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Power Sector Scenario till 2032 and Flexibilisation Requirements from Coal based Thermal Power Stations: NTPC Approach for navigating the challenges for Flexible Operation

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Outline

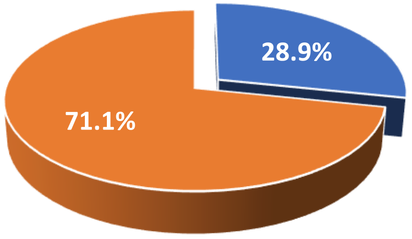
- All India vs NTPC Performance
- All India Demand Scenario and Flexibilization
- Present Flexibilization vis a vis NTPC Experience
- Preparation for future Variable Load Operation
- Challenges Ahead & Solutions
- NTPC Expectations
- Conclusion

NTPC-Powering India's Growth

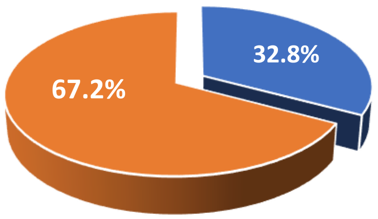
Description	NTPC	All India	% Share
Installed Capacity-Coal	59.6 GW	206.2 GW	29.2 %
Generation (BU)-Coal*	376.3	1146	32.8%
Installed Capacity-Total	73 GW	424.3 GW	17.2%
Generation (BU)-Total*	399.3	1624	24.6%

* Gen figs are for FY 2022-23

- **Total Gen:** NTPC Contributes1/4th in country's generation with only 1/6th share in installed Capacity
- **Coal Gen:** NTPC Contributes 1/3rd in country's generation.
- **Performance:** PLF of NTPC stations ~75% whereas national average is 64%



