Welcome
Dimensions - Indian Grid & Electricity Market

- **340 GW+** generation capacity
- **170 GW+** peak demand
- **~ 4 TWh** daily energy met
- **3.2 million km²** area footprint
- **1.3 Billion+** people served
- **2.5 GW+** international exchanges
- **5000+** market participants
- **50,000+** market transactions
- **100 TWh+** annual market trades
- **390,000 ckm+** EHV transmission
- **70 GW+** renewables
- **2** power exchanges
- **5000+** exchanges
- **2** power exchanges
- **10 +** HVDCs
Evolution of Indian Grid

Pre 1991: Five Regional Grids - Five Frequencies

October 1991: East and Northeast synchronized

March 2003: West synchronized with East & Northeast

August 2006: North synchronized with Central Grid

Dec 2013: All India Synchronized Grid

175 GW Renewables, Cross Border Interconnections, Distribution System Operators (DSOs), Storage, Electric Vehicles, Micro-Grids

Electricity Act, 2003

Merging of Markets

1000 MW units and HVDC, 765 kV, UMPP, Common Carrier - Transmission

Maps not to scale

Way Forward
**POSOCO - Indian System Operator**

- Integrated National Power system Operation through Six Control Centres
  - National Load Despatch Centre (NLDC)
  - 5 Regional Load Despatch Centres (RLDCs)
    - Northern RLDC (NRLDC)
    - Western RLDC (WRLDC)
    - Southern RLDC (SRLDC)
    - Eastern RLDC (ERLDC)
    - North-Eastern RLDC (NERLDC)

- Mandate through Electricity Act, 2003 Sec 26 – 29
- National Electricity Policy, 2005 Section 5.3.7
- Schedule ‘A’ Central Public Sector Enterprise (CPSE)
- Discharging Mission Critical Statutory Functions of National Importance
Role of System Operators in Indian Power Sector

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<th>Policy Making</th>
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<td>Bilateral Markets</td>
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‘Vital link’ between the administrators, planners & regulators on one end and physical system and market players on the other end
Role of POSOCO

POSOCO - Apex body to ensure integrated operation of the power system at inter-state level

Mission of POSOCO
“Ensure Integrated Operation of Regional and National Power Systems to facilitate transfer of electric power within and across the regions and trans-national exchange of power with Reliability, Security and Economy”

Generation  Transmission  Distribution
Key Areas of System Operation

Operational Planning
- Coordinating planned and emergency outages
- Assessment of transfer capability of the network
- Defense mechanisms; black start mock drills

Real Time Operation
- Close monitoring of the system parameters
  - Frequency, voltages, line loadings
- Visualization and Situational Awareness

Post Despatch Analysis
- Analysis of Grid Incidents
- Operational feedback to CEA and CTU

Power Supply Position
- Peak Demand ~ 170 GW
- Energy Met ~ 3.5 BUs/day
- Hydro Gen. ~ 712 MU/day (Max.)
- Wind Gen. ~ 370 MU/day (Max.)

Generation
- Installed capacity: 343 GW
  - Thermal: Coal-197 GW, Gas-25 GW
  - Hydro – 45 GW, Nuclear – 6.7 GW
  - Renewables ~ 70 GW
    - Wind-34 GW, Solar-22 GW

Transmission
- 11 Nos. HVDC Bi-pole/BtB
- 1 MTDC HVDC
- > 145 nos. 765 kV,
- > 1550 nos. 400 kV lines
- IR capacity ~ 78 GW
Harnessing Diversity...Regional Grids

Typical All India Load Curve

Seasonal Variation

Morning & Evening Peak @ 500 – 600 MW/min for 1 hour
International Exchanges

India

- Upto 500 MW export by India to Nepal
- Upto 1500 MW import by India from Bhutan
- Upto 650 MW export by India to Bangladesh
- Upto 3 MW export by India to Myanmar

Bhutan, Bangladesh and Nepal participating in the Indian Electricity Market
Transmission Planning

• **Need of new transmission systems:**
  – To meet forecasted demand
  – For evacuation of power from generating stations
  – For system strengthening (To achieve network security aspects)

• **Transmission Systems in India:**
  – Inter-state transmission system (ISTS)
  – Intra-state transmission system (Intra-STS)
Roles of ISTS and Intra-STS

• **ISTS schemes:** *[Top layer of national grid]*
  – Evacuation of power from inter-state generation stations which have beneficiaries in more than one state.
  – Onward transmission of power for delivery of power from inter-state generation stations up to the delivery point of the state grid.
  – Transfer of operational surpluses from surplus state(s) to deficit state(s) or from surplus region(s) to deficit region(s) as need under relevant regulation

• **Intra-STS schemes:**
  – Evacuation of power from state’s generating (both under state and private sector) stations having beneficiaries in that State
  – Onward transmission of power within the State from ISTS boundary up to the various substations of the state grid
  – Transmission within the state grid for delivery of power to the load centers within the state
Responsibilities

