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Megger

SPECIAL SOLUTION FOR CABLE FAULT LOCATION ON THE WORLD'S LONGEST HVDC INTERCONNECTOR

VikingLink

nationalgrid – ENERGINET

CASE STUDY

2024-03-21

EN
English

THE VIKING LINK PROJECT

Enable clean electricity to be transmitted through a 761 kilometre power cable system

Viking Link is a ±525 kV High Voltage Direct Current (HVDC) transnational interconnector between the United Kingdom and Denmark. With overall construction costs amounting to about £1.7 billion, it was commissioned in Autumn 2023 and began its regular operation on the 29th December, 2023.

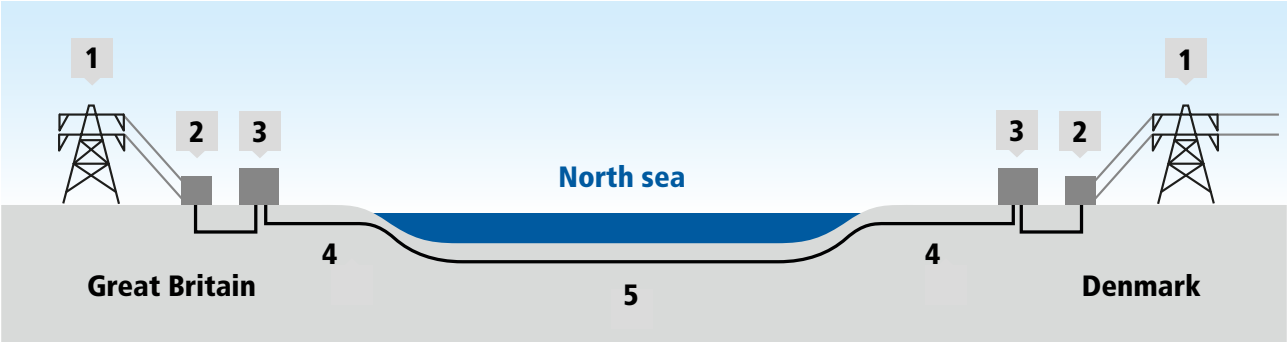
Prysmian Group and NKT manufactured, delivered and successfully installed a new world-record-holding Mass Impregnated Non Draining (MIND) cable system with a total length of 761 kilometres, capable of transmitting up to 1.4 GW of electric power bidirectionally.

Siemens Energy contributed to the success of this project by implementing their latest and most capable voltage source converter (VSC) station technology. In each converter station IGBT power electronics modules change the electric power between alternating current (AC) and direct current (DC). High Voltage DC allows for the transmission of power with the lowest possible losses over long distances, and it also makes it possible to utilise underground and subsea power cables for this purpose. High voltage AC is traditionally used in the onshore transmission and distribution power grid to deliver electric energy to customers.

The Viking Link project, a joint venture between the two Transmission System Operators (TSO) National Grid in the UK and Energinet in Denmark, is going to supply electricity to over 1.4 million UK homes, which will result in cumulative savings of more than £500 millions for consumers over the next decade, thanks to more affordable electricity imports from Denmark.

As Europe's co-ordinated and synchronised power grid is expected to become more environmentally sustainable, Viking Link will mainly share power from clean, renewable generation. However, a necessary condition for success will be its continuous operation without any unplanned downtime and therefore with as few cable faults as possible.

Megger and their sales partner Blichfeld Power & Measurements are delighted to have been chosen to provide the world's best cable fault location solution for the Viking Link project, complemented by two portable solutions, an all-new audio frequency generator and a novel high voltage measurement bridge. Because of Viking Link's rigid bipole design, where any cable fault takes out the entire interconnector, this state-of-the-art equipment will ensure quick and accurate fault finding, minimising prolonged downtime and the costs associated with unplanned outages.



