



Power System Operation: Experiences from India

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Presentation Outline

- Transmission System Development in India
- Power System Operation
- Blackouts, Defense Mechanism & Restoration
- Electricity Market in India
- Future Challenges & Concerns

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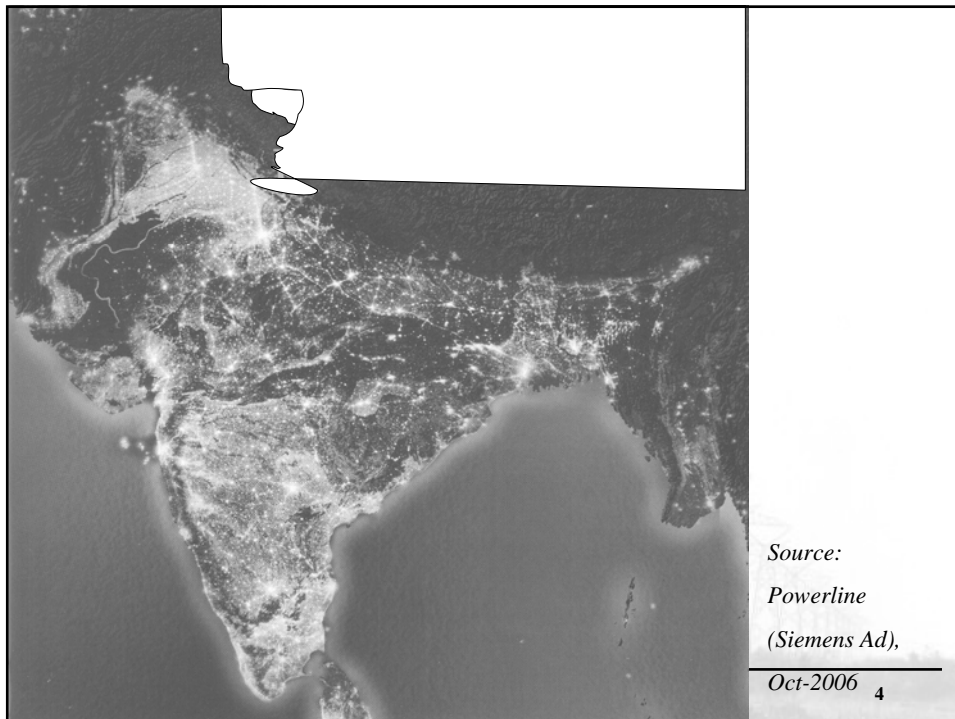
Development of the Transmission System in India

An Overview of Indian Power System

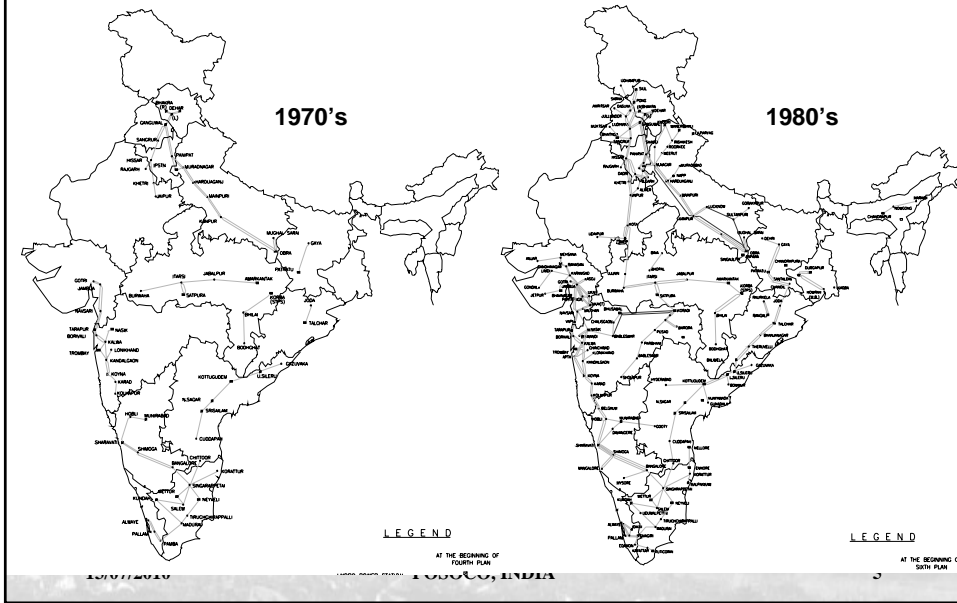
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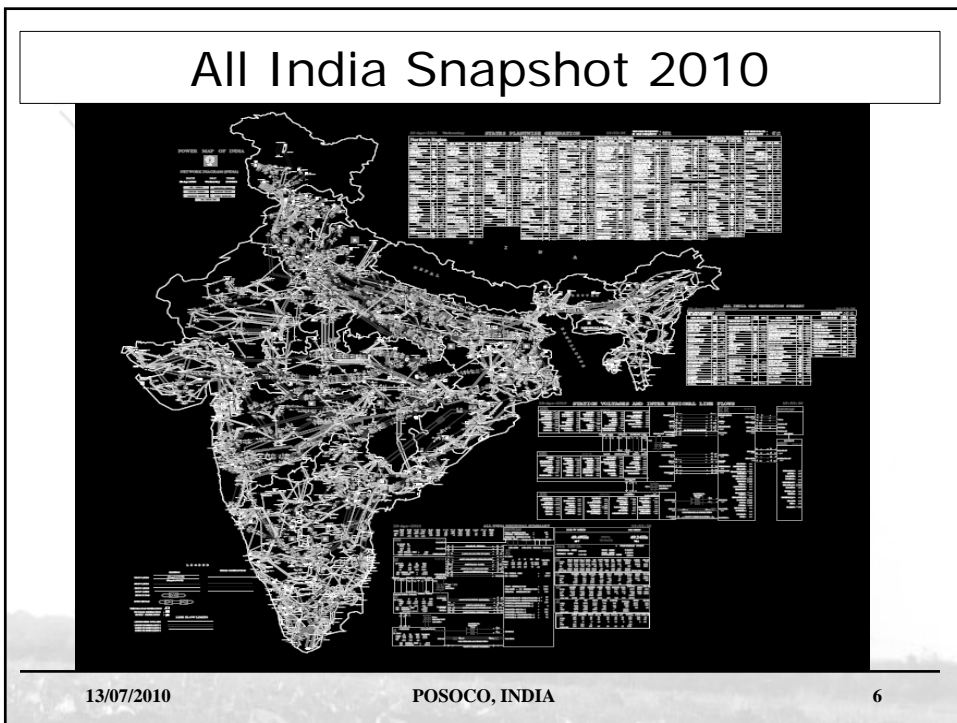
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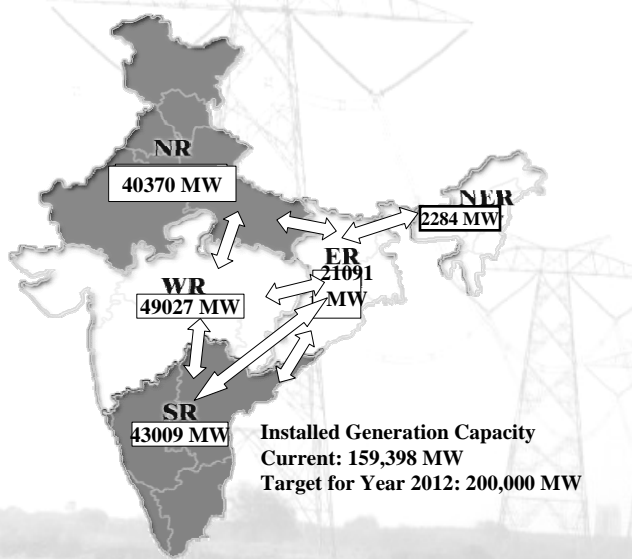
The Grid in 1970's and 1980's ...



