CMS HVDC System

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Scottish & Southern Electricity Networks

Topics

- Project Summary
- Low Fault Level Solution
- Commissioning of HVDC Link
- Operation of HVDC Link
- Future Multi-terminal System

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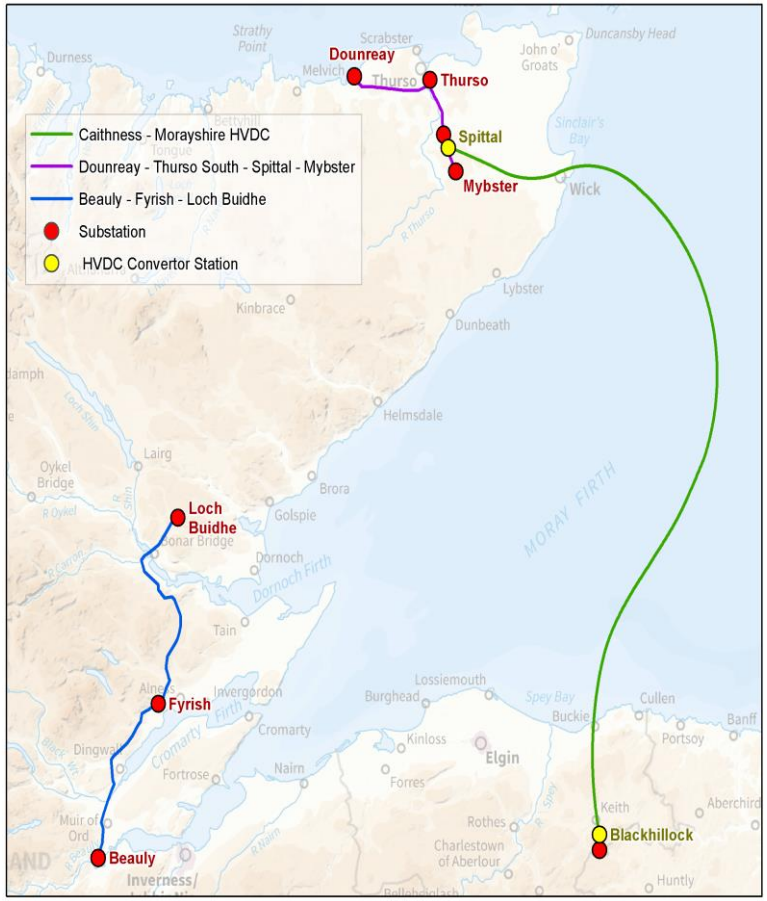
Caithness Moray HVDC

Project Summary

- Voltage Source Converter technology (ABB HVDC Light)
- Symmetrical monopole configuration
- +/- 320 kV DC Voltage
- Spittal Converter
  - 800 MW Rectifier / -720 MW Inverter
  - +/- 263 MVAr
- Blackhillock Converter
  - 1179 MW Inverter / 1080 MW Rectifier
  - +/- 394 MVAr
- Future rated for multi-terminal operation



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Caithness Moray HVDC

Project Summary

Timeline	Activity
2010	Project concept
2014 August	Contract Award
2014 onwards	Detailed Design and FAT of HVDC plant
2015	Construction Starts
2016 November	FST of Control & Protection System
2017	Electrical & Mechanical Plant Installation
2018 April	Stage 1 Commissioning
2018 November	Stage 2 Commissioning
2018 December	Hand over to National Grid

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Low Fault Level Problem

- Requirements from the technical specification (Works Information (WI)):
  - *"The Contractor ensures that the HVDC control system is capable of satisfactory and seamless operation, without supply interruption, through the range from the import of power to the export of power up to the capacity of the converter stations and vice versa for any short circuit power from the ac network between the minimum and design levels specified "*
- Contractor designed HVDC Control System with two operating modes for Spittal fault range
  - Normal Control Mode (NCM)
  - Extremely Weak Control Mode (EWCM)
- Dynamic Performance studies identified a requirement for a fast automatic transition between "*Normal*" and "Extremely *Weak*" control modes
- The performance of both Normal and Extreme Weak modes was satisfactorily demonstrated in Factory Acceptance Testing; but *transition* between modes relies on an external trigger

