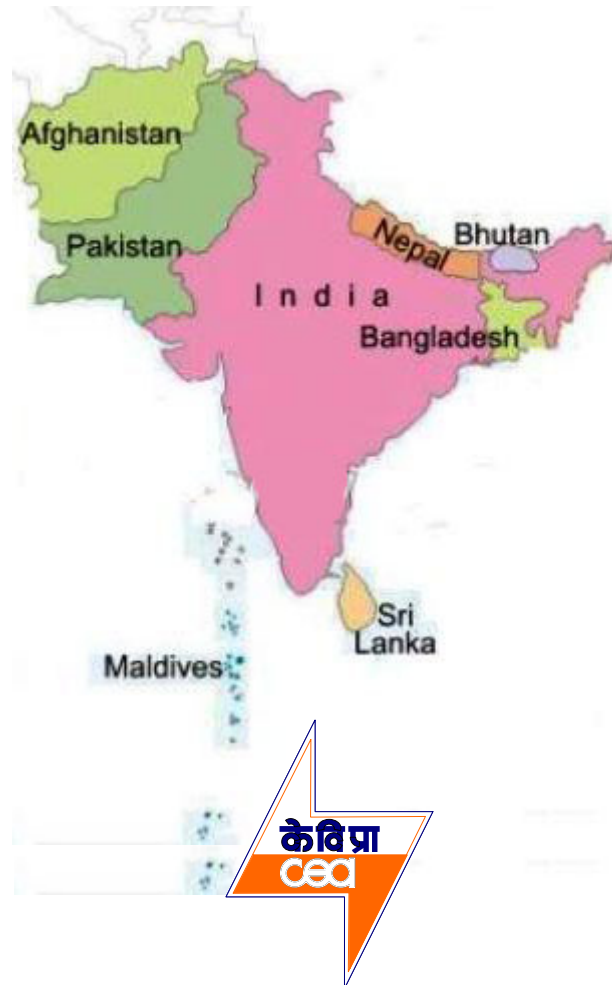


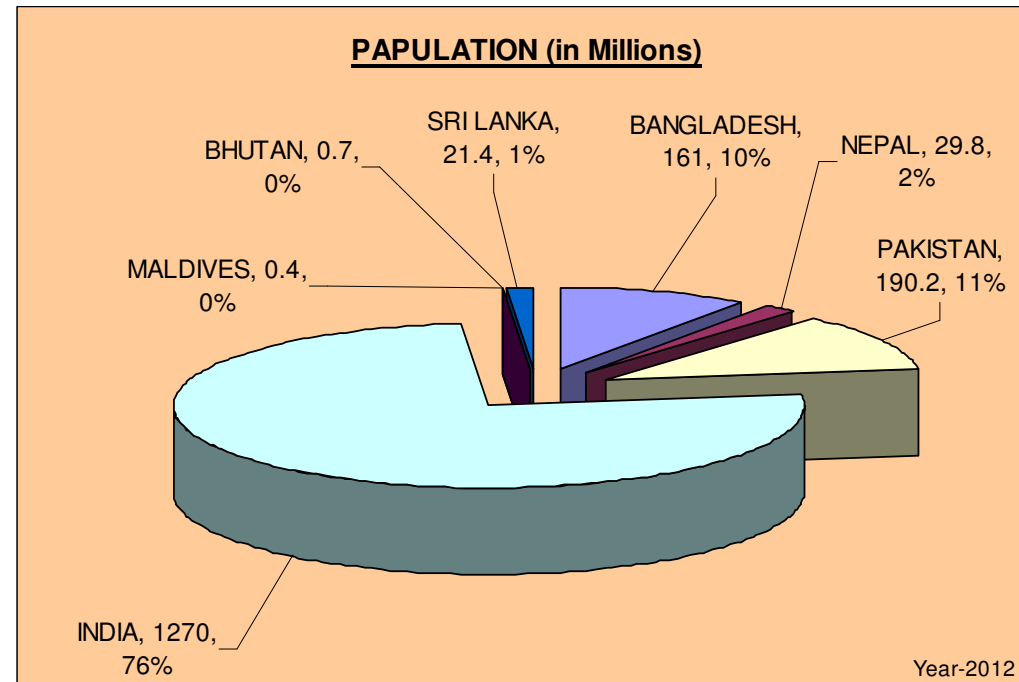


Capacity addition based on SAARC requirements:

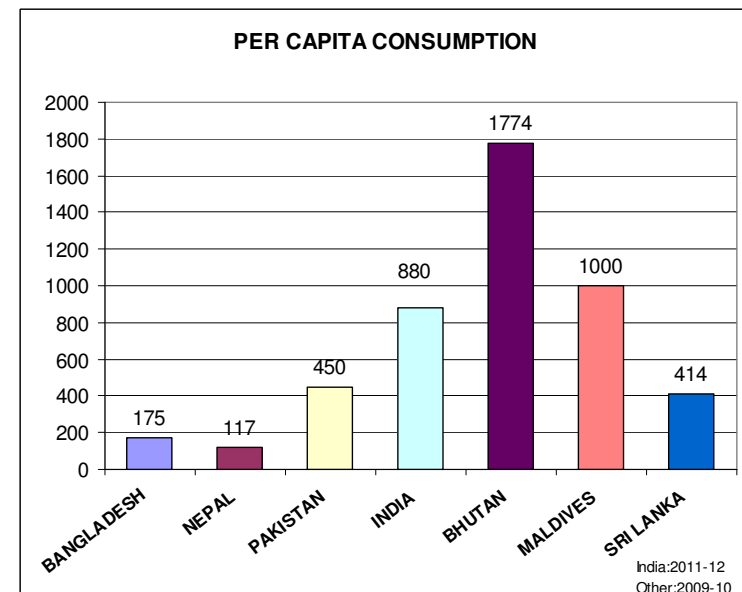
**Experience of Transmission Planning in India & Lessons
for planning of Cross border lines**

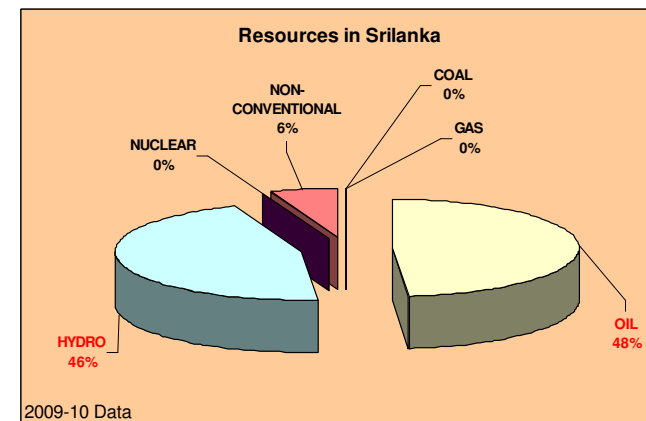
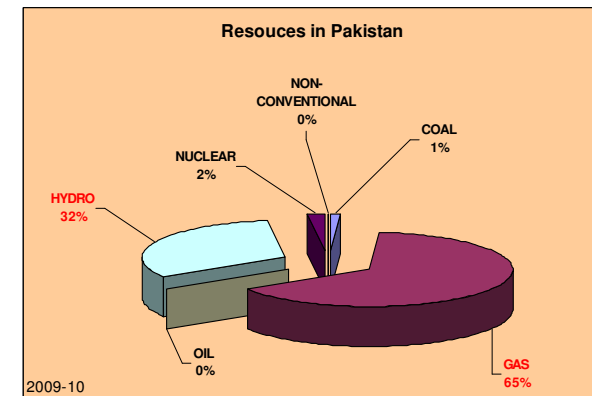
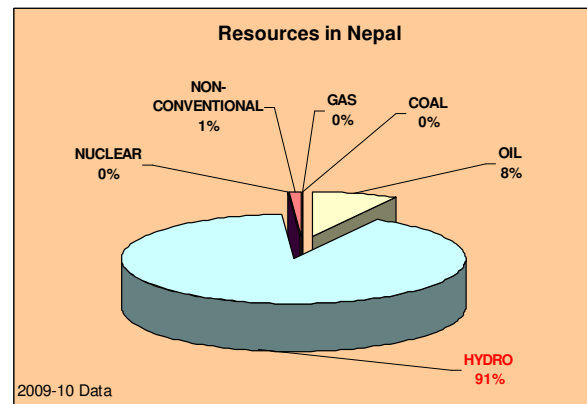
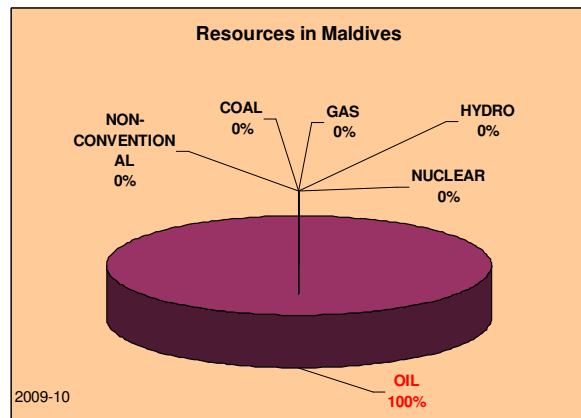
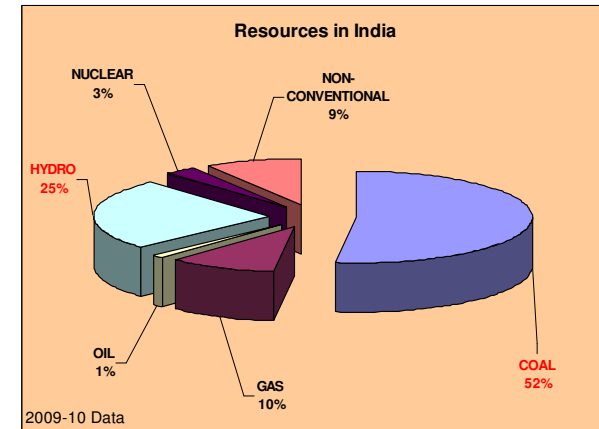
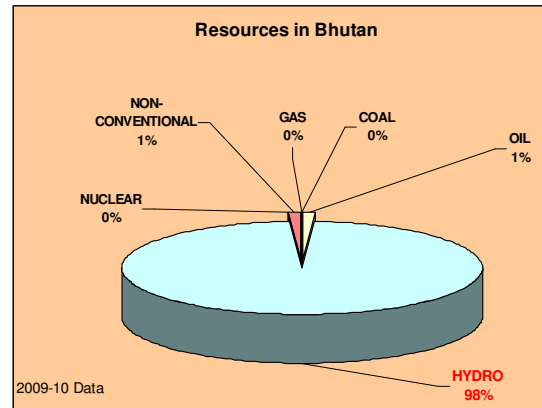
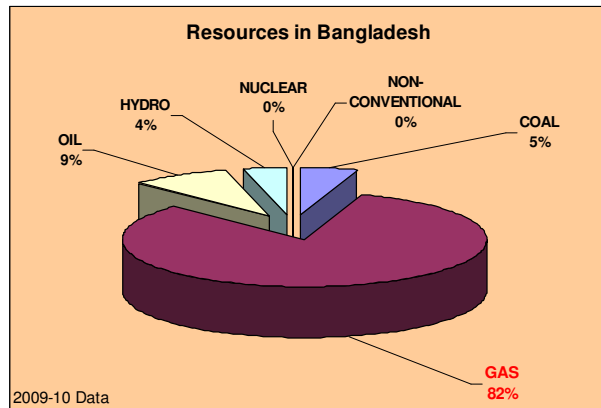
Dr. R. Saha
Central Electricity Authority (CEA)
26th Sept. 2013

