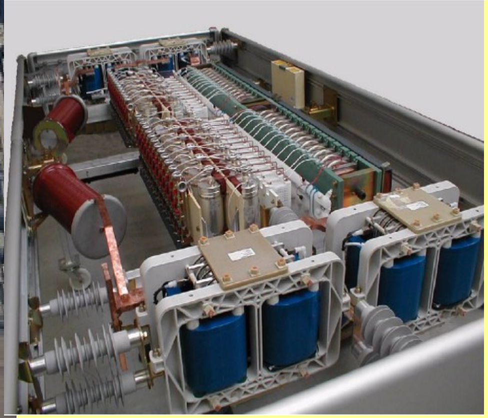
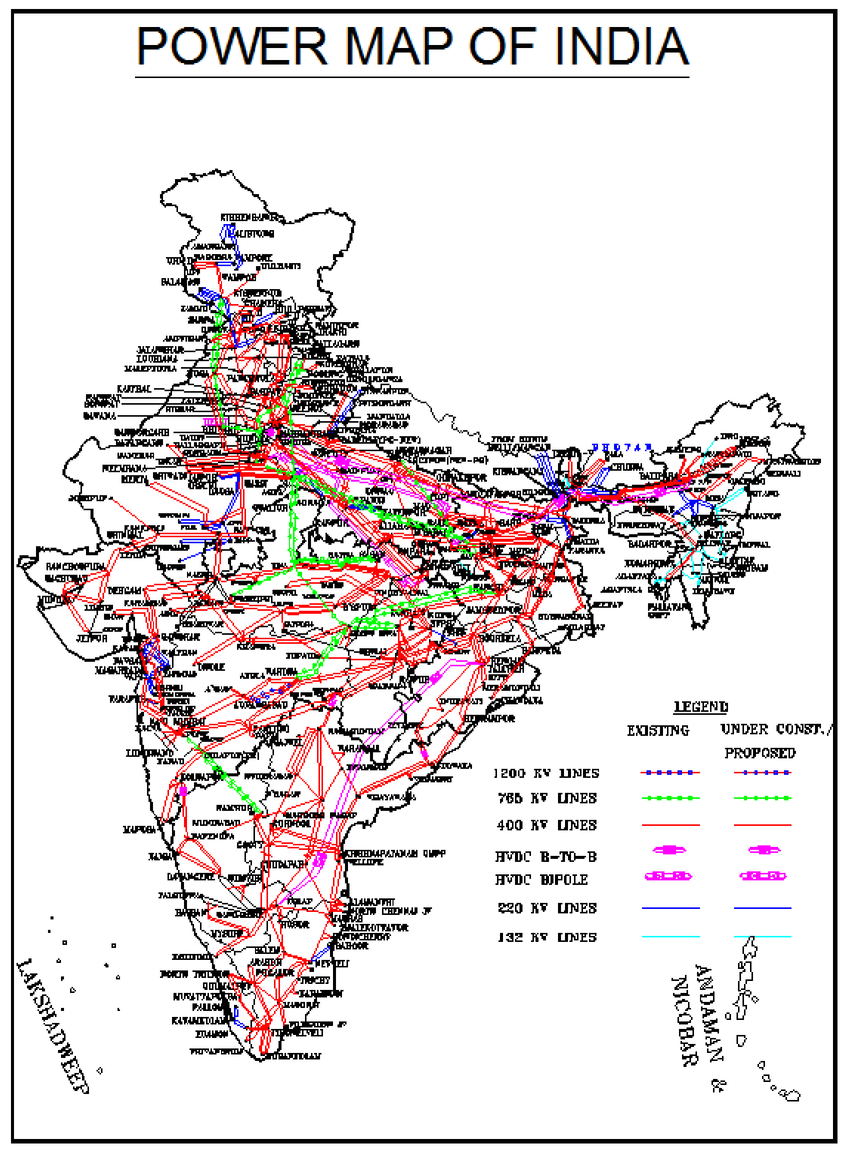
HVDC Systems in India



Outline

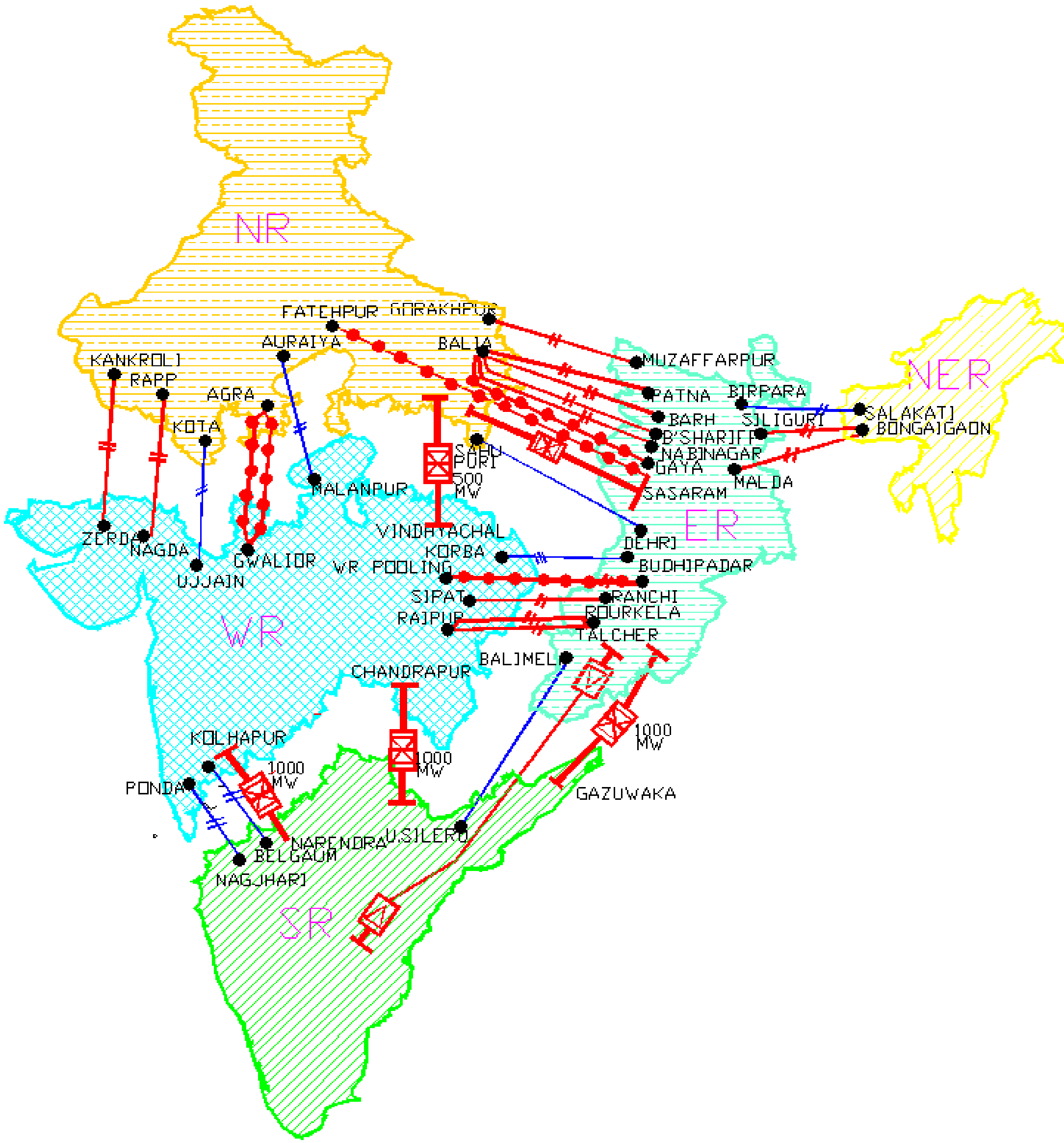
- Introduction
- HVDC Systems presently in operation
    - Main Data/Salient Features
- Upcoming Projects
- Future Challenges

Transmission Network - Present



- 765kV/400kV lines: about 1,03,000 ckms
- 220kV lines: about 132,000 ckms
- HVDC Bipole(±500kV): 7,500 ckms–3 nos.
- HVDC Back-to-back: 7 nos. (3000MW)
- FSC – 22 nos.; TCSC – 6 nos.

