Module 8
EHV AC &HVDC Transmission

Part I

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Need of EHV transmission

- Rising demand for electric power
- Geographical, demographical and environmental conditions
- Generation and transmission of power

Table 8.1: Nominal voltage and maximum operating voltage for transmission of power

Nominal system voltage(kV)	132	220	275	345	400	500	750
Maximum operating voltage (kV)	145	245	300	362	420	525	765

Necessity for EHV Transmission

- Reduction in the volume of conductor.
- Increase in transmission efficiency.
- Increase in the transmission capacity of line.
- Decrease in the installation cost of the transmission line per km.
- Economical interconnection of the power systems
- Reduction in the no. of circuits and the land requirement for transmission.

Advantages of EHV AC Transmission

- Reduction in the current.
- Reduction in the losses.
- Reduction in volume of conductor material required.
- Decrease in voltage drop & improvement of voltage regulation.
- Increase in Transmission Efficiency.
- Increased power handling capacity.
- The no. of circuits & the land requirement reduces as transmission voltage increases.
- The total line cost per MW per km decreases considerably with the increase in line voltage.

Problems With EHV AC Transmission

- Corona Loss and Radio Interference
- Line supports
- Erection difficulties
- Insulation Requirements
- Power station and substation equipment

HVAC Transmission is having severe limitations like line length , uncontrolled power flow, over/low voltages during lightly / over loaded conditions, stability problems ,fault isolation etc.

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HVDC Transmission

- First time in the history of power systems, electric power was transmitted at 110V DC to an area of one mile radius in New York by Edison using bipolar DC generators
- An era of AC transmission initiated with the invention of transformer. Transformer made the long distance high voltage power transmission possible.
- Conventionally power transmission is effected through HVAC Systems all over the world except some specific applications in electrolytic processes and adjustable speed drives.

Why DC transmission

- Restricted use of high voltage AC for underground transmission due to charging currents
- Parallel operation of AC with DC which increases the stability limit of the system or interconnection of two large AC systems by a DC transmission tie line.

Parameter	HVAC	HVDC
Losses	High	Low
Voltage regulation and control ability	Low	Better
Transfer of power	Less	More
Insulation	More	Less
Reliablity	Low	High
Asynchronous interconnection	Not possible	Possible

