Development of 1200kV Transmission System in India

V Ramakrishna, Central Electricity Authority

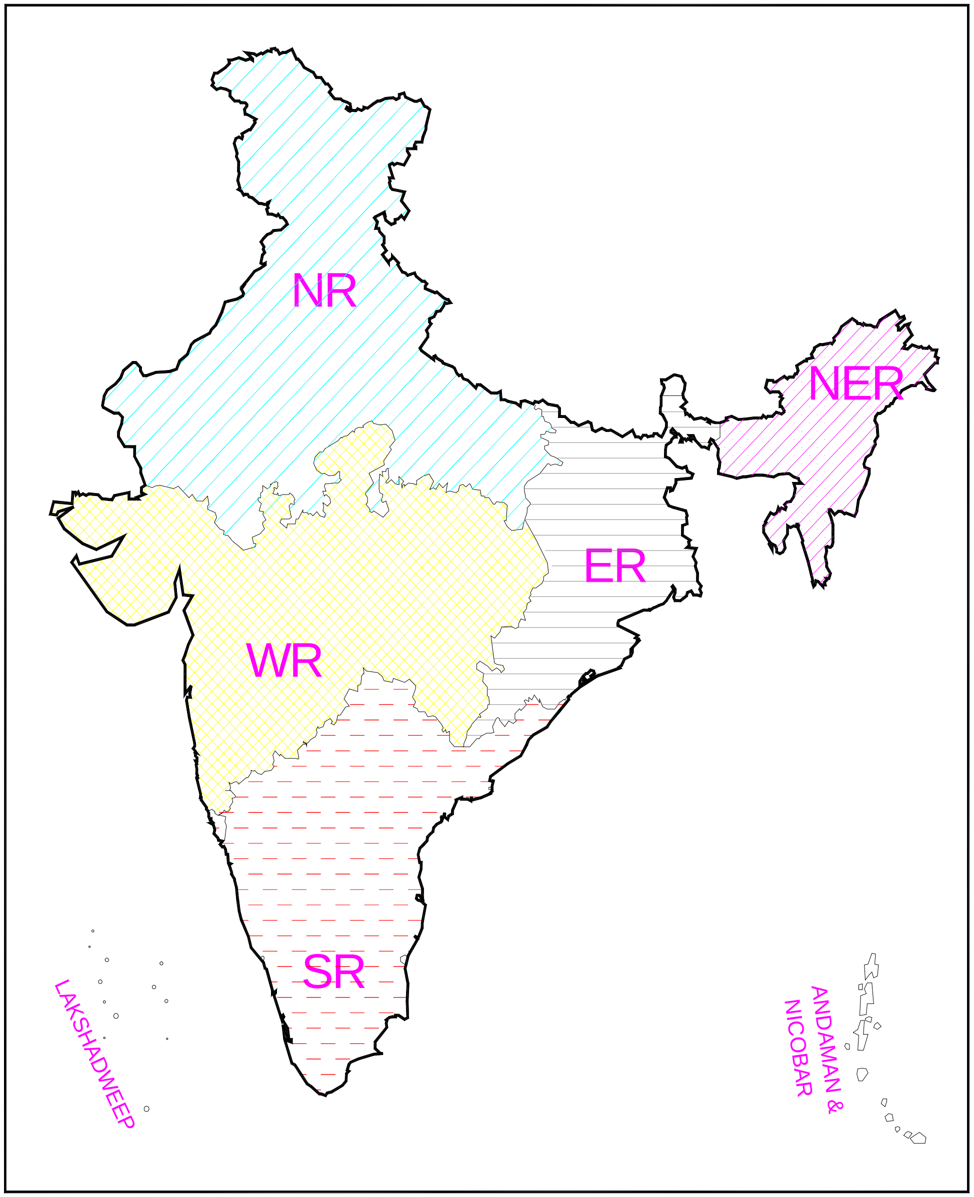
Subir Sen, Power Grid Corpn. of India Ltd.

Presentation Flow

- ❖ Overview of Indian Power System
- ❖ Future demand-supply scenario
- ❖ Consideration for high capacity 1200kV transmission corridor development
- ❖ Broad 1200kV AC technical parameters
- ❖ 1200kV UHVAC Test Station
- ❖ Summary

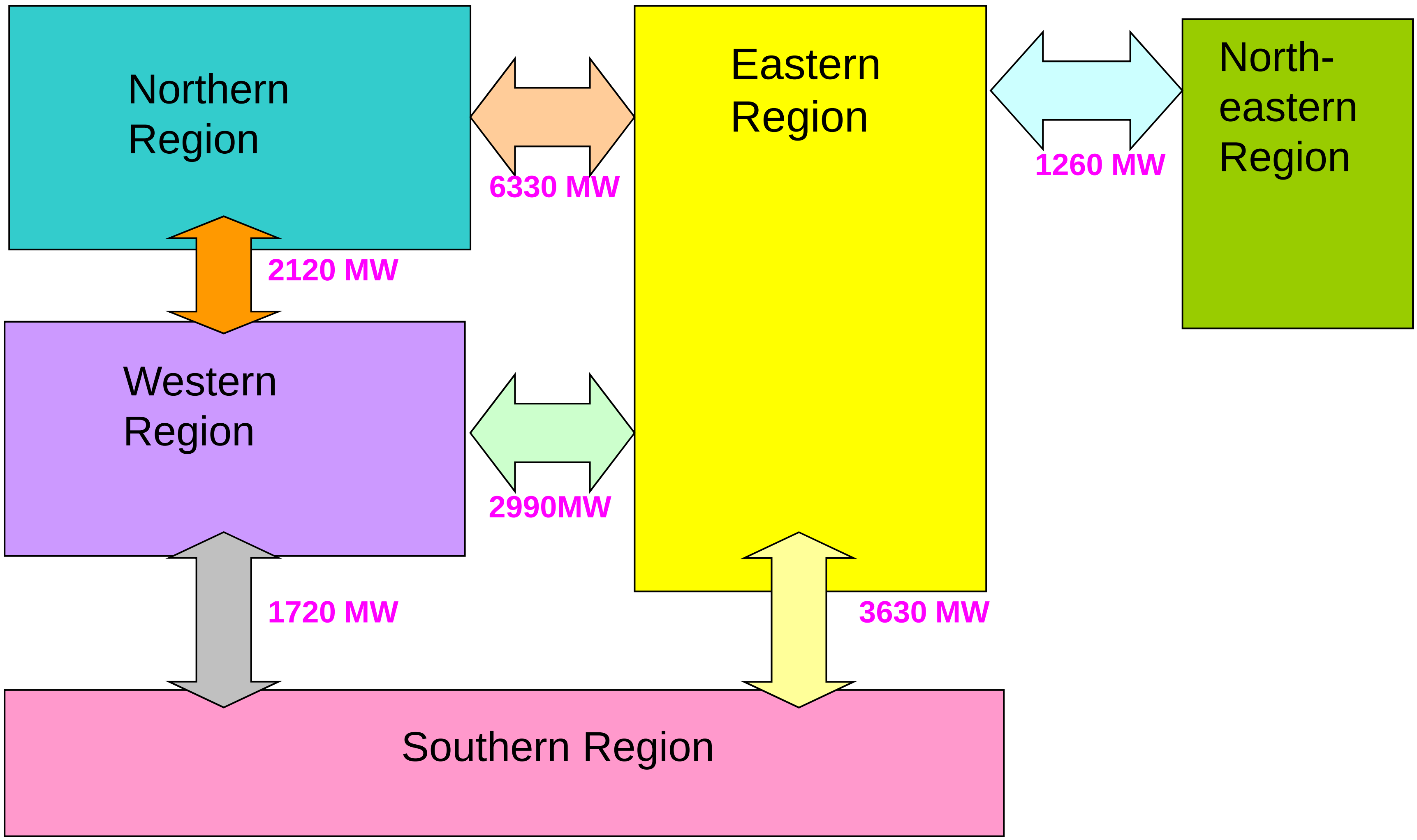
Overview of Indian Power System

Indian Power System - Present



- **Installed Capacity: 147GW**
- **Peak Demand : 109 GW**
- **Transmission Grid Comprises:**
  - **765kV Lines - 1600 ckt. km**
  - **400kV Lines - 76,000 ckt. km**
  - **220/132kV Lines - 115,000 ckt. km**
  - **HVDC bipoles - 3 nos.**
  - **HVDC back-to-back - 7 nos.**
  - **FSC – 18 nos.**
  - **TCSC – 6 nos.**
- **NER, ER, NR & WR operating as single grid of 100 GW**
- **SR Grid – 40 GW**
- **Inter-regional capacity : 18,700 MW**