HVAC = High Voltage Alternating Current
HVDC = High Voltage Direct Current

1. Existing network
2. Substation
3. Converter station
4. Underground cable
5. Subsea cable

Picture source: https://www.viking-link.com/cables/

KEY FACTS

CLIENTS

- Energinet Eltransmission A/S
- National Grid Viking Link Limited

LOCATIONS

- Megger Germany GmbH, Factory Radeburg, Germany
- Revsing substation, Jutland, Denmark
- Bicker Fen substation, Lincolnshire, England

REQUIREMENTS

- EU Project of Common Interest (PCI) 1.14
- EU tendering process, and client's contractual agreements
- Development and manufacturing of fault location container, audio frequency generator, and HV bridge
- Factory Acceptance Tests (FAT)
  Container 1 for ENERGINET / Container 2 for National Grid
- Site Acceptance Tests (SAT) and fingerprinting
  Container 1 in Denmark / Container 2 in England
- Commissioning / On-site testing

Ask the project manager for further information

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Ask the product manager for further information

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PROJECT TIME

August 2022 to October 2023.

Designed, manufactured, tested, delivered, installed, and commissinoned in 15 months. Perfectly on time.

SCOPE AND PERFORMANCE

No existing solution in the market met the application-specific requirements of the Viking Link cable system and its tender specification. Consequentially, the all-new Megger TCFL-R550 system was born, suitable for cable fault location and cable route tracing on long HVAC and HVDC cables.

- **State-of-the-art user convenience: Fully automated, centrally controlled, and integrated system**
  - Automatic switching via motorised switches for mode selection, mode execution and voltage range dial
  - Automation of all components and operating modes without any exceptions, even power burning
  - One single industrial-grade control unit, operating the entire system via one central control software
  - Easy-to-navigate graphical user interface with single rotary knob control
  - One safety master and live status monitoring for the entire system
  - In contrast to manual, analogue systems with countless buttons, knobs and variacs: Minimal training burden due to user-friendly interface, memorable even after long periods of non-use
  - Connectivity: Remote access and remote control of the entire system via 4G LTE modem and TeamViewer

- **Discharge and earthing unit – safety is paramount! Protecting personnel and equipment, facilitating high productivity**
  - Robust, fast-acting ultra high power discharge unit, designed for the repeated dissipation of the maximum stored energy
  - Discharge capability 3.6 MJ (equal to C_{max} = 320 µF when charged to 150 kV DC; C_{Viking} = 294 µF)
  - Great benefit for operator's workflow, discharge time signifcantly less than 10 seconds
  - Design successfully verified by an independent third-party HV test lab, report of performance available upon request
  - Interlocked limit switches for safe operation of the system with closed rear and side doors – no exposure to HV

- **Modern electronic HV DC source generating, up to 150 kV**
  - Being able to handle even very high break down voltage faults and high resistance faults
  - Capability to detect high energy discharges with DAS technology

- **Best-in-market long-range cable radar (TDR) with low-Z connection set for HV terminations**
  Bipolar impulse generation and new technologies for noise suppression, averaging and pulse compression

- **HV prelocation methods for both typical and longer fault distances beyond 80 km**
  Inductive-active ARM Multishot, ARM Charging, ICE, ICE Charging, Decay, Intermittent fault mode

- **Heavy-duty high power burner for conversion of high resistance faults**
  - Automated power output regulation to P_{max} = 20 $kW_{CONTINOUS}$
  - Smooth, uninterrupted burn-down process without any user interventions; no fixed voltage-current ranges or tap positions, no manual switching
  - Fully software-controlled and integrated into the automated, central control of the system
  - Unique and powerful prelocation method ARM Live Burning (Burn Arc Reflection) up to 40 kV DC

- **Surge generator (Thumper)**
  - Capacitor discharge module with multi-stage surge capacitor design
  - High energy up to 6250 J and high surge voltage up to 100 kV

- **40 foot container as per client specification**
  - CSC-certified, inner lining, furnished operator room, entry doors and maintenance hatches
  - Comprehensive climate control: air conditioning and dehumidification of the HV compartment and the operator room

NEW STANDALONE PRODUCTS

In addition to the fault locating container, the project required instruments for complementary prelocation and for geo-surveying and route tracing of subsea cables. The tender specification called for a very capable HV measurement bridge and for a transmitter of audio frequency modulated currents, appropriate for work in both the shallow and the deep water zone.