- **Central Electricity Authority (CEA):**
  - Prepare perspective generation and transmission plans and coordinate the activities of planning agencies [*Sec 73 of Electricity Act*]
  - Formulate short-term and perspective plans for development of the electricity system [*Para 3.2 of National Electricity Policy*]
  - Frame National Electricity Plan [*Sec 3(4) of Electricity Act*]
  - Considerations in National Electricity Plan:
    - Short-term and long term demand forecast for different regions
    - Suggested areas/locations for capacity additions in generation and transmission
    - Integration of such possible locations with transmission system and development of national grid
    - Different technologies available for efficient generation, transmission and distribution
    - Fuel choices based on economy, energy security and environmental considerations
Responsibilities

• **Central Transmission Utility (CTU):**
  – Network planning and development in accordance with National Electricity Plan
  – Discharge all functions of planning and co-ordination related to inter-state transmission system (ISTS) with *[As per Sec 38(2) of Electricity Act (EA)]*
    • State Transmission Utilities
    • Central government and State Governments
    • Generating Companies
    • Regional Power Committees
    • Central Electricity Authority
    • Transmission Licensees
    • Any other person notified by the Central Government in this behalf
  – Planning to be done in accordance with National Electricity Plan of CEA

• **State Transmission Utility (STU):**
  – Network planning and development in accordance with National Electricity Plan
  – Nodal agency for Intra-STS planning in coordination with distribution licensees and intra-state generators connected/to be connected in the STU grid *[Sec 39 of EA]*
CEA Manual on Transmission Planning

• Manual on Transmission Planning Criteria brought out by CEA
  – 1st Criteria issued in 1985, setting philosophy for regional self sufficiency
  – Revised in 1994
  – Latest revision : 2013
  – It covers :
    • the planning philosophy
    • the information required from various entities
    • permissible limits
    • reliability criteria
    • Broad scope of system studies, modeling and analysis,
    • Guidelines for transmission planning
For strengthening of Transmission Network

- Addition of new transmission lines/substations to avoid overloading of existing system including adoption of next higher voltage.
- Application of Series Capacitors, FACTS devices and phase-shifting transformers in existing and new transmission systems to increase power transfer capability.
- Up-gradation of the existing AC transmission lines to higher voltage using same right-of-way
- Re-conductoring of the existing AC transmission line with higher ampacity conductors
- Use of multi-voltage level and multi-circuit transmission lines
- Use of narrow base towers and pole type towers in semi-urban/urban areas keeping in view cost and right-of-way optimization.
- Use of HVDC transmission – both conventional as well as voltage source convertor (VSC) based
- Use of GIS/Hybrid switchgear (for urban, coastal, polluted areas etc)
Reliability Criteria

A. Criteria for system with no contingency (‘N-0’)
   – all the equipments shall remain within their normal thermal loadings and voltage ratings
   – angular separation between adjacent buses shall not exceed 30 degree

B. Criteria for single contingency (‘N-1’)
   – All the equipments in the transmission system shall remain within their normal thermal and voltage ratings after a disturbance involving N-1 contingency, without load shedding / rescheduling of generation
   – The angular separation between adjacent buses under (‘N-1’) conditions shall not exceed 30 degree
   – Transmission system shall be stable after it is subjected to one of the disturbances as specified
Reliability Criteria

C. Criteria for second contingency (‘N-1-1’)

– The system shall be able to survive a temporary single phase to ground fault on a 765kV line close to the bus. Single pole opening (100 ms) of the faulted phase and successful reclosure (dead time 1 second) shall be considered.

– The system shall be able to survive a permanent single phase to ground fault on a 400kV line close to the bus. Accordingly, single pole opening (100 ms) of the faulted phase and unsuccessful reclosure (dead time 1 second) followed by 3-pole opening (100 ms) of the faulted line shall be considered.

– In case of 220kV / 132kV networks, the system shall be able to survive a permanent three phase fault on one circuit, close to a bus, with a fault clearing time of 160 ms (8 cycles) assuming 3-pole opening.
Transmission Planning Studies

• Studies to be conducted for Transmission Planning:
  – Power Flow Studies
  – Short Circuit Studies
  – Stability Studies (including transient stability and and voltage stability)
  – EMTP studies (for switching / dynamic over-voltages, insulation coordination, etc)
Growth in Transmission lines

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Growth in Substation capacity

TRANSFORMATION CAPACITY (MVA)

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Challenges

• Accuracy in assumptions: Load forecasts (Long-term forecasts in Electric Power Survey; Short-term forecasts in Annual Load-generation balance report)

• Uncertainty in upcoming generation projects

• Mismatch in schedules of planned ISTS and Intra-STS network
  – Under-utilisation of assets in some areas, congestion in others

• Is N-1 contingency enough to take care of low probability high impact events?

• How to accommodate RE generation in transmission network
  – Plan for additional transmission network?

• Operation of high capacity HVDCs
  – Agra HVDC
  – Low Short-circuit ratio of NER Grid (Voltage swings / surges)
  – Bi-directional flow on HVDC link

• Integration of 175GW of Renewable energy
Future Roadmap

- Ramping Requirements
- Reserves
- Smart Grid
- Cyber-Security
- Electricity Storage
- Grid Resilience
- Energy Efficiency
- Electric Vehicles