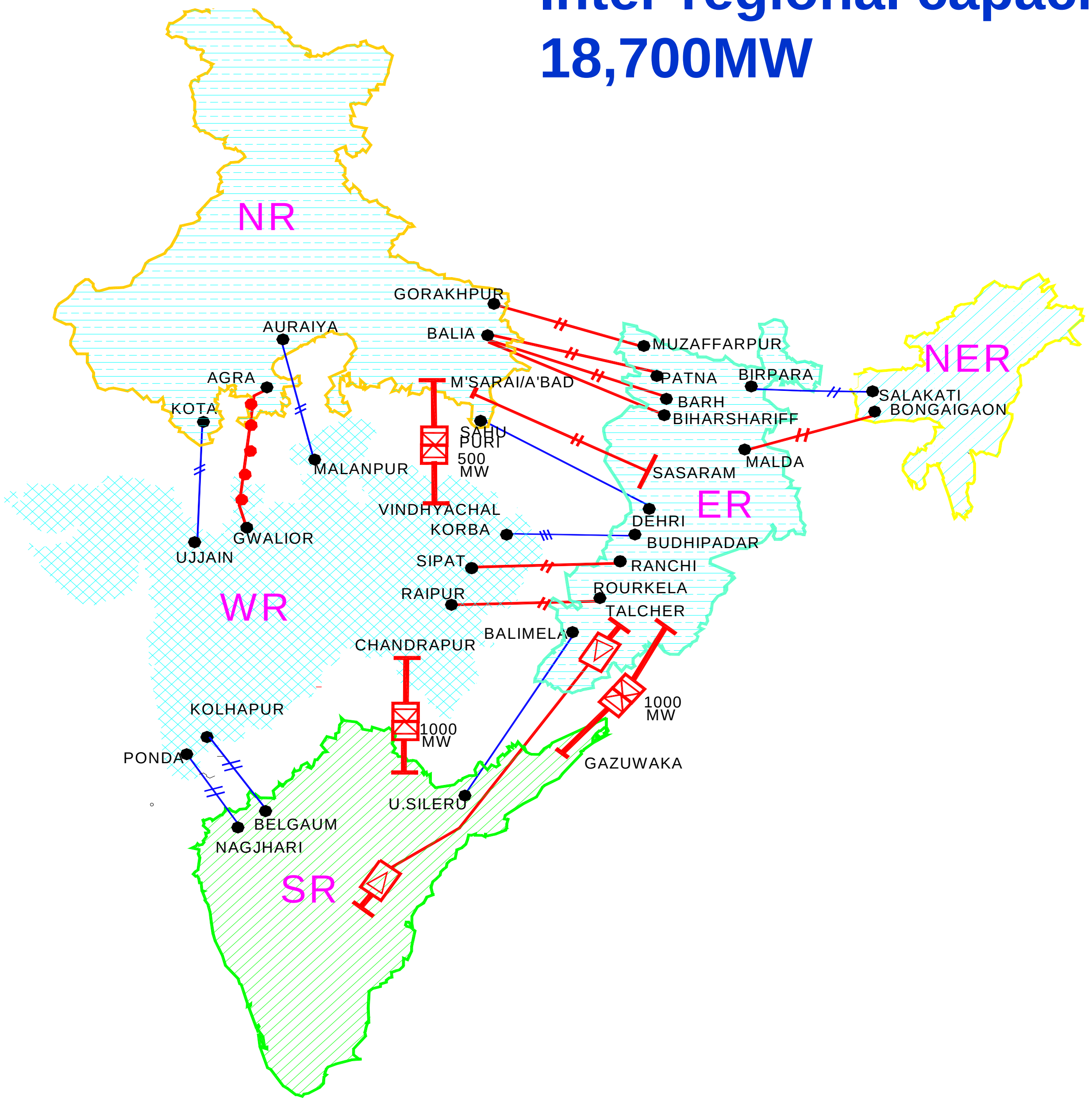
National Grid - At Present



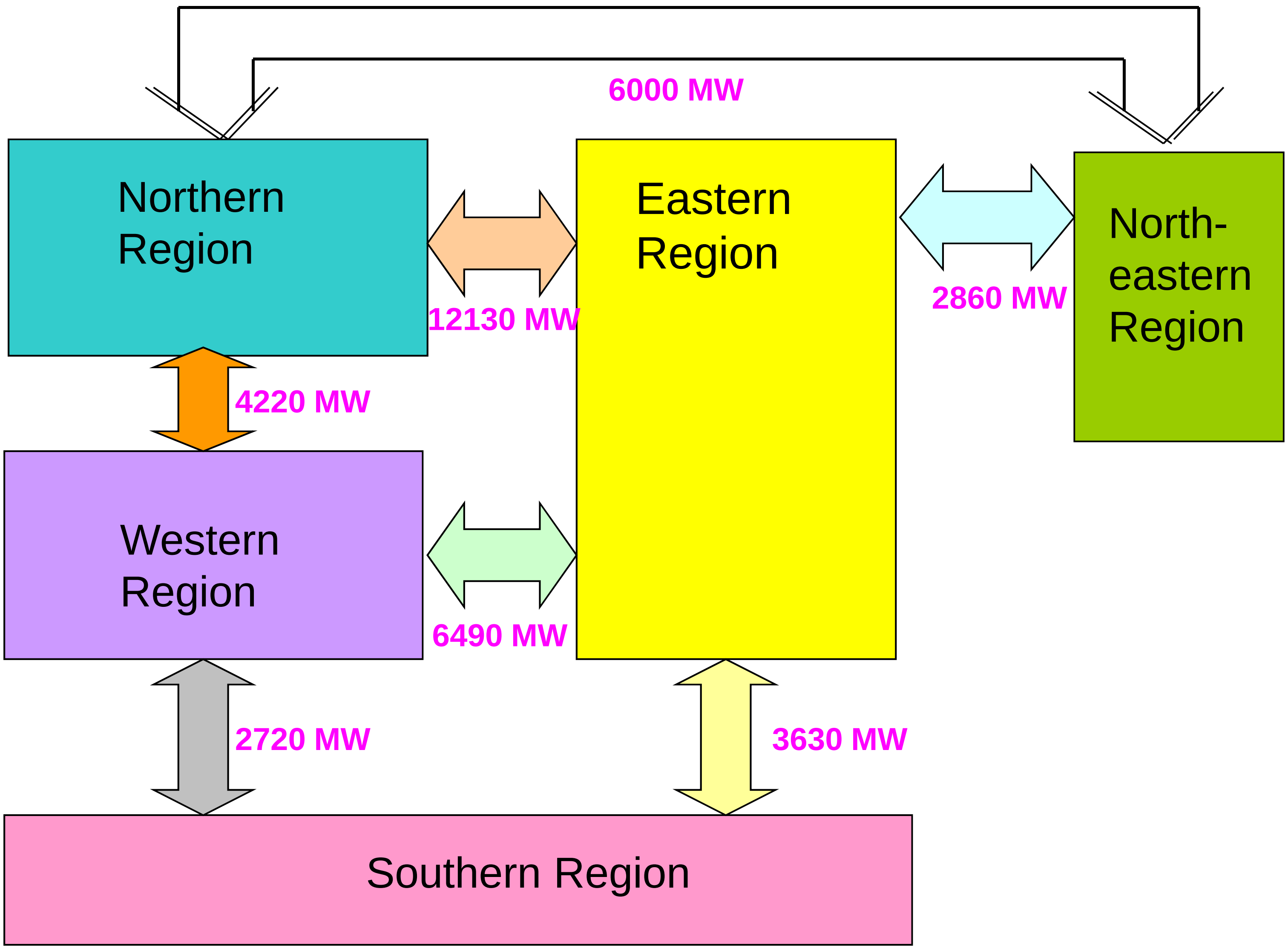
Inter-regional Capacity - 18,700MW (incl. 132kV links)

