Indian Power Sector Overview

Reddyprasad.R, Assistant Professor
Dept. of EEE, SVCE, Bangalore
Power: The Building Block of Economy

• Electricity- the most imp. Infrastructural input in the dev. & growth of economy.
• Consumption of electricity- imp. Index of advancement of the country & standard of living.
• Economic growth rate of 8-9% on a sustained basis is necessary for us to catch up with the rest of the world.
An Analogy – Power System vs Human Body

Generation :: Heart

RLDC::Brain

Sub-Transmission :: Sub-Arteries

Transmission :: Main Arteries

Distribution :: Capillaries

User
### The Generation...

#### The Heart...

<table>
<thead>
<tr>
<th>Human Body</th>
<th>Power System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Pressure</td>
<td>Voltage</td>
</tr>
<tr>
<td>Heart Beat</td>
<td>Frequency</td>
</tr>
<tr>
<td><strong>The Pulse</strong></td>
<td><strong>50 Cycles/Seconds</strong></td>
</tr>
<tr>
<td>72 Beats/Minutes</td>
<td>Load-Gen.-Mismatch</td>
</tr>
<tr>
<td><strong>Cause</strong></td>
<td><strong>Risk</strong></td>
</tr>
<tr>
<td>Stress/Anxiety</td>
<td>Heart Beat Deviation</td>
</tr>
<tr>
<td><strong>Risk</strong></td>
<td>Frequency Deviation</td>
</tr>
<tr>
<td>Heart Beat Deviation</td>
<td></td>
</tr>
</tbody>
</table>
GENERATION

- Thermal Power Plant
- Hydro Power Plant
- Nuclear Power Plant
- Diesel Power Plant
- Gas Power Plant
- Combine Cycle plant

- Solar
- Tidal
- Wind
- Geothermal
- Bio-mass
- Fuel cells
• Hydro potential in North east and upper part of Northern Region
• Coal reserves mainly in Eastern Region
• Distribution of energy resources and consumption centres are extremely unbalanced
• Necessitate power transfer over long distances
Development of the Electricity Industry in the last 50 yrs.

• The industry has mainly developed through State controlled instruments.

• Until 1975 – dev. mainly through SEBs/electricity deptts. controlled by the respective state govts.

• 1975 – The Electricity (supply) Act was amended. Intervention of the central govt in development of generation facilities led to the formation of NTPC, NHPC

• Effect of this intervention started being felt in early 80’s.
Current Scenario in India

- Power Installed Capacity: 1,73,635 MW
- Energy Generation (p.a.): 788355 MU
- Supply Demand Gap: 9.8% Peak
  : 8.5% Average
- Per Capita Power Consumption: 850 kWh
- PLF: 75.07%
**Per Capita Energy Consumption**

The bar chart illustrates the per capita energy consumption for various countries and regions. The chart shows a comparison of energy usage per person across different nations, with the USA having the highest consumption, followed by Canada and South Korea. The United Kingdom and France also have notable energy consumption levels. The "Low per capita energy consumption" note indicates regions with significantly lower per capita energy usage.
Central Sector: 54412 MW
State Sector: 82452 MW
Private Sector: 36761 MW
All India: 173625 MW

All India Installed Generation Capacity
As on 31st March, 2011
SOURCE: CEA Website
TOTAL INSTALLED CAPACITY – 173,624 MW
(as on 31.03.2011)
India has an installed power generating capacity of 173625 MW (as on 31 March, 2011) of which the thermal power stations share is 112823 MW (65%).
Thermal, Nuclear and Hydro

• Installed capacity of power plants in India till 31st March, 2011 was around 173 GW of which
  • Thermal contribution is about 65%
  • Nuclear provides 2.8% of electricity generated
  • Hydro contribution is about 21.6%
    (Exploitable potential 60% at 84000 MW)
  • Renewables –10.6%
India’s Energy Needs

• 6% increase in GDP would contribute to 9% increase in energy demand

• Energy intensity is energy consumption per unit of GDP

• High energy intensity points to energy wastages in economy which can be minimised through efficient use of energy

• India’s energy intensity is 3.7 times of Japan, 1.55 times of USA, 1.47 times of Asia and 1.5 times the world average

• Ratio for developed countries < 1
Electricity Demand Projections

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Electricity Required (Billion kWhr)</th>
<th>Installed Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>GDP Growth Rate</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7%</td>
<td>8%</td>
</tr>
<tr>
<td>2011-12</td>
<td>1031</td>
<td>1097</td>
</tr>
<tr>
<td></td>
<td>206757</td>
<td>219992</td>
</tr>
<tr>
<td>2016-17</td>
<td>1377</td>
<td>1524</td>
</tr>
<tr>
<td></td>
<td>276143</td>
<td>305623</td>
</tr>
<tr>
<td>2021-22</td>
<td>1838</td>
<td>2118</td>
</tr>
<tr>
<td></td>
<td>368592</td>
<td>424744</td>
</tr>
<tr>
<td>2026-27</td>
<td>2397</td>
<td>2866</td>
</tr>
<tr>
<td></td>
<td>480694</td>
<td>574748</td>
</tr>
<tr>
<td>2031-32</td>
<td>3127</td>
<td>3880</td>
</tr>
<tr>
<td></td>
<td>627088</td>
<td>778095</td>
</tr>
</tbody>
</table>

