



Flexibilisation Issues of Thermal Stations

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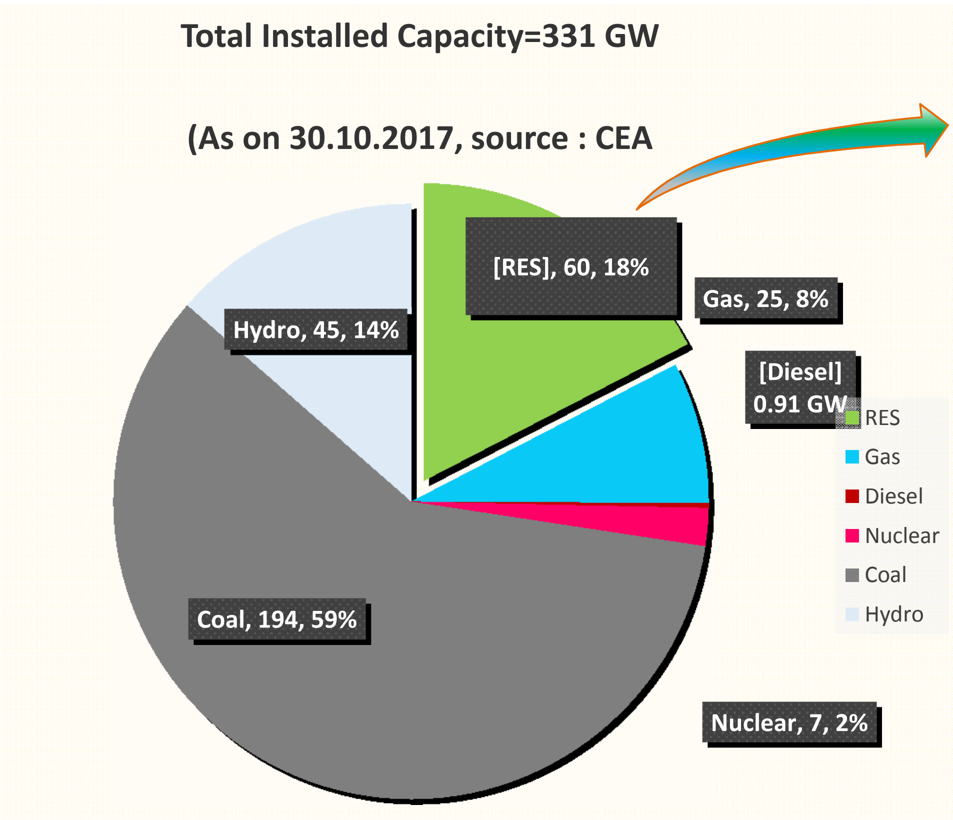
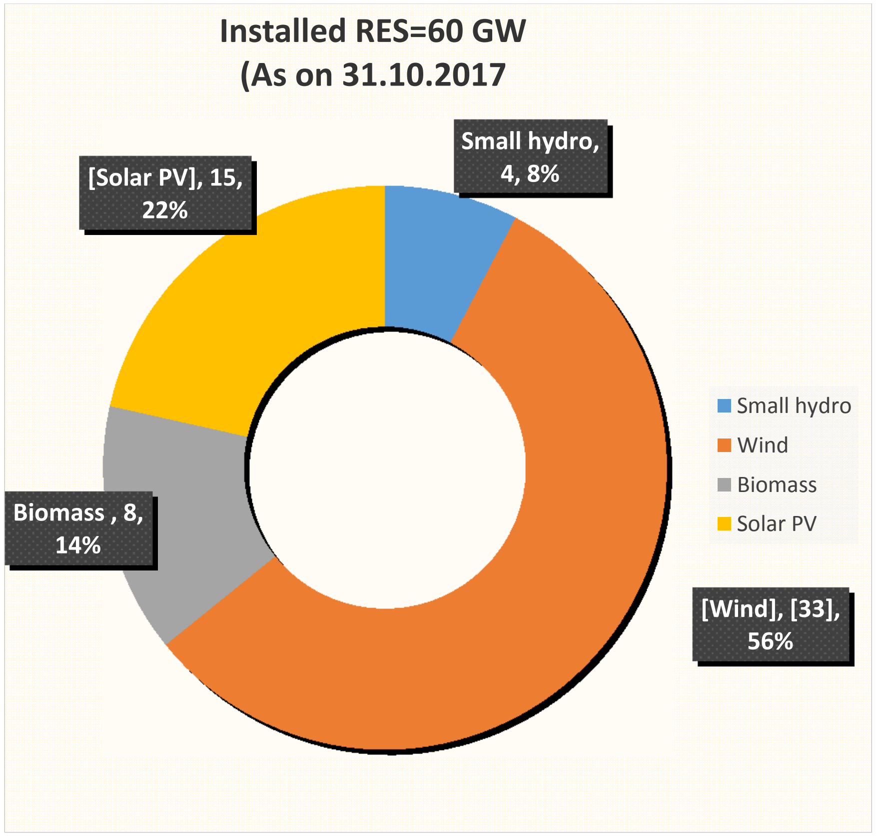
India's Present Installed /Renewable Capacity