National Grid - Present

Inter-regional capacity : 18,700MW



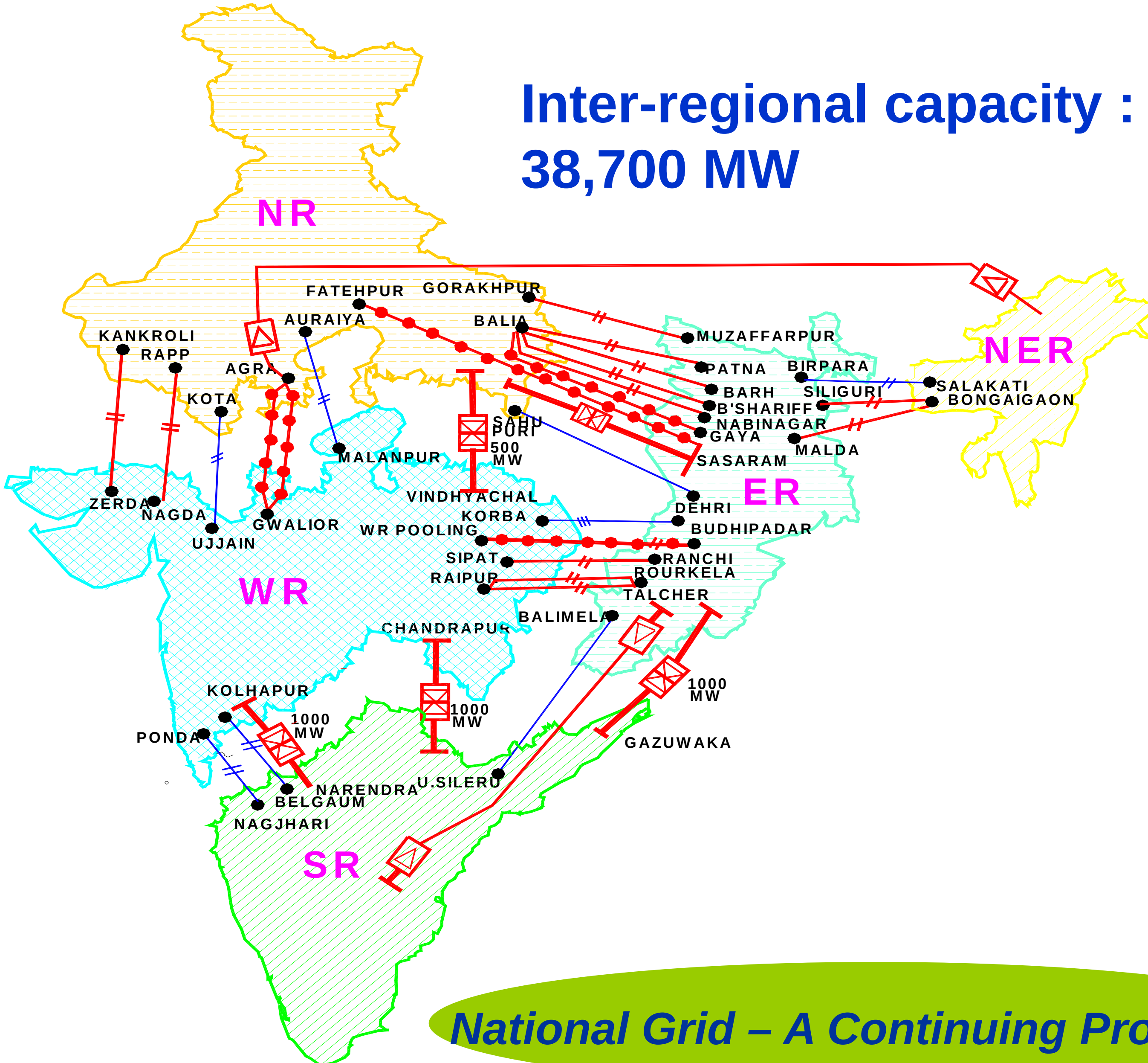
National Grid by 2012



Inter-regional Capacity - 38,700MW (incl. 132kV links)