Installed Capacity-Coal

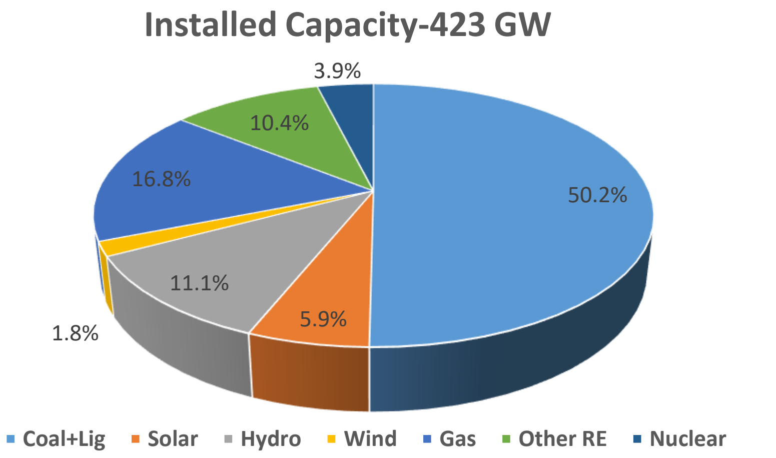


Generation (MU)-Coal

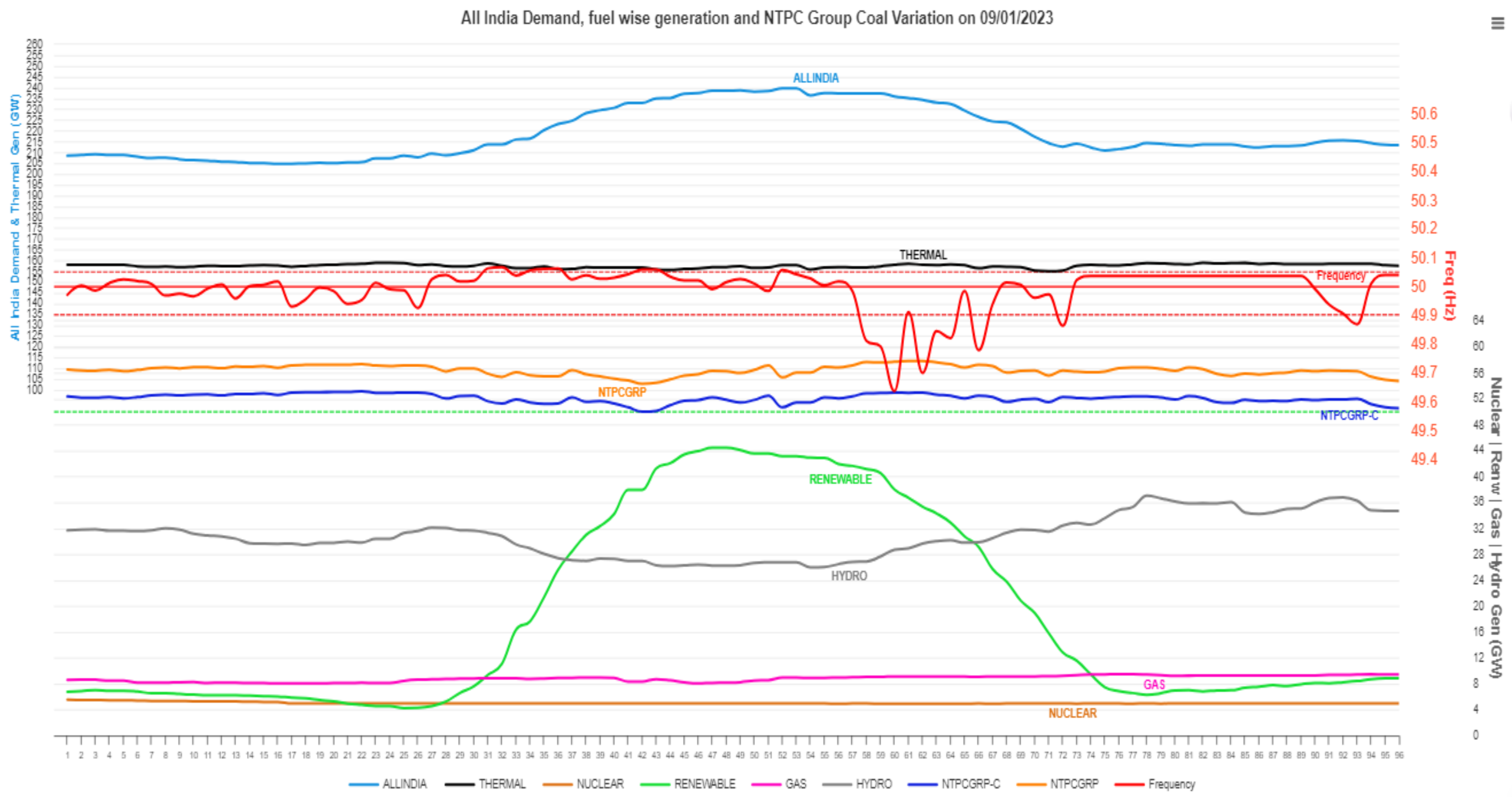
Fuel Type	Stations	Units	Capacity
	Nos	Nos	MW
Fully Owned			
Coal	27	121	52610
Gas	7	32	4017
Hydro	2	6	808
Solar	15	15	403
Total	**51**	**174**	**57838**
Joint Ventures/Subsidiaries			
Coal	9	25	7664
Gas	4	26	2494
Hydro	9	31	2949
Wind	3	3	163
Solar	15	15	2716
JV/Subs	**40**	**100**	**15986**
Total	**91**	**274**	**73824**