Source: Energy Policy Report, Planning Commission, India
## Capacity Addition Target 11th Plan

<table>
<thead>
<tr>
<th>Type/Sector</th>
<th>Central (MW)</th>
<th>State (MW)</th>
<th>Private (MW)</th>
<th>Total (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal</td>
<td>24840</td>
<td>23301</td>
<td>11552</td>
<td>59693</td>
</tr>
<tr>
<td>Hydro</td>
<td>8654</td>
<td>3482</td>
<td>3491</td>
<td>15627</td>
</tr>
<tr>
<td>Nuclear</td>
<td>3380</td>
<td>0</td>
<td>0</td>
<td>3380</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>36874</strong></td>
<td><strong>26783</strong></td>
<td><strong>15043</strong></td>
<td><strong>78700</strong></td>
</tr>
</tbody>
</table>

The pie chart represents the distribution of capacity addition targets by type:
- **Yellow**: Thermal (59693 MW)
- **Teal**: Hydro (15627 MW)
- **Green**: Nuclear (3380 MW)
Growth of India’s Power Sector

serious growth after the 60s
Growth of the Indian Power Sector:

INSTALLED CAPACITY

• **INSTALLED CAPACITY** went up from 1.36 GW in 1947 to more than 167 GW as of 31.11.10; capacity comparable to UK / GERMANY.

• Or a targeted 9.5% growth in the power sector, a capacity addition of 78,577 MW has been proposed for the 11\textsuperscript{th} Plan
Electric Energy Generation Target for the year 2010-11 830.8 BU  
Actual Electric Energy Generation during the year 811.1 BU  
Growth in generation during 2010-11 5.55%  

The details of generation and growth rates are given are given below.

<table>
<thead>
<tr>
<th>Category</th>
<th>Target 2010-11 (BU)</th>
<th>Actual 2010-11* (BU)</th>
<th>% of Target</th>
<th>Actual Last Year 2009-10 (BU)</th>
<th>Growth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal</td>
<td>690.9</td>
<td>664.9</td>
<td>96.24</td>
<td>640.5</td>
<td>3.81</td>
</tr>
<tr>
<td>Nuclear</td>
<td>22.0</td>
<td>26.3</td>
<td>119.48</td>
<td>18.6</td>
<td>41.04</td>
</tr>
<tr>
<td>Hydro</td>
<td>111.4</td>
<td>114.3</td>
<td>102.64</td>
<td>103.9</td>
<td>10.01</td>
</tr>
<tr>
<td>Bhutan Import</td>
<td>6.5</td>
<td>5.6</td>
<td>85.68</td>
<td>5.4</td>
<td>4.69</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>830.8</strong></td>
<td><strong>811.1</strong></td>
<td><strong>97.63</strong></td>
<td><strong>768.4</strong></td>
<td><strong>5.55</strong></td>
</tr>
</tbody>
</table>

*Generation excludes generation from plants up to 25 MW Capacity.*
Annual energy Generation and Growth Rate during the years 2001-01 to 2010-11

<table>
<thead>
<tr>
<th>Plan Year</th>
<th>Energy (BU)</th>
<th>Growth (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-02</td>
<td>515.2</td>
<td>3.1</td>
</tr>
<tr>
<td>2002-03</td>
<td>531.6</td>
<td>3.2</td>
</tr>
<tr>
<td>2003-04</td>
<td>558.3</td>
<td>5.0</td>
</tr>
<tr>
<td>2004-05</td>
<td>587.4</td>
<td>5.2</td>
</tr>
<tr>
<td>2005-06</td>
<td>617.5</td>
<td>5.1</td>
</tr>
<tr>
<td>2006-07</td>
<td>662.5</td>
<td>7.3</td>
</tr>
<tr>
<td>2007-08</td>
<td>704.5</td>
<td>6.3</td>
</tr>
<tr>
<td>2008-09</td>
<td>723.8</td>
<td>2.7</td>
</tr>
<tr>
<td>2009-10</td>
<td>771.6</td>
<td>6.6</td>
</tr>
<tr>
<td>2010-11</td>
<td>811.1</td>
<td>5.6</td>
</tr>
</tbody>
</table>

* Generation during 2010-11 excludes generation from plants up to 25 MW capacity.
Pattern of Monthly Energy Generation during last 4 years

Energy (MU)

Month

Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar

2010-11
2009-10
2008-09
2007-08
The month wise pattern of energy generation from Thermal, Nuclear & hydro stations and imports from Bhutan are shown graphically below:

Pattern of monthly generation during 2010-11
The growth rate of energy generation in the country since 2000-01 is given below:

<table>
<thead>
<tr>
<th>Plan</th>
<th>Year</th>
<th>Generation (BU)</th>
<th>Annual Growth (%)</th>
<th>CAGR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IX Plan</td>
<td>2001-02</td>
<td>515.3</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2002-03</td>
<td>531.6</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2003-04</td>
<td>558.3</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2004-05</td>
<td>587.4</td>
<td>5.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2005-06</td>
<td>617.5</td>
<td>5.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2006-07</td>
<td>662.5</td>
<td>7.3</td>
<td></td>
</tr>
<tr>
<td>X Plan</td>
<td>2007-08</td>
<td>704.5</td>
<td>6.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2008-09</td>
<td>723.8</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2009-10</td>
<td>771.2</td>
<td>6.6</td>
<td></td>
</tr>
<tr>
<td>XI Plan</td>
<td>2010-11*</td>
<td>811.1</td>
<td>5.55</td>
<td></td>
</tr>
</tbody>
</table>

*Generation during 2010-11 excludes generation from plants up to 25 MW Capacity.*
Operation performance of power stations- salient features

- **Gross annual generation** crossed 800 BU (811 BU)

- **Gross monthly generation** figure has crossed 75 BU mark (75.5 in Mar’11)

- **Gross daily generation** figure has crossed 2.5 BU mark (2.508 on 18th Mar’11)

- **Nuclear generation** achieved a remarkable *growth rate of 41.04%* due to improved availability of nuclear fuel

- **Generation from hydro based plants improved with a growth rate of 10.01%** due to revival of good monsoon after 2 successive yrs of deficit rainfall conditions.
Operation performance of power stations- salient features

• Thermal generation achieved a growth rate of **3.81%**. Coal based generation achieved a growth rate of 3.99%.

• **Average PLF** of the thermal based plants was **75.1%** as compared to 77.68% in 2009-10.

• **53 stations** with an aggregate installed capacity of 53827.5 MW **achieved PLF of national average**

• **19 thermal stations** with an aggregate installed capacity of 21995 MW operated **above 90% PLF**.

• **Operational availability** of thermal stations marginally **reduced to 84.24% from 85.10 %** during the previous yr. Growth rate in respect of liquid fuel based GTs, multi fuel stations as well as DG sets had a negative growth rate.
The region wise anticipated annual power supply position for 2011-12 is given in the Table below:

<table>
<thead>
<tr>
<th>State / Region</th>
<th>Energy</th>
<th>Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Requirement</td>
<td>Availability</td>
</tr>
<tr>
<td></td>
<td>(MU)</td>
<td>(MU)</td>
</tr>
<tr>
<td>Northern</td>
<td>279581</td>
<td>249145</td>
</tr>
<tr>
<td>Western</td>
<td>287757</td>
<td>256237</td>
</tr>
<tr>
<td>Southern</td>
<td>250024</td>
<td>223814</td>
</tr>
<tr>
<td>Eastern</td>
<td>105461</td>
<td>97294</td>
</tr>
<tr>
<td>North-Eastern</td>
<td>10918</td>
<td>10884</td>
</tr>
<tr>
<td>All India</td>
<td>933741</td>
<td>837374</td>
</tr>
</tbody>
</table>
The trend of national average PLF of the thermal stations since 1997-98 onwards is represented in the graph below:
Reasons for low PLF compared to last year

• *Increased forced outages* of plants

• *Unscheduled/extended plant maintenance* of some thermal units

• *Forced shut down/backing down* due to raw water problems, coal shortages and receipt of poor quality coal

• *Receipt of lower schedule* from beneficiary states.
Plant Load Factor

• 1 per cent increase in PLF effectively means capacity addition of approx 1000 MW (requiring nearly Rs.4000 Cr.)

• Increasing the PLF of SEB plants would reduce the cost of supply and benefit the SEBs.
Performance of Nuclear Units

Nuclear generation registered a remarkable growth during the year 2010-11 mainly due to improved nuclear fuel conditions and additional generation from the newly commissioned nuclear unit at Kaiga in January’11 & re-commissioning of some of the units after R&M works. Average PLF of 65.45% in the year 2010-11 achieved by the nuclear plants is highest among last 5 years due to the improved fuel availability as detailed below:

<table>
<thead>
<tr>
<th>Year</th>
<th>Targets (BU)</th>
<th>Actual Generation (BU)</th>
<th>Achievement %</th>
<th>Growth</th>
<th>PLF (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005-06</td>
<td>16.80</td>
<td>17.24</td>
<td>102.62</td>
<td>4.78</td>
<td>63.2</td>
</tr>
<tr>
<td>2006-07</td>
<td>18.41</td>
<td>18.61</td>
<td>101.09</td>
<td>7.95</td>
<td>57.5</td>
</tr>
<tr>
<td>2007-08</td>
<td>22.71</td>
<td>16.78</td>
<td>73.89</td>
<td>-9.83</td>
<td>46.4</td>
</tr>
<tr>
<td>2008-09</td>
<td>19.00</td>
<td>14.71</td>
<td>77.42</td>
<td>-12.34</td>
<td>40.8</td>
</tr>
<tr>
<td>2009-10</td>
<td>19.00</td>
<td>18.64</td>
<td>98.11</td>
<td>26.72</td>
<td>51.1</td>
</tr>
<tr>
<td>2010-11</td>
<td>22.00</td>
<td>26.28</td>
<td>119.48</td>
<td>41.04</td>
<td>65.45</td>
</tr>
</tbody>
</table>
Indian Power Sector Long Term Trends

