“Lessons from Owners and Operators”: What are the key challenges in delivery, operation, and asset management?

The National HVDC Centre

Scottish & Southern Electricity Networks
TRANSMISSION

Agenda

09:30

Introduction
Colin Foote, The National HVDC Centre

09:35

Preparing for Day One: Building Operational Readiness During Construction
Ian Reed, NeuConnect

09:55

Recent Developments from the Moyle Interconnector
Vahid Sabzpoosh, Mutual Energy

10:15

Lessons from operating the CMS link
Cameron McHardy, SSEN Transmission

10:35

Coffee Break

10:55

FIFA – extending the life of the UK's first HVDC interconnector
David Monkhouse, National Grid Ventures

11:15

Living with Software: Obsolescence, Software Lifecycles & Patch Management
Matthew Gibson, Greenlink

11:35

Learnings from Sofia windfarm
Chris Smith, RWE

11:55

Panel Q&A

12:15

LUNCH & NETWORKING

Reminders

Please keep mobile phones on silent and feel free to pop in and out of the Auditorium as you need to, as discreetly as you can.

For questions, don't shout over or interject; we have allocated time for Q&A and panel discussion.

Please be conscious of keeping to time when presenting and during coffee breaks.

Panel Q&A

Ian Reed, NeuConnect

Preparing for Day One: Building Operational Readiness During Construction

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NeuConnect

Preparing for Day One:

Building Operational Readiness During Construction

Ian Reed, Asset Manager

A Quick Recap

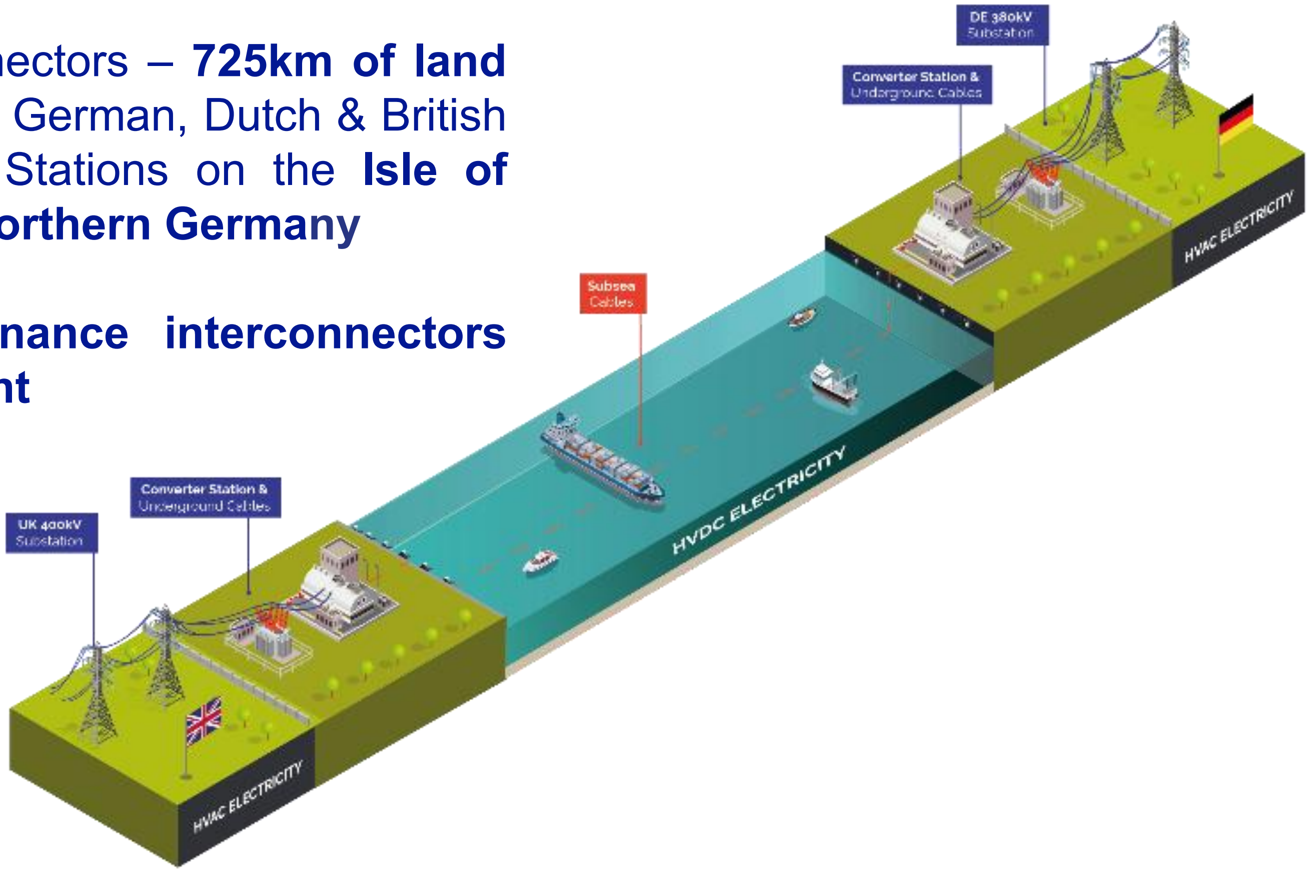
What is NeuConnect

- First direct interconnector between UK and German electricity networks - **connecting two of Europe's largest energy markets for first time**

- **1.4GW capacity** – enough to power 1.5 million homes

- One of the world's longest interconnectors – **725km of land and subsea cables** passing through German, Dutch & British waters, connecting new Converter Stations on the **Isle of Grain, Kent**, and **Wilhelmshaven, northern Germany**

- One of the very first **Project Finance interconnectors** through **£2.4bn of private investment**



Current progress

Onshore construction:

- Converter Station structures in UK and Germany now at full height with cladding works underway
- All 14 transformers now delivered (7 in each country)

Offshore cabling:

- All cabling now in place in UK waters, with 700km subsea cabling programme continuing into Dutch waters
- More than 300km of subsea cabling laid to-date

Commercial activities:

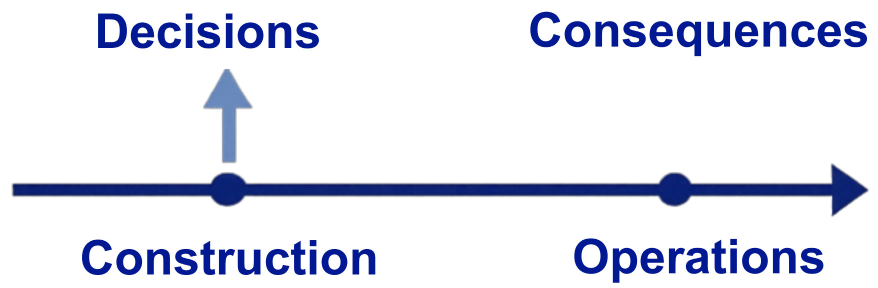
- NeuConnect certified as an Independent TSO by Ofgem, with German application ongoing
- JAO appointed as NeuConnect’s provider for auctioning cross-border transmission capacity
- Supercharge appointed to create a customer-facing Market Integration Platform

NeuConnect

Context and Differentiation

Preparing for Day One

- **Operational Readiness as Core Deliverable**
  Not something added at or deferred to commissioning
- **Early Decisions Shape Outcomes**
  Design, contracting and governance lock in long-term performance
- **Focus on Operational Outcomes from Day One**
  Not just asset completion
- **Experience-Based Learnings**
  High-level insights, not project-specific detail



"Day One performance is largely decided long before you ever switch the asset on"

Why This Matters

- **Operational challenges are often inherited**
  Driven by early design and construction decisions
- **Long-term asset constraints**
  Limited flexibility once in operation
- **Readiness reduces operational risk**
  Limits Day Two issues and protects performance
- **Early operations involvement matters**
  Reduces inefficiencies at handover

“This is about reducing the Day Two problem list before Day One even happens”

What Makes NeuConnect Different

- **Unique scale and model**
  First UK–Germany link | 725km | 1.4GW
- **Lean delivery model**
  Project finance | Small team | Long-term partners
- **Cross-border complexity**
  Multiple regimes | Governance | Flexibility
- **Future operating model**
  Efficiency | Clarity | Adaptability

Investors:

Meridiam for people and the planet

Allianz

Kansai Electric Pow power with heart

TEPCO TEPCO Fuel & Power

Lenders:

More than 20 of the world's largest banks including:

European Investment Bank

JBIC Japan Bank for International Cooperation

National Wealth Fund

Contractors:

Siemens energy

prysmian

"We don't have the luxury of getting it wrong and fixing it later"

NeuConnect

Embedding Operations During Construction

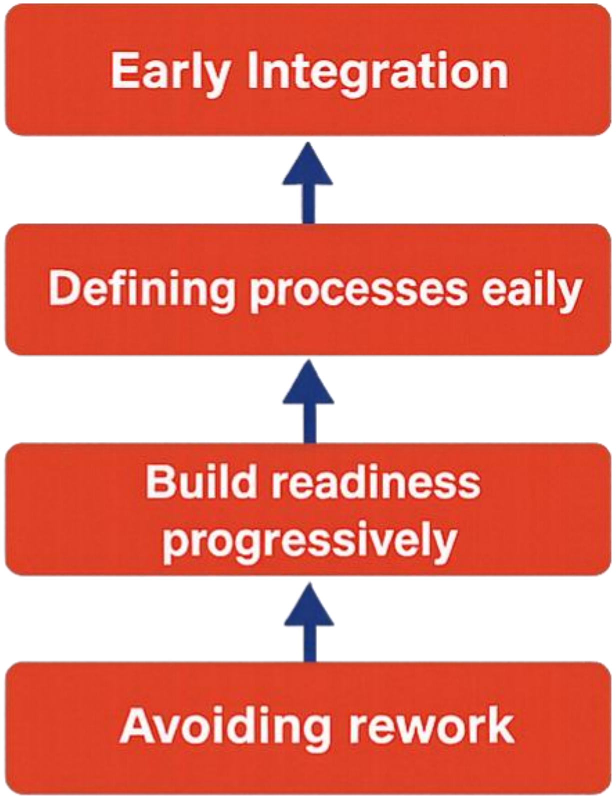
Starting Operations Early

- **Early integration**
  Ops embedded | Balance cost & schedule

- **Defining processes early**
  Control room | Governance | Ways of working

- **Build readiness progressively**
  Test | Refine | Repeat

- **Avoiding re-work**
  No compression | Smoother transition



"We treat operations as a stakeholder from day one, not a handover recipient"

The Operational Readiness Puzzle

- **Regulatory readiness**
  Licensing | Certification | Compliance
- **Asset handover**
  Documentation | Spares | Ownership
- **Market & IT**
  TSOs | Platforms | Data
- **Organisation**
  People | Governance | Processes

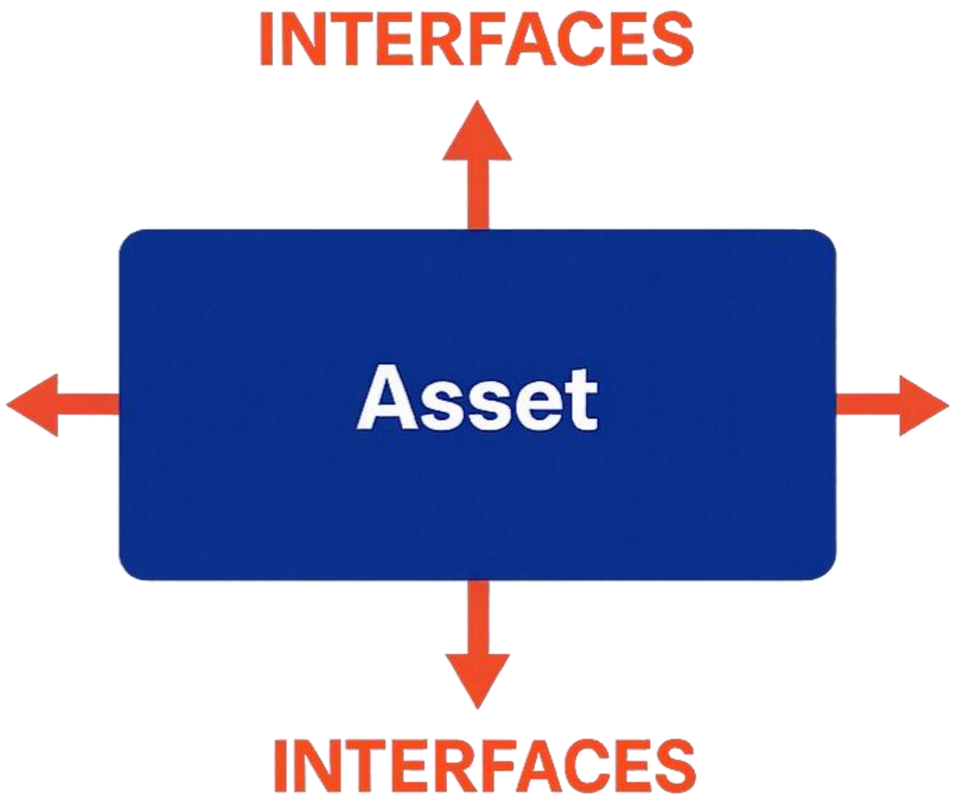
"You don't go live when the asset is built, you go live when everything is ready"

NeuConnect

Challenges, Learnings, and Takeaways

Key Challenges and Learnings

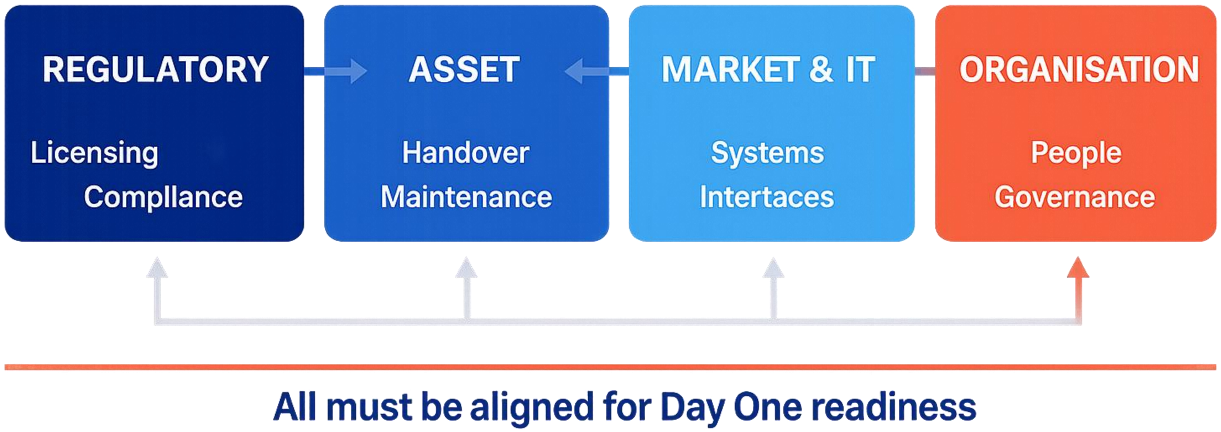
- **Moving target**
  Regulation | Market change | Adaptability
- **Designing for the unknown**
  Future ops | Assumptions | Flexibility
- **Alignment across lifecycle**
  Contractors | Incentives | Handover
- **Delivery vs long-term quality**
  Programme pressure | Operational impact
- **Complexity at interfaces**
  Vendors | Systems | TSOs
- **Clarity in a lean model**



"Most risks don't sit within the asset - they sit at the interfaces around it"

What We're Doing Differently + Key Takeaways

- **Embed operations early**
  Influence | Not react
- **Engage stakeholders early**
  Regulators | Partners | Alignment
- **Focus on interfaces**
  Systems | Organisations | Handoffs
- **Design for change**
  Flexibility | Evolving frameworks
- **Organisation matters**
  People | Governance | Decisions



"Every shortcut during construction becomes technical debt in operations"

"We're commissioning the organisation, not just the asset"

"Most of us don't struggle to operate HVDC — we struggle to inherit it"

NeuConnect

Thank you!
Any questions?

ian.reed@neuconnect.eu

Dr. Vahid Sabzpoosh– Moyle HVDC Engineer

moyle interconnector

mutualenergy

A Northern Ireland company
working for consumers

Moyle Interconnector

HVDC Centre Operator’s Forum 2026

What we're going to chat about

- Mutual Energy
- The Moyle Interconnector
- Cyber Security
- 2025/2026 Outage plans
- Synchronous Condenser
- TRV and Circuit Breaker Programs
- Tests Performed on the Replica

