

Siemens Debuts HVDC PLUS with San Francisco's Trans Bay Cable

A new 85-kilometer cable running under the San Francisco Bay can transmit up to 40 percent of the peak power needs for the City of San Francisco. The link is the world's first deployment of Siemens' next-generation HVDC PLUS technology, a transmission solution for space-constrained urban environments and remote sources of renewable energy.

By Justin Gerdes

Burgeoning electricity demand in urban areas and an ever-increasing need for low-carbon electricity, often generated far from cities, are forcing policy makers to explore innovative solutions to transmit power to population centers. Transmission solutions must be flexible, able to squeeze into congested cities, or link distant offshore wind farms to the grid. The Trans Bay Cable, which came online in November 2010 in San Francisco, California, meets this test and is the world's first deployment of Siemens' high-voltage direct current (HVDC) PLUS system.

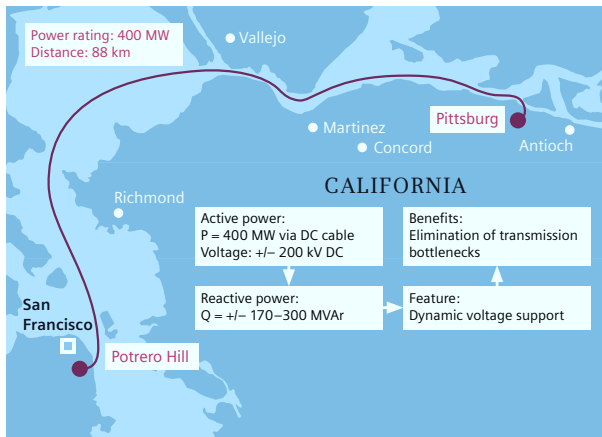
For electrical power system planners, San Francisco presents both unique and all-too-familiar challenges. They are unique in that the city is situated in an active seismic zone; they are all too familiar in that land is expensive, space for new power generation and transmission installations is limited, and residents are not likely to want

new power plants built in their neighborhood. In San Francisco, space is especially important as a limiting factor. The city sits on the nail of the narrow thumb of land poking north from San Jose. With some 800,000 residents packed onto just over 120 square kilometers, the population density of San Francisco is more like that found in Europe than elsewhere in the sprawling USA.

"Because of its very compact design, HVDC PLUS is the technology of choice for high-power transmission technology application in densely populated urban areas like San Francisco," says Siemens CEO for Power Transmission Solutions Wilfried Breuer. Breuer says that the HVDC PLUS station footprint is just a third or even a quarter that of competing technologies. Siemens achieves the narrow footprint with an innovation – newly adapted for HVDC PLUS – called the Modular Multilevel Converter (MMC).

San Francisco: proving ground for reliable, space-saving energy transmission.

Trans Bay's Underwater Route



A tale of two converter stations: easing grid congestion, enabling a more diversified electrical supply, helping to lower long-term energy costs, and improving reliability.

“The unique multilevel topology of HVDC PLUS requires no electrical filter circuits at all,” Breuer adds. “This is also a contribution for record-low converter losses.”

A Vital Link

The 85-kilometer Trans Bay Cable transmits up to 400 MW, at a voltage of +/- 200 kV, from the Pittsburg Converter Station in the East Bay, under the San Francisco Bay, to the Potrero Converter Station in the heart of San Francisco. The cable, a 25.4-centimeter-diameter bundle, was buried between 90 centimeters and 1.2 meters below the bay with an underwater hydroplow. The link eased grid congestion in the East Bay and enabled San Francisco to diversify its electrical supply away from the mainly AC grids that served the city from the south. The new HVDC link brought additional benefits. The Trans Bay Cable provides a new source of power for the City of San Francisco, helping to lower long-term energy costs, relieve congestion, and provide transmission reliability for the entire Bay Area, while

shutting down the last remaining old power plant in San Francisco. At both ends of the Trans Bay Cable, at the heart of each HVDC PLUS converter station in Pittsburg and San Francisco, is the Insulated Gate Bipolar Transistor (IGBT)-based converter. Secured in a steel-framed, metal-clad shell, the IGBTs are where the transmission is converted from AC to DC and back again. In conventional HVDC converters, line-commutated converters using thyristors as the switching devices are standard. HVDC PLUS uses a new generation of voltage-sourced converter (VSC) technology, with IGBT as the switching device. As Wilfried Breuer notes, the VSC technology, used for the first time on the Trans Bay Cable, is based on the MMC design, allowing for low switching frequencies, which results in lower system losses. The modular design provides flexibility and scalability, and therefore – with fewer elements than classic HVDC converters – design, planning, and engineering are simplified, and less time is required for installation and commissioning.

The VSC technology also uses power semiconductors with turn-on and turn-off capability. Station operators can control active power and reactive power independently from each other, and can connect to very weak power systems or even supply passive systems. The HVDC PLUS system can provide up to +/- 145 Megavolt-ampere reactive (MVar) of reactive power at the Pittsburg Converter Station and up to +/- 170 MVar of reactive power at the Potrero Converter Station to support the local Pacific Gas and Electric Company (PG&E) grids. This flexibility enables grid operators to intervene rapidly in the event of system faults or malfunctions. With no need for additional reactive power compensation equipment, HVDC PLUS installations require significantly less space than conventional HVDC installations.