National Grid – Present

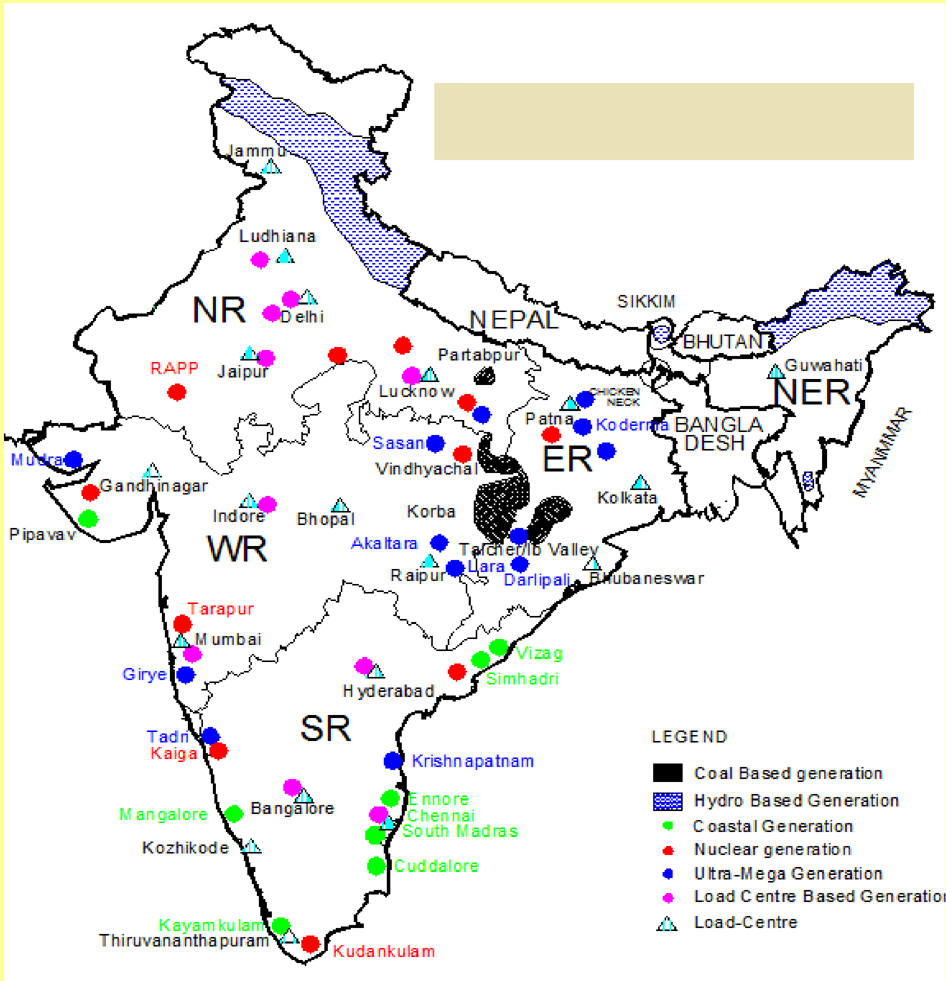


Inter-regional Capacity – 22,400MW

Energy Resources Map

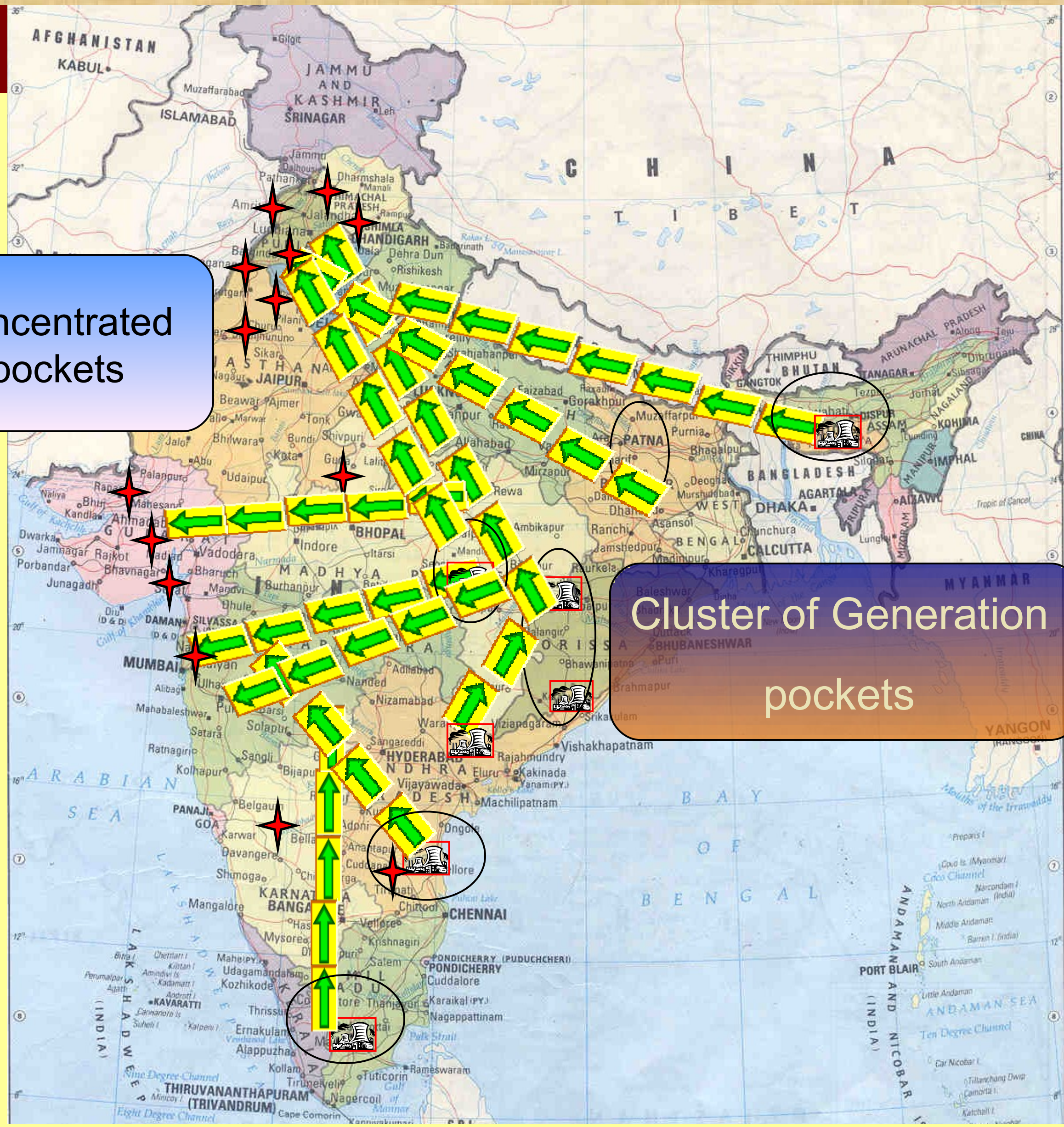
पावरग्रिड

Energy resources (coal, water etc.) unevenly distributed



- **Coal – In Central India**
  - Chhattisgarh : 58000 MW
  - Orissa : 30000 MW
  - Jharkhand : 15000 MW
  - Madhya Pradesh:16000 MW
- **Hydro – In North Eastern & Northern Himalayan region**
- **Coastal based**
  - Andhra Pradesh: 24000 MW
  - Tamil Nadu : 10000 MW
  - Gujarat : 11000 MW

