



SIEMENS

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The Smart Way

HVDC PLUS – One Step Ahead

Answers for energy.

HVDC PLUS – Maximum power in the smallest space

The customized solution for evolving power markets

Keeping the power flowing is part of our life and essential for society, just like keeping the blood flowing in our veins. Lack of power brings devastating consequences to our daily life. Nowadays, fundamental changes are affecting the power industry: deregulation and privatization of the power markets, urbanization around the world, and a growing demand for energy. Renewable energy sources are gaining importance. For these reasons, innovative and highly efficient solutions for power transmission are needed.

The global climate change poses new challenges for power generation and transmission. Innovative solutions will contribute to the reduction in CO₂ emissions and to an optimized use of energy resources. The most crucial points in today's and tomorrow's power supply are sustainability, security and efficiency.

The Siemens answer is HVDC PLUS.

As an innovation leader, Siemens has developed an advanced and universally applicable solution for power transmission up to 1,000 MW and above with HVDC PLUS. Applying advanced technologies, the well-known benefits of HVDC are now available for new applications. Examples are interconnection of weak AC grids, grid access for islanded networks or renewable energy sources, such as wind farms, both offshore and onshore.



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HVDC PLUS

The smart transmission technology of the future

- **HVDC technology in the smallest space**

Even when space is limited, HVDC PLUS enables the use of highly efficient HVDC technology.

- **Optimal connection of distributed generation**

The scalability of HVDC PLUS means that remote energy sources such as offshore wind farms can be connected to the power grid in the most suitable way.



- **Operational benefits**

Minimum time and costs for maintenance and high operational reliability make HVDC PLUS a particularly economical solution.

- **Potential environmental protection tool for CO₂ reduction**

With HVDC PLUS, islanded networks such as oil and gas platforms as well as mines can be connected without need for local generation which is less efficient. This allows for CO₂ reduction.

- **Fast and cost-efficient project execution**

Due to the standardized modular design of HVDC PLUS, time and resources are saved during both planning and implementation.

- **Support of AC system stability**

HVDC PLUS offers fast stabilization of the AC voltage in weak grids. In addition, it is also possible to feed passive networks without generation, by means of black-start capability.

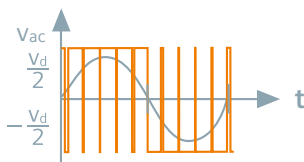
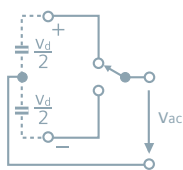
The next generation of HVDC

HVDC PLUS is the Voltage-Sourced Converter (VSC) technology which uses a Modular Multilevel Converter (MMC) design.

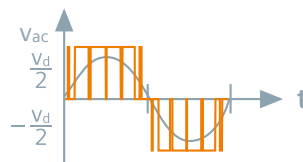
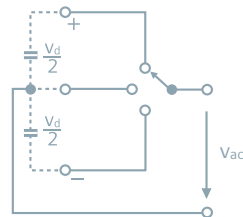
- The MMC provides a nearly ideal sinusoidal-shaped waveform on the AC side and a smooth DC voltage. Therefore, there are few if any requirements for high frequency and harmonic filters.
- The VSC offers an independent control of active and reactive power.
- MMC allows for low switching frequencies, resulting in lower system losses.

- The modular design of the MMC provides a high degree of flexibility in the converter station design.
- HVDC PLUS uses robust, proven standard components, such as typical AC power transformers and industrial class IGBTs (Insulated Gate Bipolar Transistors) used for traction and industrial drives.

