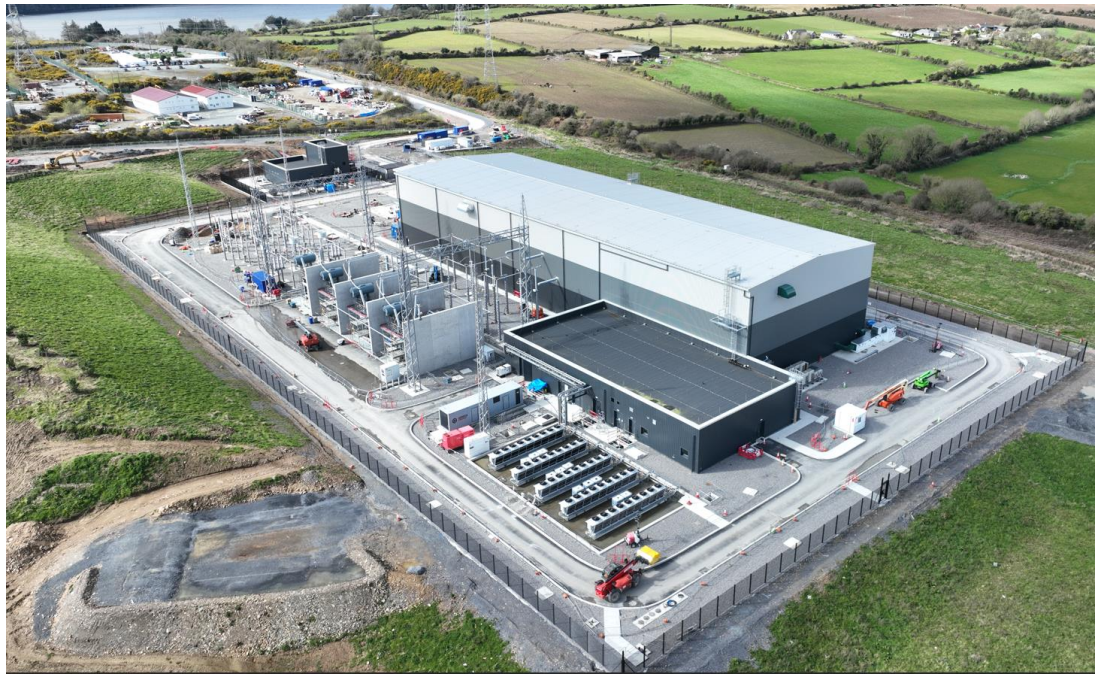
Greenlink
INTERCONNECTOR

# THE GREENLINK INTERCONNECTOR

Jonathan Ruddy, Technology Manager,
Greenlink Interconnector Ltd.



# THE PROJECT

- 504 MW of additional interconnection capacity between Ireland and the UK.
- Originally named an EU Project of Common Interest.
- One of the first privately financed interconnectors in Europe.
- Facilitating increased security of supply and reinforcing the local electricity transmission networks.