Demand Scenario and Flexibilization Requirements

Demand Scenario: Peak Demand Day-1 Sep 2023

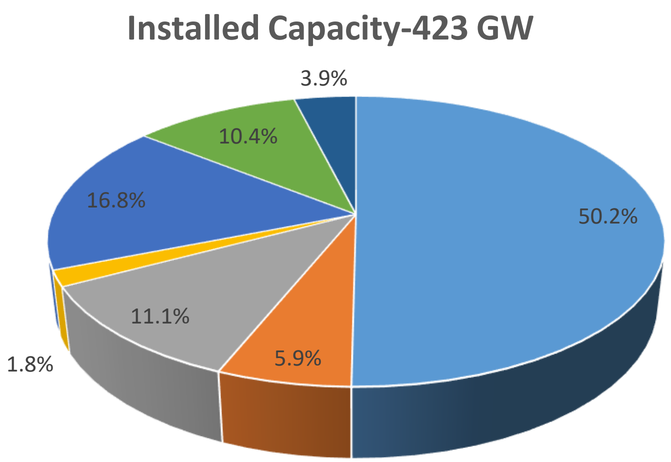


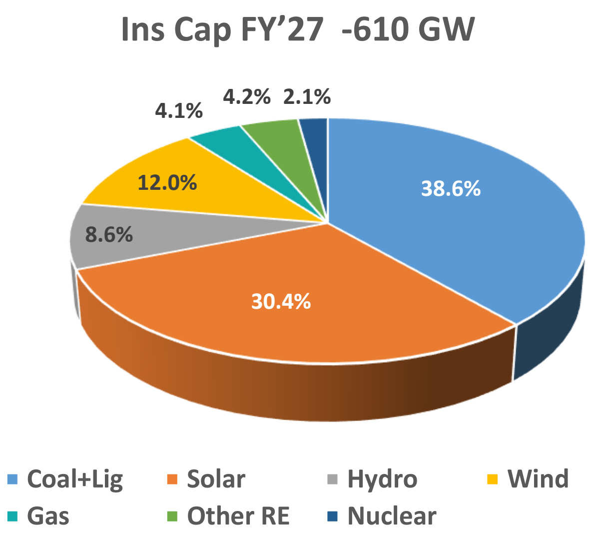
1 Sep'23	Max	Min	Difference	
	MW			%
Demand	239663	204587	35076	17%
Thermal Gen	158988	152856	6132	4%
RE Gen	**44463**	**4264**	40199	943%
Hydro Gen	**37048**	**25986**	11062	43%
NTPC Coal	53167	50016	3151	6%

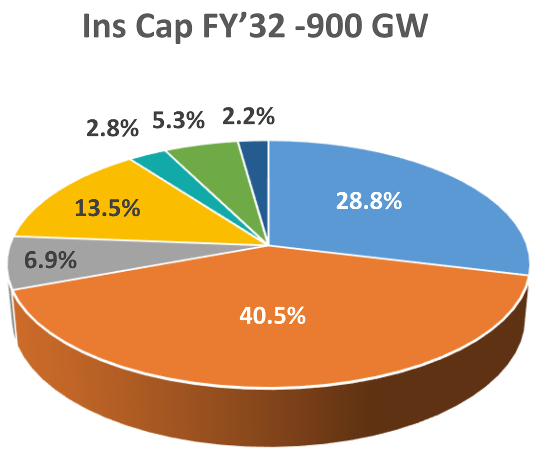


1. Present demand curve variations is moderate. Higher peaks & troughs expected by 2027 & 2032.
2. 40 GW of RE variation is absorbed largely by Hydro, Thermal & demand variation.
3. ***NTPC Coal contributes 51% of the Thermal Flexibility despite having only 28% share in coal capacity.***

Capacity Scenario: FY’24 to FY’32 (As per NEP-May 23)







Annual cap growth	FY24-27	FY 27-32
	15%	10%

Fuel	FY'24	FY'27	FY'32
Coal+Lig	**212516**	**235133**	**259643**
Gas	25038	24824	24824
Hydro	46850	52446	62178
Nuclear	7480	13080	19680
Solar	**71145**	**185566**	**364566**
Wind	43940	72896	121895
Other RE	16390	25646	47636
Total	423359	**609591**	**900422**

- ✓ Coal capacity increases marginally.
- ✓ The share of Coal decreases rapidly from 50% to 29%.
- ✓ Solar capacity share increase: 17% to 41%

Demand Scenarios: FY'24 to FY'32 (Cap Figs as per NEP -2023)