India is 3rd largest economy

Potentially 3rd largest electricity market globally by 2030

Estimated to be the fastest growing economy in the world by 2012

Indian Power Sector characterized by huge energy shortages

MAJOR REASONS FOR POWER SECTOR ILLS

- Inadequate power generation capacity;
- Lack of optimum utilization of the existing generation capacity;
- Inefficient use of electricity by the end consumer;
- Inadequate inter-regional transmission links;
- Huge T&D losses (theft) and skewed tariff structure, making SEBs unviable.
Optimum utilization of the existing generation capacity through R&M

- Old SEB units performing at low efficiency due to lack of R&M / poor maintenance. States unable to undertake R&M because of funds constraints.
- R&M is a cost effective (Rs 1 Cr/MW for thermal and Rs 60-70 Lakh/MW for hydro) and quick return option for increasing generation (new capacity @ Rs 4-5 Cr/MW).
- 170 thermal (11,000 MW) and 35 hydel (3,000 MW) units identified for R&M by CEA.
- 90 BU (20% of current annual generation) expected through R&M
Growth of Indian Power Sector: TRANSMISSION SYSTEM

• Required development of high voltage transmission system did suffer in the early years.

• During 80’s, when NTPC had the jurisdiction of creating HV transmission system along with their super thermal power stations, transmission side of the industry got a boost.

• Subsequently, PGCIL was formed out of NTPC and from 1992, PGCIL has added significantly towards creation of HV transmission system and development of the national grid

• Transmission sector opened up for private sector participation with the amendment of the ES Act in 1998
Inadequate inter-regional transmission links

• Uneven distribution of power resources (coal, hydel, etc.)

• Transporting coal costlier than transmitting power.

• Scenario of simultaneous surplus (ER) and shortage (Other regions)

• Existing interregional transmission capacity only about 22350 MW
Evolution of Grid Interconnection in India

- Local
- State
- Regional
- National

- 1950’s
- 1960’s
- 1970’s
- 1990’s
EVOLUTION OF POWER SYSTEM IN INDIA

PRE INDEPENDENCE - SMALL ISOLATED SYSTEM

PRIOR TO 60s - GENERATION/TRANSMISSION BY SEBS

DURING 60s - LIMITED INTERCONNECTION BETWEEN NEIGHBOURING STATES

70s - EMERGENCE OF CENTRAL SECTOR GENERATION (NTPC/NHPC/NUCLEAR ETC.)

PLANNING OF GENERATION/TRANSMISSION ON REGIONAL BASIS

LATE 80s – INTEGRATED GRID OPERATION THROUGH 400kV SYSTEM

LATE 90s - ASYNCHRONOUS INTER REGIONAL LINKS
            LONG DISTANCE HVDC LINKS / B2B STATIONS
Isolated systems

- *Isolated systems* developed in and around industrial & urban areas

- *Establishment of CEA* under the Electricity (Supply) Act, 1948 for coordinated development of Power Sector

- The Act also provided for formation of *State Electricity Boards (SEBs)* in the States
**State Grid Systems**

- The systems around urban and industrial areas grew into full fledged *State Grid systems*.

- The *country was demarcated into five Regions* for the purpose of coordinated power sector planning.

- *Regional Electricity Boards* were established in each of the regions for facilitating integrated operation of state systems.

- *Inter-state lines* were planned which were treated as Centrally sponsored schemes.
Regional Grid System

• 1975: *Central Sector generation* utilities created

• Benefits of these to be shared by the states of the region.

• Construction of associated transmission system for evacuation of power as well as delivery of power to the constituent states, also entrusted to these corporations

• Focus of planning and development in the transmission system shifted from *State Grid system to Regional Grid system*

• By the end of 1980's *strong regional networks* came into existence.
Peculiarities of Regional Grids in India

- Deficit Region
- Snow fed - run-of-the -river hydro
- Highly weather sensitive load
- Adverse weather conditions: Fog & Dust Storm
- Very low load
- High hydro potential
- Evacuation problems
- Low load
- High coal reserves
- Pit head base load plants
- Industrial load and agricultural load
- High load (40% agricultural load)
- Monsoon dependent hydro
Inter Region Links

• 1989: *Power Grid Corporation of India* formed to give thrust to implementation of transmission system associated with Central generating stations

• few *inter-regional links* were also planned and developed to facilitate exchange among the various regions (limited to emergency situations)

• resource planning as well as grid operation and consequently the *operational frequencies of various regions continued to be Region specific.*
Focus of planning the generation and the transmission system shifted from the orientation of regional self-sufficiency to the concept of **optimization of utilization of resources on All India basis**

A strong National Grid system would enable such an **all-India generation planning and development**
Objectives underlying the formation of National Grid

• To transfer power from surplus regions to deficit regions

• Utilise maximum resources from diversified regions

• Ensure reliable, economical and quality power
Perspective transmission plan upto 2012

Cumulative Capacity of Interregional links

MW

Existing 2007 2012

30000
25000
20000
15000
10000
5000
0

4950
14000
30000
REGIONAL GRIDS ‘GEOGRAPHICAL’

