De-Risking the Deployment of HVDC Projects at The National HVDC Centre

3rd Nov 2020

RTDS SPOTLIGHT Series

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The National HVDC Centre

The National HVDC Centre

Scottish & Southern Electricity Networks

The National HVDC Centre – About us

The National HVDC Centre

The National HVDC Centre is an Ofgem funded simulation and training facility available to support all GB HVDC schemes.

Ofgem determination takes us from Innovation to BAU for RIIO-T2

The National HVDC Centre

part of Scottish & Southern Electricity Networks

together with nationalgrid SP ENERGY NETWORKS

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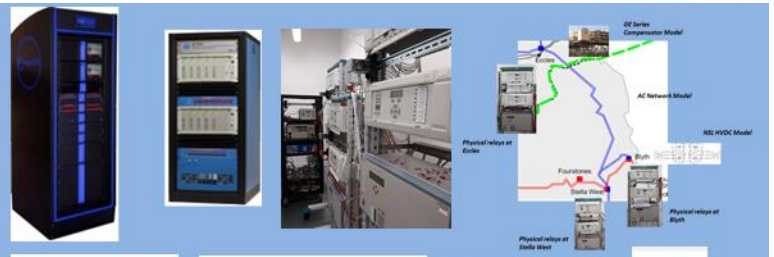
Tools

RTDS and HiL environment
(Enhanced Testing, Multi- Device Grid Integration, Protection & Control system, modification acceptance, post event investigation validation analysis)

Simulation environment (RTDS->EMT->RMS)
(Validation, Benchmarking, analysis)



Systems

Collaboration
(models, analysis, direction)

Codes, Standards, R&D
(expert input, workstream support)

The National HVDC Centre · SP ENERGY NETWORKS · Scottish & Southern Electricity Networks · nationalgrid · nationalgridESO · Grid Code · cigre · entsoe · EPRI ELECTRIC POWER RESEARCH INSTITUTE · PROMOTioN PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS

Skills

Structured Training
(Webinars, Courses, Application & Implementation)

Control training
(Operator Certification, Scenario Planning, Updates)

Research dissemination
(Analysis Techniques, Risk Quantification, Solution Definition)

Scottish & Southern Electricity Networks

1. Overview of HVDC in GB
2. Fundamental Considerations
3. Summary
4. Projects
   - *Overview*
   - *RTDS® Application*

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Development of HVDC Connections in GB

