

SWITCHGEAR FOR DIRECT CURRENT (DC) APPLICATIONS

Disconnectors, Switches, and Circuit Breakers



GE VERNOVA

Today's Environment

Globally, the utility environment is becoming more complex and utilities are having to manage new challenges such as:

- Increasing demand for electricity
- Connection of remote generation
- Growth of distant offshore wind
- Integration of variable renewable generation
- Need for security of supply
- Reduction of carbon footprint
- Land costs becoming more expensive
- New right-of-way access permits are increasingly difficult to obtain

The only choice for many utilities is to restructure their grid systems to manage these challenges. Utilities are looking for cost-effective solutions to transfer power and to improve the quality, stability and reliability of the grid which will anticipate their needs for the next few decades.

HVDC Overview

High-Voltage Direct Current (HVDC) solutions are ideal for supporting existing AC transmission systems or for building new power highways. HVDC is a system which interconnects two AC networks, converting AC voltage to DC voltage, and DC voltage to AC voltage utilizing power electronics technology. HVDC systems enable transfer of power, interconnection of grids, integration of renewables, and maximize grid performance.

Move More Power, Further

Ultra HVDC can operate at voltages up to 800 kV, enabling bulk transport of electricity over long distances. HVDC systems have lower losses than AC systems and can transmit up to

three times more power than AC networks. HVDC systems are more economical than HVAC for schemes with transmission distances more than approximately 700 km (~400 miles). The use of insulated cables in both submarine and underground applications, in combination with HVDC, allows more power to be transmitted across long water crossings, or buried out of sight adjacent to roads, railways and tunnels, which may accelerate the permitting process compared to AC or overhead DC transmission alternatives.

Integrate Renewables

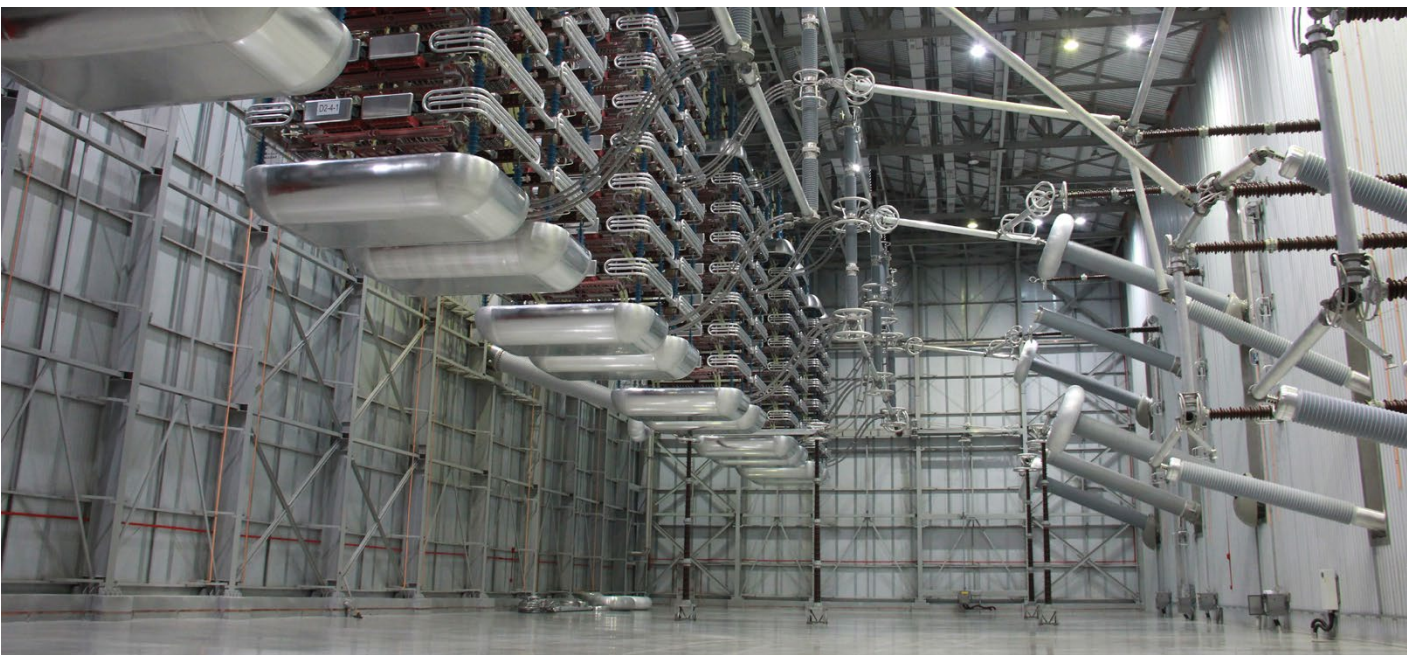
HVDC is a versatile and flexible technology, making it an ideal solution for integrating renewable energy in modern grids such as remote windfarms, both offshore and onshore. HVDC can provide additional controllability to network operators to support efficient management of transmission of mixed energy sources, including the increasing use of renewables combined with energy storage.

Interconnect Grids

HVDC enables the exchange of energy between two AC networks. In some cases, this is the only means of neighboring utilities exchanging energy since they operate at different frequencies or may not be synchronized. An HVDC interconnection has many benefits, such as allowing neighboring utilities to reduce and share 'spinning reserve', giving access to other lower cost sources of energy.

Improve Quality, Stability and Maximize Network Performance

All HVDC solutions provide a 'firewall' to prevent disturbances propagating from one network to another. They provide fast and highly controllable power transfer and today can provide reactive power into the local AC network to improve stability and quality.



Back-to-Back HVDC Interconnection

The GE Vernova Advantage

GE Vernova's HVDC switches and disconnectors are developed based on the highest standards for performance, ratings, user convenience and reliability, like IEC TS 62271-5, IEC TS 62271-313 and IEC TS 62271-314.

Every model is designed utilizing 3D design tools and analysis software to achieve the highest performance. Switches and disconnectors are thoroughly type tested and subject to routine tests to meet or exceed the latest standards and requirements. Dependent on customer requirements, GE Vernova is able to design and supply highly customized products.

Based on years of global experience, deep domain expertise, manufacturing excellence and several deployments across multiple applications and industries, GE Vernova has dedicated project teams working in partnership with our customers to ensure successful equipment implementations. GE Vernova provides customers with the following competitive advantages.

