



एनटीपीसी
NTPC
A Maharatna Company

Corporate Centre

Flexible Operation in Coal based Stations



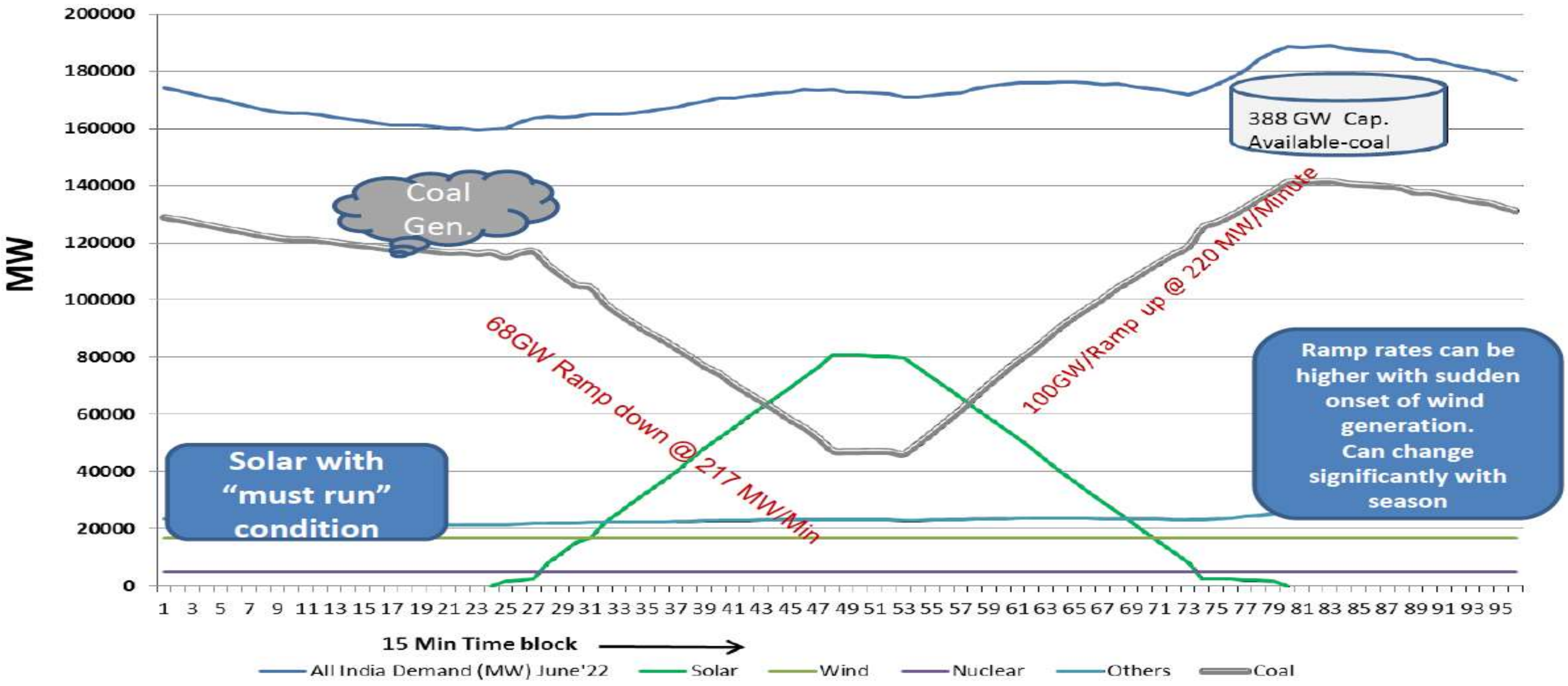


Need for Flexible Operation for Coal Station

- Growth in Renewable Energy expected from ~70GW presently to 175GW by 2022.
- Generation of Renewable Energy is unpredictable to different weather conditions.
- Limited availability of Hydro, Pumped Storage & availability of Gas for Gas based Station.