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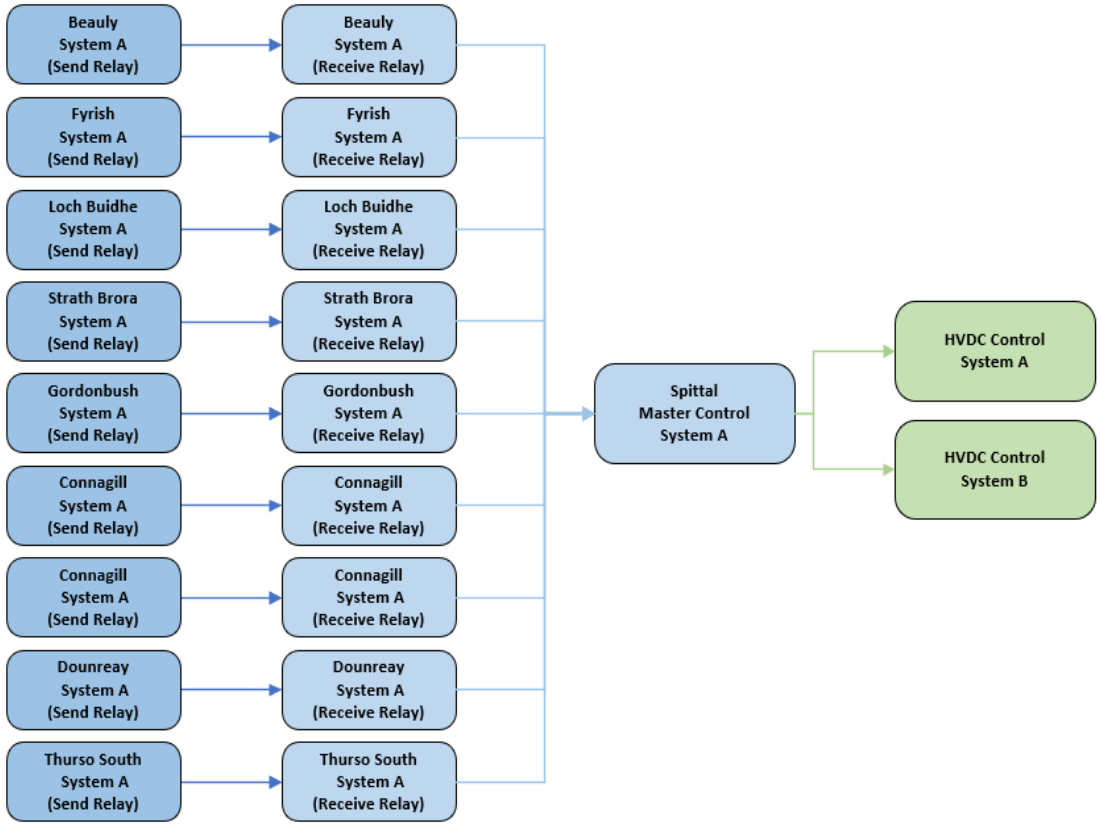
Low Fault Level Solution

System Status Signals North of Beauly (SSSNoB) Scheme

- Solution identified was for a bespoke network monitoring scheme
- Transition criteria was for complete loss of 275 kV connection between Beauly 275 kV busbar and Spittal 275 kV busbar
- Scheme monitors LEO status of switchgear on 275 kV network
- Transition takes less than 50 ms
- Automatic transition to EWCM after trigger criteria met
- Manual transition back to NCM from SSEN Transmission Control Centre required
- Scheme is fully redundant utilising diverse communication routes
- Redundant signals interfacing with both HVDC Control System utilising two out of two voting



Commissioning of HVDC Link

SHET Terminology	ABB Terminology	Timeline
Stage 1	Equipment Testing	April 2018
	Subsystem Testing	August 2018
Stage 2	System Testing	November 2018
	Trial Operation	December 2018

Stage 2 Commissioning Programme

- HV Energisation
- Terminal Operation Tests
- Low Power Transmission Tests
- High Power Transmission Tests
- Black Start Test
- Heat Run Test