01-Sep-23				Evening 8 PM		Afternoon 2PM		Night- 2 AM	
Fuel Type	MW	On Bar %	MW on Bar	LF	MW delivered	LF	MW delivered	LF	MW delivered
Coal+Lig	212516	86%	182764	85%	154435	86%	156263	88%	160832
Gas	25038	60%	15023	72%	10816	55%	8263	65%	9765
Hydro	46850	80%	37480	60%	22488	70%	26236	50%	18740
Nuclear	7480	80%	5984	75%	4488	75%	4488	75%	4488
Solar	71145	70%	49802	0%	0	70%	34861	0%	0
Wind	43940	70%	30758	58%	17840	30%	9227	45%	13841
Other RE	16390	40%	6556	30%	1967	20%	1311	20%	1311
Total	**423359**		**328366**		**212034**		**240649**		**208977**

Expected Scenario (2026-27)									
				Evening 8 PM		Afternoon 2PM		Night 2 AM	
Fuel Type	MW	On Bar %	MW on Bar	LF	MW delivered	LF	MW delivered	LF	MW delivered
Coal+Lig	235133	86%	202214	91%	183004	63%	127395	94%	190082
Gas	24824	40%	9930	72%	7149	42%	4170	65%	6454
Hydro	52446	80%	41957	60%	25174	36%	15104	50%	20978
Nuclear	13080	80%	10464	75%	7848	75%	7848	75%	7848
Solar	185566	70%	129896	0%	0	80%	103917	0%	0
Wind	72896	70%	51027	58%	29596	40%	20411	45%	22962
Other RE	25646	40%	10258	30%	3078	20%	2052	20%	2052
Total	**609591**		**455747**		**255849**		**280897**		**250376**

Expected Scenario (2031-32)									
				Evening Peak (8 PM)		Afternoon 2PM		Night- 2 AM	
Fuel Type	MW	On Bar %	MW on Bar	LF	MW delivered	LF	MW delivered	LF	MW delivered
Coal+Lig	259643	86%	223293	100%	223293	44%	98249	100%	223293
Gas	24824	40%	9930	72%	7149	42%	4170	65%	6454
Hydro	62178	80%	49742	60%	29845	36%	17907	50%	24871
Nuclear	19680	80%	15744	75%	11808	75%	11808	75%	11808
Solar	364566	70%	255196	0%	0	80%	204157	0%	0
Wind	121895	70%	85327	58%	49489	40%	34131	45%	38397
Other RE	47636	40%	19054	30%	5716	20%	3811	20%	3811
Total	**900422**		**658286**		**327301**		**374233**		**308634**
					340552				336810

1 Sep'23-Peak Demand Day (239 GW):

- **2 PM:** 65% of Peak demand met by Coal & 14% by Solar
- Solar variation 34 GW (14%) absorbed by Wind (5 GW), Hydro (8 GW) Gas (2 GW), coal (8 GW) & demand variation (11 GW).

2026-27:

- **Peak Demand:** 277 GW
- **2 PM:** 45% from Solar & 37% from Coal
- Solar fluctuates from 0 to 37% (104 GW) which is to be accommodated by Wind (10 GW), Hydro (10 GW) Gas (3 GW), Coal (56 GW) & demand variation (25 GW)

2031-32:

- **Peak Demand:** 366 GW
- **2 PM:** 55% from Solar & 26% from Coal
- Solar fluctuates from 0 to 55% (204 GW) which is to be accommodated by Wind (15 GW), Hydro (12 GW) Gas (3 GW), Coal (125 GW) & demand variation (42 GW)
- Storage Solutions to supply 10 to 20 GW

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Flexible Operation at NTPC- Business Requirements; Intervention Areas

Learning Within

Flexible Operation at NTPC: Business Requirements

Business Requirements

Technical

- ❖Faster Ramps
- ❖Stable Lower Load
- ❖Safe Operation
- ❖Environment Friendly

Commercial

- ❖ To Make Station Flex Ready
- ❖ Part Load Operation Compensation
- ❖ Incentivization for Part load Operation