Robust Design Leveraging Cutting-Edge Technology Provides High Performance and Lower Total Cost of Ownership

- Durable spring-spring mechanism with five times more reliability than hydraulic, pneumatic or hydraulic-spring designs.
- HVDC switches are specifically designed to address HVDC constraints and are derived from conventional AC breaker with self-blast technology, with improved technology and performance for DC applications.
- HVDC disconnectors use the latest technology of contacts in order to ensure maximum protection against pollution and ice, ensuring limited overhead clearance and a very short phase to phase distances, without a middle electrode.
- All switchgear is designed to operate within extreme environmental conditions with available options for high elevation, very low and high temperatures (-50°C to +60°C), seismic zones, polluted areas, and corrosive atmospheres.

Manufacturing Excellence to Ensure Highest Quality Standards

- Global manufacturing sites certified according to ISO 9001 and ISO 14001 standards
- Products are manufactured utilizing GE Vernova's Advanced Production System ensuring the highest level of quality
- Customized designs available to meet customer application requirements

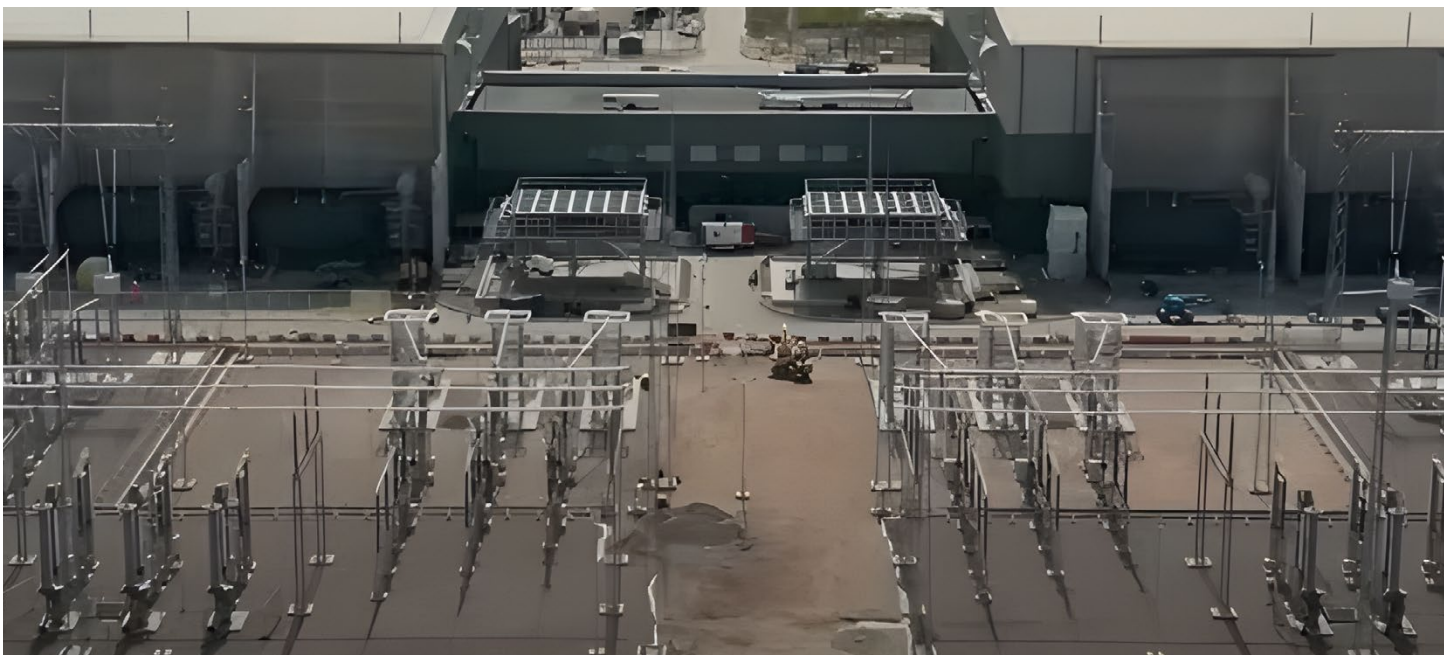
Extensive Research, Testing and Proven Field Experience Resulting in Enhanced Reliability

- R&D Competence Centers and associated testing laboratories assure extensive research and testing for DC applications
- Specific HVDC tests are carried out in laboratories to ensure best performance over lifetime of assets
- 400,000+ units of circuit breakers and disconnectors for AC and DC installed worldwide and in service in more than 100 countries

Optional Features for Enhanced System Compatibility and Digital Integration and In-House Expertise

- Complete monitoring system available for asset management and digital substation integration
- Full life-cycle support for products, spare parts management and technical training by GE Vernova subject matter experts
- Local Product Sales Specialists provide strong product and technical support

**according to CIGRE Report TB 510.*



HVDC Substation Viking Link, Denmark-UK

GE Vernova's HVDC Technologies

Line Commutated Converters

Line Commutated Converters (LCC) is a mature, cost-effective HVDC technology based on thyristor power semiconductors, which enable the bulk transfer of power of up to 8 GW with low losses and inherent DC fault protection. LCC is available as point-to-point overhead line and submarine/land cable and is ideally suited for back-to-back schemes.

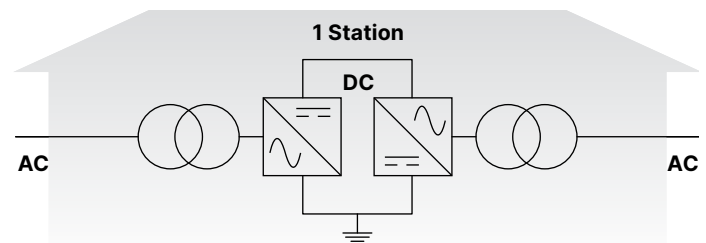
Voltage Source Converters

Voltage Source Converters (VSC) is a newer technology based on power transistors with a reduced footprint compared to LCC technology. VSC is an ideal technology for submarine/land cable interconnection, integrating renewables, offshore and urban infeed applications. VSC is available as point-to-point, back-to-back, submarine/land cable and offshore schemes. VSC has distinct technical advantages over the traditional LCC schemes because it creates an AC waveform that allows the scheme to control real and reactive power independently and transmit real power into a very weak AC network, which is not possible with LCC.