Installed Generation Capacity
Current ~ 173 GW
Target for Year 2012: 200 GW

<table>
<thead>
<tr>
<th>Inter regional Link</th>
<th>MW capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>NER-ER</td>
<td>1,260</td>
</tr>
<tr>
<td>ER-NR</td>
<td>7,930</td>
</tr>
<tr>
<td>ER-SR* (excl. Talcher-Kolar bipole)</td>
<td>1,130</td>
</tr>
<tr>
<td>ER-WR</td>
<td>2,990</td>
</tr>
<tr>
<td>SR-WR</td>
<td>1,720</td>
</tr>
<tr>
<td>WR-NR</td>
<td>4,220</td>
</tr>
<tr>
<td>Other 132 KV Links</td>
<td>600</td>
</tr>
<tr>
<td>Talcher Kolar HVDC Bipole</td>
<td>2,500</td>
</tr>
<tr>
<td>Total as on date</td>
<td>22,350</td>
</tr>
<tr>
<td>Target for 2012</td>
<td>37,700</td>
</tr>
</tbody>
</table>
INTER-REGIONAL LINK CAPACITY
11th PLAN (2012)

37,150 MW OF INTER-REGIONAL POWER BY 2012
## Inter-Regional Transmission Capacity – 11th Plan

<table>
<thead>
<tr>
<th>Name of System</th>
<th>Power Transfer Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BiswanathCharhiyali – Agra HVDC Bipole at + 600kV</td>
<td>4000</td>
</tr>
<tr>
<td>NER-NR total</td>
<td>4000</td>
</tr>
<tr>
<td>Bongaigaon – Silliguri 400kV D/C</td>
<td>1000</td>
</tr>
<tr>
<td>NER-ER total</td>
<td>1000</td>
</tr>
<tr>
<td>Barh – Balia 400kV D/C (Quad Moose)</td>
<td>1200</td>
</tr>
<tr>
<td>Sasaram – Fatehpur 765kV S/C (40% Series Comp.)</td>
<td>2300</td>
</tr>
<tr>
<td>ER-NR total</td>
<td>3500</td>
</tr>
<tr>
<td>Rourkela – Raipur 400kV D/C line-2 (with TCSC)</td>
<td>1400</td>
</tr>
<tr>
<td>North Karanpura - Sipat 765kV S/C</td>
<td>2300</td>
</tr>
<tr>
<td>Hirma – Sipat 400kV D/C</td>
<td>1000</td>
</tr>
<tr>
<td>Hirma – Raipur 400kV D/C</td>
<td>1000</td>
</tr>
<tr>
<td>ER-WR total</td>
<td>5700</td>
</tr>
<tr>
<td>Agra-Gwalior 765kV S/C line-1 (operation at 765kV)</td>
<td>1200</td>
</tr>
<tr>
<td>Agra-Gwalior 765kV S/C line-2</td>
<td>2300</td>
</tr>
<tr>
<td>Kaukroli – Zerda 400kV D/C</td>
<td>1000</td>
</tr>
<tr>
<td>RAPP-Nagda 400kV D/C</td>
<td>1000</td>
</tr>
<tr>
<td>NR-WR total</td>
<td>5500</td>
</tr>
<tr>
<td>Parli – Raichur 400KV D/C</td>
<td>1000</td>
</tr>
<tr>
<td>ER-WR total</td>
<td>1000</td>
</tr>
<tr>
<td>All India (addition during 11th Plan)</td>
<td>20700</td>
</tr>
</tbody>
</table>
Transmission System for Hydro development in NER

30-35 GW of Hydro potential in North-eastern Region
10 GW from Sikkim and Bhutan

- Substantial power from this region would be required to be transmitted to NR/WR over distances exceeding 2000 km.
- Right of way constraints in the chicken neck area.
- Hybrid network of EHVDC and high capacity 400 kV AC developed.
Acquiring Right of Way (ROW) for constructing transmission system is getting increasingly difficult. This necessitates creation of high capacity “Transmission Highways”, so that in future, constraints in ROW do not become bottleneck in harnessing natural resources.

Four major power regions of the country namely, North-Eastern, Eastern, Western and Northern are now operating as one synchronous grid.
NATIONAL GRID : THE ADVANTAGES

• STRONG BACKBONE ‘ANYWHERE TO ANYWHERE’ TRADING
• ECONOMIC OPERATION
• OPTIMAL UTILISATION OF SCARCE NATIONAL RESOURCES
• HARNESS DIVERSITY
  – SAVING OF 13,000 MW BY YEAR 2012
• ADDED STABILITY
• BOUNDARY-LESS OPERATION
• HUB AND SPOKE ARRANGEMENT
• GENERATORS HAVE READY EVACUATION PATH

THE NATIONAL GRID ENVISAGED BY POWERGRID IS A HYBRID NETWORK COMPRISING A 765 kV HUB WITH 400 kV AC AND 500 kV HVDC SPOKES
CHEAP HYDRO POWER FROM THE NORTH-EAST AND PIT HEAD THERMAL POWER FROM THE EAST ENTERS THE RING AND EXITS TO POWER STARVED REGIONS.
International Interconnections