SAARC countries



□ Per Capita Energy consumption(kwh/per annum)
- an index of economic and social development





Potential Resources of SA countries

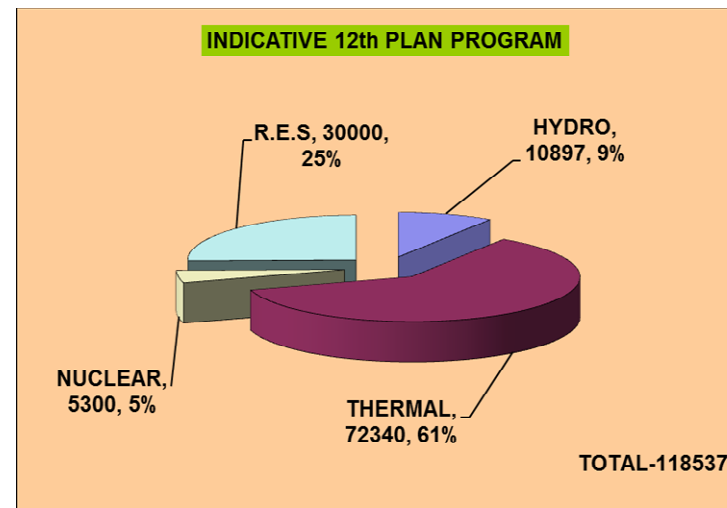
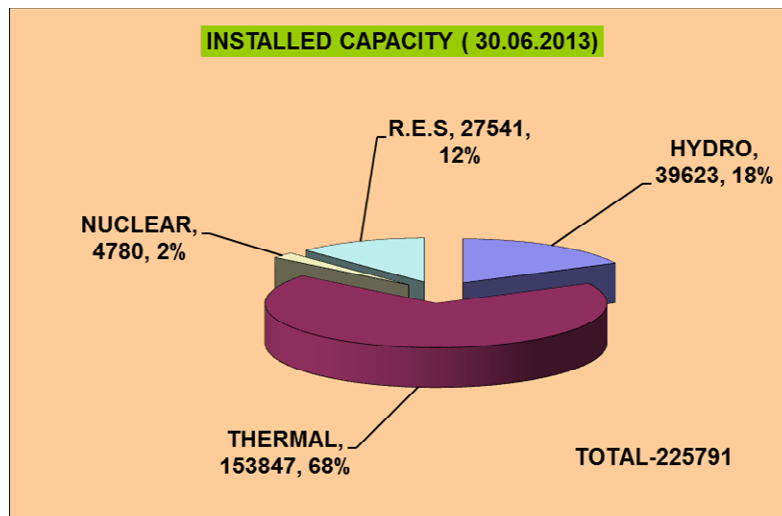
Potential Aspects

- Hydro potential in Nepal ~ 80 GW, Bhutan~ 30 GW & India~ 50 GW.
- Each of the SAARC countries has grid frequency of 50Hz.
- Power transmission voltages in SAARC countries are either of the following or a combination thereof:
110kV,132kV,220kV,400kV,500kV , 765kV AC.
- Global endeavour to minimize effect of carbon dioxide emission by harnessing and integrating electricity generation from renewable and non conventional energy sources such as wind, solar etc. with main grid.
- **Common Electricity Grid being envisioned amongst SAARC would enable to:-**
 - **Optimize utilization of energy resources of entire SAARC region**
 - **Extend energy co-operation in terms fossil fuel management**
 - **Optimize investment in electricity generation**
 - **Improve Demand side management**
 - **Enhance energy security of the South Asia region.**
 - **Increase per capita consumption**
 - **Supply quality power to the end users**
 - **Reduce carbon emissions and carbon intensity**
 - **Improve Social and Economic benefits to the South Asia region.**

Indian Power Scenario

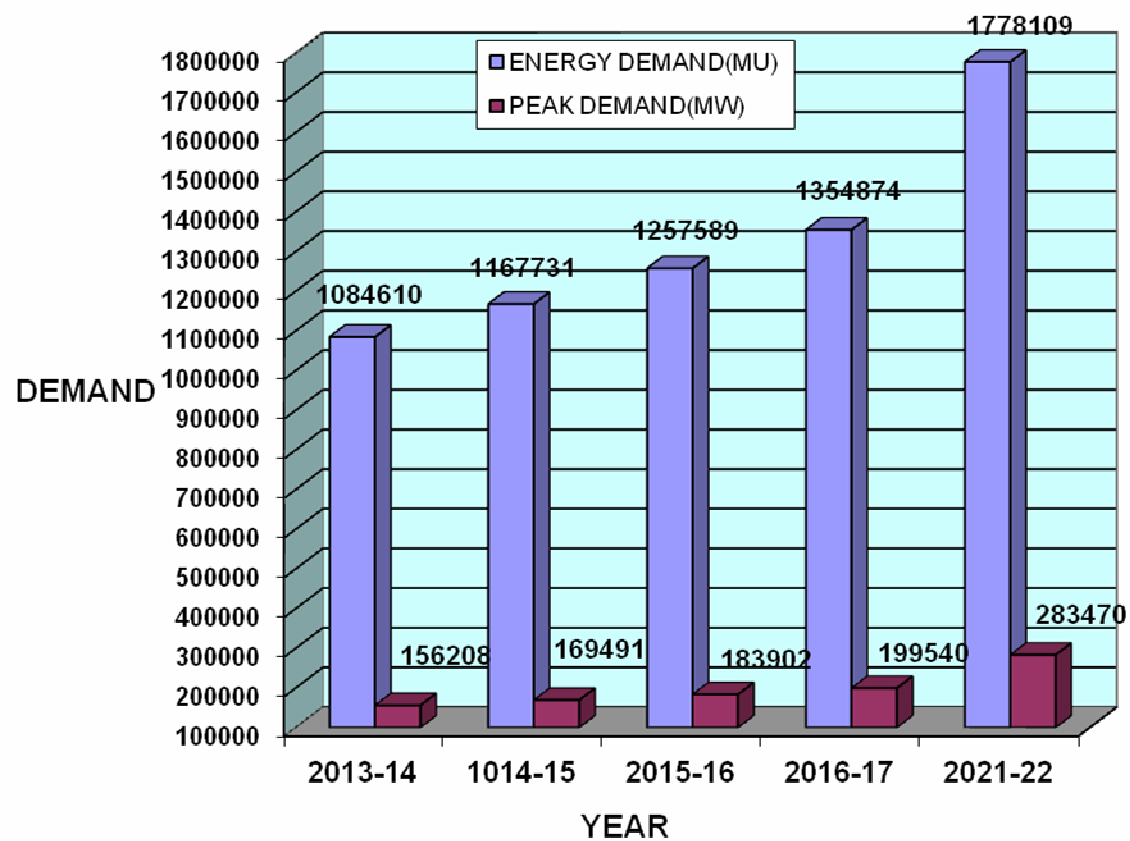
Power Generation

- Installed Generation Capacity is about 225 GW (June'13); Capacity addition during the 12th Plan (i.e. by 2016-17) is 88.5 GW (Pvt. Sector-46825 MW, Central-26182 MW, States-15530 MW).