All India Snapshot 2010



Regional Grids – ‘Geographical’

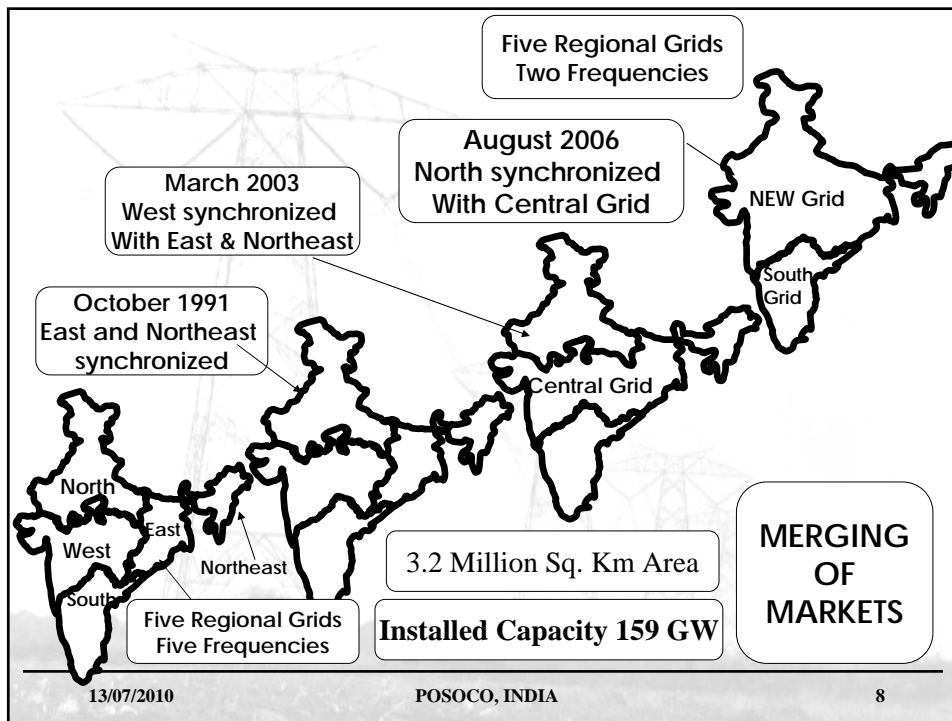


Installed Generation Capacity
 Current: 159,398 MW
 Target for Year 2012: 200,000 MW

Inter regional Link	MW capacity
NER-ER	1,260
ER-NR	6,330
ER-SR* (excl. Talcher-Kolar bipole)	1,130
ER-WR	2,990
SR-WR	1,720
WR-NR	4,220
Other 132 KV Links	600
Talcher Kolar HVDC Bipole	2,500
Total as on date	20,750
Target for 2012	37,700

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October 1991
 East and Northeast
 synchronized

March 2003
 West synchronized
 With East & Northeast

August 2006
 North synchronized
 With Central Grid

Five Regional Grids
 Two Frequencies

North
 West
 East
 South
 Northeast

Five Regional Grids
 Five Frequencies

3.2 Million Sq. Km Area

Installed Capacity 159 GW

**MERGING
 OF
 MARKETS**

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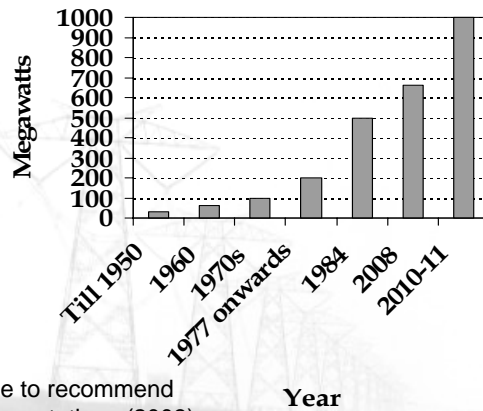
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Generation Technology

- Till 1950 largest unit size was 30 MW
- Units of 200/210/500 MW form the backbone of the thermal capacity in the country (nearly 60 %)
- 30 MW to 200 MW in 27 years
- 200 MW to 500 MW in 7 years
- 500 MW to 660 MW in 24 years
- 660 MW to 1000 MW in 3 years

Growth of thermal unit size



www.cea.nic.in: Report of the committee to recommend next higher size of coal fired thermal power stations (2003)

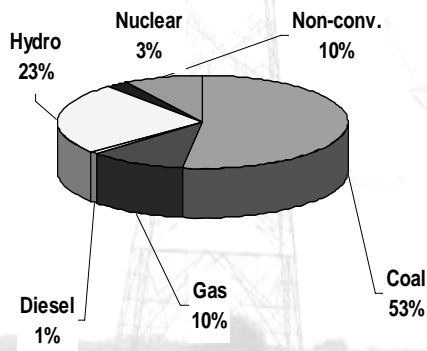
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Very Large Grid

Installed Capacity > 159GW



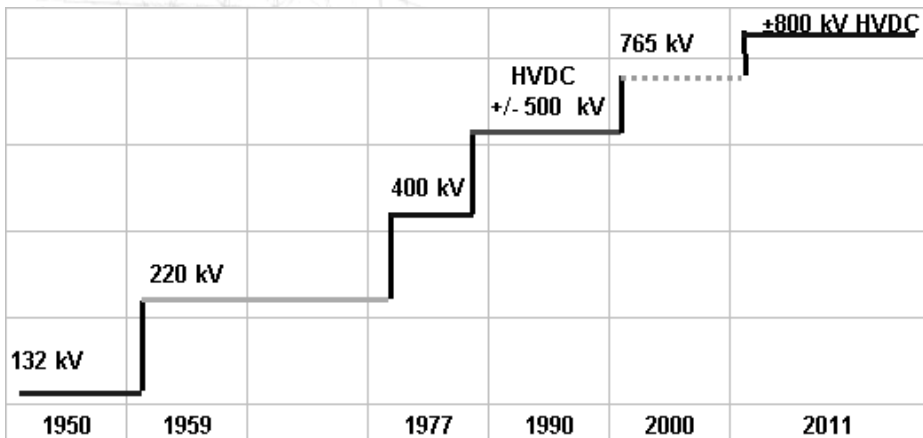
Type	Installed Capacity (GW)
Coal	84.2
Gas	17.0
Diesel	1.2
Total Thermal	102.4
Hydro	36.9
Nuclear	4.6
Non-conv.	15.5
TOTAL	159.4

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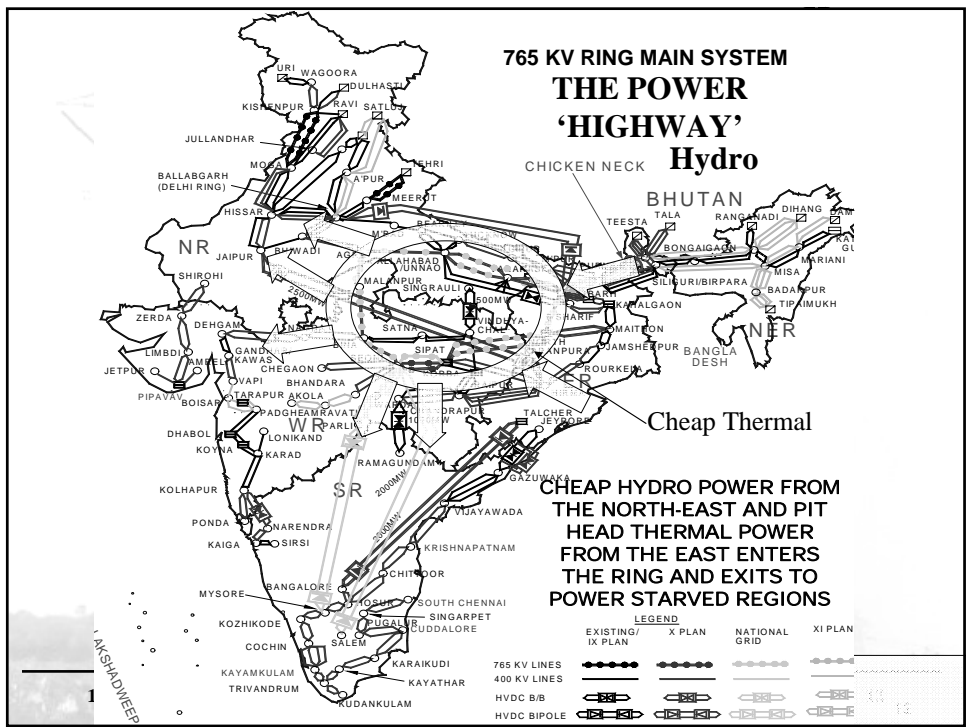
Transmission technology



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Renewable Energy : Wind Power

