HVDC Transmission System

HVDC Transmission System

Introduction

HVDC Transmission System

HVAC vs HVDC Transmission System

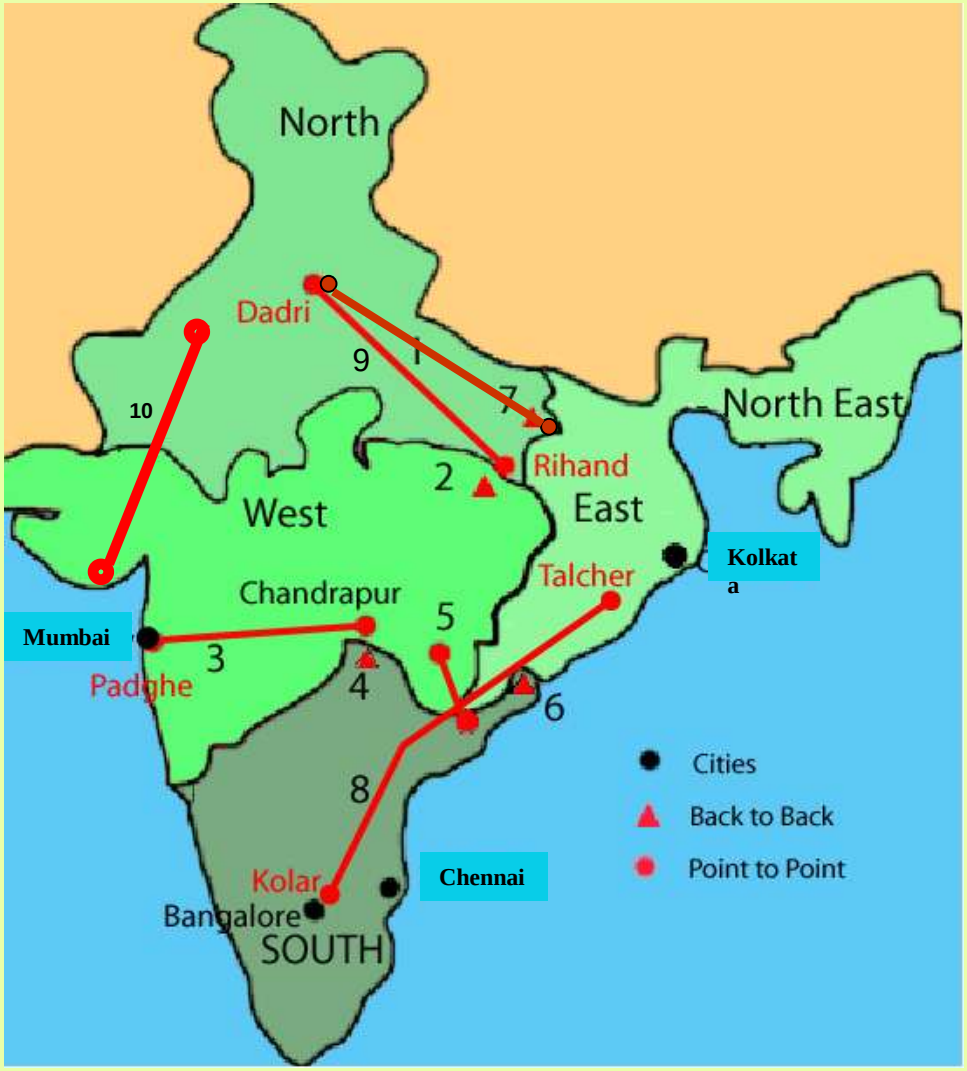
VSC HVDC Transmission system

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)