Anticipated Indian Scenario in 2022

with 100 GW Solar & 60 GW Wind



Dimensions for Flexible Operation for Coal Station

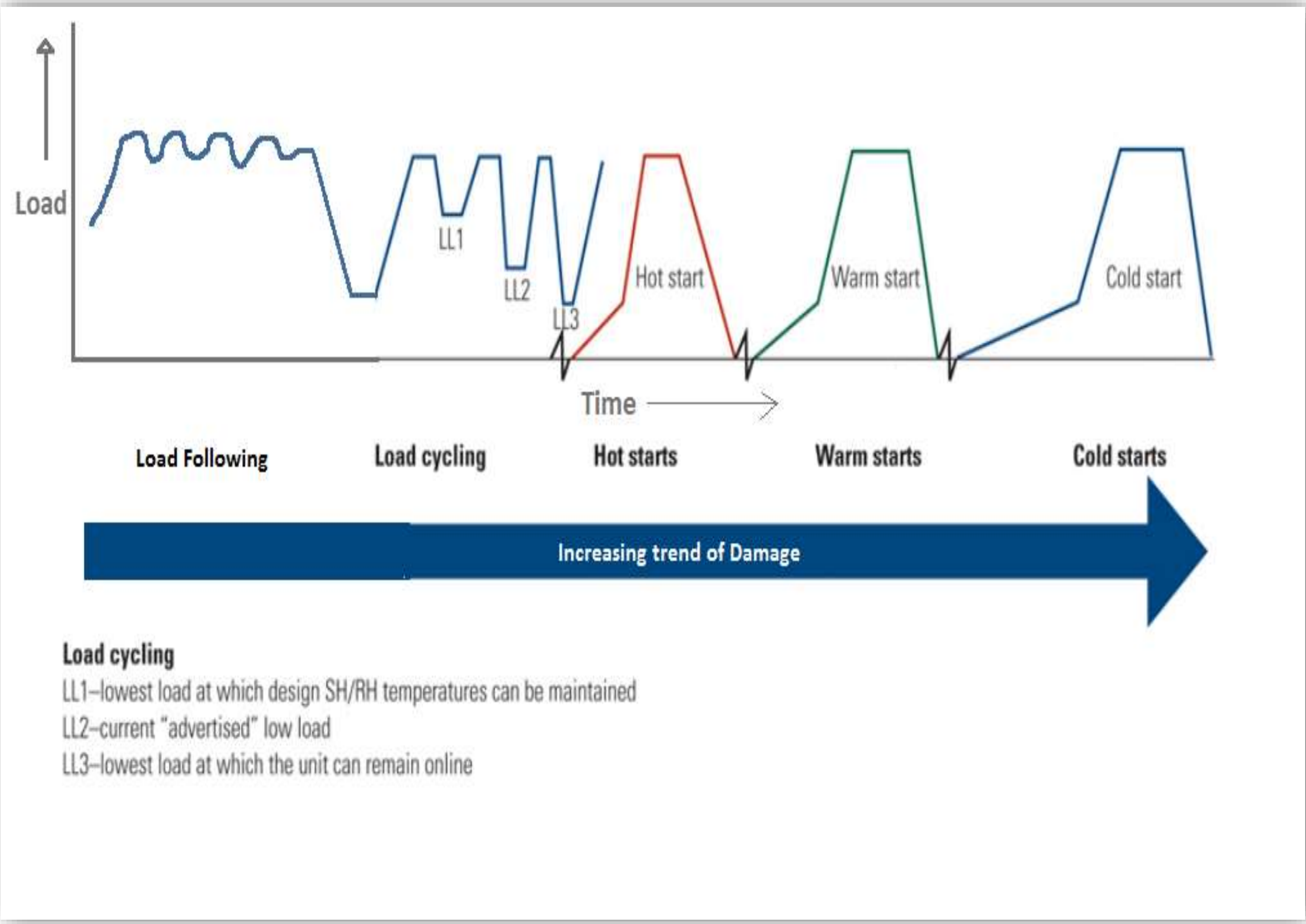
- Stable Low Load Operation (40% of MCR or below)
- Increased Ramp Rate (Both Upward & downward)- continuous or in a band
- Frequent start-up
- Reduced effect on life of Equipment
- Efficient Operation even at low load
- Minimal impact on environment

Type of Cycling on Thermal Plants

What is Cyclic operation ?