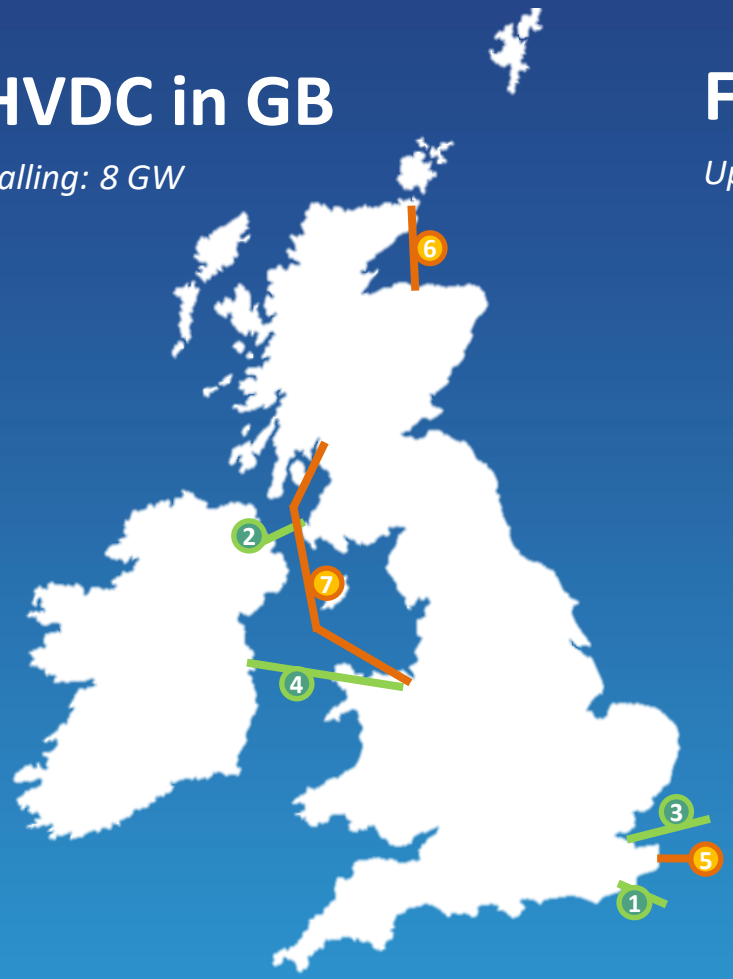
Current HVDC in GB

7 HVDC Links - Totalling: 8 GW

Interconnectors:
1) Cross Channel (IFA)
2) Moyle
3) BritNed
4) EWIC

New Interconnector:
5) Nemo

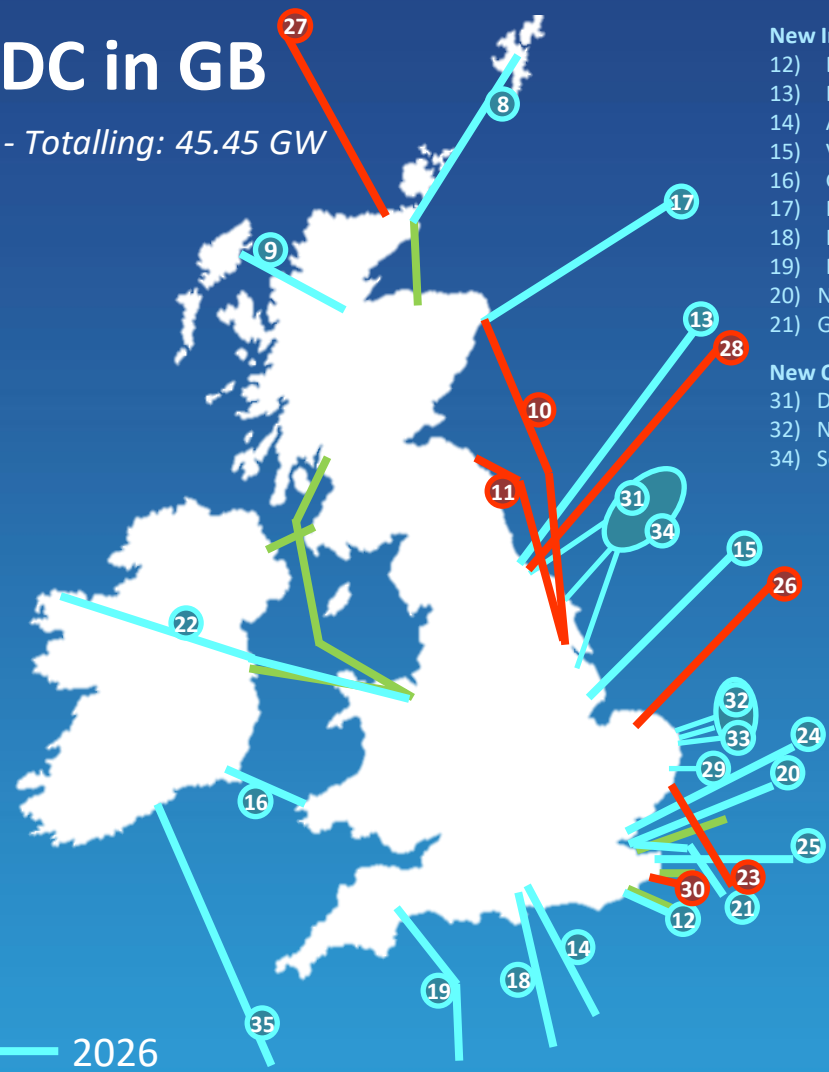
New Embedded Links:
6) Caithness – Moray
7) Western Link



