

# From far away

## Efficient and cost-effective long-distance power transmission with HVDC

**ABHAY KUMAR, ALF PERSSON – As the energy needs of the world increase, the demand for long-distance energy transmission also rises. Areas needing electrical energy are often located far away from the source of energy, be it water, solar or wind. ABB's HVDC Classic technology serves as a cost-effective alternative to AC transmission for long-distance and bulk-power transmission as well as for interconnecting asynchronous AC networks. For connecting remote and large-scale generation to load centers HVDC is an attractive solution with extremely low transmission system losses. ABB continues to create HVDC solutions to suit the many scenarios encountered in the transmission world.**

**H**VDC technology uses thyristors for conversion and typically has a power rating of several hundreds of megawatts, though many are in the 1,000 to 3,000 MW range, and some even as high as 8,000 MW. HVDC is suitable for overhead lines as well as undersea/underground cables, or a combination of cables and lines. It can also be configured as back-to-back HVDC stations. This configuration enables two asynchronous grids to exchange power and ensures that in the event of a disturbance in one, the other supports it.

The interconnection through HVDC does not add to the short-circuit capacity of the networks. This allows for less-frequent replacement of the heavy-duty switchgear equipment, keeps grids immune from disturbances and minimizes affected areas. By controlling its power flow, an HVDC system stabilizes the grid in the interconnected networks and increases the security of supply. As HVDC systems cannot be overloaded, uncon-

trolled cascade tripping of lines is avoided. For example, during the massive 2003 blackout that affected the entire northeastern United States, the HVDC connections shielded the Quebec system in Canada from frequency swings.<sup>1</sup>

HVDC lines use the right of way (m/MW) very effectively and can also be operated at reduced voltage in case some section of a line has issues with insulation withstand capability. HVDC technology enables long underwater transmission links with low losses. Traditional AC transmission systems with underwater cables cannot be longer than about 60 to 100 km as it would require massive reactive compensation en-route.

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#### Footnote

- 1 <http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/BlackoutFinal-Web.pdf>

## 1 The NorNed station



## 2 A selection of ABB's HVDC commissions

- The Itaipu project in Brazil supplies 50 Hz power into a 60 Hz system and economically transmits large amounts of hydropower (6,300 MW) over long distances (800 km).
- The Leyte-Luzon project in the Philippines supplies bulk geothermal power across an island interconnection and improves stability to the Manila AC network.
- The Rihand-Delhi project in India transmits bulk thermal power (1,500 MW) to Delhi, ensures minimum losses, least amount of right-of-way, and better stability and control.
- The Garabi project in Argentina is an independent transmission project transferring power from Argentina to Brazil. The back-to-back HVDC system ensures a supply of 50 Hz bulk power (1,100 MW) to a 60 Hz system under a 20-year power supply.

The interconnection, which is based on market coupling, has led to power trading between the two countries and increased the reliability of electricity supply in both.

### Sustainability showcase: NorNed

The 580 km NorNed HVDC monopolar transmission link with a 700 MW /  $\pm 450$  kV transmission capacity, is the longest underwater high-voltage cable in the world → 1. Commissioned in 2008, the converter stations are located at the Feda substation in Norway and at the Eemshaven substation in the Netherlands – a span of 580 km. The interconnection is jointly owned by the two state power grid companies, TenneT in the Netherlands and Statnett in Norway. The interconnection, which is based on market coupling, has led to power trading between the two countries and increased the reliability of electricity supply in both.

To optimize cable costs and cable losses, NorNed has two fully insulated DC cables at  $\pm 450$  kV although it is a monopolar link. This makes the DC current small and creates low cable losses, but requires a higher converter voltage and has a record voltage of 900 kV for a 12-pulse converter.

Scandinavia has a largely hydro-based production system whereas the Netherlands and surrounding countries have a system based largely on fossil fuels. Hydropower is easily regulated and stored in existing dams. This allows the

Dutch grid to be optimized by using hydropower to cover peak loads during the day. At night, power can be transported back to Scandinavia, thereby saving electric energy in the dams. The result is a more stable output from the fossil-fuel-fired plants, thus minimizing emissions. Additionally, the stabilized grid allows integration of new renewable generation in the form of wind power.

The security of supply has improved since production resources in a larger area are available as a backup in the event of network disturbances. The electricity market has benefitted as the link has enabled electricity trading between two distant, isolated markets.

The link demonstrates that HVDC technology offers the unique capability to build long underwater or underground cable transmission lines with low losses. The NorNed link has losses of only about 4 percent.

### North-East Agra

ABB has built HVDC transmission projects all around the world → 2. A unique project is currently under construction in India. When commissioned in 2016, the North-East Agra HVDC link, officially known as  $\pm 800$  kV / 6,000 MW HVDC Multi Terminal NER/ER-NR/WR Interconnector-I, will

ABB's HVDC transmission system was chosen in large part because of the advantage of the technology needing only a minimum right of way.

### 3 The North-East Agra HVDC link will cover a distance of 1,728 km.



be the first multiterminal HVDC project at 800kV. The link comprises four terminals in three converter stations with a 33 percent continuous overload rating, enabling an 8,000MW conversion. It will be the largest HVDC transmission system ever built, having the highest converter capacity at 8,000MW and the first one having 800kV indoor DC halls.

Power Grid Corporation is constructing this HVDC link to transmit clean hydro-

the technology needing only a minimum right of way.

The system will have two  $\pm 800$  kV converter poles in Biswanath Chariali and two  $\pm 800$  kV converter poles in Alipurduar, whereas Agra will have four  $\pm 800$  kV converter poles. As each converter pole has a nominal rating of 1,500MW with a continuous overload rating of 2,000MW, it is possible to compensate for the loss of any converter pole.