Peculiarities of Variable Renewable power

- Variability
- Uncertainty
- Geographically Confined
- Low inertia

Impact on System

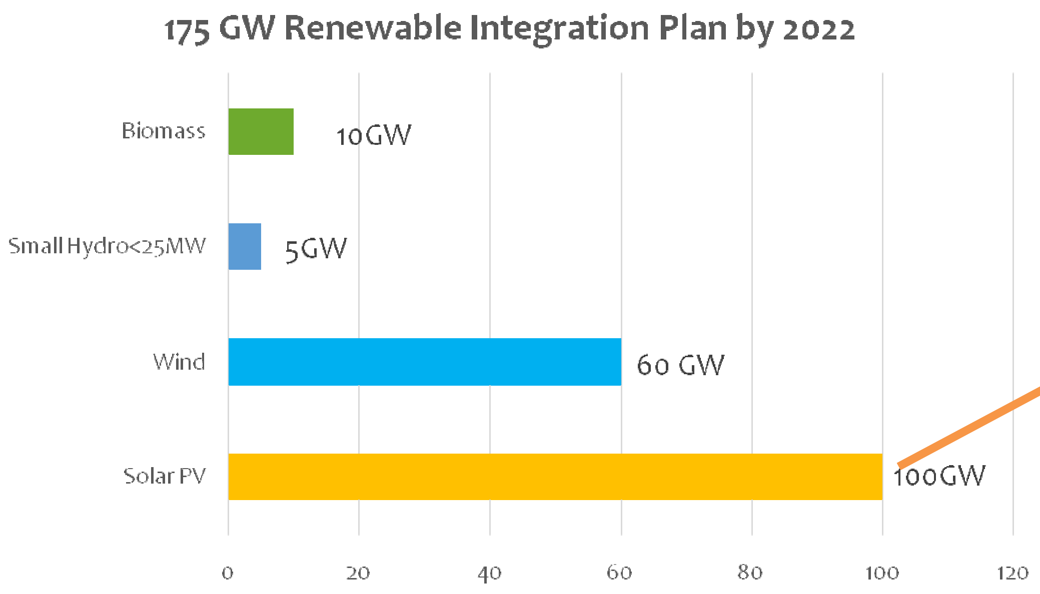
- Difficulty in load frequency control
- Difficulty in scheduling of tertiary reserves
- Requirement of enhanced transmission network and its under utilisation
- Increase in requirement of ancillary services and hence increased system operation cost
- Increase in transmission cost due to all above factors