Source: National Grid Interconnector Register 01 08 2019

Future HVDC in GB

Up to 34 HVDC Links - Totalling: 45.45 GW



New Island Links
8) Shetland
9) Western Isles

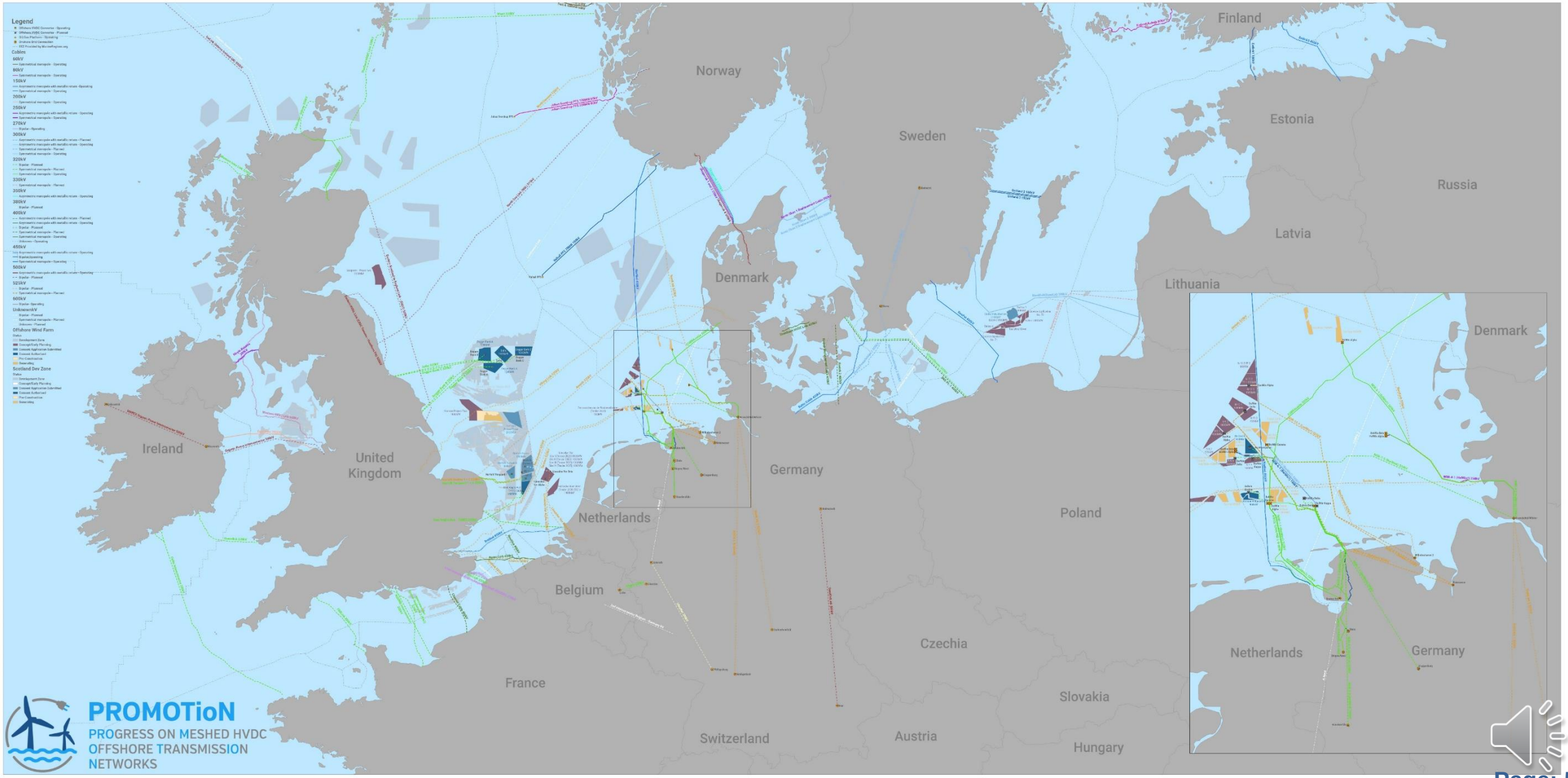
New Interconnectors
12) ElecLink
13) NSL
14) Aquind
15) Viking
16) GreenLink
17) NorthConnect
18) IFA2
19) Fablink
20) NeuConnect
21) Gridlink

New Offshore Wind Connections
31) Dogger Bank
32) Norfolk Vanguard
34) Sofia

New Embedded Links
10) Eastern Link 2
11) Eastern Link 1

Additional Interconnectors
26) Aminth
27) Atlantic Super Connection
28) Continental Link

Beyond GB



PROMOTioN
PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS

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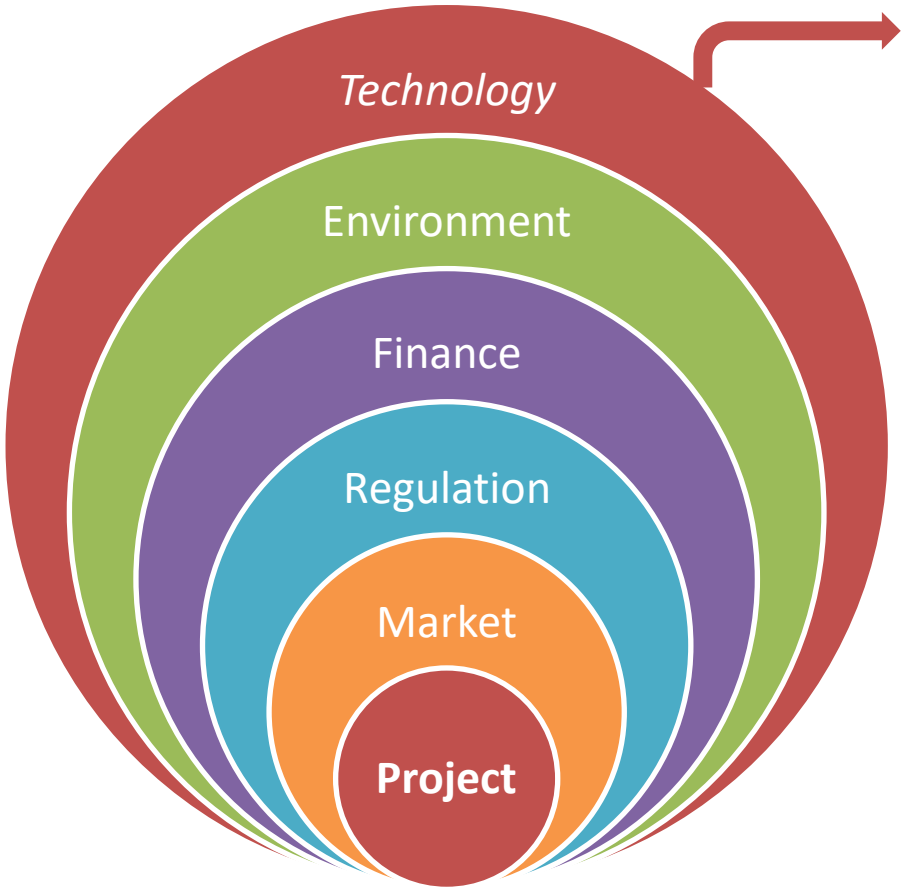
Fundamental Considerations