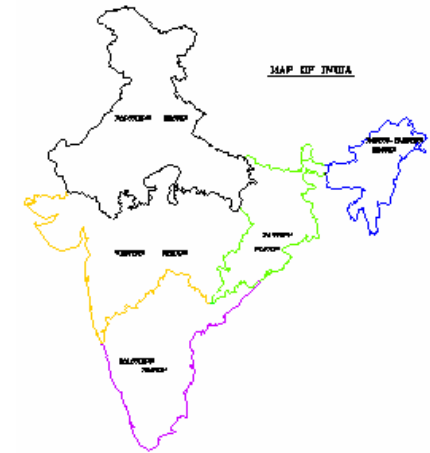


- System Demand as of now is about 140 GW and it is likely to grow to about 200 GW by 2016-17.
- Generation Capacity of **RES** is 27.5 GW; 30 GW is envisaged to be added by 2016-17.
- 50 GW Hydro initiative launched. Of this ~ 35000 MW in NER
- Cost Economics favors power transmission from pit-head compared to transportation of coal

PEAK (MW) & ENERGY (MU) Demand (AS PER 18TH EPS REPORT)



Power Transmission Scenario in India



- Indian Electricity Grid(s) is geographically demarcated into 5-Regions-NR,WR,SR,ER & NER.
- Power System is comprising ISTS System (CTU, PVT. Sector) and intra-State Transmission.
- 5 Regional Grids (NR,WR,SR,ER & NER) are interconnected & National Electricity Grid is on the horizon.
- NR-WR-ER-NER is one synchronous Grid
- SR Grid shall be synchronized by early 2014 and five grids shall be ONE SYNCHRONOUS GRID in India.
- Regional concept of Power system planning transformed into National concept.
- Endeavour to harness and integrate Renewable Energy Generation (RES) with the main Grid; 30GW addition is envisaged by 2016-17
- Open and growing electricity market, physical power trading & trans country power exchange are the Indian Power Sector development scenario over a decade.

Electricity Market in India.....a Paradigm Shift

Electricity Act 2003 :

Providing a competitive framework for accelerated development of the Power Sector:

- ◆ Delicensing of Generation.
- ◆ Power Transmission as licensed activity
- ◆ Power Trading as distinct activity (many CERC licensed traders are in power trading)
- ◆ Transmission licensee to provide **non-discriminatory open access** to its transmission system for use by any licensee or generating company for wheeling its power on payment of transmission charges.
- ◆ Environment for competition among Generators/Traders to choose their customers and vice-versa.

Transmission Planning & Development

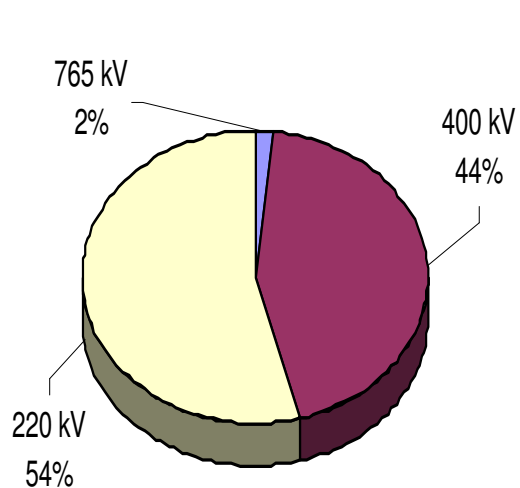
- Electricity grids are comprising Inter-State (mainly by CTU/PGCIL) and intra-State Transmission (mainly by STU).
- Power system planning has been aligned with the Transmission Planning Criteria (n-1/n-1-1 contingency), EA,2003, National Electricity Policy, Tariff policy, Electricity Grid Code, Regulations and market orientation of the Electricity Sector.
- Transmission planning exercises are carried out in-coordination by CEA, CTU, STUs & other Stakeholders – system finalization & review at Regional Standing Committee on Power System Planning.
- High capacity Transmission system for UMPPs (~4000MW) at **Tilaiya (Bihar), Sasan(MP), Mudra (Gujarat), Krishnapatnam (AP)**, Chattisgarh (RfQ),Orissa(RfQ), Cheyyur (TN), Karnataka.
- Identified green corridors for evacuation of Renewable Energy Generation, integrating with the main Grid.
- Transmission System Development followed on Tariff Based Competitive Bidding (TBCB) Policy- Inter State (5-1-11) & Intra-State(5-1-13)
- Transmission charge recovery mechanism based on Point of Connection (PoC) Tariff methodology

Technologies for Transmission

- ☐ EHV/UHV AC: 132kV, 220kV, 400kV, 765kV, 1200kV
- ☐ HV/UHV DC: $\pm 500\text{kV}$, $\pm 800\text{kV}$
- ☐ **FACTS**-Dynamic Controllers (HVDC, TCSC, SVC & STATCOM)
- ☐ Hybrid: Combination of AC & HVDC
- ☐ Multi-circuit & Multi-Voltage Tower line
- ☐ Compact Towers (optimizing RoW requirement)
- ☐ High ampacity HTLS conductors
- ☐ GIS Technology

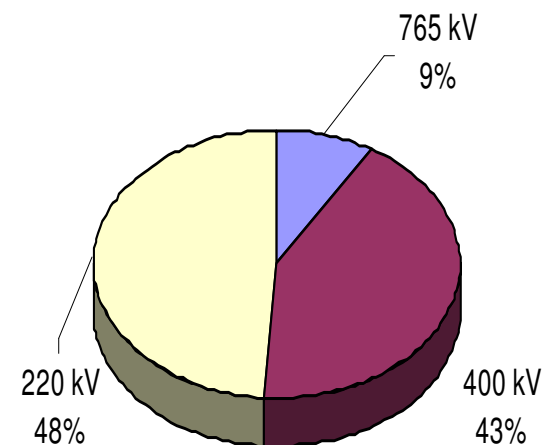
- ☐ **Time stamped Synchro-Phasor Technology** (PMUs/ WAN) for greater operational visibility, intelligent decision making by system operators, and for improving reliability, security and optimal utilization of resources.

➤ Transmission growth & Sub-Station growth

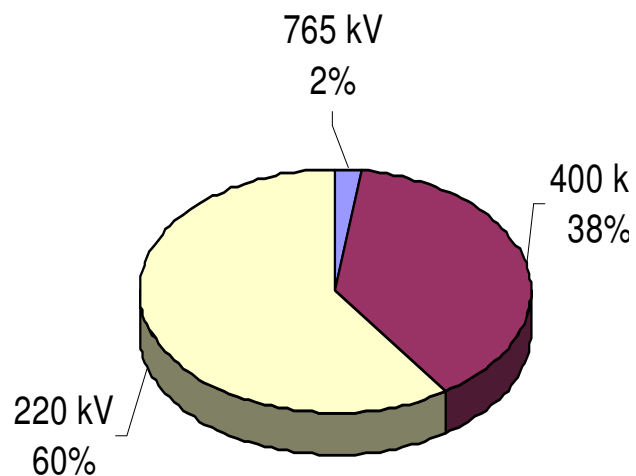


By 2011-12

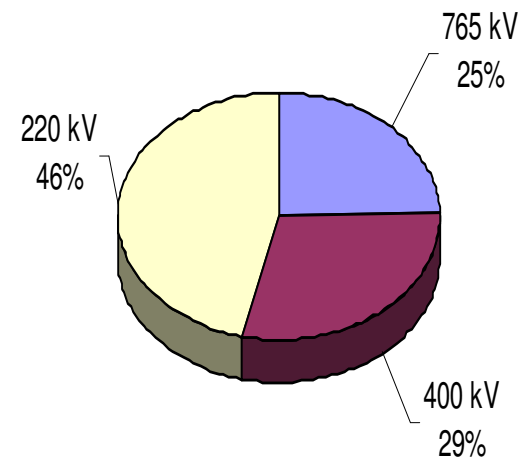
Circuit km.(ckm)