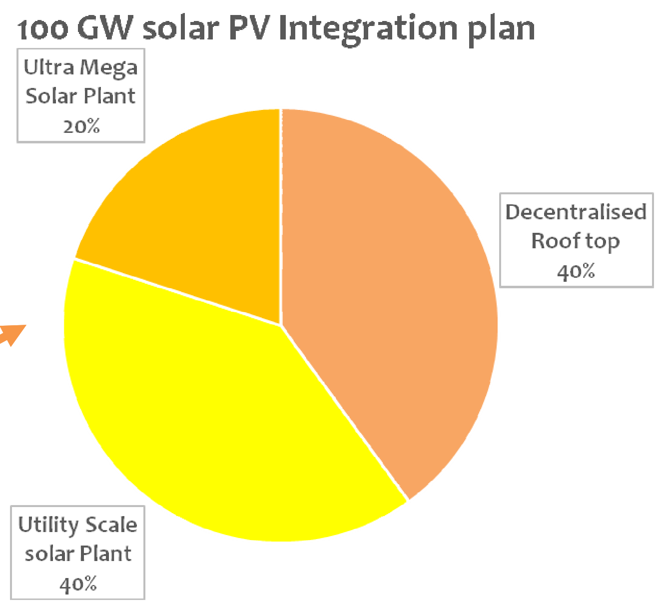
Impact on existing Plant

- Lower PLF due to ducking of load curve
- High ramping requirement
- Two shifting and cycling of plants
- Increased forced outage and O&M cost
- Equipments life time reduction
- Poor heat rate and high Aux. Power

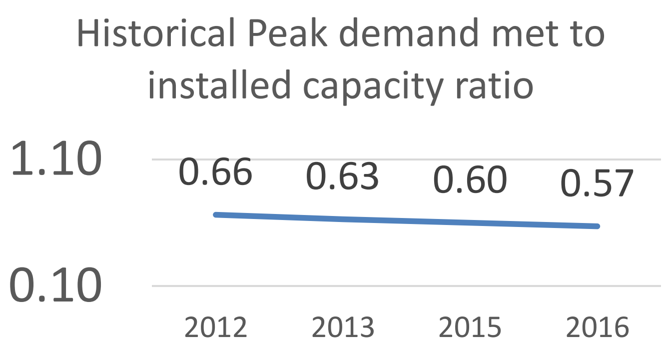
Future Renewable Integration Plan

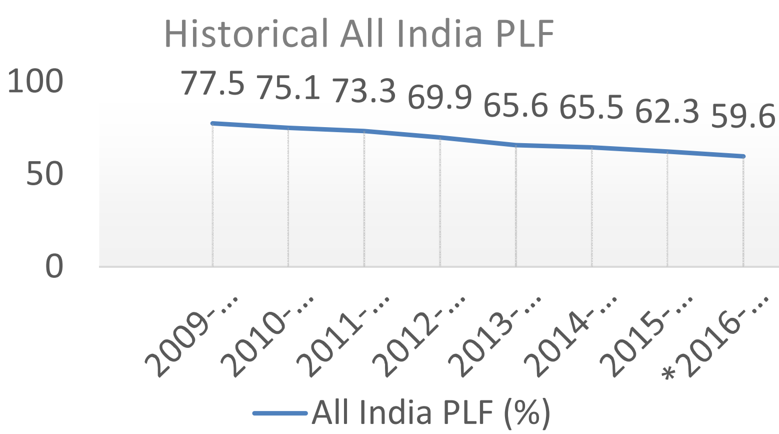
India's Intended Nationally Determined Contribution (INDC) aims to base **40% of the total installed power generation capacity on non-fossil fuel resources by 2030** with international support on technology transfer and financing. This includes Government of India's ambitious target of achieving 175GW of RE by the year 2022.



