Flexibility Requirement in Indian power system

01st December 2017
Indian Power System

- Peak Demand ~ 160 GW
- Energy Met ~ 3.5 BUs/day
  - Hydro Gen. ~ 712 MU/day (Max.)
  - Wind Gen. ~ 310 MU/day (Max.)
- Generating Stations ~ 900 Nos.
- Generating Units ~ 2200 Nos.
- > 7000 Sub-stations,
- > 3100 transformers
- 10 Nos. HVDC Bi-pole/BtB
- > 100 nos. 765 kV lines
- > 1300 nos. 400 kV lines,
- > 3200 nos. 220 kV lines
- 26 ISTS transmission licensees

Indian Power Market

- Licensed Traders - 43 Nos.
- Market Participants > 3000 Nos.
- Two Power Exchanges (PXs)
  - Indian Energy Exchange
  - Power Exchange of India Ltd.
- Open Access Volumes
  - Transactions ~ 45,000 Nos./yr.
  - Bilateral ~ 14,000 Nos.
  - Collective (PX) ~ 31,000 Nos.
- Energy ~ 100 BUs/yr.
  - Bilateral ~ 65 BUs
  - Collective (PX) ~ 35 BUs
- Short Term ~ 10 %

International Interconnections

- Nepal
- Bhutan
- Myanmar
- Bangladesh
- 250 MW export
- 1400 MW import
- 600 MW export
- 3 MW export
Typical All India Load Pattern

Typical Ramp rate of 250 MW/min

Special Days ~ 500 MW/min
**Increasing trend of demand met**

- Hourly demand met pattern

- Maximum, Minimum and Average Demand met pattern.
Hourly Variability of Demand

Hourly Variability of All India Demand

Hourly Variability in MW

2008 2009 2010 2011 2012 2013 2014

Year
Increasing Flexibility Requirement

- Peak demand increasing year after year
- Difference between daily peak and lean is showing an increasing trend
- Growth during peak hours is much more than lean hours
- Need for more flexible generation to counter this gap
Ramping in All India Demand
All India Thermal Generation

5 minute intervals of a day
Solar Generation

Solar gen as % of total capacity

Percentage of Capacity

Time Block of the day

NPKUNTA SOLAR GENERATION VARIABILITY RAMP UP BLOCK

Per block variation in MW

% of time
Flexibility index = \((\text{Max} - \text{Min})/\text{Max}\) over the years
All India Plant Load Factor (%) of Thermal Power Stations
Coal and Lignite based
Ancillary Services

RRAS Providers: 48 Nos.
Capacity under RRAS: 51 GW
Maximum ‘Up’ Regulation: 3746 MW
Maximum ‘Down’ Regulation: 1946 MW

Lowest Variable Charge ~ Rs. 1.25 / Unit (CGPL– WR)
Highest Variable Charge ~ Rs. 8.12 / Unit (Anta LF– NR)
RRAS Despatch:
Up – 6 MU / day (Avg.)
Down – 1 MU / day

Energy Despatched:
Up – 6 MU / day (0.2% of Energy met)
Down – 1 MU / day (0.03% of Energy met)

Avg. Daily Number of RRAS Instructions: 06 to 07 Nos.
Energy Despatched:
Up – 6 MU / day
Down – 1 MU / day
# Pumped Storage Plants in India

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of Project / State</th>
<th>Installed Capacity</th>
<th>Pumping Mode Operation</th>
<th>Reasons for not working in Pumping mode</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No. of units x MW</td>
<td>Total (MW)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Kadana St. I &amp; II Gujarat</td>
<td>2x60 + 2x60</td>
<td>240</td>
<td>Not working</td>
</tr>
<tr>
<td>2</td>
<td>Nagarjuna Sagar Andhra Pradesh</td>
<td>7x100.80</td>
<td>705.60</td>
<td>Not working</td>
</tr>
<tr>
<td>3</td>
<td>Kadamparai Tamil Nadu</td>
<td>4x100</td>
<td>400</td>
<td>Working</td>
</tr>
<tr>
<td>4</td>
<td>Panchet Hill - DVC</td>
<td>1x40</td>
<td>40</td>
<td>Not working</td>
</tr>
<tr>
<td>5</td>
<td>Bhira Maharashtra</td>
<td>1x150</td>
<td>150</td>
<td>Working</td>
</tr>
<tr>
<td>6</td>
<td>Srisailam LBPH Andhra Pradesh</td>
<td>6x150</td>
<td>900</td>
<td>Working</td>
</tr>
<tr>
<td>7</td>
<td>Sardar Sarovar Gujarat</td>
<td>6x200</td>
<td>1200</td>
<td>Not working</td>
</tr>
<tr>
<td>8</td>
<td>Purlia PSS West Bengal</td>
<td>4x225</td>
<td>900</td>
<td>Working</td>
</tr>
<tr>
<td>9</td>
<td>Ghatgar Maharashtra</td>
<td>2x125</td>
<td>250</td>
<td>Working</td>
</tr>
</tbody>
</table>