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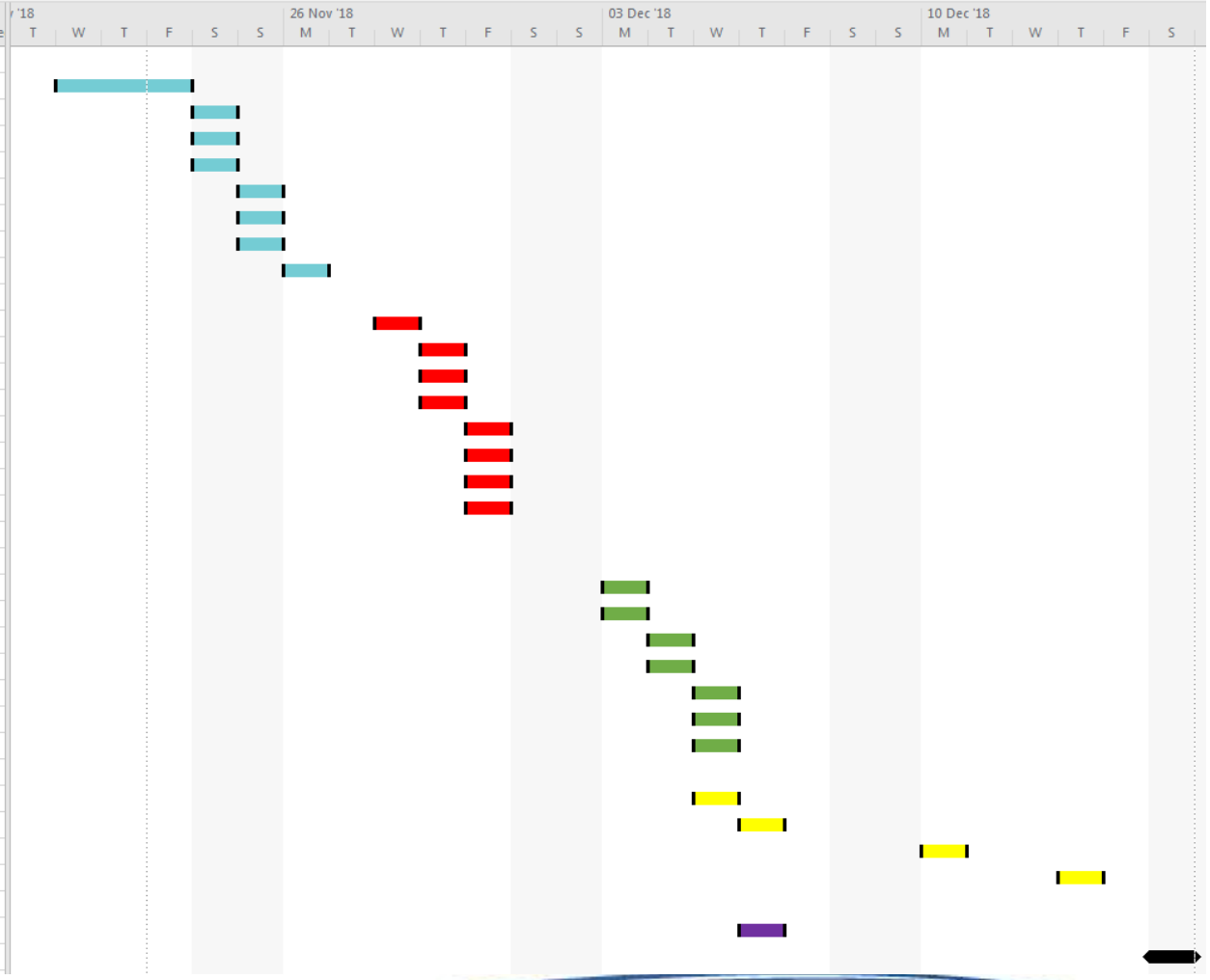
Commissioning of HVDC Link