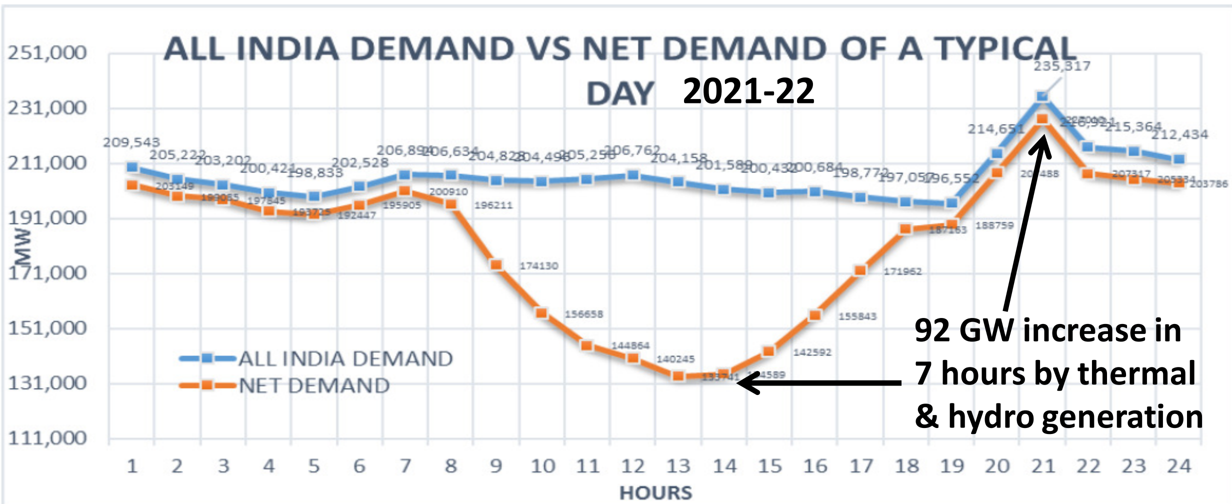


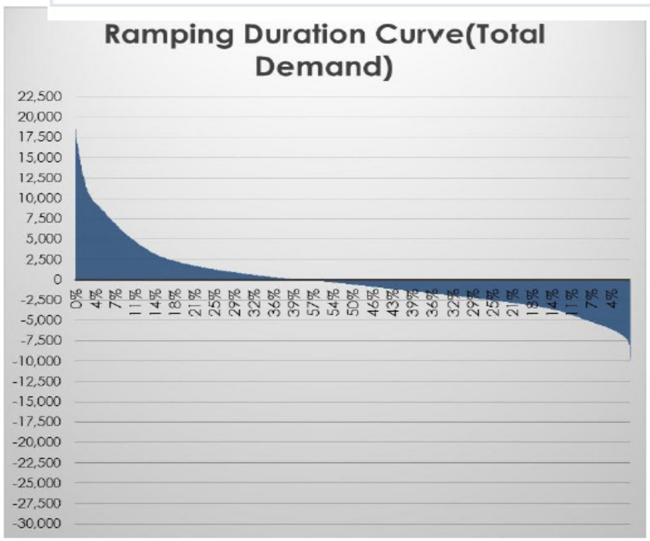
Today's Scenario: Cycling without Renewable Integration

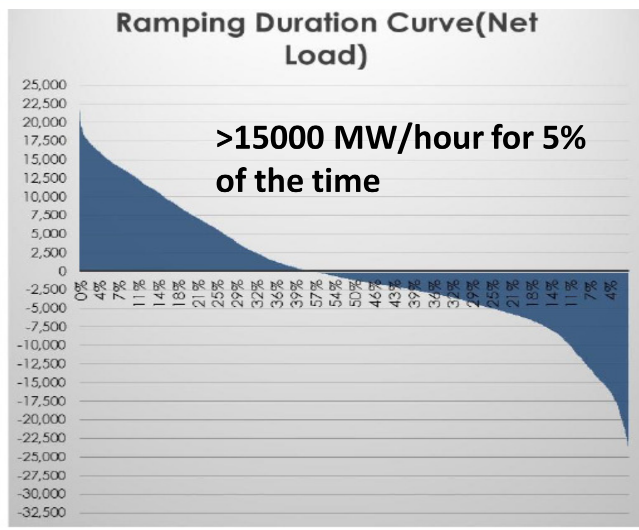




- In last five years, conventional capacity was added rapidly but in same proportion electricity demand did not rise, which caused lower PLF and lower peak to installed capacity ratio.
- It is likely to fall further due to rapid addition of RE.