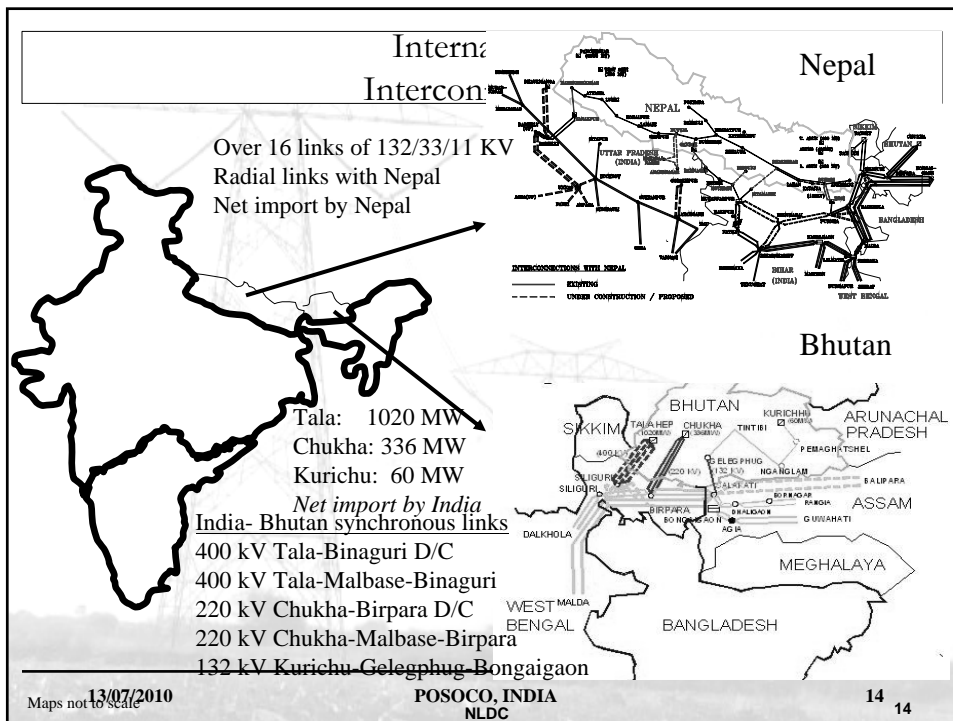


India: 5th Largest Wind Power Producer

Total Renewable Energy Sources ~ 13 GW

Wind Installed Capacity ~ 10 GW

Estimated Wind Potential ~ 45 GW

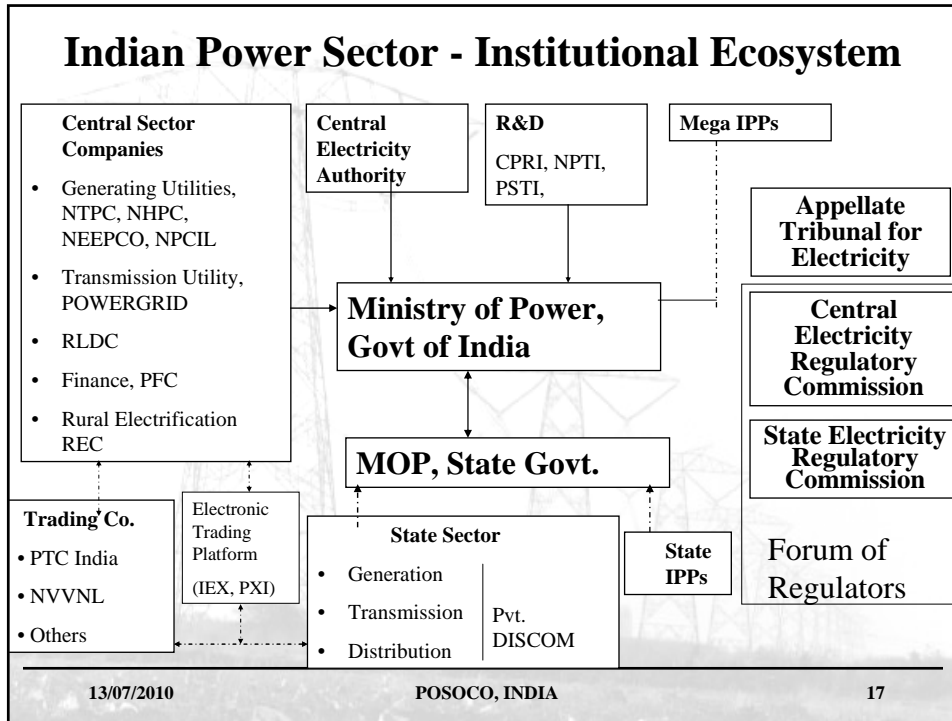


Power System Operation

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Legislation, Regulation And Governance

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Transmission

- A licensed activity
- Transmission Utilities
 - Central Transmission Utility (CTU) – POWERGRID
 - State Transmission Utilities (STU)
- Non discriminatory open access
 - Implemented successfully in Inter-State transmission since May-2004
 - Implementation under progress in the States
- Charges and incentives
 - Linked to line availability, immune to power flow, neutral to buyer, seller, traders
- N-1 criterion for normal corridors, N-2 for high density corridors
- “Power Highways” under implementation
 - 765 KV HVAC ring across regions
 - 800 KV HVDC from North-East to the Northern Region

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Regulators – Central & State

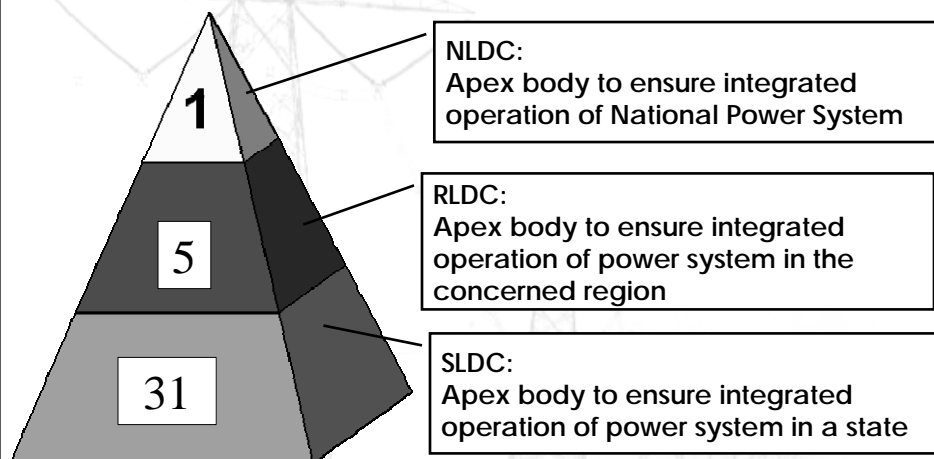
- Central Regulator (Section 79, Electricity Act 2003)
 - Tariff for Central Generators / generating companies with more than one beneficiaries
 - Inter-state transmission of electricity
 - Tariff for inter-state transmission of electricity
 - Issue licenses – transmission/trading
 - Adjudicate disputes
 - Specify Indian Electricity Grid Code
- State Regulator (Section 86, Electricity Act 2003)
 - Tariff for generation, supply, transmission, wheeling of electricity within the state
 - Electricity purchase and procurement process of the distribution licensees, including the price of procurement of electricity
 - Intra-state transmission and wheeling of electricity
 - Specify state grid code

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System Operation Hierarchy

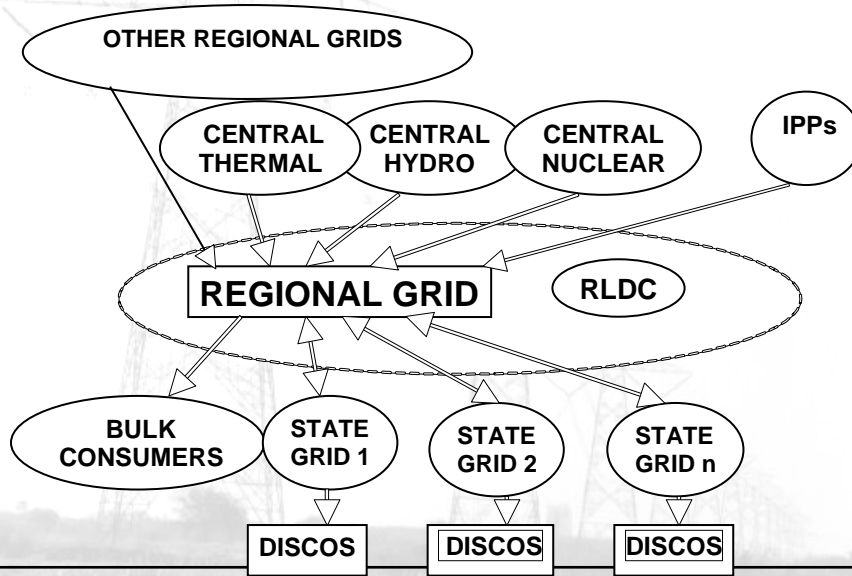


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System Operation - Regional Level