GANTT CHART

	Task Name	Start	Finish	Pre
1	**Blackhillock - HV Energisation & Terminal Operation**			
2	BL-HVTO_01: Energisation of Convertor Station without DC cable	Wed 21/11/18	Fri 23/11/18	
3	BL-HVTO_02: Block / De-block	Sat 24/11/18	Sat 24/11/18	
4	BL-HVTO_03: Protective Systems	Sat 24/11/18	Sat 24/11/18	
5	BL-HVTO_04: System supervision	Sat 24/11/18	Sat 24/11/18	
6	BL-HVTO_05: Reactive Power Control (Q Control)	Sun 25/11/18	Sun 25/11/18	
7	BL-HVTO_06: Active Voltage Control (ACVC)	Sun 25/11/18	Sun 25/11/18	
8	BL-HVTO_07: Loss of Auxiliary Power Supply	Sun 25/11/18	Sun 25/11/18	
9	BL-HVTO_08: High Reactive Power (+/- 394MVAR completed)	Mon 26/11/18	Mon 26/11/18	
10	**Spittal - HV Energisation & Terminal Operation**			
11	SP-HVTO_01: Energisation of Convertor Station without DC cable	Wed 28/11/18	Wed 28/11/18	
12	SP-HVTO_02: Block / De-block	Thu 29/11/18	Thu 29/11/18	
13	SP-HVTO_03: Protective Systems	Thu 29/11/18	Thu 29/11/18	
14	SP-HVTO_04: System supervision	Thu 29/11/18	Thu 29/11/18	
15	SP-HVTO_05: Reactive Power Control (Q Control)	Fri 30/11/18	Fri 30/11/18	
16	SP-HVTO_06: Active Voltage Control (ACVC)	Fri 30/11/18	Fri 30/11/18	
17	SP-HVTO_07: Loss of Auxiliary Power Supply	Fri 30/11/18	Fri 30/11/18	
18	SP-HVTO_08: High Reactive Power (only +131 MVAr export complete)	Fri 30/11/18	Fri 30/11/18	
19	SP-HVTO_08: High Reactive Power (-263MVAr import)			
20	**Low Power Transmission Tests**			
21	SPBL-LPT_01: Deblock / Block	Mon 03/12/18	Mon 03/12/18	
22	SPBL-LPT_02: Protective Actions	Mon 03/12/18	Mon 03/12/18	
23	SPBL-LPT_03: Active Power Control	Tue 04/12/18	Tue 04/12/18	
24	SPBL-LPT_03 RI AC Harmonics, DC Harmonics	Tue 04/12/18	Tue 04/12/18	
25	SPBL-LPT_04: Reactive Power Control	Wed 05/12/18	Wed 05/12/18	
26	SPBL-LPT_04 RI AC Harmonics, DC Harmonics	Wed 05/12/18	Wed 05/12/18	
27	SPBL-LPT_05 AC Voltage Control	Wed 05/12/18	Wed 05/12/18	
28	**High Power Transmission Tests**			
29	SPBL-HPT_01 Power Ramp IMPORT 600MW only	Wed 05/12/18	Wed 05/12/18	
30	SPBL-HPT_02 Power Ramp EXPORT 800MW	Thu 06/12/18	Thu 06/12/18	
31	SPBL-HR_01: Power-Ramp & Noise Test: IMPORT 720 MW	Mon 10/12/18	Mon 10/12/18	
32	SPBL-HR_01: Heat Run 800MW Export	Thu 13/12/18	Thu 13/12/18	
33	**Additional Transmission Tests**			
34	SP_BS_01 Black Start Spittal	Thu 06/12/18	Thu 06/12/18	
35	**Handover to GB System Operator (National Grid)**	Sat 15/12/18	Sat 15/12/18	



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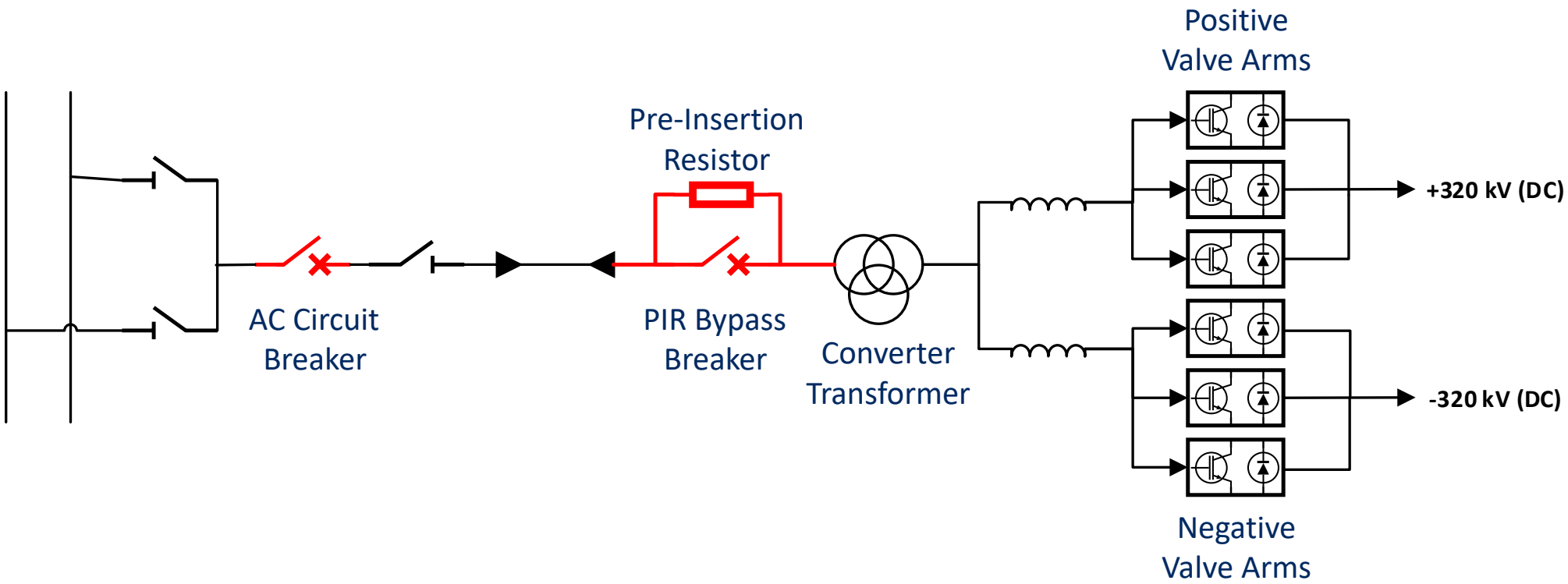
Commissioning of HVDC Link