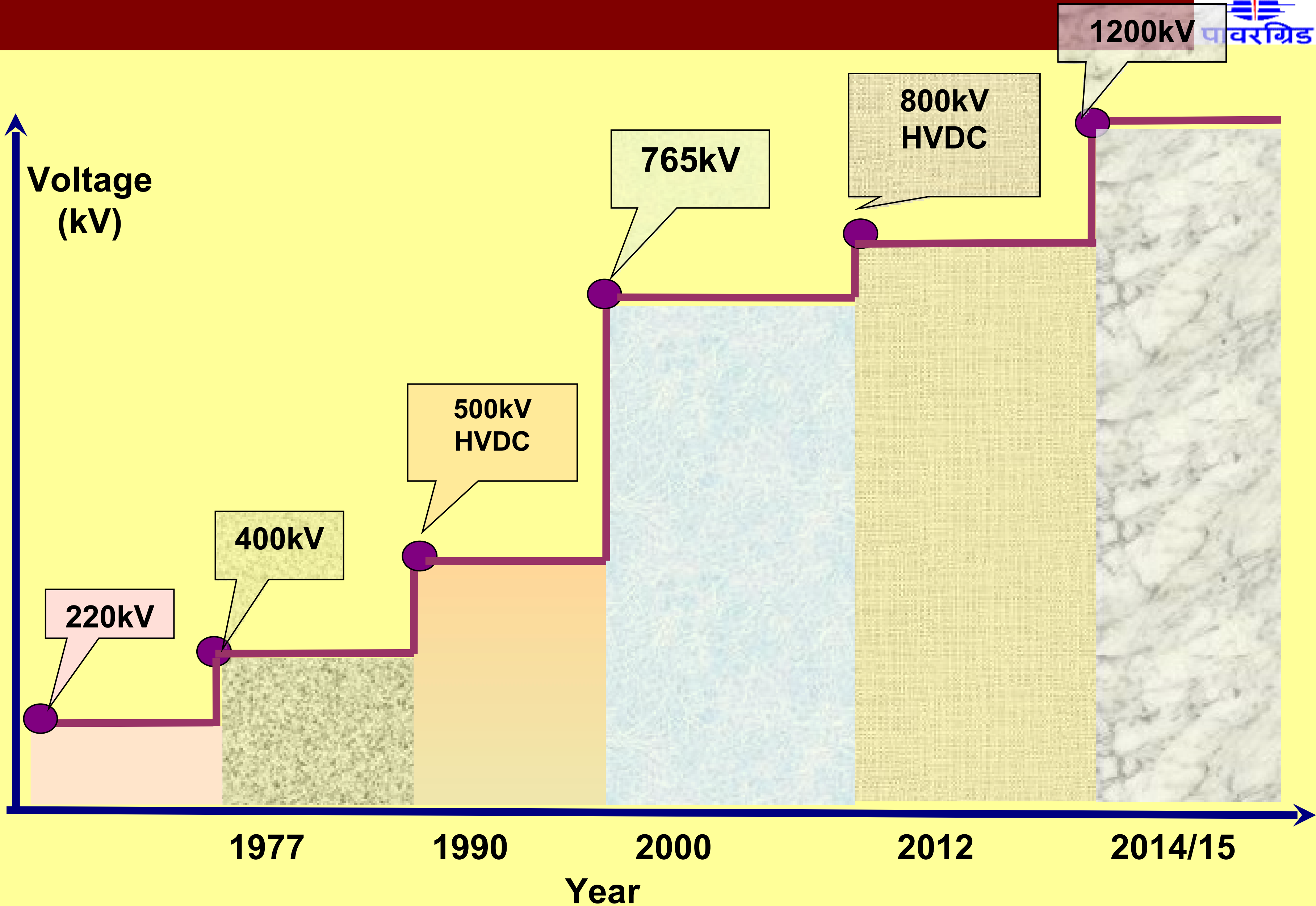
Creation of Transmission Highways



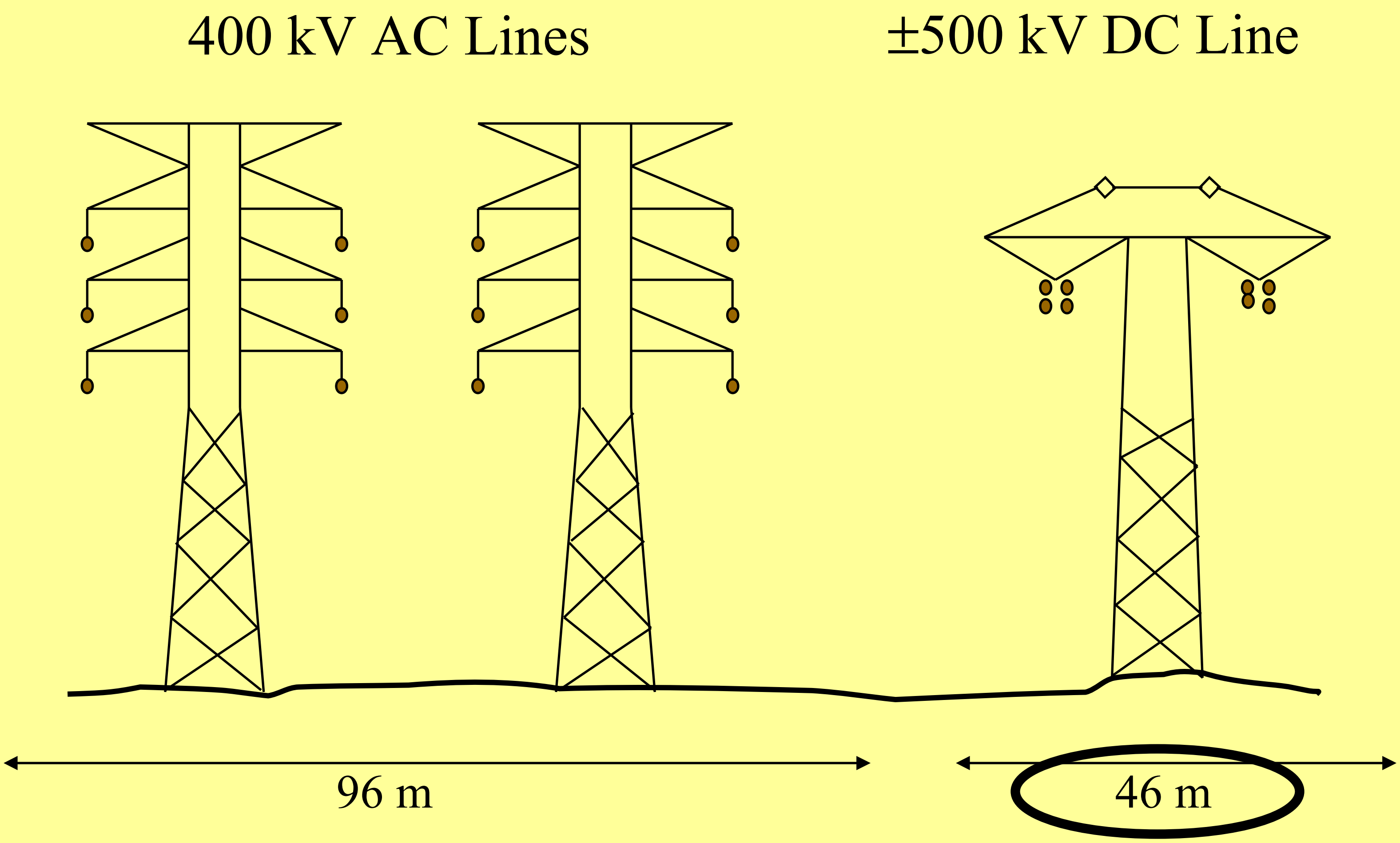
Cluster of Concentrated Demand pockets

Cluster of Generation pockets

Increase in Transmission voltage



Comparison of right of way



Voltage wise Trans. Corridor Density

Voltage	**132 kV**	**220 kV**	**400 kV**	**765 Kv**	**±500 kV HVDC**	**±800 kV HVDC (approx)**	**1200 kV (approx)**
ROW Meters(M)	27	35	52 (400 KV S/C Twin Moose Conductor)	64 (765 KV S/C Quad Bersimis conductor)	46	70	90
Capacity (MW) (Typical values of Stability Limits for AC system)	70-80	160-170	500-600	2500-3000	2000-2500	6000-6400	6000-8000
MW/m	3	5	15	45	46	90	90

Advantages of HVDC

- Controlled Power Exchange
- Improve stability of AC system
- Transmission at Reduced Voltage
- Minimize power reduction in case of pole outage
- Benefits at low ambient temperature
- Asynchronous link

HVDC Systems presently in operation

(Main Data/Salient Features)

± 500 kV , 1500 MW Rihand – Dadri HVDC Project.

Date of Commisioning: Dec-1991

Main Data:

Power rating	: 1500MW
No. of Poles	: 2
AC Voltage	: 400 kV
DC Voltage	: ± 500 kV
Converter Transformer-	
Rihand Terminal	: 6 x 315 MVA
Dadri Terminal	: 6 x 305 MVA

Length of over head DC line: 816 KM.

± 500 kV , 1500 MW Rihand – Dadri HVDC Project.