Intervention Areas

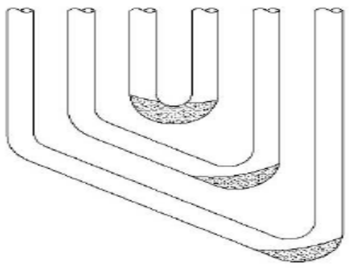
- Boiler
- Turbine
- Operations
- Control Systems

On an average NTPC Units Flex 15 GW on daily basis. Non Pit Head Stations Flex from 55% to 100%. This has resulted in challenges in Boiler, Turbine, Control Systems which NTPC is addressing on continuous basis.

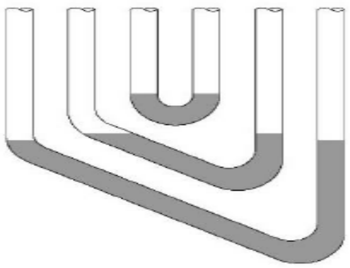
Boiler- Fatigue Failure Control

Challenges

- Temperature Variations leading to High BTL
- Poor Combustion (Reliability Issue, Higher Risk, Efficiency Issues)
- Coal Pipe Chocking & Duct Ash Accumulation
- High FEGT
- Economiser Steaming



Full & Partial Chokage Due to Exfoliation

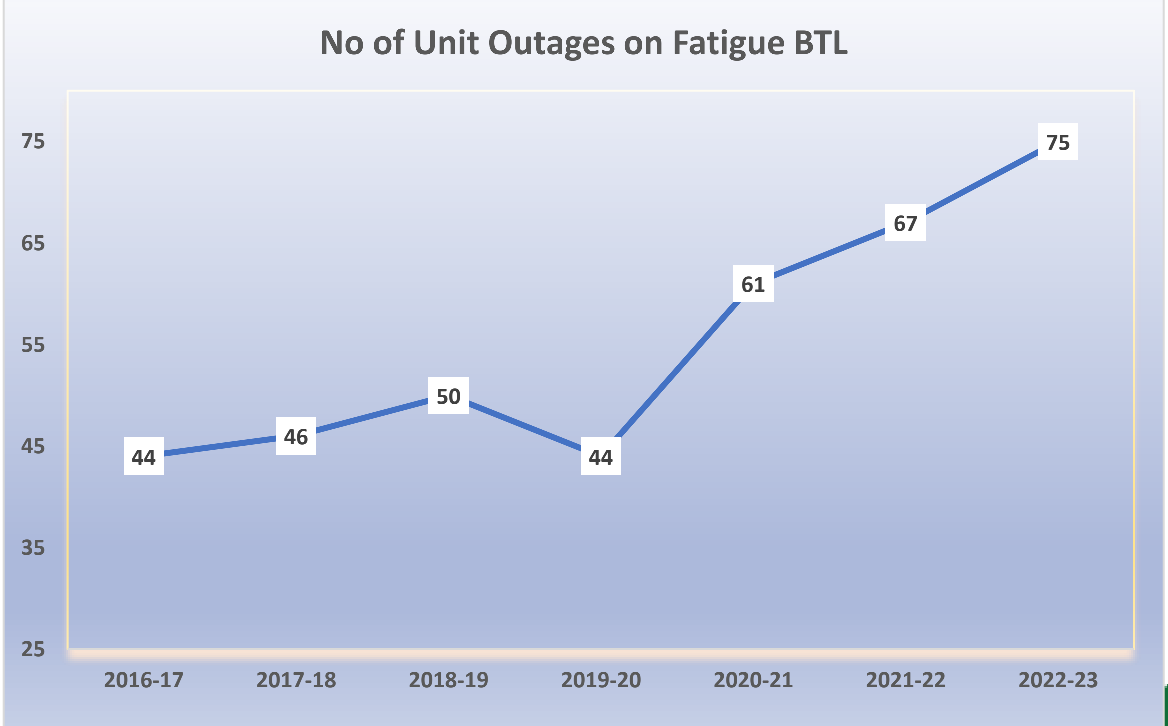


Full Chokage Due to Condensate

Source: EPRI

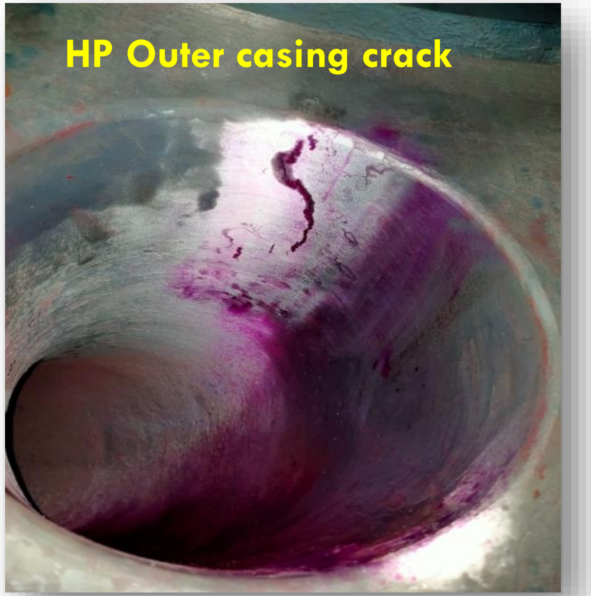
Mitigation Measures

During Unit Operation *(Damage Mechanism due to large variation in Steam temperatures)*	**Ramping:** Large variation in Steam Temp (25 to 40 C)
	Mitigation: Loop Tunning Groups
	Optimum Scheduling: Engagement with grid agency to optimize load variations.
	Condensate blockade in pendant loops during high spray to control tube metal temperature.
During Unit Shutdown	Identifying Incipient Defects by Cyclic Hydro.
	Dry air preservation to prevent tube pitting.
During Unit Overhaul	Attachment modifications as per EPRI guidelines.
