



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.

Impact of Variable Renewable Power

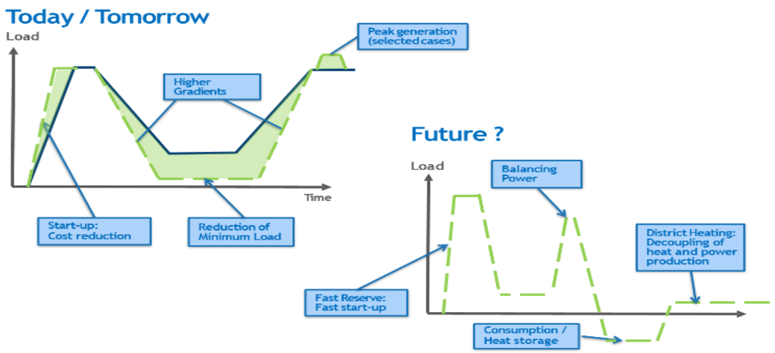
The Variability, Uncertainty, and the Geographically Confined VRE will be challenging for the grid operators as well as generators.

Impact on System

- Difficulty in load frequency control
- 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

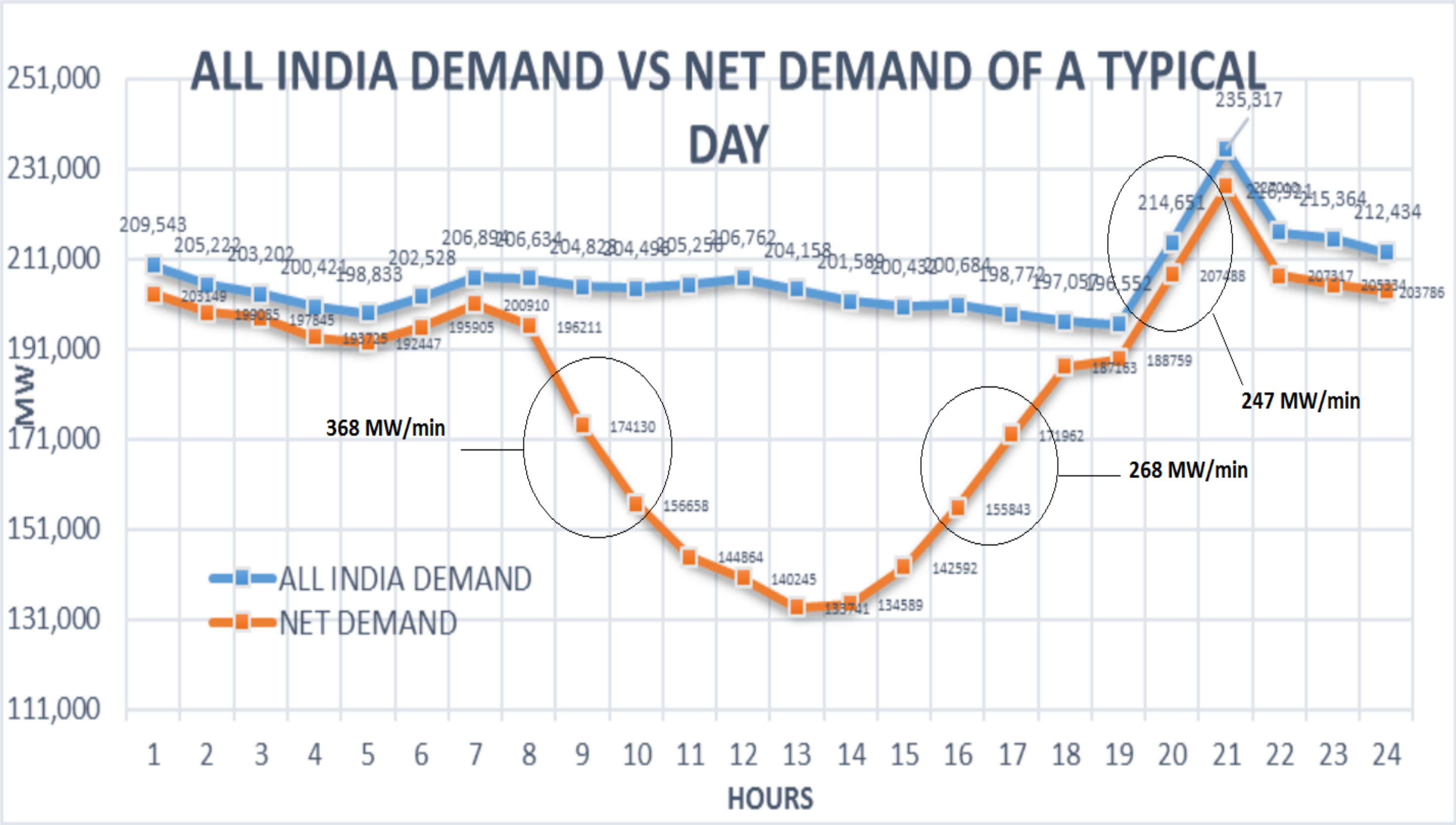
Impact on existing Plant

- 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 Net Demand Curve (2021-2022)

Source: CEA



- 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.

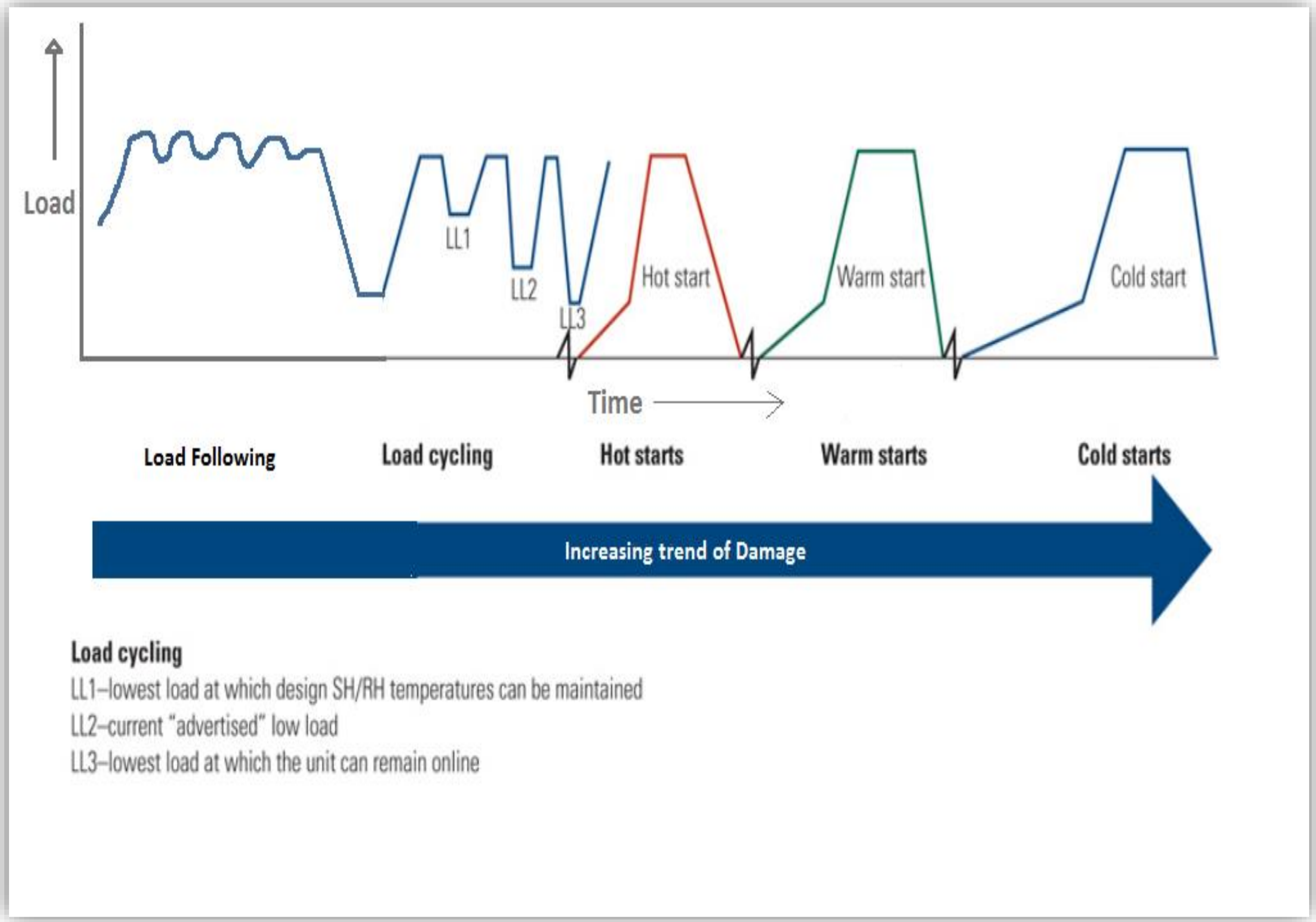
* Based on Draft NEP projections for 2021-22