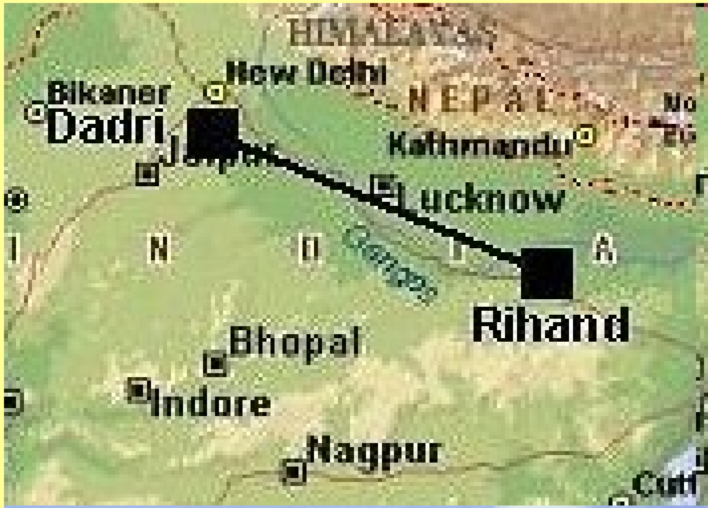
System Salient Features:

- ±500kV,1500MW HVDC Bi-Pole Transmission link supplies Bulk Power from Thermal Power Plant of Rihand (Eastern part of Northern Grid) to Dadri (Western part of Northern Grid).

- Each pole continuous power carrying capacity is 750 MW with 10% two hours overload and 33% five seconds overload capability .

- Reverse power flow capability available.

- During inclement weather condition power transmission is possible at ±400 kV DC voltage.



2 x 250 MW HVDC Vindhyachal Back to Back Station.

Completion date: April 1989

Main Data:

(i)	Power rating	: 2 x 250 MW.
(ii)	No. of Blocks	: 2
(iii)	AC Voltage	: 400 kV
(iv)	DC Voltage	: ± 70 kV
(v)	Converter Transformer	: 8 x 156 MVA

2 x 250 MW HVDC Vindhyachal Back to Back Station.

System Salient Features:

(i) It connects Vindhyachal Super Thermal Power Stations (Western Region) to Singrauli Super Thermal Power Stations (Northern Region) in Indian Grid.

(ii) Each Block power carrying capacity is 250 MW.

(iii) Bidirectional power flow capability is available.

(iv) The project achieve load diversity of Northern and Western region in Indian Grid by meeting high demand from surplus power available in either regions

(v) First commercial Back to Back HVDC Station in India

2 x 500 MW HVDC Chandrapur Back to Back Station.

Start date: November 1993

Completion date: Dec 1997

Main Data:

Power rating	: 2 x 500 MW.
No. of Blocks	: 2
AC Voltage	: 400 kV
DC Voltage	: 205 kV
Converter Transformer	: 12 x 234 MVA

2 x 500 MW HVDC Chandrapur Back to Back Station.

System Salient Features:

(i) It connects Chandrapur Thermal Power Stations (Western Region) to Ramagundum (Southern Region) Thermal Power Stations in Indian Grid.

(ii) Each Block power carrying capacity is 500 MW.

(iii) Bidirectional power flow capability is available.

(iv) The project achieve load diversity of Western and Southern region in Indian Grid by meeting high demand from surplus power available in either regions

(v) Second commercial Back to Back HVDC Station in India.

± 500 kV ,2000 MW, HVDC Talchar – Kolar Transmission Link

Completion date: June 2003

Main Data:

Power rating	:	2000 MW
No. of Poles	:	2
AC Voltage	:	400 kV
DC Voltage	:	± 500 kV
Converter Transformer-		
Talcher	:	6 x 398 MVA
Kolar	:	6 x 398 MVA

Length of over head DC line: 1369 KM.

This is the longest (1369 Km.) commercial HVDC link in India

Up gradation of ± 500 kV HVDC Talchar – Kolar link from 2000 MW to 2500 MW

- HVDC Talchar – Kolar link was designed for 2000 MW continuous rating with inherent short term overload capacity depending on-
  - Ambient temperature
  - Prevailing voltages at Talcher and Kolar
  - Cooling mechanism.

- Further, DC Bipole lines with quad conductor was capable to transmit 1250 MW continuously with marginal incremental loss .

- The inherent overload capability was utilized to meet the system contingencies by up gradation of Talcher – Kolar HVDC link capacity from 2000 MW to 2500 MW .

- This enhanced capacity is to be used only under contingency and not for increasing HVDC Capacity for firm transfer of 2500 MW

1 x 500 MW HVDC Sasaram Back to Back Station.

Completion date: Sep 2002

Main Data

(i) Power rating : 1 x 500 MW.

(ii) No. of Blocks : 1

(iii) AC Voltage : 400 kV

(iv) DC Voltage : 205 kV

(v) Converter Transformer : 6 x 234 MVA

Connects Pusauli (Eastern Region) to Sasaram (Eastern part of Northern Grid) of Indian Grid (Power Transfer mainly from ER to NR)

2 x 500 MW HVDC Gazuwaka Back to Back Station.

Completion date: Block 1 : Feb 1999
Block 2 : March 2005

Main Data:

(i) Power rating : 2 x 500 MW.
(ii) No. of Blocks : 2
(iii) AC Voltage : 400 k
(iv) DC Voltage : 205 kV (Block 1)
177 kV (Block 2)
(v) Converter Transformer
Block 1 : 6 x 234 MVA
Block 2 : 6 x 201.2 MVA

2 x 500 MW HVDC Gazuwaka Back to Back Station.

System Salient Feature

(i) It connects Jeypore (Eastern Region) to Gazuwaka (Southern Region) Thermal Power Stations of Indian Grid

(ii) Each Block power carrying capacity is 500 MW.

(iii) Bidirectional power flow capability available.

(iv) The project achieve load diversity of Eastern and Southern region in Indian Grid by meeting high demand from surplus power available

± 500 kV, 2500 MW HVDC Ballia – Bhiwadi Transmission Link.

Pole 1 Commissioned on 31-03 10

Main Data:

Power rating : 2500 MW

No. of Poles : 2

AC Voltage : 400 kV

DC Voltage : ± 500 kV

Length of over head DC line : 780 Km.

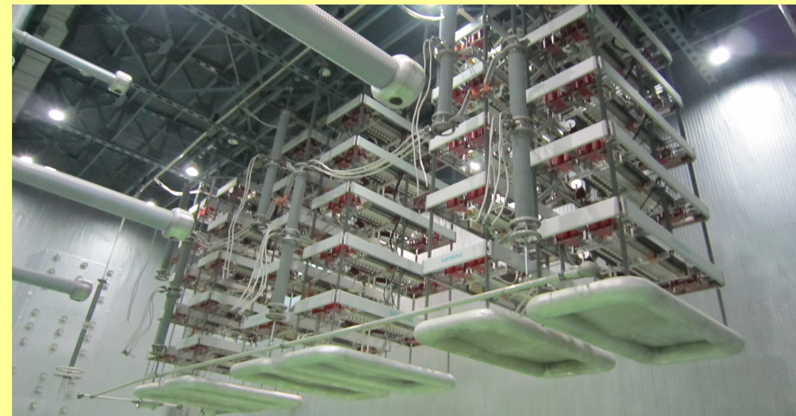
Converter Transformer

Ballia : 8 x 498 MVA

Bhiwadi 8 x 498 MVA

± 500 kV, 2500 MW HVDC Ballia – Bhiwadi Transmission Link

System Salient Features:



(i) Bi-Pole ± 500 kV, 2500 MW HVDC 780 km Transmission lines from Ballia (Eastern part of India) to Bhiwadi (Northern part of India) of Indian Grid.

(ii) Each pole power carrying capacity is 1250 MW.

(iii) During unfavorable weather condition, operation at 70% to 80% DC voltage is possible.

(iv) Reverse power flow capability is available.