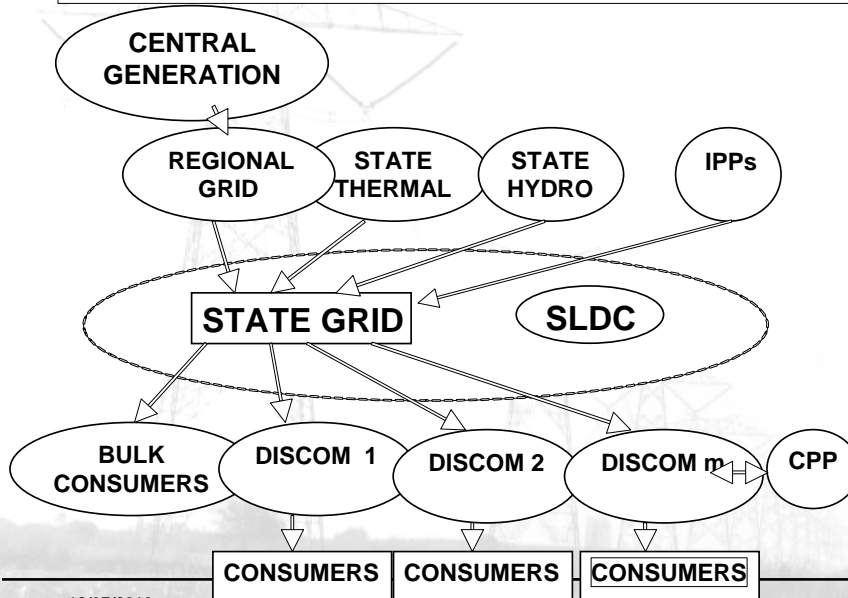


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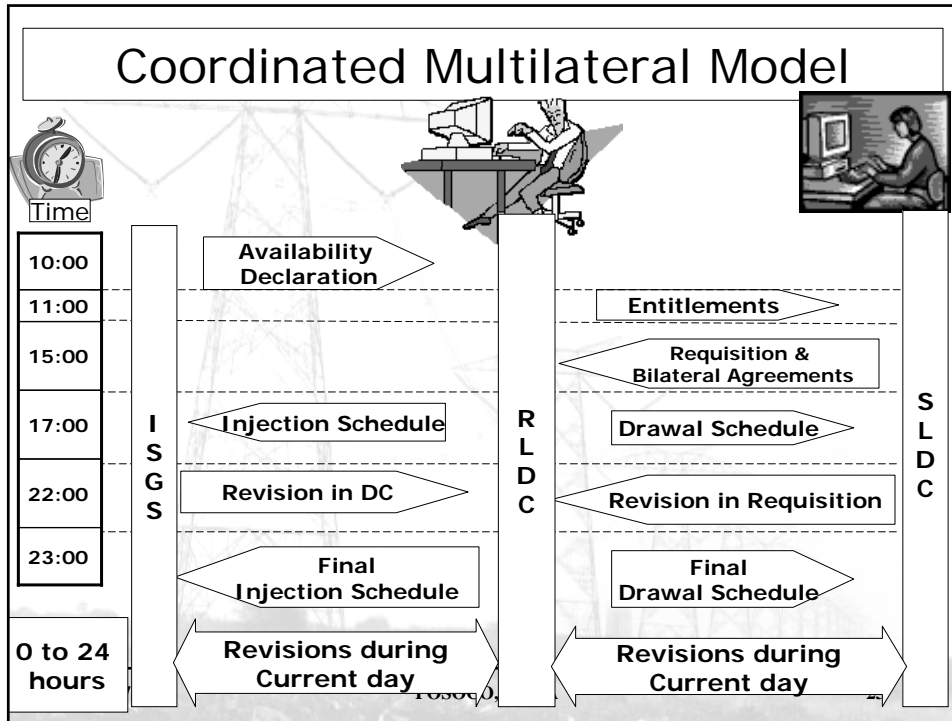
System Operation - State Level



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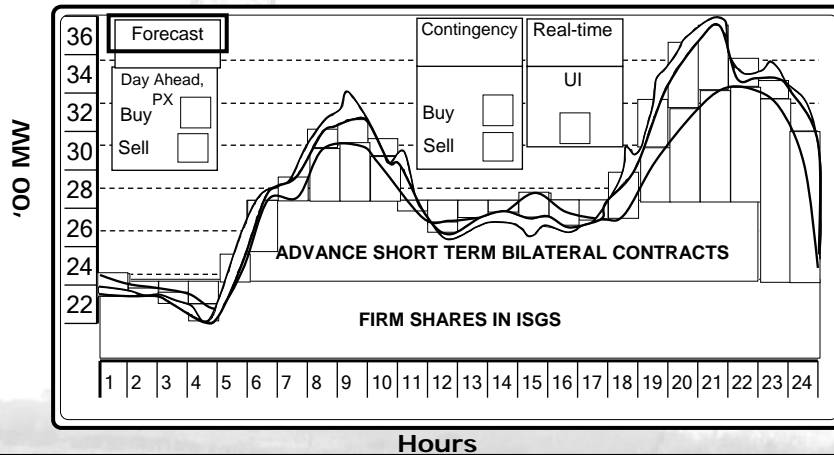
Settlement System – ABT & UI

- ABT is a scientific settlement system for contracted sale & purchase of power
- Has three components
 - Fixed Charges or capacity charge
 - Linked to day-ahead declared availability/subscription
 - Variable Charges or fuel charges
 - Linked to before the fact energy schedules
 - Charges for deviation from commitments
- Frequency actuated signal
 - Signal transmitted at the speed of dynamics to be controlled
- Real time pricing stretched to its physical limits
 - Merit order
 - Economic load management
- Incentives for helping the grid
- Opportunities for a diligent player
- Simple, dispute-free weekly settlement system

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A Typical Dispatch

Surpluses/Deficits - Balance supply and demand



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Regional Grid Operation Philosophy as per IEGC

- Operated as loose power pools
- States have full operational autonomy
- State power system treated as notional (flexible) control area
- Very tight control of actual interchange by state utilities & Inter State Generating Stations not mandated
- Deviations from net drawal schedules appropriately priced

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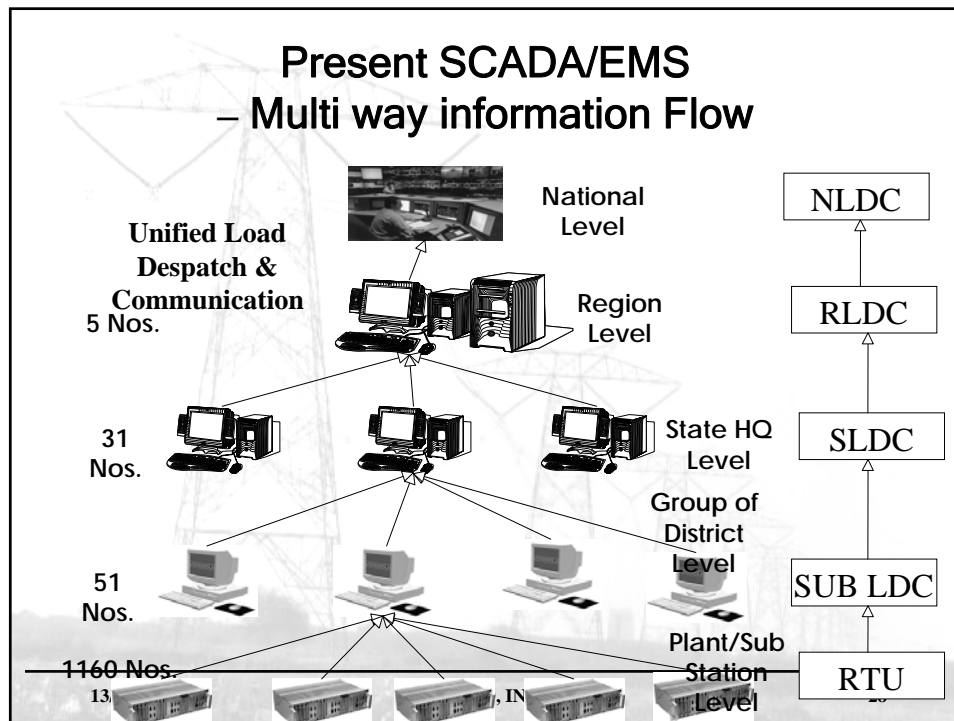
GRID MANAGEMENT FUNCTIONS

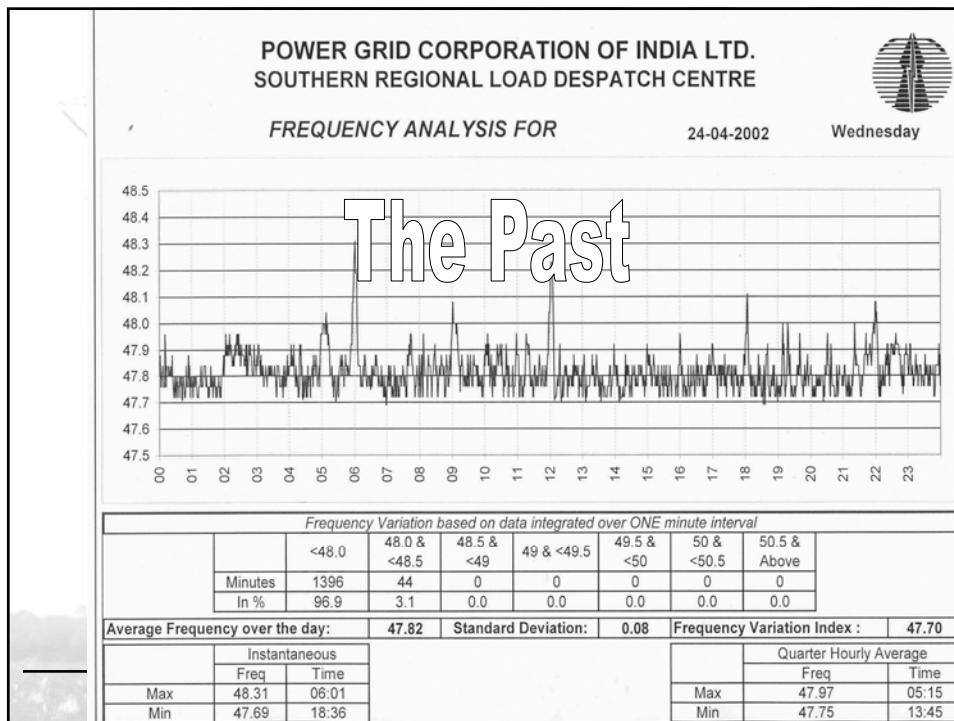
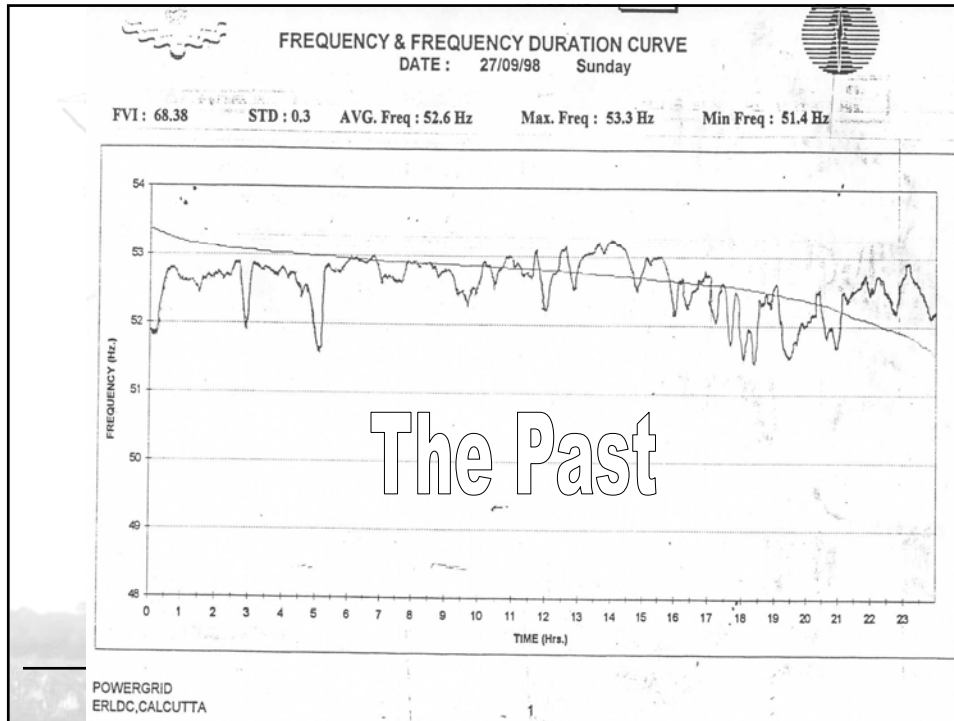
- Ex-ante functions
 - Scheduling
- Real-time functions
 - Supervision & control of system parameters
 - Facilitating Open Access transactions
- Post-facto functions
 - Settlement system operation
- Interaction with stakeholders