Why HVDC Transmission system…

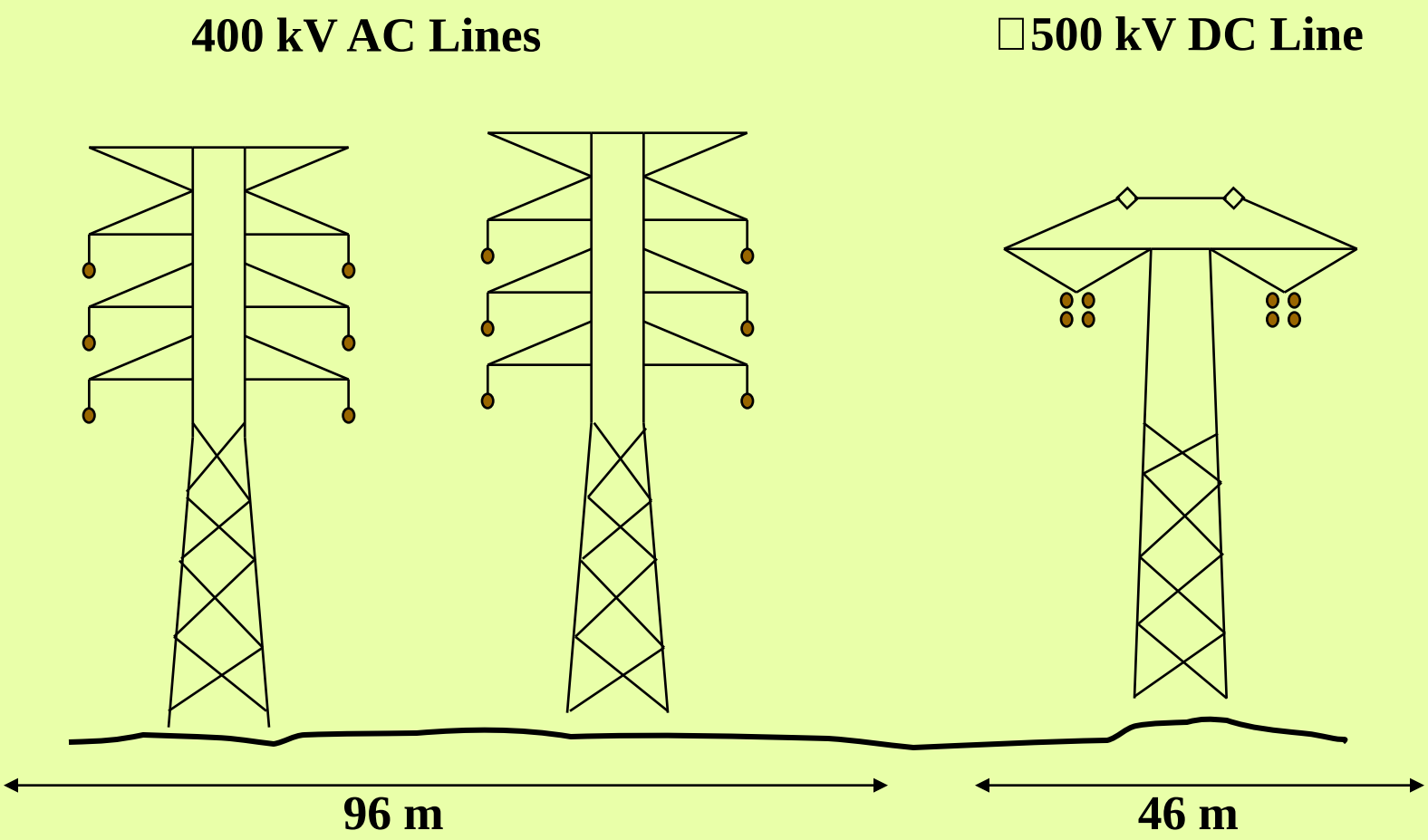
- Asynchronous connection (enables to connect two different electrical networks having different frequency & voltage)
- Power flow control (enables the stability of electrical network)
- Added benefit to the transmission like stability, power quality etc.

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)