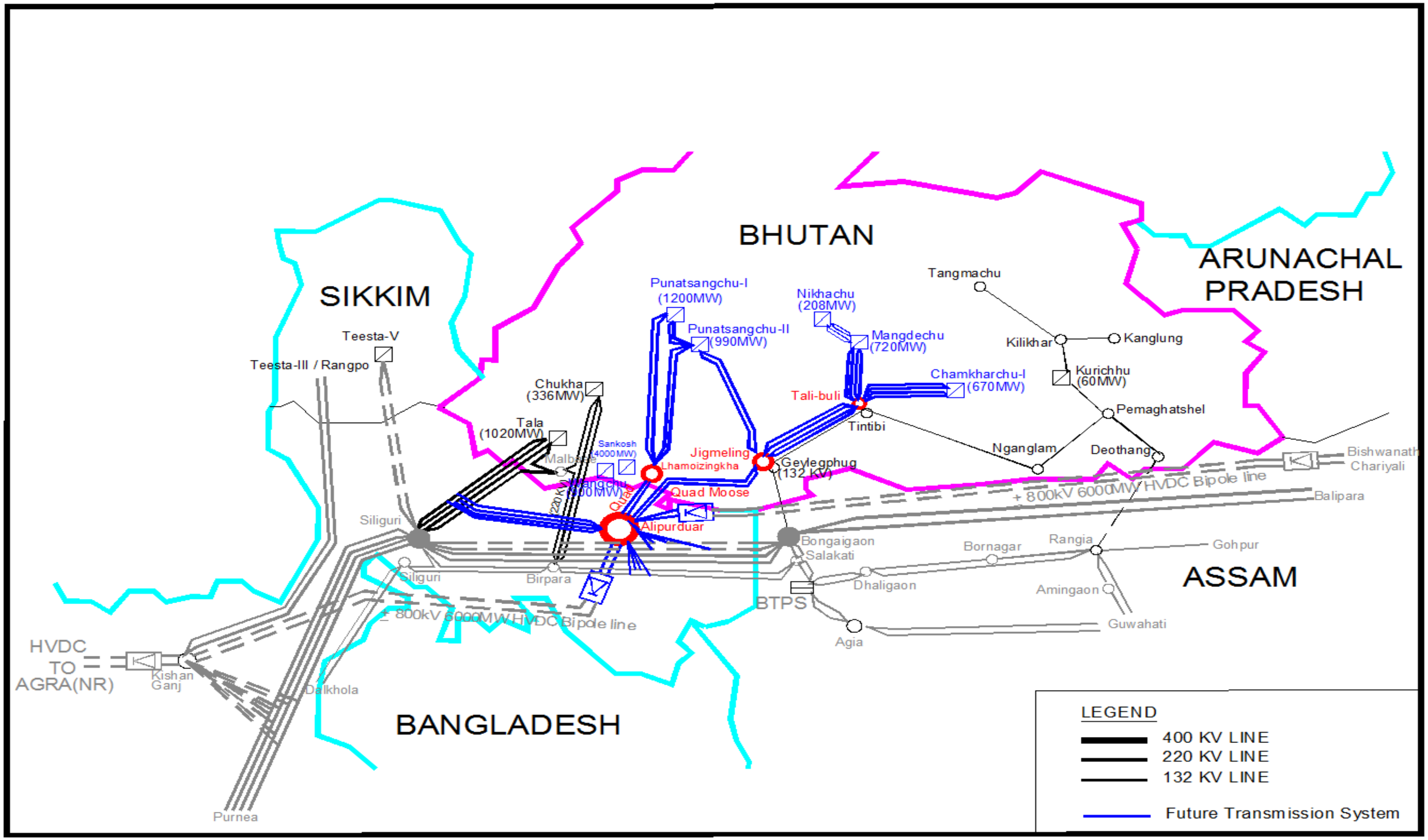
± 500 kV, 2500 MW HVDC Ballia – Bhiwadi Transmission Link

Switchable Configuration of Spare Converter Transformer

- Arrangement of Spare Converter Transformer for quick restoration of Pole in case of failure of Converter Transformer.
- Each Pole is having a dedicated Spare Converter Transformer with switching arrangement.
- Transformer Configuration being used for the first time.

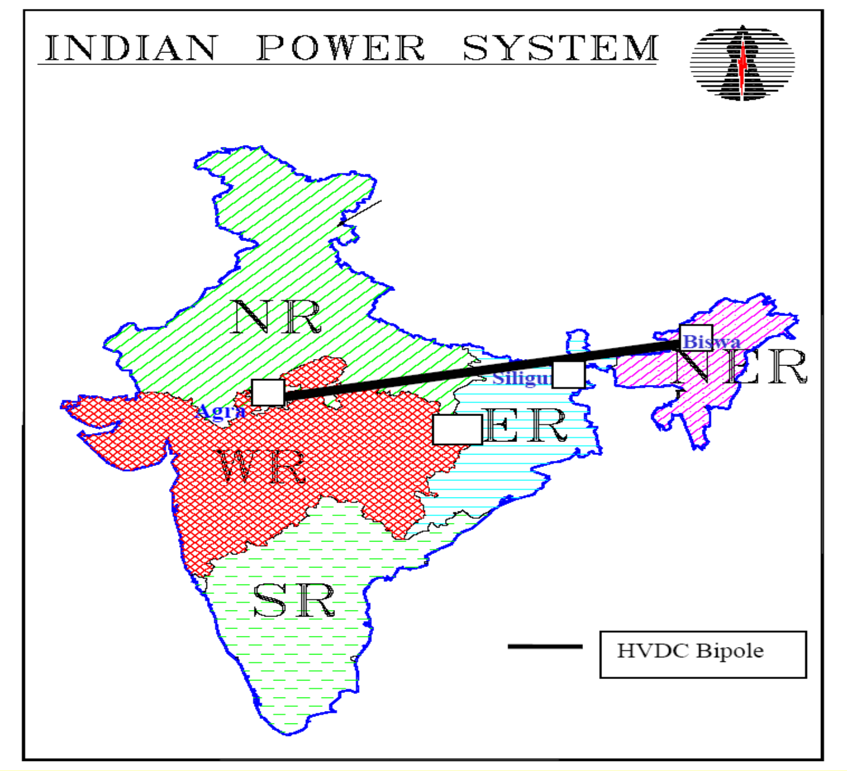
Upcoming Projects

800 KV HVDC Multi Terminal System



- North-Eastern Region has a large quantum Hydro Electric Power potential.
- Under Hydro Development program of Govt of India, this power has to be evacuated to load centres of Northern and Western Regions

800 KV HVDC Multi Terminal System



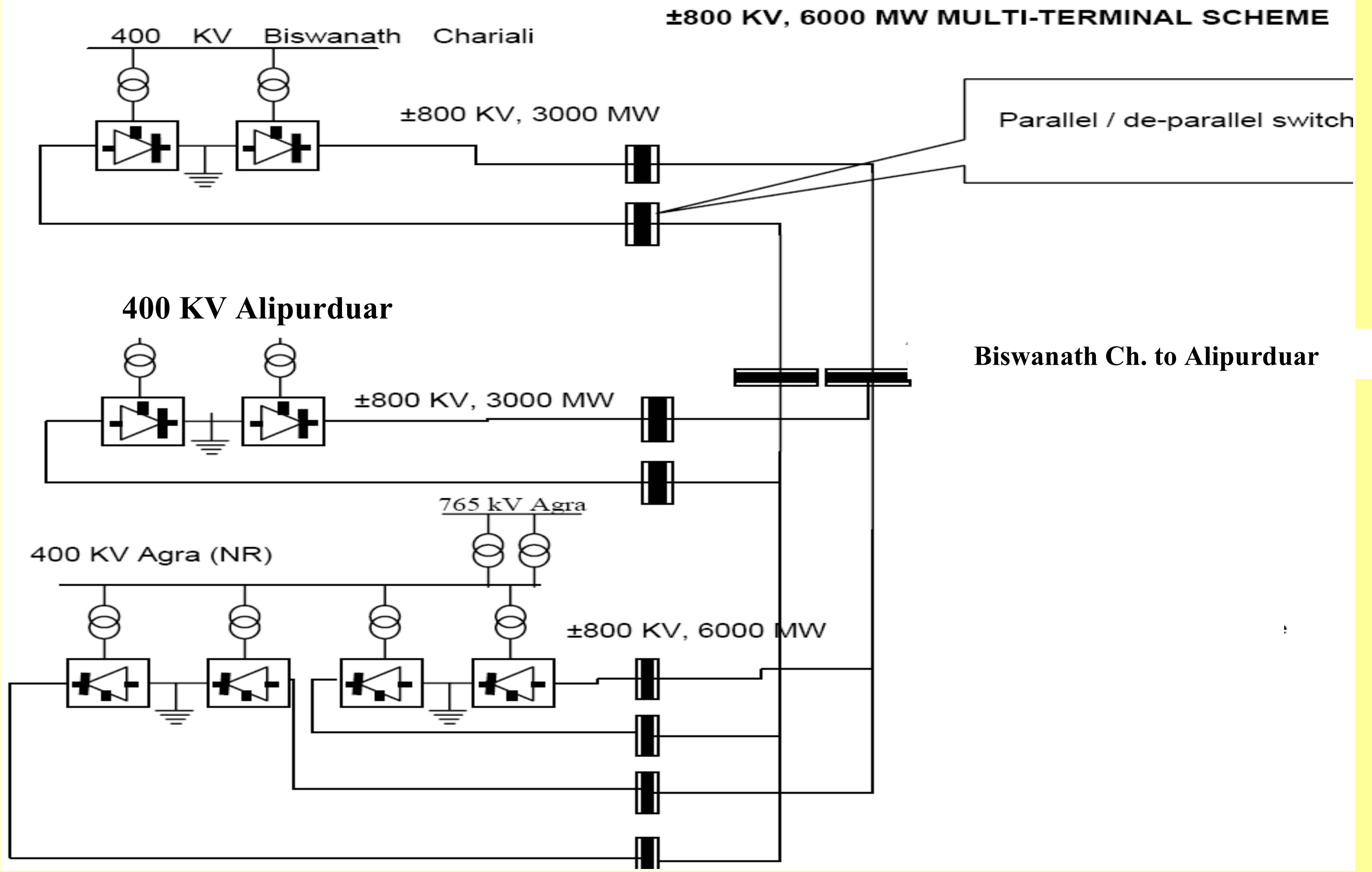
POWERGRID is installing +/-800 kV, 6000 MW HVDC multi-terminal system of approx length of 1728 km from North Eastern Region to Agra