# KEY FEATURES

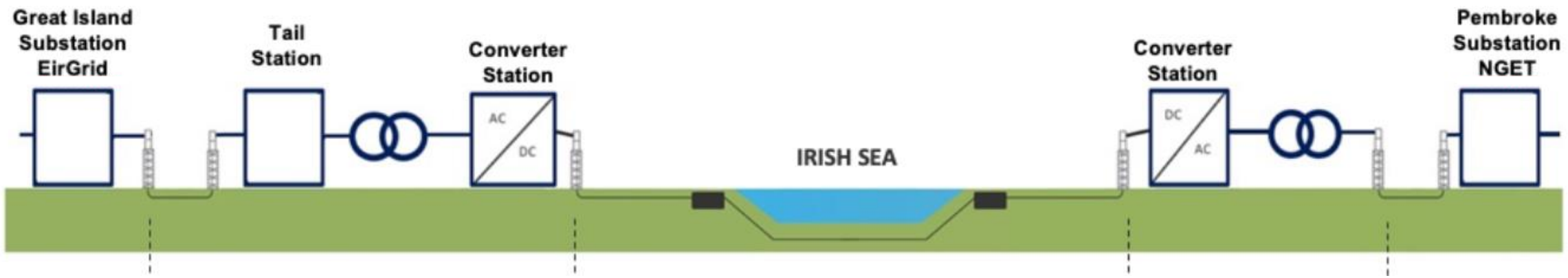



Image: Siemens Energy

- Loughtown Tail Station GIS
- 220 kV AC Ireland grid connection

- DC Cable: 160km sea, 30km Land cable
- ± 320kV DC Cable

- UK (Pembroke Sub-station)
- 400 kV AC UK grid connection

- ±171 Mvar normal reactive power Capacity
- 3 + 1 spare 188 MVA transformers installed on each side

- Overload capability to ±700 MW and ±230 Mvar
- Approx. 1km AC cable on both sides for connection to the grid substations

# GREENLINK INITIATIVES

As part of the overall project Greenlink Interconnector Limited have run several initiatives in the areas around both converter sites

## Greenlink Initiatives

- Decarbonisation Strategy
  - Installation of solar panels for residents around both sites
  - Planting of 14,245 indigenous trees at and around the converter sites to enhance the biodiversity in the area and aid with decarbonisation
  - Solar Energy Store Units used at Penfro during construction to reduce the requirement on two generators on site
  - EV Charging points installed at both sites
- Cut and fill initiative
  - The project targeted a 100% reuse of excavated material with no diversion of inert material to landfill
  - A total of 200,000m3 of inert soil material was fully reused, saving over €14.8m and negated approx. 15,000 rigid truck movements and reducing the carbon footprint of the project by over 1,000 tons of CO2
- Local amenity Improvements
  - New carpark built at landing site in Baginbun beach for residents – new coffeeshop and sauna have now opened as a result
  - New street lighting and footpaths installed along the cable route in Ramsgrange

## Project Facts and Figures

- 2 transition cable joint bays
- 30 cable joint bays
- 1 offshore joint
- 6 major HDDs and 6 micro-HDDs
- 30 km of land DC cable
- 160 km of marine DC cable
- 1,299,320 man hours worked up to 30th Jan 2024
- Potential to power 380,000 homes
- Supports the growth and integration of low carbon energy

# PROJECT TIMELINE

**2017-18** Early development, environmental and technical studies began

**2019** Marine planning applications submitted

**2020** Irish and Welsh onshore planning applications submitted

**2021** All environmental and planning consents granted. EPC contract awarded to Siemens Energy and Sumitomo Electric


**2022** Construction and Manufacturing begin

**2023**; 326km of Submarine Cable Manufactured (Hitachi, Japan). Four approx. 1km long Horizontal Directional Drills constructed, and HDPE ducting installed. Route preparation linear feature removal, boulder clearance, and pre-lay grapnel runs undertaken.

**2023 / 2024;** 326km of Submarine Cable transported, transpooled, laid and buried, four number shore end cable pull in's installed, and external protection rock berms constructed.