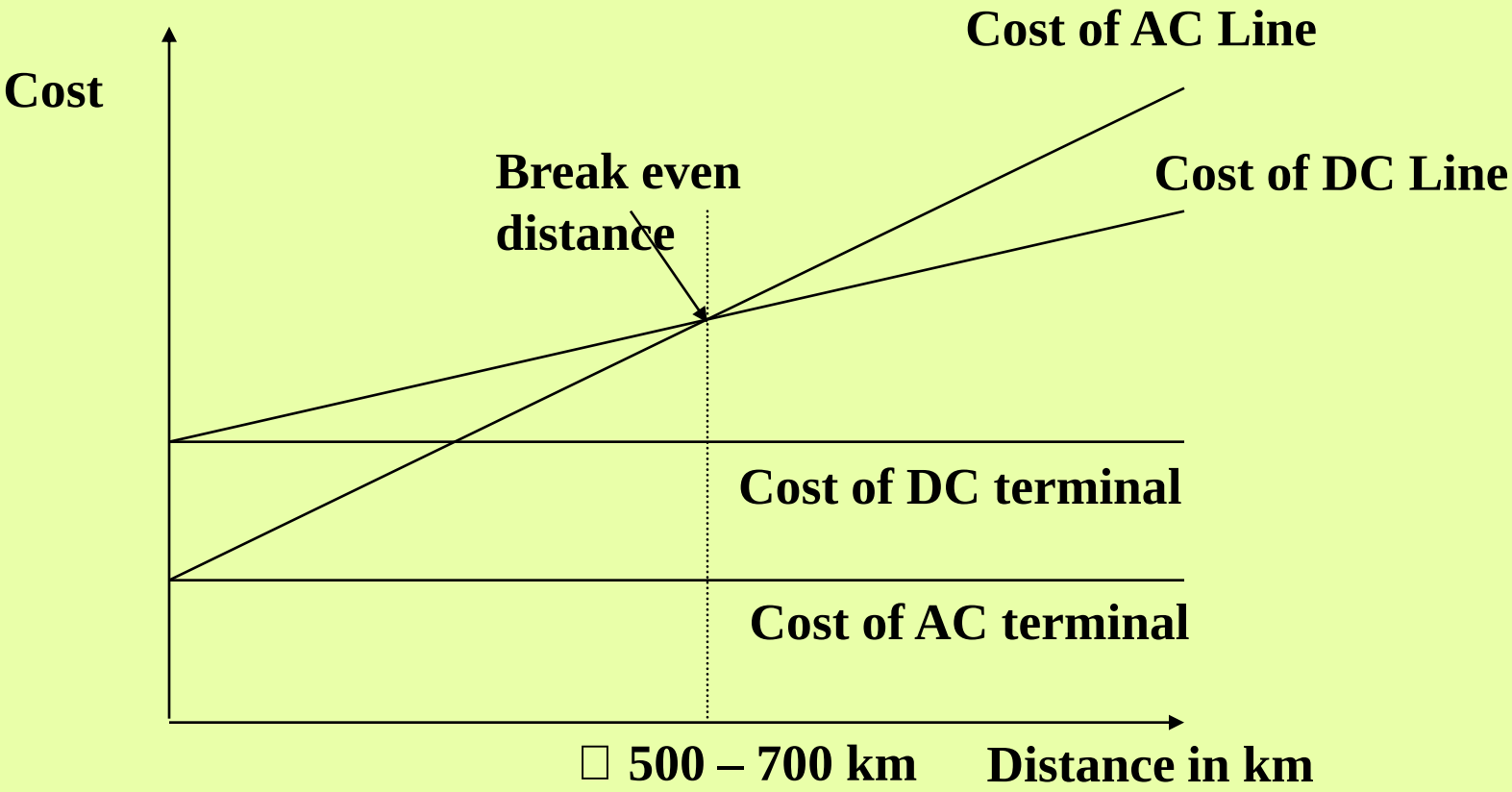
HVDC Transmission vs HVAC Transmission system

Comparison of right of way



HVDC Transmission vs HVAC Transmission system

Cost Comparisons –AC vs DC Transmission



HVDC Transmission vs HVAC Transmission system

		HVAC	HVDC
1.	Power Transmission Capability	Low	High (e.g. 3000 MW Bipole)
2.	Distance	Limited by Stability considerations. Switching Stations required.	No Limitation. Cheaper Alternative for Long Distances
3.	System Connection	Synchronous	Asynchronous
4.	Right of Way requirements	High	Low
5.	Power Control	No	Yes
6.	Features – Frequency Control, Reactive Power Control, Damping of Oscillations etc.	Not Available	Available

HVDC Transmission vs HVAC Transmission system

		HVAC	HVDC
7.	Tapping of Power Connection	Simple	Costly, Multi-terminal Scheme required
8.	Economical Alternative for	Low to Medium distance, Medium Power Range.	Long Distance Bulk Power Transmission
9.	System Short Circuit Level (SCL)	Contributes to System SCL	Does not contribute to System SCL
10 .	Pollution Effects	Relatively Lesser	More Pronounced Higher insulator creepage distance is required

Comparison of power transfer intensity at different voltage level….