National Grid by 2012

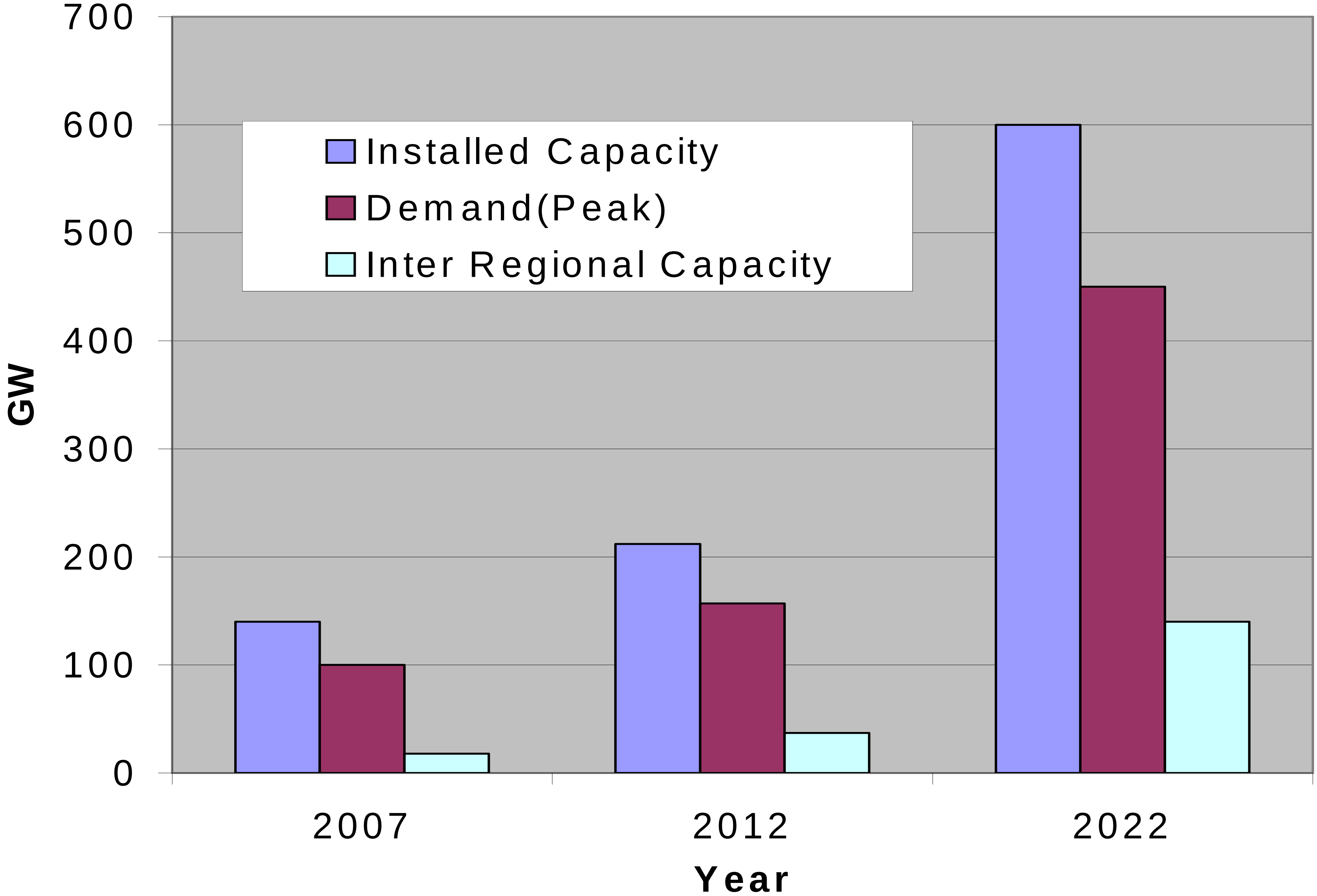
Inter-regional capacity : 38,700 MW



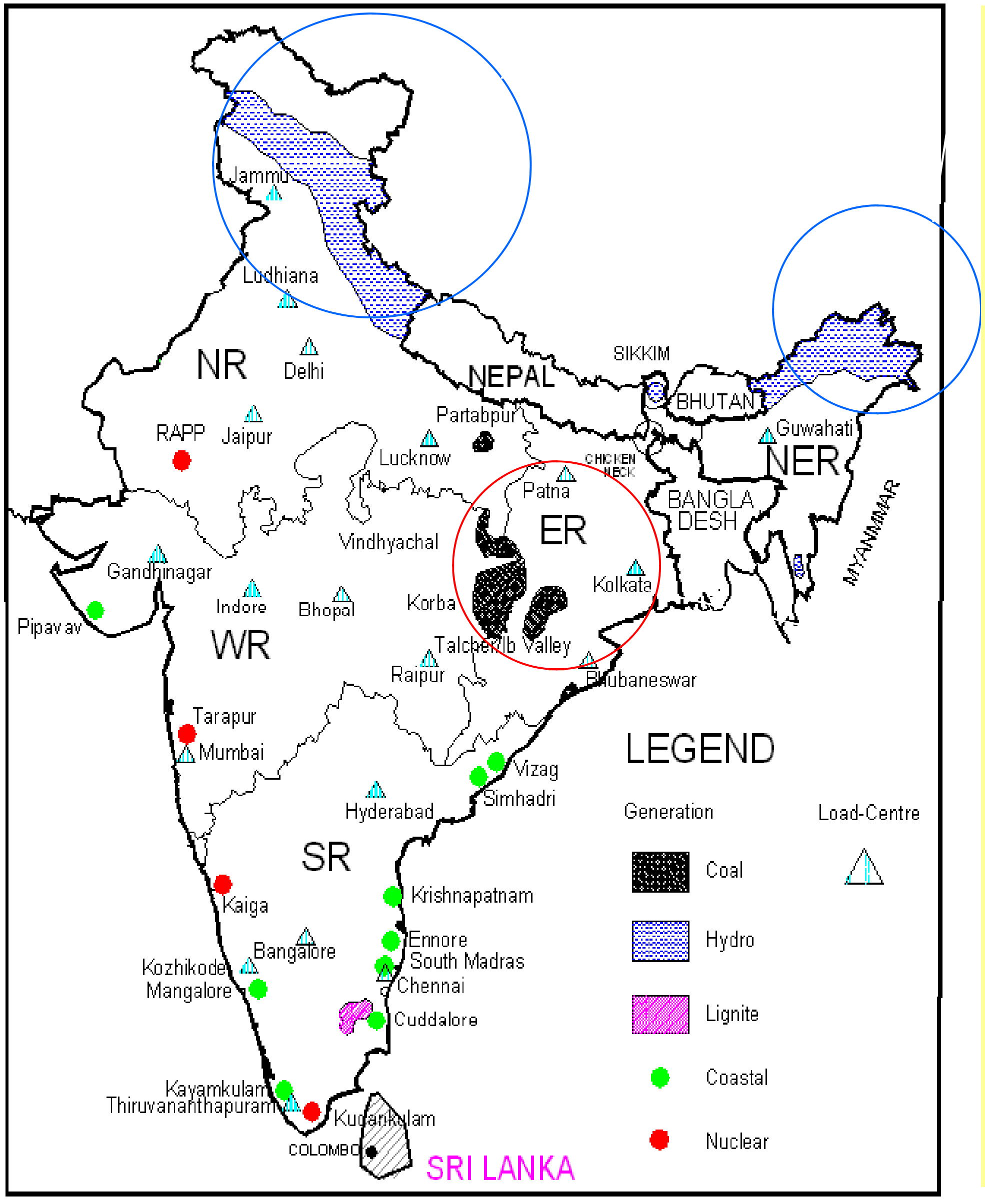
National Grid – A Continuing Process

Future Requirement

Growth of Installed Capacity/Demand



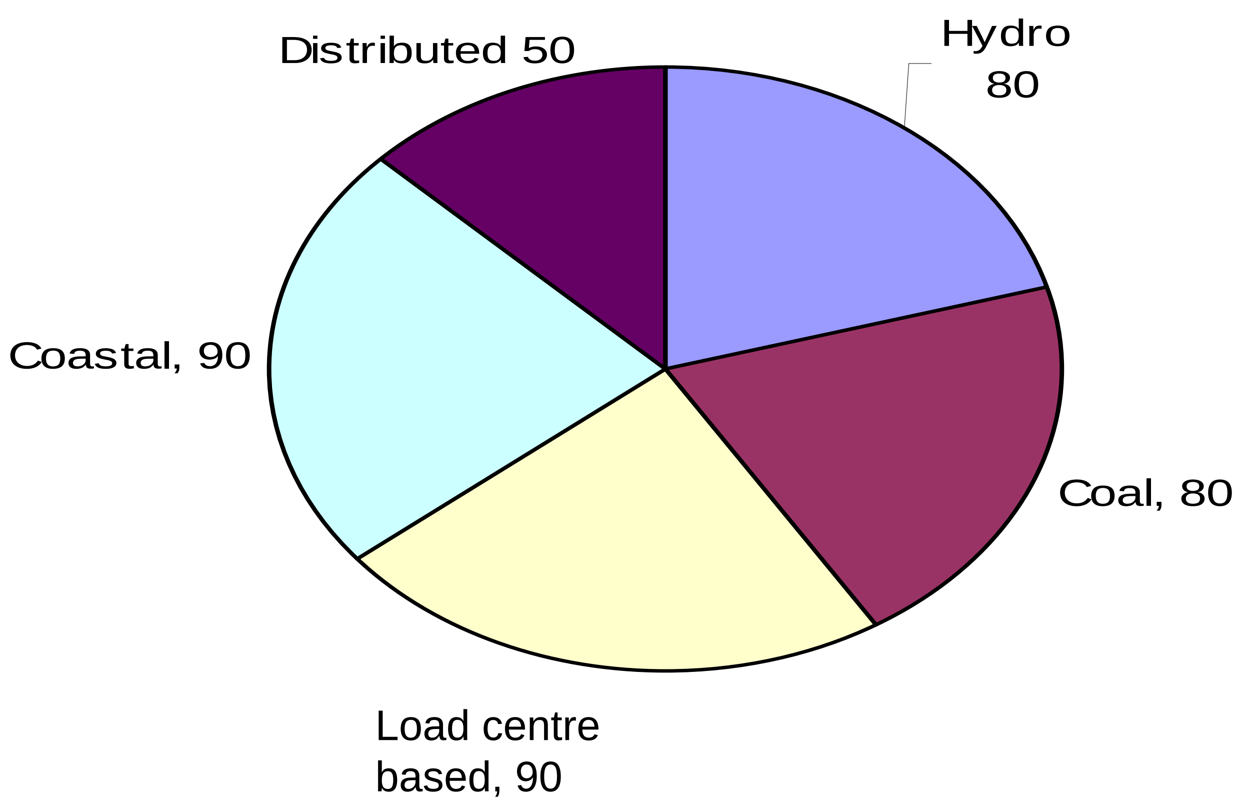
Energy Resource Map



- **Hydro potential in NER and upper part of NR**
- **Coal reserves mainly in ER**
- **Ensure optimal utilisation of resources – strong National Grid is in place and capacity is being enhanced continuously**