Nepal

Over 16 links of 132/33/11 KV
Radial links with Nepal
Net import by Nepal

Bhutan

Tala: 1020 MW
Chukha: 336 MW
Kurichu: 60 MW
Net import by India

India- Bhutan synchronous links
400 kV Tala-Binaguri D/C
400 kV Tala-Malbase-Binaguri
220 kV Chukha-Birpara D/C
220 kV Chukha-Malbase-Birpara
132 kV Kurichu-Bongaigaon

Sri – Lanka

Madurai (India) and Anuradhapura (Sri Lanka) through ±500 KV HVDC under sea cable

Bangladesh

400 KV AC line between Baharampur (India) and Bheramara (Bangladesh) with 500 MW HVDC sub-station at Bheramara

Maps not to scale
Control Centres

• Bulk electric power systems comprise of hundreds of generating units interconnected by an intricate web of transmission & distribution spread across vast geographical stretches.

• For ensuring a reliable and quality supply to the consumers, the power system must be operated within the prescribed reliability standards.

• The system operators positioned at well-equipped control centres provide the coordination services that are vital for operating the system within the operating limits.
Load Despatch Centers in India

• The control of the grid is planned to be done at 3 levels of hierarchy namely NLDC, RLDC and SLDC.

• Each level of hierarchy has definite roles and responsibilities
Hierarchy of Indian Power System

- **National Grid**: 1
- **Regional Grids**: 5
- **State Utilities**: 33

**Surplus Regions**
- **NR**: North Region
- **WR**: West Region
- **ER**: East Region
- **NER**: North-East Region
- **SR**: South Region

**Deficit Regions**
- **29400 MW**

The map illustrates the distribution of surplus and deficit regions across India, with the surplus regions highlighted in green and the deficit regions in red.
Role of NLDC

- Economy and Efficiency of National Grid
- Scheduling and dispatch of electricity over the inter-regional links
- Monitoring of operations and grid security of National Grid
- Restoration of synchronous operation of National Grid
- Trans-national exchange of power
- Feedback to CEA & CTU for national Grid Planning
- Dissemination of information

Supervision & control

Supervision

Coordinate

RPC for regional outage Plan

Inter Regional Links

Accounting

RLDC

Coordinate
Role of RLDC

Exclusive functions

- Real time operation, control & contingency analysis
- Generation scheduling/re-scheduling
- Restoration
- Metering & data collection
- Compiling & furnishing of operation data
- Operation of Regional UI pool Account. Reactive energy account and Congestion charge account
- Operation of ancillary services
Role of RLDC

Functions
• optimum scheduling and despatch of electricity
• Monitor grid operation
• Keep accounts of electricity transmitted
• Exercise Supervision and control over the ISTS
• Real time operations

Apex body for integrated operation

For ST Open Access Nodal Agency

SLDC

Comply the directions

Central

State

Licensee
Generating company
Generating station / Sub-stations
any other concerned person

Directions
Role of SLDC

SLDC – Apex body in a State

- Optimum scheduling and despatch
- Monitor grid operations
- Keep accounts of electricity transmitted
- Activities of Real-time operation
- exercise supervision and control

Licensee,
generating company,
generating station, sub-station and any other concerned person

Ensure compliance
Directions and exercise supervision and control

RLDC
Role of RPC

- Facilitate the stable and smooth operations of the system
- Functions:
  - regional level operation analysis
  - facilitate inter-state/inter-regional transfer of power
  - facilitate planning of inter-state/intrastate transmission system
  - coordinate maintenance of generating units
  - coordinate maintenance of transmission system
  - protection studies
  - Planning for maintaining proper voltages
  - Consensus on issues related to economy and efficiency

MS SRPC shall certify Availability of transmission system
Prepare Regional Energy Account, Weekly UI, Reactive & Congestion charge account

Decisions

RLDC/SLDC/CTU/
STU/ Users
Role of CTU

- to undertake transmission of electricity through ISTS
- to ensure development of an efficient, co-ordinated and economical ISTS

CTU/to provide non-discriminatory Open Access
- Will not engage in trading and generation
- For LTOA & MTOA nodal agency
Role of STU

- to undertake transmission of electricity through intra-state transmission system
- to ensure development of an efficient, co-ordinated and economical intra-state transmission system

STU/to provide non-discriminatory Open Access
Long-term plan (10-15 years)

CEA

- Identification of major inter state/regional lines including system strengthening schemes
- Planning schemes shall also consider:
  - CEA’s:
    - Long-term perspective plan
    - Electric Power Survey of India report
    - Transmission Planning Criteria and guidelines
    - RPC Feedback
    - NLDC/RLDC/SLDC feedback
    - CERC Regulations
    - Renewable capacity addition (MNRES)

Annual plan (5 year forward term)

- Continuous inter/intra state transmission system
- Continuously updated to reflect load projections and generation scenarios
- NEP
- Avoid congestion
Role of CEA