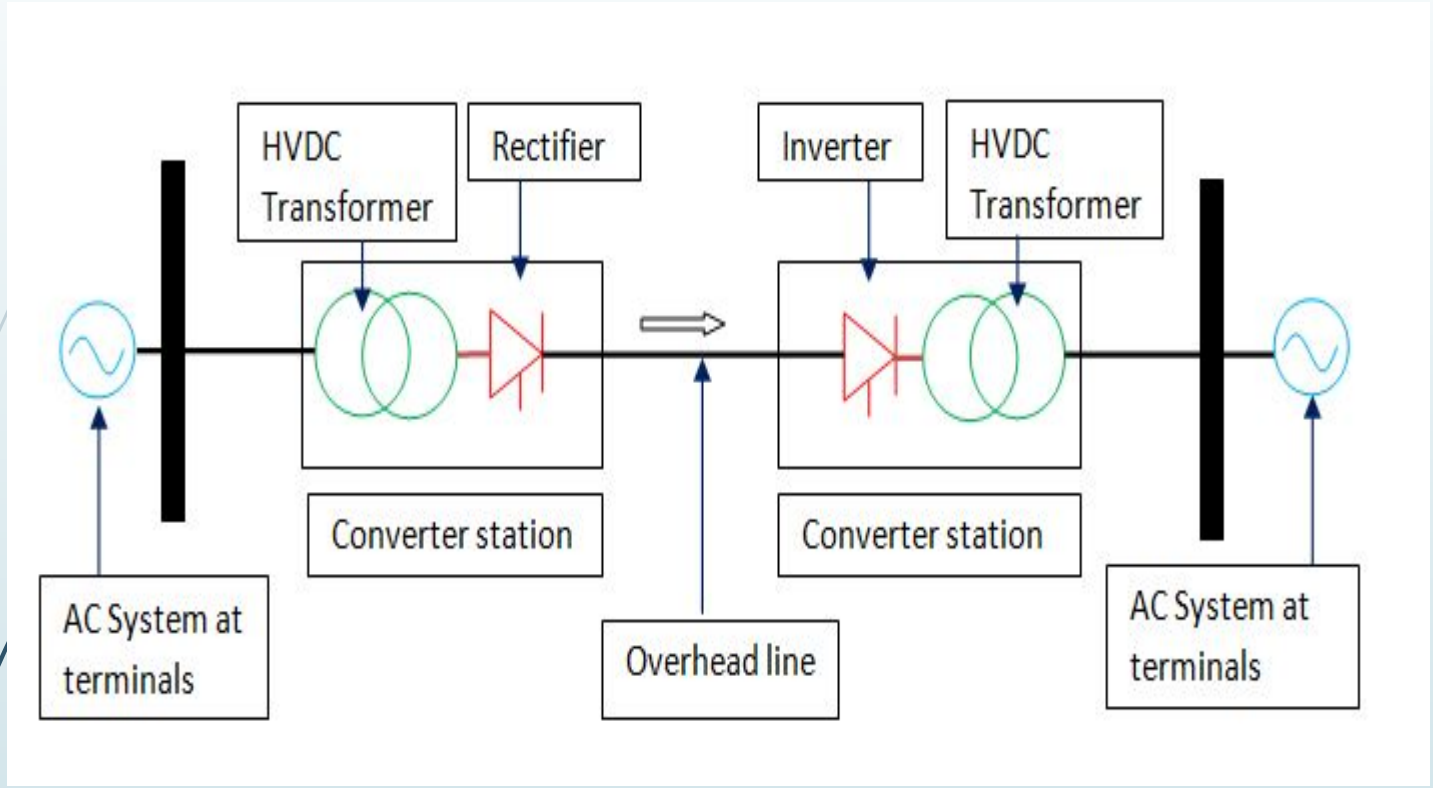

Figure 8.1 : overview of HVDC Transmission substation

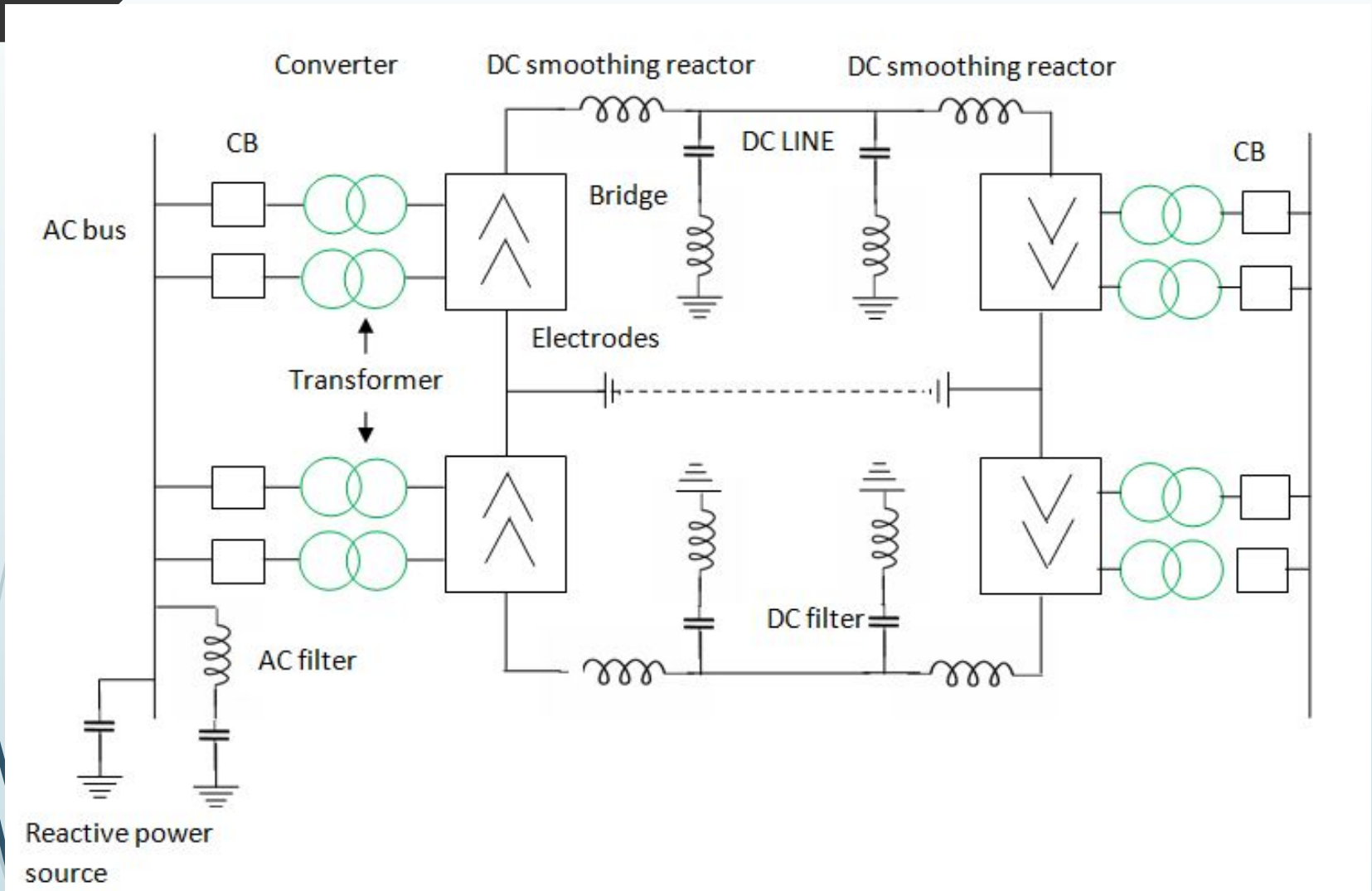

Figure 8.2 : Components of HVDC transmission

Components of HVDC Transmission

- Converter stations- Rectifier and Inverter and Located at end points of HVDC transmission
- Converter transformer-Connected between converter valves and the AC bus. It is specially designed transformer that can withstand direct voltage stress and harmonic losses.
- DC Reactor-Connected in series with rectifier and smooth the DC components . Under short circuit conditions, protects rectifier
- Filter-eliminate generated harmonics during the conversion process