BIFRÖST

HIGH VOLTAGE BRIDGE

- Voltage drop method for the best results
- 20 kV DC with maximum charging current of 850 mA for long HVAC and HVDC cables
- Accuracy: better than 1% of the total cable length
- Incorporates temperature data of the interconnector for even higher accuracy and precision
- Integrated internal discharge unit for cable capacitances of more than 600 µF
- Automated and centrally controlled via graphical user interface with single turn-and-click rotary knob operation
- Project-specific set of connection leads, suitable for HV terminations
  - Lead length up to 180 m (1)
  - Far end HV jumper cable, 180 m (2)

HUMMINGBIRD

AUDIO FREQUENCY GENERATOR

- The most powerful tone generator in the world
- State-of-the-art human-machine interface
- Easy-to-adjust input parameters: voltage, current and frequency
- Frequency of 10…40 Hz in steps of 1 Hz, designed for excellent surveying, route tracing and pinpointing of low resistance faults on subsea cables
- I_{max} up to 100 A
- P_{max} up to 40 kW
- Set of connection leads, suitable for HV cable terminations

FACTORY ACCEPTANCE TEST (FAT)

FAT 1

LOCATION

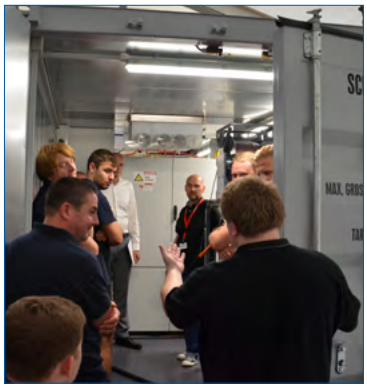
Megger Factory, Radeburg, Germany

TIME

2023, July 24 - 28

PARTICIPANTS

- Team Denmark (ENERGINET)
- Team UK (National Grid)
- Blichfeld Power & Measurements
- Team Megger Germany



CONTENT

- Seminar on cable fault location basics, plus hands-on demonstrations
- Factory acceptance test
- Strict comparison of the presented products against Viking Link tender specification, carried out by the ENERGINET team
- Verification of all operating modes and features
- First equipment training, answering questions

FAT 2

LOCATION

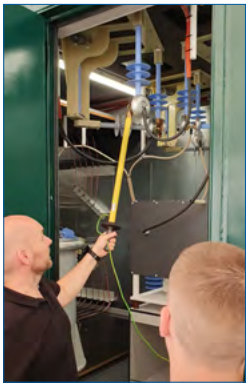
Megger Factory, Radeburg, Germany

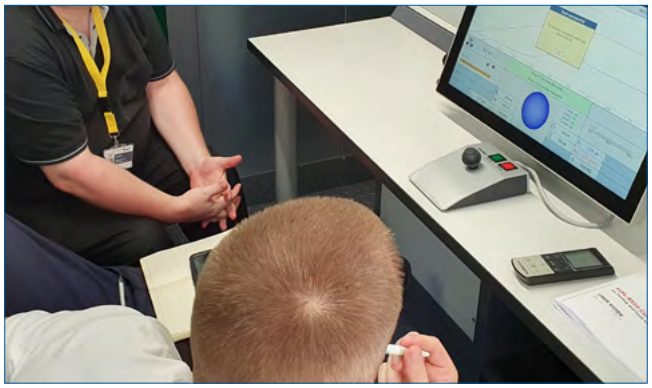
TIME

2023, August 22 - 23

PARTICIPANTS

- Team UK (National Grid)
- Team Megger Germany





CONTENT

- Additional hands-on training with detailed explanation of technology and system features
- Factory acceptance test by the National Grid team
- Strict comparison of the presented products against the Viking Link tender specification, carried out by the National Grid team
- Verification of all operating modes and features