**Total** 4785.60

Source: “Large scale integration of Renewable Energy Sources-Way forward” Report by CEA
Pumped Storage

MW +gen
MW -Pump

Typical day of June month

5 minute samples in a day (tot 288)
Provisions Regarding Ramping

- **Provisions in the Indian Electricity Grid Code (IEGC):**
  - Operating Code (Section 5.2):
    - System Security Aspects - Ramping of
      - All thermal units greater than 200 MW.
      - All Hydro units greater than 10 MW
    - Sudden change in generation / load by the utilities of more than 100 MW without prior intimation to and consent of the RLDC.
  - Scheduling and Despatch Code (Section 6.4)
    - Generators to declare rate of ramping up / ramping down in a 15 minute block.
    - Acceptable ramping rate – 200 MW/ Hour (in NER 50 MW/ Hour)

- **CEA Standard Technical Features of Super-Critical Units**
  - Ramp rate: + 3% per minute (above 30% loading)
  - Technical minimum load of super critical units – 40%
  - Two shift operation mandated
Technical minimum

• **CERC grid code fourth amendment regulations 2016**
  – Technical Minimum - 55%
  – Implementation is notified by CERC

• **Beneficiaries (DISCOMs) are directed to compensate for the Heat rate degradation**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Unit loading as a percentage % of installed capacity of the unit</th>
<th>Increase in SHR for supercritical units (%)</th>
<th>Increase in SHR for sub – critical units (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>85-100</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>2</td>
<td>75-84.99</td>
<td>1.25</td>
<td>2.25</td>
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<tr>
<td>3</td>
<td>65-74.99</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>55-64.99</td>
<td>3</td>
<td>6</td>
</tr>
</tbody>
</table>
Increasing granularity of Despatch Interval

5-minutes scheduling:

- Reduced the steep ramps
- Eliminates sharp discreet changes
- Reduced frequency fluctuations
- Facilitates better load management
- Facilitates integration of renewables
Flexible Generation

• **Hydro**
  – Plan and implement more pumped storage
  – Operational norms to incentivize flexibility

• **Thermal**
  – Grid Code clauses on flexibility (ramp rate, minimum)
  – Incentives for flexible generation
  – Two-shift operation of thermal plants
  – Primary, Secondary and Tertiary Controls

• **Renewables**
  – Low Voltage Ride Through (LVRT)
  – Draft CEA standards notified
HVDCs in India
- 4 back to back HVDCs
- 6 bipole HVDC links
- 1 MTDC
- 1 more planned

CEA Transmission Planning Criterion (Section 18)
- More than 2000 MW over long distance more than 700 km.
- Corridors of AC lines carrying heavy power flows (total more than 5000 MW)
Signs of Inflexibility

• Difficulty in balancing demand and supply
  – Frequency excursions

• Renewable curtailment
  – Inability to balance

• Area Balance Violations (Deviations)

• Electricity Markets
  – Price volatility

http://www.nrel.gov/docs/fy14osti/61721.pdf
Way Forward

- Power systems are already flexible, designed to accommodate variable and uncertain load.
  - New actors RE, distributed generation, storage etc. to be accommodated

- Need for ‘Flexible’ Systems
  - Flexible Generation
  - Flexible Transmission – FACTs, HVDC
  - Flexible Distribution – Price responsive demand
  - Flexible Markets -
    - More Frequent market operation, Ancillary services, Demand response

- Policy / Regulatory Framework for Flexibility
  - Measuring Flexibility
  - Metrics for performance
  - Incentivizing and paying for flexibility
  - Policy support to anticipate flexibility needs and support system flexibility
  - Flexibility considerations can be integrated into the design of procurement policies
Flexibility Requirement in Indian Power System

Thank You

https://posoco.in/download/flexibility_requirement_in_indian_power_system/?wpdmdl=711