- Start up/Shut down (Hot/Warm/Cold)
- On load cycling (LL1,LL2,LL3)
- Higher ramp rate
- High frequency load variations (RGMO/AGC)

- Thermal fatigue combined with creep is the main cause of damage.
- Cyclic load variations within SH/RH temp. control range may be tolerable
- Start/stops are the severest in terms of life consumption



Cyclic Operation-Safety Concern

- Sub-optimised combustion can lead to frequent tripping on flame failure, furnace pressurisation, slagging and clinkering
- Low flue gas temp below Acid Dew point can lead to duct , APH basket and ESP fields corrosion. Even chances of Collapse of ESP
- Due to corrosion boiler drains may also burst leading to unsafe situation

Cyclic Operation- Impacts

- Fast & Frequent thermal cycling of components lead to fatigue, creep
- Stresses on components and turbine shells resulting from changing pressure & temp
- **Failures of boiler tubes** caused by cyclic fatigue, corrosion fatigue and pitting
- Overheating of Reheater and superheater leading to oxide scale formation and chocing of tubes due to its exfoliation
- **Cracking in dissimilar metal welds, headers and valves,** and other thick-walled components due to rapid changes in steam temperature.
- LPT last stage blade is prone failure due to handling of Wet steam.




Cycling and Fast Ramping- Cycle Chemistry

- **Corrosion caused by oxygen** entering the system (e.g., during start-up), and changes to water quality and chemistry, resulting from, e.g. falling pH
- **Condensation from cooling steam**, which in turn can cause corrosion of parts, leakage of water, and an increased need for drainage.
- **Oxidation, e.g, from exposure to air** on start-up and draining; oxides in boiler tubes can dislodge due to thermal changes.
- **Corrosion of turbine parts**, not only from oxides but also from wet steam that occurs on start-up, during low-load operations

Cycling and Fast Ramping- Impact on η and environment

- Heat rates typically degrade at partial load due to lower steam parameter (Pr and temp) and Low Feed water temp at ECO inlet.
- Excess air can cause high dry flue gas loss
- NOX and SO2 rates are also affected by loading. Startup emissions of CO2, NOX, and SO2 may be significantly higher than steady-state emissions rates.
- Ramp ups in power output may also result in higher than steady-state emissions.
- Low flue gas temp below acid Dew point can damage APH basket and flue gas duct.

