

Report of the Committee

on

Wear & Tear, O&M and Plant Lifespan Implications

due to flexible operation

1. Background

In a meeting held under the Chairmanship of **Secretary (Power)** on **27.05.2025** where NTPC expressed serious concerns over two-shift operations and 40% load flexing, citing their adverse impact on unit health. NTPC also expressed that operating units below 55% load is technically not feasible, particularly due to issues such as poor coal quality. Further, it was stated that NTPC is already experiencing high boiler tube leakages, frequent flame failures, and a significant increase in generator and turbine failures over the past three years. It was mentioned by NTPC that repeated ramp-ups and ramp-downs are accelerating wear and reducing the lifespan of thermal units. NTPC added that consequently they are not in a position to support two-shift operations.

Secretary (Power) observed that CEA and GRID-INDIA, in consultation with generators, should first thoroughly examine the potential damage to the country's thermal plant fleet including wear and tear, O&M, and plant lifespans before considering implementation of two-shift operations.

Thereafter, a committee was constituted in CEA with the following composition:

1. Shri B.C. Mallick, Principal Chief Engineer-II - *Chairman*
2. Sh. Surata Ram, CE(TPRM), CEA/Sh. Pravir Kumar - *Member Convener*
3. Sh. SK Pandey , CGM , DVC - *Member*
4. Sh. Partha Nag , CGM , NTPC - *Member*
5. Sh. R. Sahoo, GM, WBPDCCL - *Member*
6. Sh. Manoj Kumar Agrawal, Executive Director, NRLDC, GRID-INDIA - *Member*
7. Sh. S Bhattacharya, GM, BHEL – *Member*
8. Shri Shubhramshu Patnaik, Partner, Deloitte India – *Member*

Followings are the representative as Special Invitees: -

1. Sh. AK Sinha, Technical Director, Intertek
2. Sh. Ripu Bhanjan Singh, USISPF
3. Sh. Rohit Yadav, Deputy Director, CEA
4. Sh. Vikalp Saini, Assistant Director, CEA

The **mandate of the Committee** was to examine the **potential damage to thermal power plants** on account of flexible operation and also to examine the impact of two-shift operations in generating units. The terms of reference (TOR) of the committee:

- i. Assessment of increase in wear & tear, increase in O&M and impact on plant's life.
- ii. Analysis of operation data of generating units where damages has been reported due to flexible operation.
- iii. Conduct feasibility study for two-shift operations and examine impact on units' life.

Three meetings of the committee were held with the participation of representatives from CEA, NTPC, DVC, BHEL, Grid India, Intertek, USISPF on 02.07.2025, 19.08.2025 and 15.10.2025.

2.1. Present Grid scenarios:

GRID-India informed that most inter-state Generating Stations (ISGSs) and several state generating stations have technically achieved 55% Technical Minimum Load (TML). However, it was highlighted that a significant number of generating units are constrained from operating flexibly due to commercial and regulatory reasons. GRID-India emphasized that with increasing penetration of renewable energy, the Indian power system is witnessing a pronounced duck-curve phenomenon, characterized by surplus renewable generation during mid-day hours and steep evening ramp (~60 GW) requirement.

The all-India diurnal demand variation is of the order of 75 GW, with national ramping requirements typically in the range of 250–300 MW per minute, rising to 500 MW per minute on certain days. Achieving India's target of 500 GW of renewable energy capacity and 50% non-fossil energy by 2030 is contingent upon significantly enhancing grid flexibility through a combination of flexible thermal operation (40% MTL), two-shift operation, battery energy storage systems (BESS), and pumped storage projects (PSPs).

GRID-India highlighted the prevailing grid security challenges during May 2025, wherein system frequency remained above the Indian Electricity Grid Code (IEGC) operating band for nearly 20% of the time, with sustained high-frequency conditions during solar hours for almost four hours within the 06:00-18:00 hrs window. On 25 May 2025, despite backing down the national thermal fleet to approximately 58% and curtailing nearly 10 GW of solar generation through TRAS emergency down dispatch, system frequency still rose to 50.48 Hz, posing a serious concern for safe and secure grid operation. The extent of RE curtailment month wise as intimated by Grid India is given below.