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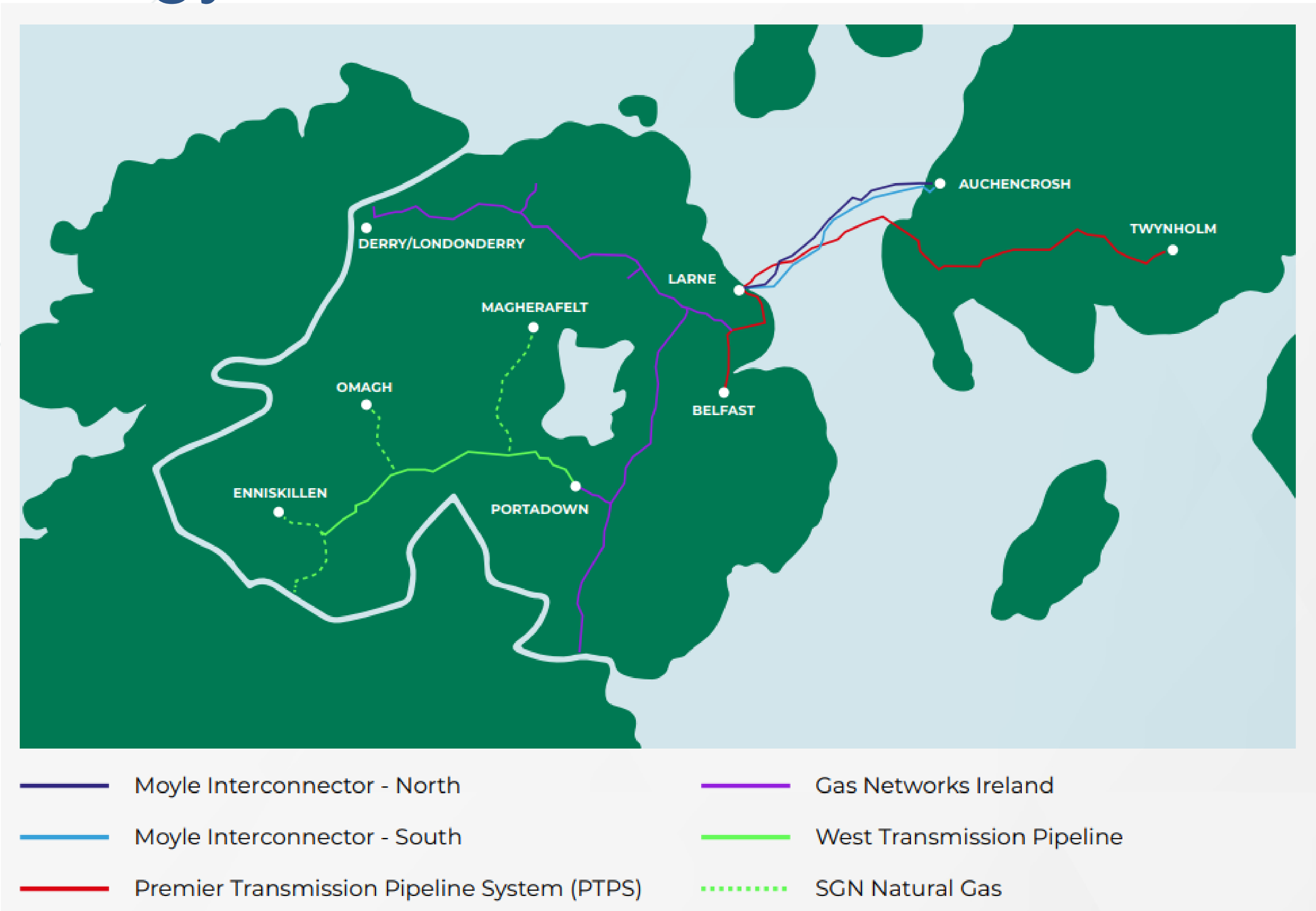
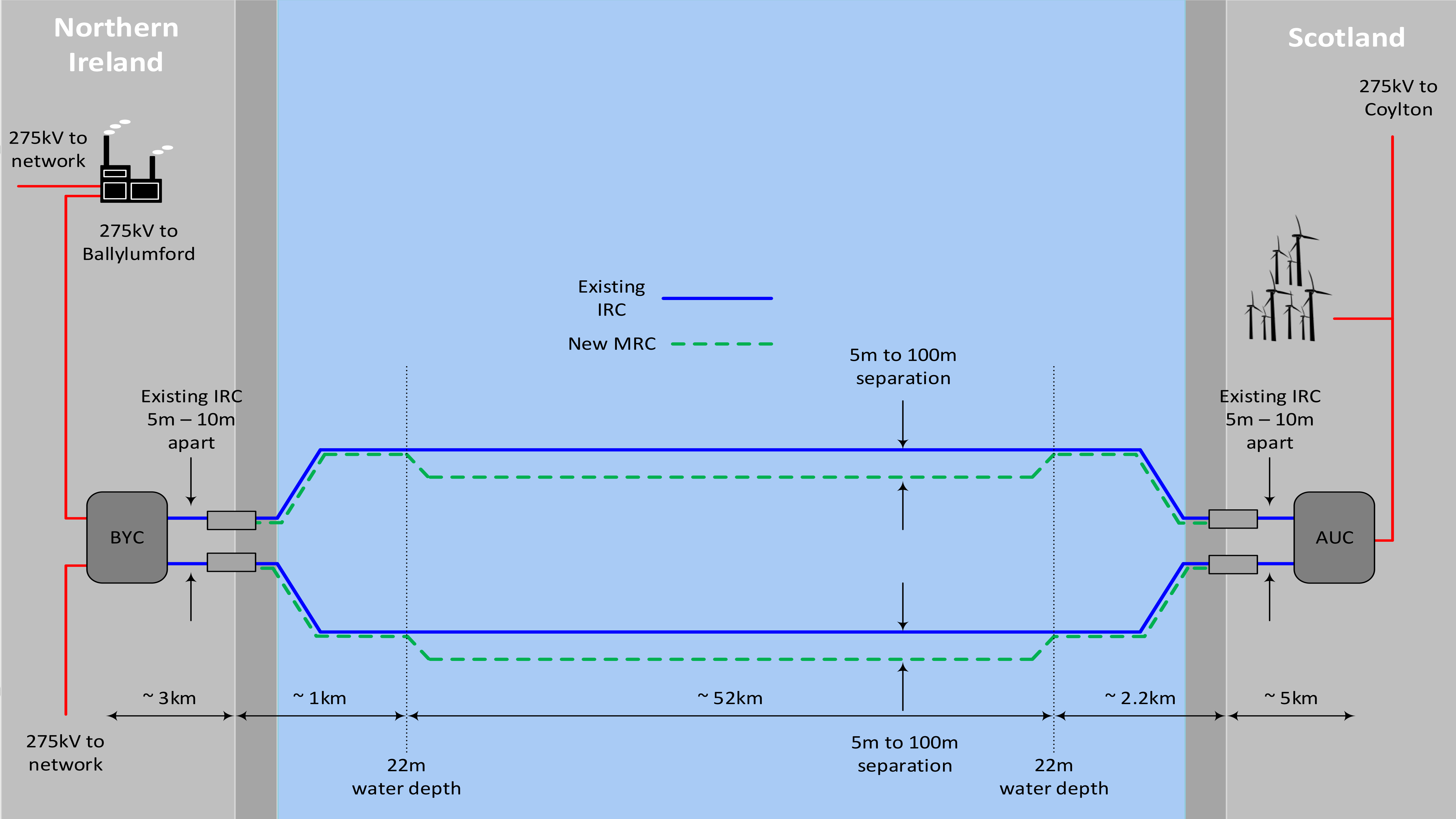
Mutual Energy's assets




Northern Ireland
Scotland
275kV to network
275kV to Ballylumford
275kV to Coylton
Existing IRC
New MRC
5m to 100m separation
Existing IRC 5m – 10m apart
Existing IRC 5m – 10m apart
BYC
AUC
~ 3km
~ 1km
~ 52km
~ 2.2km
~ 5km
275kV to network
22m water depth
5m to 100m separation
22m water depth

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Ballycronan More

Auchencrosh

mutual-energy.com

Ancillary Services

- Provides up to 100MW of Frequency Limit Control (FLC) to NI
- Provides up to 100MW of Emergency Power Control (EPC) to GB
- Could do fast power reversal
- Static Firm Frequency Response (SFFR)

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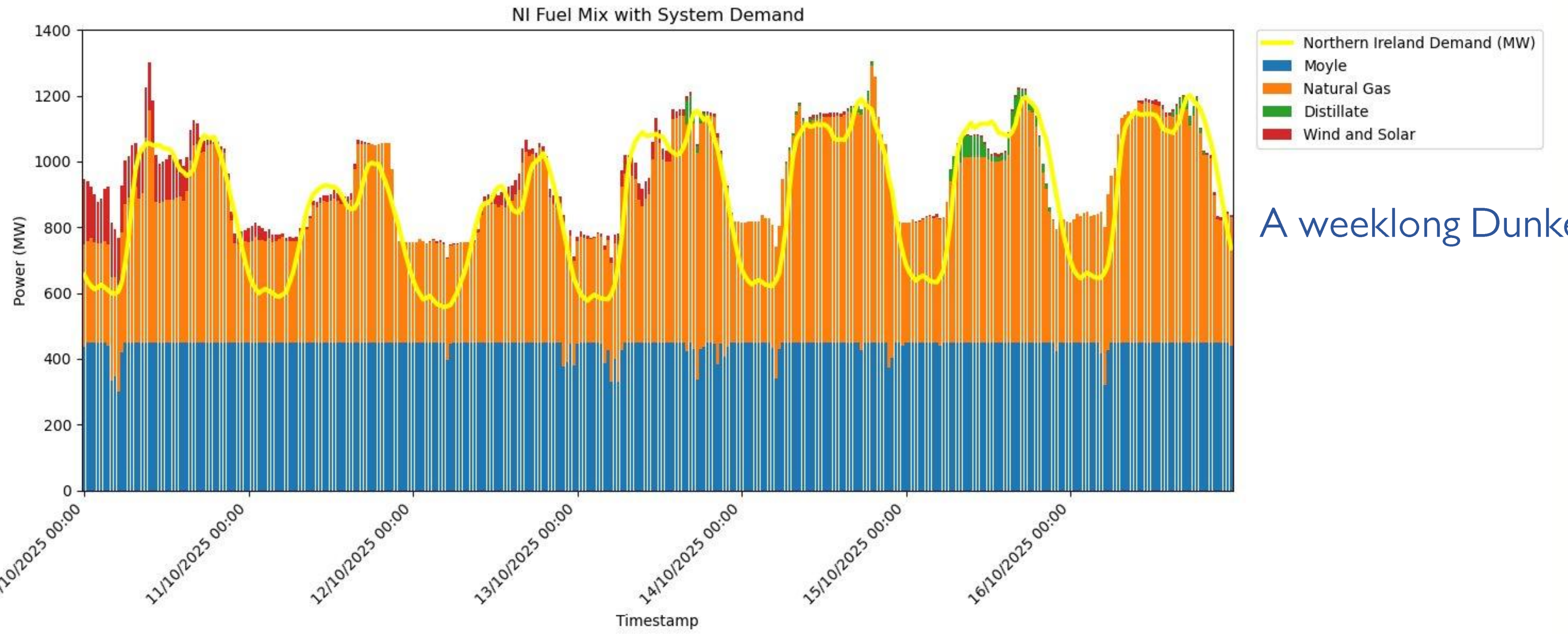
Moyle Critical to NI Electricity Supply



A weeklong Dunkelflaute

Total NI electricity consumption	Total Moyle energy import to NI
7279 GWh	2426 GWh

33%

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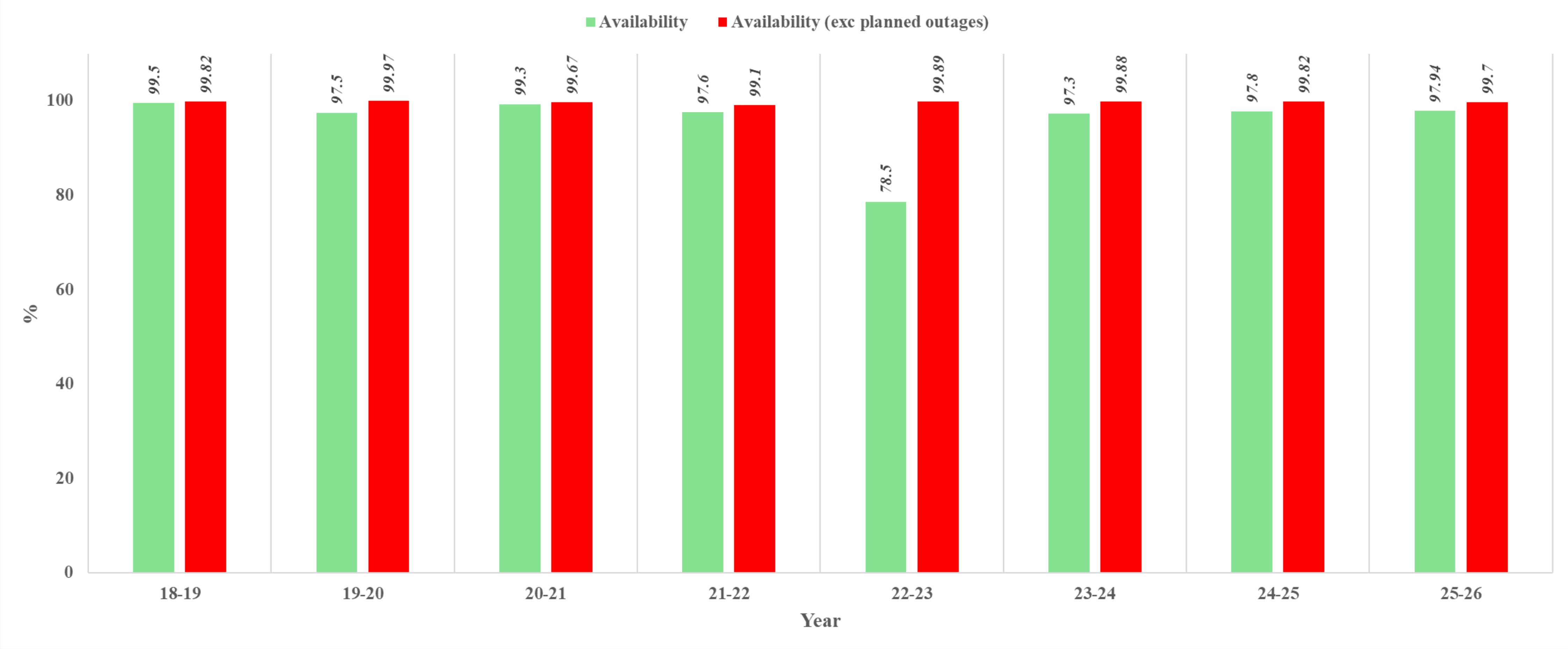
Availability



Cyber

- Siemens Energy engaged
  - Maintain digital twin
  - Advise on patch releases
  - Deploy on replica
  - Deploy on live system
  - Provide Security Operations Centre

- Independent experts providing penetration testing

Penetration test in HVDCC

Test Strategy

- Focused testing of Moyle Replica
- Component-level and system-level testing
- Testing in the replica in its intended operational setup

Areas of Assessment

- Management, engineering, and operational interfaces
- Network segmentation and trust boundaries
- Control, protection, and supervisory interactions

Objectives

- Identify component and architectural weaknesses
- Assess propagation of vulnerabilities
- Evaluate evidence for live system assurance