HVDC Schemes

Back-to-Back Scheme

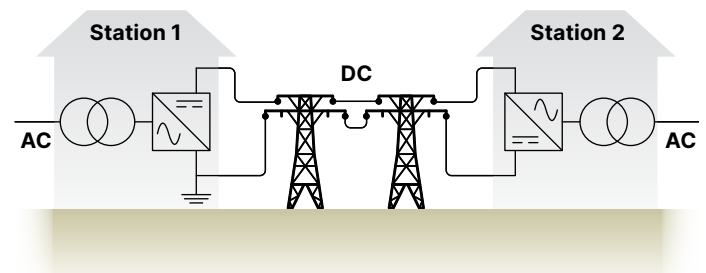
Suitable for frequency changing and asynchronous connections. This scheme provides fast, accurate power flow, limiting the spread of cascading faults and provides increased system flexibility relative to new generation requirements. Once interconnected, the two systems' daily and seasonal cost differences can also be improved.



Back-to-back scheme is suitable for frequency changing and asynchronous connection

Point-to-Point Scheme

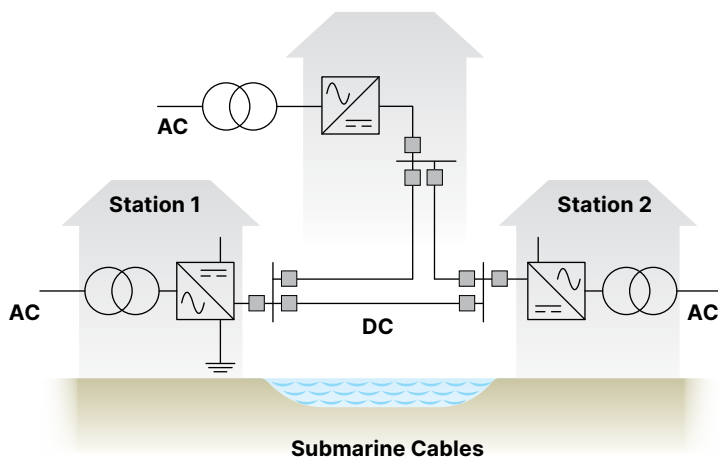
Commonly used for bulk transfer of power applications utilizing overhead lines over long distances providing a low cost, fully functional, reliable and environmentally friendly way to transmit power.



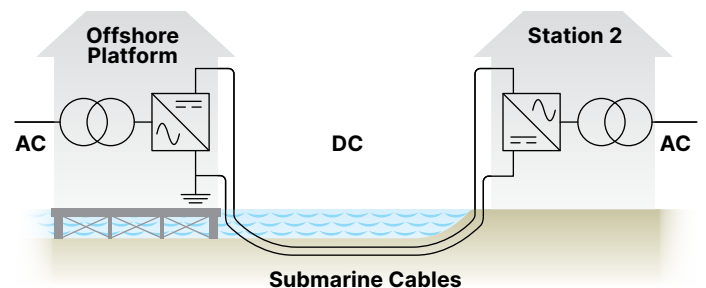
Point-to-point overhead line is suitable for bulk transmission overland

Submarine/Land Cable Scheme

Where the power exchange or transmission crosses water, or an environmentally sensitive region, cables may be the favored method of interconnection between the HVDC converter stations. HVDC transmission is particularly attractive and may be the only technically feasible method of transmitting power using cables.



Point-to-point submarine cable bulk transmission underwater or underground



Submarine scheme provides bulk transmission from offshore platform to shore

HVDC Switches Overview

Switches for HVDC applications are designed to close and open very rapidly in case of fault or for maintenance purposes. The switches may have to commute load current while maintaining the flow of power within a DC substation and its availability.

All HVDC switches are activated by the highly reliable spring-spring mechanism and benefit of a huge experience and installed base of AC circuit-breaker technology.

Types of HVDC Switches

- HVDC Switches
 - Neutral Bus Ground Switch (NBGS)
 - Neutral Bus Switch (NBS)
 - Ground Return Transfer Switch (GRTS)
 - Metallic Return Transfer Switch (MRTB)
- Bypass Switch (BPS)
- High-Speed Switch (HVVSS)
- Fast-Acting Discharge Switch (FADS)

Key Features

- DC current switching
- Dielectric withstand in open position over long time intervals
- High creepage distances require a long column
- Optional Features:
 - Use of surge arresters in addition to capacitors
 - Low temperature or seismic applications
 - CBWatch3 Monitoring System
 - Closing resistors for special applications



HVDC Substation Bina, India

HVDC Switches

Where more than one HVDC pole shares a common transmission conductor (typically the neutral) it is advantageous to be able to commutate the DC current between transmission paths without interrupting the DC power flow.

Figure 1 shows a typical Single-Line Diagram (SLD) for a HVDC transmission scheme utilizing DC side switchgear. The following switches can be identified from Figure 1.

NBGS – Neutral Bus Ground Switch

This switch is normally open but when closed it solidly connects the converter neutral to the station earth mat. Operation with this switch can normally be maintained if the converter can be operated in a bipole mode with balanced currents between the poles, that is, the DC current to earth is very small. The switch is also able to open, commutating a small DC unbalance current out of the switch and into the DC circuit.

NBS – Neutral Bus Switch

An NBS is in series with the neutral connection of each pole. In the event of an earth fault on one pole, that pole will be blocked. However, the pole remaining in service will continue to feed DC current into the fault via the common neutral connection. The NBS is used to divert the DC current away from the blocked pole to the ground.

GRTS – Ground Return Transfer Switch

The connection between the HVDC conductor and the neutral point includes both a high-voltage disconnector and a GRTS and is used as part of the switching operation to configure the HVDC scheme as either a ground return monopole or a metallic return monopole. The disconnector is maintained open if the HV

conductor is energized in order to isolate the medium voltage GRTS from the high voltage.

The GRTS is closed, following the closing of the disconnector in order to put the HV conductor in parallel with the earth path. The GRTS is also used to commutate the load current from the HV conductor transferring the path to the earth (or ground return) path. Once current flow through the HV conductor is detected as having stopped, the disconnector can be opened, allowing the HV conductor to be re-energized at high voltage.

MRTB – Metallic Return Transfer Breaker

The MRTB is used in conjunction with the GRTS to commutate the DC load current between the earth (ground return) and a parallel, otherwise unused, HV conductor (metallic return).

The MRTB closes in order to put the low impedance earth return path in parallel with the metallic return path. The MRTB must also be able to open, causing current flowing through the earth return to commutate into the much higher impedance metallic return path.