HVDC PLUS: Grid Access in Remote Areas

Congested urban settings are just one area of application for HVDC PLUS systems. Their scalability and flexibility are also well suited for settings where local AC grids are not available, such as oil and gas platforms or mines, or where distant sources of renewable power, such as concentrated solar power plants or offshore wind farms, need to be connected to the grid. In Europe, groups and developers such as the European Wind Energy Association (EWEA), Friends of the Supergrid (FOSG), and the North Seas Countries Offshore Grid Initiative (NSCOGI) are working to connect far-flung clean energy projects to form an integrated European grid. Owing to EU policy, demand for new capacity is strong. The European Network of Transmission System Operators for Electricity (ENTSO – E) estimates that the share of wind power in Europe of around 10 percent needs to be tripled to meet the EU’s 2020 climate protection targets. Transpower Offshore GmbH is using HVDC PLUS systems to connect wind projects BorWin2 (800 MW) and HelWin1 (567 MW) in northern Germany to the grid. The BorWin2 project

will connect the wind farms Veja Mate and Global Tech I; the HelWin2 project will link the wind farms Nordsee Ost and Meerwind from the North Sea to shore. The VSC technology of HVDC PLUS simplifies the interconnection of these future smart grids. Another important perspective for HVDC PLUS in Europe is the expansion of the Mediterranean power transmission network driven by Medgrid in parallel to the Dii, an industrial initiative to start implementation of the Desertec concept. This idea involves supplying North African power markets and would deliver up to 15 percent of Europe’s electricity by 2050. HVDC transmission lines would link multiple solar power plants in North Africa to the continental grid via sea cables traversing the Mediterranean Sea. In November 2009, a consortium of a dozen companies, led by Munich Re and including Siemens, E.ON, ABB, and Deutsche Bank, formally launched the Dii organization, which intends to set up a reference project by 2015 in order to demonstrate delivery of solar power to Europe. The France-centered initiative Medgrid, founded in 2010, concentrates especially on the grid connection and

works with Dii to implement the respective cable links.

From Smart Power to Bulk Power

Siemens is also deeply involved in the application of a technology complementary to HVDC PLUS – UHV (ultra-high voltage) DC transmission. Last year, Siemens, in collaboration with the utility China Southern Power Grid, built the world’s first 800-kV HVDC transmission link. Completed in mid-2010, the Yunnan-Guangdong transmission system carries up to 5,000 MW of hydroelectric power over a distance of 1,400 kilometers to the industrial Pearl River Delta and the power-hungry megacities of Guangzhou and Shenzhen. The carbon-free electricity transported over the new UHV DC link is expected to reduce CO₂ emissions by over 30 megatons annually compared to what would have been produced by additional fossil-fueled power plants in Guangdong Province. “HVDC PLUS and UHV DC are major enablers to make remote renewable power generation accessible for urban areas,” says Siemens’ Breuer. “With a shift from combustion car engines

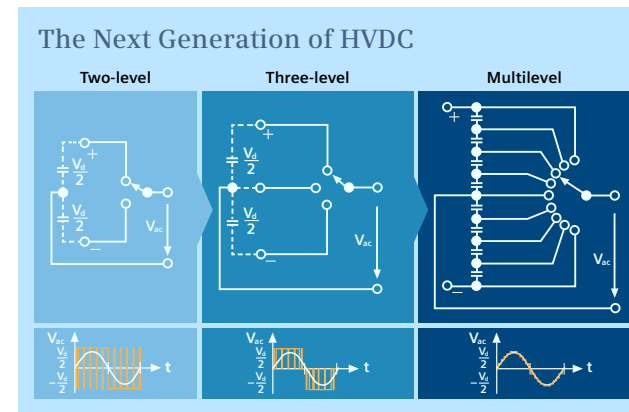
to an increasing number of electrically powered battery cars, the load demand in cities is expected to increase in the next decades.” When imported electricity reaches the places where people live and work, concerns about aesthetics, cost, and space usually persuade planners to eschew overhead lines for underground cables – an ideal application for HVDC PLUS. “Right-of-way and environmental acceptance for conventional overhead lines is limited, forcing power transmission of the future to utilize underground cables,” Breuer says.

HVDC PLUS: the Business Case

Siemens says it intends to duplicate the model used to develop the Trans Bay Cable project on future transmission projects. “Besides the technical merits, the Trans Bay Cable project is a further example of Siemens’ success with developer projects,” explains Breuer. “Unlike the classic procedure of request for quotation/tender evaluation process, we managed to team up with the project developer at a very early stage of the project idea, saving the time and money for the developer to engage a technical consultant. In return, we negotiated the EPC (Engineering, Procurement, and Construction) contract on a market-price-related basis.” Michael Cyrus, COO of SteelRiver Infrastructure Partners, which owns and operates the Trans Bay Cable, praises the team that came together to build the cable. “Pattern Energy’s highly experienced transmission team, along with SteelRiver, Prysman, Siemens, and the Trans Bay Cable team, has developed a world-class transmission asset that will help ensure the reliability of the San Francisco Bay Area’s current and future power needs.”

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Further Information
www.siemens.com/energy/hvdc



Graphics: Rainer Schubert, independent

HVDC PLUS technology’s Modular Multilevel Converter (MMC) provides low switching frequencies with reduced system losses and increased flexibility in converter station design.