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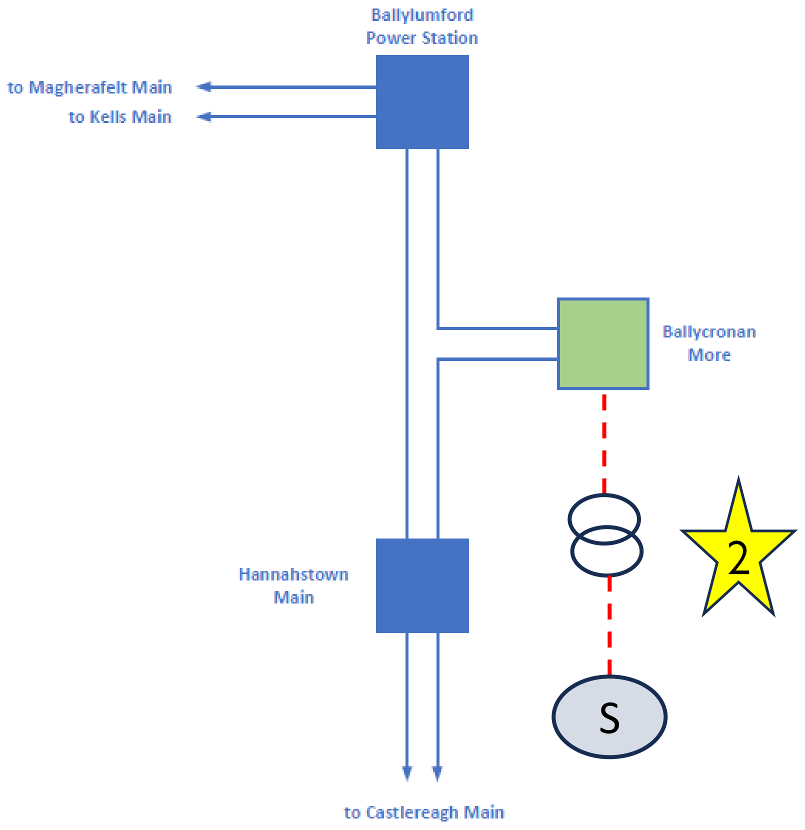
Capacity

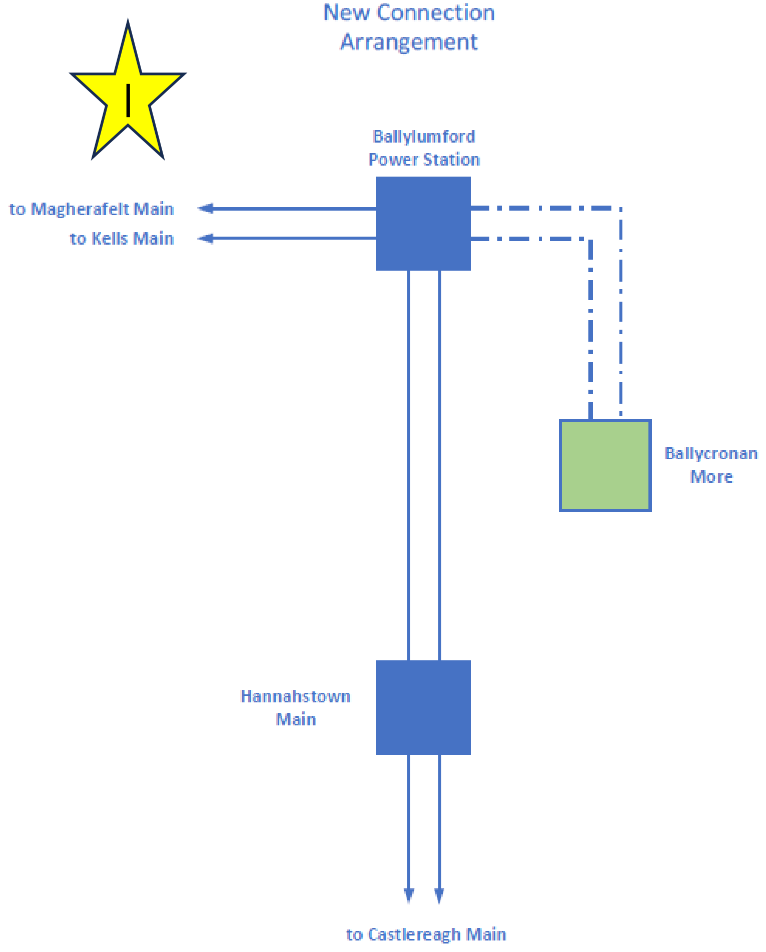
Import 450 MW
Export 400 MW

500/600 MW

Existing Connection Arrangement

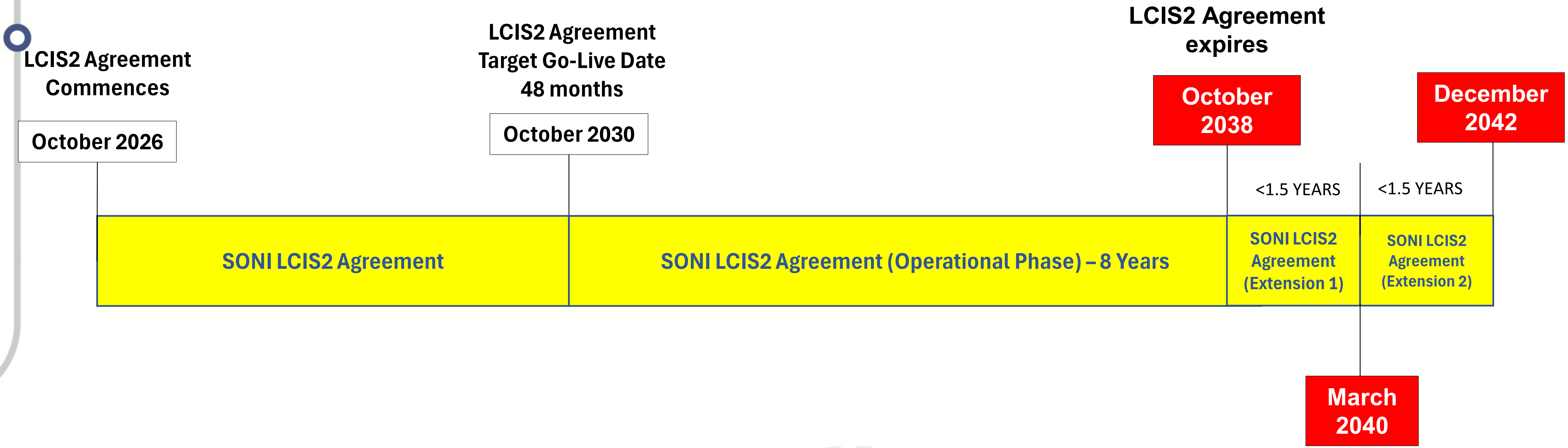


New Connection Arrangement



Synchronous Condenser

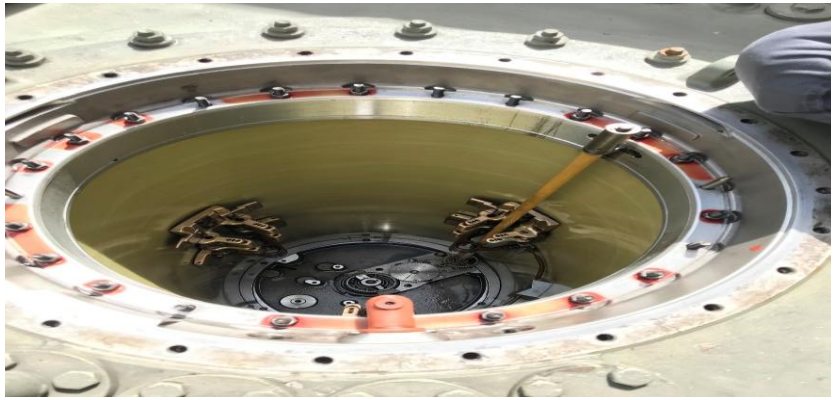
- LCIS 2 is a competitive auction run by SONI and Eirgrid
- SONI procuring 4000-6000 MW.s Inertia for Northern Ireland



Outage Plan-2025

- Involved over 4000 hours of effort
- 4 cranes delivered over 500 lifting operations throughout the week
- 88 individual radiators were replaced on all 6 transformers at BYC and 5 at AUC
- The 6 transformers at AUC had tapchangers replaced
- 8 valve cooling UPS were replaced across both sites
- Software update for control system
- Routine maintenance

Tapchangers replacement



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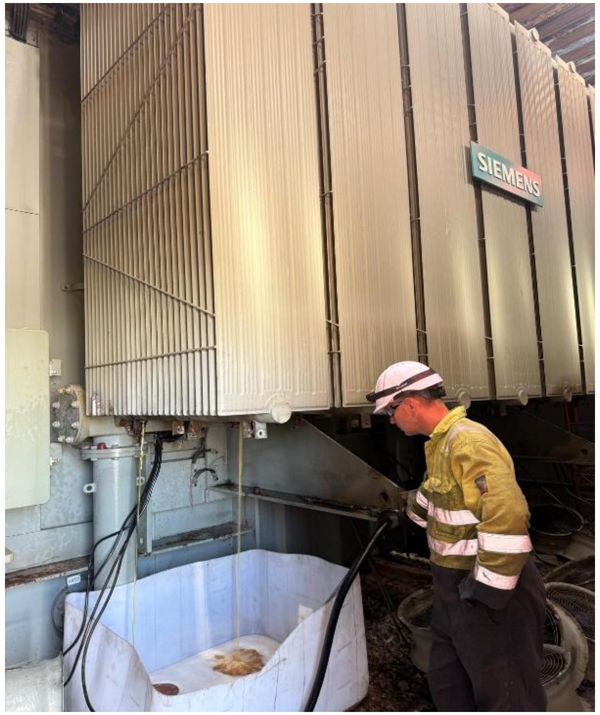
Radiator replacement



WINDER POWER
ENERGY DELIVERED

Winder Power's Transformer Services division is proud to have delivered essential shutdown works at the Ballycronan and Auchencrosh substations in support of the Moyle Interconnector, a key link between the electricity networks of Northern Ireland and Great Britain.

Outage Plan-2026

- Tapchanger replacement at BYC
- Cyber security
- Valve cooling fans
- Routine maintenance

SSTI

Changes:

- ✓ Change of SSTI Bandpass filter from 5-40Hz to 10-40Hz for SSTI AC Protection function.
- ✓ Activation of a separate SER Message of SSR Protection trip routed additionally to Load Dispatch Centers

Purpose: to exclude the "Inverter Based Control responses 5Hz-6Hz oscillations" for the SSTI Protection frequency window.

Risk: loss of Pole Control Redundancy during update of the other system or update the DC Protection System during Pole outage.

Mitigation: Pretest on Replica

SSTI

1- Negative test to test SSTI protection stability. No protection action should take place.

- Long run Steady State
- 3ph to ground AC fault at Moyle converter busbar Ballycronan More

2- Positive test to check SSTI trip behaviour. SSTI protection at Ballycronan More must pick up.

f_mod = 5 Hz

f_mod = 11.35 Hz

f_mod = 15 Hz

➢ Same tests, but with the HVDC power direction swapped (the SSTI_AC protection at Ballycronan More should not trip).

Questions?

Vahid.sabzpoosh@mutual-energy.com

FIFA – extending the life of the UK's first HVDC interconnector

David Monkhouse, National Grid Ventures

nationalgrid
ventures

National Grid Ventures Interconnector Portfolio

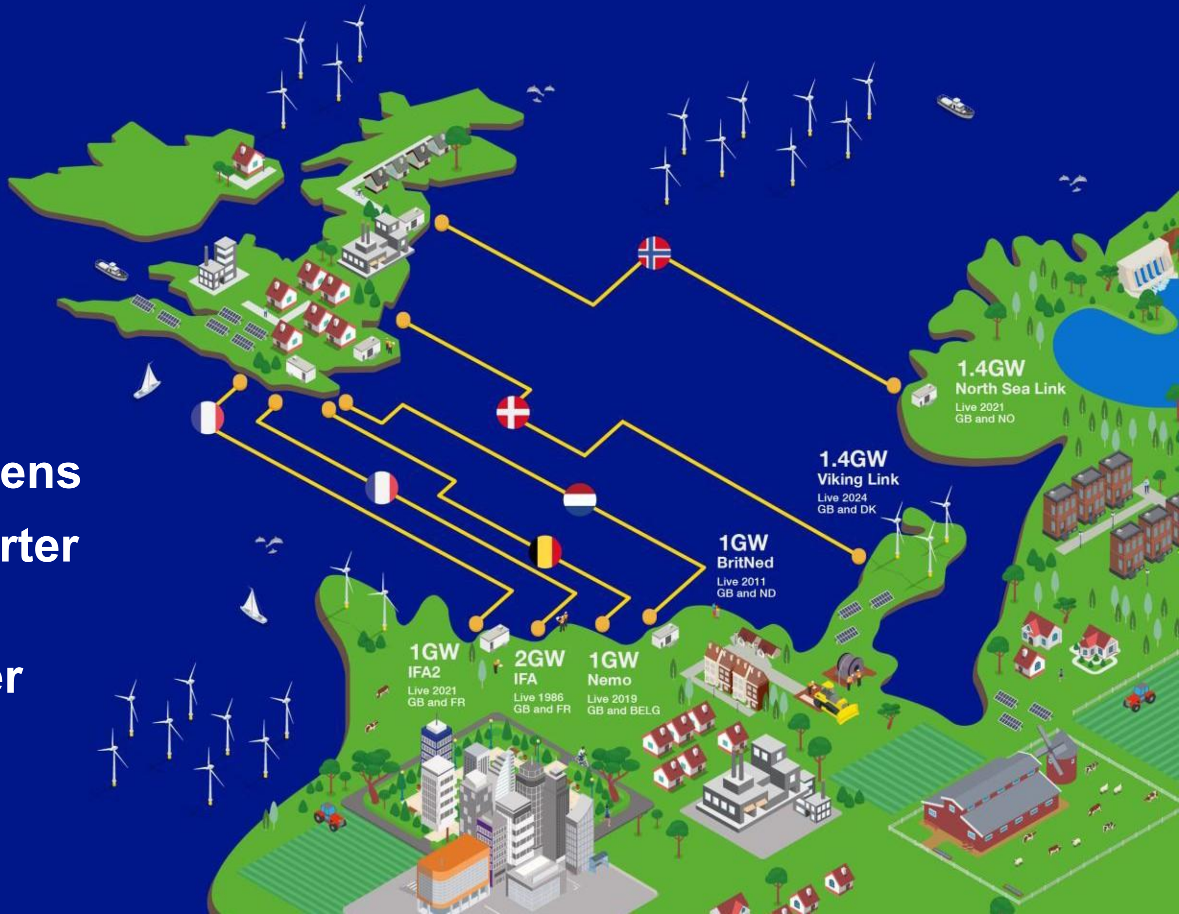
6 projects

Total capacity = 7.8GW

Suppliers: GE, Hitachi, Siemens

2 x Line Commutated Converter technology

4 x Voltage Source Converter technology



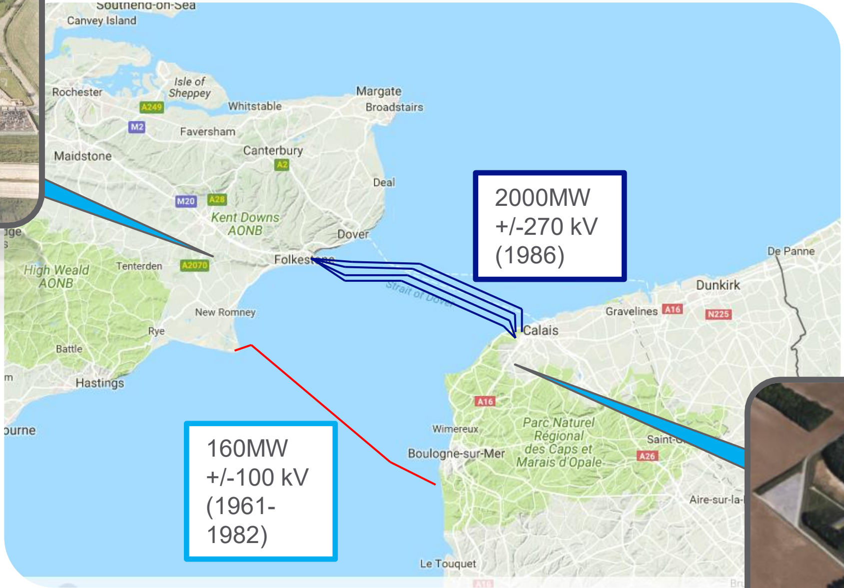
IFA2000

Sellindge IFA Substation

- NGIC & RTE (1986)
- LCC, 2000 MW
- 270 kV dc
- 2 Bipoles
- 73km
- 400kV AC connection
- NG Share £391m (£1.5billion today)

Why an interconnector to France?