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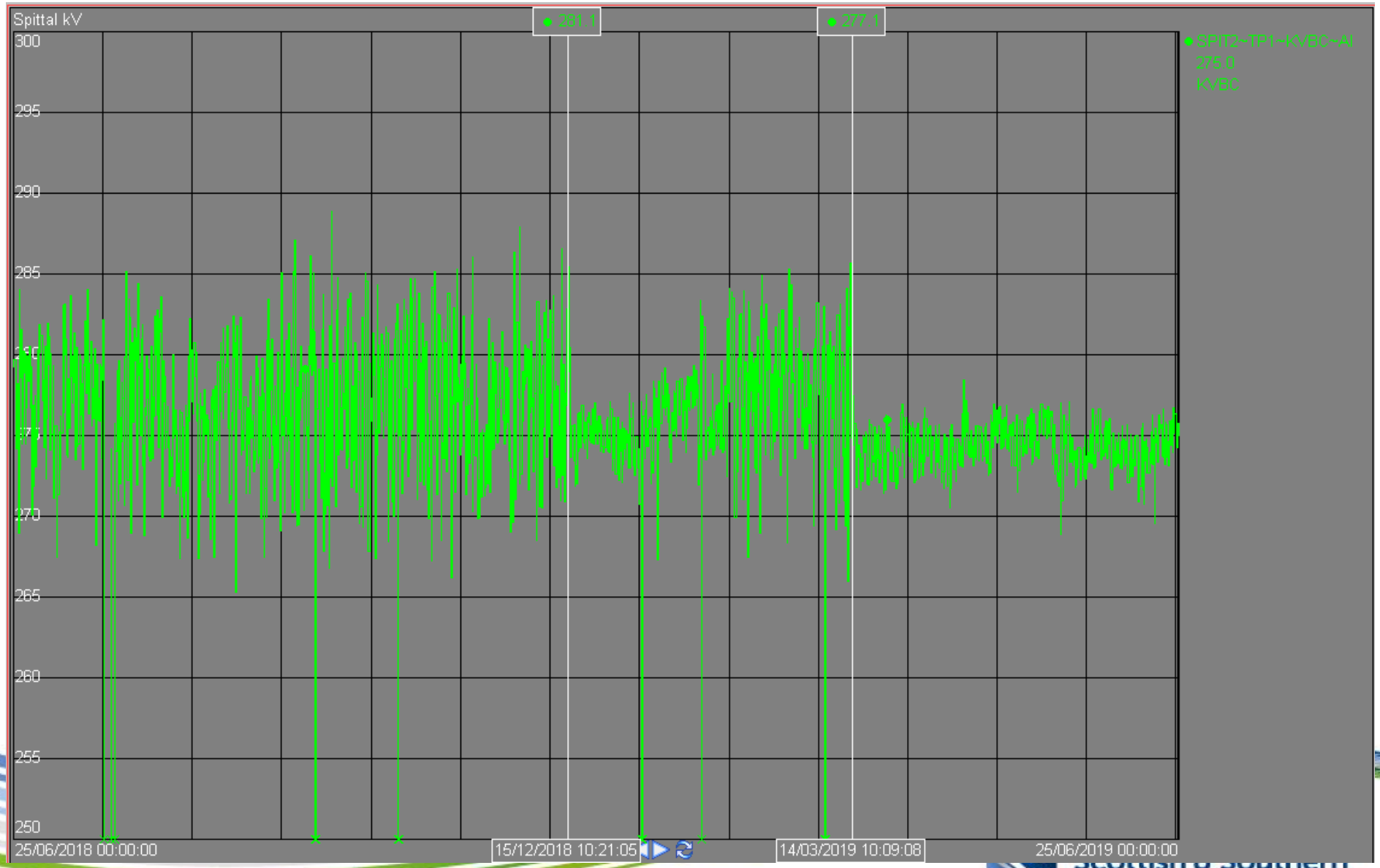
Operation of HVDC Link