If for instance Pole 1 in Agra is lost, Poles 2, 3 and 4 can still supply the rated 6,000MW to the Agra region → 4.

At full capacity, the North-East Agra HVDC link will be able to supply

## The solution also acts as a firewall, isolating disturbances and preventing them from spreading from one network to the other.

electric power from India's northeast region to Agra, the city of the Taj Mahal, over a distance of 1,728km → 3.

enough electricity to serve 90 million people based on average national consumption.

One converter station (Biswanath Chariali) will be in the state of Assam, and a second (Alipurduar) in the state of West Bengal in eastern India. The other end of the DC line will terminate at Agra, where two bipolar converters will be connected in parallel. The 800kV equipment yard at Agra will be indoors.

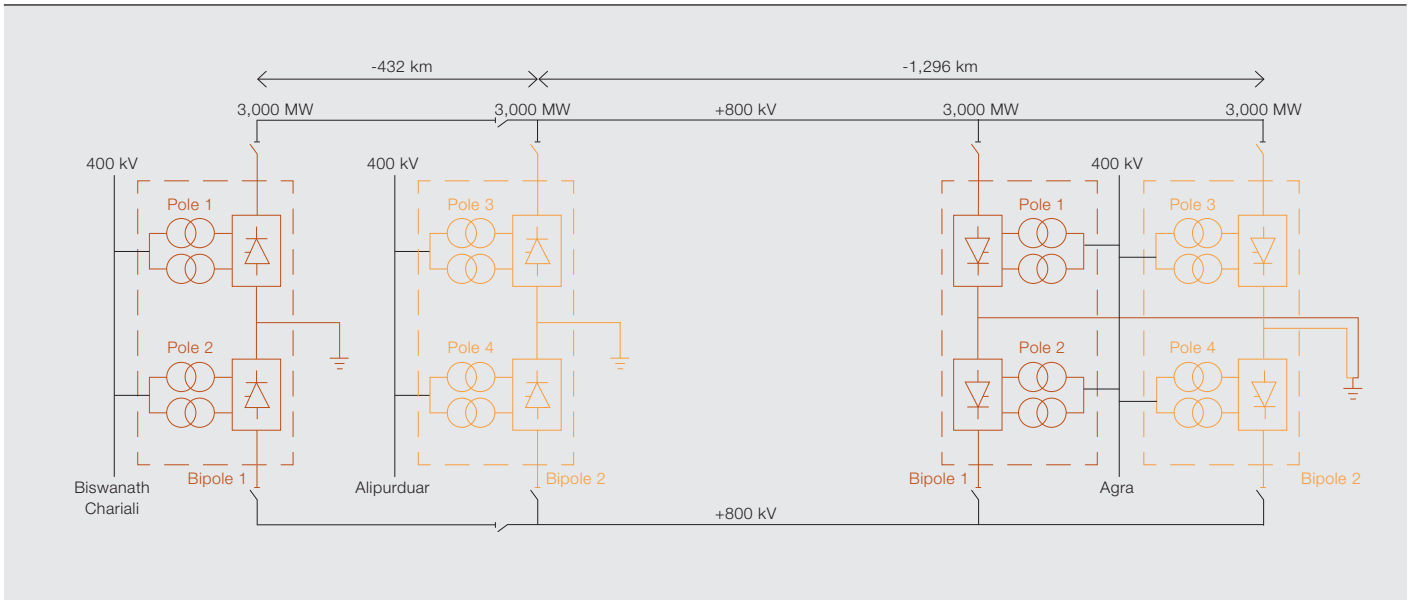
Multiterminal HVDC links are unique to ABB. The North-East Agra HVDC link will be the second ABB-built multiterminal HVDC link. The first of this kind was built by ABB in North America in the early 1990s. The Québec-New England HVDC link is a large-scale three-terminal transmission link (2,000MW / 450kV) commissioned in 1992. ABB recently received a contract to refurbish the 20-year-old control and protection systems of the link with the newest modular advanced control systems (MACH).

Northeast India has abundant untapped hydropower resources of the order of 50 to 60GW scattered over a large area, but load centers are hundreds or even thousands of kilometers away. Transmission lines must pass through a very narrow patch of land (22km × 18km) in the state of West Bengal, which has borders with Nepal and Bangladesh. ABB's HVDC transmission system was chosen in large part because of the advantage of

### Railroad DC Tie

The Sharyland station, located at the border of Mexico and the southern tip of Texas in the United States, was the first 150MW back-to-back DC tie station → 5. It was commissioned in 2007.

#### 4 Multiterminal arrangement in North-East Agra HVDC link



#### 5 Sharyland station



ABB is currently constructing a second 150 MW back-to-back HVDC converter station adjacent to the existing site. The two stations, part of the Railroad DC Tie Expansion project, will work in parallel to provide a transmission capacity of up to 300 MW. This will further increase the power transfer capacity between Texas and Mexico and secure the reliability of power in the Rio Grande Valley.

To learn more about ABB's reference projects, please visit [www.abb.com/hvdc](http://www.abb.com/hvdc)

### ABB designed a solution that includes unique black-start emergency assistance.

The Mexican and the Texan AC networks are not synchronized so connecting them as a normal AC interconnection was not possible. The Sharyland station enables power exchanges between the Electric Reliability Council of Texas (ERCOT) grid and the Mexican

national grid, operated by the Comisión Federal de Electricidad (CFE), and increases power reliability in the Rio Grande Valley. HVDC technology enables bidirectional power flow between both grids, thereby allowing each grid to rely on the other in times of emergencies or peak demand.

ABB designed a solution that, in addition to the normal properties of an HVDC station, includes unique black-start emergency assistance. The solution also acts as a firewall, isolating disturbances and preventing them from spreading from one network to the other.

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