Likely Capacity addition in next 15 years

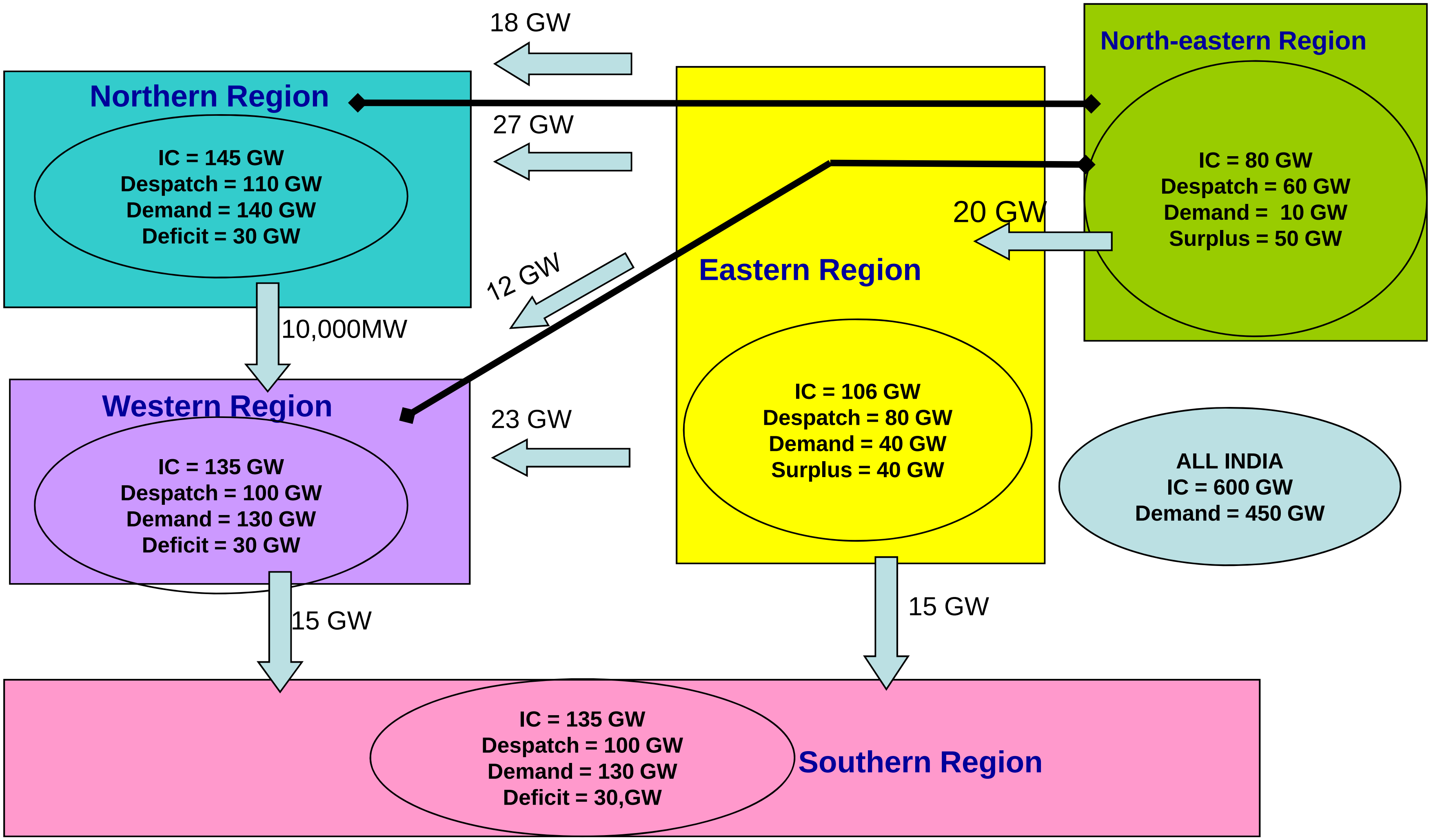
- **Peak Demand : 450GW**
- **Inst. Capacity : 600GW**
- **Additional capacity addition of about 390GW would be required**



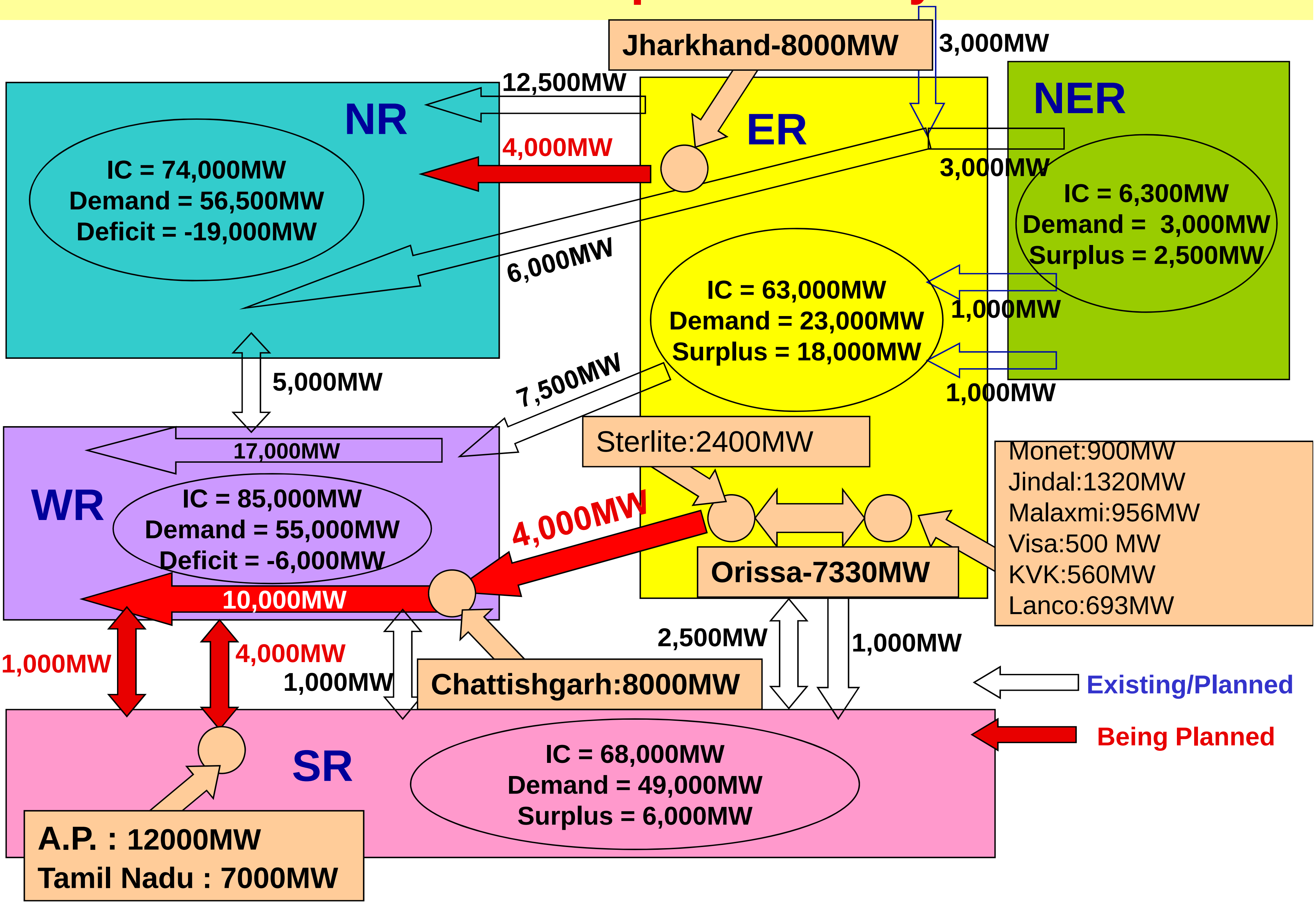
Future Demand-Supply Scenario

Region	Installed Capacity (GW)	Availability (GW)	Peak Demand (GW)	Surplus(+) /Deficit (-) GW
Northern	145	110	140	(-) 30
Western	135	100	130	(-) 30
Southern	135	100	130	(-) 30
Eastern	105	80	40	(+) 40
North-eastern	80	60	10	(+) 50
Total	**600**	**450**	**450**	

Likely power transfer requirement between various regions in next 15 years



Power Transfer Requirement by 2014-15



Transmission Development

Consideration for Future Transmission Development

1. Requirement of Bulk power transfer over Long Distances from resources rich area/region to load centers

2. ROW constraints, limited Transmission corridors available

3. High Short Circuit Levels

4. Variation and regulation in Power Flow

Power Flow Pattern

1. **Variation in generation**
   - High hydro in monsoon and summer
   - In winter only during peak hours
   - Power flow variations due to commercial/operational reasons

2. **Variation in load demand**
   - Daily basis (peak and off-peak)
   - Seasonal variations

Due to above, each transmission corridor has varied power flow pattern ranging from high to low loading, results into wide variation in voltages

Present Technologies & its Limitations

- 400 kV Twin Moose - upto 600-700MW
- 400 kV Quad Moose - Upto 1200-1500MW
- 765 kV Line - upto 2000/3000 MW
  - Sipat – Seoni first 765 kV line operated at rated voltage
- HVDC bipole - $\pm$ 500 kV upto 2000-2500MW