DC Switch in Champa, India

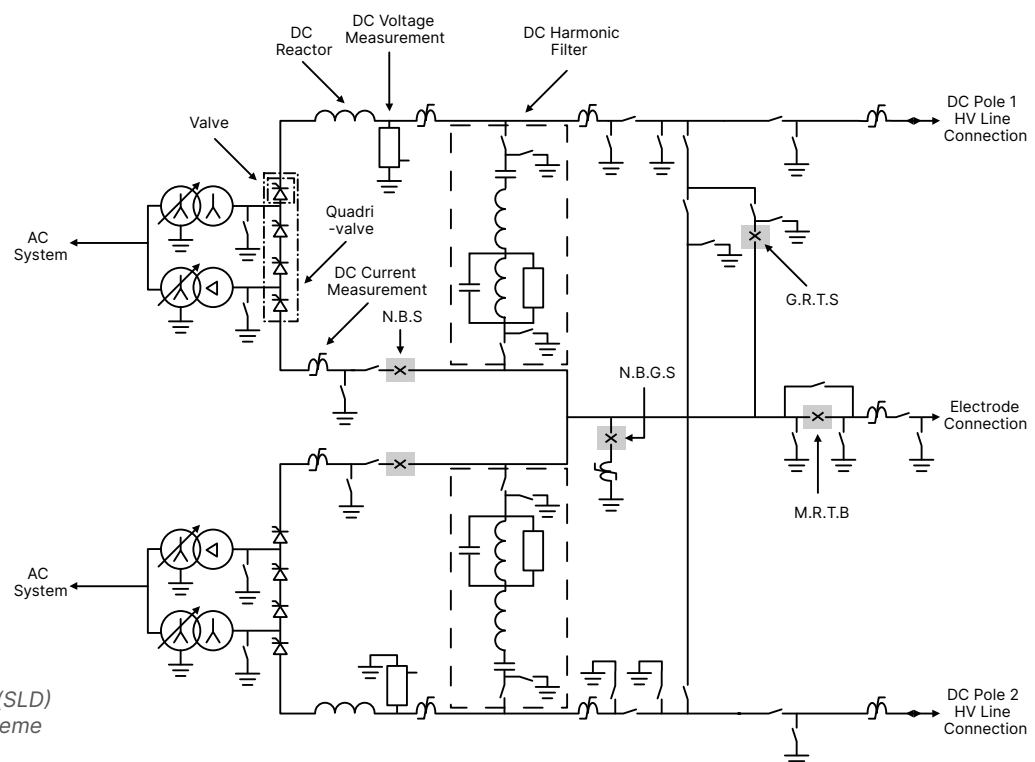


Fig. 1: Single-Line-Diagram (SLD) of a HVDC transmission scheme with DC switchgear

Bypass Switch (BPS) and Fast-Acting Discharge Switch (FADS)

This switching device can be used either as a HVDC by-pass or a fast discharge switch.

As a by-pass switch, it is connected across each converter valve group in HVDC schemes using more than one independent converter per pole. It closes rapidly to by-pass a converter group that is being taken out of service and commutate the current back into a valve group that is being taken back into service.

As a FADS, it is connected between one pole and a resistance connected to the ground. It remains opened until a fault occurs in the AC network. AC circuit breaker clears the fault, but a trapped charge remains in the HVDC line and shall be discharged before the AC circuit-breaker recloses and reenergizes the poles 300 ms later.

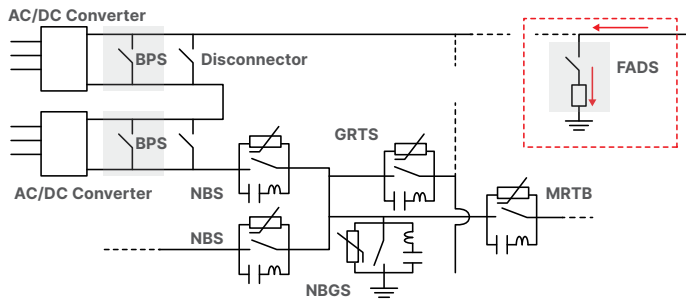


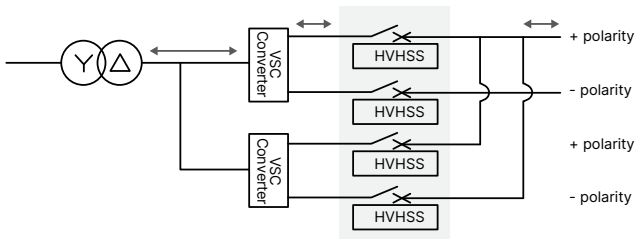
Fig. 2: SLD of a HVDC transmission scheme using a BPS and FADS

High-Speed Switch

High-Voltage High-Speed Switches (HVHSS) can be used either as a line paralleling switch or either as converter paralleling switch.

As a line paralleling switch, it is connected in series to one or more high-voltage pole conductors allowing one or more lines to be connected in parallel or to revert to a single-line operation while maintaining the flow of HVDC power.

As a converter paralleling switch, it is connected in series to each converter at the high voltage DC terminal where two or more converters are connected in parallel onto a common pole



SLD for converter paralleling switch applications

Technical Data

RATINGS	HVDC SWITCHES	BPS AND FADS	HVHSS
Voltage	Up to 170 kV	Up to 800 kV	Up to 400 kV
Current	Depending on applications and project requirements - several currents available on demand.		
Temperature Range	-50°C to +50°C	-30°C to +50°C	-50°C to +50°C

conductor. It is designed to allow additional converter(s) to be connected in parallel or to disconnect some of them while conducting the load current.



Bypass Switch BPS during Testing



SLD for line paralleling switch applications

HVDC Disconnectors Overview

Disconnectors for HVDC applications are designed to specific constraints and requirements typical for DC applications, that are quite different compared to AC applications. They are requested to withstand DC voltage open gap and to ground to ensure safety for the people in the substation and to permit proper and safe layout configuration. In some cases, like for filter applications, they are requested to break a sum of harmonic currents at a certain voltage (smaller than the rated voltage of the disconnector) due to the ripple created by harmonics on the reactances.