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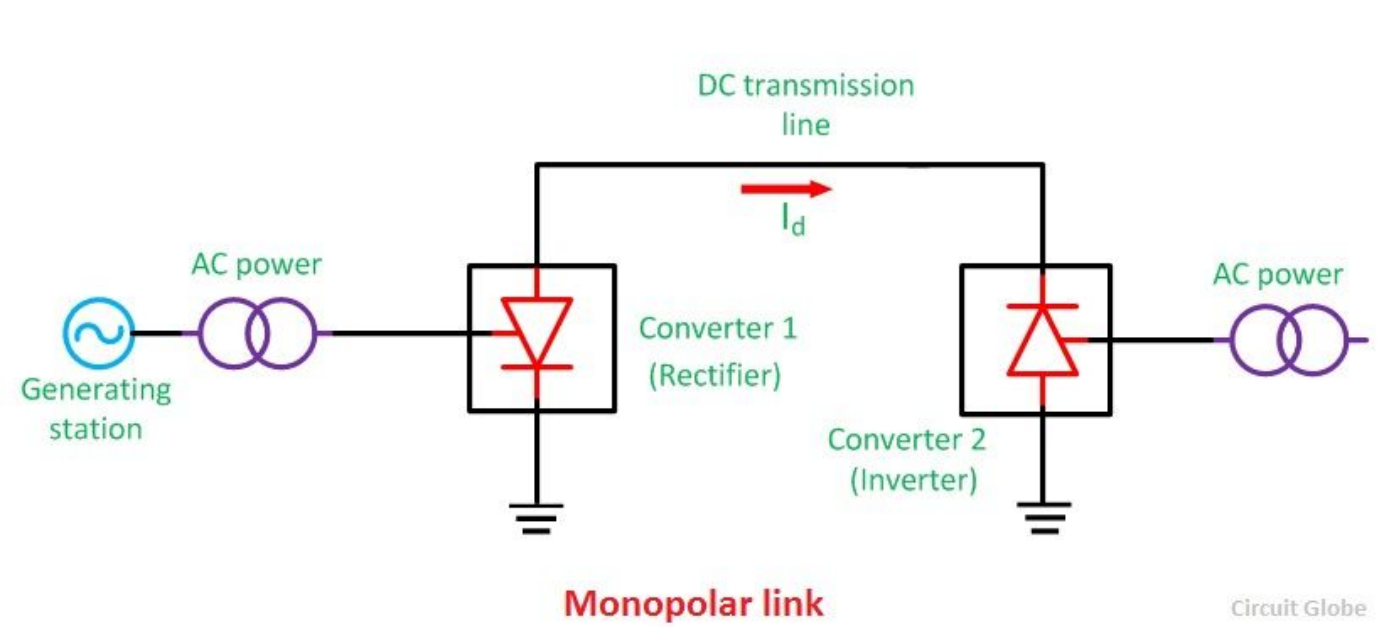
