Reliability – from Load Forecasting to System Operation in Indian Power System

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July 25, 2007

- **Background**
- Evolution of power grids in India
- Establishment of regulatory framework
- Operational philosophy in vogue

- **Reliability aspects**
- Long term, mid term and short term (operational / outage) planning
- Day ahead scheduling of generation associated with real time operation
- Grid voltage vis-à-vis reactive power
- Other pertinent issues, like, network security, restoration procedures, mock trial for black start, etc.

- **Intro**
- In 1947 about 1360 MW of generation spread all over India, but in and around urban agglomerations through isolated generation
- River-valley projects and SEBs in federal structure with plants of higher capacity and interconnection in fifties and sixties leading to formation of state grids
- Seventies and eighties saw inter-state transmission forming 5 regional grids with installation of units of 200 / 500 MW size mainly by Central Govt.
- Later on in nineties and this decade with HVDC B2B and bulk supply between point to point made synchronously connected all but Southern Region (still connected with Eastern, Western through HVDC only) towards formation of national grid

- Side by side, adding of generation by IPPs
- Unbundling of power sector with generation, transmission and distribution as distinct entities
- Formation of regulatory bodies at Central and State level with the responsibility of fixing tariff
- Transmission still remains a monopoly, though joint sector venture made
- Open access has made trading in power possible

- Under such complex power system, reliability assumes great importance right from load forecasting, going through planning, design and establishment of supply system, to operation of system to balance continuously supply and demand depending upon reliability of each and every component of system

- **Reliability aspect of planning**
- Long term planning
  - CEA at the helm of affairs working with SEBs at grass-root level collects data on new demand in commercial, industrial, domestic, public services and irrigation and possible growth in existing ones
  - Works out projected peak demand and energy requirement on five-year basis for the next few five-year plans ahead based on combination of partial end use technique and trend analysis through extrapolation
  - T & D losses, load factor, diversity factor, etc. state / regional / national system-wise considered along with growth rate
  - Recession in Economy, restructuring of SEBs, etc. are other significant factors that influence scenario, also considered.

- Scrutinized by various Govt. Depts. including Planning Commission from the perspective of public funding based on prioritization in power sector
- CEA under integrated resources planning then makes details of generation commensurate with load considering aspects of planned and forced outage, system improvement, R & M of old but still running plants, projected new and renewable energy sources.
- In the process possible new corridors and those to be augmented are identified for haulage of power.

- Transmission planning starts with the philosophy of achieving a level of operating performance with adequacy and security, thus in turn with a trade-off between cost and risk with the level of uncertainty taken care of.
- It is based on combination of deterministic and stochastic approach.
- While refining corridors in terms of voltage in the process also determined site and size of substations
- Though generation de-licensed, grid expansion has a good planning oversight from CEA (in perspective plan) to POWERGRID (in mid-term plan)

- Additionally to augment generation coming up are ultra mega power projects of 4,000 MW capacity and above.
- With Central Govt. intervention augmentation of distribution under APDRP is in full swing with monitoring of bus as low as at 11 kV level.

- Mid term planning
  - Who does planning for 8760 hours of the year - DISCOMS, STUs, SLDCs?
  - IEGC talks about meeting demand without overdrawing from grid, a need to trade-off between interrupting consumer load without compromising with the grid security. ARR file doesn’t include quality of service, like, how many consumers would have to suffer power cuts and for what duration.
  - Under the scenario of shortage of energy as well as peak power, reliability of supply is commensurate not only with availability, but also with grid security.

- Outage Planning
  - With state grid codes existing, there is no problem in coordinating outage within states.
  - For jointly owned units and other Central Govt. owned units it is often difficult to arrive at consensus.
  - On the other hand units also can get away with slippage in maintenance plan thus running the risk of forced outage (less reliable).

- **Reliability aspect of day ahead scheduling**
  - Most of the hydro generation has little flexibility on account of irrigation requirement, barring few in respect of scheduling.
  - Similarly with coal-fired stations that cannot go below 70% due to poor quality of coal, scheduling is quite rigid and predictive, hence reliability may not be of much consequence.

- **Reliability aspect of real time operation**
- Two very pertinent parameters
  - Frequency: With operating philosophy of states as notional control area and no tight control mandated, as evidenced also from allowable frequency range of 49.0 to 50.5 Hz, frequency linked Unscheduled Interchange (UI) mechanism encourages control areas to monitor and control their off take to complement grid security.

- This unique real time pricing mechanism shows how with self-healing property markets take care of reliability, by complementing while causing economy even under shortage condition maintaining sovereignty of the utilities.
- Spot price linked to frequency that is collectively controlled and effectively stabilized, is tinkered by regulator through UI vector from time to time to achieve economy and reliability by creating a pseudo competitor. Regulator after public hearing and debate notifies UI price curve to cause economy and quality in the grid. However with different imbalances or UI prices for each regional grid, particularly when 4 regions are synchronously connected, fairly tight control is required if the network is to operate with reliability.

- Voltage: Simple scheme operating at inter-utility level with generators obliged to provide reactive power, but not compensated separately and value of static and dynamic reserve yet to be appreciated by the stakeholders

- **Network security**
- Real time contingency analysis for better situational analysis is an area of concern from the point of view of network security.
- Exceptional events, like, smog during winter, earthquake, weather related disturbances lead to large number of line tripping.
- Large design margin, as adopted for newer lines, reduces chance of failure, while for earlier constructed lines reliability is a big issue.
- UFLS and UVLS with pre-determined settings avert catastrophic failures.
- In the context of national grid, deliberations are going on for effecting Special Protection Scheme, such as, Wide Area Network Measurement and Control to contain widespread effect of system disturbance and improving reliability of large integrated system.

- **Restoration procedures**
- Based on grid code, clear-cut procedure exists for restoration in case of black out or brown out. But mock trial is necessary to see effectiveness of the same, as restoration in past has taken anything from an hour to 24 hours.
- In case of national grid, though vulnerability is more, early restoration through large islands with balancing of supply and demand reliably by proper identification may be possible.

- **Conclusions**
- Indian power sector has grown many times in the last six decades after independence.
- With the unbundling and open access power trading is going on in the context of electricity for all by 2012.
- Though reliability could not be measured or assessed, right from load forecasting to system operation its role and impact could be felt at component as well as system level.