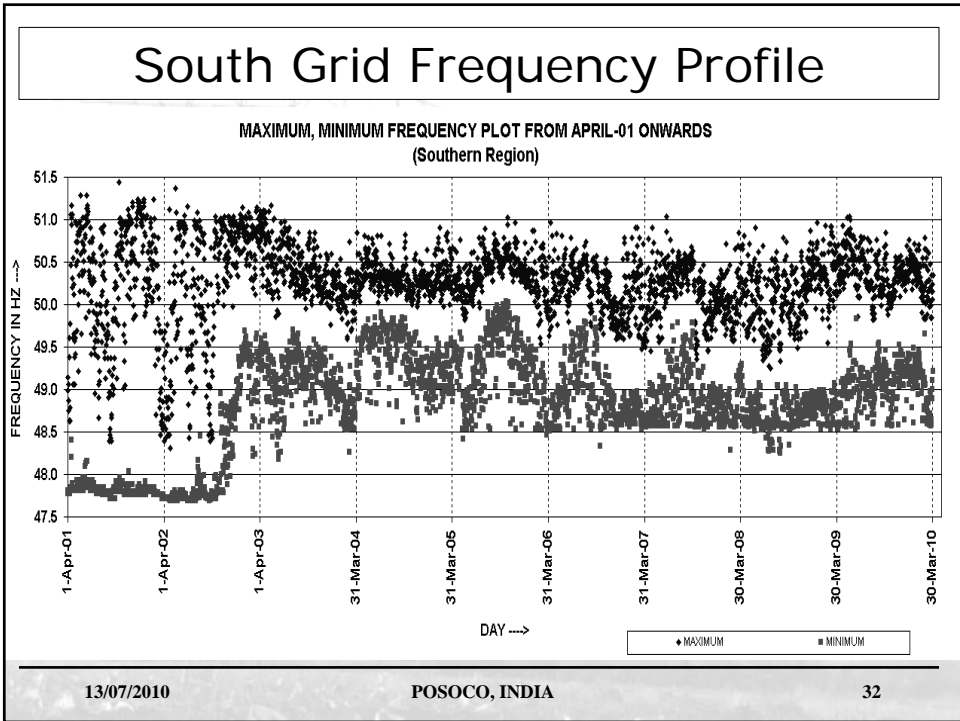
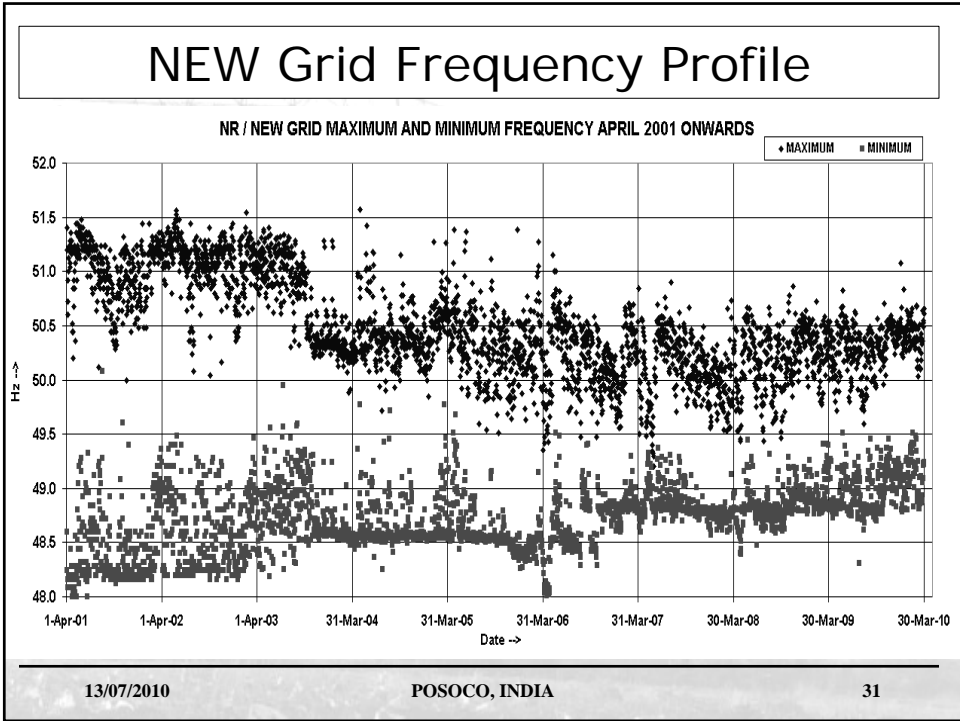
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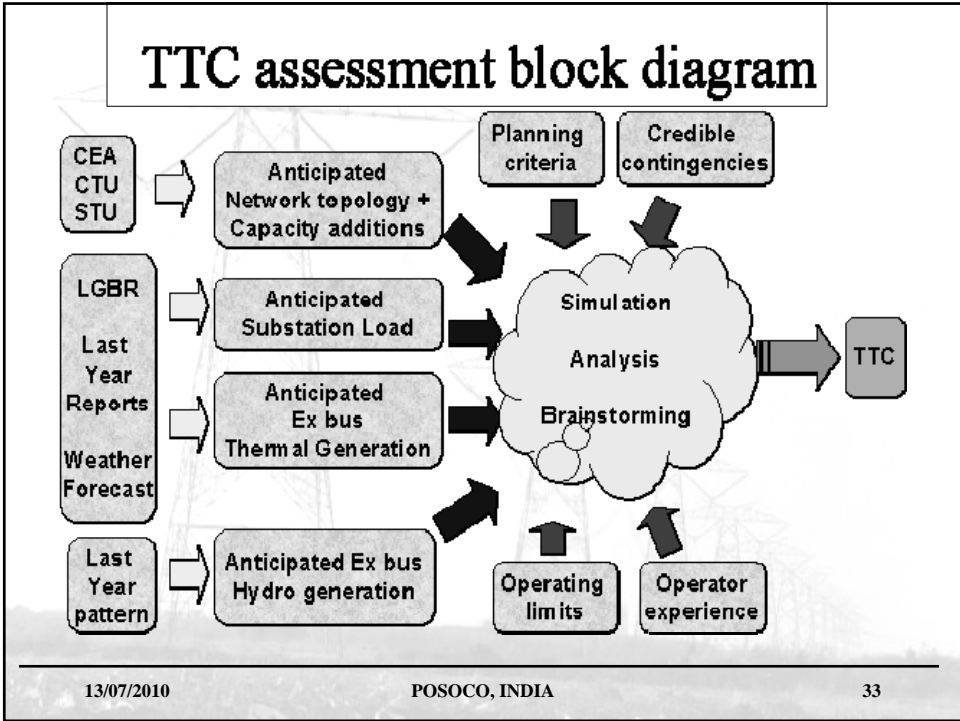
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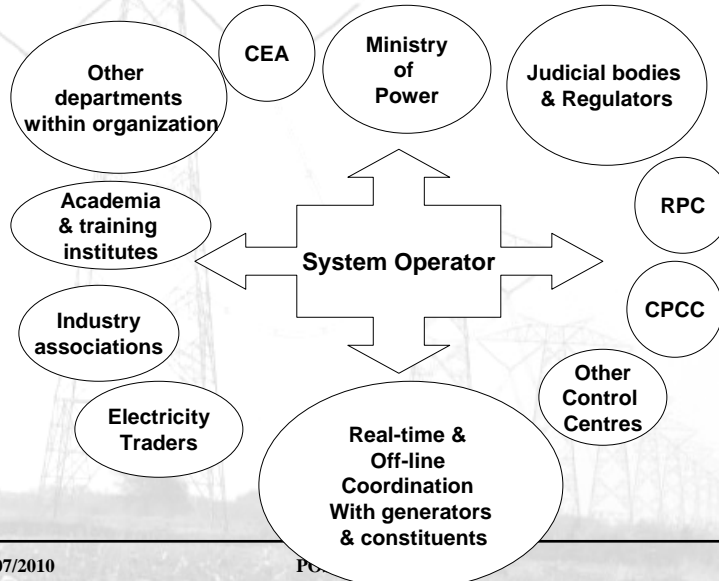