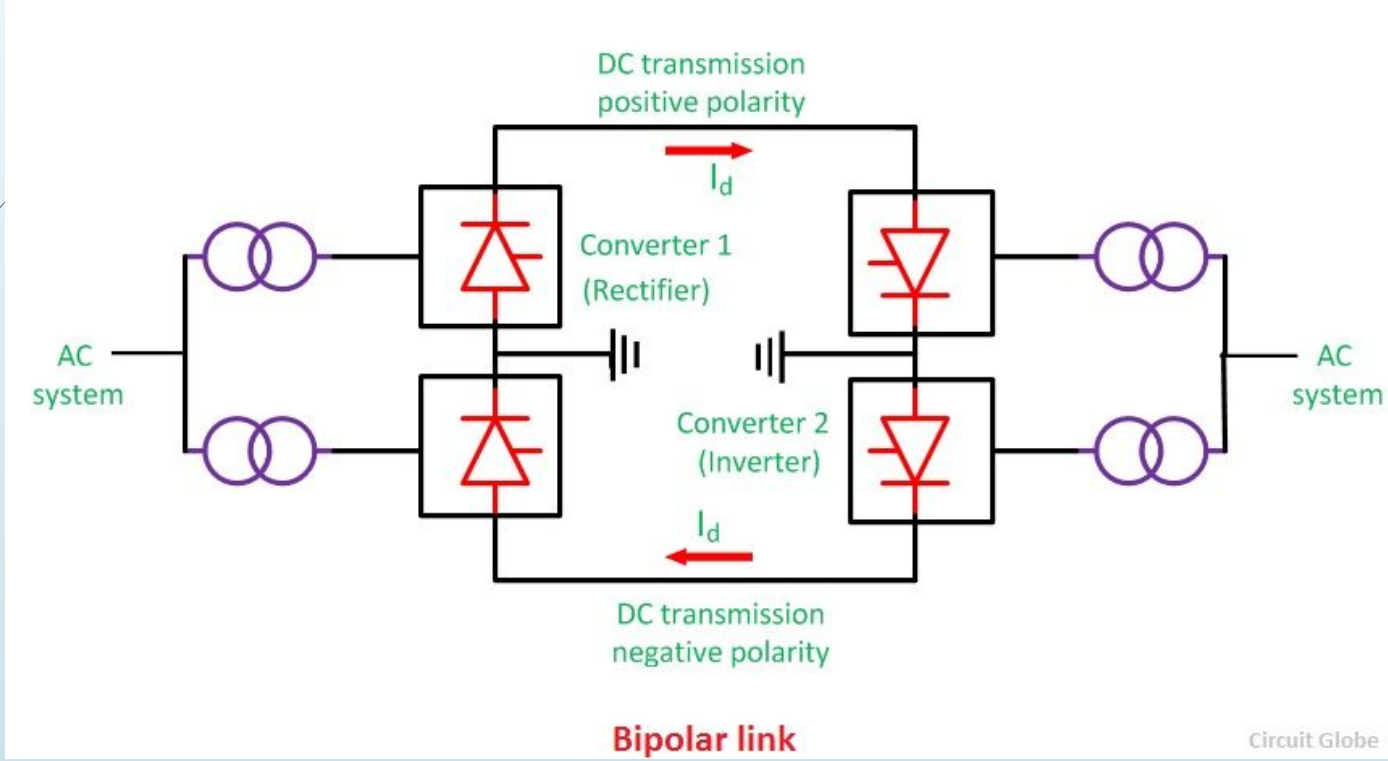
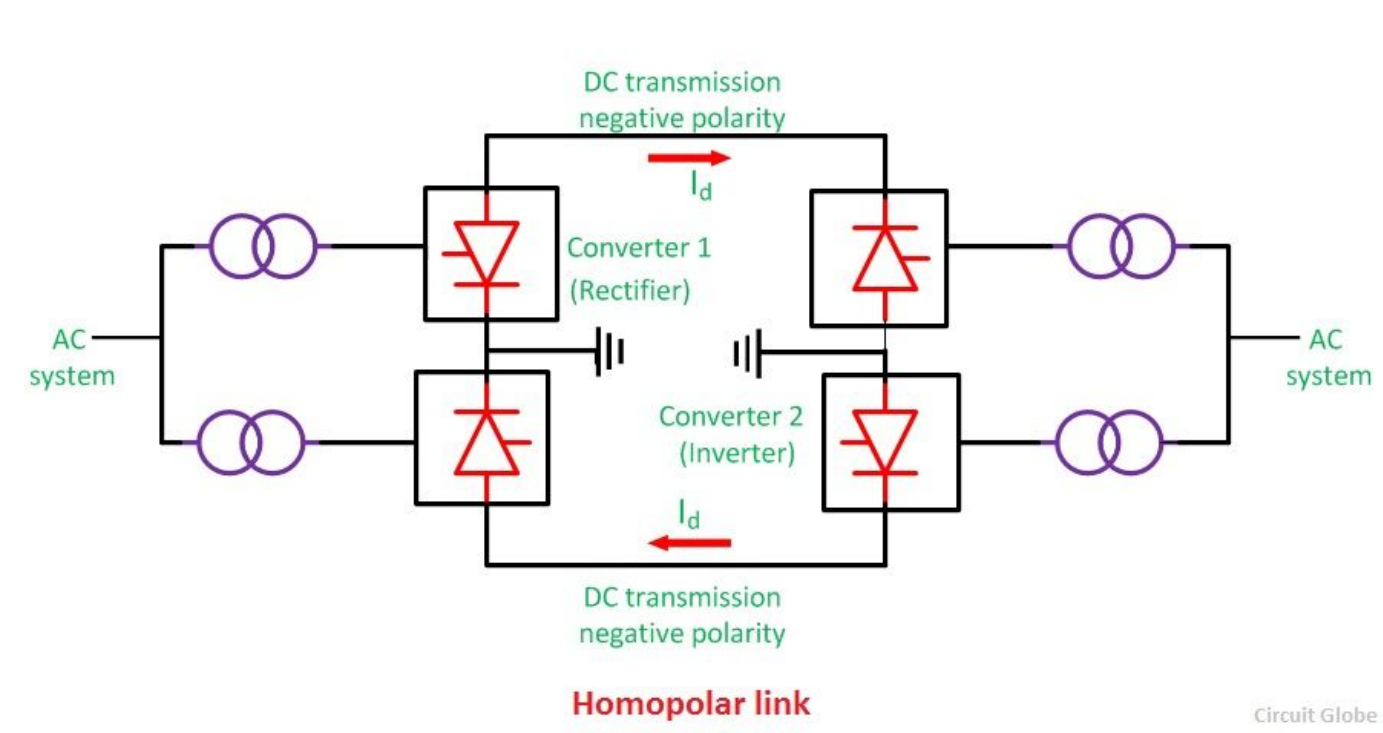
Monopolar link