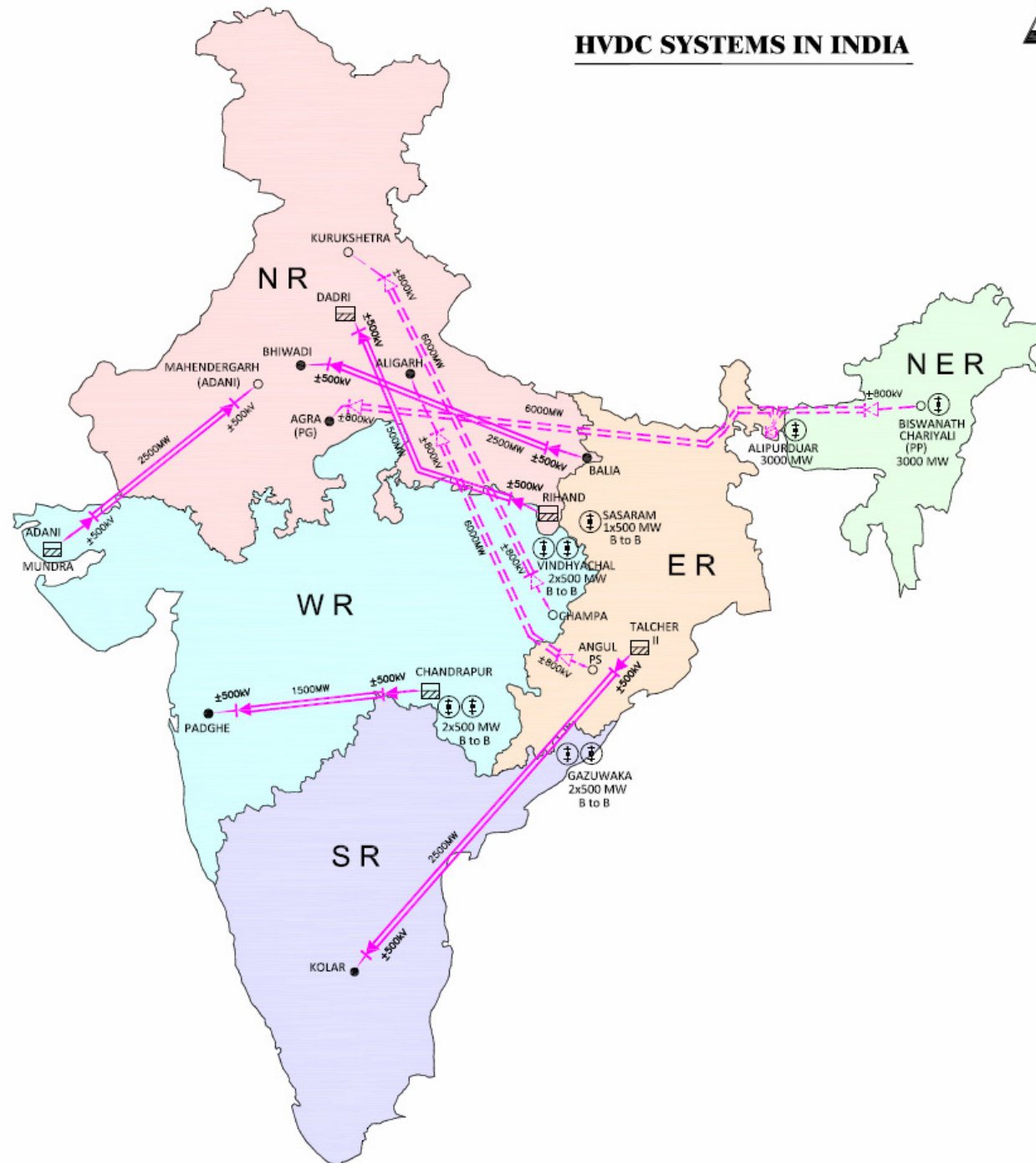
By 2016-17



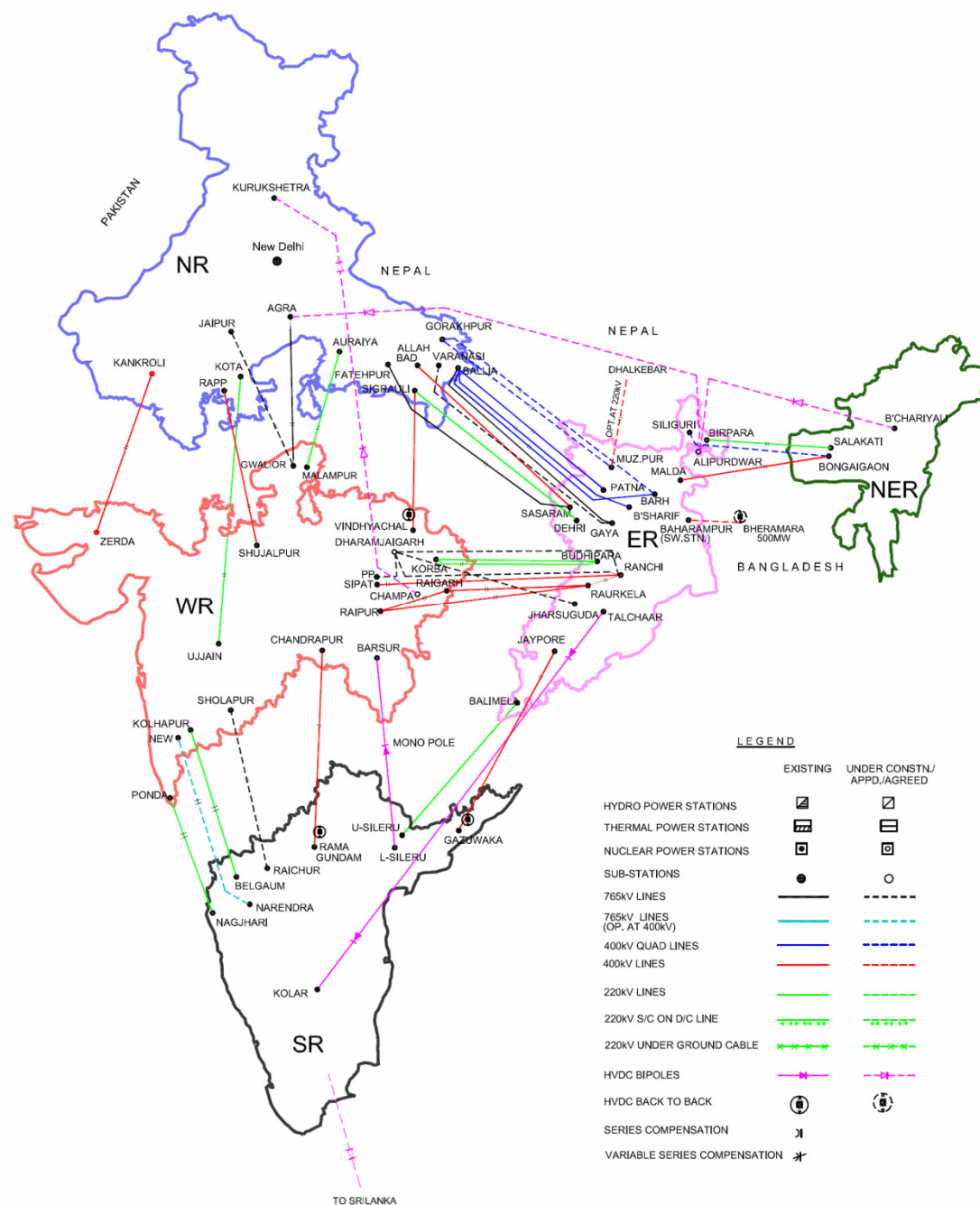
Sub-Station MVA



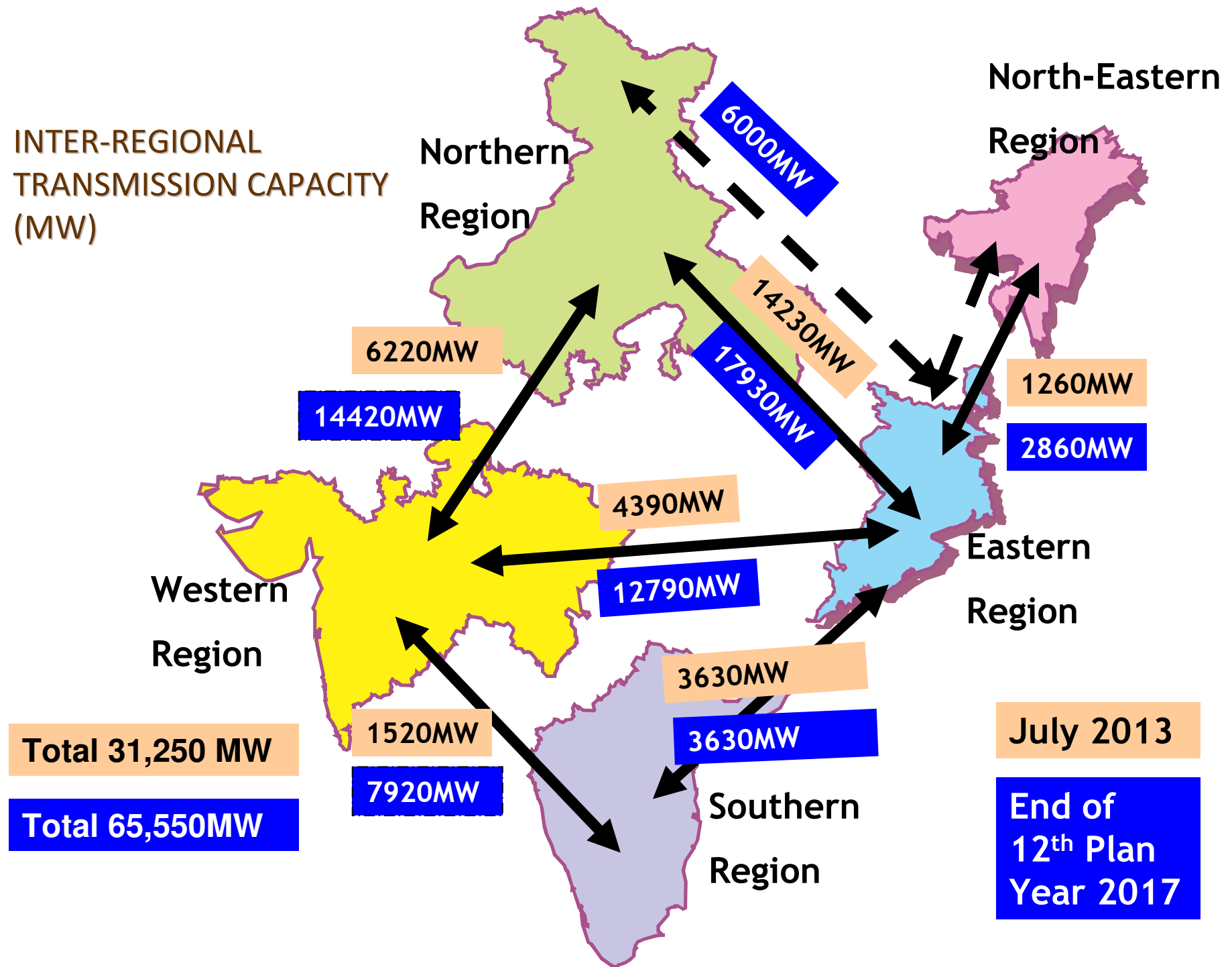
HVDC SYSTEMS IN INDIA



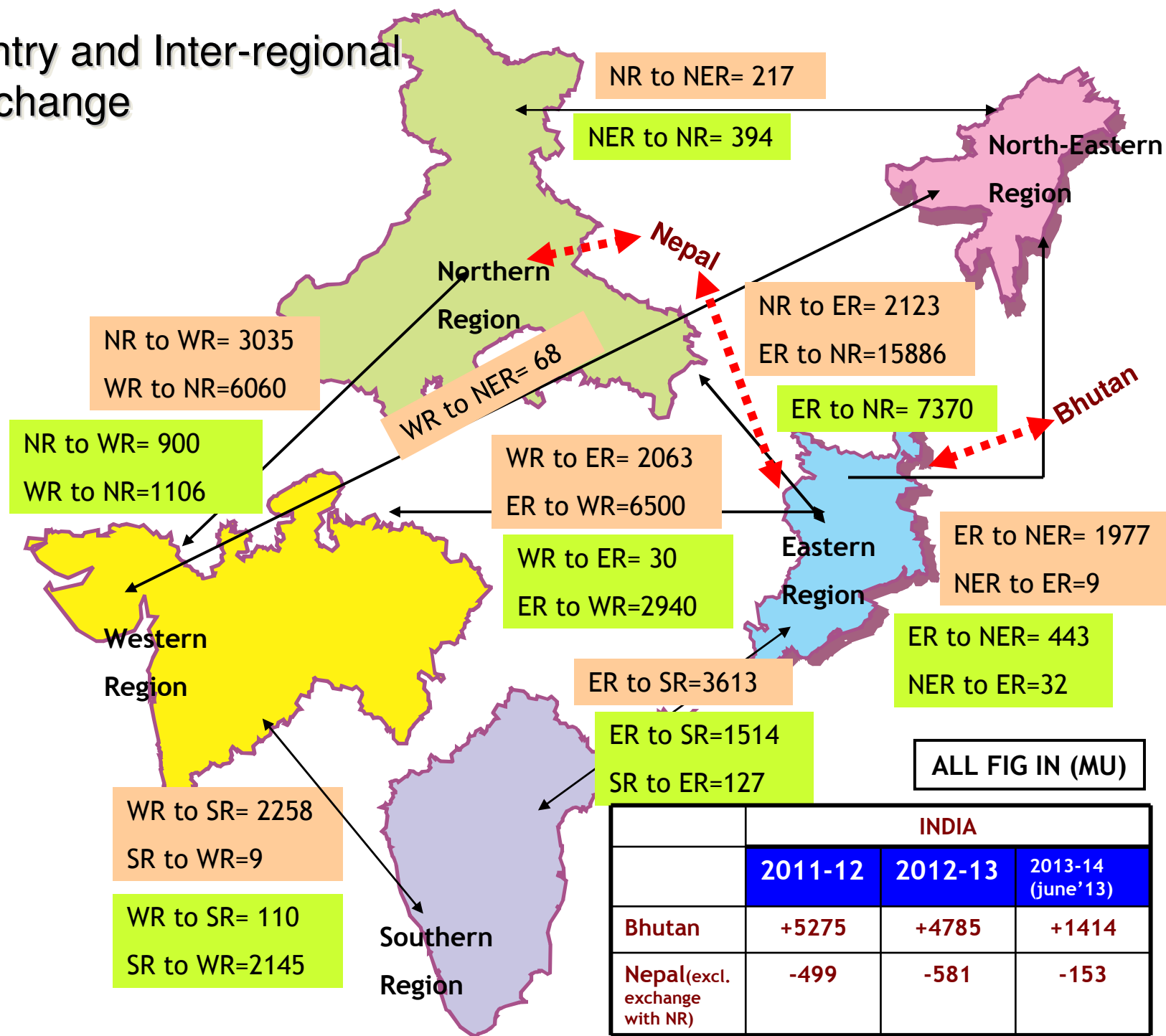
Inter-Regional Transmission Map of India



INTER-REGIONAL
TRANSMISSION CAPACITY
(MW)