Interactions with Stakeholders

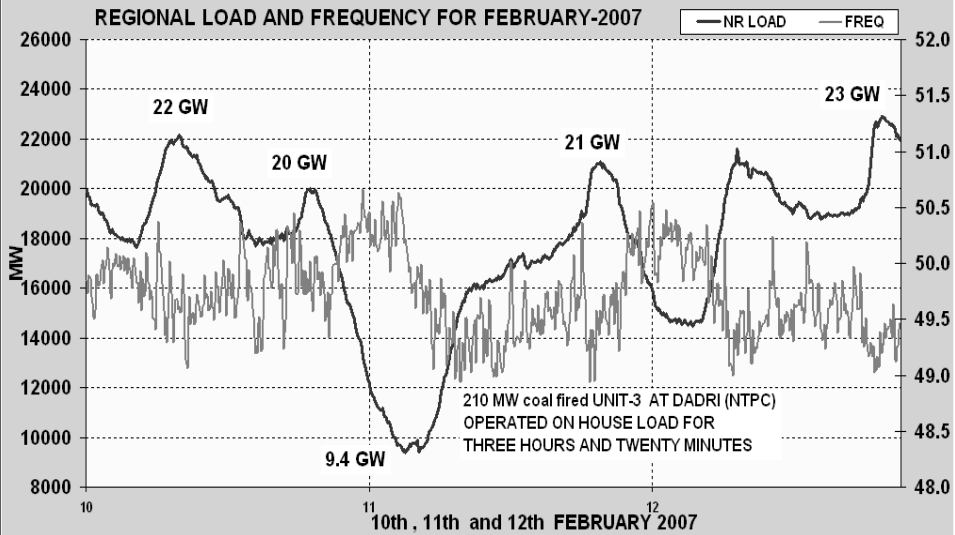


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Unforeseen Load Crash: 8 Hour Test Of Nerves

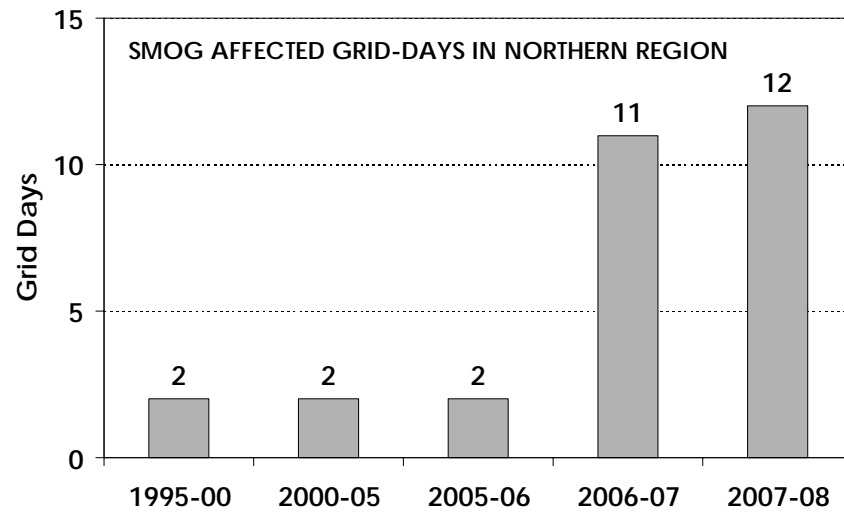


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Increasing Impact of Weather: 'Killer Smog'



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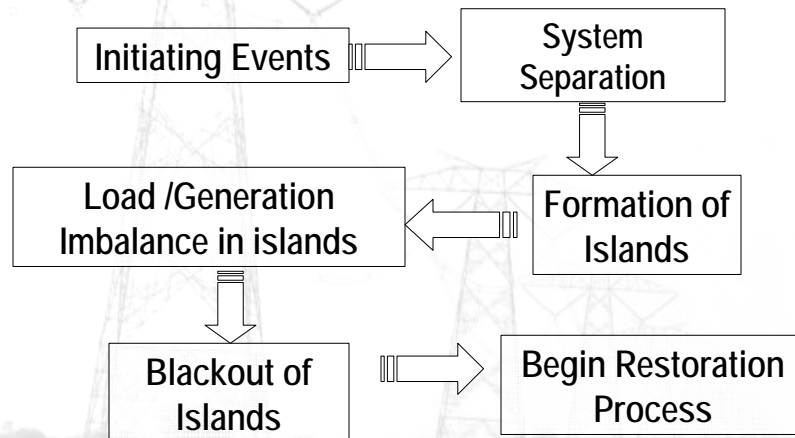
Blackouts, Defense & Restoration

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Common Sequence of events in blackouts



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Defense Plan Ingredients

- Coordinated with planning, operations, and maintenance
- Help better utilize system margins
- Clear understanding of the requirements and consequences
- Coordination with neighboring systems
- High performance equipment - reliability
- Emphasis on security
- Real-time measurements and reliable communication
- Planned & designed for future system and technology expansions

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Restoration: Objectives

- Extending start up/survival power to all the Thermal power plants and Synchronising at least one unit at all power stations
- Restoring normal system operation as early as possible
- Restoring essential loads
- Establishing all interconnections
- Minimizing amount of unserved energy
- Resume contracted and economic despatch

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Restoration Process

- Top-down / Build down strategy
 - Restore backbone transmission system, usually from outside assistance.
 - Restore critical generating station and substation load from transmission system.
 - Bring on more generation.
 - Restore underlying transmission system.
 - Continue restoring load.
- Bottom-up/Build-up Strategy
 - Select units to black-start.
 - Start and stabilize black-start units.
 - Determine restoration transmission path.
 - Begin expanding island(s) by restoring transmission and load.
 - Synchronize island(s) when appropriate.
- A combination of the above ...

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Defense Plans

- Under Frequency Relays
 - Operation In Stages
 - 48.80 Hz, 48.60 Hz, 48.20 Hz, etc.
- Rate of Change of Frequency Relays
- Under Voltage Relays
- Islanding Schemes
- Special Protection Schemes
- Wide Area Measurement
 - Implementation of Phasor Measurement Units

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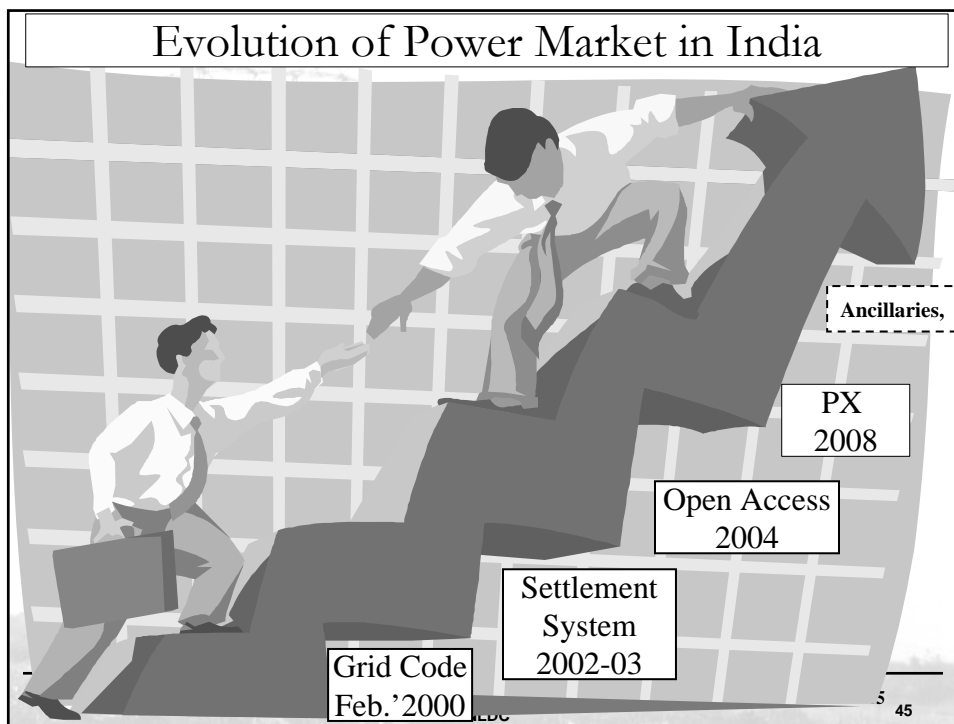
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Electricity Market in India