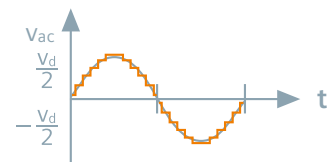
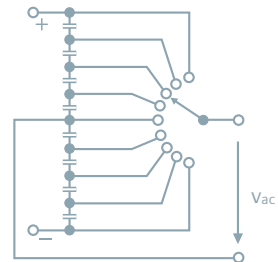
Two-level



Three-level



Multilevel



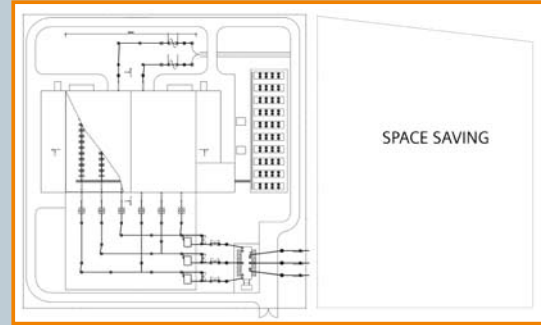
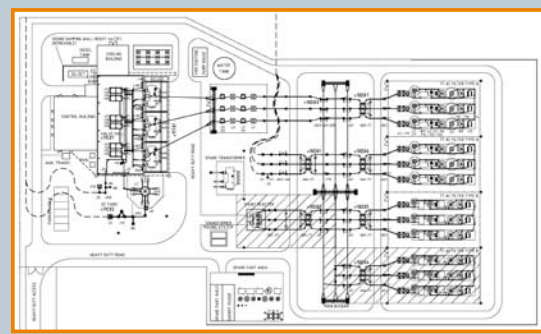
Grid access in minimum time

HVDC PLUS reduces the time and resources expended during the project development phase. The relatively low number of components simplifies design, planning, and engineering tasks. Thanks to the modular design with fewer elements than conventional HVDC systems, installation and commissioning also require considerably less time and less space than conventional systems.

Compact and adaptable station layout

The MMC technology makes HVDC PLUS converters compact and adaptable.

- A low profile converter building can be selected when visual resources are critical or alternatively the station footprint can be reduced by increasing the height of the building.
- A small site footprint reduces costs.
- Indoor installation of reactors and switchgear is possible, but not required.
- HVDC PLUS is an appropriate solution where space is limited or costly. Examples are offshore platforms or congested areas in large cities.



Scalable system design

The MMC technology offers a high degree of flexibility. This allows the most suitable solution to the given power transmission task.

- Efficient use of HVDC technology at any rating up to 1,000 MW.
- An HVDC PLUS point-to-point transmission system can easily be expanded into a multi-terminal system with three or more converter stations.



Grid access

In the emerging world of offshore connections Siemens has taken the early lead. Siemens offers comprehensive turnkey grid access solutions, ranging from first feasibility and power system studies to the engineering, procurement, construction, and commissioning of entire grid connections.

- Oil platforms can be supplied with power from efficient land-based generation sources.
- Large offshore wind farms can be connected to the grid with HVDC PLUS when an AC solution is not feasible.



Economical and Environmental benefits

Environmental constraints will play an important role in the power system developments.

- MMC with low switching frequencies – reduced losses.
- Less components – lower time and cost demands for planning, engineering, construction, and commissioning.
- Lower space requirements – reduced property costs.
- Power electronics with self-commutated converters, such as MMC offer benefits for power transmission.



Operational advantages

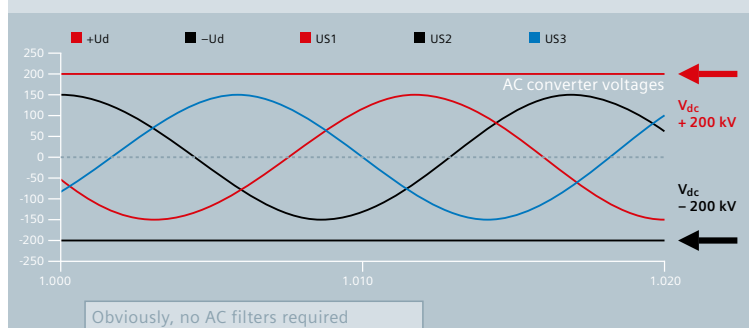
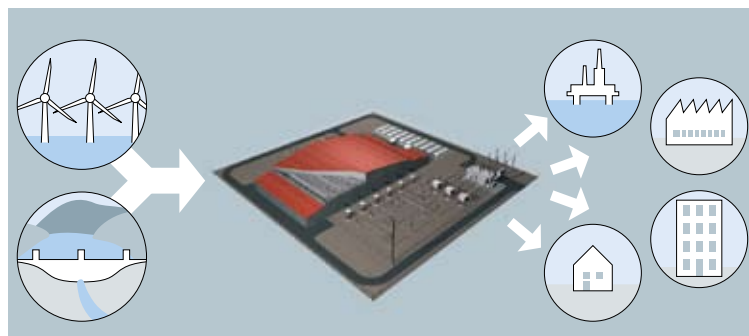
- A very high level of system availability, full redundancy for all key parts of the converter.
- Online real-time monitoring of all main components.
- Minimized maintenance and service requirements.
- Standard control and protection system, Win-TDC (Simatic) hardware and software, proven in practice in a wide range of applications worldwide.
- A minimum quantity of AC components due to reduced requirements to harmonic and high frequency filtering.