**2023** Main civils complete and all major HVDC/HVAC equipment on site

**2024** Energisation and Commissioning

# IRISH CONVERTER STATION PROGRESS

**Nov 2022**

**Feb 2023**

**May 2023**

**Aug 2023**

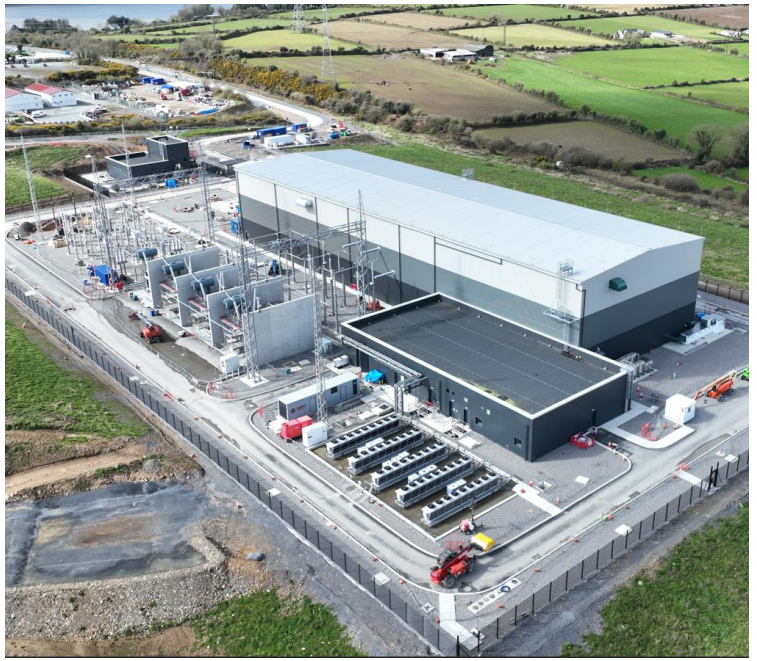
**Nov 2023**

**Jan 2024**

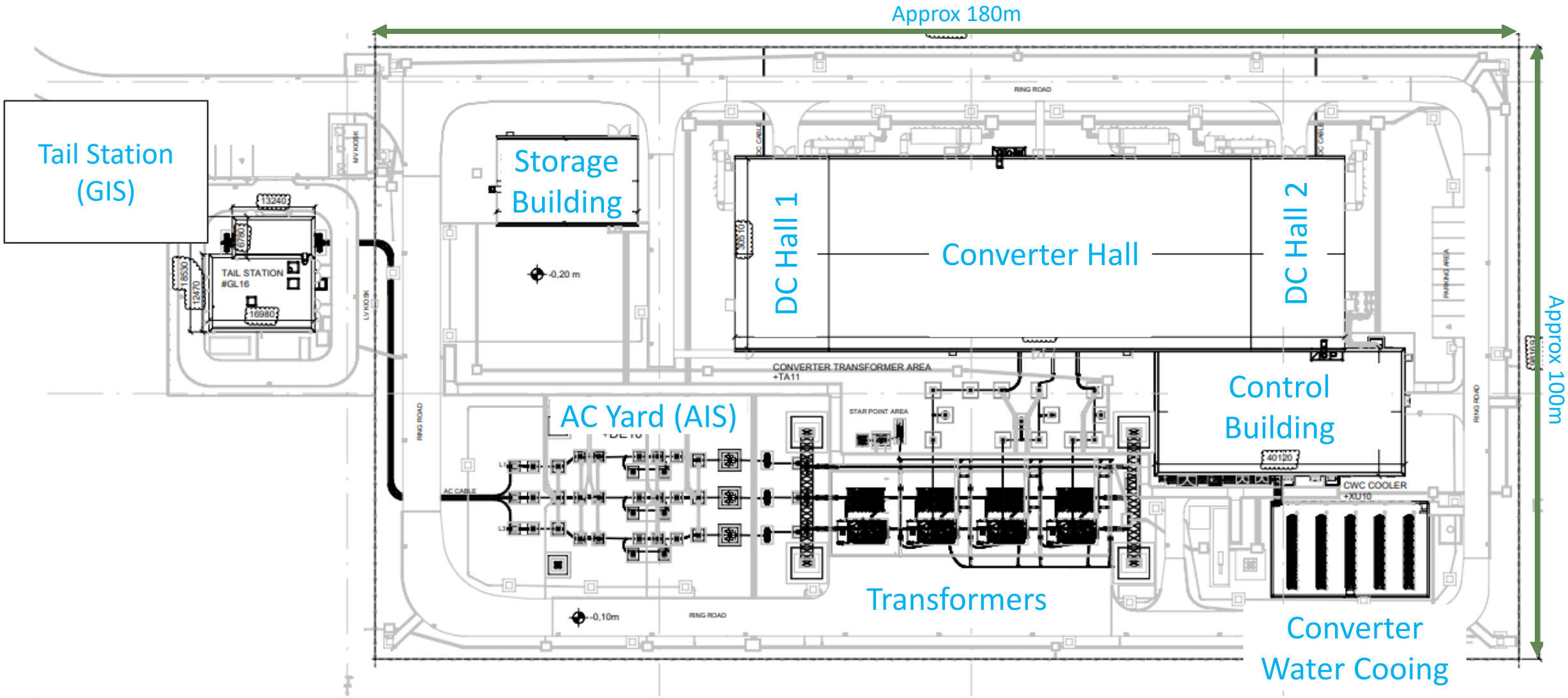
# CURRENT STATUS

# CURRENT STATUS

- Construction of both converter stations and a GIS tail station, complete. Pre-commissioning and commissioning of all equipment ongoing.
