HVDC Transmission System
Introduction
HVDC Transmission System
HVAC vs HVDC Transmission System
VSC HVDC Transmission system
HVDC Technology - Contributing to SAARC Inter connections
  • India Bangladesh HVDC Interconnector
  • India Sri Lanka HVDC Interconnector
Way Forward
HVDC system in India

1 – Rihand-Dadri (1500MW)
2 – Vindyachal (500MW)
3 – Chandrapur-Padghe (1500 MW)
4 – Chandrapur-Ramagundam (1000MW)
5 – Barsoor-Lower Sileru (200MW)
6 – Gajuwaka 1 & 2 (500MW each)
7 – Sasaram (500MW)
8 – Talcher-Kolar (2500MW)
9 – Balia – Bhiwadi (2500 MW)
10– Mundra-Mahendragarh (2500 MW)
Asynchronous connection (enables to connect two different electrical networks having different frequency & voltage)

Power flow control (enables the stability of electrical network)

Added benefit to the transmission like stability, power quality etc.
Why HVDC Transmission system...

- Environmental advantages (lesser right of way requirement)
- Lower line losses compared to AC line
- Economical (only two conductor for transmission & lesser tower height)
Comparison of right of way

400 kV AC Lines

500 kV DC Line

96 m

46 m
Cost Comparisons – AC vs DC Transmission

HVDC Transmission vs HVAC Transmission system

Cost

Break even distance

Cost of AC Line

Cost of DC Line

Cost of DC terminal

Cost of AC terminal

☐ 500 – 700 km Distance in km
## HVDC Transmission vs HVAC Transmission system

<table>
<thead>
<tr>
<th></th>
<th>HVAC</th>
<th>HVDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Power Transmission Capability</td>
<td>Low</td>
</tr>
<tr>
<td>2</td>
<td>Distance</td>
<td>Limited by Stability considerations. Switching Stations required.</td>
</tr>
<tr>
<td>3</td>
<td>System Connection</td>
<td>Synchronous</td>
</tr>
<tr>
<td>4</td>
<td>Right of Way requirements</td>
<td>High</td>
</tr>
<tr>
<td>5</td>
<td>Power Control</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>Features – Frequency Control, Reactive Power Control, Damping of Oscillations etc.</td>
<td>Not Available</td>
</tr>
<tr>
<td></td>
<td>HVAC</td>
<td>HVDC</td>
</tr>
<tr>
<td>---</td>
<td>-------------------------------------------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>7.</td>
<td>Tapping of Power Connection</td>
<td>Simple</td>
</tr>
<tr>
<td></td>
<td>Simple</td>
<td>Costly, Multi-terminal Scheme required</td>
</tr>
<tr>
<td>8.</td>
<td>Economical Alternative for</td>
<td>Low to Medium distance, Medium Power Range.</td>
</tr>
<tr>
<td></td>
<td>Low to Medium distance, Medium Power Range.</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>System Short Circuit Level (SCL)</td>
<td>Contributes to System SCL</td>
</tr>
<tr>
<td></td>
<td>Contributes to System SCL</td>
<td>Does not contribute to System SCL</td>
</tr>
<tr>
<td>10.</td>
<td>Pollution Effects</td>
<td>Relatively Lesser</td>
</tr>
<tr>
<td></td>
<td>Relatively Lesser</td>
<td>More Pronounced</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Higher insulator creepage distance is required</td>
</tr>
</tbody>
</table>
Comparison of power transfer intensity at different voltage level:

<table>
<thead>
<tr>
<th></th>
<th>400kV AC (approx.)</th>
<th>765kV AC</th>
<th>±500kV DC</th>
<th>±800kV DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROW (m)</td>
<td>46</td>
<td>64</td>
<td>52</td>
<td>70</td>
</tr>
<tr>
<td>Capacity (MW)</td>
<td>Upto 600-700</td>
<td>Upto 2500-3000</td>
<td>Upto 2000-2500</td>
<td>Upto 6000-6400</td>
</tr>
<tr>
<td>MW/m</td>
<td>15</td>
<td>45</td>
<td>48</td>
<td>90</td>
</tr>
<tr>
<td>Reactive generation (MVAR/km)</td>
<td>0.60</td>
<td>2.4</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Conventional (LCC) HVDC connected to Weak AC System can have issues such as:

- Voltage instability
- Harmonic instability
- Resonance
- High Load rejection Over-Voltages.

Can be addressed through VSC HVDC Solutions.
Line Commutated vs Voltage Source Converters....

HVDC CLASSIC

- Line-commutated current-sourced Converter
- Thyristor with turn-on Capability only
- Direct-light-triggered Thyristor (LTT)
  - Up to 10000 MW
  - MI Cable up to 600 kV
  - OHL up to 800 kV

HVDC VSC

- Self-commutated voltage-sourced Converter (VSC)
- Semiconductor Switches with turn-on only and turn-off Capability, e.g. IGBTs
- XPLE Cable up to 320 kV DC
- MI cable up to 525kV-600kV
- Half bridge up to 1,56 kA
- Full bridge up to 2 kA

Courtesy: Siemens
Line Commutated vs Voltage Source Converters….