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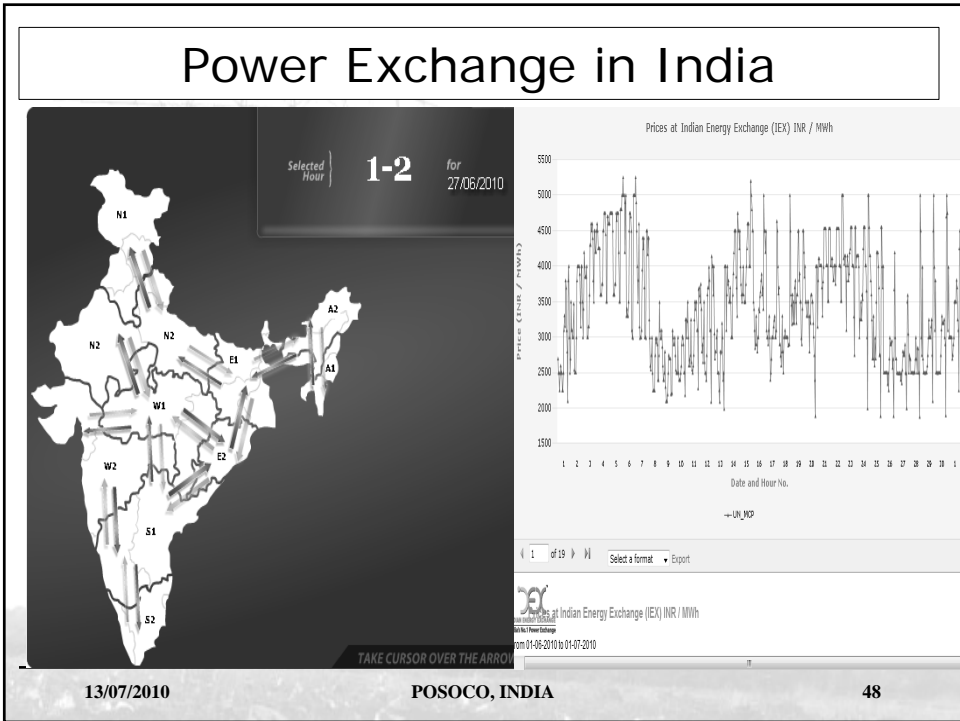
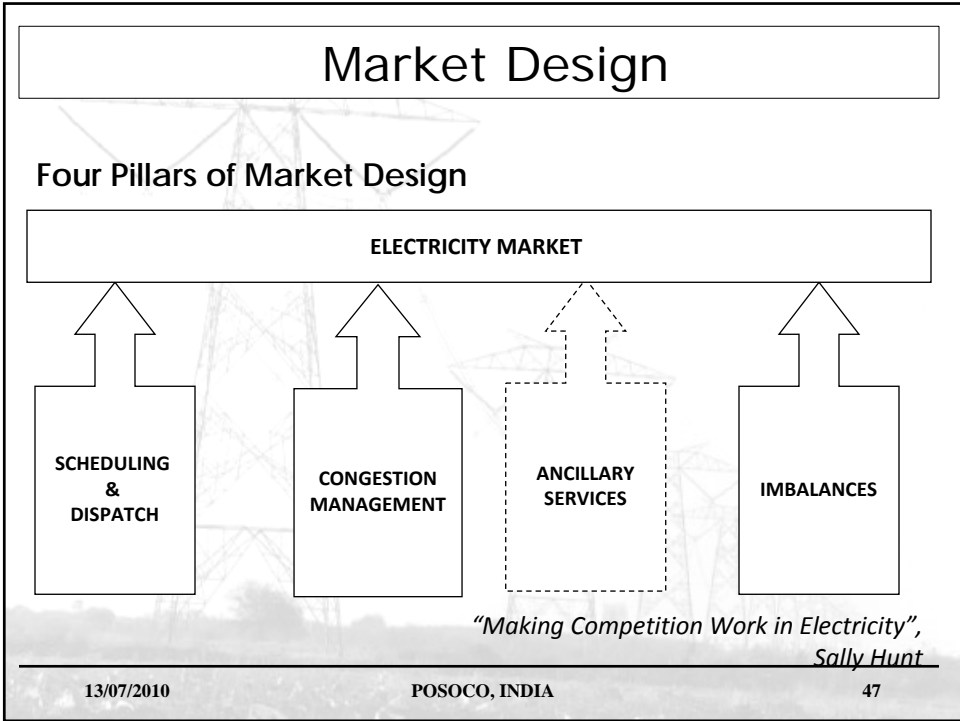
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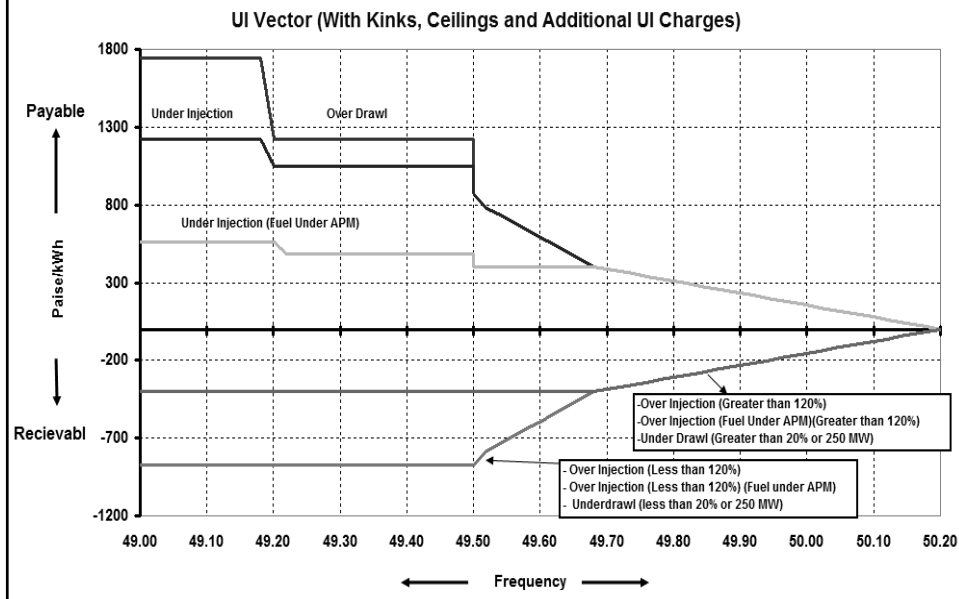
INDIAN ELECTRICITY MARKET

ENABLERS	STRUCTURE
Legislation Indian Electricity Act 2003	Balancing Mechanism Frequency linked Unscheduled Interchange
National Electricity Policy 12-Feb-2005, Para 5.7.1(d)	Short-term Bilateral Contingency Day-ahead
Regulation IEGC-Feb 2000 ABT Order-Jan2000 Open Access-May-2004 Power Exchange-Feb-2007	Day-ahead Power Exchange Multiple Power Exchanges
Execution CTU/STU, RLDC/SLDC Grid & Market Operation Control Centres & SEMs ABT settlement: in stages 2002-03	Short-term Bilateral First-come-first served Three-month ahead
	Long-term Bilateral Shared resources (ISGS) Own resources