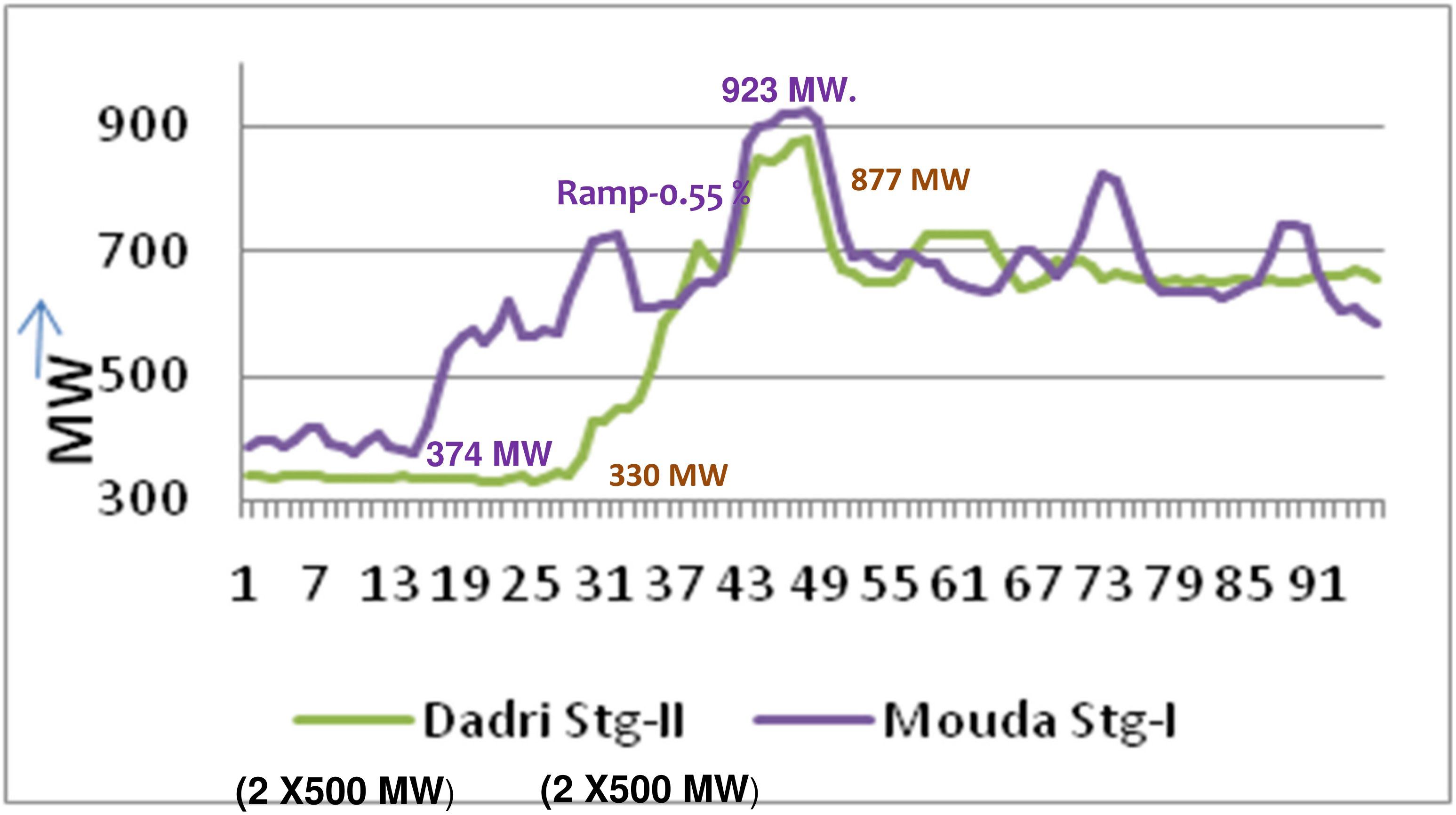




- Installed capacity ~ 523 GW *
- Peak hour ramp rate is 247 MW/min.
- Ramping down rate with sun rise is highest i.e. 368 MW/ min.
- Duck belly demand to peak demand ratio is 61% which will lead to partial loading and two shifting i.e. cycling of fossil based power plants and hence low PLF.

Source: CEA

Flexible operation



Flexibilization: Need for Benchmarking

Defining
- Defining from different perspectives

Measuring
- Metrics
- Quantifying

Operational -isation
- Sources, options
- Preparedness for Coal based plants

Compensation/ Incentivisation
- Regulatory framework
- Market structure and mechanisms

- **Quantity (MW)** which is required to be kept in reserves
- **Turndown**
  - Minimum boiler load:
- **Cycling capability**
  (start-up to full load best achieved time taken)
  - -Very hot start-up: <1h
  - -Hot start-up: 1.5–2.5 h
  - -Warm start-up: 3-5 h
  - -Cold start-up: 6-7 h
- **Ramp rate**
  - -30-50% load: %/min
  - -50-90% load: %/min
  - -90-100% load: %/min