**Line-Commutated Converters**
- Use semiconductors which can turn on by control action
- Turn-off and “commutation” rely on the external circuit
- Require an AC system with rotating machines at all times
- Cannot feed into a “dead load” (e.g., a resistor)

**Self-Commutated Converters**
- Use semiconductors which can turn on or off by control action
- Turn-off can be whenever you want
- Can feed into any type of AC system or load
VSC BASED HVDC - technological advantage

- Active and Reactive power is controlled independently
- Controls of AC voltage is very fast as compared to conventional HVDC (almost 20 time faster)
- Has Black Start Capability
- No contribution to short circuit current
- No need for fast telecommunication between two station
- Very Fast Power reversal possible
- Operates in all four quadrant of its Capability curve, can be used as STATCOM.
No filters required

A standard transformer design can be used without special requirements to withstand DC voltage or harmonic currents in symmetrical monopole configuration.

The modular rack-type converter arrangement provides flexibility with respect to building height versus length. It allows to lower building height compared to conventional HVDC converters.

The converter modules are operated with a low switching frequency resulting in low converter losses.
VSC HVDC Application

Connecting Wind Farms To Grid
VSC HVDC Application

- Providing shore power supplies to islands and offshore oil & gas platforms
- Connecting offshore wind farms to land power networks
VSC HVDC Application........

Connecting City Infeeds.....
EVACUATION FROM POWER PROJECTS IN BHUTAN

LEGEND

- 400 KV LINE
- 220 KV LINE
- 132 KV LINE
- Future Transmission System

HVDC Technology - Contributing to SAARC Grid Interconnections… (India – Bhutan)
HVDC Technology - Contributing to SAARC Grid Inter Connections… (India – Bhutan)

India – Bhutan are already having HVAC Transmission links in operation.

Hydro power from Bhutan is also to be routed through Alipurduar (West Bengal) pooling point.

The Power from Alipurduar is being transmitted to load centres in Northern Region through ±800 kV, 6000 MW HVDC Multiterminal Transmission Link
HVDC Technology - Contributing to SAARC Grid Inter Connections… (India – Bhutan)

±800 kV, 6000 MW HVDC NER-Agra Multi-terminal Transmission Link – Salient Features

• It is the first 800 kV HVDC project in the world having 12 pulse Converter Terminals.
• The project is designed with continuous 33% overload feature which is first of its kind in the world.
• Each pole of the Multi-terminal is designed for 2000 MW which is the highest capacity poles in the world.
• The Earth electrodes are designed for 5000 A DC continuous current which shall be 1st of its kind in the world
• This is the first 800 kV Project in the world having Indoor DC Hall (75x75X 40 meter) for DC Yard Equipment i.e. Smoothing Reactors, DC Filters, DC Disconnectors etc at Agra Terminal.
A Major Milestone toward harnessing capacities and resources of SAARC Nations to address the growing energy needs ….

- 1x500 MW High Voltage Direct Current (HVDC) back-to-back India Bangladesh Interconnector
- In operation since September 2013
- Addition of 1x500 MW HVDC Back to Back (Block 2) at the same location of Block 1 under procurement
- Link Capacity to be increased to 1000 MW by 2017-18
HVDC Technology - Contributing to SAARC Grid Inter Connections… (India – Bangladesh)

±800kV, 7000 MW, Rangia (India), Barapukuria (Bangladesh), Muzaffarnagar (India) Multi Terminal HVDC Link (Under Discussion)
HVDC Technology - Contributing to SAARC Grid Inter Connections… (India – Srilanka)

1000 MW HVDC Bipole Transmission Link Project having Overhead line and Submarine Cable (Under Discussion)
Way Forward…..

• **Regional Cooperation is the need of the hour for optimal utilization of regional resources.**

• **An example of the regional cooperation in the neighborhood is seen in the form of Central Asia South Asia -1000 (CASA-1000) HVDC project which envisages a ± 500 kV, 1300 MW HVDC Multi Terminal project involving Tajikistan, Afghanistan and Pakistan which is under procurement as present.**

• **Similar opportunities exist for transfer of hydro-electric power generated in North East India to the other SAARC Countries like Afghanistan, Bangladesh and Pakistan.**
HVDC Transmission provides necessary features to help in providing system stability which assist in prevention of Cascaded disturbances.

Considering the above aspects, HVDC is going to play an important role in developments of ‘Smart Grids’ with better controllability of Power Flow.

Further the potential in renewable generation could also be used to power up the SAARC Countries

HVDC Technology is going to play a pioneering role in realizing all these scenarios of regional cooperation along with the local requirements of the country in future.
Thank you