- will formulate short-term and perspective plans for transmission system
- specify technical standards for construction of electrical plants, electric lines and connectivity to the grid
- specify safety requirements for construction, operation and maintenance of electrical plants and electrical lines
- specify grid standards for operation and maintenance of transmission lines
- specify conditions for SEMs
- Promote and assist timely completion of schemes
- To collect and record electrical data- cost, efficiency
- To carry out investigation (Electrical system)
- **Shall Prepare National Electricity Plan (NEP)**
## Power Sector Institutions (Pre 1990)

<table>
<thead>
<tr>
<th>Institution</th>
<th>Year</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEA</td>
<td>1950</td>
<td>Arbitration, Advice, Power Policy</td>
</tr>
<tr>
<td>CPRI</td>
<td>1960</td>
<td>Power Engineering Research</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equipment Testing and Certification</td>
</tr>
<tr>
<td>REC</td>
<td>1969</td>
<td>Finance and Planning for Rural Electrification</td>
</tr>
<tr>
<td>MOEF</td>
<td>1974</td>
<td>Policy, Legislation</td>
</tr>
<tr>
<td>NTPC</td>
<td>1975</td>
<td>Thermal Power Generation</td>
</tr>
<tr>
<td>NHPC</td>
<td>1975</td>
<td>Hydro Power Generation</td>
</tr>
<tr>
<td>PFC</td>
<td>1986</td>
<td>Finance for Power Projects, T&amp;D and Renovation</td>
</tr>
<tr>
<td>PGCIL</td>
<td>1989</td>
<td>Regional Grid Monitoring, Transfer of Power, Transmission Line Construction</td>
</tr>
<tr>
<td>EMC</td>
<td>1989</td>
<td>Energy Conservation Information, Research, Training</td>
</tr>
</tbody>
</table>
Organisation Structure

• MOP in the Union GOI
• CEA as the Statutory technical wing of the MOP, GOI, to assist in overall planning, coordination & regulation of power development programmes of the country.
• A no. of corporations under GOI to develop and operate power stations which include NTPC, NHPC, NEEPCO etc.
• REC, a GOI company for assisting the SEBs in the development & programmes of rural electrification.
• PGCIL, under GOI to establish & maintain HV transmission system and regional load despatch centres.
Organisation Structure (contd.)

• PFC under GOI to assist the various EBs & other organisations in the power sector.
• Department of Energy/Power under various state governments.
• SEBs under respective state governments to take care of generation of thermal and hydro power as also transmission & distribution within their own states. Some of the state governments have also set up power generation corporations.
• Professional organisations like CPRI, NPTI, Energy Management Centre, Council of Power Utility etc.
The Indian Electricity Act, 1910

- Provided basic framework for electric supply industry in India.
- Growth of the sector through licensees. License by State Govt.
- Provision for license for supply of electricity in a specified area.
- Legal framework for laying down of wires and other works.
- Provisions laying down relationship between licensee and consumer.
The Electricity (Supply) Act, 1948

- Mandated creation of SEBs.
- Need for the State to step in (through SEBs) to extend electrification (so far limited to cities) across the country.
Main amendments to the Indian Electricity Supply Act

- **Amendment in 1975** to enable generation in Central sector.

- **Amendment in 1991** to open generation to private sector.

- **Amendment in 1998** to provide for private sector participation in transmission, and also provision relating to Transmission Utilities.
The Electricity Regulatory Commission Act, 1998

• Provision for setting up of Central / State Electricity Regulatory Commission with powers to determine tariffs.

• Constitution of SERC optional for States.

• Distancing of Government from tariff determination.
Energy Conservation Act, 2001

• The Act primarily ensures energy efficiency in consumption & consequently Demand Side Management (DSM) for reducing need for installing new capacity.

• Bureau of Energy Efficiency (BEE) has been set up on 1st March, 2002 for formulating norms for processes, consumption standards, testing, certification and labeling procedures etc.
Electricity Act 2003

It is a comprehensive legislation replacing Electricity Act 1910, Electricity Supply Act 1948 and Electricity Regulatory Commission Act 1998.

The aim is to push the sector onto a trajectory of sound commercial growth and to enable the States and the Centre to move in harmony and coordination.

The objective is to introduce competition, protect consumer’s interests and provide power for all.
The Act provides for National Electricity Policy, Rural Electrification, Open access in transmission, phased open access in distribution, mandatory SERCs, license free generation and distribution, power trading, mandatory metering and stringent penalties for theft of electricity
Salient features of the National Electricity Policy

• Access to Electricity: Available for all households in next five years.
• Availability of Power: Demand to be fully met by 2012. Energy and peaking shortages to be overcome and spinning reserve to be available.
• Supply of Reliable and Quality Power of specified standards in an efficient manner and at reasonable rates.
• Per capita availability of electricity to be increased to over 1000 units by 2012.
• Financial Turnaround and Commercial Viability of Electricity Sector.
• Protection of consumers' interests.
Objectives of National Tariff Policy

• Ensure availability of electricity to consumers at reasonable and competitive rates

• Ensure financial viability of the sector and attract investments

• Promote competition, efficiency in operations and improvement in quality of supply
Generation

• To provide availability of over 1000 units of per capita electricity by 2010, more than 1,00,000 MW will be required during 2002-12.