- Land and submarine cable installation and jointing complete.
- Reactive and active power flow tests later this year

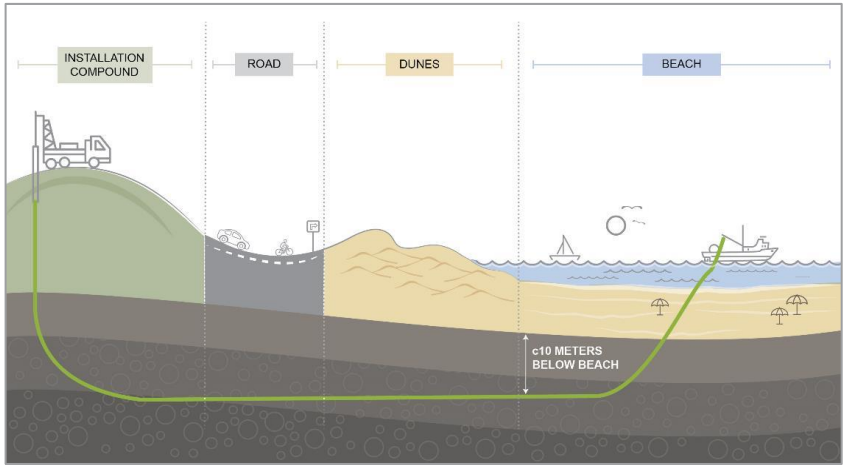
# CONVERTER STATION LAYOUT



# DC CABLE

- Approximately 29 km of DC onshore cable installed in Ireland and Wales
- 21 joints were made on the Irish land Cable
- 5 joints were made on the Welsh land cable.
- Land cable: Aluminium XLPE with a cross section of 1200mm²
- Submarine cable: Aluminium XLPE with a cross section of 1100mm²

