Offshore Coordination Project – National Grid ESO (Link)
- The Great Grid Upgrade – National Grid (Link)
- Pathway to 2030 Holistic Network Design ('HND') (Link)
- Network Options Assessment ('NOA') / NOA Refresh (Link)
- Offshore Transmission Network Review ('OTNR') (Link)
- 'Finding Space for Offshore Wind' – The Crown Estate (Link)
- Information about the three UK transmission owners (Link)
- Carbon Trust CBRA Guidance – The Carbon Trust (Link)
- Xodus Interconnectors and Cables – case studies available on request (Link here; contact details follow below)

Thank You

Edward Walker MEI MIEMA CEnv MIMarEST CMarTech MCIWEM C.WEM
Environmental Specialist – Coastal Energy
T +44 131 385 7372
E edward.walker@xodusgroup.com

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