SITE ACCEPTANCE TEST (SAT)

SAT 1

LOCATION

Revsing substation, Denmark

TIME

2023, September 26 - 28

PARTICIPANTS

- Team Denmark (ENERGINET)
- Team Megger
- Blichfeld Power & Measurements

CONTENT

- Site acceptance test and asset handover
- Initial checks after delivery to verify the good condition of the products
- Real world hands-on training for the ENERGINET team
- Making connections to both poles (NKT terminations), including the TDR low-Z connection set for long cables
- Recording a full TDR fingerprint, including the cable end reflection and a reasonable segmentation
- Intensive application of the tone generator for route tracing and GPS surveying of the true geographical cable path
- HV bridge measurement applying the 4-wire voltage drop measurement to the complete Viking Link cable system, demonstration of the internal discharge unit handling the maximum stored energy in 2x 294 µF; HV jumper cable (motorised drum) connected to the far end terminations on the UK side (length 180 m)
- Storage, backup and systematic documentation of results

SAT 2

LOCATION

Bicker Fen substation, England

TIME

2023, October 18 - 19

PARTICIPANTS

- Team UK (National Grid)
- Team Megger

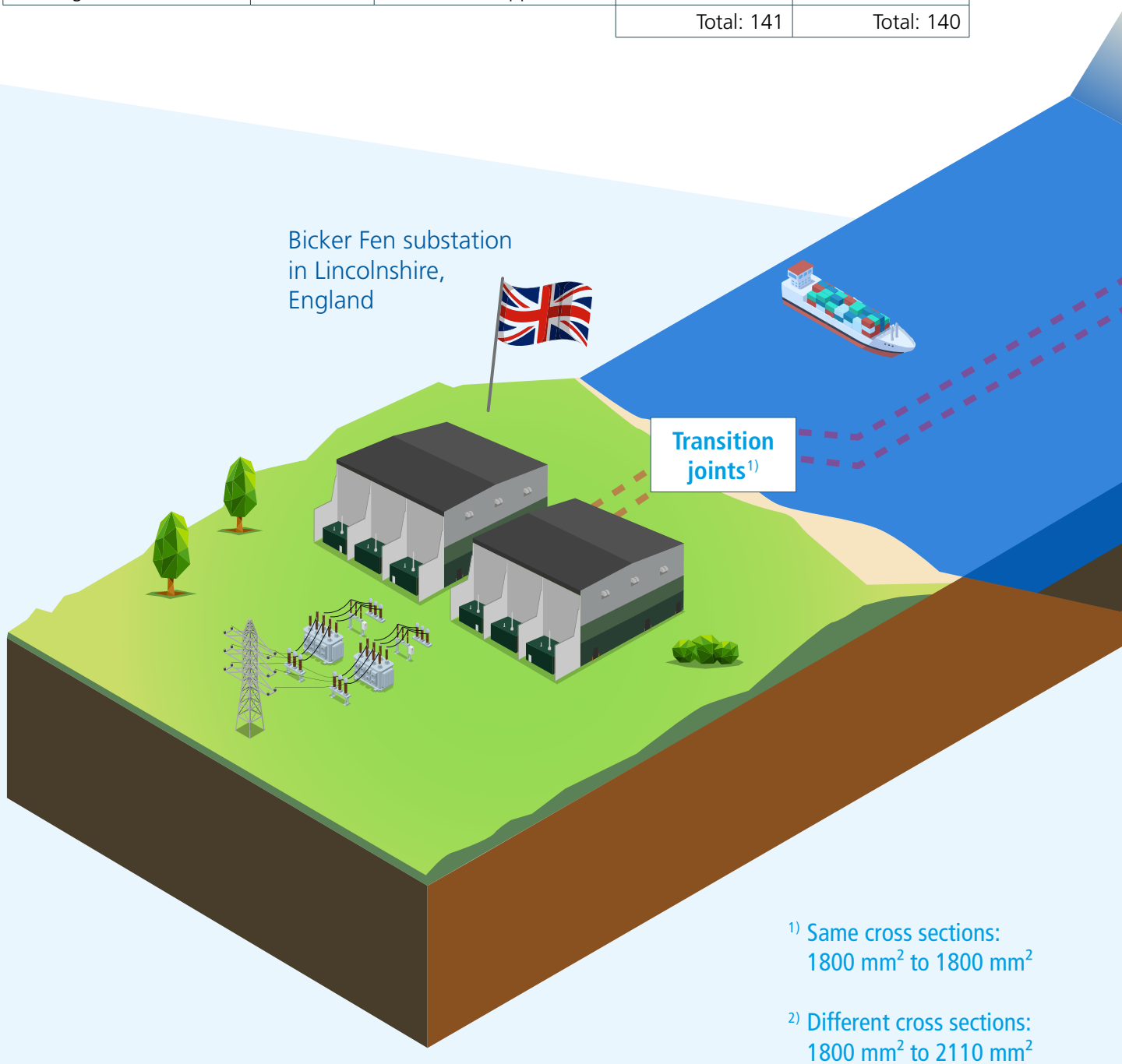
CONTENT

- Site acceptance test and asset handover
- Initial checks after delivery to verify the good condition of the products
- Real world hands-on training for the National Grid team
- Making connections to both poles (Prysmian Group terminations), including the TDR low-Z connection set for long cables
- Recording a full TDR fingerprint, including the cable end reflection and a reasonable segmentation
- HV bridge measurement applying the 4-wire voltage drop measurement to the complete Viking Link cable system, demonstration of the internal discharge unit handling the maximum stored energy in 2x 294 µF; HV jumper cable (laid in a pipe) connected to the far end terminations on the Danish side (length 180 m)
- Storage, backup and systematic documentation of results

CABLE SYSTEM

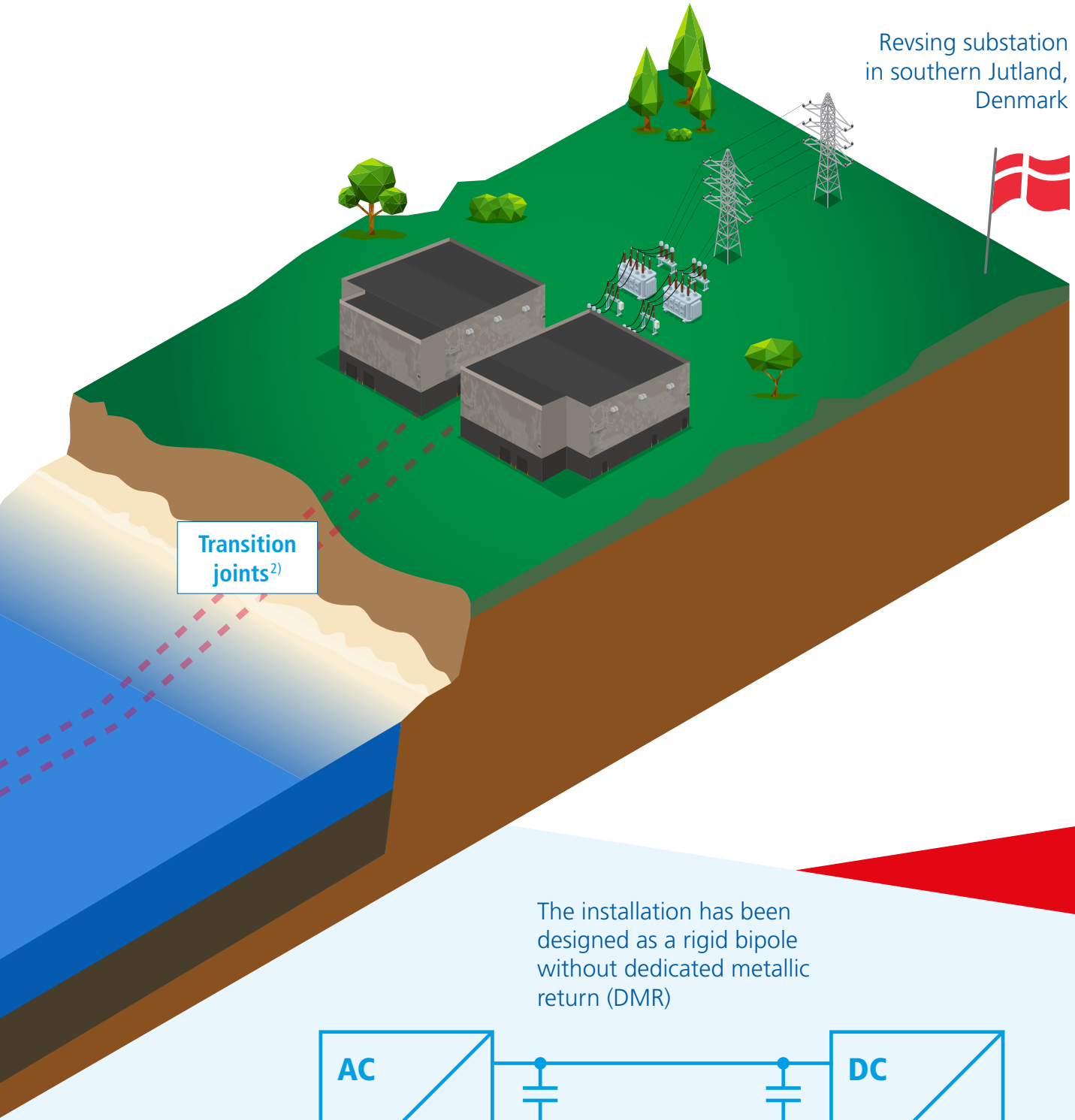
- 761.4 km HVDC interconnector (Pole 1)
- Mass Impregnated Non Draining (MIND), manufactured by Prysmian Group and NKT
- 1.4 GW at 525 kV DC, bidirectional