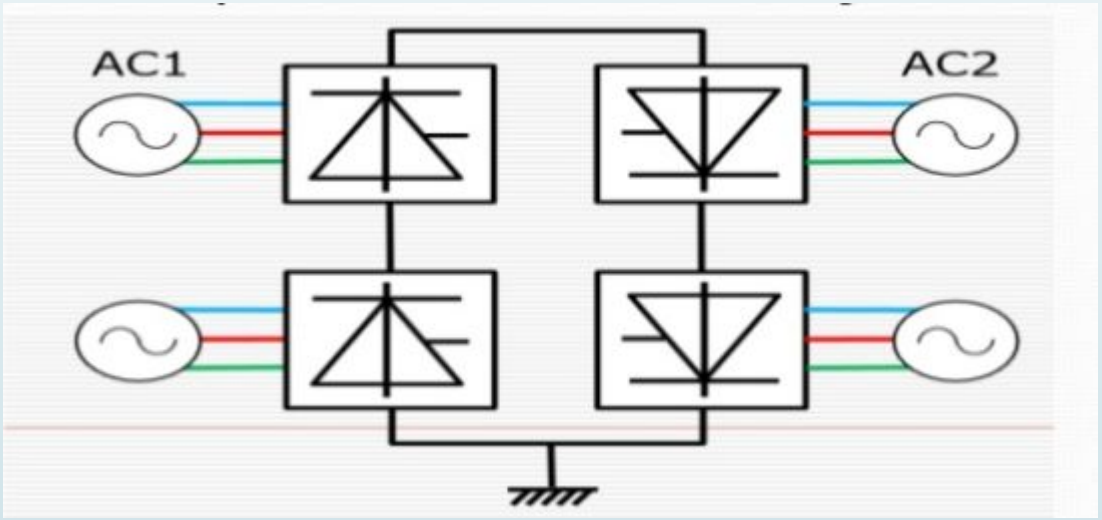
Bipolar link



Homopolar link



Back to back HVDC link



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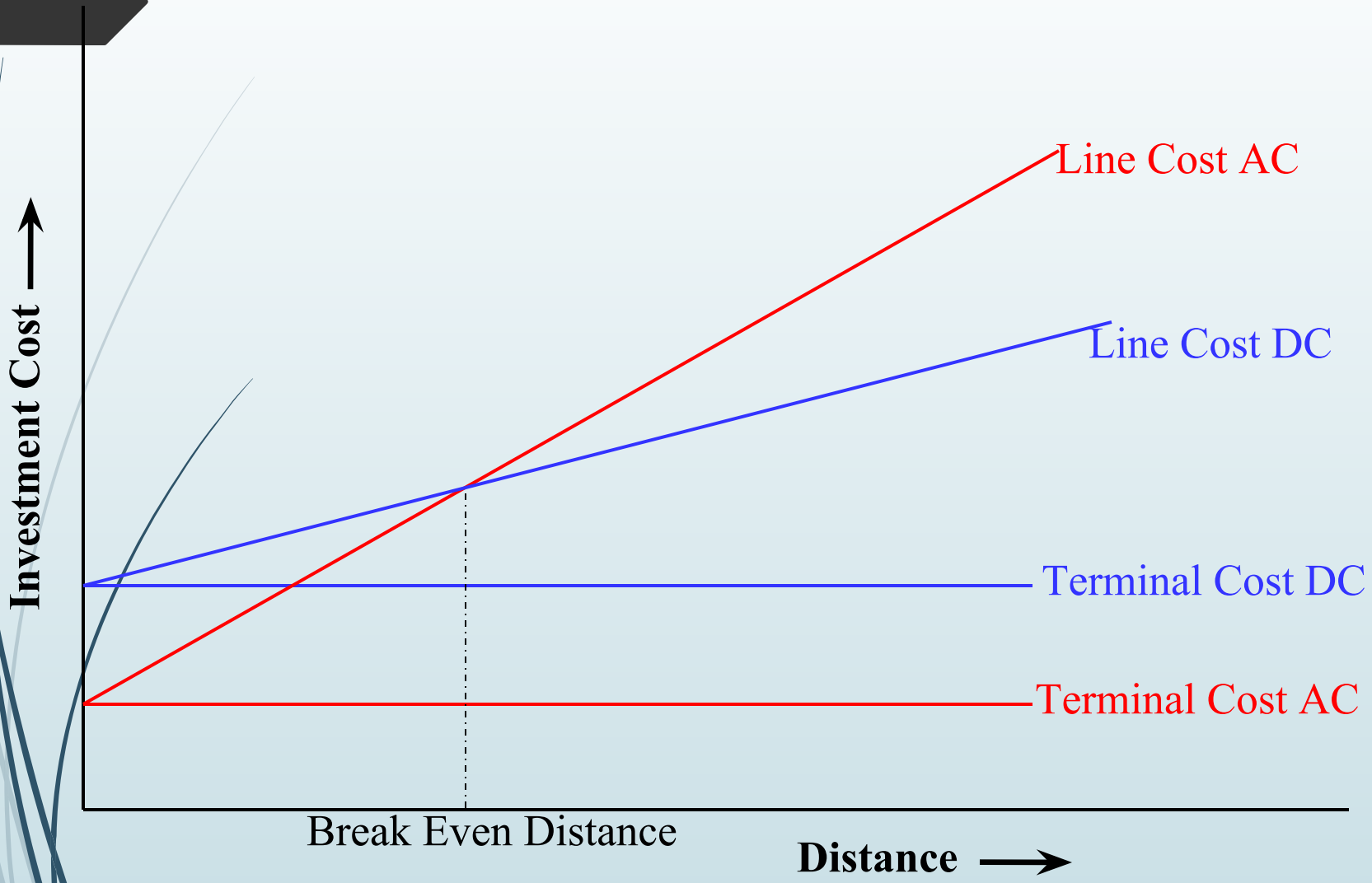
Topics to be covered