We can assign a flexibility index for each unit based on the above parameters

International Energy Agency Characteristics of Flexibility

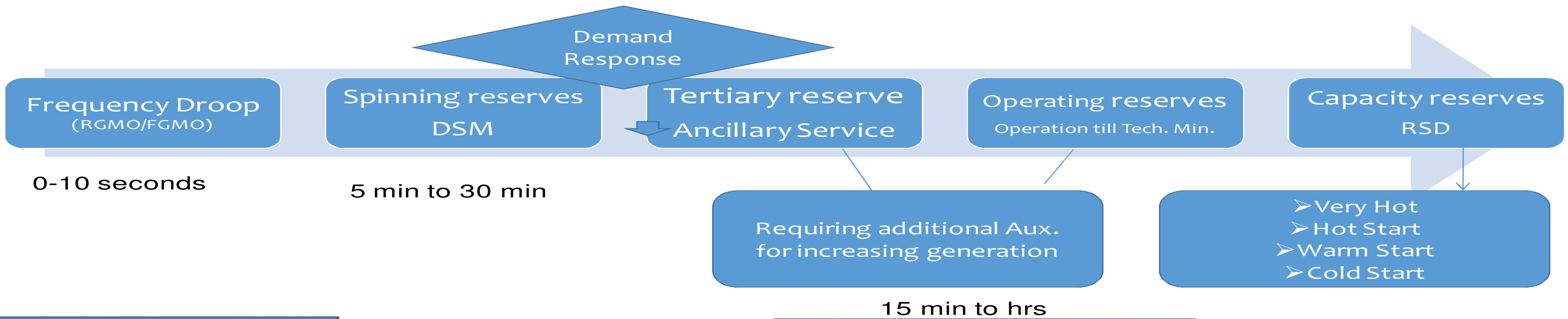
Ramp
- 4-8 % Flexible
- <4% Inflexible

Start-up
- 2-5 Hour Flexible
- 5-7 Hour Inflexible

Minmum Load
- 20-40 % MCR Flexible
- 40-60% Inflexible

Units on Pan India basis are needed to be classified with according to age ,vintage,make,coal source and tagged with flexibility index

Operationalisation of flexibility



- Studies carried out at NTPC Dadri (490 MW) for :Flexible control Retrofitting" - Condenser Throttling
- The ramp rates achieved : 3.6 % at lower load ramp size of 10%, and 5% at higher loads

- Pilot successfully completed at NTPC Dadri (490 MW) for on AGC for operationalisation of Spinning Reserves

- Another Pilot to be carried out at NTPC Simhadri

- Ancillary Service Regulation
- Technical Minimum at 55%
- Part Load compensation based on Heat Rate,APC & Sp. Oil
- Forecasting

- Fleet wide monitoring
- Reducing stresses during start-up
- Reducing the level of minimum loads
- Part Load optimization
- Structured APC Reduction Programme
- Tuning of auto-control loops
- Sliding Pressure Operation

Capacity Building

Integration Cost of Flexibilisation

System level Cost Components

- Profile costs – because of variability
  - There is a requirement of back-up capacity
  - Decrease in full –load hours of capital intensive dispatchable power plants
  - VRE supply may exceed demand and thus over produce
- Balancing Costs- because of uncertainty.
  - Day ahead forecast errors cause unplanned intra day adjustments of dispatch able power plants and require operating reserves to respond within minutes to seconds
- Grid related costs
  - VRE located far off from load centres- requiring investments in transmission
  - Cost of congestion management

Machine level Cost Components

- 1. Increases in maintenance, operation (excluding fixed costs), and overhaul capital expenditures
- 2. Cost of heat rate changes due to low load and variable load operation
- 3. Cost of start-up fuel, auxiliary power, chemicals, and extra manpower for start-ups
- 4.Cost of Short-Term Efficiency loss (as already provided in compensation)
- 5. Cost of long-term heat rate increases (a part of which is not restored even after overhauling)
- 6. Long-term generation capacity cost increases due to unit life shortening
- 7. Cost of replacement power (DSM). (associated with EFOR-Equivalent Forced Outage Rates).