			Number of joints	
Segments	**Length**	**Cross sectional area**	**Pole 1**	**Pole 2**
Underground Denmark	75.9 km	2110 mm² copper	53	53
Subsea North Sea	619.6 km	1800 mm² copper	29	28
Underground UK	65.9 km	1800 mm² copper	59	59
			Total: 141	Total: 140



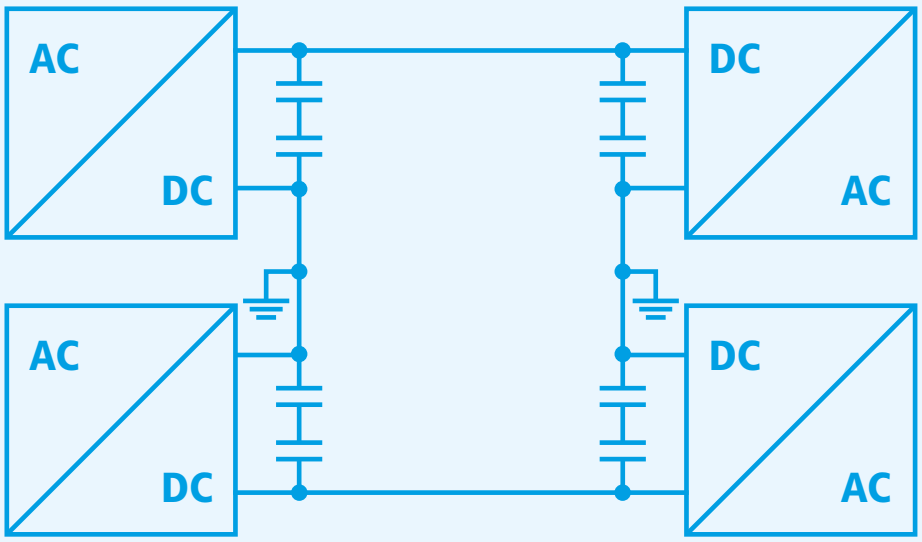
[1)] Same cross sections: 1800 mm² to 1800 mm²