- Caithness Moray HVDC link is in service since 16th December 2018
- Completed trial operation on 30th December 2018
- Summary of outage works to date:
  - 6 week planned outage between February & March for planned cable repair work
  - 1 forced outage due to valve cooling system pressure for 1 day
  - 3 day outage on Blackhillock Converter for corrective maintenance
- Typical load flows up to 350 MW dispatched by NG
- Converters offering improved voltage stability to adjacent AC networks
- Reduction in THD by approx. 50% whilst Converter in operation
- Two successful automatic transitions between NCM & EWCM

Operation of HVDC Link



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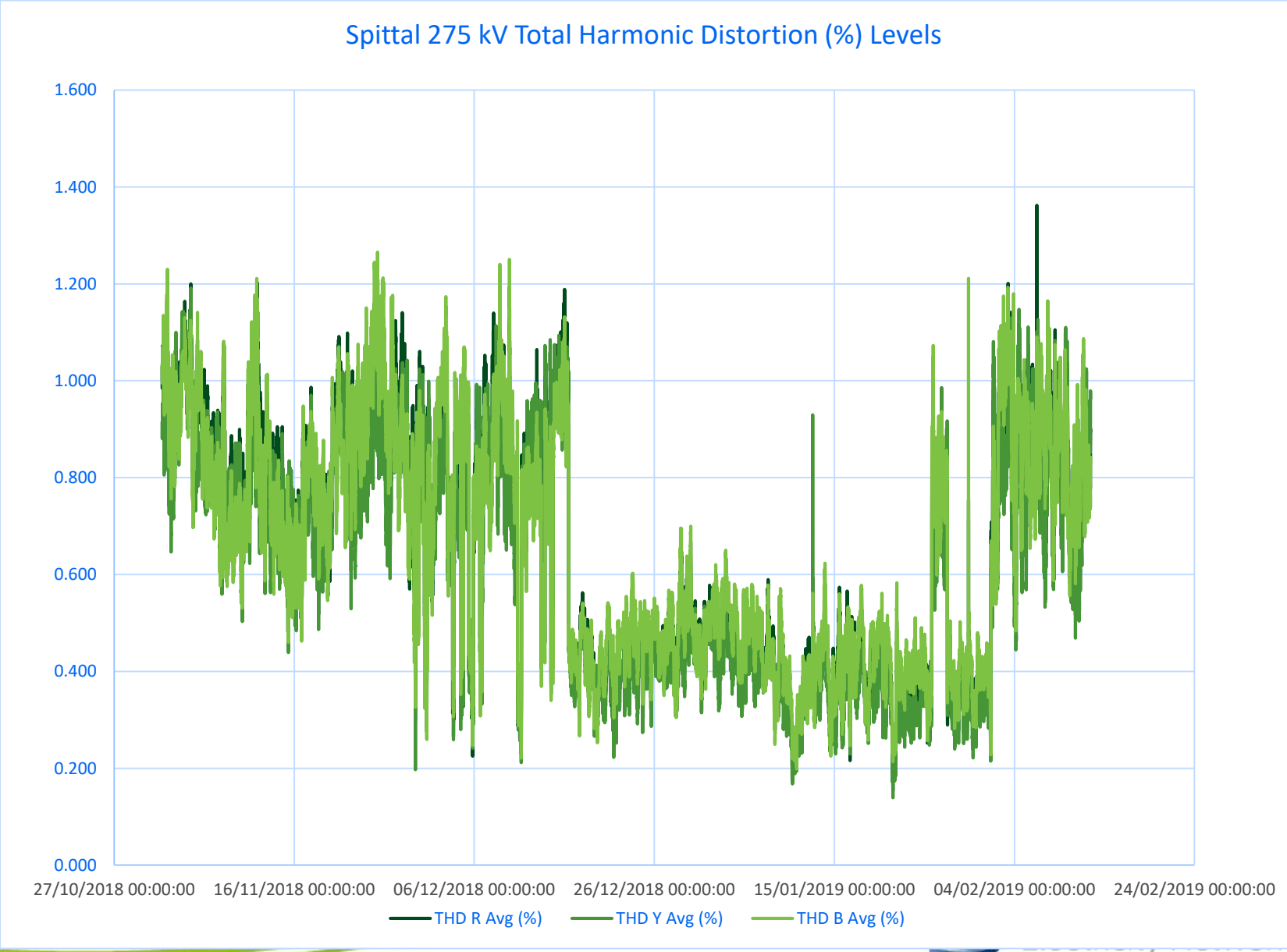
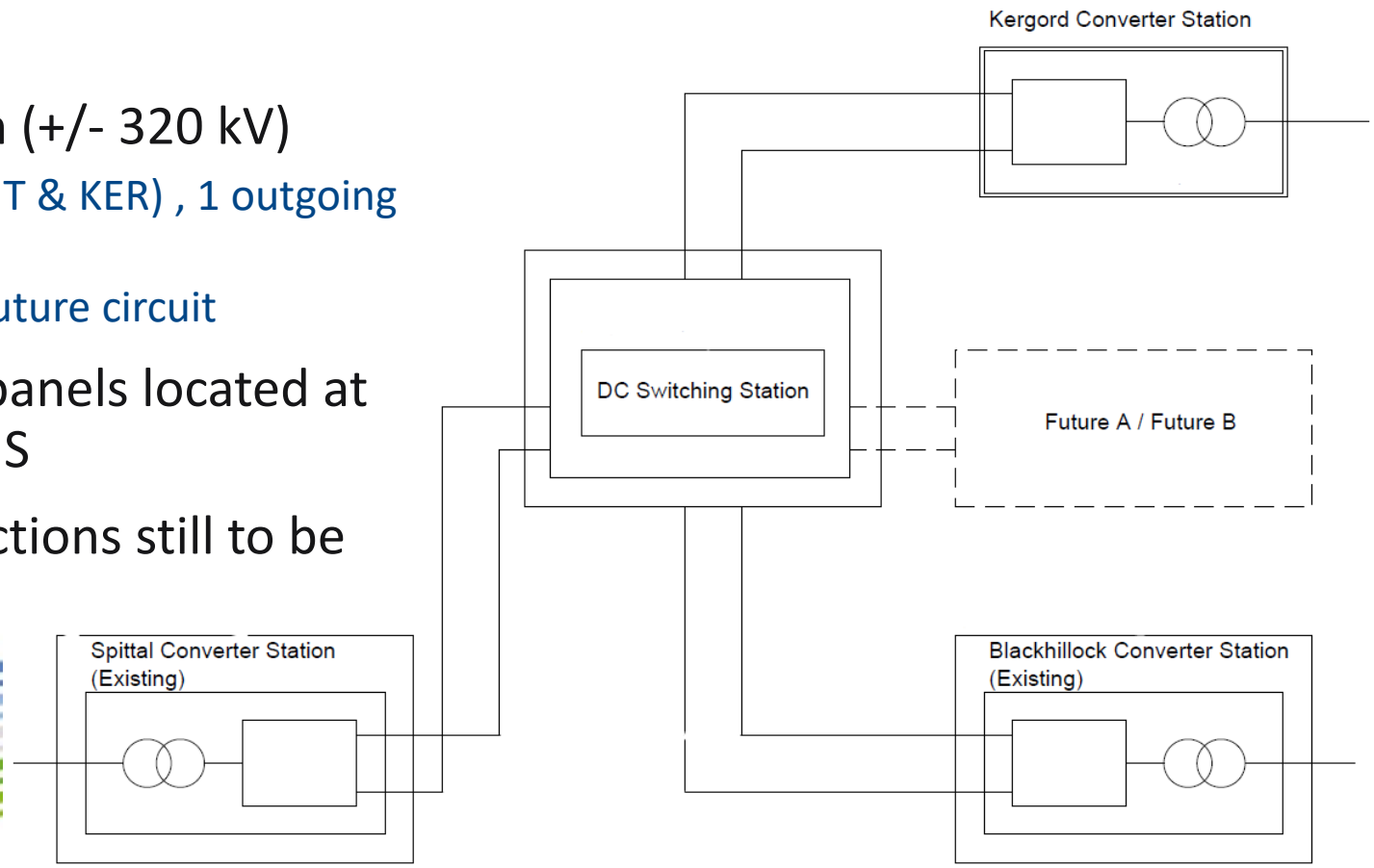
Operation of HVDC Link