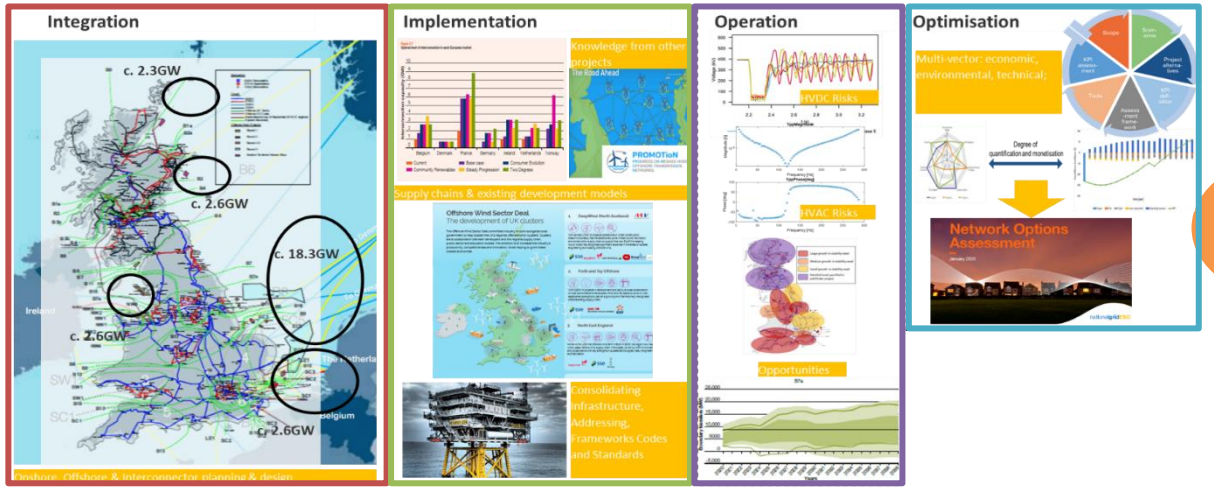
- Function
  - Embedded
  - Interconnector
  - Generation connection
  - Hybrid
- Project lotting
  - Turn key?
- Technology
  - LCC
  - VSC
  - Other
- Topology
  - Symmetrical monopole
  - Bi-pole
  - Bi-pole with metallic return
- Rating
  - State-of-the-art?
- Compliance (i.e Grid Code)
  - P-Q
  - Fault infeed / ride-through
  - Harmonics
- System Integration

Feasibility and options | Planning & Development | Tender / Bid | Base Design | Detailed Design | Factory system test / Factory Acceptance test | Commissioning | Operational support | Upgrade | Refurbishment

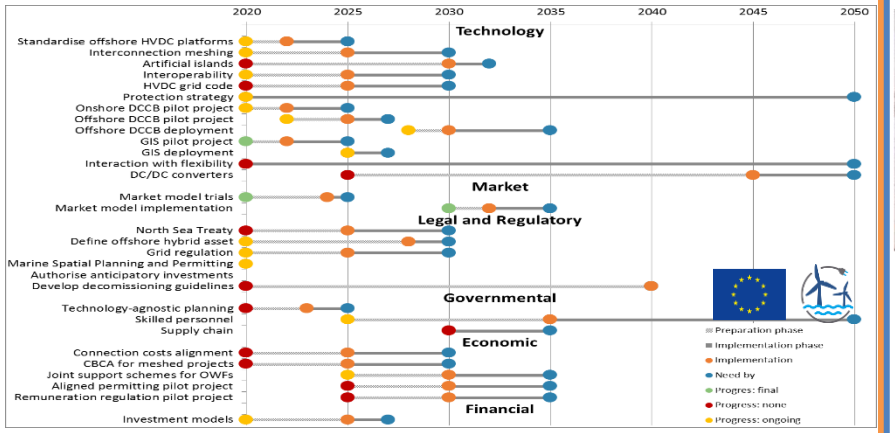
What to consider for development and integration of HVDC in GB?

The National HVDC Centre

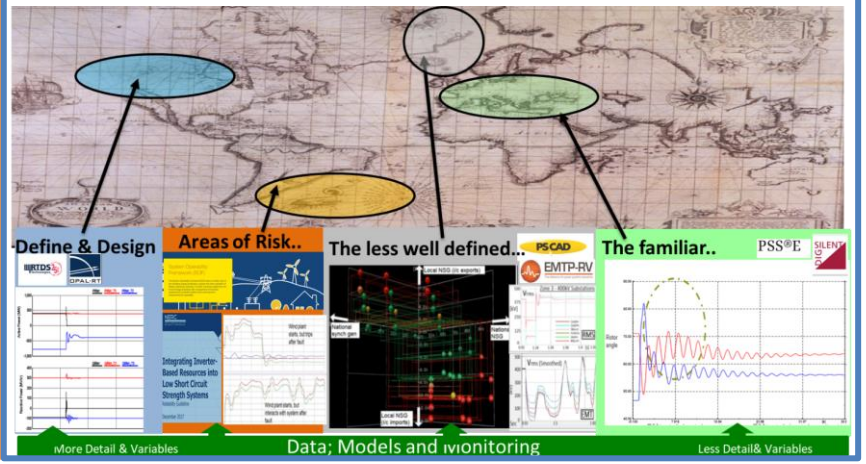
- Collaboration is required at different levels to successfully:
  - De-risk HVDC deployment across onshore and offshore applications;
  - Integrate HVDC into electricity networks rich in converter-based sources; and
  - Develop HVDC devices, standards and codes in an optimised way.