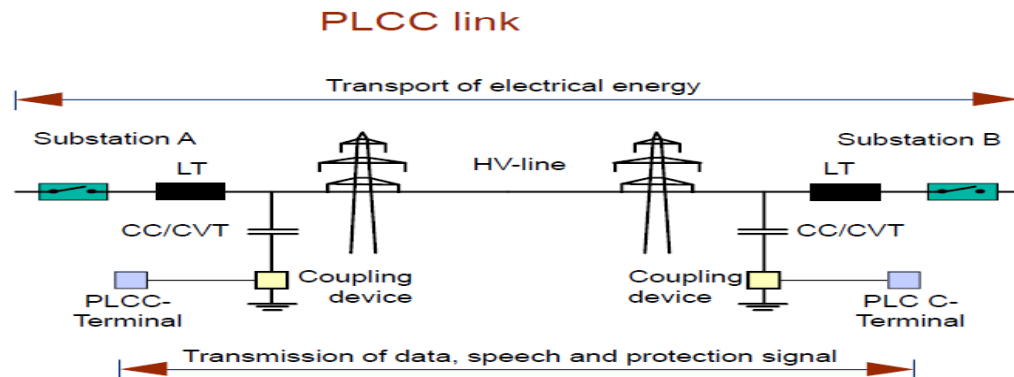
Trans-country and Inter-regional Energy Exchange



2012-13

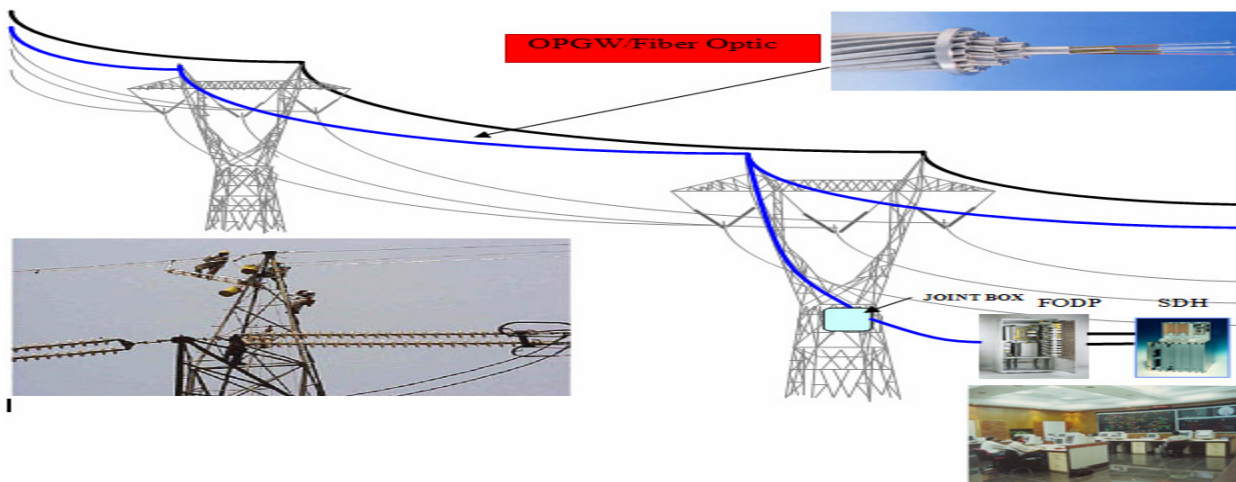
2007-08

High speed Reliable Communication (OPGW)the need for efficient operation of Grid



- Frequency congestion:
- Limited Bandwidth
- Lack of redundancy in physical path