Types of HVDC Disconnectors

- HVDC Disconnector
- HVDC Earthing Switch
- By-Pass Disconnector
- HVDC Filter DSC and Earthing Switch
- LVDC DSC and Earthing Switch
- LVDC Filter DSC and Earthing Switch
- Valve Hall Earthing Switch

Key Features

- Self-protected design of contacts (L-type contact) preventing pollution deposit and hot spots
- HVDC design of post insulators
 - High value of minimum creepage distance enforcing height
 - Dedicated shed profiles
- Specific layout design (also 2 or 3 post insulators for each contact side)
- High seismic performances
- Special design of anti-corona rings

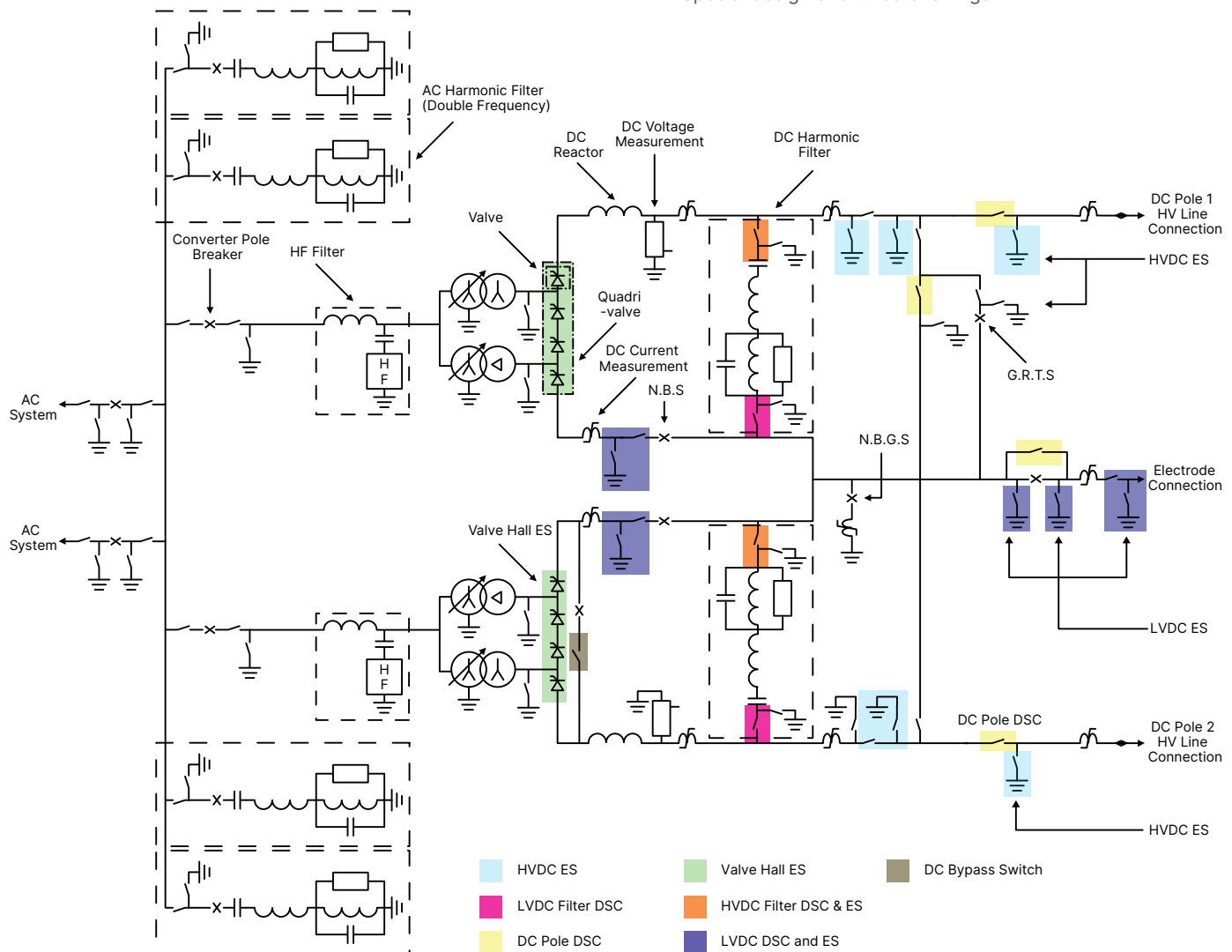


Fig. 5: SLD of a HVDC transmission scheme indicating the typical location of DC disconnectors and earthing switches

Knee-Type Disconnecter

GE Vernova's knee-type disconnector SPO/SPOL has been designed with one rotating and two fixed insulators. Thanks to its folding arm design (knee), it requires limited overhead clearance and a very short phase-to-phase distance. The outstanding gap factor allows a relatively short air gap and a lighter arm. No electrodes are needed in the middle.

The center of gravity is quite low, with great advantages for balancing, seismic withstand and operating torque. The low operating torque permits sure operation using a motor drive mechanism as well as easy manual operation and it does not stress the rotating insulator. The design is contact rebound-free resulting in very smooth movement and a relatively fast operation (about 10÷15 s for a 550 kV disconnector).

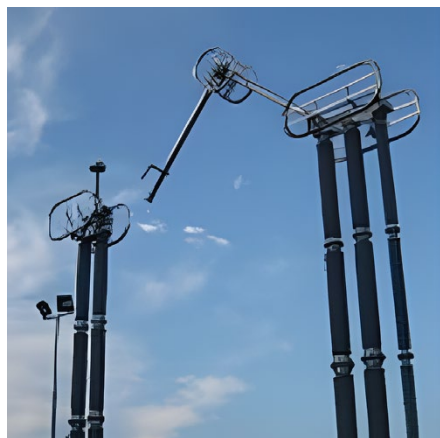
L-Contact

The main contact can be of the L- type, the solution patented by GE Vernova helping to ensure the highest protection against air pollution and ice. The L-Contact is also maintenance-free and therefore represents the best technical choice for DC applications.



Center Break Disconnecter

The center break disconnector type S2DA is the most commonly used and economical disconnector, but requires an increased distance. In the center break design the two arms rotate and the disconnector opens in the center.



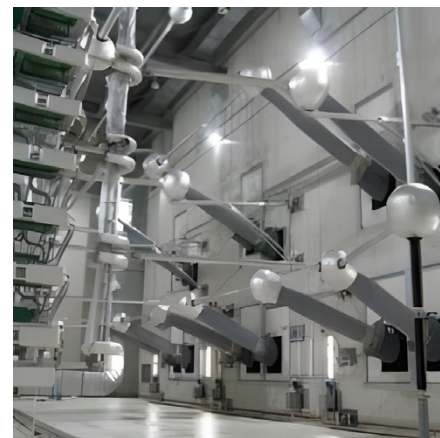
Vertical Break Disconnecter

The vertical break disconnector has one rotating and two fixed insulators. The double movement of the blade ensures excellent performance in terms of ice breaking and short-circuit withstand.