- Economic advantages of DC over AC
- HVDC in India

Economical advantages of HVDC

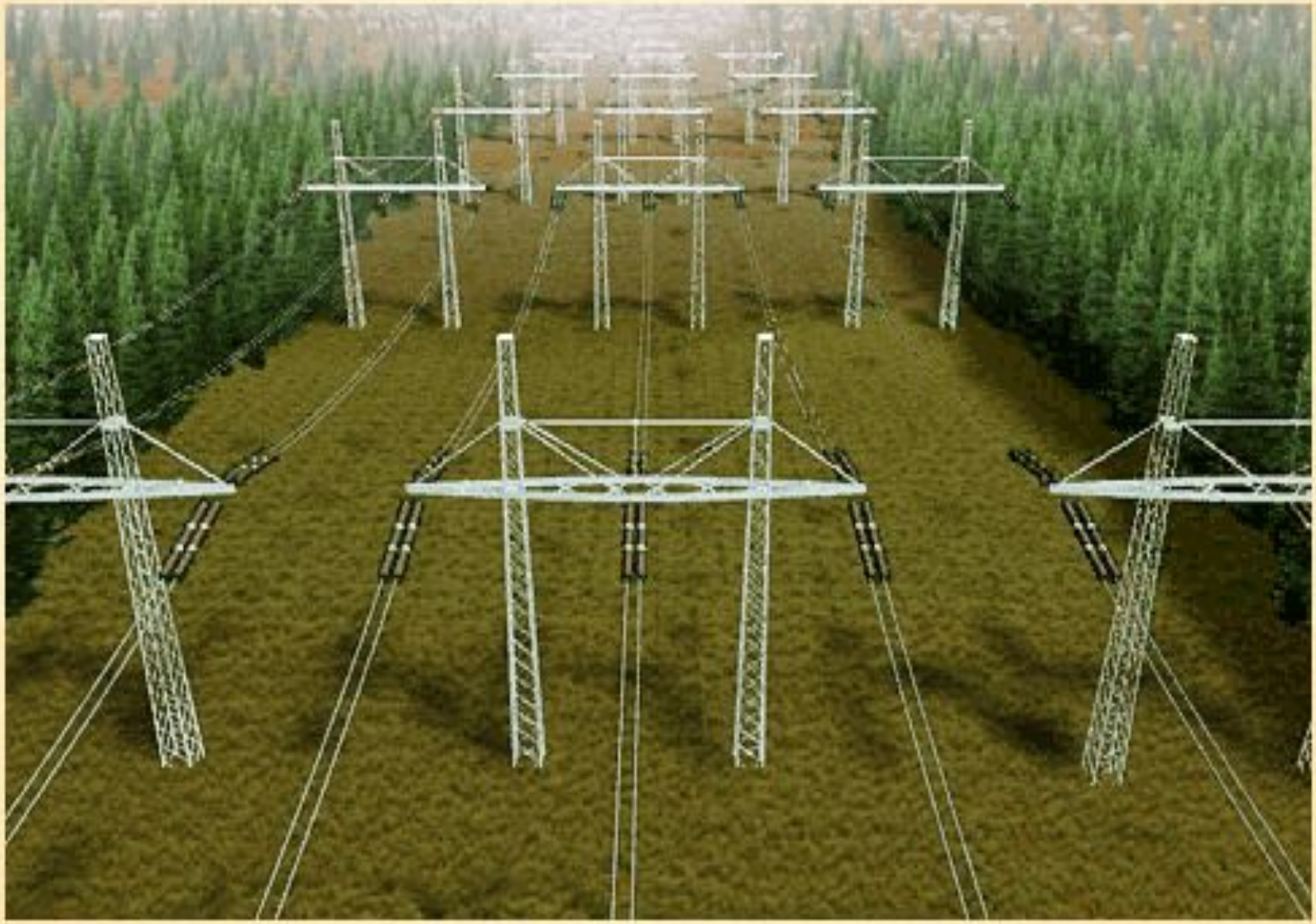
- DC line is simple and cheaper as compared to AC lines but line terminal equipment is costlier in case of DC as compared to AC
- Line Losses are less.
- HVDC line can be built in stages.
- Economic over long distances.