Stabilization of the AC network

The VSC technology features make HVDC PLUS fully suitable for AC voltage control. The advantages are especially apparent in connections with weak AC networks.

- Low dependency on short-circuit power, voltage, and frequency of the AC networks.
- Reactive power can be generated or consumed independently from active power transmission.
- Unbalance control for compensation of large single-phase loads.



Proven performance – first installed HVDC PLUS project

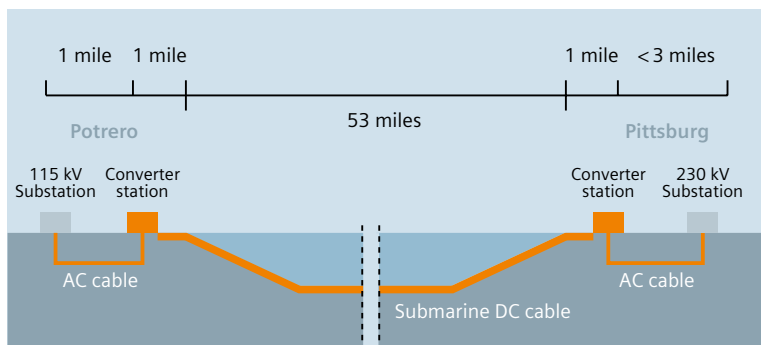
In very many cases, areas of high power demand are not close to areas of generation. Connecting offshore windfarms to the grid, increasing availability of electric power supply on oil platforms or transmitting power via submarine cables across the sea are perfect examples of where HVDC PLUS is the preferred solution for providing efficient and reliable power transmission over long

distances. The Trans Bay Cable link, the first HVDC PLUS system in the world, is provided by Siemens and transmits up to 400 MW of power from Pittsburg in the East Bay to Potrero Hill in the center of San Francisco since 2010 – covering a distance of 85 km right across the bottom of the San Francisco Bay.

Example of application

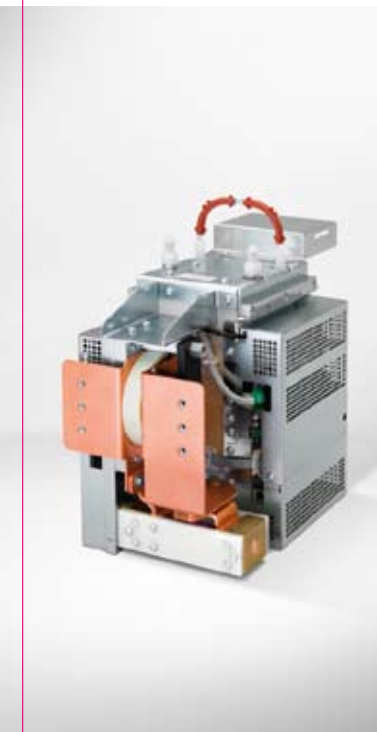
First HVDC PLUS System in the World: Trans Bay Cable Link, San Francisco, USA

The HVDC PLUS system for Trans Bay Cable LLC transmits up to 400 megawatts and +/- 170 MVar Reactive Power Support at a DC voltage of +/- 200 kV. It is the first order for Siemens using its innovative HVDC PLUS technology. The main advantages of the new HVDC PLUS link are the increased network security and reliability due to network upgrade, reduced system losses and reliable provision of power from the East Bay generation site right to the center of the city. Since its commissioning in 2010, the HVDC transmission helps to meet the City of San Francisco's future electrical demand and it is a highly energy-efficient, cost-effective solution.