	400kV AC	765kV AC	±500kV DC	±800kV DC
(approx.) ROW (m)	46	64	52	70
Capacity (MW)	Upto 600-700	Upto 2500-3000	Upto 2000-2500	Upto 6000-6400
MW/m	15	45	48	90
Reactive generation (MVAR/km)	0.60	2.4	-	-

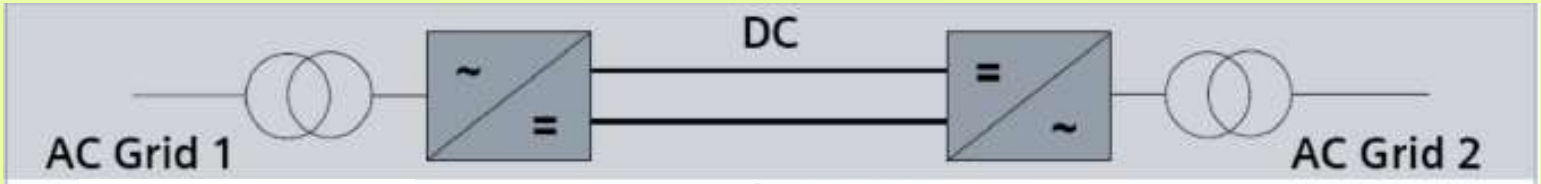
Constraints of Conventional (LCC) HVDC…

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	HVDC VSC
Line-commutated current-sourced Converter	Self-commutated voltage-sourced Converter (VSC)
Thyristor with turn-on Capability only	Semiconductor Switches with turn-on only and turn-off Capability, e.g. **IGBTs**
	
▪ Direct-light-triggered Thyristor (LTT) ▪ Up to 10000 MW ▪ MI Cable up to 600 kV ▪ OHL up to 800 kV	▪ 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" (eg 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.**

VSC BASED HVDC-technological advantage

- **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……

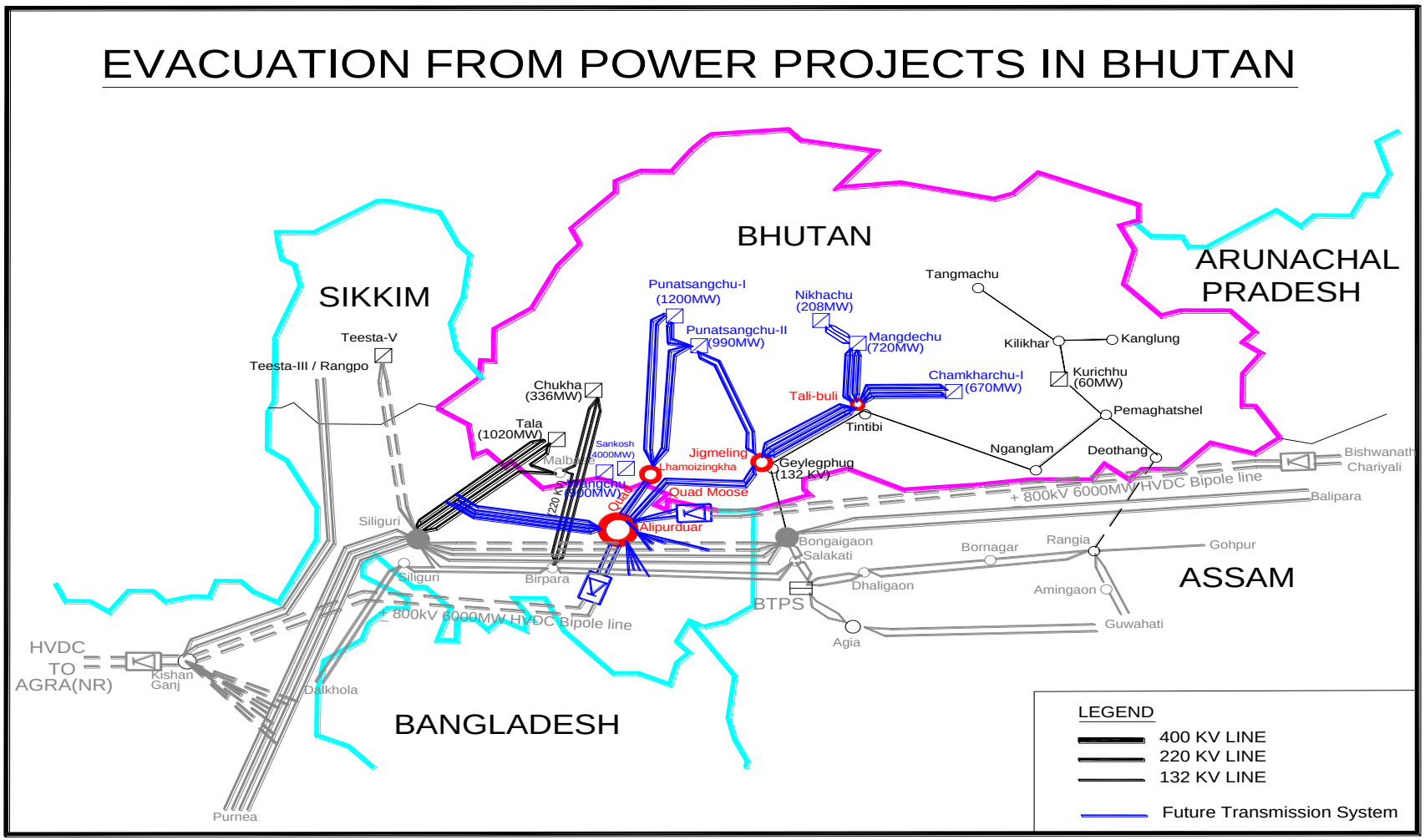
VSC HVDC Application……..