• No requirement of licensing for generation. Techno-economic clearance for thermal generation project no longer required. For hydro generation, concurrence of CEA required only above certain capital expenditure. Captive generation, freed from all controls.
Transmission

• Simultaneous planning of adequate transmission capacities to avoid mismatch between generation and transmission facilities.

• Non-discriminatory Open Access in transmission introduced to promote competition.
Distribution

• Real challenge of reforms lies in the efficient management of the distribution system.
• Private sector participation in distribution to be encouraged.
• Energy Audits, energy accounting and declaration of results to be made mandatory.
• HVDS to be introduced.
• Stringent measures against theft of electricity.
Electricity (Amendment) Act, 2007


The main features of the Amendment Act are:

• Central Government, jointly with State Governments, to endeavour to provide access to electricity to all areas including villages and hamlets through rural electricity infrastructure and electrification of households.

• No License required for sale of electricity from captive units.

• Definition of theft expanded to cover use of tampered meters and use for unauthorized purpose.

• Theft made explicitly cognizable and non-bailable.

• Deletion of the provision for elimination of cross subsidies. The provision for reduction of cross subsidies would continue.
ACCELERATED POWER DEVELOPMENT AND REFORMS PROGRAMME

The Accelerated Power Development Reforms Programme (APDRP) was launched in 2002-03 for implementation in the 10th Plan as additional central assistance to the states for strengthening and up gradation of sub-transmission and distribution systems of high-density load centres like towns and industrial areas.

The main objectives of the programme were to *reduce AT&C loss* and to *improve quality and reliability of supply*. 
Upgradation / Strengthening of sub-transmission and distribution system

• Fix Static meters on all HT and LT consumers and high accuracy tamper proof meters for other consumers.
• Get Energy audit conducted for all distribution circles and sub divisions.
• Introduce time of the day metering for HT and LT consumers.
Launched on 4th April, 2005 for the attainment of the National Common Minimum Programme (NCMP) goal for providing access to electricity to all households in the country in five years.

**Rural Electrification Corporation (REC)** is the nodal agency for the scheme. Under the scheme 90% capital subsidy would be provided for overall cost of the project for provision of:

**Rural Electricity Distribution Backbone (REDB)** with at least one 33/11 kV (or 66/11kV) substation in each block

**Village Electrification Infrastructure (VEI)** with at least one distribution transformer in each village/habitation.

**Decentralized Distribution Generation (DDG) Systems** where grid supply is either not feasible or not cost-effective.
Legislative/administrative Initiatives taken by the
Government to improve the health of Power Sector (recap)

- Electricity Laws (Amendment) Act, 1998 to facilitate private
  investment in transmission.
- Ultra Mega Power Projects (UMPPs)
- Setting up of Power Trading Corporation.
- Development of merchant power Plants
- New Hydel Policy to provide thrust to Hydro capacity addition.
- Accelerated Power Development & Reforms Programme
- Energy Conservation Act in place
- Electricity Bill 2001 tabled in Parliament
- Settlement of Outstandings of PSUs with States
- Private participation in transmission
- Development of transmission projects through competitive
  bidding
Power Sector – Reforms to Drive Growth

PREVIOUSLY
- Losses of SEB’s
- Irregularity of payment to Suppliers
- Capex planned impacted
- Acute Shortage
- Focus on Generation
- T&D Losses

REFORMS
- Settlement of SEB’s dues
- Electricity Act, 2003
- APDRP (Accelerated Power Development and Reforms Program)
- AREP (Accelerated Rural Electrification Program)
- Power Trading

GOING FORWARD
- Rising role of Private Sector
- Increased project size (Ultra Mega Generation & Transmission Projects)
- New technologies
- Thrust on Hydro and Nuclear
**Strengths and opportunities in the sector**

- Abundant coal reserves (enough to last at least 200 years).
- Vast hydroelectric potential
- Large pool of highly skilled technical personnel.
- Impressive power development in absolute terms (comparable in size to those of Germany and UK).
- Expertise in integrated and coordinated planning (CEA and Planning Commission).
Strengths and opportunities in the sector (contd.)

• Emergence of strong and globally comparable central utilities (NTPC, POWERGRID,).
• Wide outreach of state utilities.
• Enabling framework for private investors.
• Well laid out mechanisms for dispute resolution.
• Political consensus on reforms.
• Potentially, one of the largest power markets in the world.
POWER SCENARIO IN INDIA

- Booming energy demand
- Increasing role of private participation
- Liberalisation from government
- Huge losses in transmission and pilferage
Thank you!
Three Phase Transmission Line
Symmetric Line Spacing – 69 kV
Birds Do Not Sit on the Conductors
Bundled Conductor Pictures

The AEP Wyoming-Jackson Ferry 765 kV line uses 6-bundle conductors. Conductors in a bundle are at the same voltage!

Photo Source: BPA and American Electric Power
Transmission to Distribution Transformer
Transmission Level Transformer

230 kV surge arrestors

Oil Cooler

Radiators W/Fans

115 kV surge arrestors

Oil pump
Tree Trimming: Before
Tree Trimming: After
Transmission Line Corridors from the Air

Image Source: Jamie Padilla