Future Multi-terminal System

- Caithness Moray system is future designed for 5-terminal operation
- Shetland connection planned for completion Q2 2024
- Kergord Converter (+/- 320 kV)
  - 600 MW Rectifier / 540 MW Inverter
  - +/- 197 MVAr
- DC Switching Station (+/- 320 kV)
  - 2 incoming circuits (SPIT & KER) , 1 outgoing circuit (BLHI)
  - Space provision for 1 future circuit
- Full suite of replica panels located at HVDC Centre for CMS
- Future HVDC connections still to be defined



Blackhillock HVDC Converter Station

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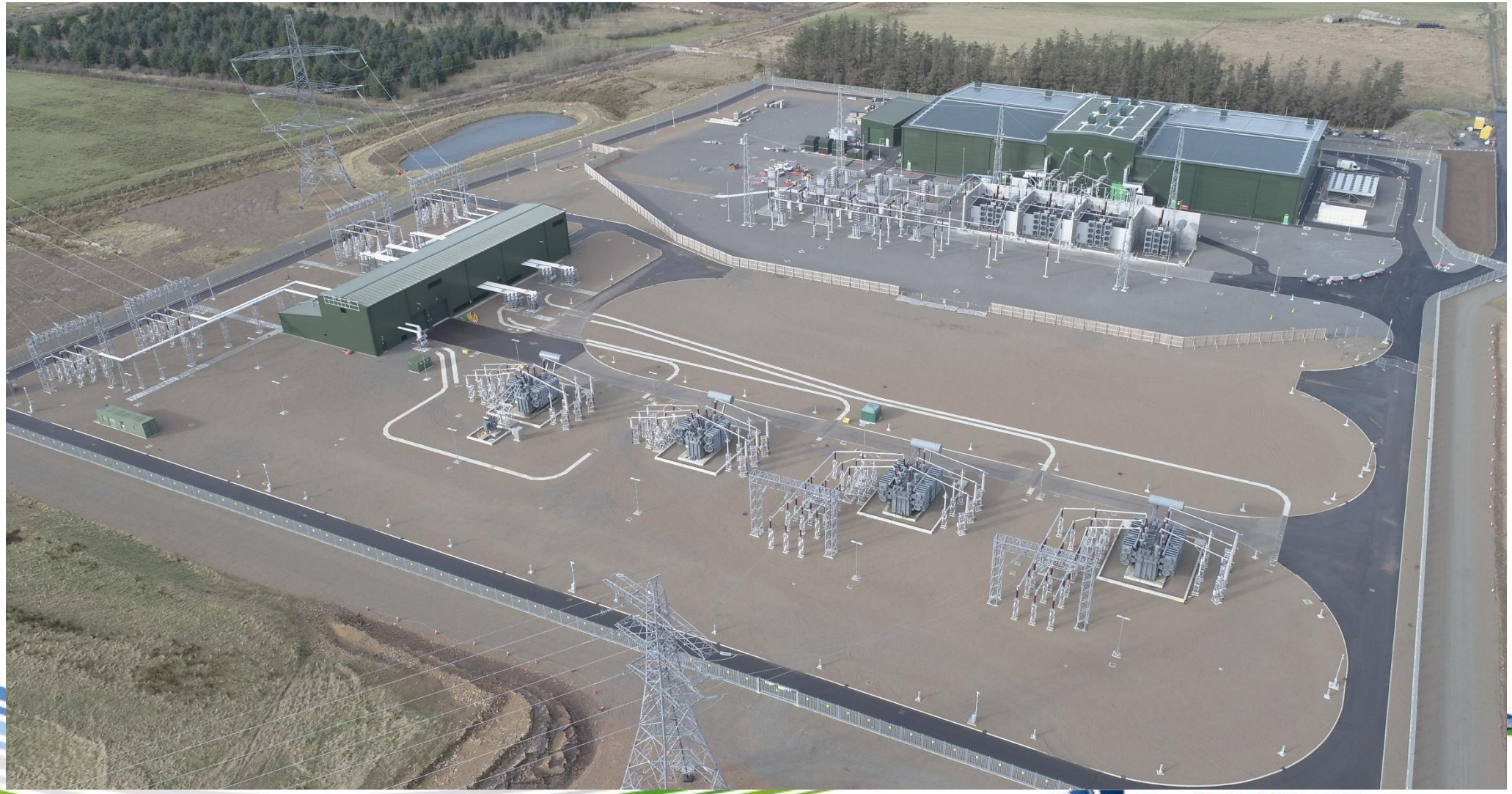
Spittal HVDC Converter Station



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