- **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…..

HVDC Technology -Contributing to SAARC Grid Inter Connections… (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)

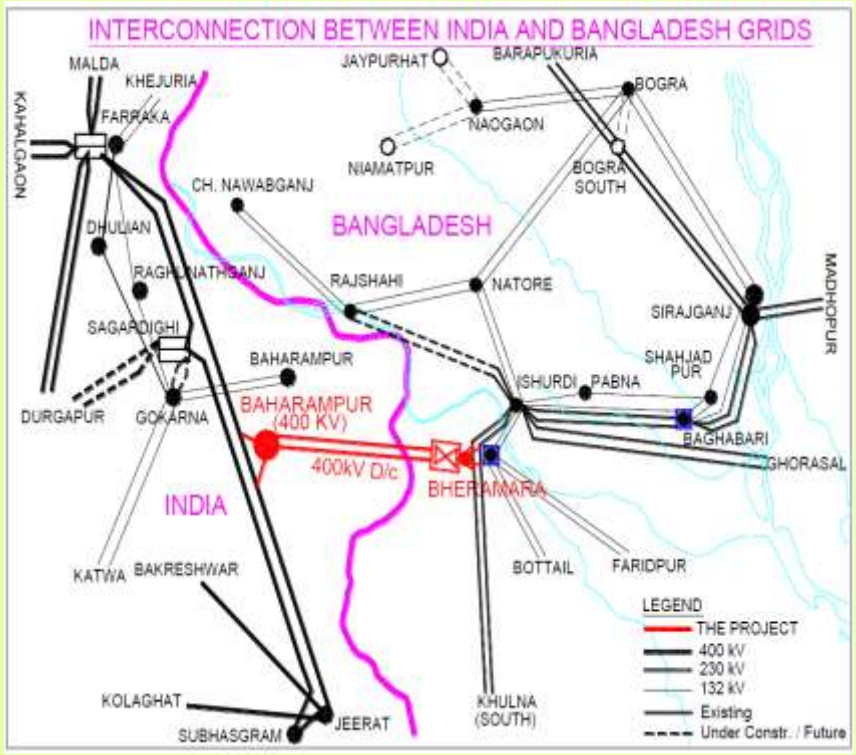
±800 kV , 6000 MW HVDC NER-Agra Multi-terminal Transmission Link – Salient Features

- 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.