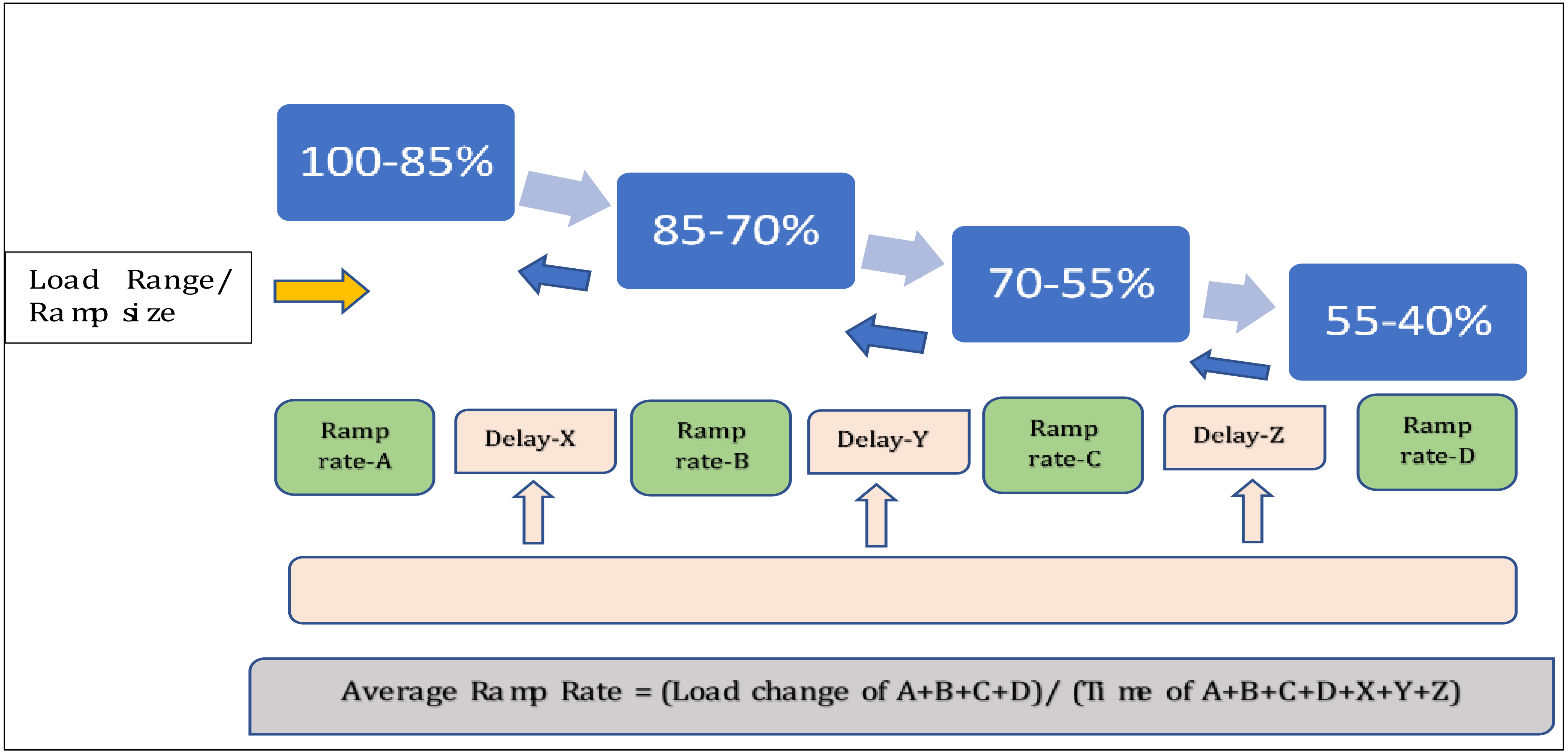
Basic practices to be set right

- All auto loops are to be made available and fine tuning of CMC to be carried out to take care minimum deviation of important parameters.
- Attemperator system (isolating valves and control valves) and control valves are to be set tight and fast response to the changing demand system
- Optimise minimum coal loading in a mill by fine tuning primary air flow vs coal flow curve to avoid lean air mixture and possible flame failure tripping.
- Dirty air flow test at regular interval to evaluate partially plugged coal pipes and burners
- Burner tilts are to be operational in full range in auto and SADC damper operation are to checked and correct feedback to be made available.
- WWSB and LRSB operation scheduling at higher load during opportunity.

Basic practices to be set right

- Water chemistry instrumentation should be set right and linked with DCS.
- SCAPH operation to be made through to contain flue gas temp less than acid dew points
- To check condenser- air- leak Helium leak detection may be deployed
- DM water storage will require nitrogen blanketing to prevent oxygen in feed water system
- Boiler side high energy piping hanger indicator are to be marked and monitored.
- Low load FRS to be used to reduce flow rate in economiser during cold or warm start up.