	Both Side Fin Welding (earlier only one side).
	Checking of attachments by DPT.
	Checking of innermost bend for cracks.
	Adoption of RFET, AET, Exfoliation, Ther Flow, Thermovision test



Turbine- Challenges and Mitigation Measures

Challenges	High Vibration of Rotor Train.
	Increased Ovality & Decreasing hardness of Casings.
	Increased Potential of LP Blade Failure.
	Severe Deposition on Turbine Blades.
	Damage to Turbine Valves
	Excessive Exhaust Hood spray leading to LP blade erosion



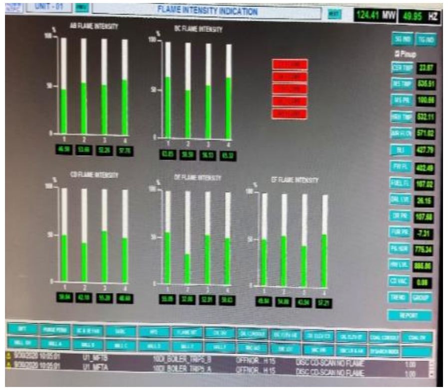
Challenges	Actions
HP casing crack	RLA of casing every 6 yrs (13 yrs). Replacement of casings & rotor in 15 yrs (25 Yrs)
Chance of LP blade crack	Frequent inspection- 2 yrs (4 Yrs) , MPI- In-situ PAUT- 2 yrs (4 yrs)
LP Turbine blade fluttering	Mistuning of free standing blades, Installation of BVMS system
High vibration of rotor trains	Turbine Bearings inspection in every 2 yrs (4 yrs).
Increasing ovality & reduction in hardness of Casing	More frequent replacement of casings, rotors.
Damages of steam valve internals	Frequent inspection & maintenance

High metal temperature of blading, seals, Turbine rotating and stationary structures as well as Cold Reheat Piping => excessive distortion and/or creep damage (Casing and Rotor)