- Diversity in availability of power plants
- Diversity in national demands
- Differences in generation mix FR-GB = high market spread



Les Mandarins IFA Substation

- IFA Can supply 4% of total UK annual demand

IFA 1 (IFA2000) history

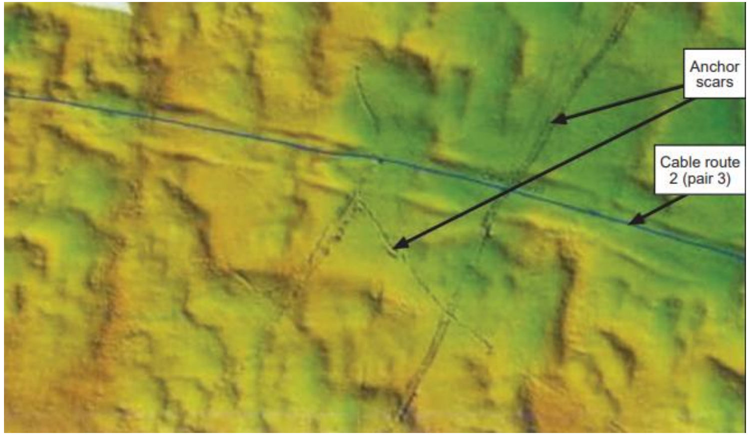
- 1961 - IFA 160, the first Cross Channel Link transmitting 160MW at +/-100kV dc.
- Symmetrical monopole design with the cable laid directly on the seabed. The GB converter station was situated at Lydd, close to Dungeness. Due to frequent third party cable damage, multiple repairs and poor availability, the link was abandoned by 1981 when development of IFA2000 was underway.
- 1985/6 - IFA 2000 – the second Cross Channel Link is commissioned and enters service transmitting 2000MW at +/-270kV dc. The convertor stations were provided by different contractors, GEC in the UK and CGEE Alsthom (under license from GE) in France. The first multi-vendor project!

IFA 1 (IFA2000) history

- 2012/13 - Valve Replacement Project - this replaced the HVDC Control and Protection, thyristor valves and associated equipment at both ends and on both Bipoles with a common design.

- 2016 – 2 of the 4 submarine cable pairs off Folkestone damaged by a ship dragging its anchor.

- 2021 – on the 15th September, Bipole 1 is damaged by fire.



Converter transformer valve winding bushing failures

- The first failure occurred one month after commissioning in October 1986 on T11A.
- The damage was extensive and the transformer was replaced by the spare transformer and the original replaced under warranty.
- There have been numerous failures while in service and many bushings having been removed from service due to defects found upon further inspection or bushing failures.
- Failures were a result of poor stress shield design around the bushing/transformer interface.
- FEA undertaken in 2003 by Weidmann to design a new stress shield that could be retrofitted to the existing transformers

Figure 3: Discharge Path

Figure 4: Oil End Terminal

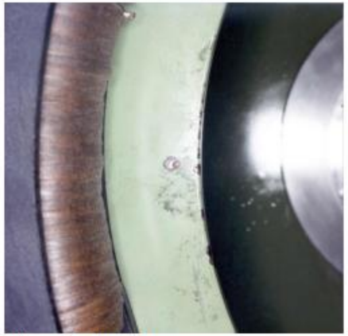
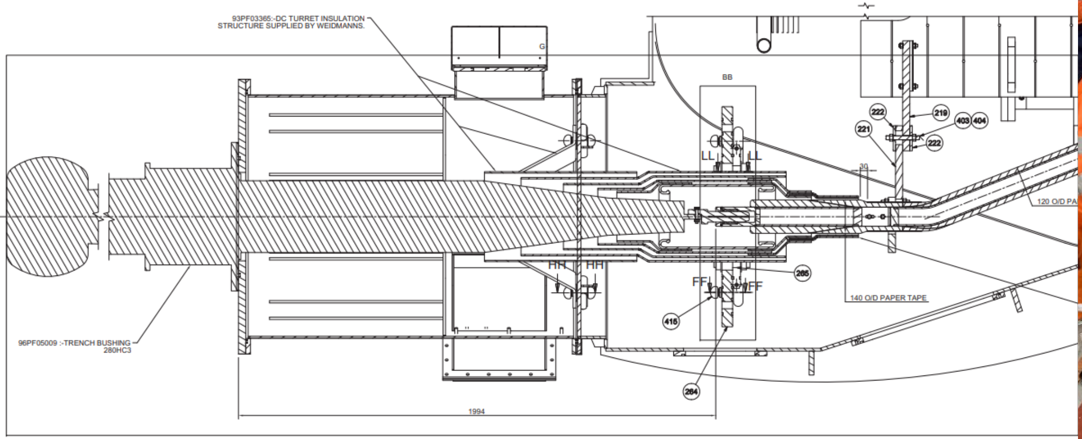


Figure 5: CT Area

Figure 6: Flange Air Side

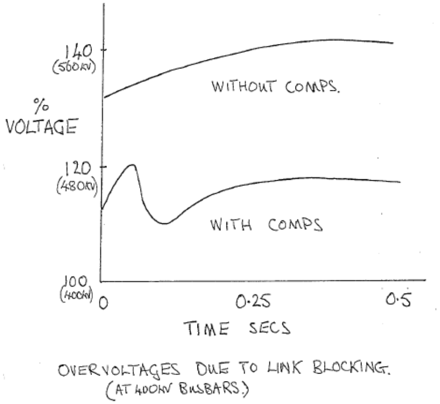
Converter transformer valve winding bushing failures

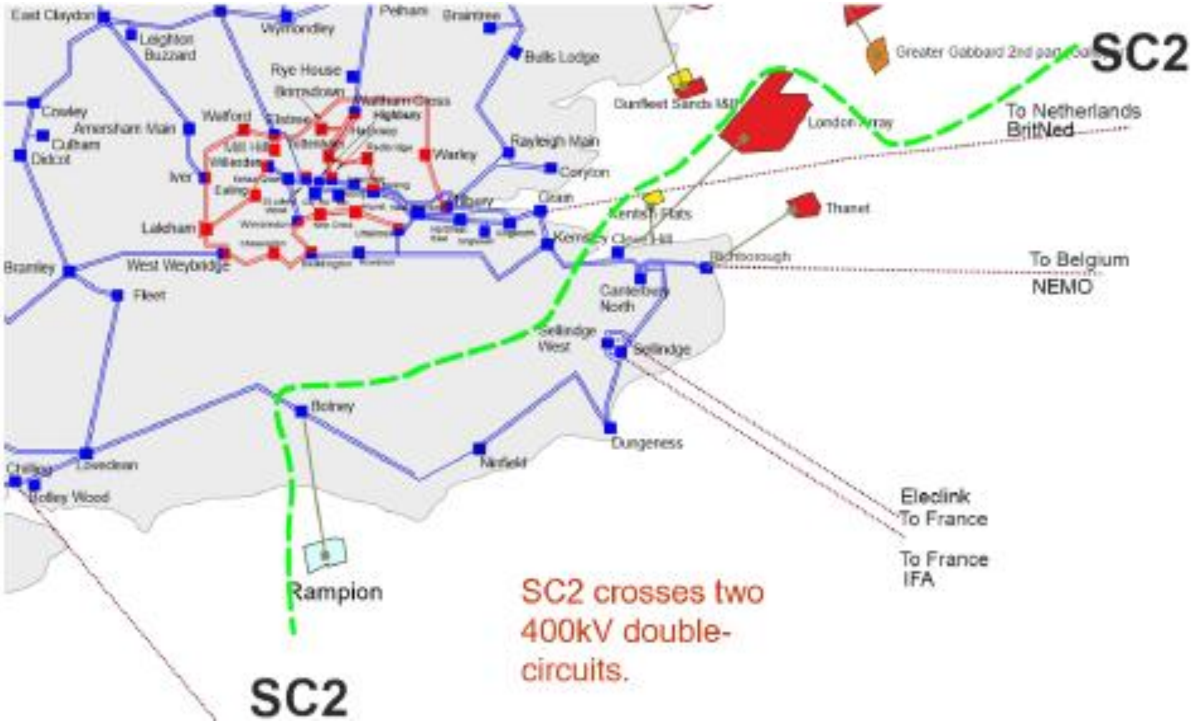
- All “A” transformers retrofitted with new stress shields from 2003 onwards.
- Bushing slightly redesigned in 2011 (coincident with spare transformer purchase) to improve internal stress grading in view of increased test requirements
- Although performance much improved, 3 bushing failures occurred, including 1 catastrophic failure
- As of May 2026 outage, all original bushings have been replaced with a new type (HSP or GE).



Sellindge Static Compensators – need case

- During early design studies, it was recognised that a sudden load rejection or trip of IFA2000 would create high Temporary OverVoltages (TOV) on the 400kV system, especially during 400kV circuit outages
- Studies indicated TOV's of 140% of 400kV worst case.





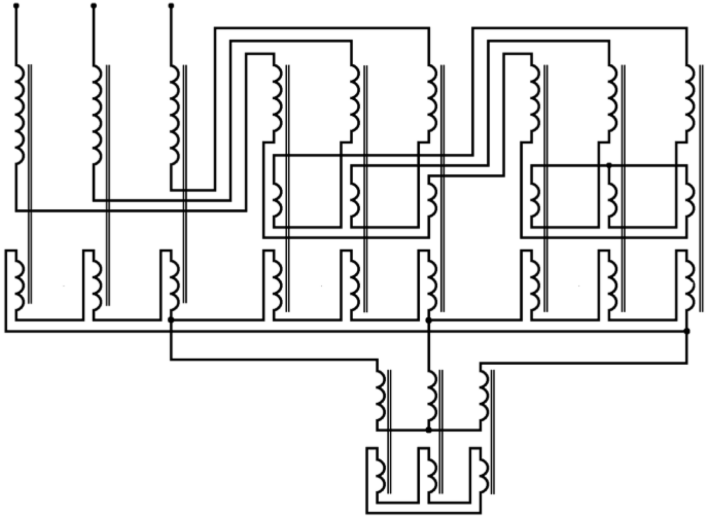
Sellindge Static Compensators – need case

- With a need for fast acting dynamic compensation established, various solutions were investigated:
  - Synchronous Compensator (rotating machine)
  - Thyristor based Compensator (emerging technology at the time)
  - Saturated Reactor Compensator (established technology, but relatively uncommon and of smaller power ratings than required at Sellindge)

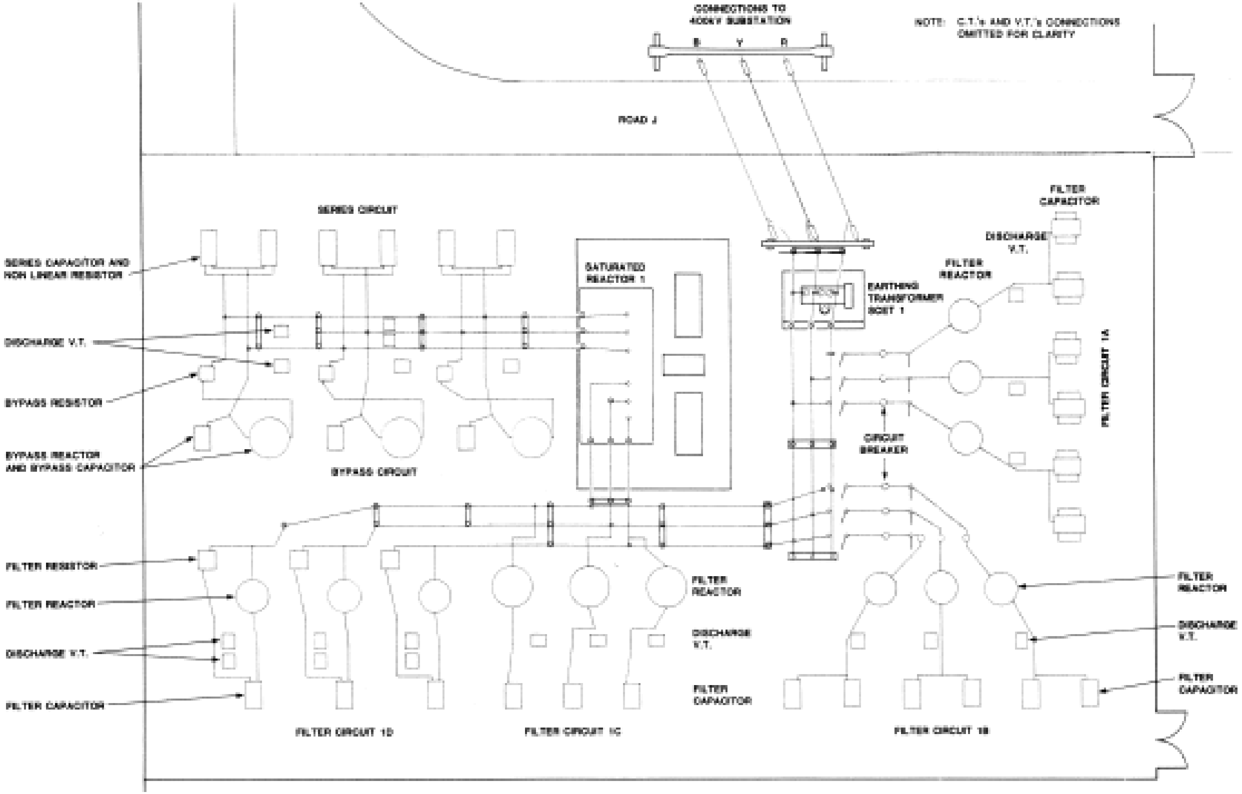
- Because a large but short term (seconds) inductive capability was required the inherent overload capability of the saturated reactor proved to be the best option.
- The disadvantage of a Saturated Reactor Compensator is the reactor is very noisy and has relatively high losses compared to the other options.
- The original design required that 2 Static Compensators were required to manage TOV at 6000MVA system short circuit level and 2000MW dc transmission.
- Ultimately, 3 x Static Compensators were provided giving 3 x 50% redundancy – 2 are installed at Sellindge and 1 is installed at Ninfield. Only the 2 at Sellindge compensators are owned by NGV, the Ninfield Compensator is owned by NGET.

Sellindge Static Compensators – need case

- Saturated Reactor, harmonic compensated Treble Tripler, with mesh loading reactor. Invented by Dr Erich Friedlander of GEC in the 1960's



Sellindge Static Compensators – need case



Static Compensator Refurbishment

Why refurbish?

- The system need is still there – in fact the 400kV system is weaker than in 1986 following generator closures
- Inherent overload (3.3pu for 0.5 seconds) – power electronic based equivalents (e.g. STATCOM) do not have appreciable overload
- Relatively simple compared to a modern device – comprehensive protection, but the control system is essentially a tapchanger control.
- Limited auxiliaries – reactor oil cooling system, no converter water cooling, no HVAC
- Small footprint – would a +150/-500Mvar STATCOM fit in the same space?
- But can you still purchase a saturated reactor?

Static Compensator Refurbishment

- Saturated Reactor (Treble Tripler), 56kV, 157.3MVA, 1453A, OFAF cooling – 3 new reactors have been procured

Static Compensator Refurbishment

- Reactors, Capacitors and Resistors forming various shunt and series capacitor banks and filter banks – reactors and resistors will be replaced
- Shunt banks are switched by 72.5kV class SF6 circuit breakers (originally GEC FG1) – will be replaced

Static Compensator Refurbishment

- Comprehensive protection provided by electromechanical relays dating from 1985 – capacitor protections to be replaced
- Automatic control (tapchanger and switched bank control) performed by bespoke GEC PPC2000 microprocessor system – be replaced by modern PLC

Static Compensator Refurbishment








19

THE GREENLINK INTERCONNECTOR

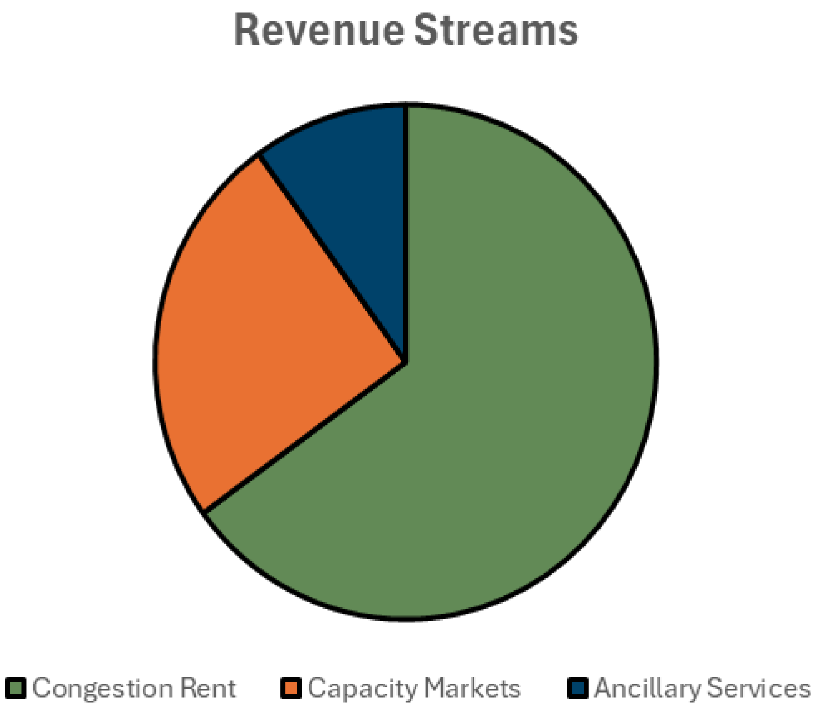
Diarmuid Murphy & Matt Gibson
Greenlink Interconnector Ltd.