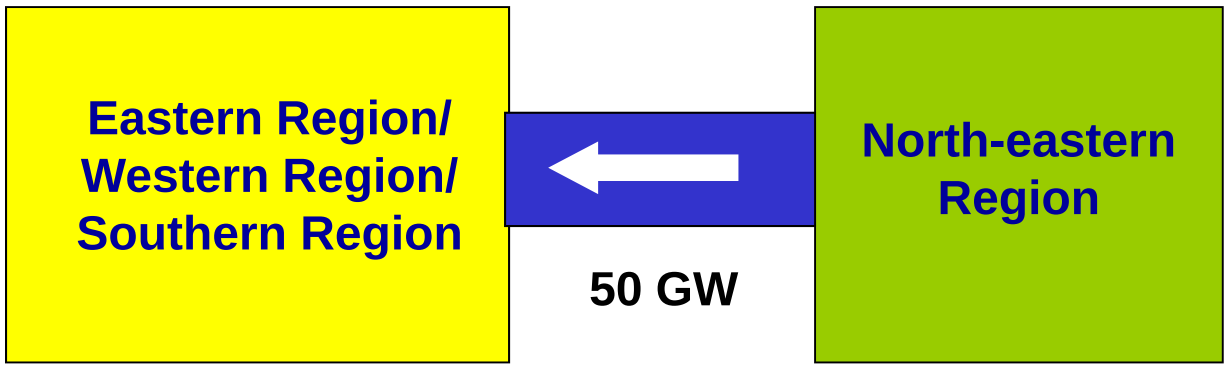
Need

1. **Development of hybrid transmission system for maintaining critical parameters as well as regulations of power flow**

2. **Increase in MW flow per metre of ROW**

3. **Controlling high Short Circuit Levels**

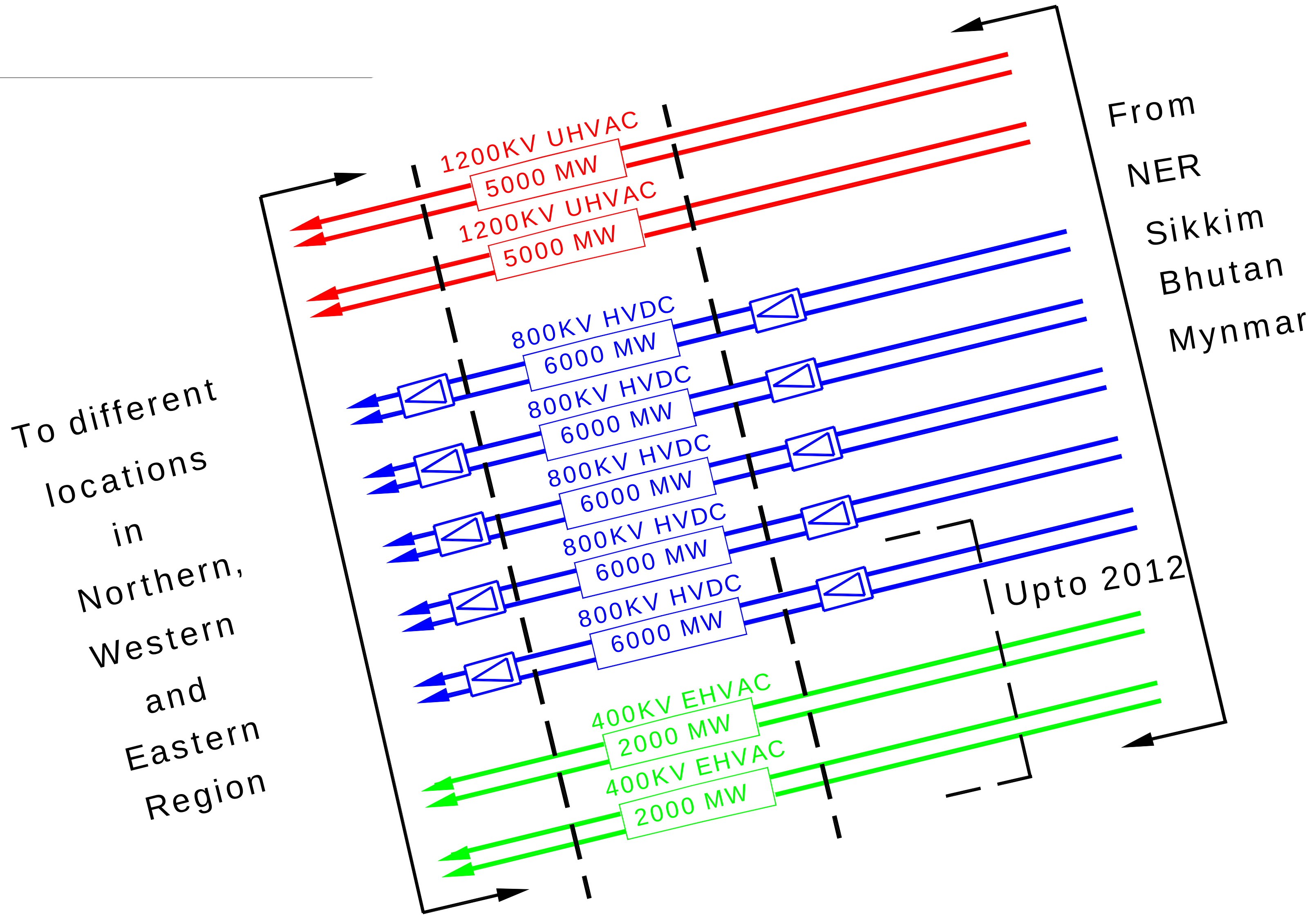
Transmission System through Narrow Area



- **Requirement of Power Flow between NER & ER/WR/NR: 50 GW**
- **Required Transmission Capacity : 57.5 GW (15% redundancy)**
- **Existing & planned Capacity : 9.5 GW**
- **Additional Trans. Capacity to be planned : 48 GW**

  Options :
  1. ±800kV HVDC : 8nos.
  2. ±800kV HVDC : 5nos.; 765kV EHVAC : 6nos.
  3. ±800kV HVDC : 4nos.; 1200kV UHVAC : 2nos.
- **Selection of Next Level Transmission Voltage i.e. 1200kV UHVAC in view of :**
  - Loading lines upto **Thermal Capacity(10000 MW)** compared to **SIL(6000 MW)**
  - Saving **Right of Way**

Transmission System through Narrow Area



1200kV AC Transmission System – Considerations

- In Chhattisgarh State, projects with total capacity of about 35,000 MW have been planned to be commissioned progressively in the next 4-5 years.

- Power from these projects is to be transferred to bulk load centres in the Western and Northern Regions.

- To facilitate exchange of such quantum of power, strengthening of East-West and East-North transmission corridors in WR is required.

- Further, it has been observed that growth of interconnection at 400kV/765kV level would result into increase in short circuit level at various EHV substations beyond the limit (40kA)