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

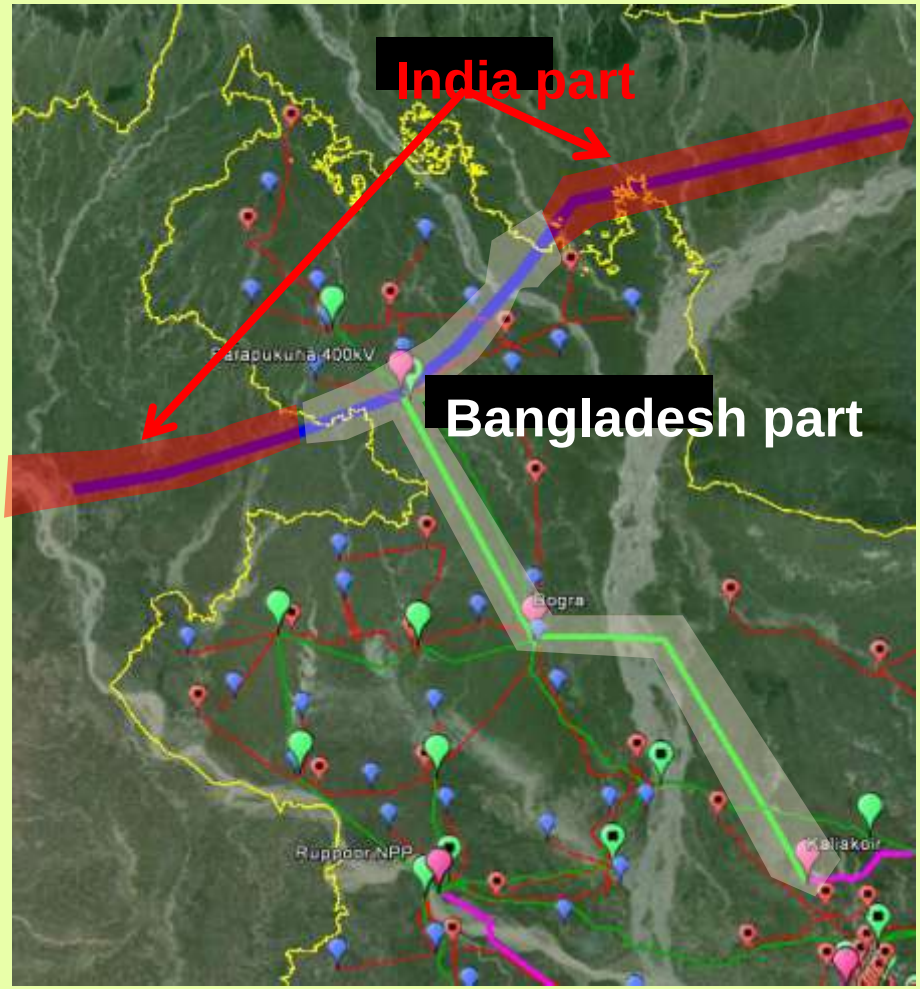
A Major Milestone toward harnessing capacities and resources of SAARC Nations to address the growing energy needs ….

- 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



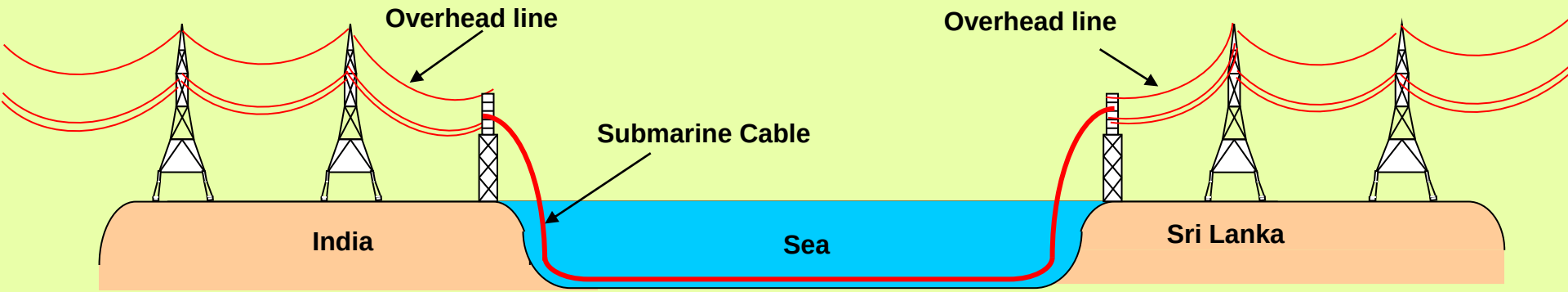
HVDC Technology -Contributing to SAARC Grid Inter Connections… (India – Bangladesh)

±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)



Transmission System in the Sea Route : Submarine Cable

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 Tazikistan, 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.**

Way Forward…..

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 plays 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