Valve Hall Earthing Switch

The valve hall is an important component of the HVDC system. The grounding of a valve hall's elements is ensured by highly customized earthing switches.



Technical Data

RATINGS	KNEE-TYPE DISCONNECTOR	CENTER BREAK DISCONNECTOR	VERTICAL BREAK DISCONNECTOR
Voltage	245 to 800 kV	36 to 550 kV	72,5 to 800 kV
Current	Up to 6,600 A (8,000 A for short period)	Up to 5,000 A	Up to 5,000 A
Temperature Range	-50°C to +50°C	-50°C to +50°C	-50°C to +50°C

Manufacturing Excellence

GE Vernova's investments in research and development (R&D) are significant, allowing utilities and grid operators to benefit from the latest technologies and innovations.

With more than a century of designing, developing and manufacturing products for the electrical grid, GE Vernova's manufacturing centers of excellence are located globally and are specialized, state-of-the-art facilities with ISO 9001 certification.

The facilities for R&D and manufacturing are based in the United States, Canada, Brazil, India, Indonesia, Italy, France, Germany, Russia, China, and Japan. The same industrial concept is applied in all locations.

Advanced Production System

The Advanced Production System (APS) is the framework for contemporary manufacturing excellence in all GE Vernova manufacturing sites. It is based on lean tools for continuous improvement of safety, quality, cost, and delivery.

APS brings together a wide range of best practices and standards in seven domains such as Basics, Environmental, Health & Safety (EHS), Supply Chain, Project Delivery, Manufacturing, and Quality & Leadership to create and sustain world-class manufacturing excellence.



Competence Center for Live Tank Circuit Breakers in Villeurbanne, France

Certified Quality

R&D, manufacturing and commercial units are fully certified according to ISO 9001. This means that during the entire production process, all employees, all equipment and all of the company's operations are dedicated to the highest quality standards and permanent improvement.

The Quality Management System assures the highest level of quality at every step of the value chain.

Qualified staff on the production lines have proven experience in the assembly of circuit breakers and disconnectors. For each step of the production process, detailed operational instructions are used at the respective workstation. Complete traceability of material and workmanship is ensured by means of robust processes and quality controls.



High-Voltage Testing of Live Tank Circuit Breakers



Competence Center for Disconnectors in Noventa di Piave, Italy

Extensive Testing Capabilities

All switchgear is type-tested in world-class laboratories such as KEMA, CESI and CERDA, in full compliance with international standards such as IEEE, IEC, GOST and DL standards. Specific homologation processes (additional tests, specific reports) are provided as per customer requirements.

The following tests are performed according to the latest international standards and specifications like IEC TS 62271-5 and IEC TS 62271-314:

- Seismic performance
- Dielectric performance
- Mechanical endurance test
- Power testing
- Temperature rise test
- Environmental testing



Outdoor Testing for Disconnectors

Optional Features for Advanced System Capabilities



DWatch

HVDC disconnectors can be produced natively with an active monitoring system that can monitor operational parameters of the disconnector in real time and record all operating curves. The system is composed by DWatch and LWatch.



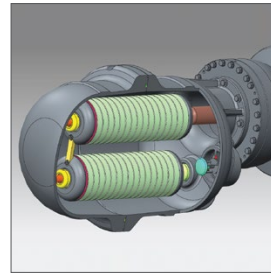
Sensors on Live Parts

HVDC disconnectors are available with several sensors that can monitor the position of the live part in real time; temperature of live part and the leakage current of the insulators polymers and ceramic.



Modular Circuit Breaker Monitoring: CBWatch3

CBWatch3 monitors critical health indicators of HVDC switches, such as gas density, timing, travel and contact wear. This allows users to optimize and schedule maintenance programs accordingly. The collected data can easily be integrated to asset management programs.



Pre-Insertion Resistance

Series closing resistors limit overvoltages associated with switching of unloaded transmission lines. The resistors reduce voltage disturbances and increase the life of associated equipment in the substation.



Earthing Switch: Valve Hall

Component in high-voltage installations, functions as a safety and grounding system. It ensures proper dissipation of electrical faults, stabilizes equipment potentials, and provides a low-resistance path to earth, protecting both personnel and equipment during abnormal operating conditions, effectively mitigating system disruptions. Typical in parallel of valve hall bushings.



Making-breaking Duties and Cable Discharge

The opening of the filter consist on a breaking operation of a sum of harmonic currents at a certain voltage (amply smaller than the rated voltage of the disconnector) due to the ripple created by this harmonics on the reactances.

SPOL disconnector can be equipped with dedicated fast whip device for such duty.



Low Temperature and ICE Applications

HVDC switches provide sealing and breaking performance as well as mechanical operations guaranteed at very low temperatures, down to -50°C . This ensures reliable performance even in the harshest environments around the world.

HVDC disconnectors are available with high ice breaking performances in accordance with IEC and IEEE. Ice breaking up to 42 mm can be provided.



High Seismic Ratings

HVDC switches are available with high seismic performance in accordance with IEEE, ETG, IEC, etc. This standard qualifies the switches for earthquake levels up to 0,5 g. Higher ratings are available on demand.

Value-Added Services

Enhancing Asset Reliability, Up-Time, and Performance

Dedicated project teams are located in all regions throughout the world, providing support and expertise to assist customers during different project phases. Local field service teams are also available worldwide, providing immediate support, training, and supervision.

GE Vernova offers complete services for all current and legacy air-insulated switchgear including: DC switches, dead tank and live tank circuit breakers, generator circuit breakers, compact and hybrid switchgear, disconnect switches, and instrument transformers.



Asset Performance Management

As part of improving the maintenance and asset replacement strategies, GE Vernova employs stress assessment analysis, SF₆ monitoring and online condition monitoring to allow comprehensive centralized asset management.



Renovation & Modernization

GE Vernova has the technical expertise to deliver customized engineered solutions to extend the life of ageing equipment. The service teams at GE Vernova are experienced in solving obsolescence issues and overhauling substation equipment as required.



Maintenance and Spare Parts

Maximizing the life cycle performance of circuit breakers through the right maintenance strategy, strategic spare parts stock and toll-free 24/7 hotline support.