One Rectifier station in Biswanath Chariali (in North Eastern Region), second one in Alipurduar (in Eastern Region) and Inverter station at Agra (in Northern Region)

800 KV HVDC Multi Terminal System

- Converter stations at Biswanath Chariali and Alipurduar each handles a power of 3000 MW and Converter station at Agra handles 6000 MW power
- This Tr. System originates from Assam and passes through West Bengal, Bihar and terminates in Uttar Pradesh
- First Multi Terminal project in India

800 KV HVDC Multi Terminal System



Salient features of 800 KV multi-terminal HVDC project

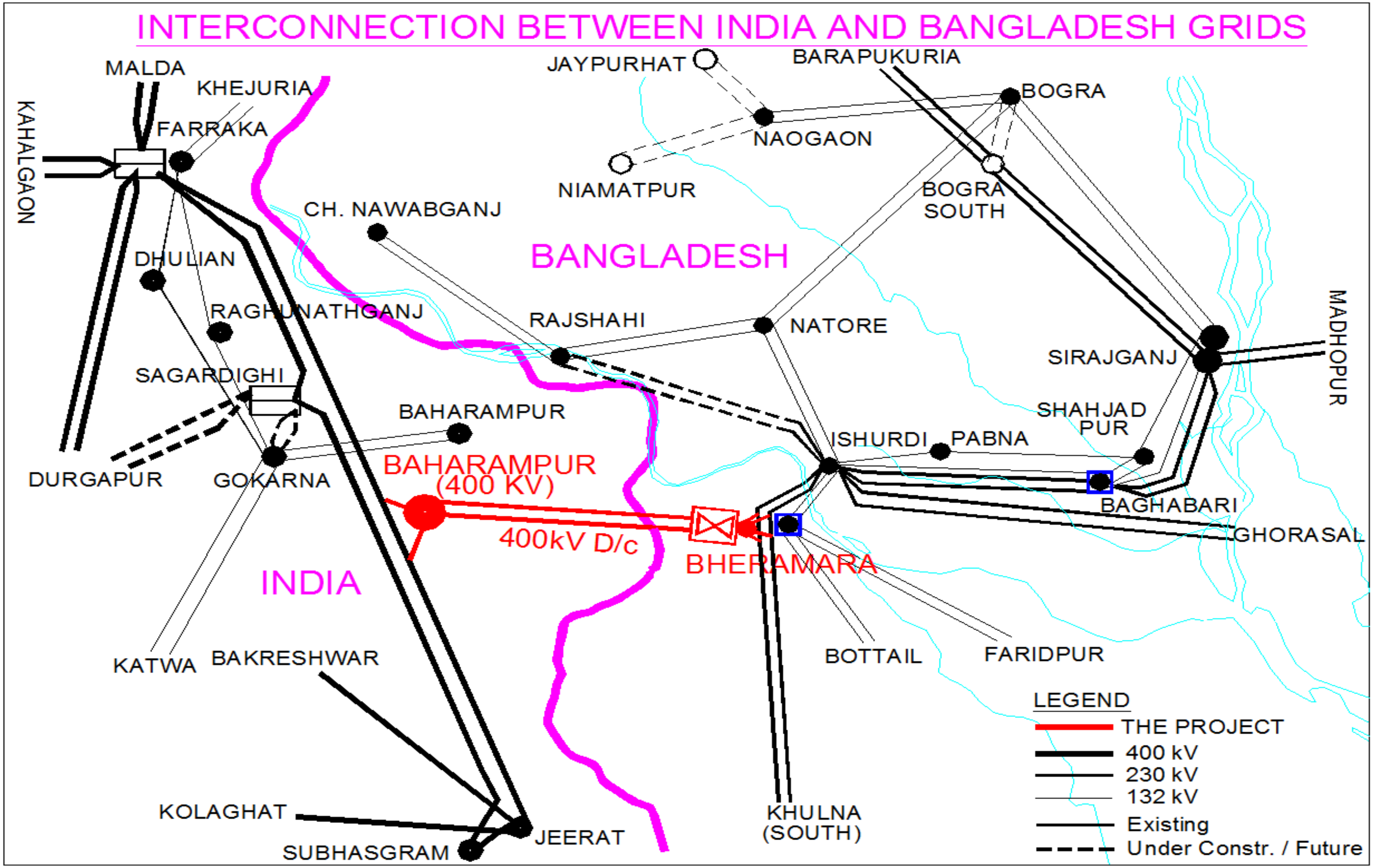
- First ±800 KV Multi-Terminal HVDC project in the world.
- First 12 pulse 800 KV terminal of the world
- First Multi-Terminal with continuous 33% overload feature
- After considering the continuous 33% overload feature, this will be the highest capacity HVDC project of the world.
- Each pole of the Multi-terminal shall be designed for 2000 MW which is the highest capacity poles in the world.
- The Earth electrode shall be designed for 5000 A DC continuous current which shall be 1st of its kind in the world.

HVDC Multi terminal System- Advantages

- Create power pooling points to collect power from S*everal* Generating Stations and to transport it on ± 800 kV DC bipolar lines (power highway) to major Load Centers located far away

- Efficient Utilization of ± 800 kV Line by connecting parallel HVDC Converters physically at different locations (eg Rectifiers 450 km apart) to the same.
- 33 % Continuous Overload Capability gives higher availability for Nominal Power Transmission -(For North East –Agra Multi terminal)