A Roadmap for HVDC



A Map of Network Stability Analysis Re-drawn



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Use of RTDS® along with Replicas can be part of the solution

- International experience has shown RTDS and replica controls allow you to fully address interactions
  - Multiple facilities globally in operation doing this kind of work
- Physical hardware housed at a trusted 3rd party facility inherently manages IP
- Benefits across the lifetime of an HVDC system

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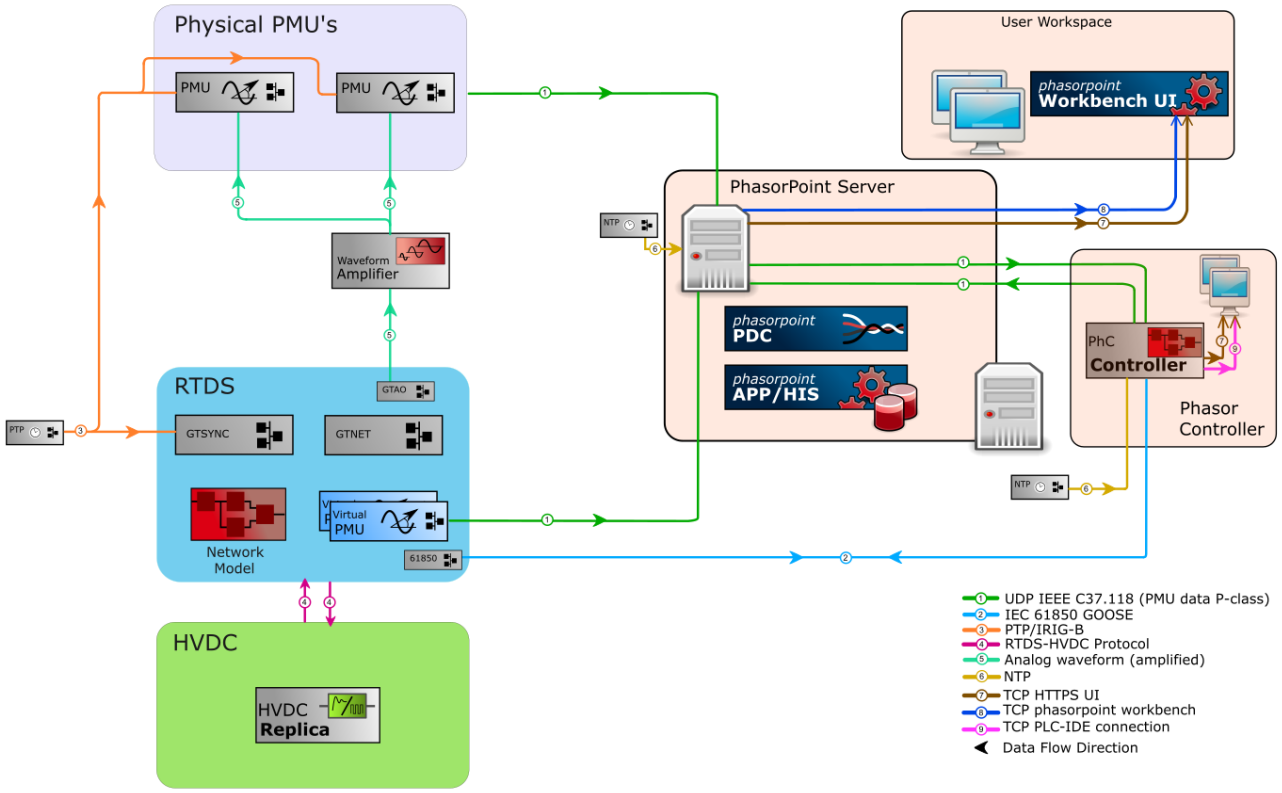
Phasor Point

Phaser Point – Overview

The National HVDC Centre

- National Innovation Allowance (NIA) Funded Project
  - The Phasor Point project is part of SSEN Innovation program – SSEN, GE , HVDC Centre are project partners
  - This Project Aims to estimate the system strength using GE's WAMPAC technology - Phasor Point Wide Area Monitoring System (WAMS) + PhasorController.
  - As part of this project HIL testing of the WAMS along with physical and simulated PMU would be done