Type of Cycling on Thermal Plants

NTPC A Maharatna Company

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

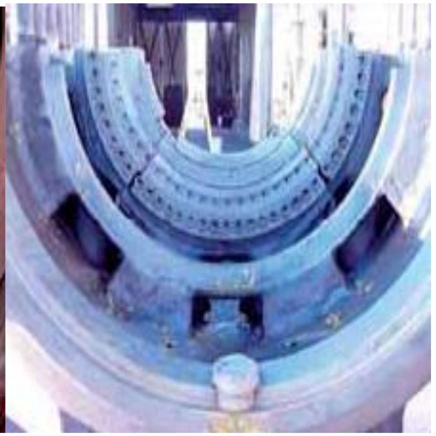
- Sub-optimised combustion can lead to frequent tripping on flame failure, furnace pressurisation, slagging and clinkering

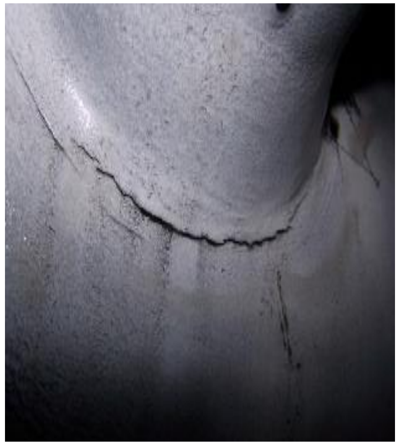
- Low flue gas temp below Acid Dew point can lead to duct , APH basket and ESP fields corrosion. Even chances of Collapse of ESP

- 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 SO_2 rates are also affected by loading. Startup emissions of CO_2, NOX, and SO_2 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.

Systematic Ramp down At Dadri u#6

A Maharatna Company

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**

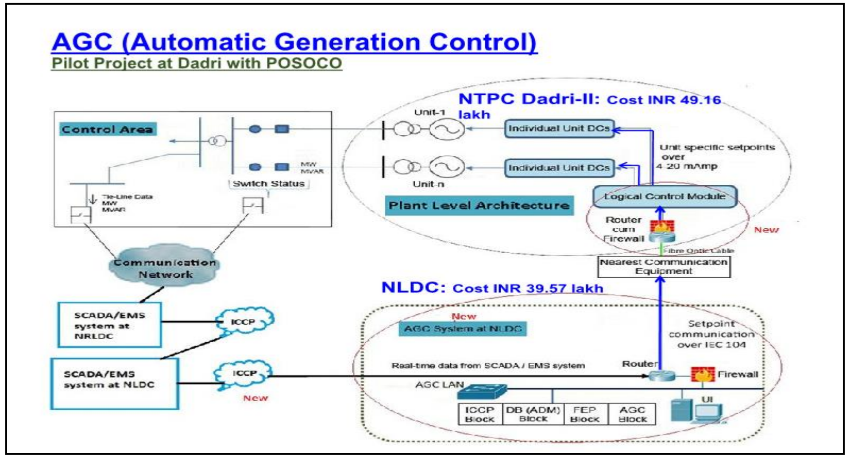
  Boiler Fatigue Monitoring System

  EOH (Equivalent Operating Hours)

  ESH (Equivalent Start up Hours)

Activities under implementation in flexibilisation

Automatic generation control as pilot project successfully implemented in 5 projects – Dadri, Mauda, Barh, simhadri and Bongaigaon.



All units are to be covered under AGC and load set point can be adjusted from NLDC control room.

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, 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.