1200kV AC Transmission System – A Case Study

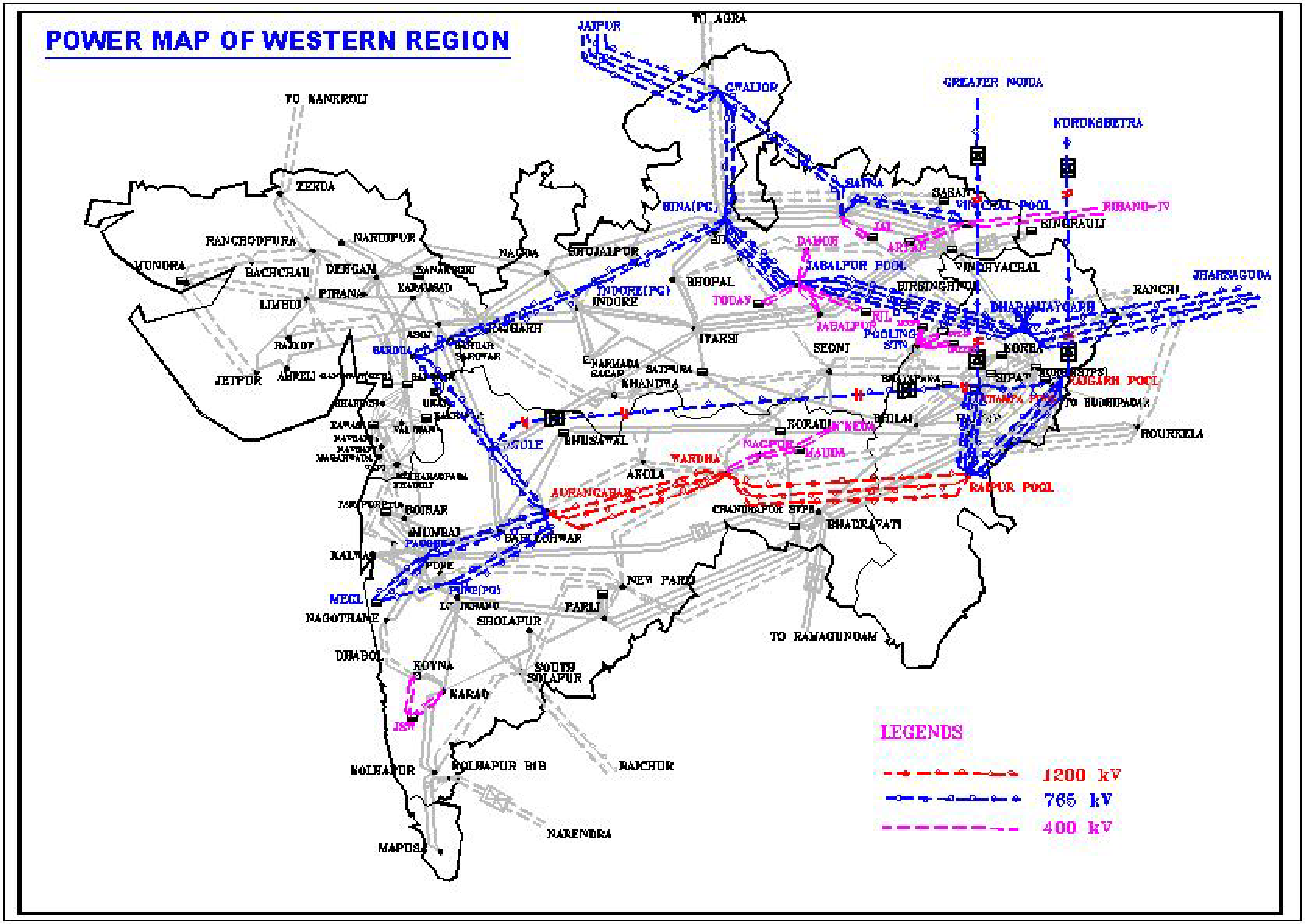
- Considering quantum of power transfer on long-term as well as to address high short circuit level, a high capacity 1200kV transmission corridor i.e, Raipur-Wardha and Wardha- Aurangabad is proposed

- Projects are being developed in a phased manner with less power transfer requirement initially, it is proposed that this high capacity East-West transmission corridor shall be operated initially at 400kV level.

  Accordingly, with suitable design 1200kV S/c line is initially proposed to be operated as a 400kV (quad) D/c line so that system redundancy can be maintained.

  Subsequently, with the increase in power transfer requirement through this corridor, line shall be operated at 1200kV level

Proposed 1200kV AC Transmission Corridor



Line Parameters

❖ **Line parameters of 1200kV/765kV/400kV Transmission System**

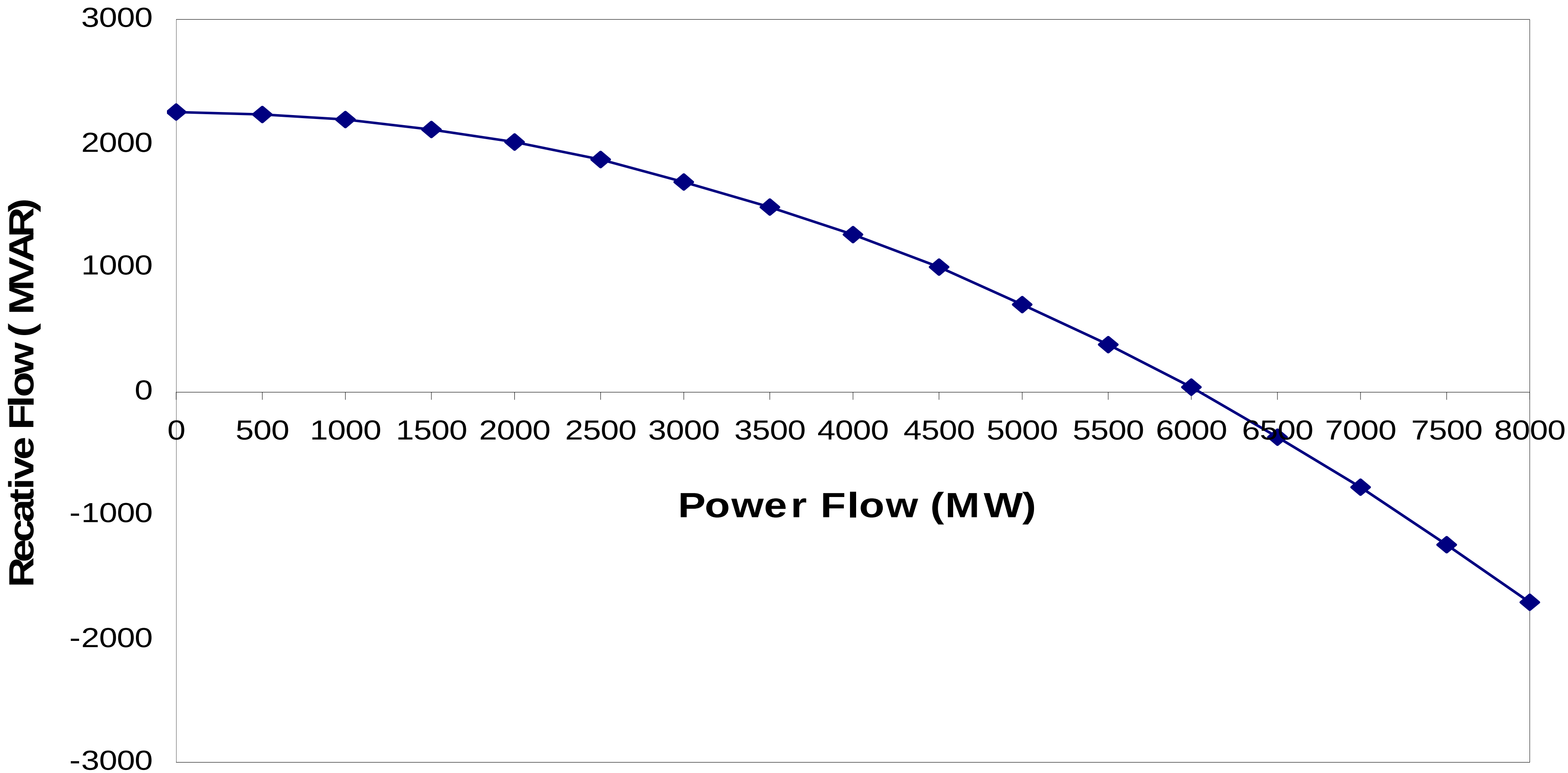
	1200 kV	**765kV**	**400kV**
Nominal Voltage (kV)	1150	765	400
Highest voltage(kV)	1200	800	420
Resistance (pu/km)	4.338×10^{-7}	1.951×10^{-6}	1.862×10^{-5}
Reactance (pu/km)	1.772×10^{-5}	4.475×10^{-5}	2.075×10^{-4}
Susceptance (pu/km)	6.447×10^{-2}	2.4×10^{-2}	5.55×10^{-3}
Surge Impedance Loading (MW)	6030	2315	515

Base kV :1200kV/765kV/400kV; *Base MVA :100 MVA*

Large Variation of Reactive MVAR

- Reactance of 1200kV AC line is 1/3rd of 765kV system
- Susceptance (charging capacitance) is 2½ times more of 765kV line
- Wide difference in the electrical parameters shall lead to the problems of reactive power (VAR) balance
- Huge Reactive Power Generation by 1200kV line about 6 MVAR/km
- These uncompensated lines shall generate huge capacitive charging reactive power for which static reactive compensation devices like shunt reactor, bus reactor of adequate size is to be provided