Lessons from Owners & Operators – Living with Software: Obsolescence, Software Lifecycles & Patch Management

AGENDA

- Introduction
- Asset Value – How an interconnector Earns Revenue
- SEM-GB Interconnection Context
- What's changed (our understanding since we last spoke): HVDC assets age in layers
- Obsolescence: From Future Risk to Live Issue
- Why Patching Behaves Like Maintenance
- Owner Experience – What Surprised Us
- Replicas / Sandboxes: De-Risking Change
- What we are changing as an owner
- Industry Alignment
- Closing

ASSET VALUE – HOW AN INTERCONNECTOR EARNS REVENUE



Market Regimes

- Regulated (RAB Model)
- Merchant
- Cap & Floor (Ofgem regime)
- Hybrid regime possible

Congestion Rent

- Price difference between the connected jurisdictions.
- Power flows from high to low price area (generally)
- 60% to 75% of revenue can be attributed to Congestion Rent
- Daily total can range from low negatives to > €1m (magnitude of losses/gains depends on installed capacity)

Capacity Market

- Capacity markets help TSOs ensure there is enough generational capacity to meet demand
- Auctions take place every year at the T-4 and T-1 time frames
- 15% to 25% of revenue can be attributed to Capacity Markets depending on auction prices

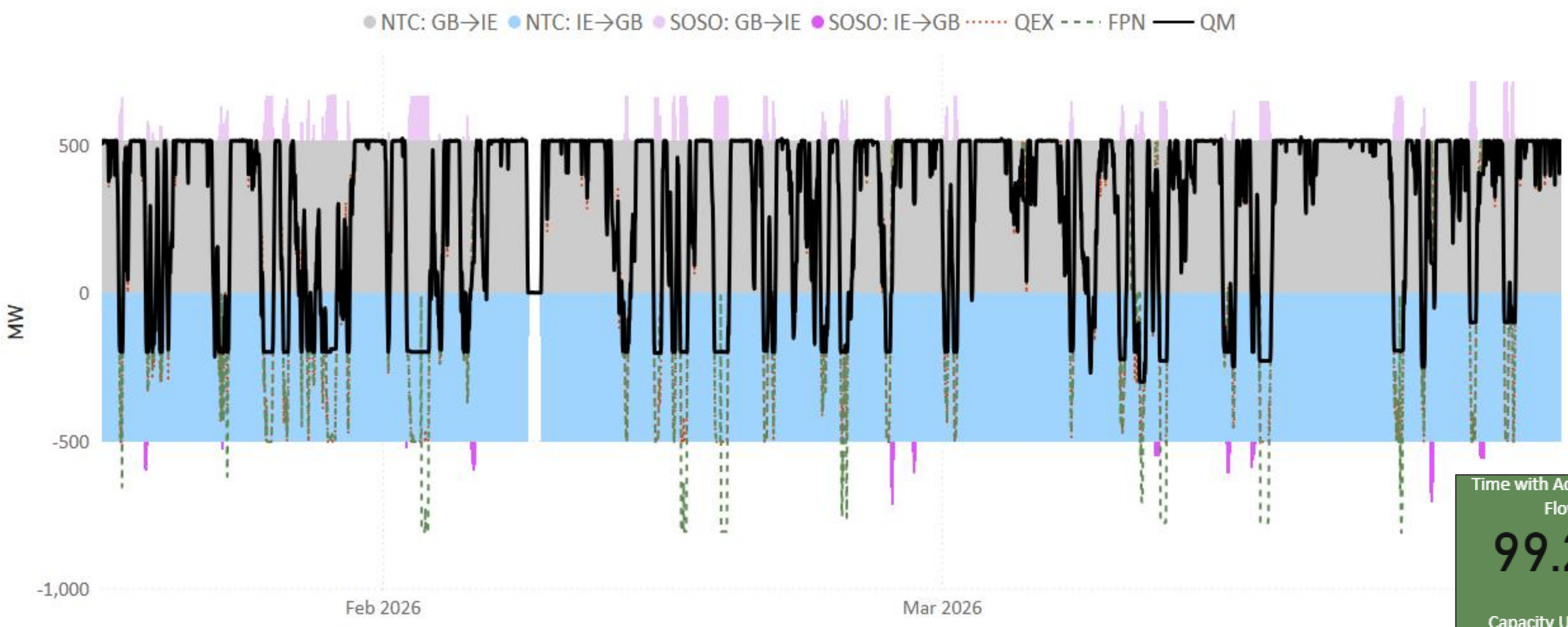
Ancillary Services

- Ancillary Services differ between jurisdictions but generally include:
- Operating Reserves
- Reactive Power Services
- Restoration Services
- 10% to 20% of revenues can be attributed to Ancillary Services depending on market arrangements

SEM-GB INTERCONNECTION CONTEXT

Greenlink INTERCONNECTOR

Overview of Greenlink Operations



Time with Active Power Flow

99.2%

Capacity Utilisation

73.0%

HVDC ASSETS NOW AGE IN LAYERS

Layered Aging of HVDC Assets

HVDC assets consist of multiple layers aging at different rates, from long-life physical equipment to fast-evolving digital and cybersecurity systems.

Digital and Software Lifecycle Challenges

Control hardware and system software have shorter refresh cycles and evolve rapidly, requiring ongoing updates and support management.

Cybersecurity and Compliance Layer

Cybersecurity demands continuous patching and regulatory compliance, often forcing urgent system updates regardless of other layer status.

New Asset Management Mindset

Owners must integrate software lifecycle and cybersecurity management with traditional asset maintenance to ensure system availability.

OBSOLESCENCE: FROM FUTURE RISK TO LIVE ISSUE

Greenlink INTERCONNECTOR

OBSOLESCENCE ≠ END OF LIFE → NOW AN OPERATIONAL DRIVER

Primary Control system | **Security / Compliance** | **Software system layer** | **Hardware / supply pressure** | **Intervention / action**

Shift observed:

Lifecycle decisions now impacting *early-life operation*

Hardware, software and licensing cycles misaligned with asset life

What's driving it:

Vendor end-of-support timelines

Cyber / NIS2-type compliance requirements

Hardware availability & market volatility

Operational impact:

Forced intervention windows

Increasing coupling with outages

Deferral often increases cost *and* risk

WHY PATCHING BEHAVES LIKE MAINTENANCE

IT can be patched

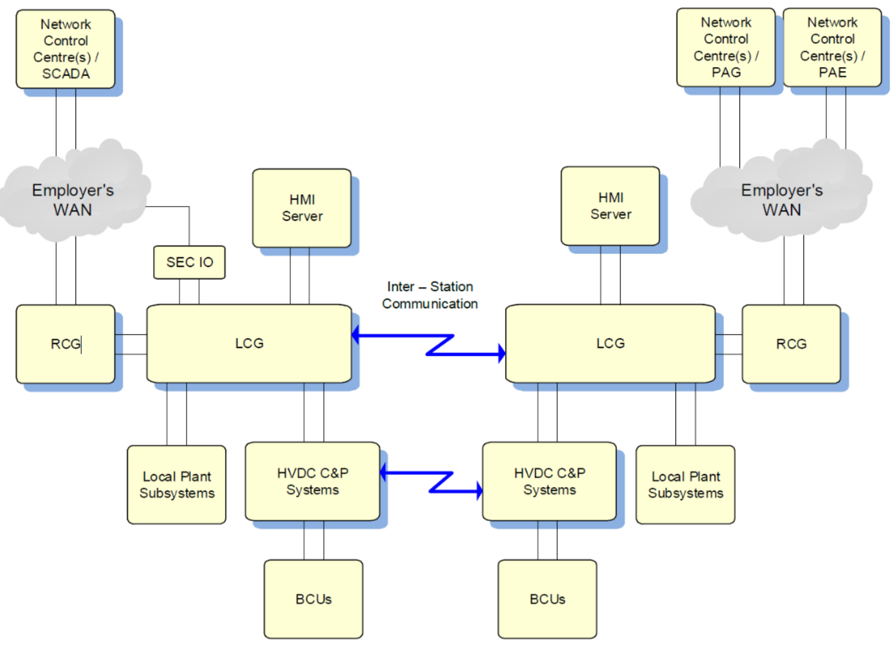
IT patching ≠ OT / HVDC patching

Control system updates require:

- outage windows
- rollback certainty
- pre-testing

Cyber fixes now compete with:

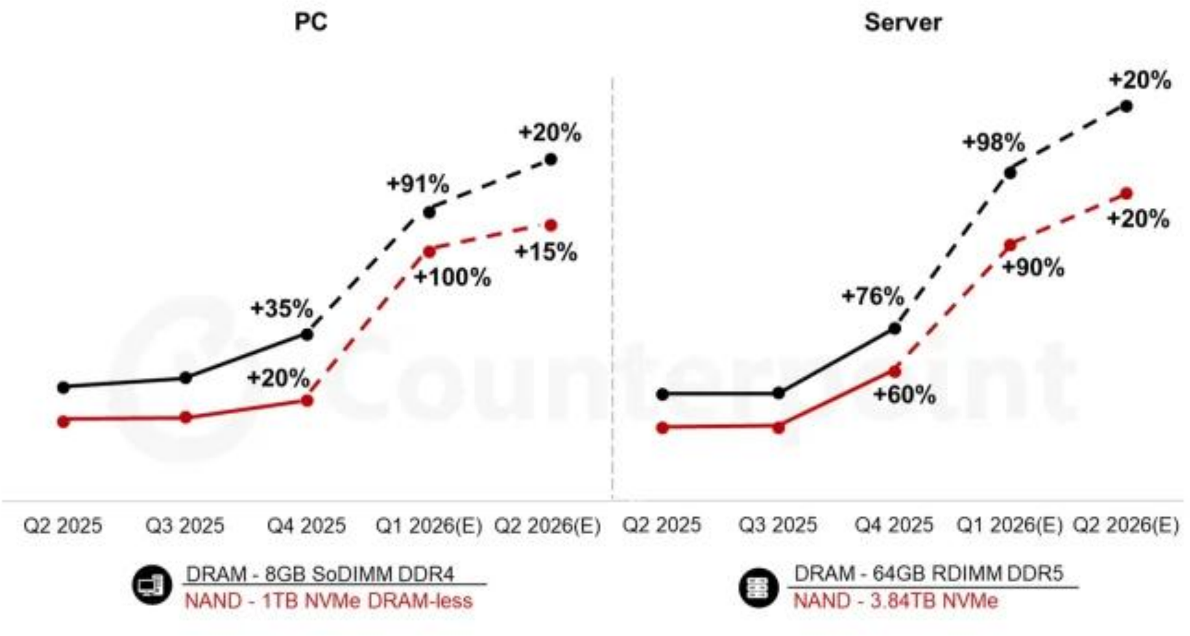
- market availability
- operational margins



OT must be planned!

OWNER EXPERIENCE – WHAT SURPRISED US

Greenlink INTERCONNECTOR



Source : www.wccftech.com/memory-nand-prices-surged-90-percent-in-q1-2026/

Counterpoint

<u>We underestimated how fast IT infrastructure ages</u>

- Software risk emerges within first years of operation
- Deferring change often:
  - increases cost
  - compresses future outages
  - May result in a 'newer' upgrade becoming available
- "Minor" updates can carry major operational risk
- Absence of testing environments increases risk
- Significant price volatility in servers and memory
- Supplier cycles now drive refresh timing

REPLICAS / SANDBOXES: DE-RISKING CHANGE

Greenlink INTERCONNECTOR

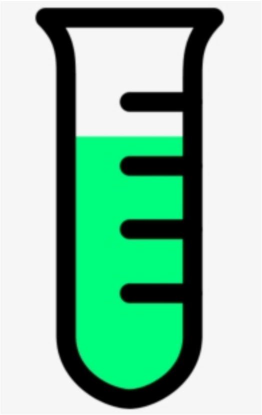
Live System

- Risk of Change
- Outage Exposure
- Limited Rollback

Replicas and sandboxing

- Increasing industry use of:
  - software replicas
  - test environments
- Enables:
  - patch testing
  - upgrade rehearsal
  - training

Replica



- Safe Validation
- Test before deployment
- Full rollback capability

Question is no longer **“do we need one?”**, but **“how do we resource it?”**

WHAT WE ARE CHANGING AS AN OWNER

Controlled, repeatable intervention — **not reactive change**

1
- Lifecycle visibility
- Obsolescence tracking

👉 Interpretation: We now understand the problem early

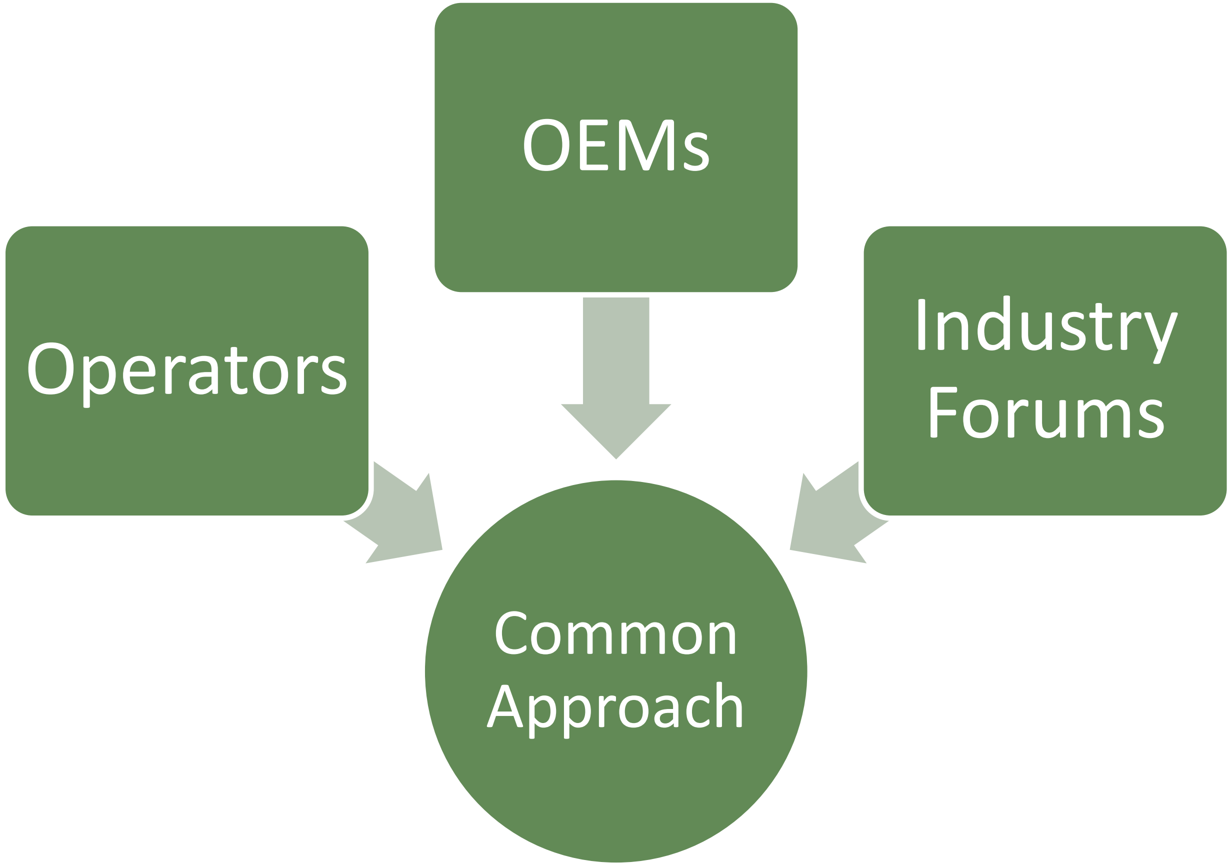
2
- Replica / sandbox validation
- Controlled environment

👉 Interpretation: Don't test on live systems

3
- Planned outage delivery
- Verified recovery

👉 Interpretation: Intervention is controlled and repeatable

INDUSTRY ALIGNMENT



These challenges are not unique — **they are industry-wide**

- Convergence across operators, OEMs and forums
- Increasing alignment on lifecycle and software risk
- Moving toward common approaches to intervention

The industry is moving in the same direction

- From reactive fixes → planned lifecycle management
- From vendor-led → owner-led decisions
- From isolated learning → shared experience

This is not a Greenlink problem **— it's an HVDC reality**

Software now defines availability.
Availability defines value.