1 X 500 MW India Bangladesh Interconnector project



1 X 500 MW India Bangladesh Interconnector project

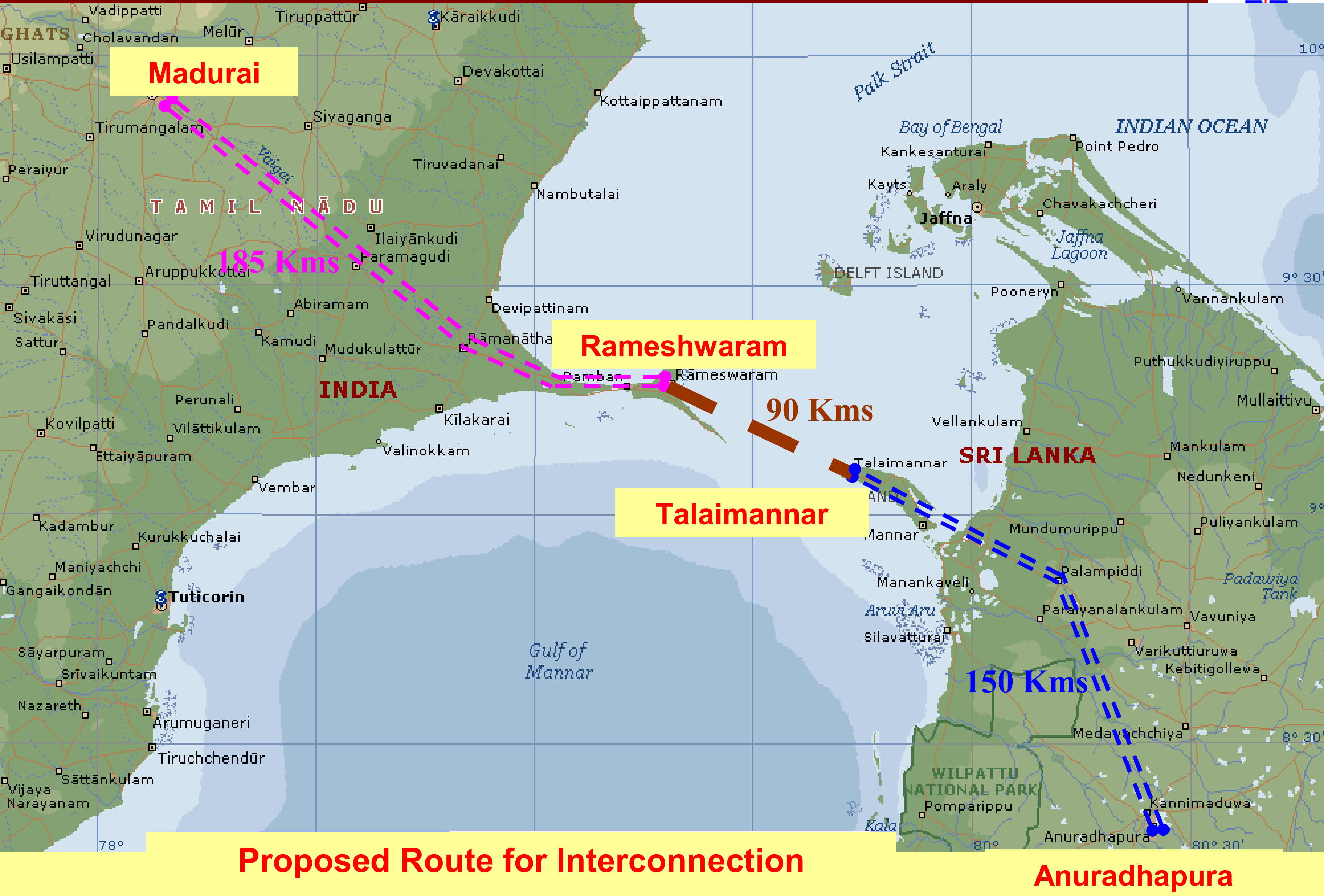
The first interconnection between Eastern Region, India and Western Grid, Bangladesh

POWERGRID's Consultancy assignment

Scope –

- Pre Award Engineering
- Finalisation of Bidding Documents, Assistance in Tender evaluation,
- Post Award Engineering
- Construction Supervision

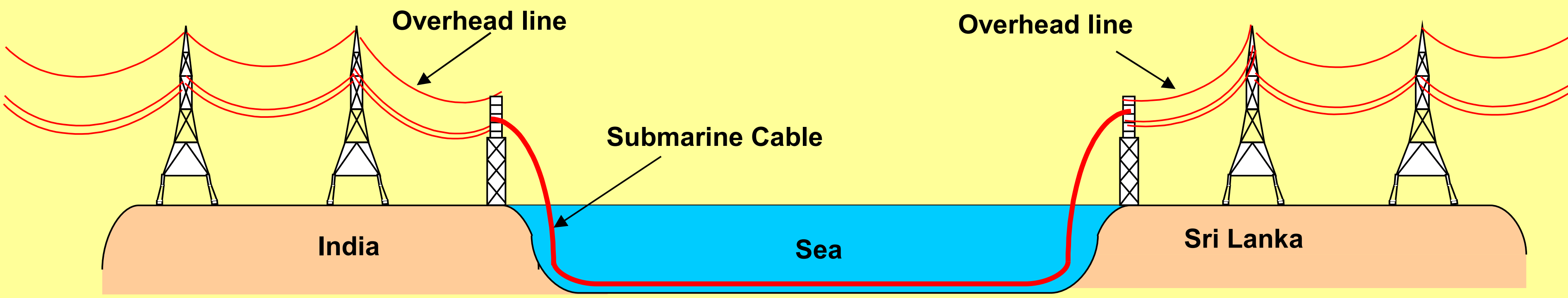
India – Sri Lanka Interconnection



Proposed Route for Interconnection

Indo-Srilanka HVDC Inter Connecter Link

- ± 400 kV, 4 x 250 MW HVDC Bipole Transmission Link
- From Madurai (India) to Sri Anuradhapura (Sri Lanka)
- Project having Overhead line (app 334 km) and Submarine Cable (app 90 Km)

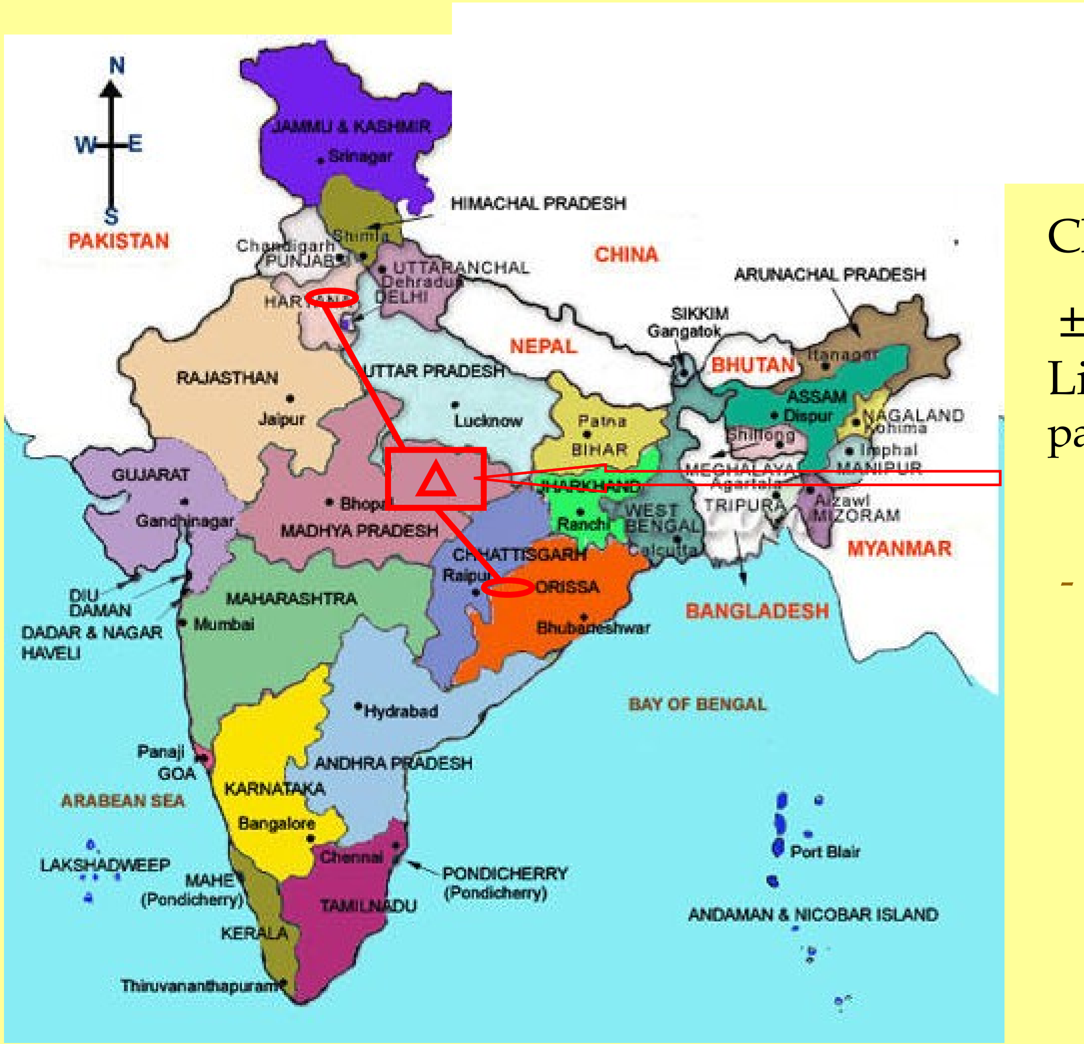


Transmission System in the Sea Route : Submarine Cable

Champa- Kurukshetra ± 800 KV , 3000 MW HVDC Link

- IPP generation projects coming up in Chhattisgarh for transfer of power to different target regions viz. Western and Northern region.
- Above generation projects are mainly coming up in Raigarh (near Kotra), Champa-Janjgir and Raigarh (Near Tamnar) complex.
- Based on the transmission system requirement for transfer of power to Northern Region from these generation projects , following WR – NR interconnector for IPP Projects in Chhattisgarh is proposed :-
    - Establishment of 3000MW 800KV HVDC Bipole Terminal Station each at Champa Pooling Station (WR) and Kurukshetra (NR) respectively (provision to upgrade the terminals at 6000MW at a later date).