[2)] Different cross sections: 1800 mm² to 2110 mm²



Revsing substation in southern Jutland, Denmark

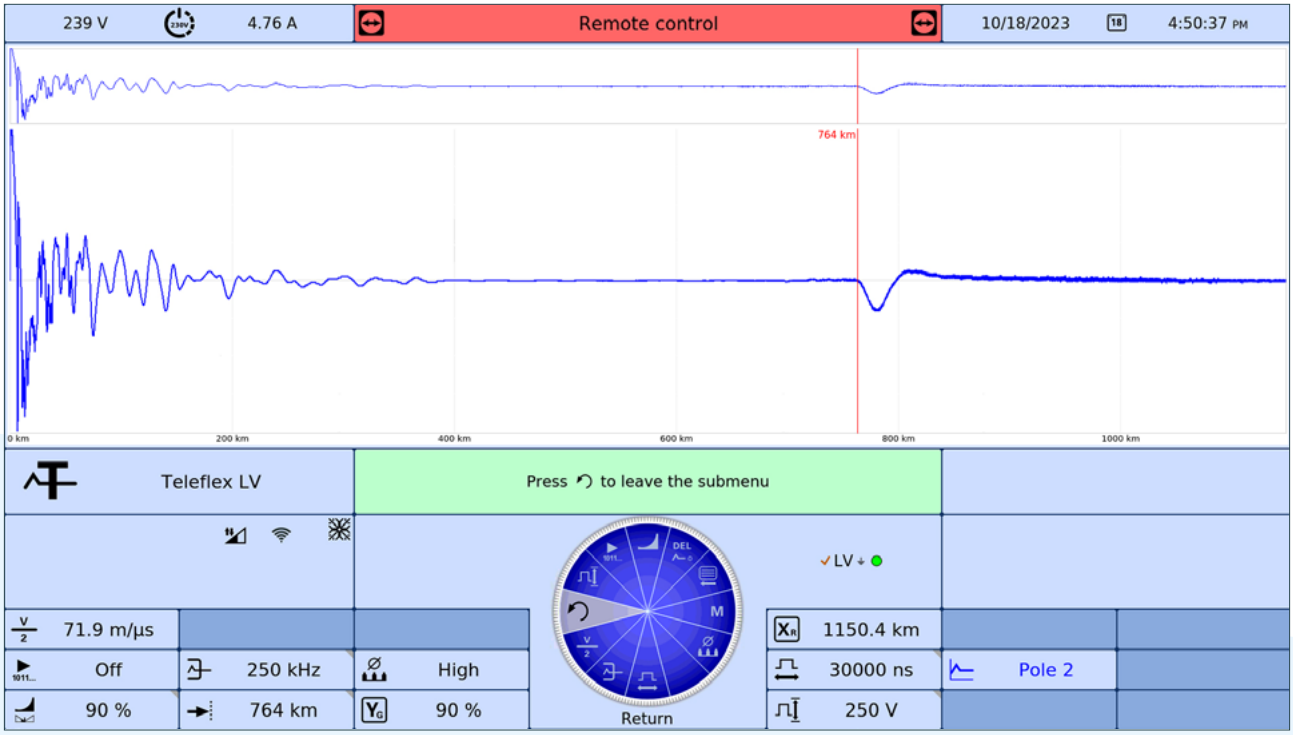
The installation has been designed as a rigid bipole without dedicated metallic return (DMR)