Software → Availability → Value

Greenlink

INTERCONNECTOR

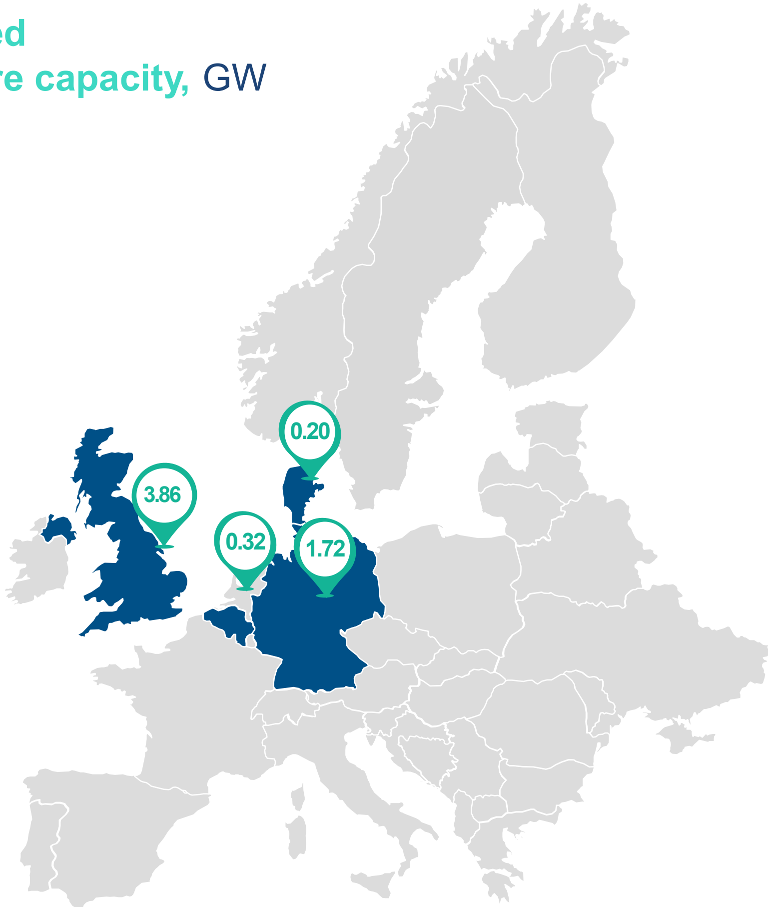
Sofia Offshore Wind Farm

Chris Smith
Lead Electrical Engineer for Sofia Wind Farm
Principal Engineer RWE Renewables

SOFIA OFFSHORE WIND FARM | RWE

RWE: global leader in offshore wind

Installed offshore capacity, GW



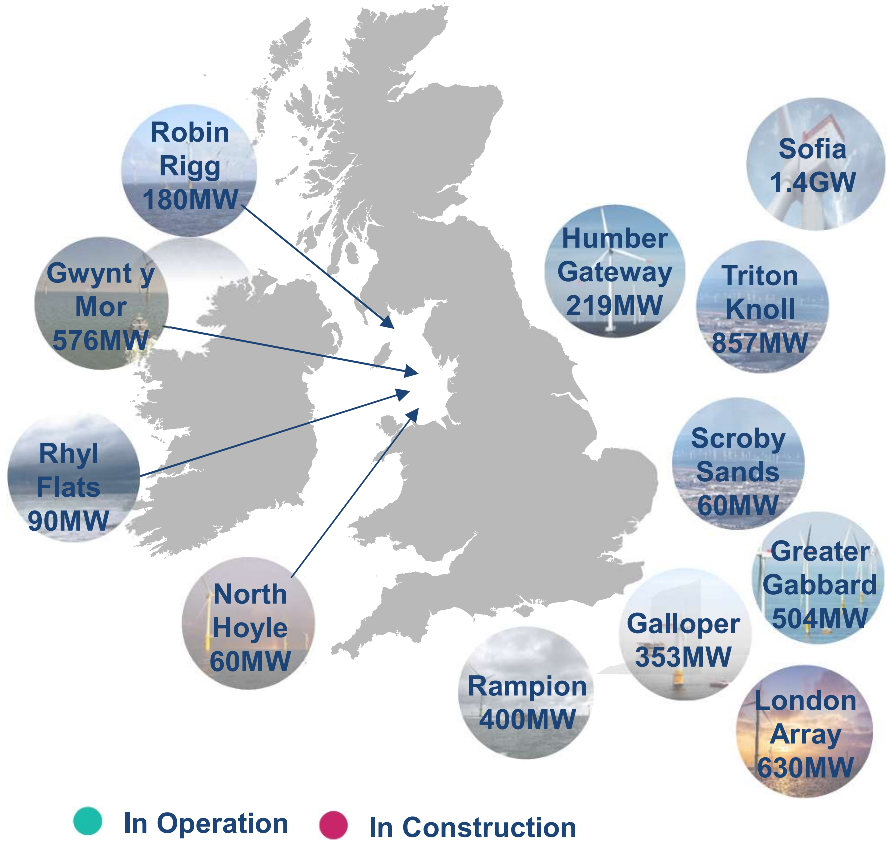
Key facts

- RWE operates **19 offshore wind farms in 5 countries**.
- RWE **owns 3.3 GW of offshore wind globally**, with an operating capacity of 6.1GW .
- In the UK, RWE has been awarded Contract for Difference (AR7) for its **Norfolk Vanguard East** and **Norfolk Vanguard West**, its **two Dogger Bank South** and the **Awel y Môr** offshore wind farm projects, with a combined capacity of **6.9GW of capacity.**
- RWE now has **six HVDC projects in the UK**, Sofia was the first.

RWE’s role in offshore wind in the UK

- The UK is RWE’s largest market and plays a critical role in how we achieve our target of net zero carbon emissions by 2040.
- RWE currently operate **19 offshore wind farms globally, eleven of those in the UK** with a total installed capacity of almost ~3.8GW.
- We have **five UK projects under construction** totalling 2.3GW: **Sofia** nearing completion, the **Norfolk Vanguard and Doggerbank South** projects.
- RWE has the **UK’s largest offshore wind development pipeline** with multiple projects in development likely to add at least another 6 GW to the UK’s offshore wind capacity.
- RWE expects to **invest around £15 billion in the UK** in new green technologies and infrastructure by 2030.

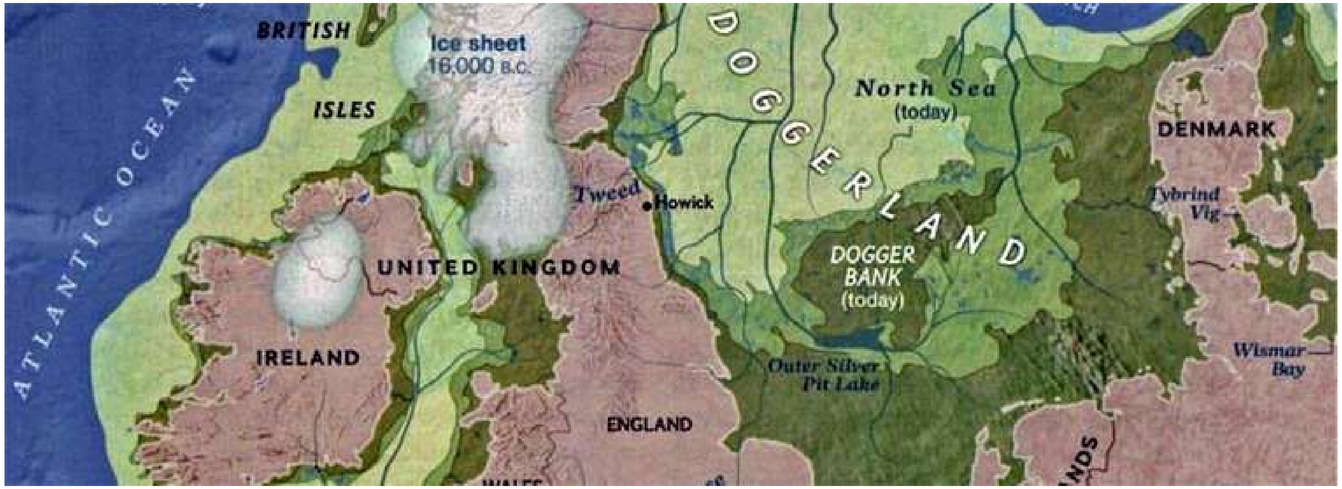
- **UK offshore wind farms operated, fully or partly owned by RWE**



Development of the project - Forewind

About Forewind

- A consortium formed in November 2008 consisting of RWE, SSE, Statoil and Statkraft, with the projects secured in AR3.
- March 2017 Statkraft sold its share to Statoil and SSE.
- August 2017 the projects were divided amongst the share holders.



Division of Projects

- SSE and Equinor (formally Statoil), developed the Creyke Beck A & B and the Teesside A project.
- RWE (formally Innogy), developed the Teesside B project, renamed to Sofia.

Sofia site: Dogger Bank in the central North Sea

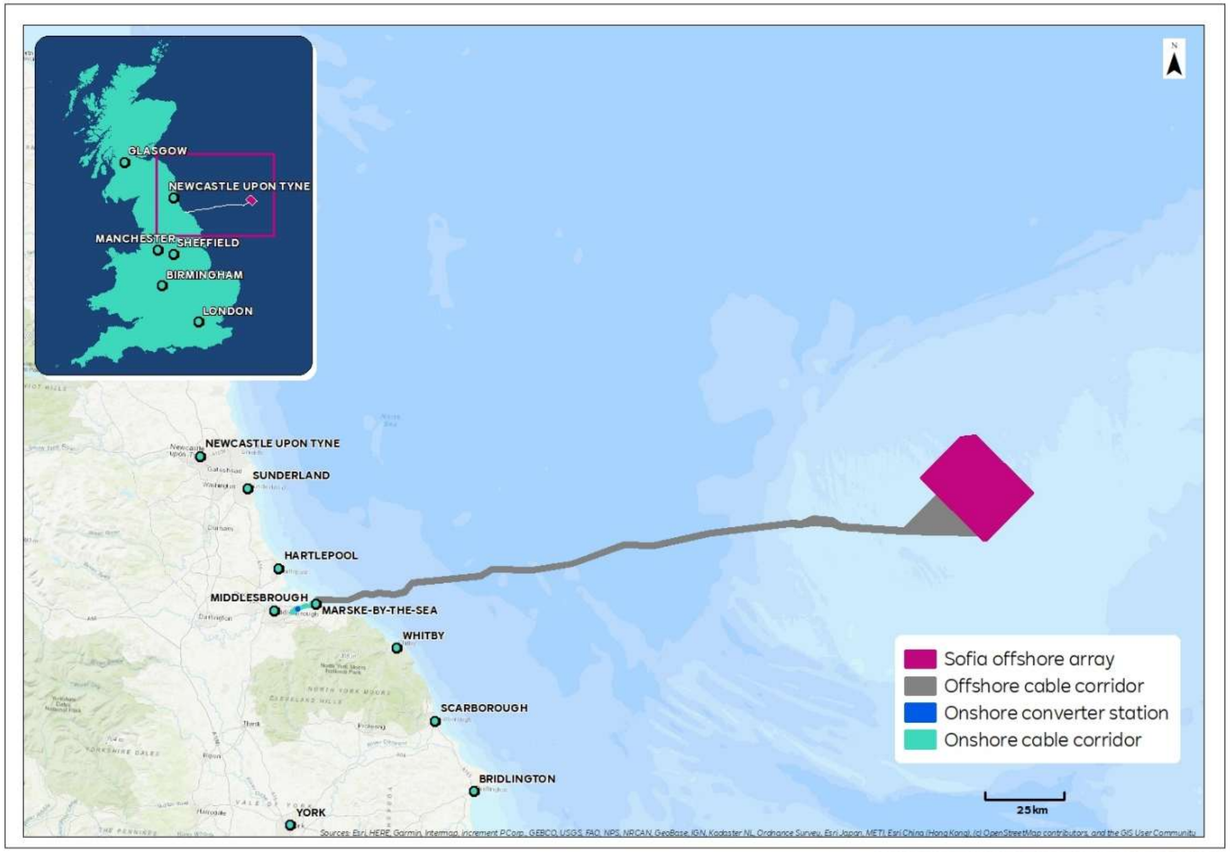
SOFIA OFFSHORE WIND FARM | RWE

About Sofia

- One of the **largest single offshore wind farms** in the world, and one of the farthest from shore - **195km** from the North-East coast.

Key UK benefits

- A more than **£3 billion investment** in the UK's electricity infrastructure.
- AR3 (2019) strike price **(£39.65 per MWh)** making offshore wind the UK's cheapest source of new electricity.
- More than **2.5 million tonnes** of carbon emissions saved per year compared to the use of fossil fuels.
- Significant economic opportunity with supply chain benefits, **direct and indirect jobs** and contracts.



Key facts & figures

SOFIA OFFSHORE WIND FARM | RWE

1.4GW
Installed capacity
The largest project in RWE's offshore wind portfolio

195km
Distance to the North East coast
To the nearest point on the North East coastline

593km²
Site size
Roughly the same size as the Isle of Man

100
Number of turbines
Each 14MW capacity

220km
Distance to landfall
To the connection point between Redcar and Marske-by-the-Sea

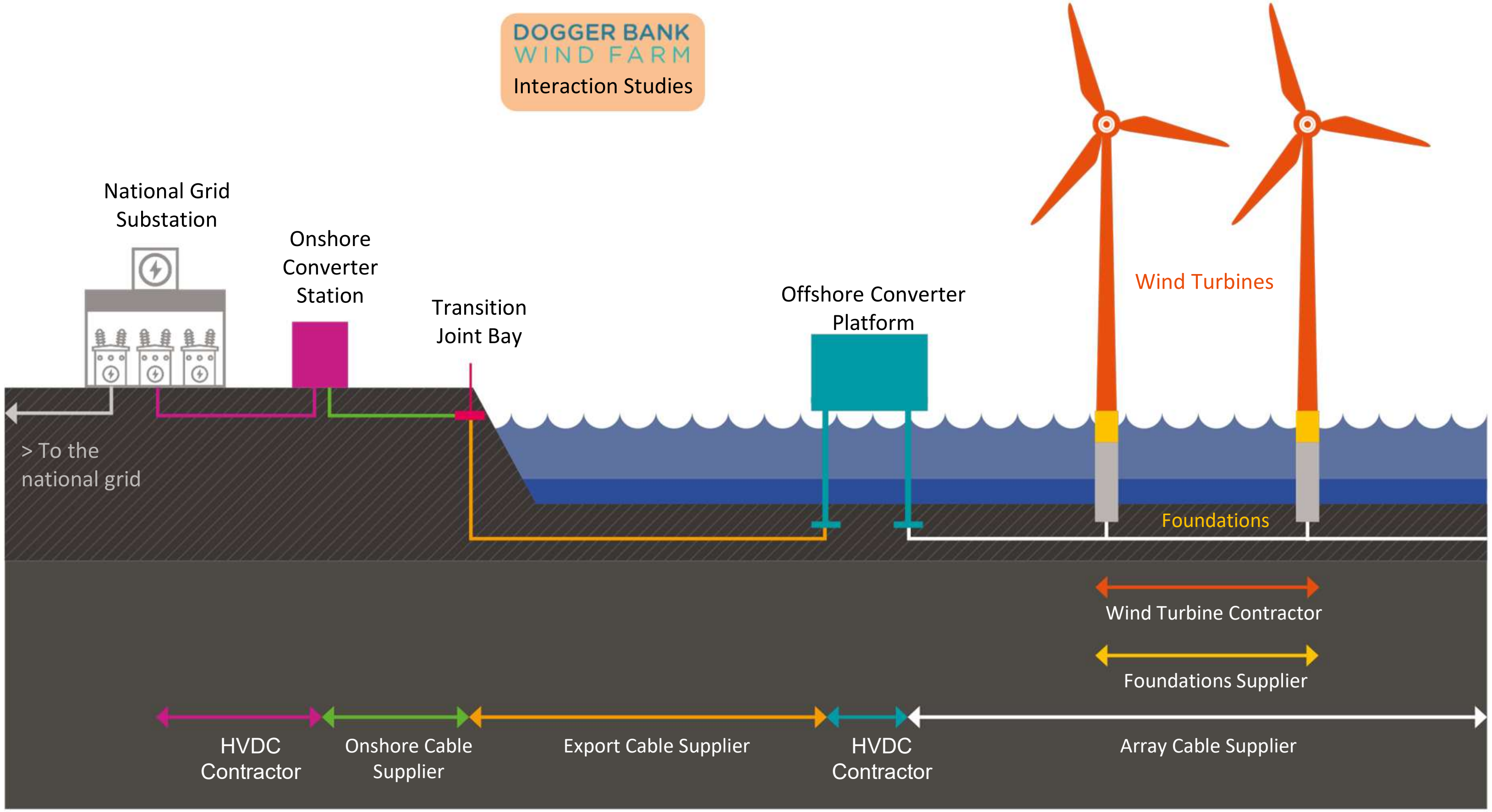
1.2 million
Number of UK homes
That could be powered by electricity generated by Sofia