Operations and Controls- Challenges and Mitigation

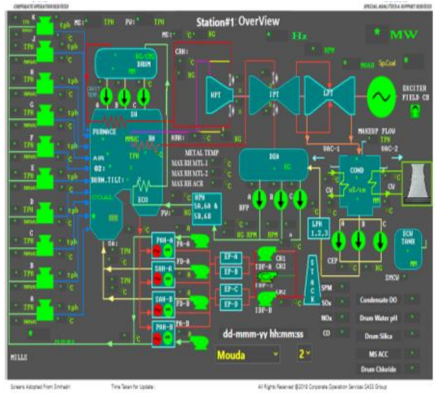
Area	Challenges	Mitigation Measures
Operations	• High Ash deposition on ducts. • Soot blowing difficulty, Need > 70% load for 3 hr in a day • Flame disturbance tripping on Coal Quality variations • Higher chances of outage due to single Aux Eqp approach. • Chemistry parameter variation (PH, Conductivity, DO etc)	• Unlearn and Relearn Strategy • New Operational Practices
Controls	• AGC • RGMO	• Loop Tuning • Interventions through Policy advocacy for changes in procedures

Variations in coal quality



Combustion and Flame Stability

Ash Deposition at Low Loads



Tuning - Control loops

Flexible Operation at NTPC- Partnerships and Tests with Expert Agencies/OEM's

Learning Outside

Various Studies on Variable Load Operation

Study Associates	Station	Scope
J-Coal/TEPCO, Japan	Vindhyachal 11, Mauda 3,4– 500 MW	MTL @55% with 3% ramping. Efficiency at different part load condition
IGEF/VGBE, Germany	**Dadri U 6 (500MW)**	**MTL (40%) & 3% Ramping**
GE, USA	Talcher-K Unit 1 (500 MW)	MTL (40%)
USAID/BHEL	Mauda Unit 2 (500 MW)	MTL (40%)
EPRI, USA	Solapur, Gadarwara, Simhadri, Bongaigaon, Farakka and Unchahar	Identifying gaps in O&M practices
USAID/INTERTEK, USA	Ramagundam U#2 (200 MW) Jhajjar U# 1 (500 MW)	Cost of flexing due to start up and load following
Engie Lab (France/Belgium)	Dadri Unit 4 (200 MW) Farakka Unit 6 (500 MW)	Strategy for transition to flexible opn. and Estimation of Capital Cost

Common Observations of the Pilot Studies

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- Parameter Fluctuation
  - Excessive fluctuations in Steam temperatures.
  - High Drum level swings during ramping.
- Flame disturbance during ramping.
- Occasional furnace pressurisation.
- Stalling of Primary Air fans at low loads.
- Low boiler flue gas exit temperature, leading to acid corrosion.

Ramp
- Command @ 3%
- Actual @ 1.3-1.4%

40% MTL
- 1 Each of BFP, FD, ID, PA
- Flame Failure if any aux trips

Tests
- Controlled Environment
  - Quality Coal
  - Expert Presence

Ramp test at Tata Maithon & DVC Andal results was at par with Dadri

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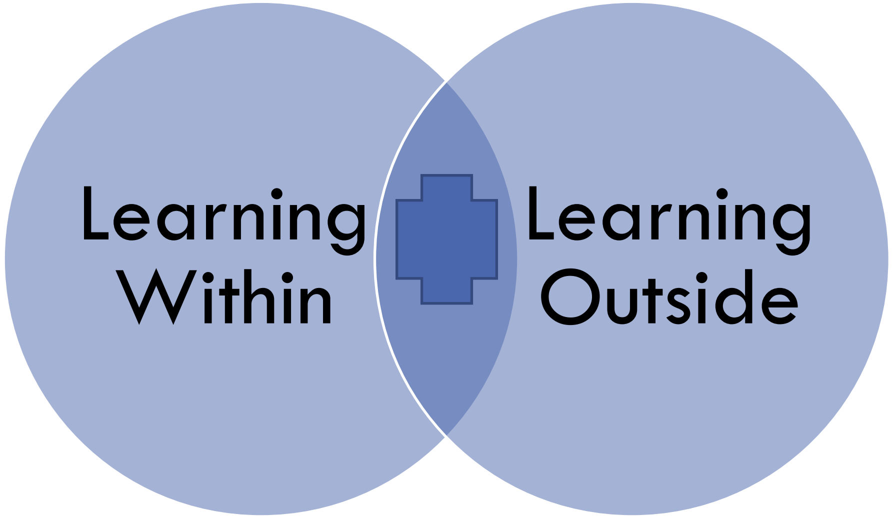
Flexible Operation at NTPC- Implementation of Learnings