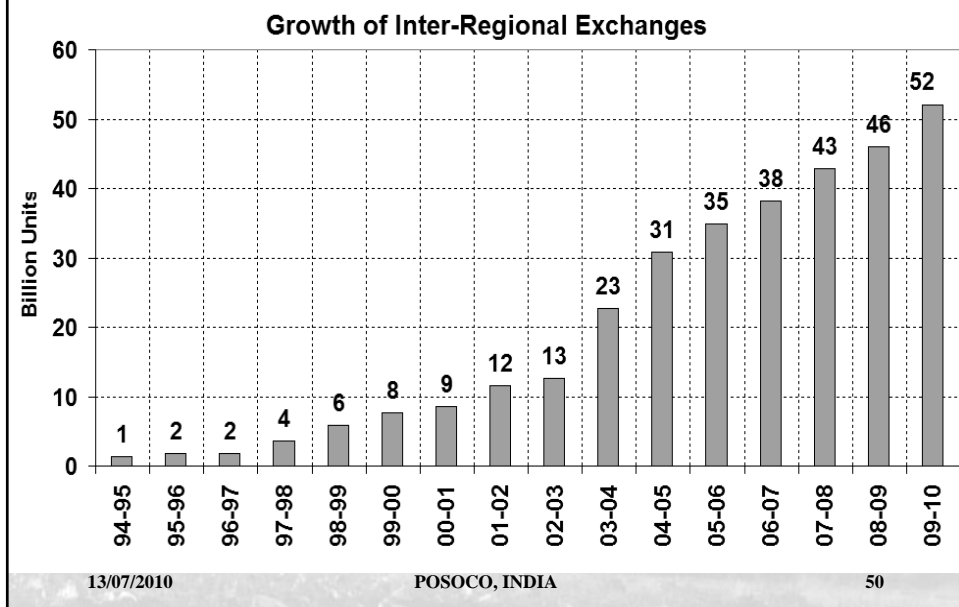
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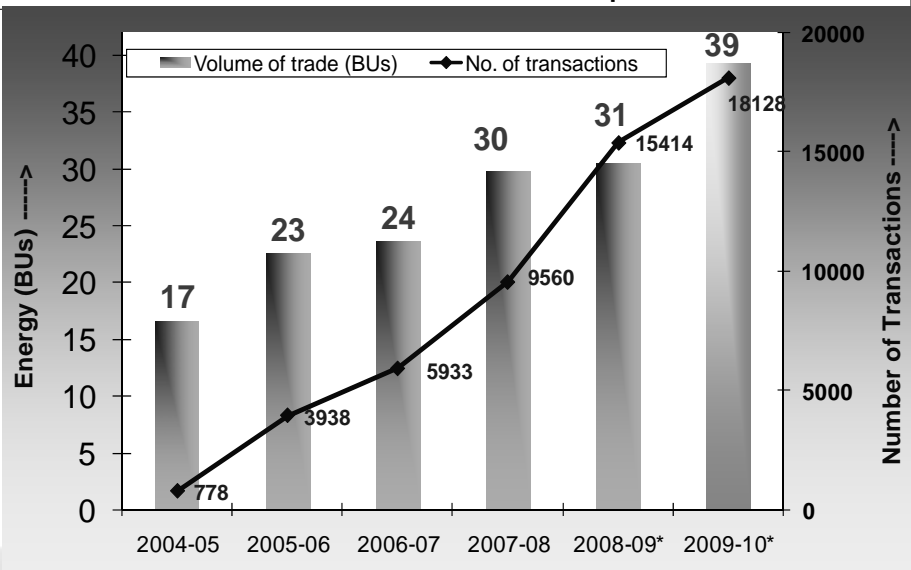
UI Vector (Effective 3-May-10)



Inter – Regional Exchanges



Trade under Short-Term Open Access



*Includes Bilateral + Collective transactions

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Electricity Market in India: Key Success Factors

- Control area demarcation & boundary metering
- Seams Management
- Robust transmission system
- Assessment of Transfer Capability by the System Operator
- Balancing mechanism
- Clear Methodology for
 - Transmission charge sharing
 - Treatment of transmission losses
- Streamlined scheduling and settlement mechanism
- Transparency and non-discriminatory implementation
- Dispute redressal mechanism
- Congestion management

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Future, Challenges & Concerns

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Ancillary Services in Indian Context

- Proposed Ancillary Services in India
 - Frequency Control Ancillary Services (FCAS)
 - Network Control Ancillary Services (NCAS)
 - Power Flow Control Ancillary Services (PFCAS)
 - Voltage Control Ancillary Services (VCAS)
 - System Restart Ancillary Services (SRAS)

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WAMS Initiatives By POWERGRID

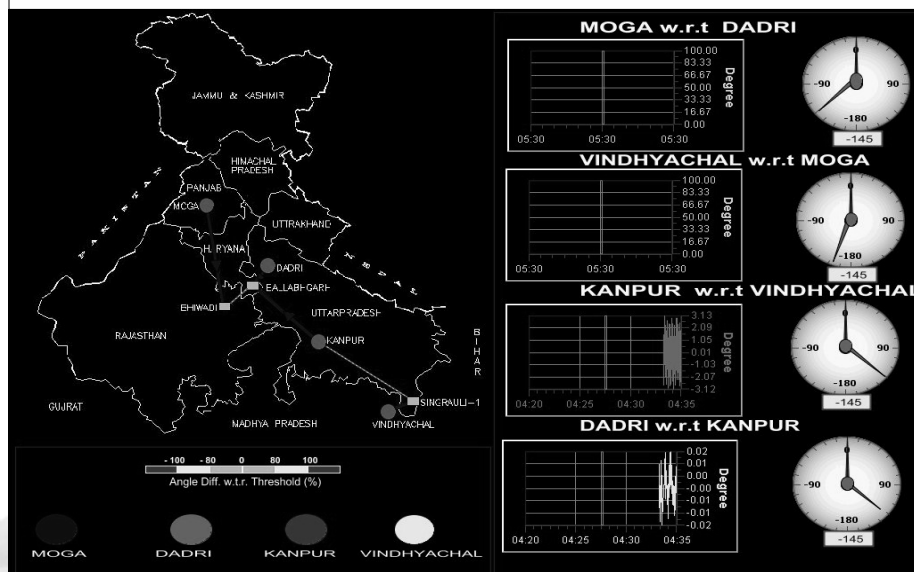
- Western Region
 - PMU at 25-30 Locations
 - Participation by the Industry and the Academia
 - Project duration – 3 years
- Northern Region
 - Pilot project
- PDCs located at the respective Regional Load Despatch Center (RLDC) (Northern and Western)

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PMU Visualization in Control Center



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Regulatory Initiatives: Maiden Regulations

- Green Power
- Renewable Energy Certificates (REC)
- Power Market Design
- Congestion Management
- Open Access
- Revision to Indian Electricity Grid Code (IEGC)
- Development of Ancillary Services
- Review of Transmission Pricing
- Review of Transmission Loss sharing

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RENEWABLES

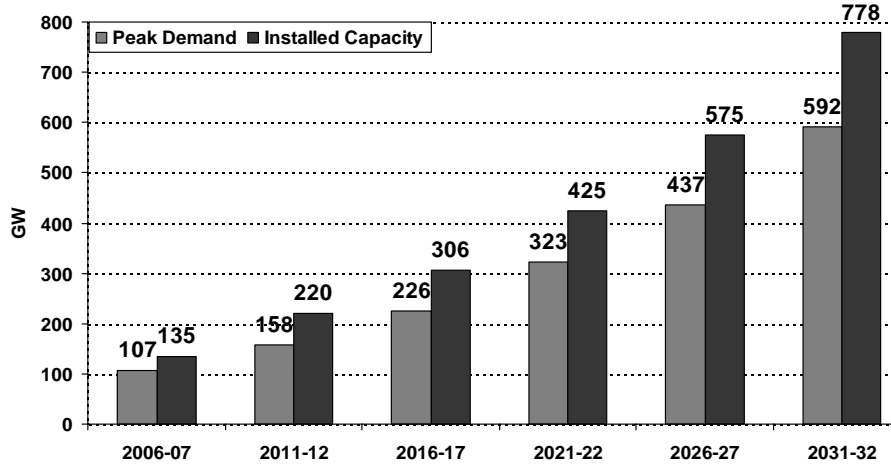
- Recently CERC has come out with Renewable Energy Certificate (REC) Regulation for “Green Energy Promotion”
- *NLDC is designated* as nodal agency for the Purpose of REC Regulations
- Trading Mechanism for RECs

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Projected Peak Demand and Installed Capacity at 8% GDP growth



Estimated Investment Requirement for 2012 Target: US \$ 200 Billion

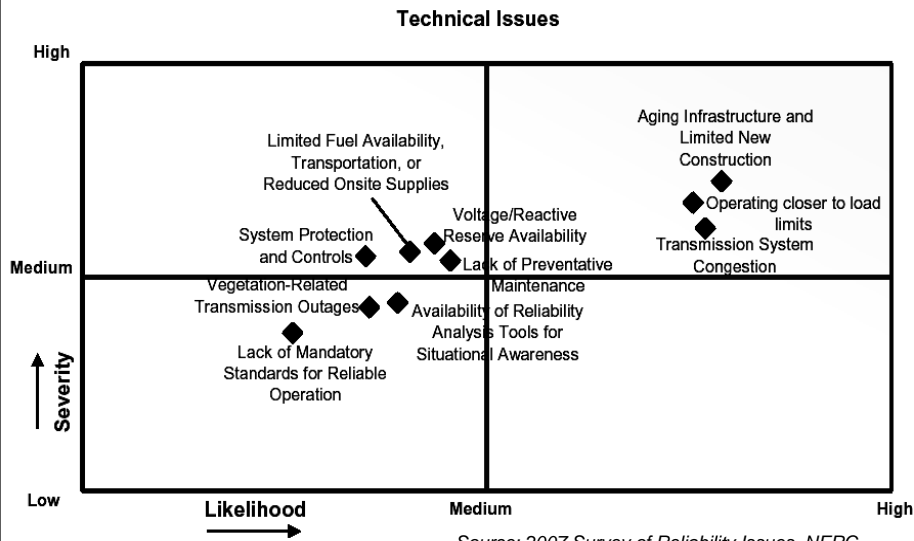
Source: Integrated Energy Policy, Govt. Of India

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Technical Challenges



Source: 2007 Survey of Reliability Issues, NERC

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