OPGW communication



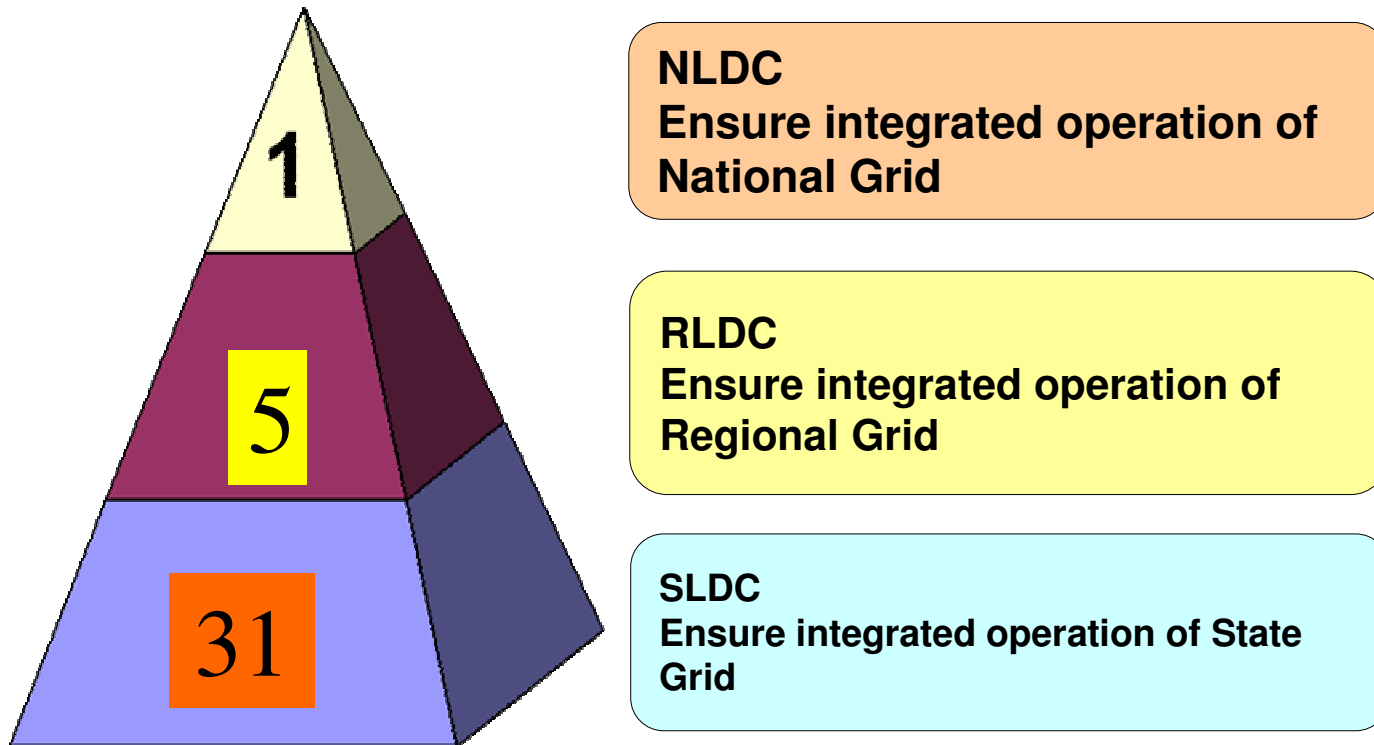
High Capacity Power Transmission Corridors (HCPTC) for IPPs	Ckm		Transformation Capacity (MVA)		HVDC Transmission	
	765 kV	400 kV	765/400	400/220	MW	Ckm
HCPTC – I (Phase-I Generation Projects in Orissa)	2,907	228	12,000	0	0	0
HCPTC – II (IPP Projects in Jharkhand)	1,755	560	6,000	0	0	0
HCPTC – III (IPP Projects in Sikkim)	0	862	0	2,300	0	0
HCPTC – IV (IPP Projects in Bilaspur Complex, Chhattisgarh & IPPs in MP)	310	100	3000	0	0	0
HCPTC – V (IPP Projects in Chhattisgarh)	7,355	1,646	27,000	1,000	10,000	4,400
HCPTC – VI (IPP Projects in Krishnapatnam , AP)	700	40	3000	0	0	0
HCPTC – VII (IPP Projects in Tuticorin Area, TN)	975	440	0	0	0	0
HCPTC – VIII (IPP Projects in Srikakulam Area, AP)	1290	0	4500	0	0	0
HCPTC – IX (for transfer of power from SR IPPs)	1275	400	8000	0	0	0
Total	16,567	4,276	63,500	3,300	10,000	4,400

Robust Transmission Infrastructure (Existing/ under construction)

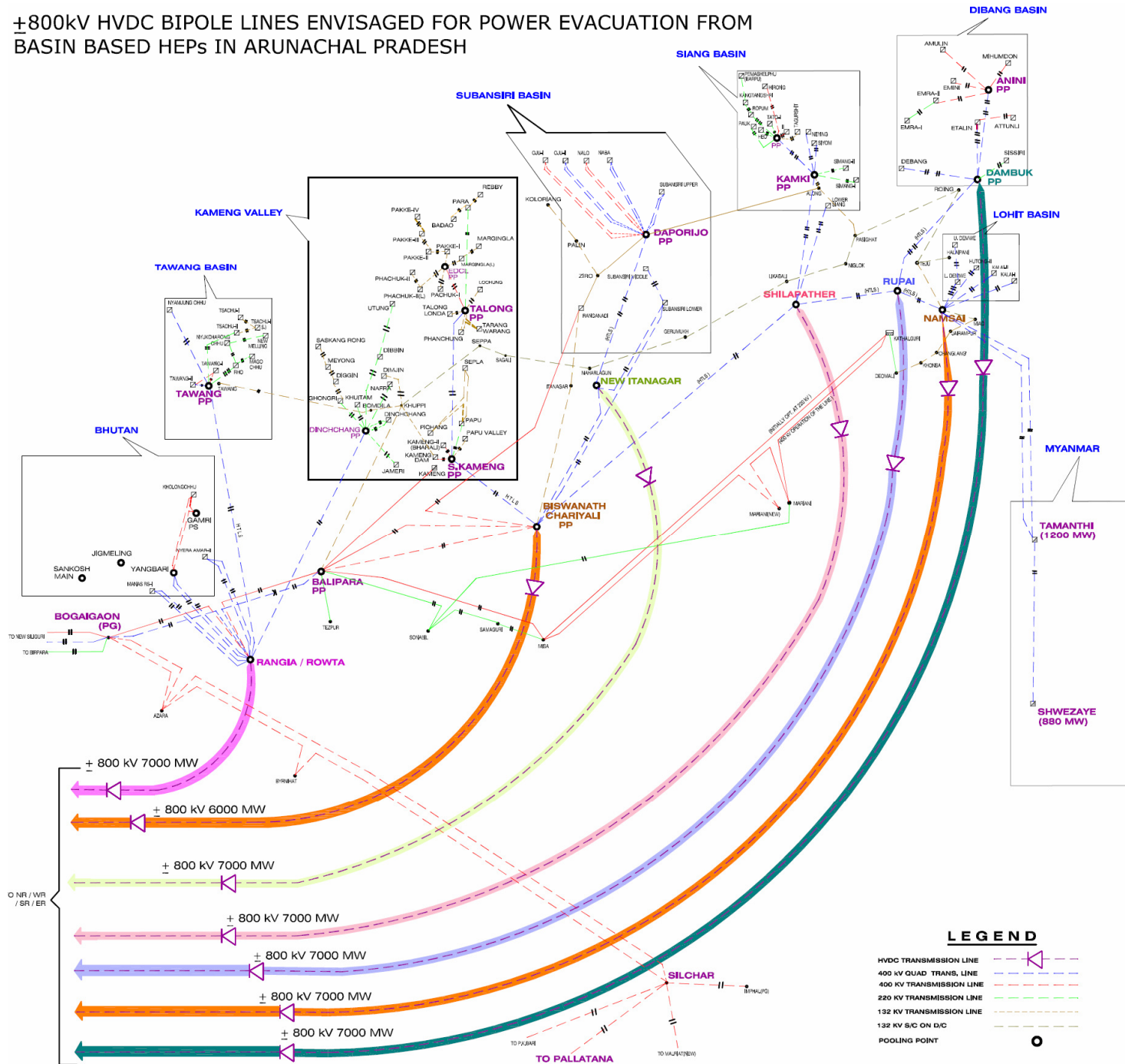
- ✓ **HVDC Terminal Station : 13500 MW**
- ✓ **HVDC Bipole ($\pm 800\text{kV}$, 6000MW) Planned : 3 nos. (18,000 MW) 4307x2 ckm.**
- ✓ **10nos. High Capacity (765kV,400kV) corridors are under implementation**
- ✓ **8 nos. Green Corridors have been planned for evacuation of bulk power from RESs**
- ✓ **TCSC – 5 nos. ; FSC – 33 nos.**
- ✓ **SVC – 1 no.**
- ✓ **765kV lines: 7576 ckm**
- ✓ **400kV lines: over 1,19,600 ckm**
- ✓ **220kV lines: over 1,41,660 ckm.**
- ✓ **IR Capacity: 29150 MW
by 2016-17: 65550 MW**