It is Time For Flexible Generation Management

Actual Cost of Generation(Cyclic Load)= Cost of generation (Base load) + Integration Cost

- Time to learn how to minimise equipment damage and asses the true cost of cycling to find out actual cost of generation.
- True cost of operation arrives often years later. So, if cost of cycling is unknown making profits becomes a matter of luck rather than good management.
- Find out what, in terms of fuel cost and cycling cost , is the least expensive combination of units to meet system load?
- Knowing cycling cost would help in deciding either shut down unit (and incur cyclic damage) or to operate at minimum load.
- High fuel cost units(poor merit order) may require to cycle more than low fuel cost units, so they should be designed accordingly for heavy cycling duty. Old units with suitable cyclic modification, if required, can also be allocated for cyclic duty.

Capability Evaluation of NTPC Units for Flexibility

- **Dadri 210 MW & Simhadri 500 MW has been studied by VGB Power Tech, Germany Under Special Task Force,IGEF.**

Key Findings

- Measures for three scenarios -50%,40% & 25% Minimum loads
  - **Proper Coal Quality maintenance is Vital**
  - Low Load Stable operation with 2 Mills is possible but requires **boiler safety systems modification** to allow continuous two mill operation.
  - Considering minimum load below 50%, the provision of 5% Frequency control power becomes nearly impossible
  - Advanced C&I solutions with automatic start-up, more ambitious set points and optimized underlying control loops would gently enhance flexibility

- Present Capability of NTPC Units
  - Units are capable of sustaining Technical minimum load of 55% MCR with out oil support
  - Ramp rate of 500 MW units varies between 1-1.5 %
  - Ramp rate of 200 Mw Units varies between 1.5-2%
- Main Concerns
  - **Varying Coal quality, specially low VM coal is a major concern for flame stability at low load**
  - SH/RH Steam Temperature variations & Boiler Tube metal temperature excursions during Ramp-up/Down

Flexible Operation – Road Map (Short Term)

Identification of Units for Flexible operations

- Wide participation to be ensured. Mechanism for Pan India operationalization to be evolved.
- Presently Units with high cost are undergoing flexibilisation.
- The units situated near RE rich region may also require to undergo load variations due to areas balancing issues
- **Going for addition of 100% Supercritical Coal Fired Plants with 4-5% efficiency gain, and each 1% efficiency gain shall reduce the CO_2 emissions by 2.5%, but running them on part load will undermine the gains**
- Old Units and lesser efficient Units to run on flexible mode with lesser running hours.

Short term Action Plan

- Test Runs by OEMs at Technical Minimum Loads
- Base line data to be captured
- Optimisation of Operational practices
- Optimisation of control loops
- Capacity Building

Flexible Operation – Road Map (Medium Term/ Long Term)

Medium Term

- Modification / Retrofitting for enhanced flexible operation
- Pilot Project taken up at Dadri 490 MW Unit with Siemens for retro fitting Flexible Control module “SPPA-T3000”
  - Enhanced ramp rate of 3.6%
  - 7% Primary response by condensate Throttling
- With the good results available,the same can be replicated in other units.

Long Term

With International cooperation and OEM’s support

- Study of Two NTPC Stations (Ramagundam & Jhajjar) Under USAID
- Study for cost and impact of Cyclic loading by International Consultant
- Flexibilisation study at VSTPS by Jcoal
- Study by BHEL & GE (OEMs)
- Policy framework implementation based on report for adequate compensation for part load and Start-up compensation

Way Forward….

The integration of a significant share of variable renewables into power grids requires a substantial transformation of the existing networks in order to:

a) Policy orientation towards minimising **levelised system cost of electricity rather than looking at RE tariff in isolation.** This requires a **market redesign.**

b) Promote and **prioritise non Variable RE** such as Hydro, Biomass, Geothermal, Solar with storage, Solar Hybrid

c) Wider participation of units for AGC, so that effective ramp rate requirement on individual units can be minimised and better load frequency control can be obtained.

d) Introduce energy storage capacity to store electricity from variable renewable sources when power supply exceeds demand and aimed at increasing system flexibility and security of supply.

e) Centralized RE forecasting mechanisms need to be tightly integrated with system operations. Advanced decision-making and control systems need to be implemented that enable system operators to respond significantly faster to changed grid conditions.

Thank You