Champa- Kurukshetra ± 800 KV , 3000 MW HVDC Link



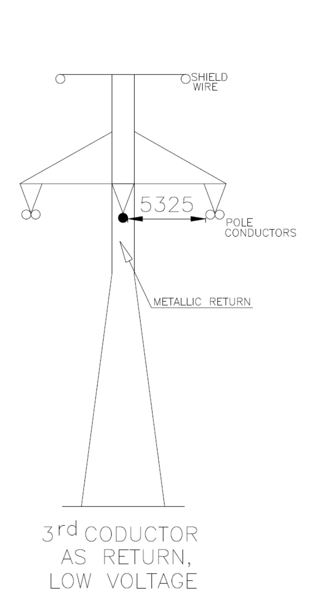
Champa- Kurukshetra

± 800 KV , 3000 MW HVDC Link (upgradable to 6000 MW by parallel converters)

- *Return Current (both Monopolar and Bipolar) through Third Conductor*

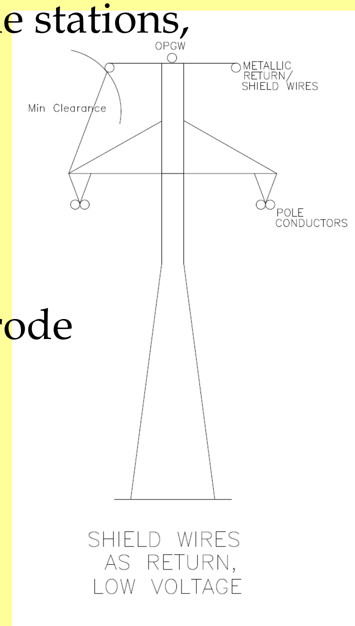
Advantages of having **Third Conductor** for Return path:

- It <u>eliminates</u> the <u>element of uncertainty</u> about the proper functionality of the earth electrode station.



It shall avoid acquisition of separate land for each earth electrode stations, construction of electrode stations which involves requirement of large amount of steel rods and coke.

The construction of new Transmission Line between Earth Electrode Station and respective HVDC terminal station shall be avoided.

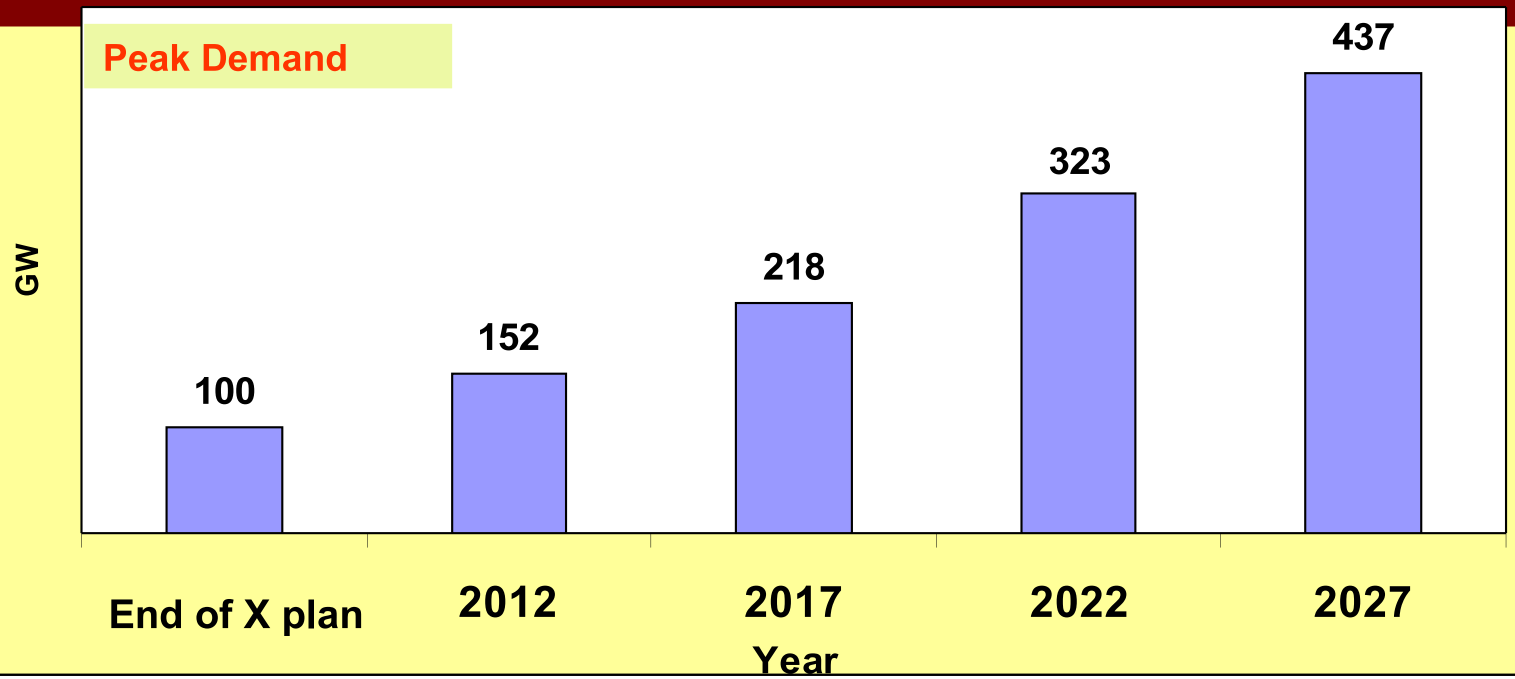


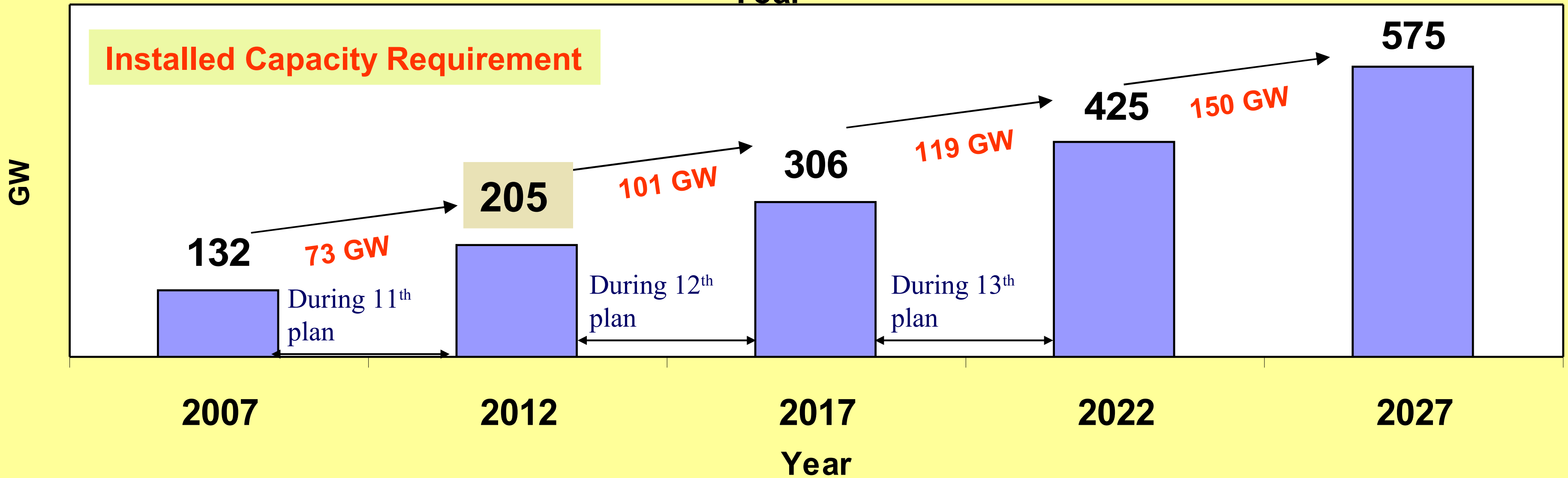
Future Challenges

Growth Drivers

- Transmission growth driven by
  - Strong GDP growth – requiring massive expansion of Power Sector
  - Uneven distribution of energy resources
  - Change in generation profile

Future Power Scenario





Need of new initiatives in Transmission

- **Need of long distance Transmission system**
- **Minimum use of land and Right-of-Way**
- **Optimal cost per MW transmission**
- **Optimal Transmission Losses**

HVDC Technology….

One of the Solution….


Thank You