Grid Operation Hierarchy in India

➔ System Operation and Control from various SLDC/RLDC/NLDC Control Centers by POSOCO

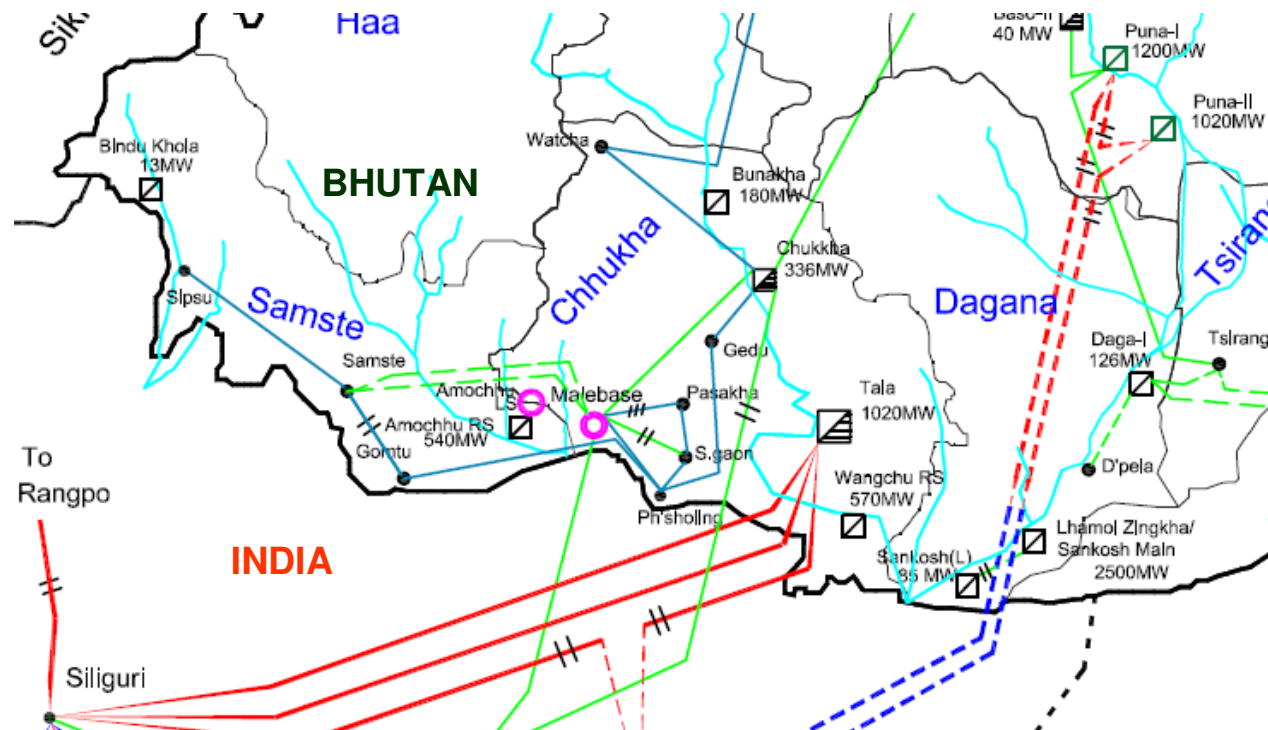


+800kV HVDC BIPOLE LINES ENVISAGED FOR POWER EVACUATION FROM BASIN BASED HEPs IN ARUNACHAL PRADESH



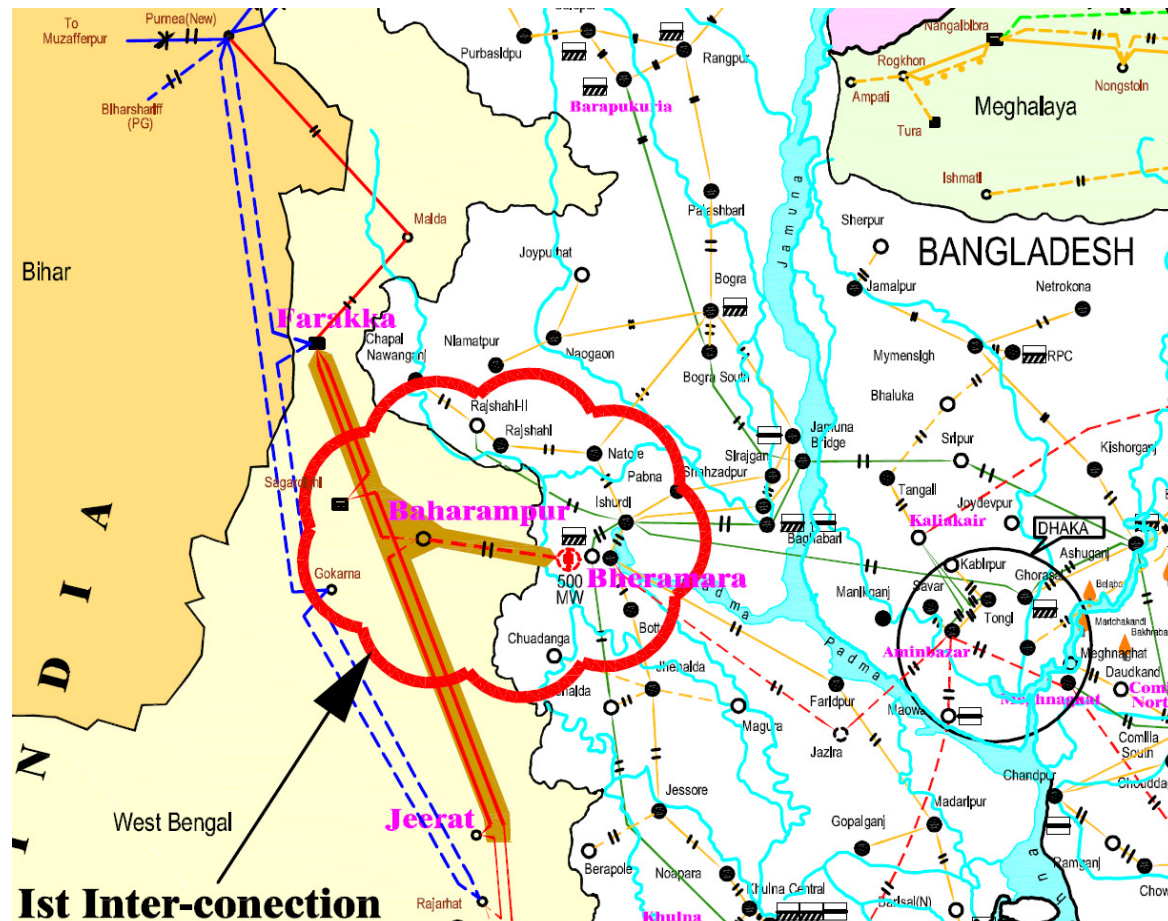
India-Bhutan Grid interconnection & Power Trading

- India and Bhutan have terms of cooperation for exchange of power between the two countries.
- Bulk of power generated at Chukha, Kurichhu and Tala HEPs in Bhutan, is exported to India after meeting the internal demand of Bhutan.
- During winter time when hydro generation is minimal, Bhutan used to import power from India.
- Bhutan has embarked on harnessing hydro potential and identified HEPs of about 24 GW by 2030 at its various Basins



Indo-Bangladesh Interconnection

- Asynchronous electrical grid interconnection between India and Bangladesh with 400kV D/C cross-border interconnection and 500MW HVDC Back-to-Back Link at Bangladesh, has been commissioned on 30th Aug., 2013.
- Bangladesh will import 250 MW from central generating stations and procure an additional 250 MW from open electricity market in India.