252m
Turbine height
To the tip of the rotor blade

35m
Deepest water depth
At the wind farm site on Dogger Bank

20m
Shallowest water depth
The same height as the Angel of the North

Contract Structure



Wind Turbine Generators: contract with Siemens Gamesa for 100 SG 14-222 DD turbines

SOFIA OFFSHORE WIND FARM | RWE

Technology	• **14MW state-of-the-art turbines** • **Three blade horizontal axis with 108m blades cast in a single mould** • **222 metre-diameter rotor sweeping an area of 39,000 m².** • **25 year design life and 25% more powerful than SGRE's previous version.** • **One turbine can provide enough energy to power approximately 18,000 average European households every year.** • **Sofia will be the first project to install this model.**
Current status	• **Contract to supply and install 100 turbines awarded in March 2021.** • **~80 installed**

The Wind Peak installing a turbine at sea (May 2025)

WTG Foundations and Array Cables: EPCI contract with Van Oord

Technology	• **The 100 foundations will be 80 to 90 metres in length and weigh 1200 to 1400 tonnes each.** • **There will be 109 individual array cables, totalling approximately 360 kilometres, installed in 18 strings feeding into the offshore converter station.** • **Van Oord's jack-up vessel Aeolus will install the foundations and cable installation vessel Nexus will install the cables.**
Current status	**Van Oord awarded contract to supply and install the foundations and array cables in March 2021.**

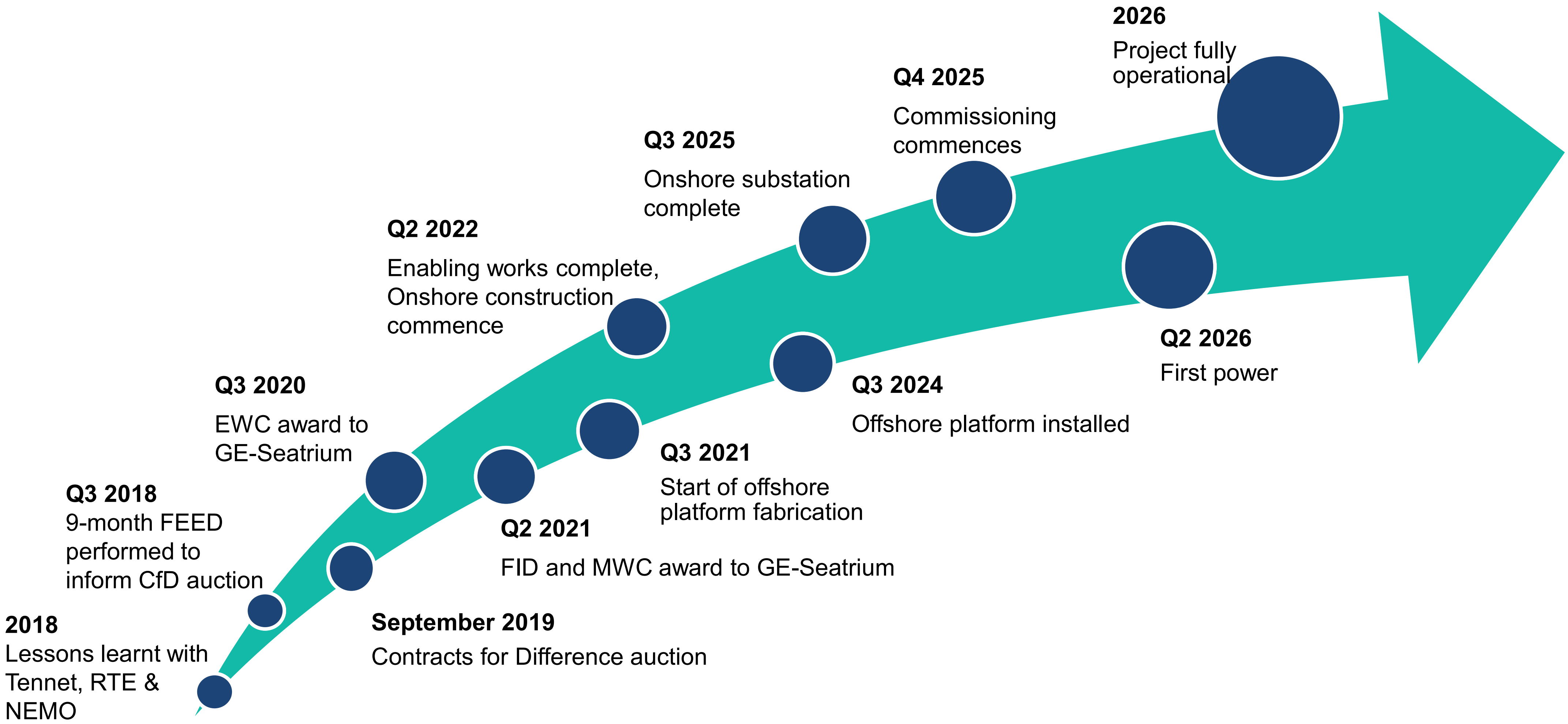
Export Cables: contract with Prysmian Group

Technology	• **320kV HVDC export cable plus fibre optic communications** • **A turn-key high voltage submarine and land export cable connection** • **Use of brand-new cable installation vessel *Leonardo da Vinci***
Current status	**Prysmian Group was awarded the contract to supply and install the export cables in March 2021. Sofia the first project to use the Leonardo da Vinci vessel**

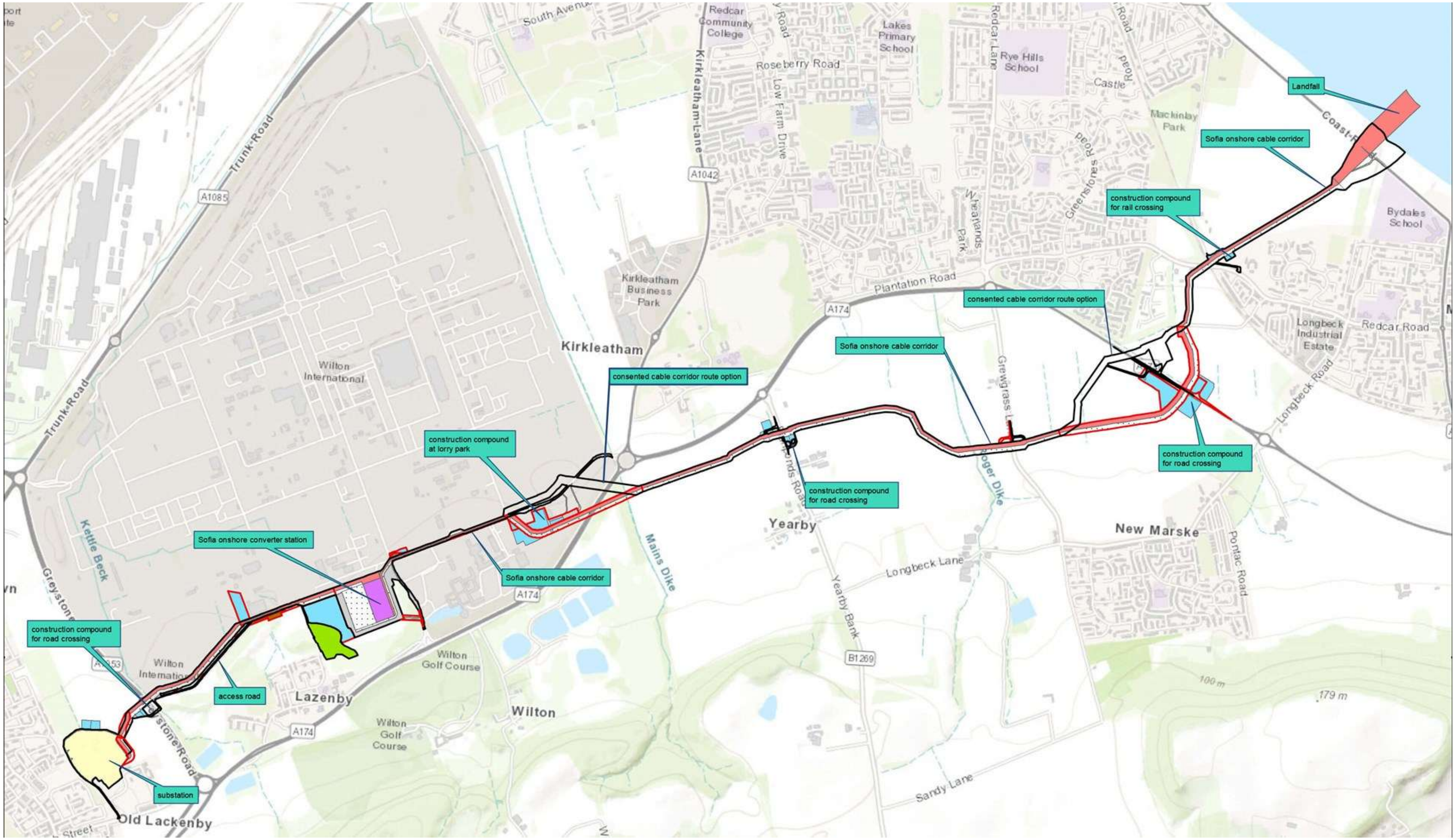
Leonardo da Vinci lays the first cables off Redcar beach (September 2023)

Sofia project timelines (HVDC focus)

SOFIA OFFSHORE WIND FARM | RWE



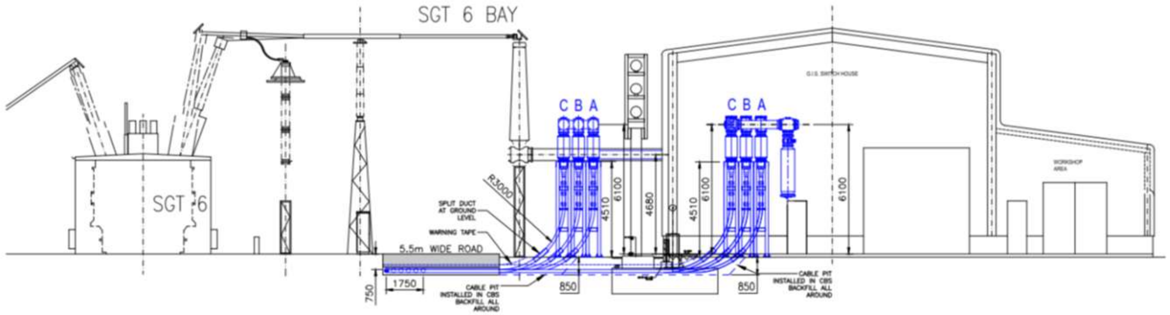
Onshore Cable Route

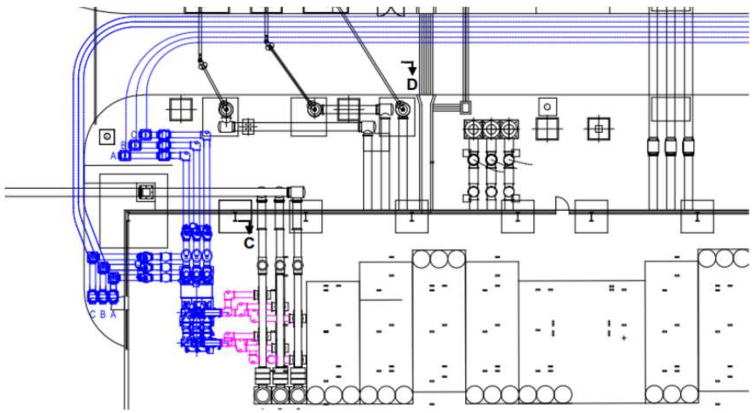


Grid Connection into NGET Lackenby Substation

The design consists of;

- **One circuit of two sets of 400kV cables, with separate GIS disconnectors to enhance availability**
- **Legacy Alstom GIS switchgear extended**