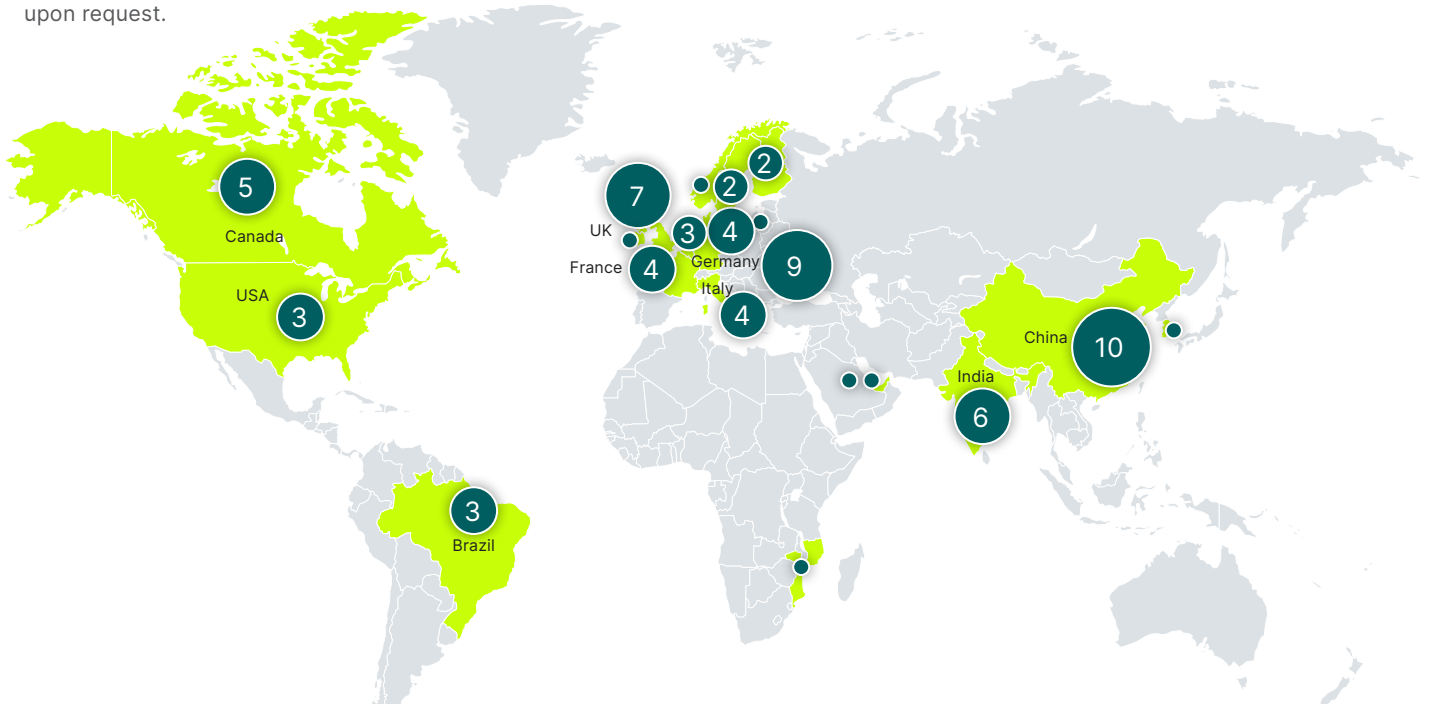
Technical Training

GE Vernova provides on-site technical training such as modular and competence development training as well as e-learning and educational partnerships. These skills not only enhance team knowledge, but increase productivity.



GE Vernova's HVDC References

GE Vernova has designed and supports an installed HVDC capacity of more than 35 GW globally in a broad range of applications and environments. The list below details a selected representation of HVDC projects with DC switchgear. A complete list is available upon request.



Belgium/UK

- Nemo Interconnector, 412 kVdc

Brazil

- Belo Monte I and II, 800 kVdc
- Rio Madeira, 600 kVdc

Brazil/Uruguay

- Melo, 515 kVdc

Canada

- Chateaguay, 408 kVdc
- Lower Churchill, 350 kVdc
- NECEC, 362 kVdc
- Nelson River Bipole I and II, 450 kVdc

Canada/USA

- CHPE Champlain Hudson Power Express, 408 kVdc

China

- Cheju-Haenam Cable, 180 kVdc
- China – Dianxibei, 800 kVdc
- Hulunbair-Lianoning, 515 kVdc
- China – Liubei, 800 kVdc
- Luxi-Luoping, 400 kVdc
- China – Nanjing, 800 kVdc
- Nuozhadou Guangdong, 500 kVdc
- Shuanglong-Zhexi, 800 kVdc
- Three Gorges, 515 kVdc
- Xiangjaba-Shangai, 800 kVdc

Denmark/Netherlands

- Cobra Cable, 330 kVdc

Denmark/Norway

- Skagerrak, 300 kVdc

Denmark/Sweden

- Kontin Skan, 300 kVdc

Denmark/UK

- Viking Link, 525 kVdc

Finland/Sweden

- Fenno-skan, 515 kVdc
- Fenno-skan, 515 kVdc

France/Italy

- Sacoi I and II, 200 kVdc
- FIL, 325 kVdc

France/UK

- IFA1 Interconnector, 270 kVdc
- IFA2 Interconnector, 350 kVdc

Germany

- BalWin 4, 525 kVdc
- Borwin III and V, 362 kVdc
- Dolwin I - II - III - V - VI, 326 kVdc
- GK Dürrohr, 145 kVdc
- LanWin 1, 525 kVdc
- Nord EON, 245 kVdc
- SuedLink Vorhaben 3, 525 kVdc
- SuedOstLink 5a, 525 kVdc
- SuedOstLink, 525 kVdc

India

- Champa I and II, 800 kVdc
- Chandrapur-Padghe, 500 kVdc
- Pugalur-Kerala, 350 kVdc
- Raighar Pugalur, 800 kVdc
- Sasaram, 205 kVdc
- Vizag, 205 kVdc

Ireland/UK

- GreenLink, 325 kVdc

Italy

- Adriatic Link, 515 kVdc
- Sapei, 515 kVdc
- Tyrrhenian Link, 515 kVdc

Italy/Montenegro

- Monita, 500 kVdc

Korea

- Dangjing-Godeok I and II, 530 kVdc

Mozambique

- Cahora Bassa, 533 kVdc

Netherlands

- Ijmuiden Ver Beta, 525 kVdc
- Ijmuiden Ver Gamma, 525 kVdc
- Nederwiek 2, 525 kVdc