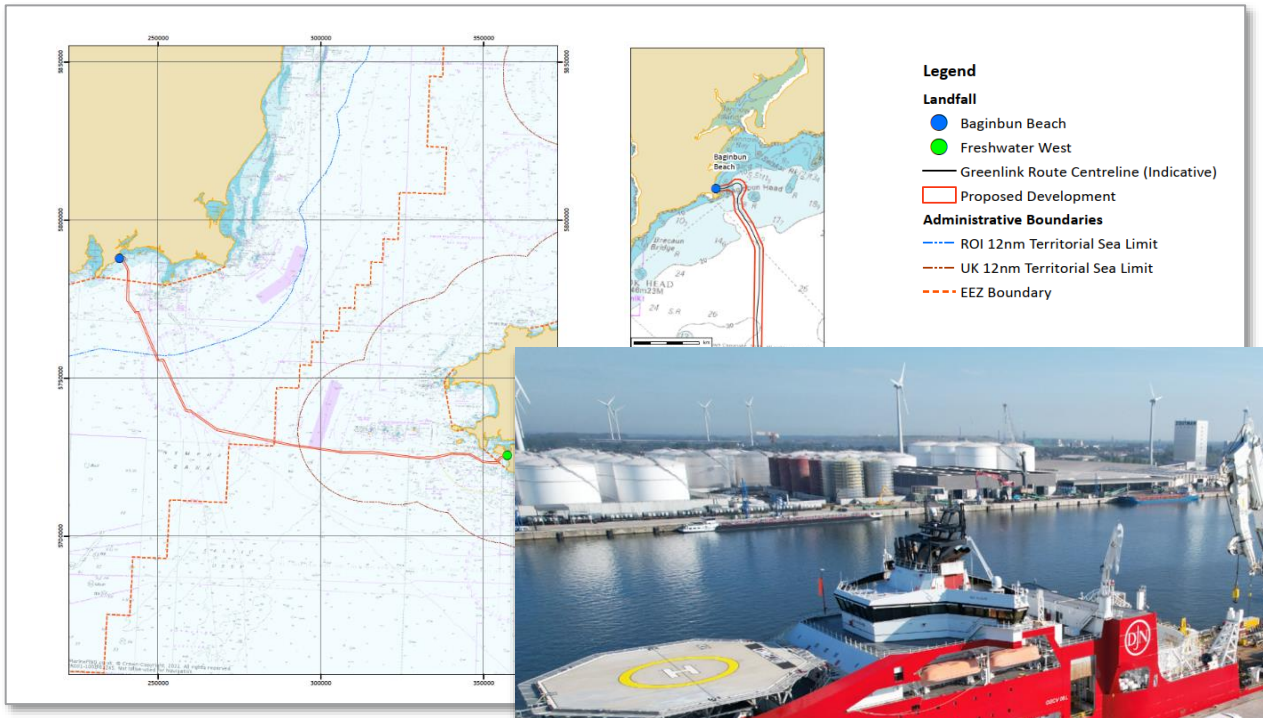
# HORIZONTAL DIRECT DRILLING


*Landfall Horizontal Directional Drill (HDD)*

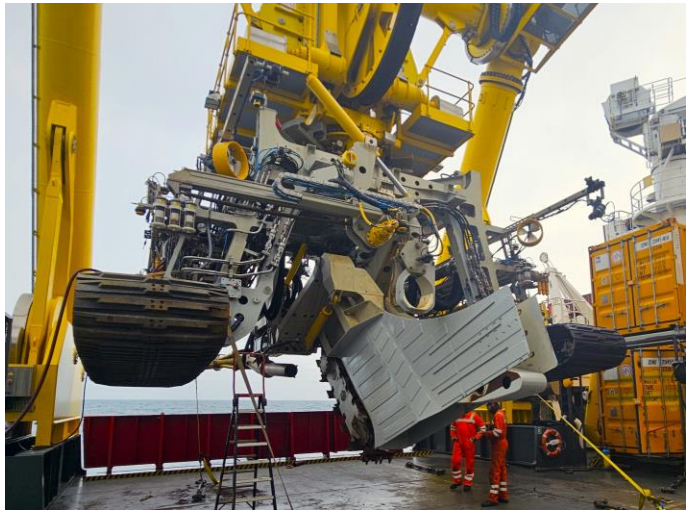
- Horizontal Direct Drilling (HDD) was used install ducting from the transition joint bays to the submarine cable.
- HDD was used to limit the disturbance to nearby roads and the landfall beach.
- HDD minimises the environmental impact of damage to the beach and the sea floor that is required to run the DC cable.

# OFFSHORE CABLE INSTALLATION




- Bundled cable arrangement offshore
- Laid in two campaigns:
  - 1: Welsh Campaign
  - 2: Irish Campaign
- Then the offshore joint is completed between the two cables.
- Cables buried at sea with combination of jetting and trenching
- Concrete mattresses and rock placement used for protection.

# Cable Burying



- The swordfish was used in both cutting and jetting configurations to bury the cable up to 1m deep.

- The Simon Stevin fall pipe vessel will be used to bury the cable with rock.
- Two types of rock load will be used 1-5” filter rock, and 5-40 kg armour rock.