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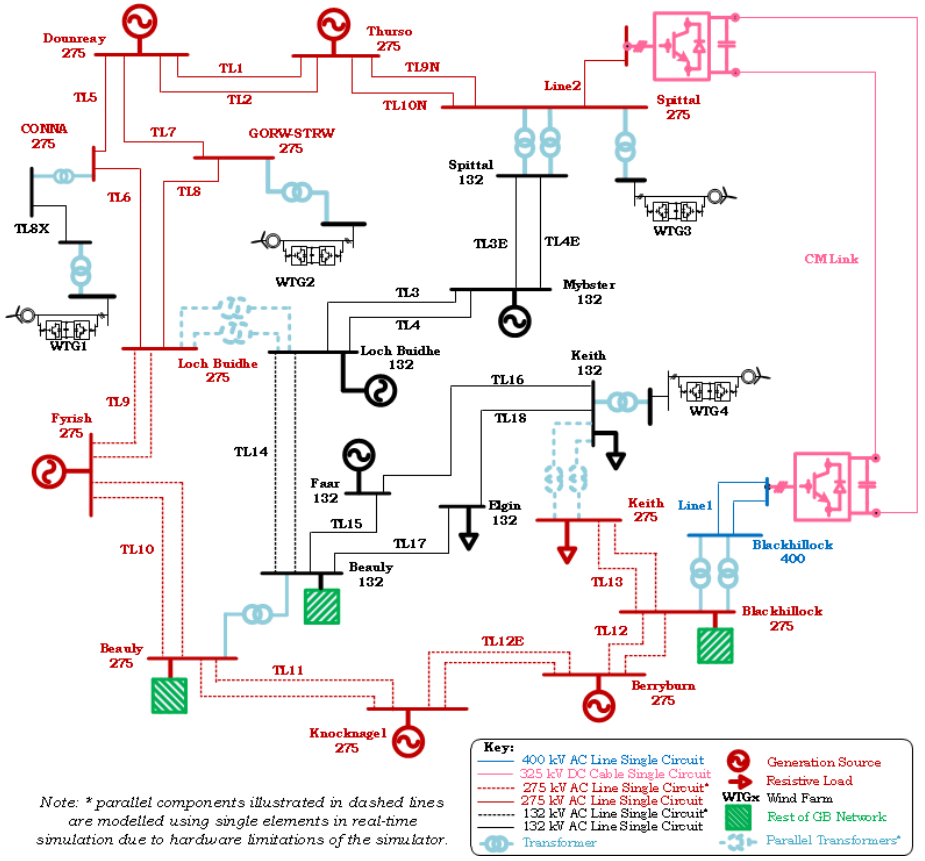
Phaser Point – RTDS® Application

The National HVDC Centre

- **Modelled** North of Scotland AC Network in RSCAD
- **PMU:** Both physical PMU and Simulated RSCAD PMU would be used to send information to the PhasorPoint WAMS
- **System Strength** PhasorController would calculate the system strength of the North of Scotland Network based on the inputs from PMU .
- **Mode Change In CMS Replica:** The system strength estimation would be used as a input to CMS replica to change the operation mode of the CM link.

Simplified North of Scotland Network Modelled using RTDS



*Note: * parallel components illustrated in dashed lines are modelled using single elements in real-time simulation due to hardware limitations of the simulator.*

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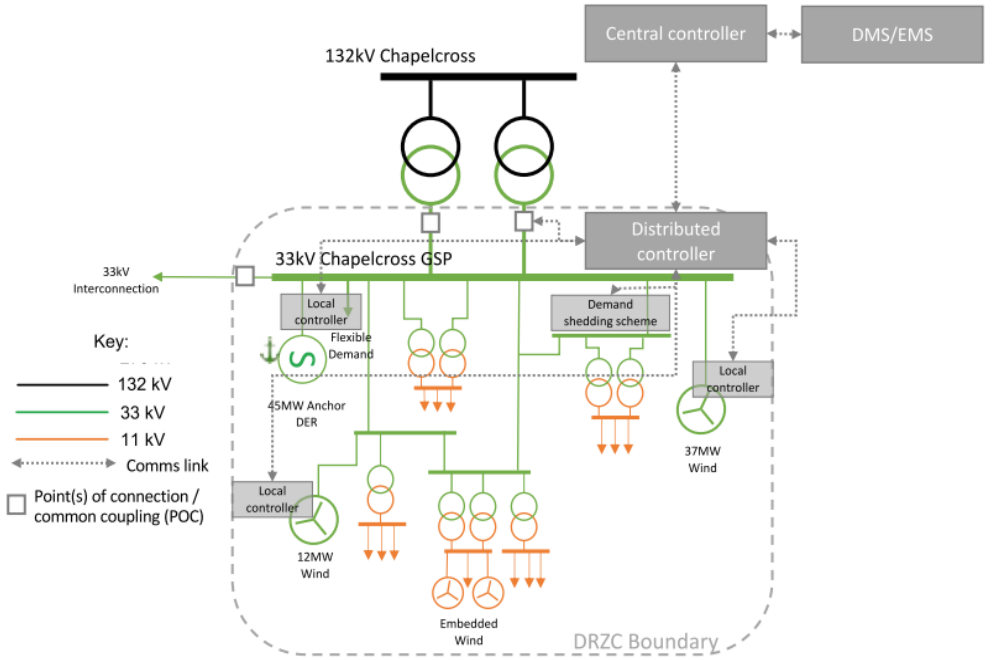
Distributed ReStart