NTPC Initiatives for Flexible Operation-Dadri U 6 & Simhadri U 4

Processes Implemented

- ✓ Intelligent Proactive Process control
  - (MS HRH temp, Flue gas temp. etc.)
- ✓ Single drive operation (Higher Efficiency & Lower Reliability)
- ✓ Automated Milling System
- ✓ Condition monitoring system
- ✓ Combustion Optimisation
- ✓ Boiler Fatigue Monitoring system (BFMS)
- ✓ Unit Response Optimisation (Reduce Over & Undershoots)

Work with M/s Siemens & Emerson

Hardware E&C (Control panel, BFP R/c valves replaced)
ID, FD ,PA , Mill SGC
Sliding pressure implementation
TDBFP and MDBFP SGC
BFMS : Commissioning done
Condensate throttling, Unit control, Drum & S/H control

NTPC Strategy for Variable Load Operation

3-Pronged Strategic Approach for Variable Load Operation

Technology

- Control & Monitoring System for early warning & smooth operation
- Schematic & Technological/Metallurgical upgrades
- Partnership (National/Global)

Technical Up-gradation

- OEM/Expert Support
- Boiler Combustion System
- Boiler Fatigue Monitoring System
- Vibration Monitoring System
- Control Optimization etc

Process

- Capital OH reduced from 6 to 4 Yrs.
- Optimisation of Overhauling Interval
- Control Loop Tuning
- Studies- OEM/ Experts

Regulatory Support

- Incentives for making units Flex Ready
- Compensation Mechanisms for Low Load Operation
- Higher Incentives for Voluntary low load contribution.
- Uniform implementation for all grid connected entities irrespective of Ownership

People

- Training & Development.
- Centralized Tuning group
- Collaboration with International agencies like EPRI, JICA etc
- Simulator training

NTPC Expectations

Industry Peers

- All Gencos including states at 55% MTL
- OEM support
- Collaboration

Regulators

- Compensation for life consumption (Capex,Opex, Additional Spares)
- Incentivization

Grid Operator

- Flexible Rules and Procedures
- Stable Grid, Less frequency variations
- Forecasting

Govt of India

- Policy Support
- Low Cost Funding
- Balanced capacity

Change is Inevitable; Growth is Optional

CEA Phasing Plan for implementation of 40% Technical Minimum Load

- **Criterion:** Based on COD**.** The criterion for selecting of the units should be more inclusive and should inter-alia include the factors like Size, Location, Age, ECR, Distance from mines, Environmental issues, OEM availability etc
- **Pilot: 11 Units. More data**
- **Treatment of Supercritical Units:** Dry to wet Changeover
- **Technical Challenges**
  - Flame Stability: Poor Coal, Rainy Season
  - Ash Settlement
  - Attachment Failures

Compensation Methodology-CERC

Capex: (Systems/modifications required.)	Additional Capital Spares
	Drive Turbine ACV modification / BFP R/C valve modification
	Condition Monitoring System (BFMS; TSE; Rotor Flux Monitor; Partial Discharge Monitor)
	Control equipment/strategies upgradation
	Turbine VMS (Blade VMS; Casing VMS)
	Combustion Optimisation Module

Approximate Cost: **90 Cr**

- Irrespective of R&M

Fixed Cost: Penalty to be removed as generator is bearing the cost in DSM. Double penalty will adversely impact generator viability.

O&M Cost: Due to increased life consumption (damage cost). Introduce Flexibility Factor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Thank You


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