Average Ramp rate Calculation



Procedure of Ramp test

- Put the machine in to CMC mode with all auto loops in service
- Take clearance from RLDCs for Ramp test from 500MW TO 275MW and up to 500 MW
- Both TDBFP in service with MDBFP in auto stand by mode.
- Run the unit with 6 mills in service at 500 MW
- 1^{ST} RAMP FROM 500 TO 425 MW @ 3% (75 MW DOWN IN 5 MIN) with sliding pressure mode
- Cut out 6^{th} mill and stabilize unit with 5 mills
- 2^{nd} ramp down from 425 MW TO 350 mw @3% (75 mw down in 5 min)
- Cut out 5^{th} mill and stabilize the unit with 4 mills with 4 mills
- 3^{rd} ramp down from 350 MW TO 275 MW and stabilize with 4 millis with both TDBFP

Pilot Study for Minimum load operation

LOAD(%) RAMP DOWN	MAJOR ACTION TAKEN	OBSERVATION	REMARK
420 MW(84%)	One Mill Cut Out	MS TEMP maintaining high Eco outlet o2% =3.1%	Steam temp fluctuation
330MW(66%)	2ND Mill Cut out	HRH steam temp maintaining low	Steam temp fluctuation
280MW(55%)	4 Mill in service	One TDBFP recirculation valve opened and due to Feed water flow imbalance Drum level dipped HRH steam temp maintaining low Flame intensity <35%	Drum level fluctuation Steam temp fluctuation
250MW(50%)	One TDBFP was withdrawn	Super heater temp after de-superheater is less than Sat temp(alarm) Delta T left and right after de-superheater >20degc	Flame intensity stable Steam temp fluctuation
230MW(46%)	3RD Mill was cut out	Flame intensity improved, Flue gas temp after APH was <113 deg C at SAH and <108degc at PAH outlet	Flue gas temp of 108°C is below the acid dew point which is approx. at 122°C as per a sulfur content of 0.3%. This situation will lead to corrosion within the flue gas duct and ESP
200 MW(40%)	O2% increased to 4.3% to improve mill outlet temp and windbox to furnace DP Single BFP and 3 mills in service	Mill outlet temp improved >70 degc Flame intensity remaining the same	**FW Flow and drum level fluctuation , flue gas temp running below acid dew point causing potential for corrosion** **Steam temp parameter fluctuating**

Software packages required to be incorporated

- **Automatic Mill Operation (Mill Scheduler)**
- **Main Steam Temperature Control**
- **Reheat Steam Temperature Control**
- **Automated Start of Fans and Pumps**
- **Integrated Start up automation**
- **Up grading Flame detection system**
- **Flue Gas Temperature Control**
- **Online coal flow measurement system**

Condition Monitoring System installation

- **Condition monitoring**

  Boiler Fatigue Monitoring System

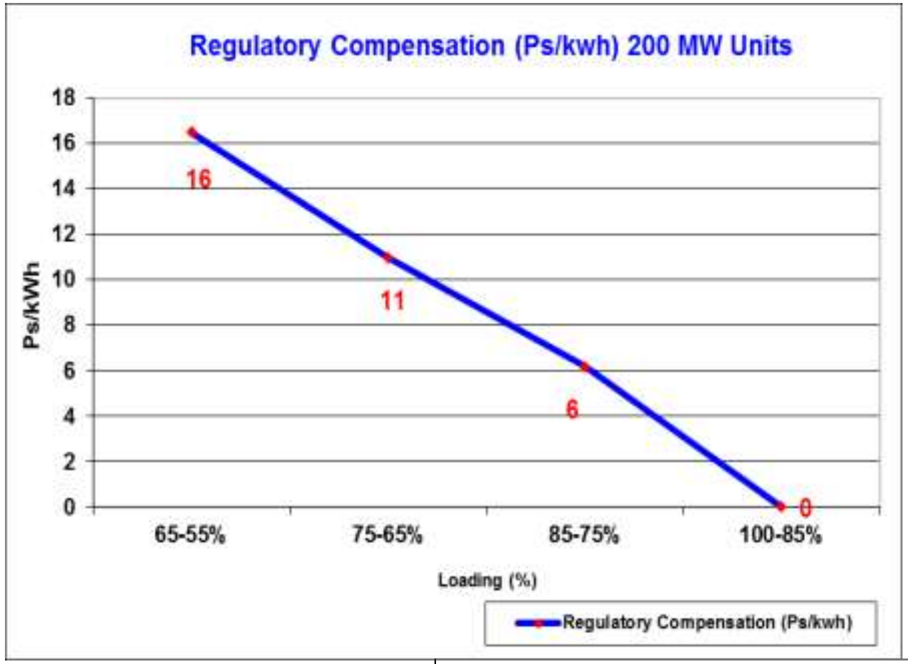
  EOH (Equivalent Operating Hours)