The National HVDC Centre

- National Innovation Competition (NIC) Funded Project
  - National Grid ESO, Scottish Power Energy Networks, TNEI are Project Partners
- Distributed Energy Resources (DER) – Restore Power
  - System studies –Restoration Strategy
  - Transformer energization and Block Load Pick up
  - Development of Wide area controller
  - Protection studies
  - Ensuring the performance of Anchor Generator (DER)
  - Connecting other non Anchor DER
  - Live Field Trails



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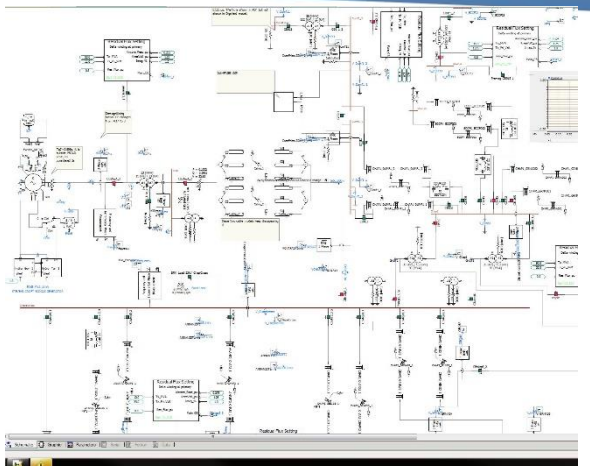
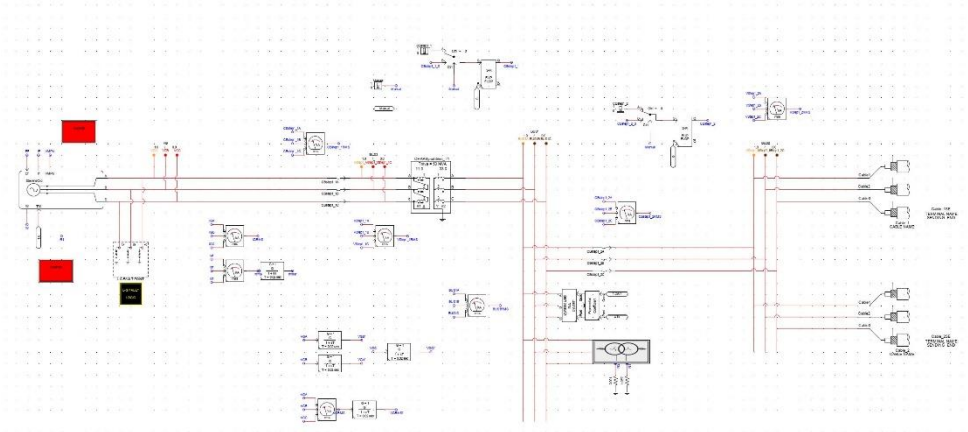
Distributed ReStart – RTDS® Application

The National HVDC Centre

- RTDS Model development
  - Import the Chapel cross network Model from PSCAD to RSCAD
  - Enhance the Anchor Generator Model along with protections and other details
  - Further expansion of RSCAD model to include other part of network
- RSCAD Studies & HIL Testing
  - Energization Studies
    - 33kV/132kV Transformer energization
    - 132kV Circuit Energization
    - 132/400kV SGT energization
  - RTDS HIL Testing
    - Generator Protection Testing
    - Distributed Wide area controller Testing



PSCAD to RSCAD



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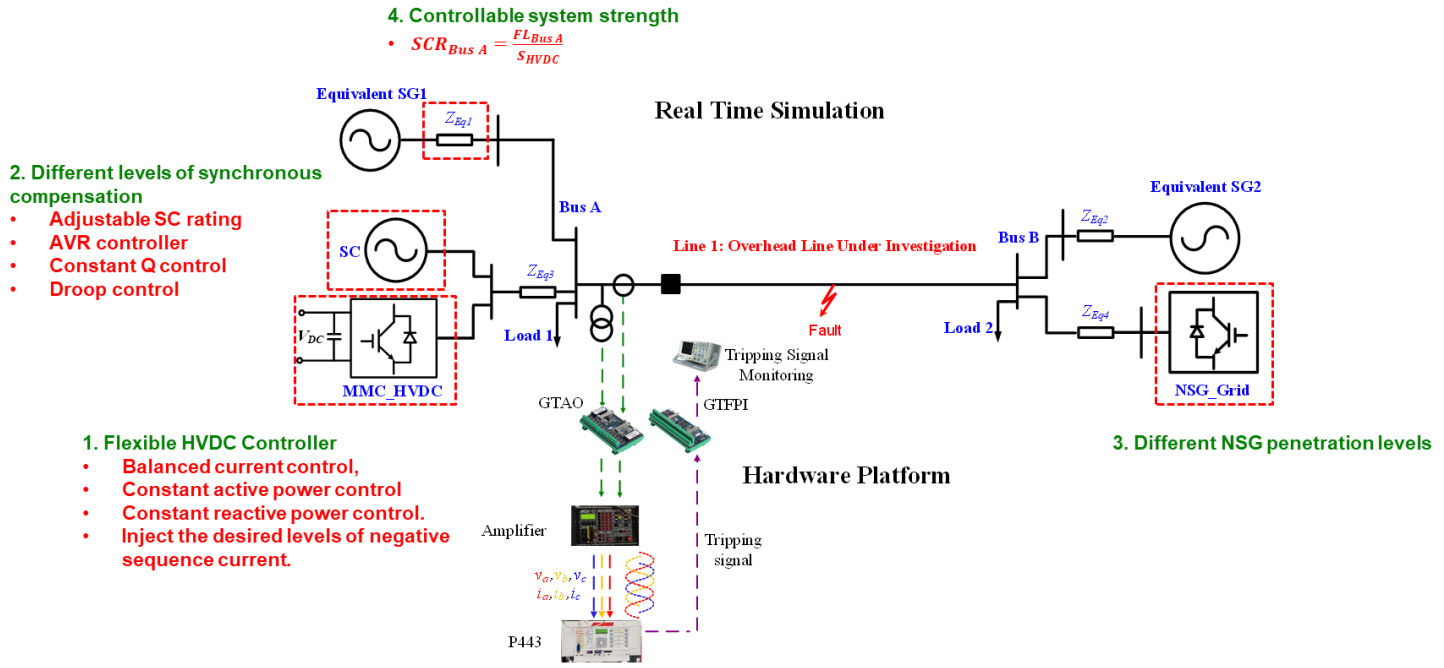
Protection Test Bench