Month	Maximum RE Down		Duration of RE Down	
	MW	Date of Max RE Down (MW)	Hrs	Date of Max RE Down (Hrs)
May	11383	31-05-2025	6.75	25-05-2025
June	13574	01-06-2025	7.25	01-06-2025
July	4623	29-07-2025	4.25	01-07-2025
August	11263	10-08-2025	8.00	24-08-2025
September	13637	28-09-2025	7.25	28-09-2025
October	23432	12-10-2025	8.25	02-10-2025
November	16413	09-11-2025	6.25	02-11-2025

GRID-India further informed that due to the inability of several thermal stations-particularly at the intra-State level-to operate at 55% MTL, maximum renewable energy curtailment more than 23 GW, as indicated in the above Table had to be undertaken during high solar generation periods, underscoring the urgent need for deeper thermal flexibility. It was also pointed out that several generating units are already operating below 55% MTL, including Shree Cement ($\approx 30\%$ of DC), Rajpura ($\approx 50\%$), Talwandi Sabo ($\approx 50\%$), Adani Raigarh ($\approx 45\%$), and Mahan ($\approx 45\%$). Shree Cement's merchant plant in the Northern Region was specifically cited, which operates at around 45 MW (30%) during solar hours and ramps up to full capacity (≈ 150 MW) during non-solar hours, demonstrating the technical feasibility of low-load operation.

2.3 International Scenario on flexibility/ Minimum Technical Load (MTL):

The minimum technical load (MTL) of coal-fired power plants operating in various country is given below:

Country	Typical MTL (Baseline Fleet)	Achievable MTL with Flexibility Measures / Retrofits	Remarks on Flexible Operation
China	50–60% of rated capacity	$\sim 30\%$ (some units 20–30%)	Large baseload-oriented fleet; national retrofit programs to support high RE integration
Denmark	$\sim 30\%$	$\sim 20\text{--}25\%$	Smaller but highly flexible coal fleet; advanced combustion control and operating practices
United States	40–50%	$\sim 30\text{--}40\%$ (limited cases lower)	Majority of units designed for baseload operation; limited deep-flexibility retrofits
Japan	$\sim 30\%$	$\sim 15\text{--}20\%$ (Flex-USC designs)	Modern USC/Flex-USC units with strong focus on part-load efficiency and cycling capability
Germany	$\sim 40\%$	$< 20\%$ (specific units $\sim 12\text{--}15\%$)	Extensive retrofits driven by very high wind and solar penetration

2.4 CEA's positions on Minimum Technical Load (MTL) and 2-shift operation

CEA had also envisaged the requirement of two-shift operation much earlier and incorporated relevant provisions in:

- Technical Specifications of Sub-critical Thermal Power Projects (September 2008), and

- Standard Technical Features for BTG Systems for Supercritical 660/800 MW Units (July 2013).

Central Electricity Authority (CEA) initiated countrywide 40% low load operation pilot study/tests in association with international partners (IGEF, DEA, JCOAL) and OEMs (BHEL, GE, SIEMENS) since 2018 which demonstrated the 40% low load operation capability of coal-based generators. Considering high ash content in Indian coal, and after 5 years successful multiple pilot study/test, CEA notified flexible operation regulation in 2023 regarding 40% minimum technical load (MTL) of coal-fired power plants to be achieved phase-wise by 2030.

CEA also published following two reports wherein the requirement of 40% load operation and 2-shift operation was envisaged for integration of renewable generation into grid:

- **“Flexible operation of thermal power plant for integration of renewable generation”**- a roadmap for flexible operation of thermal, gas and hydro power stations, published in 2019.
- **“Flexibilisation of coal-based power plants”**- a roadmap for achieving 40% Technical Minimum Load, published in 2023.