Power Module

Converter Arm Segment



Project references



World's first VSC HVDC with 2x 1,000 MW: INELFE, France–Spain

The INELFE/Siemens transmission links 1 and 2 between Baixas, west of Perpignan in France, and Santa Llogaia, south-west of Figueras in Spain, is an important component of the trans-European electricity network. The installation can transmit rated power of 1,000 MW per link with minimal transmission losses. The converter stations use HVDC PLUS voltage-sourced converters in a modular multilevel converter arrangement (VSC-MMC) with a transmission voltage of ± 320 kV DC. The power will be transmitted over a distance of about 65 kilometers with underground cables in trenches and in a tunnel through the Pyrenees for about eight kilometers. The project illustrates the unique capability of VSC technology to meet special technical demands. The independent exchange of reactive power for each network, as well as the black-start capability, which enables the HVDC system to restart a collapsed network, are particularly worth mentioning. The converter stations are scheduled to be ready for tests by the end of 2013.



864 MW offshore HVDC PLUS link SylWin1, Germany

Siemens will supply the world's largest voltage-sourced converter (VSC) offshore system with a rating of 864 MW for the SylWin1 project. Siemens' HVDC PLUS link will connect the Dan Tysk wind farm to the German shore. The converter will be installed on an offshore platform, where the voltage level will be stepped up and converted to ± 320 kV DC. The platform will accommodate all electrical equipment required for the HVDC converter station: two transformers, four AC cable compensation reactors, and high-voltage gas-insulated switchgear (GIS). Similar to the BorWin2 and HelWin1 projects, the Siemens wind power offshore substation (WIPOS®) will be designed as a floating, self-lifting platform. The energy will be transmitted via subsea and land cable to Büttel, where an onshore converter station will reconvert the DC to AC and feed it into the 380 kV AC grid. The transmission link is scheduled to start operation in 2014.



800 MW offshore HVDC PLUS link BorWin2, Germany

For the BorWin2 project, Siemens will supply the voltage-sourced converter (VSC) system – using Siemens HVDC PLUS technology – with a rating of 800 MW. The wind farms Veja Mate and Global Tech 1 are designed to generate 800 MW and will be connected through Siemens’ HVDC PLUS link to shore. The converter will be installed on an offshore platform, where the voltage level will be stepped up and then converted to ± 300 kV DC. The platform will accommodate all the requisite electrical equipment for the HVDC converter station, two transformers, four AC cable compensation reactors and high-voltage gas-insulated switchgear (GIS). The Siemens wind power offshore substation (WIPOS) will be designed as a floating, self-lifting platform. Power will be transmitted via subsea and land cable to Diele close to Papenburg, where an onshore converter station will reconvert the DC back to AC and feed it into the 380 kV AC network. The entire transmission link is expected to begin operation in 2013.



576 MW offshore HVDC PLUS link HelWin1, Germany

For the project HelWin1, Siemens will be supplying a voltage-sourced converter (VSC) system with a rating of 576 MW using Siemens HVDC PLUS technology. The wind farms Nordsee Ost and Meerwind are designed to generate 576 MW and will be connected through a Siemens’ HVDC PLUS link to shore. The converter will be installed on an offshore platform, where the voltage level will be stepped up and then converted to ± 250 kV DC. The platform will accommodate all the requisite electrical high-voltage AC and DC equipment for the converter station. Similar to the BorWin2 project, the Siemens wind power offshore substation (WIPOS) will also be designed as a floating, self-lifting platform. Energy will be transmitted via subsea and land cable to Büttel, northwest of Hamburg, Germany, where an onshore converter station will reconvert the DC back to AC and transmit it into the high-voltage grid. The entire transmission link and grid connection is expected to be in operation by 2013.

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Siemens AG
Energy Sector
Power Transmission Division
Power Transmission Solutions
Freyeslebenstrasse 1
91058 Erlangen, Germany

For more information, please contact
our Customer Support Center.
Phone: +49 180 524 70 00
Fax: +49 180 524 24 71
(Charges depending on provider)
E-mail: support.energy@siemens.com

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