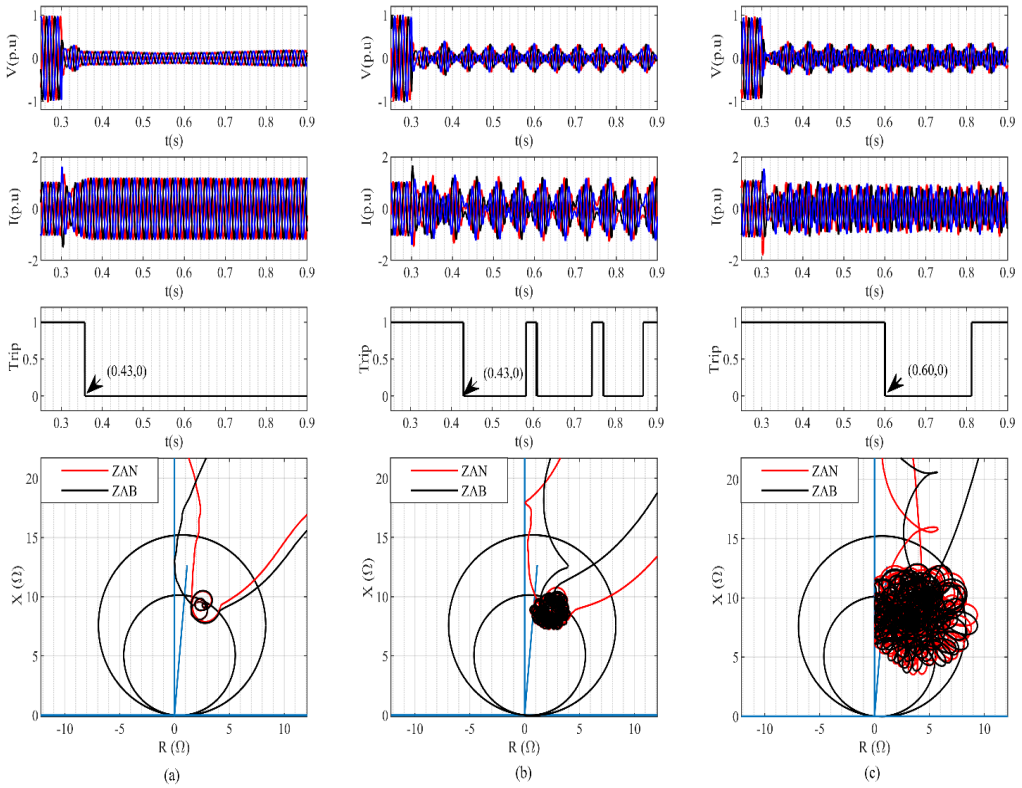
Protection Test Bench – Overview

- This project is part HVDC Centre research and innovation program for the year 2020
  - This project is done by University of Strathclyde in coordination with the HVDC Centre.
  - This project aims to create a test bench in RSCAD that could be used to test the effect of HVDC Converters, Non-Synchronous Generators and Synchronous condenser on AC protection



Protection Test Bench **–** RTDS® Application

- Developed Benchmark model was used to test the Distance protection
- The Test Bench RSCAD model has the full flexibility to adjust modes and level of contributions from the HVDC Converter, NSG and the synchronous condenser.
- Effect of system strength along the with change in the levels of HVDC Converter, NSG and SC can be seen in the polar impedance plots.



Thanks for listening.

Any questions, please?

- For further information, please visit www.hvdccentre.com ; OR email: info@hvdccentre.com

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