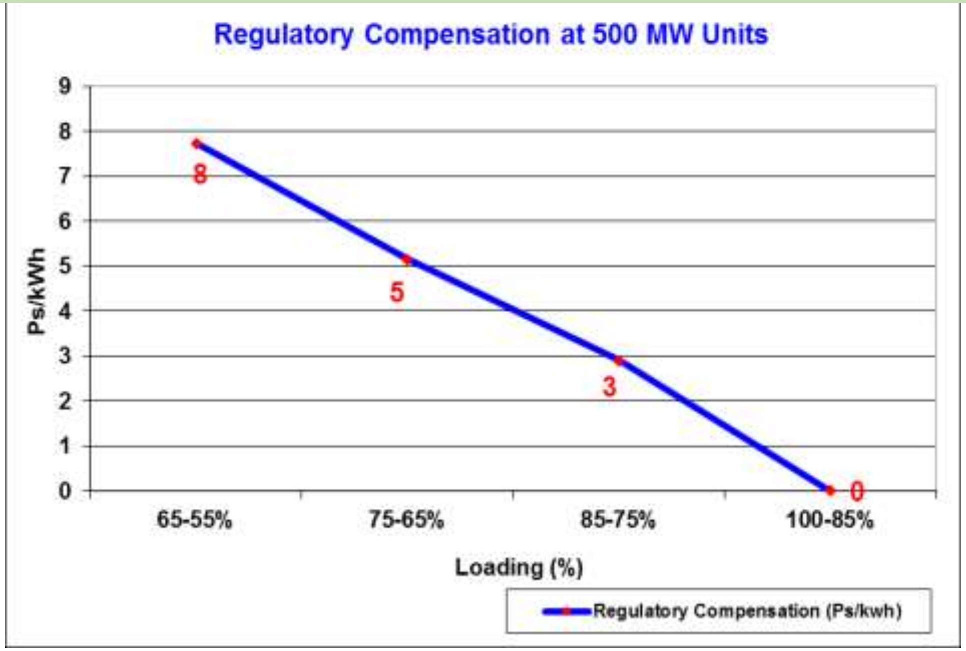
  ESH (Equivalent Start up Hours)