Saudi Arabia

- Yanbu-NIC South, 500 kVdc

Saudi Arabia Gulf States

- CGCIA, 222 kVdc

South Korea

- EP#1 and EP#2, 500 kVdc

Sweden

- Danderyd-Jarva, 300 kVdc
- South West Link, 315 kVdc

UAE

- Lightning, 408 kVdc

UK

- Doggers Bank A, B, C, 325 kVdc
- East Anglia 3, 325 kVdc
- Hornsea 3, 325 kVdc
- Norfolk Vanguard East, 320 kV
- Norfolk Vanguard West, 320 kV
- Sofia, 325 kVdc
- Western Link, 600 kVdc

USA

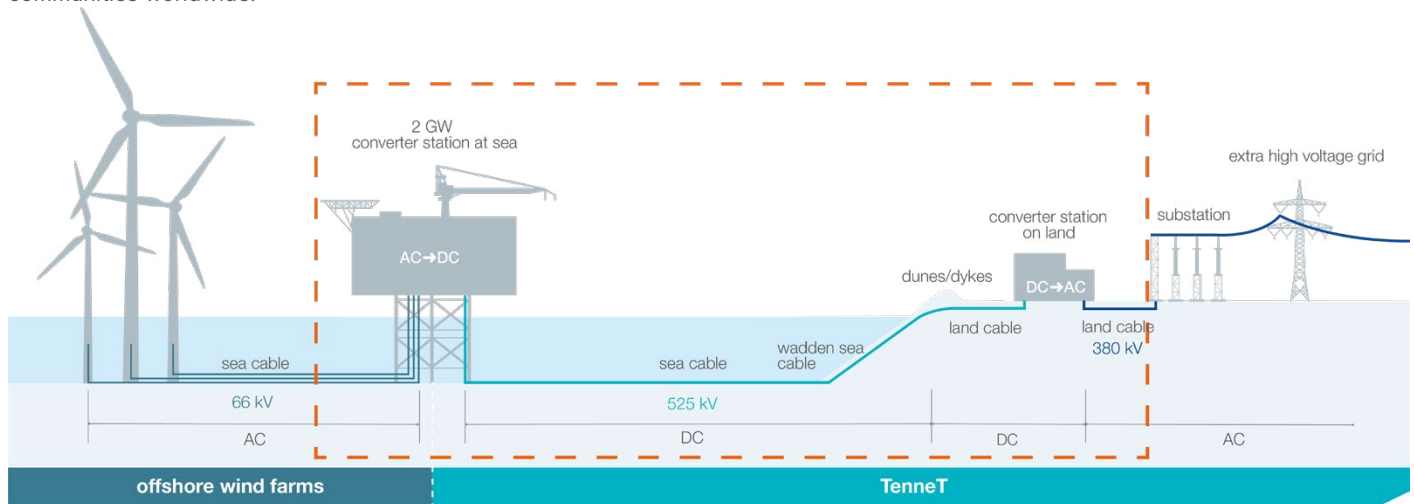
- Celilo, 515 kVdc
- McNeill, 270 kVdc
- SunZia Southwest Transmission Project, 528 kVdc

Case Study – Netherlands-Germany HVDC 2GW Projects

2GW is an innovative standardized project designed at 525 kV DC achieving more with less: activating economy of scale by integrating advanced technologies standardized to reduce operational costs. Within the project, GE Vernova plays a pivotal role by developing and implementing state-of-the-art HVDC systems that improve power generation while minimizing environmental impact. GE Vernova's expertise in research, engineering, and project management supports the development of efficient, eco-friendly energy infrastructures. GE Vernova's contributions enhance system reliability and performance, ensuring the project meets its ambitious targets for renewable energy and grid expansion. This collaborative initiative drives significant progress towards a more sustainable future for communities worldwide.



TenneT 2GW Configuration Overview



Source: TenneT 2GW Project - www.tennet.eu/2gw-program

This HVDC bipole offshore solution by GE Vernova ensures high availability and reliability. It features ± 525 kV poles, allowing single-pole operation if needed. The offshore section includes converter valves for AC-DC conversion, with optional AC filters. The onshore section has DBS systems, AC cables, and transformers to integrate power into the 400 kV AC grid. The system minimizes transmission losses and ensures stable power delivery, making it ideal for offshore wind farms and long-distance power transmission.

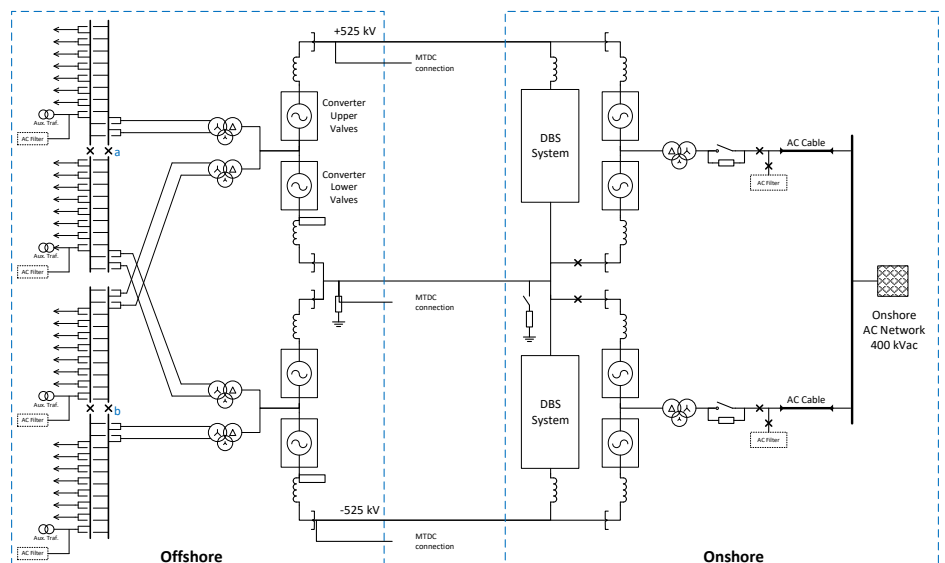
This HVDC bipole offshore solution was applied to following projects:

Germany

- BalWin4 - 2029
- LanWin1 - 2030

Netherlands

- IJmuiden Ver Beta - 2029
- IJmuiden Ver Gamma - 2030
- Nederwiek 2 - 2031



For more information, visit
gevernova.com/grid-solutions

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