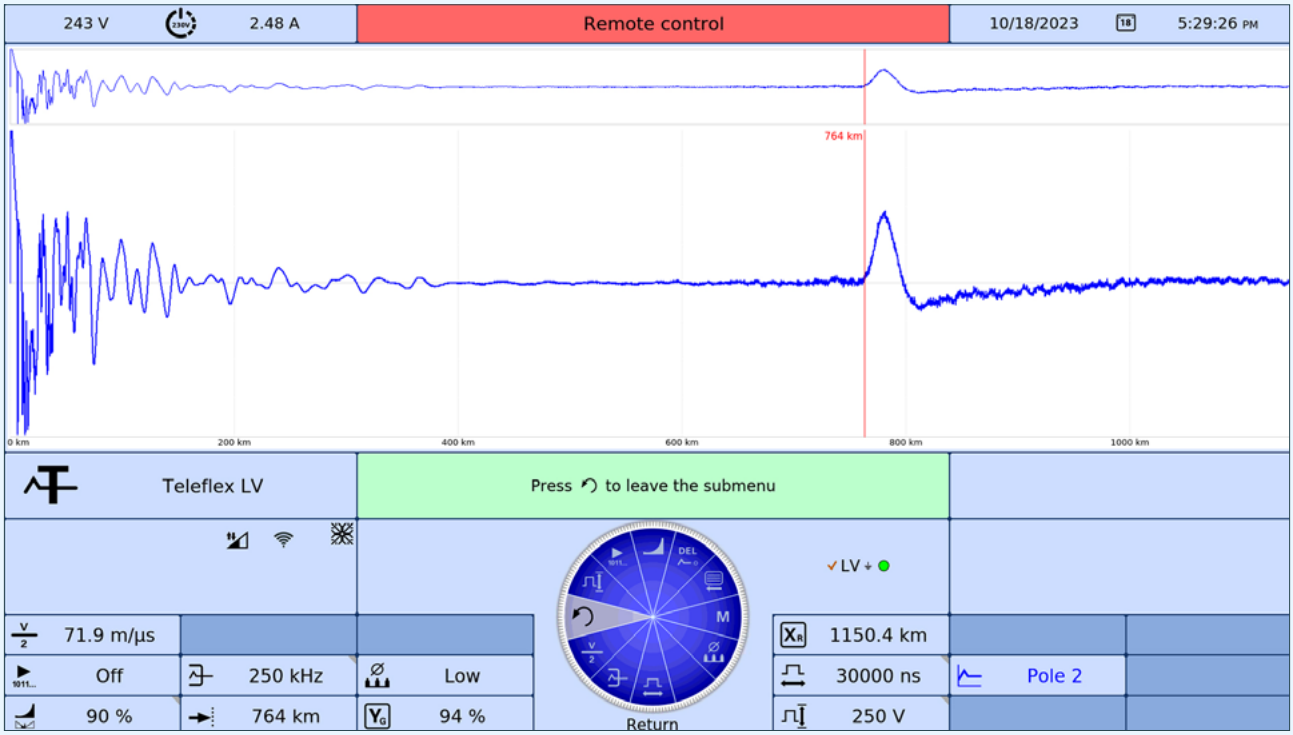
In any event on one pole, the other pole can still maintain 700 MW of power transfer.

NEW RECORDS

TDR fingerprint during commissioning:
This trace shows the entire cable length with the far end short-circuited



TDR fingerprint during commissioning:
This trace shows the entire cable length with the far end open



NEW WORLD RECORDS

TDR/CABLE RADAR "TELEFLEX RDR"

- Longest-ever successful TDR measurement of 761 km
- Cable end reflections were captured
- Comprehensive fingerprinting with precise segmentation

HIGH VOLTAGE BRIDGE "BIFRÖST"

- Longest-ever successful bridge measurement of 761 km
- 4-wire voltage drop method applied to the entire link (both poles 2x 761 km, far-end jumper cable between poles, connection leads)
- Accuracy noticeably < 1% of the total cable length
- Fast and safe discharge of 2x 294 µF at 20 kV DC = 118 kJ

AUDIO FREQUENCY GENERATOR "HUMMINGBIRD"

- Most powerful tone generator in the world
- Transmitter for cable route tracing and GPS surveying, as well as pinpointing of low resistance faults
- Highly satisfying tracing results: seamless execution and very accurate data (as per the documentation)

READY FOR YOUR PROJECT

Protect your investments with innovative solutions.

Committed to make the HVDC supergrid work.

Send us your project request

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