1200kV Wardha – Aurangabad line reactive power characteristic

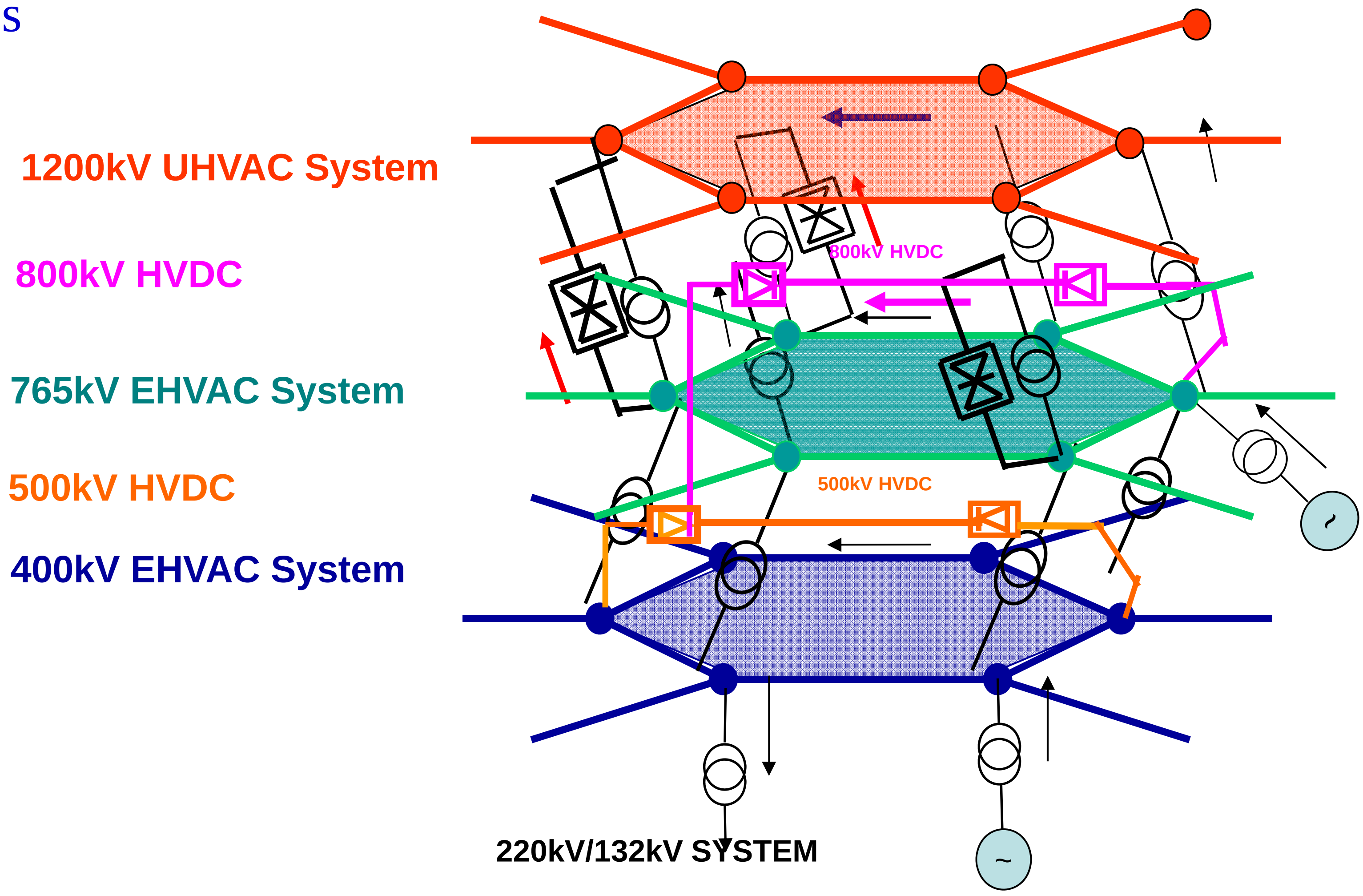


Reactive Power Management of 1200kV Lines

- Maintaining constant/optimum level of power flow on the 1200kV AC system under different operating conditions
- To control power through 1200kV AC system a layered system of 1200kV AC transmission corridor along with ±800kV, 6000MW HVDC system shall be developed
- Control and regulation mechanisms
  - Exchange of power between 1200kV AC system and lower level network (765kV/400kV) through HVDC back-to back links at strategic locations
  - Control of power flow on the 800kV HVDC bipole lines
- Dynamic Reactive Power Management through Series and Shunt Compensation

Maintaining Uniform power flow through 1200kV System

Layered high capacity transmission network with control & regulation features



Increase in Short Circuit Level

- Indian system is designed for max. short circuit level – 40kA
- After 30 years of operation, it is expected that fault level at various S/s shall increase beyond its limit in next 4-5 years
- Most of these s/s are either major pooling stations or high capacity trans. Interconnections with major generation complex/substations
- Development of 1200kV transmission corridors shall facilitate in controlling high short circuit level, although other mitigating measures are also being taken

Broad Parameters

Other 1200kV Parameters

Based on the preliminary studies, broad parameters determined as under :

Sl No.	Description/Parameters	Unit	Value
1	System Nominal Operating parameters		
(i)	Phase – Phase	kV	1150
(ii)	Frequency	Hz	50
(iii)	Number of phases	Nos	3
2	System Maximum Voltage (Ph-Ph)	kV	1200
3	System Insulation Levels		
(i)	Full wave impulse withstand voltage (1.2/50 microsec.)	kV	2400
(ii)	Switching impulse withstand voltage (250/2500 micro sec.) dry and wet	kV	1800
(iii)	One minute power frequency dry and wet withstand voltage (rms)		1200

Other 1200kV Parameters ...contd

Sl No.	Description/Parameters	Unit	Value
4	Short Circuit Level	kA	50
5	Corona extinction voltage	kV	762
6	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 762 kV rms for 1200kV system	Micro V	1000
7	Creepage Distance	mm/kV	25 i.e. (Total 30000 for 1200kV system).
8	Bus Bars/Equipment Interconnections		
(i)	Tubular Bus/Connections		Twin Al. 4” IPS tubes with 450mm/550mm spacing.
(ii)	Height	m	18.00
(iii)	Strung Bus/Equipment Connections Conductor Bundle		Octa Bundle Bersimis with 450 mm sub conductor spacing

Other 1200kV Parameters ...contd

Sl No.	Description/Parameters	Unit	Value
9	Clearances		
(i)	Minimum Phase to Phase Clearance	m	12.30
(ii)	Minimum Phase to Earth Clearance	m	8.30
(iii)	Sectional clearances	m	10.5
(iv)	Phase to Phase distance (Pie Structure)	m	27.00
10	System neutral earthing	-	Effectively earthed

Field Studies on 1200kV AC System

- POWERGRID has undertaken various studies and tests to determine the configuration of its 1200kV transmission lines, like
  - corona cage studies
  - air gap insulation studies
  - tests for voltage distribution on the insulator string
  - long term studies on test line for measurement of AN, RIV & voltage gradient measurement at ground level

1200kV Test Station

Establishment of 1200 kV AC Test Station

- To develop 1200kV technology indigenously, POWERGRID in collaboration with manufacturers establishing a 1200kV AC Test Station at Bina

- This endeavour shall benefit the Indian Power sector and manufacturers for
  - Optimisation of transmission cost
  - Ease in O&M

1200KV UHVAC Test Station

- A 3 phase 1200kV Test Lines (S/C & D/C) of about 1 km length are being constructed. Salient features:
  - Variable Phase to Phase Spacings
  - Variable Ground Clearance
  - Upto 12 sub-conductor bundle
  - Variable Bundle diameter

- A 1200kV 3-phase test bay is being constructed to charge these Test Lines

1200KV UHVAC Test Station

- Test station shall be fully equipped with testing instrument for field testing

- Extensive developmental tests shall be conducted on the test line as well as on s/s equipments installed in the Test Bay jointly by Utilities, Manufacturer & Research Institute

Summary

Summary

- To meet growing power transfer requirement and environmental friendly development, 1200kV AC system along with ±800kV, 6000MW HVDC system has been planned in the Indian Power System
- Reactive power management for 1200kV AC system is an important aspect which require detail analysis for suitable static and dynamic reactive compensation
- Results of some of preliminary studies discussed
- More studies and field tests are under process to finalise all the critical electrical parameters
- Establishment of a 1200kV AC Test Station at Bina is under progress

Thank You