# KEY FEATURES

**Frequency Response**

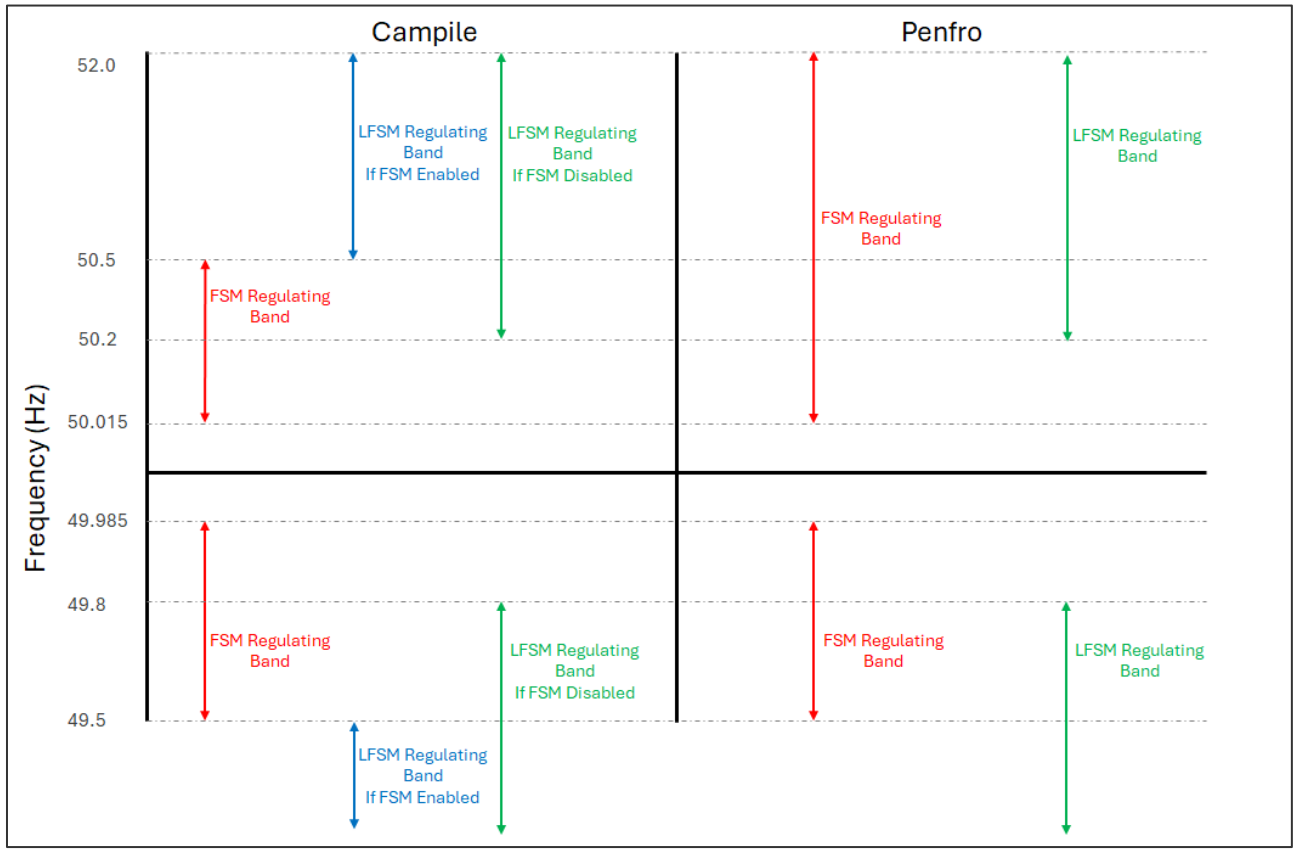
- LFSM, FSM
- UK grid code required FSM up to 52 Hz
- Irish grid code requires LFSM at 49.5 Hz but also a response at 49.8 Hz.

**Reactive Power Control**

**Fast Active Power Reversal within 2s**

**Black Start / Restoration**

**Power Oscillation Damping**



# Commissioning and Testing

# Performance Testing

**FPT = Functional Performance Tests:**

- Tests completed on actual project hardware, running generic software.
- **Objective:** Check operation of individual cubicles and correct interaction, functionality and interfacing of components/systems

Tests include:

- System Redundancy and Switchover
- AD/DC switching sequences
- Blocking sequences
- Active and reactive power control
- Trip tests
- Loss of auxiliary power
- Loss of telecommunication
- Operator controls