Future Activities in Flexibilisation

- Part load boiler efficiency improvement → SADC,Feeder, O2 Biasing → Machine Learning based Combustion & Optimization
- Ramp Rate Improvement > 2 % → Maintaining Modified Sliding Pressure in AUTO → Model Predictive CMC
- Parameters within band → Steam Temp Excursion Reduction → Model Predictive SH/RH Temperature Control
- Stable Min. Load → Control loop Optimization → SCAPH control at lower loads, Mill Scheduler, Auto-tune blocks

Proposed Plants :

<u>13 units</u>

Dadri #5

Unchahar #6

Mouda #1 ,2

Rdm #4,5,6,7

Korba #7

Farakka#6

Vind#11,12,13

Costs of Flexibilisation

System Costs

- Sub optimal utilisation because of **variability**
  - Requirement of back-up capacity
  - Decrease in full load hours of capital intensive dispatch-able 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

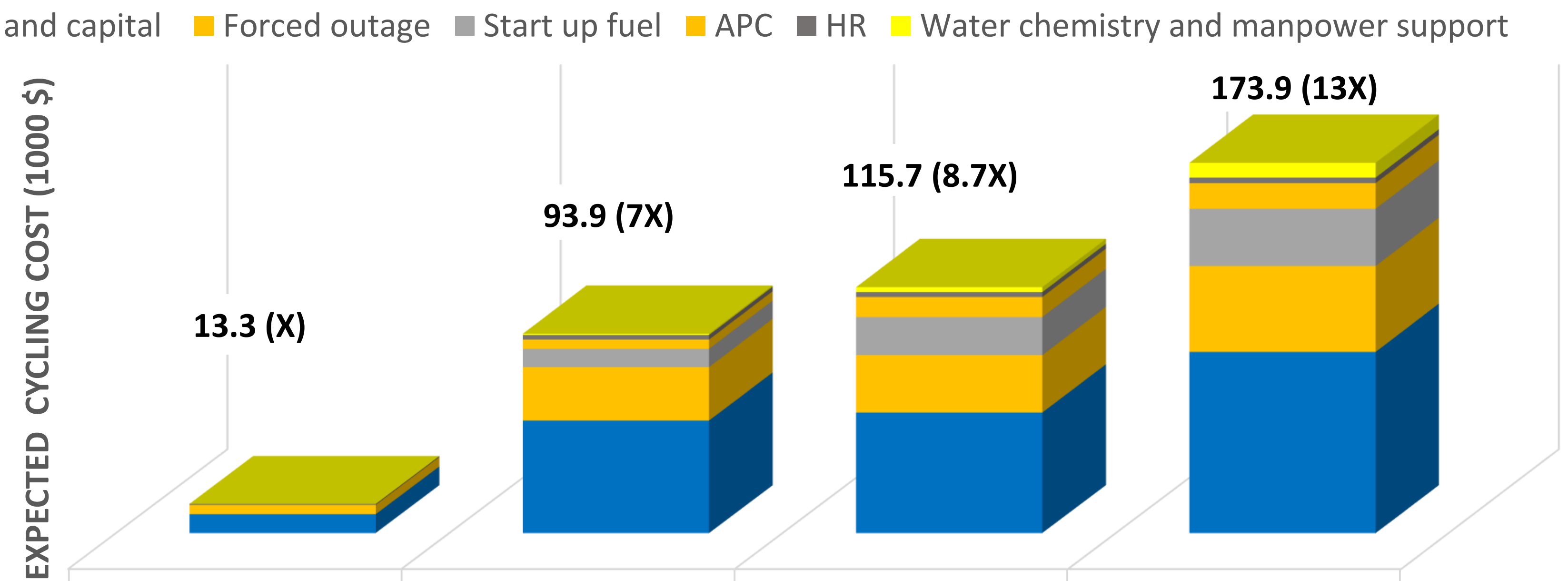
Costs at Generator level

Increased OPEX

- Increase in Forced Outage
- Start-up Costs
- Loss of Useful Life of components due to fatigue and creep
- Reduction in Efficiency
- Environmental Costs
- Cost of increased consumption of water, chemicals etc.
- Increased CAPEX requirement
- Retrofits/modification for readiness for increased flexibilisation

Costs of Flexibilisation

TYPICAL CYCLING COST FOR A 500MW COAL FIRED POWER PLANT (USA) (COST ARE SHOWN IN 2008 DOLLARS) ,SOURCE:-INTERTEK APTECH



	Load follow down to 180MW	Hot Start	Warm Start	Cold Start
Water chemistry and manpower support	0	0.6	2.3	6.9
HR	0.5	2.1	2.3	2.6
APC	0.5	4.4	9.4	12
Start up fuel	0	8.5	17.8	26.8
Forced outage	3.9	25.1	26.9	40.2
Maintainance and capital	8.9	53.2	57	85.4

Conclusion

- **Assessment of true cost of cyclic damages of equipment**
- **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**
- **Regulatory compensation provision at present not significant.**

Thank You