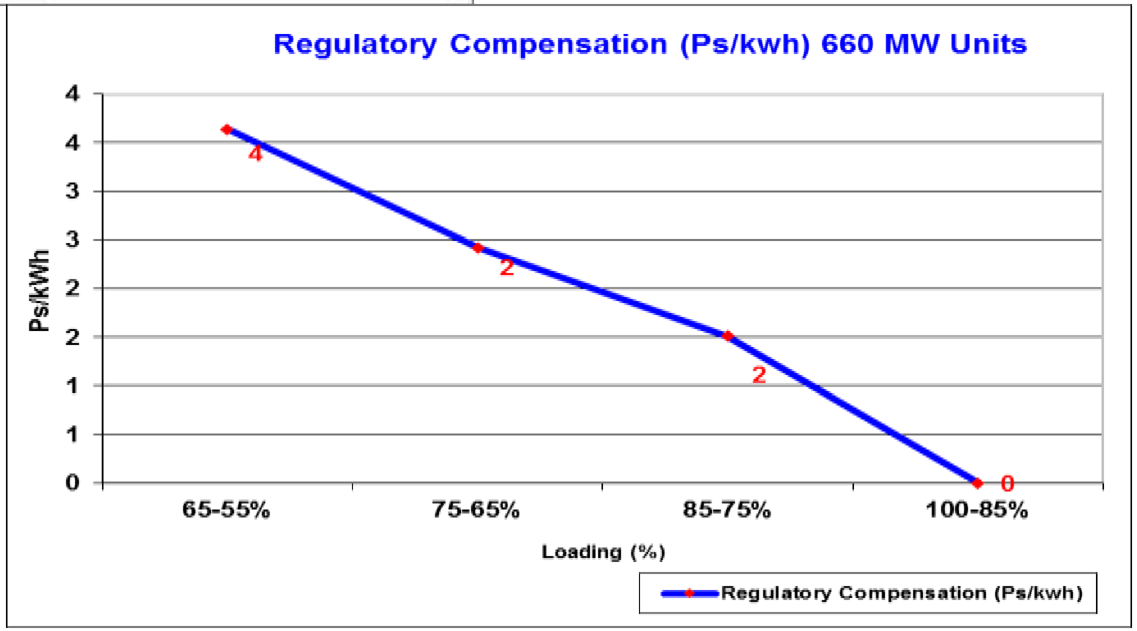
Cost of cycling to Generating Companies

- Modification cost required for making units cyclic ready
- Loss of useful life
- Increased O&M expenses
- Start up fuel cost
- Loss of availability due to forced outage
- Poorer heat rate
- Increased Aux. Power Consumption

Present Regulatory compensation on OPEX







Key interventions in flexibilsation

- Pilot studies on flexibilsation conducted in two of NTPC plants (Dadri, simhadri) in association with IGEF. Based on the feedback given, Advance Process control system is under implementation in Simhadri and provisioning of software and hardware components are under implementation in Dadri(500 MW).

- USAID'S GTG carried out techno commercial studies at two units of NTPC – Ramagundam(200 MW) and Jhajjar(500 MW).
- In association of J-COAL pilot studies conducted for minimum load operation along with ramp testing at Vindhyachal(U#11, 500 MW)
- With BHEL, Similar pilot studies were conducted for minimum load operation and ramp test at Mauda(500 MW), the final report of which have been submitted.

Initiatives under implementation in flexibilisation

AGC- Automatic Generation control is 5% ramp both up and down in 3 min time interval with remote control lying with RLDCs and it is already implemented in Dadri st#2 (2*500 MW),Simhadri(St#2), Mouda st#2(2*660 MW), Barh(2*660 MW) and Bongaigaon is under implementation.

Condensate throttling –it is a proven measure for Primary Frequency Control, enabling a quick increase in turbine power in case of a steep reduction of frequency in the grid.
It is implemented in Dadri U#6 (500 MW) for 7% power increase in 20 secs.

Advance process control- Under implementation in all units of Simhadri(4*500 MW)-

Combustion Optimization –
Faster load Ramp up/Ramp Down
SH/RH Temperature Excursion Reduction
Reduce Min stable load

Minimum load operation-Dadri u#6(500 MW)- Smart controllers for MS/ HRH steam temp are commissioned and are in service, other recommendations like Mill scheduler, Auto start of Fan and Pump, flue gas temp controller through Scaph and regulating type recirculation valves are under execution in association with M/S Siemens.

Conclusion

- **Assessment of true cost of cyclic damages of equipment is difficult.**
- **Cyclic cost along with higher fuel cost impact the generators at part load**
- **Units ranked poor in merit order may be subjected to higher frequency of cycling in spite of high efficiency**
- **Regulatory compensation provision at present not significant to attract generator for investment to enable units for flexibilsation**

Thank You