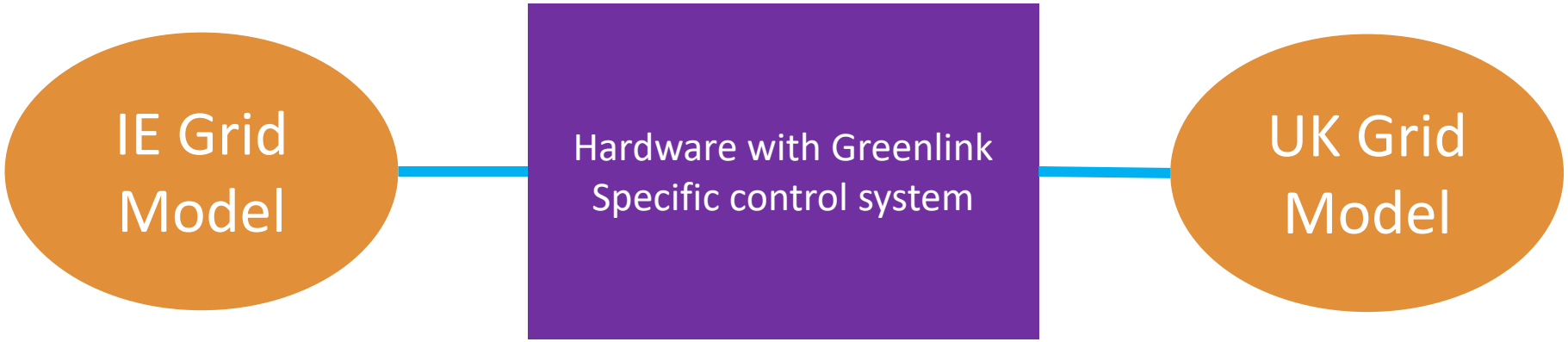
- The AC System Representation is made using a Simplified Thevenin Source Equivalent (infinite bus)

# Performance Testing

**DPT = Dynamic Performance Tests:**

- Tests completed using actual project software running on factory hardware
- **Objective:** analyze the interaction between the AC and DC systems as well as to verify the proper Converter Control and Protection behavior under dynamic, transient and steady state conditions.
- A Real Time Simulator (RTS) is used for digitally simulating the interconnector control and protection systems using generic hardware.
- An Electromagnetic Transient Program for DC Applications is used for PC based digital simulation of the interconnector.
- The AC system is represented by a simplified Thevenin source equivalent or a reduced model of the AC network.

# DPT SETUP




AC equivalent Model in RTDS (digital twin)

**Test Groups:**

- **Frequency Response**
- **Fault Ride Through**
- **Voltage/Reactive Power Control & Compliance**
- **DC protection**
- **Blackstart & Restoration**
- **Etc.**

# COMMISSIONING TESTS

**Commissioning testing will include:**

**Station Testing:**

- Campile and Penfro converter stations energised.
- Converter stations connected to the Irish and UK grids.
- HVDC subsea cable disconnected.
- Only reactive power in STATCOM mode can be tested.
- <40 commissioning tests

**System Testing:**

- HVDC cable connected.
- Converter stations energised and connected to the grid.
- Active and reactive power flow can be tested.
- >100 commissioning tests

# CHALLENGES/LESSONS LEARNED

- Unique market arrangements between SEM and GB driving designs which may differ from standard practice

- EMT/RMS MODELS
  - PSCAD Version for compliance – V5 now required as of Jan 2023. Contract signed and development began on V4.6.3 in Sept 2021.
  - Power Factory version for compliance
  - TSAT model

- TSO requirements/grid code changing after contract signature

- SSTI data – takes time – do screening studies in tender phase
  - New connections nearby requiring further SSTI studies post energisation

- Grid connection build – Clarity of TO specifications/requirements

- Telecommunications are complex & with a lot of stakeholders

- Engage with C&P designs, operator specifications and testing schedules from a very early stage in the project

# Any Questions?

Contact: jonathan.ruddy@greenlink.ie

Greenlink

INTERCONNECTOR