India-Nepal Cross Border Links and Power Exchange

- Power exchange between NEA and utilities on the Indian side has since been taking place on the principle of catering to the power needs of isolated local areas of both of the sides of the border. About 12 cross border interconnections facilities are in operation for bilateral power exchange and the quantum of power import by Nepal is presently to the extent of 100-120 MW.
- India also supplies about 70 MU free power from Tanakpur HEP (120 MW) to Nepal under the Mahakali treaty through the 132kV Tanakpur-Mahendranagar S/C line.
- **Cross border 400 kV Muzaffarpur (India)- Dhalkebar (Nepal) D/C line between eastern part of India and Nepal is being established; India and Nepal grids would be thereafter operated in synchronous mode for power trade/exchange.**
- **Initially power will be imported by Nepal through the link and later, when various HEPs in Nepal would be set up the link would facilitate to export power from Nepal to India.**

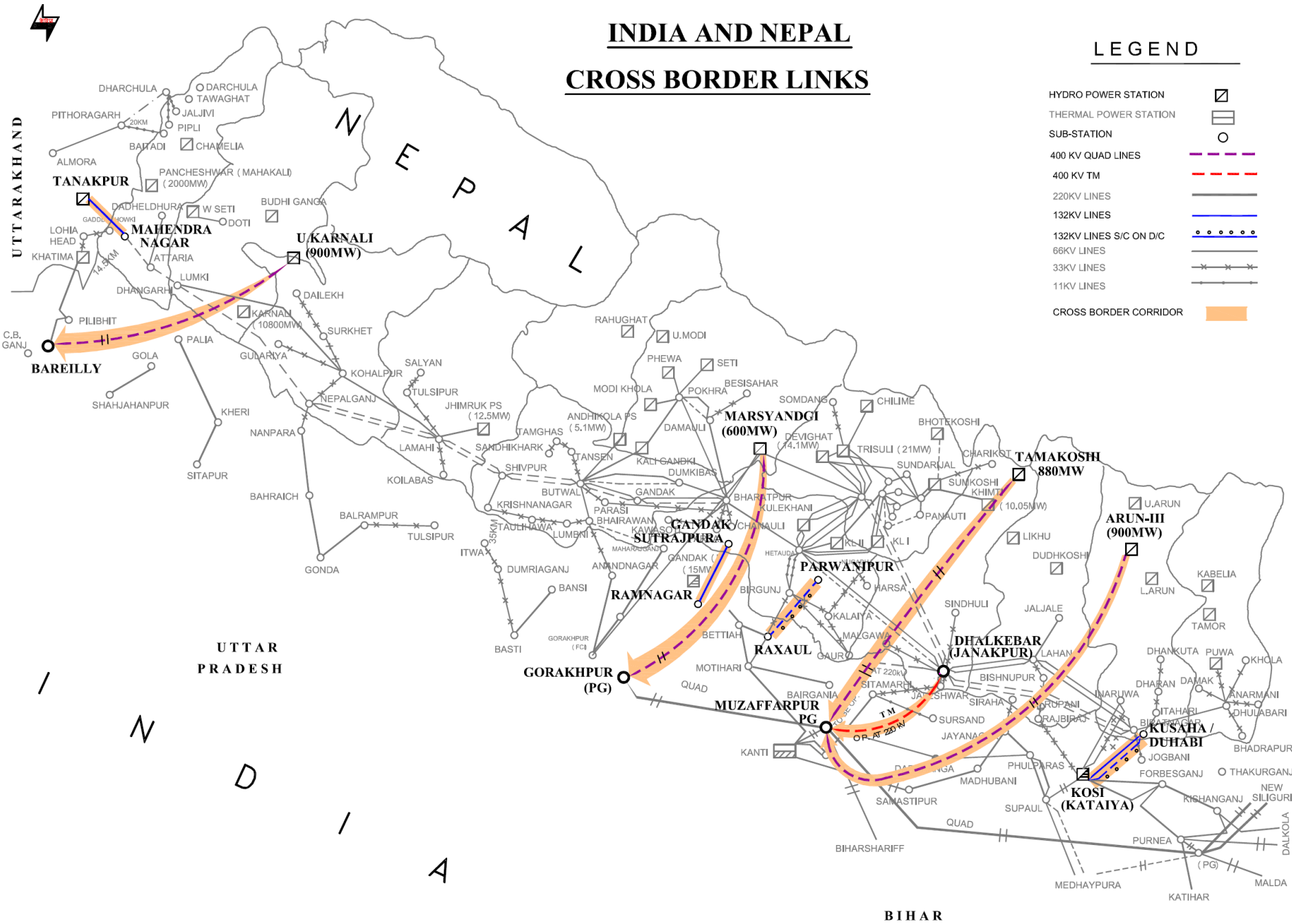
HEPs in Nepal under Development Phase:

- 600MW Upper Marsyangdi
- 900MW Upper Karnali
- Arun-3 (900MW)
- 880MW Tamakoshi-3
- Namlan (303 MW)

INDIA AND NEPAL CROSS BORDER LINKS

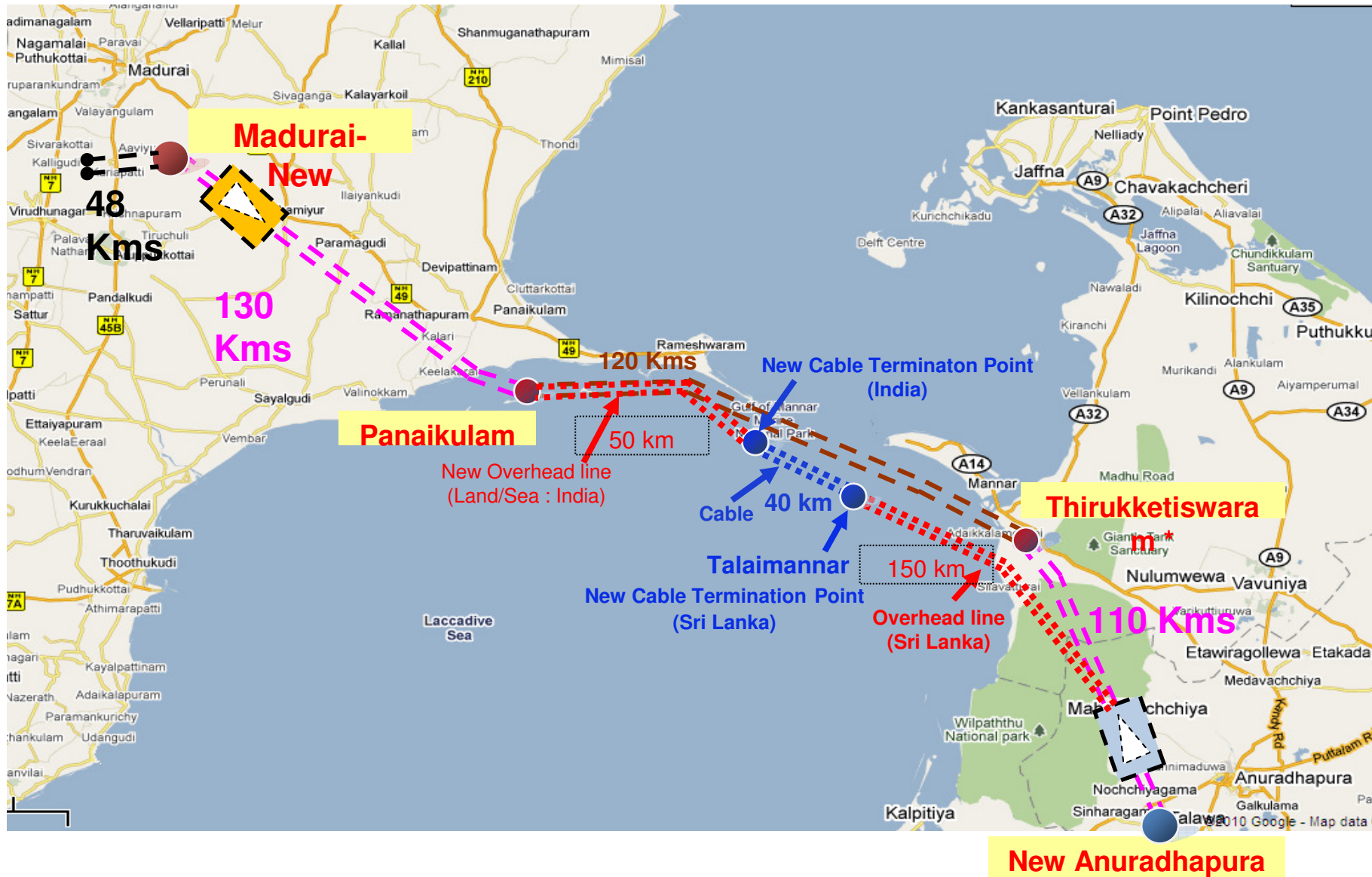
LEGEND

HYDRO POWER STATION	
THERMAL POWER STATION	
SUB-STATION	
400 KV QUAD LINES	
400 KV TM	
220KV LINES	
132KV LINES	
132KV LINES S/C ON D/C	
66KV LINES	
33KV LINES	
11KV LINES	
CROSS BORDER CORRIDOR	



Prospective Indo-Sri Lanka Cross Border Link

- $\pm 400\text{kV}$ 1000MW HVDC Bipole link between the two countries has been identified for power exchange of 1000 MW.
- Cost economics is being evaluated.



Prospective India-Pakistan Link

- Pakistan is having 500kV AC Transmission system whereas, Indian grid has 400kV and 765kV AC systems (220kV & 132kV voltage levels are common in both the countries).
- Cross border Asynchronous Interconnection by 400 KV AC double circuit line with 500 MW HVDC back to back terminal in Pakistan is being studied.

T H A N K S