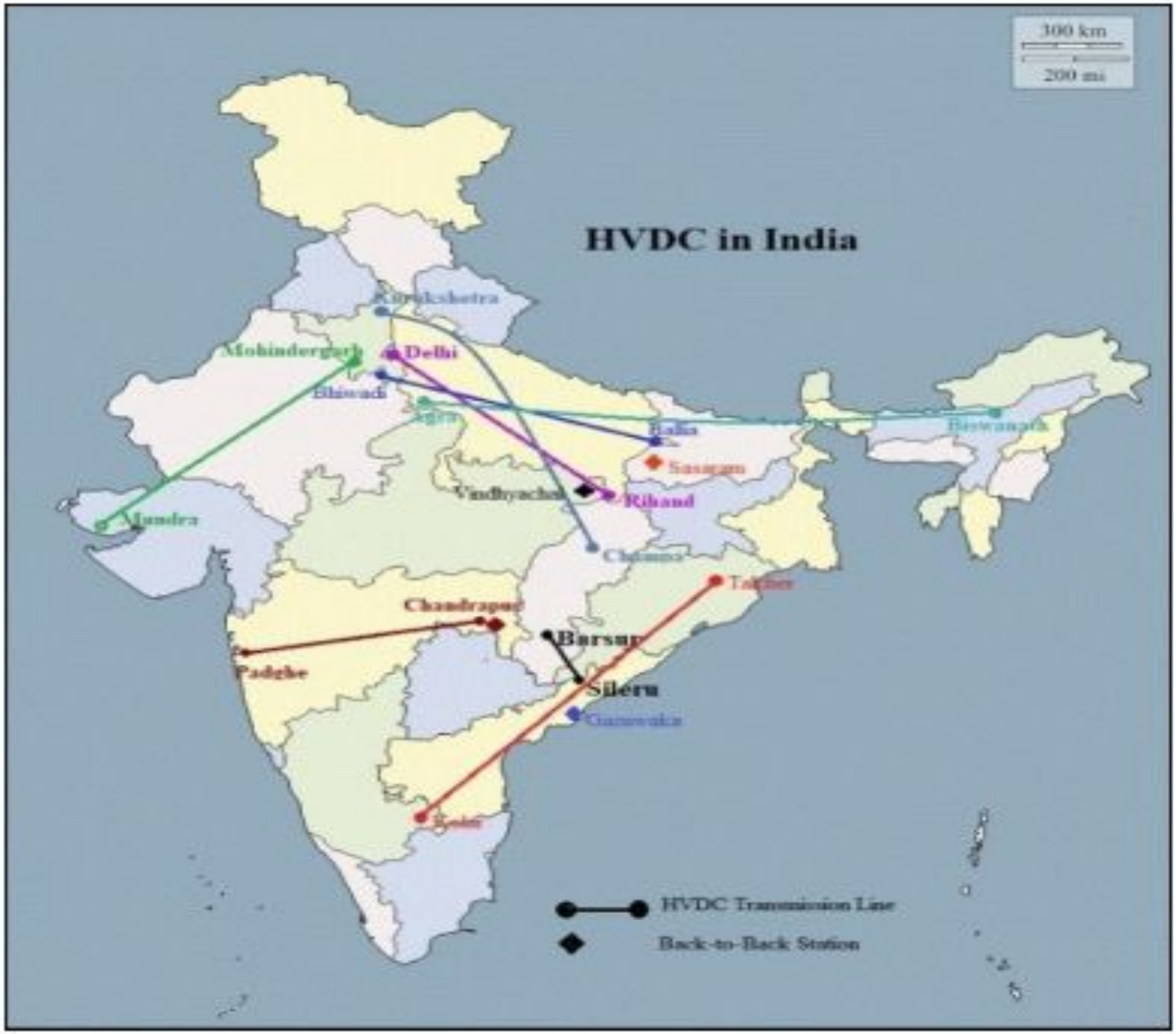
COST: AC v/s DC Transmission



DC Transmission Line Corridor

AC Transmission Line Corridor




300 km
200 mi
HVDC in India
Kurukshetra
Mohindergarh
Delhi
Bhiwadi
Agra
Balia
Biswanath
Sasaram
Vindhyachal
Rihand
Mundra
Champa
Talcher
Chandrapur
Barsur
Padghe
Silieru
Gazuwaka
HVDC Transmission Line
Back-to-Back Station

HVDC Bipolar line

Name	Length (km)	Volt (kV)	Power (MW)	Year
Sileru-Barsur	196	200	100	1989
Rihand-Delhi	814	500	1500	1990
Chandrapur-Padghe	752	500	1500	1999
Talcher-Kolar	1450	500	2500	2003
Ballia - Bhiwadi	800	500	2500	2010
Mundra - Haryana	960	500	2500	2012
Champa-Kurukshetra	1365	800	2 x 2000	2016
Biswanath-Agra	1728	800	6000	2016

Name	Voltage(kV)	Power(MW)	Year
Vindhyachal	176	500	1989
Chandrapur	205	2 x 500	1998
Gajuwaka Block 1	205	500	1999
Sasaram	205	500	2003
Gajuwaka Block 2	176	500	2005