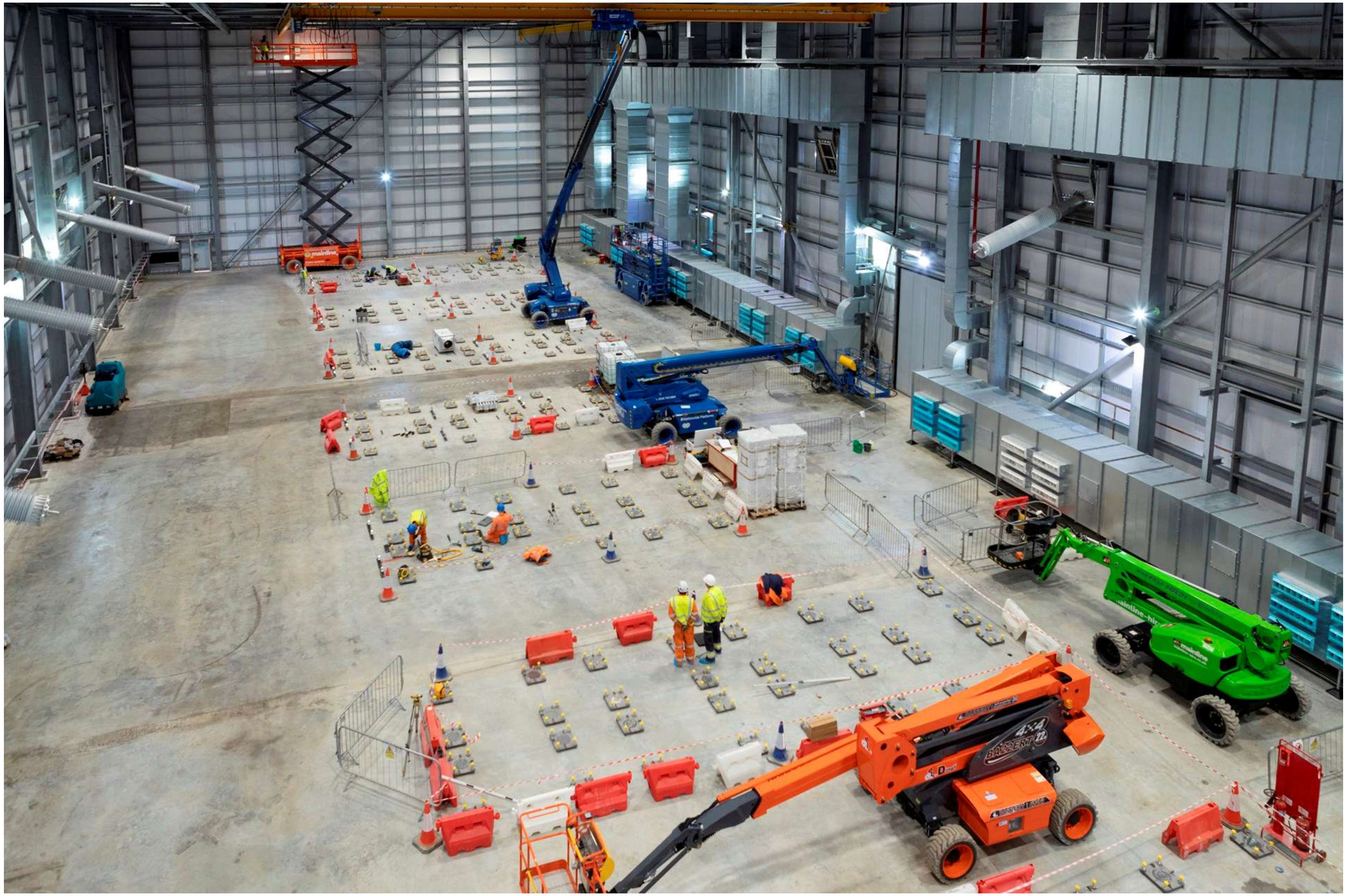
Onshore Converter Substation

- Completion of enabling works February 2022

Onshore Converter Substation

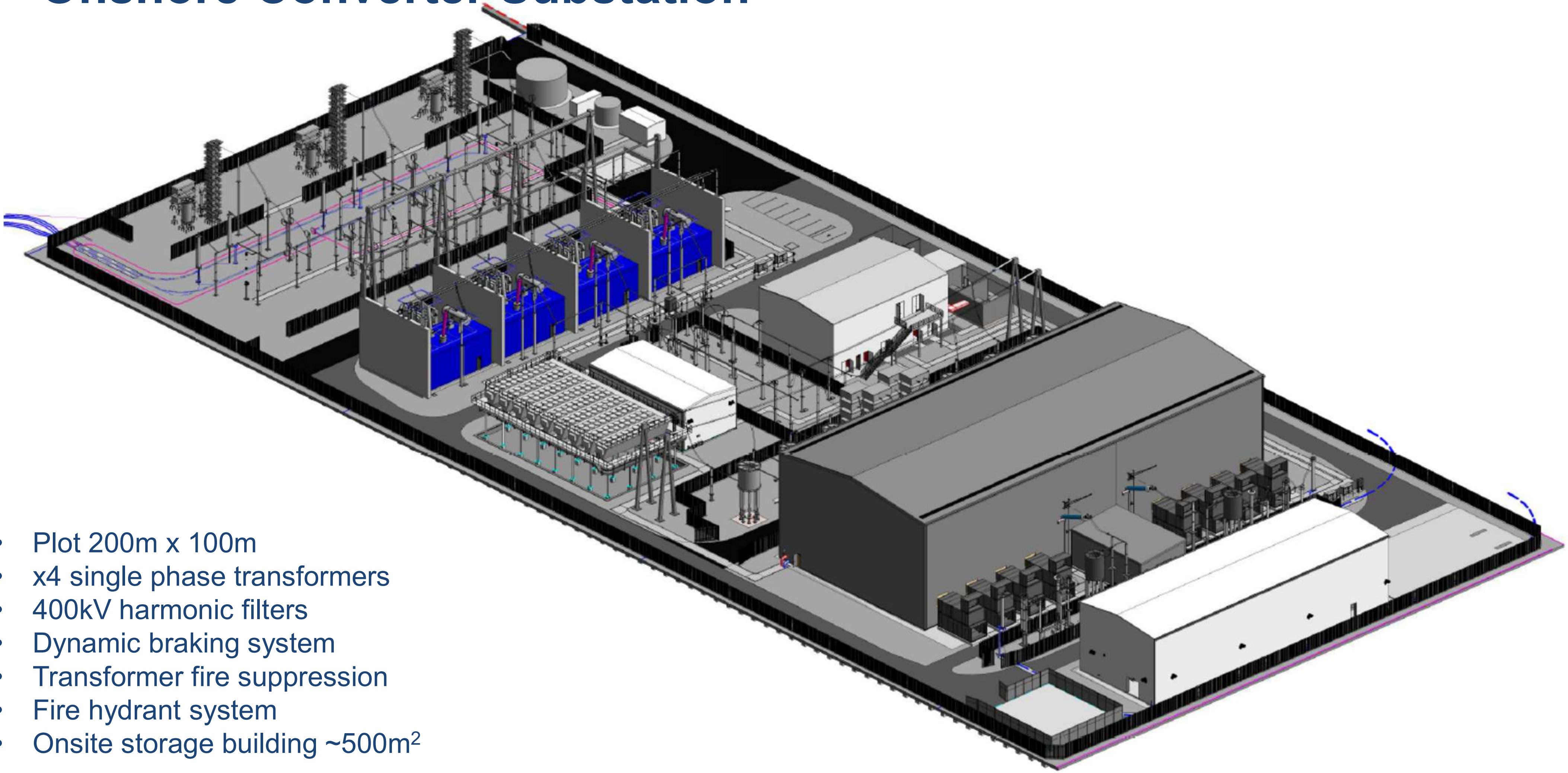
- Civil works progressing June 2023

Onshore Converter Substation



- Early fit out of valve hall
  April 2024

Onshore Converter Substation



- Plot 200m x 100m
- x4 single phase transformers
- 400kV harmonic filters
- Dynamic braking system
- Transformer fire suppression
- Fire hydrant system
- Onsite storage building ~500m^2

Dynamic Braking System

- Rated for 1320MW for 2s.
- To achieve fault-ride through for 85% retained voltage for 180s, the wind farm is curtailed from 1320MW to 1258MW (<5%) which provides a continuous capability.

Onshore Converter Substation

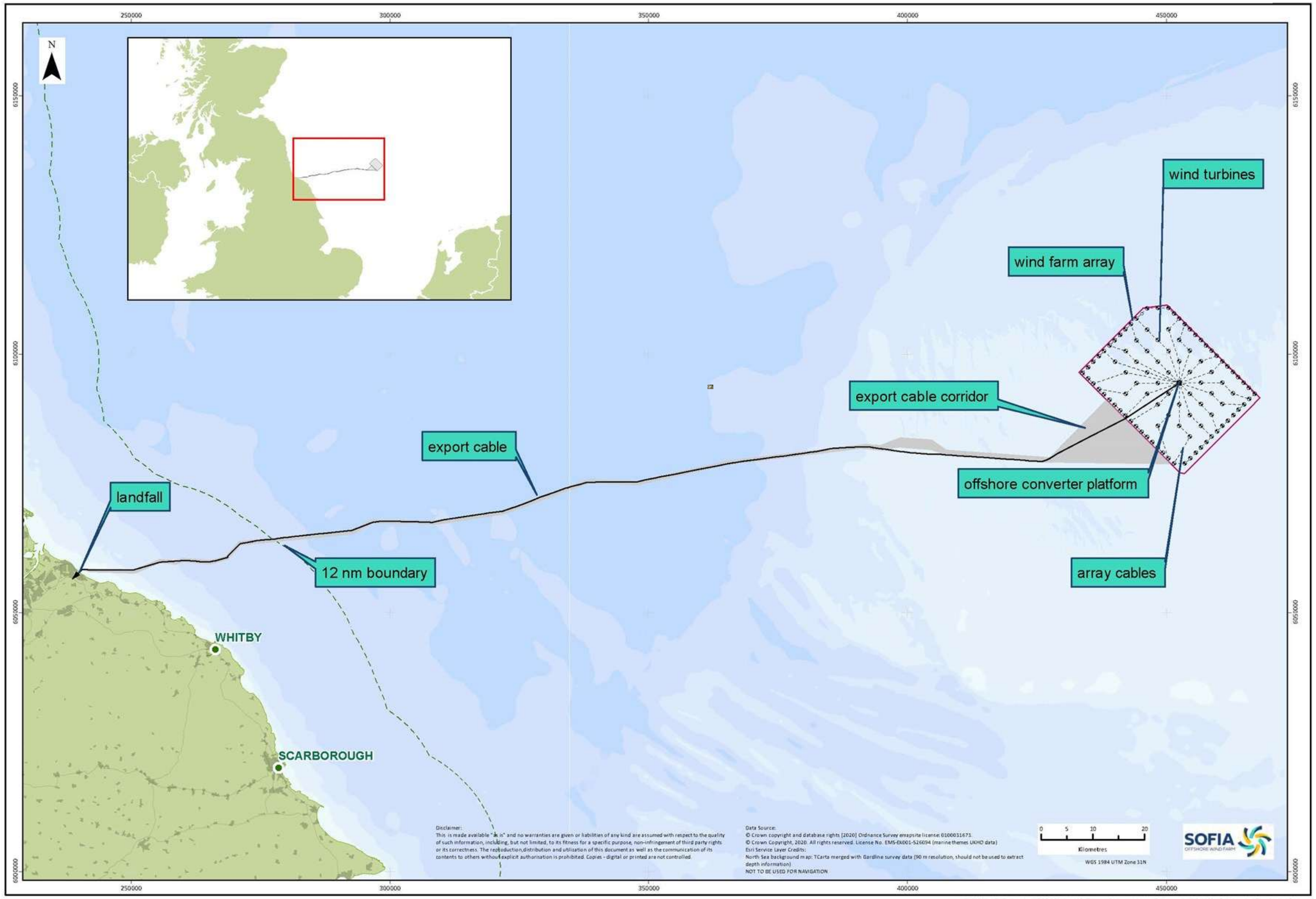
- Onshore converter substation March 2026

Interaction Studies

- Sofia have jointly contracted RTEi to perform Interaction Studies with the neighbouring Doggerbank C project being developed by SSE and Equinor.

- Scope includes
  - EMT simulations (desk based PSCAD), to investigate power oscillation damping control interaction, frequency control interaction, impact of fault recovery including power and voltage recovery, system energizations (sympathetic interactions), high frequency harmonic interactions and to validate the SSTI study with the presence of both HVDC converter systems.
  - Hardware in the Loop (control systems), to validate key simulations and to investigate specific risk items identified during EMT simulations.

Offshore Cable Route

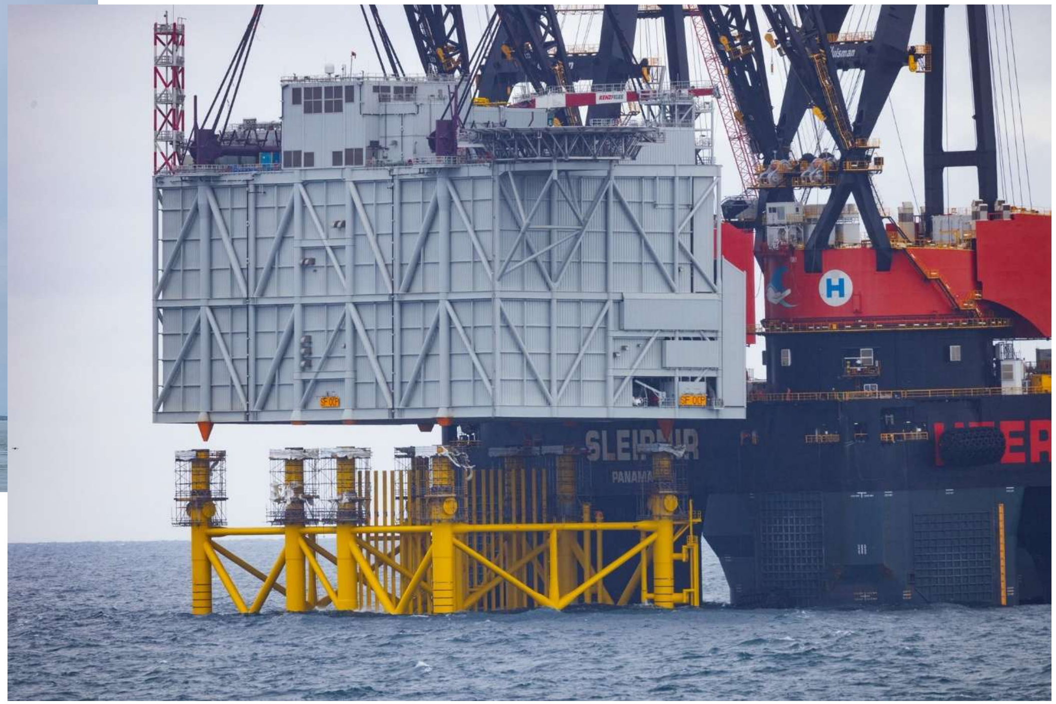


Offshore Converter Substation

Offshore converter topside and jacket load-out July 2024

Offshore Converter Substation

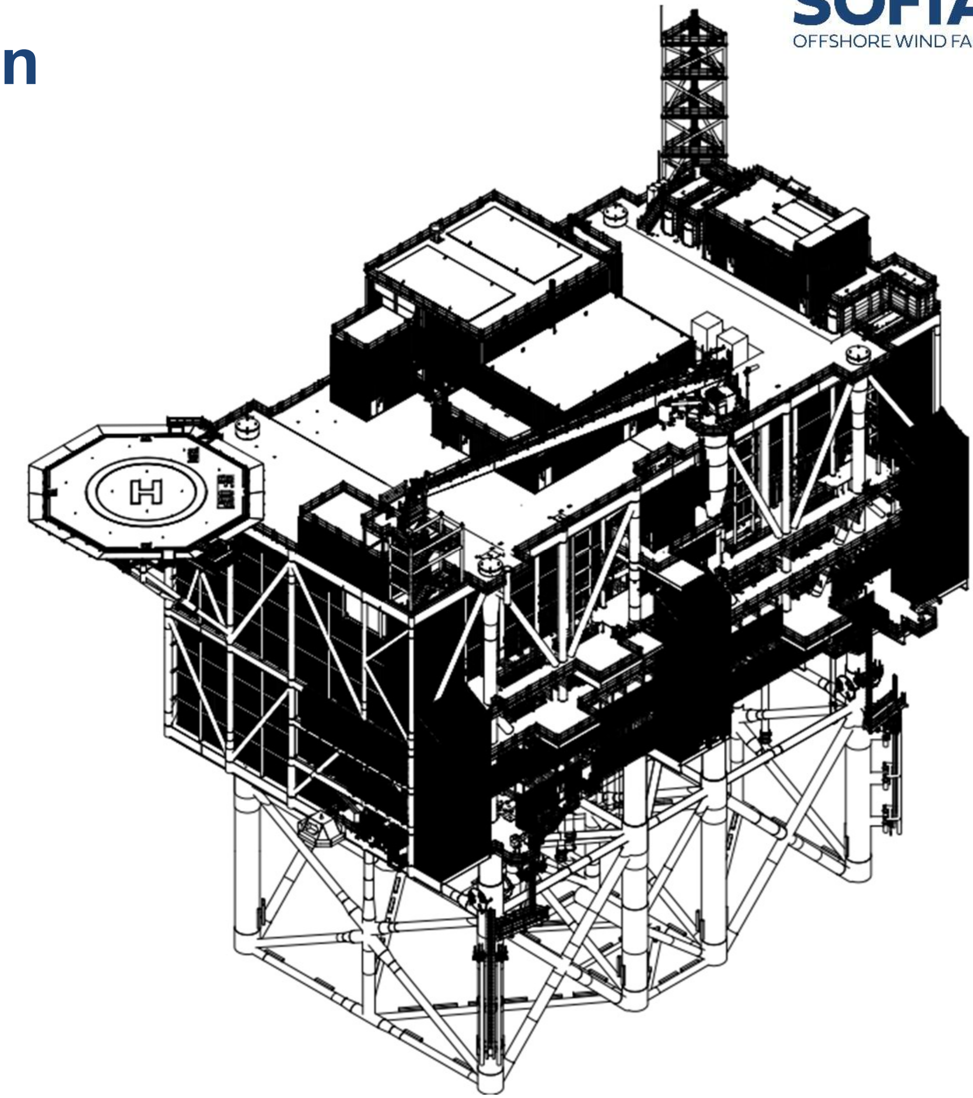
- Sail-away August 2024



- Installation August 2024

Offshore Converter Substation

- Topside ~10,751 tonnes (measured weight at lift)
- Jacket & Piles ~7,000 tonnes
- Topside size approx. 78m x 36m x 33m
- 6 decks
- Helideck
- 66kV switchgear (18 arrays) located in the centre of the platform.
- Transformers located on the top deck with valve halls located beneath with the reactors halls on the first deck.
- Transformers rated at 70%, hence 924MW when operating on a single transformer
- DNV approach to secondary system
- Fibre optic communication via the export cable with Starlink satellite backup



Offshore Converter Substation

- March 2026

Summary

- Stage 2 commissioning is ongoing
- Positive technical engagement from GE throughout the project with both the client and the client's technical consultant

More information on the project can be found at sofiawindfarm.com

Operations & Maintenance vessel Acta Centaurus, departing after first rotation (December 2025)

Thank you