As per the above reports, the utilities shall conduct detailed study/tests and cost benefit analysis for finding the most optimal solutions to improve the flexibility of plants as the measures required are plant specific and shall depend on the level of flexibilisation. This may be done in consultation with OEM/main plant (BTG) manufacturer /BTG designer.

Enabling two-shift operation and operation at lower technical minimum loads below 55% is crucial to avoid renewable curtailment and ensure secure grid management. It was also deliberated in meeting that running a unit at 40% load is **operationally less damaging** compared to repeated **Reserve Shut Down (RSD)** cycles. Hence, analyzing wear and tear impacts of two-shift operation and establishing a technical basis for compensation and operational planning is essential.

Therefore, conducting a pilot study on two-shift operation is indispensable for assessing wear and tear impacts, determining appropriate compensation mechanisms, and addressing operational concerns in a structured manner. The initiation of the pilot at the earliest is critical to enable implementation of two-shift operations on selected units within the next two years, in line with evolving grid requirements.

2.5 CERC’s direction for 2-shift operation

GRID-India apprised the Committee that CERC, vide order dated 29.03.2025 in Suo Motu Petition No. 2/SM/2025, directed to conduct pilot projects for two-shift operation of thermal generating stations, and tasked NLDC with identification of suitable candidate units (covered in Section 62 of Electricity Act 2023, rail-fed, preferably >500 MW). Accordingly, NLDC identified candidate units and communicated the same to NTPC vide letter dated 22.05.2025, requesting confirmation of unit readiness and submission of start-up cost data for hot and warm starts.

However, NTPC, vide its letter dated 13.06.2025, sought exemption from participation in the proposed pilot study, citing technical and operational constraints, reliability concerns, and the comparatively higher efficiency and environmental performance of its units. GRID-India highlighted that as per the CERC order, the pilot project for two-shift operation is mandatory, and that incentives during the pilot period have also been specified by CERC. The pilot study is essential for a realistic assessment of wear and tear, increased O&M expenditure, and operational impacts, which would enable formulation of a robust and evidence-based compensation mechanism.

2.6 Operational/ technical data of NTPC's power plants for analysis for damages

NTPC generating units are presently operating at 55% Minimum Technical Load (MTL); however, NTPC has not operated its units below this level. NTPC submitted that it is witnessing an increased incidence of Boiler Tube Leakages (BTL), which, according to NTPC, are attributable to thermal fatigue arising from low-load and flexible operating conditions. NTPC emphasized that, from the perspective of grid balancing and minimization of equipment damage, multiple ramp-up and ramp-down cycles per unit per day should be avoided, as such operating patterns significantly aggravate thermal stresses and fatigue damage.

NTPC also highlighted that total 692 Boiler Tube Leakages (BTL) were reported fleetwide from FY 2021–22 to September 2025, averaging 6.68 BTL per unit. 10 instances of flame failure and 11 of 15 BTL events at Farakka were attributed to fatigue failure, overheating, and weld joint failure.

The committee members requested NTPC on 1st meeting held on 02.07.2025 to submit operational/ technical data in a prescribed format of any unit which was operating flexibly up to 55% MTL leading to damage.

After several reminders and persuasion, NTPC submitted operational/ technical data on 07.10.2025 to the Committee for analysis (after three months). Data pertaining to Farakka Unit–2 (210 MW) of age 39 years old and Jhajjar Unit–3 (210 MW) of age 13 years, covering outage categorization, ramping behavior, and operational events during flexible operation. NTPC submitted that the data reflects increased mechanical and thermal stresses experienced by plant components due to flexible operation at 55% MTL.

2.6 OEM perspective on damages

As per OEM (BHEL), although equipment damage is being observed under flexible operation regimes, such damage cannot be attributed solely to flexible operation. Generally, the observed deterioration comprises two distinct components:

- (i) Damage arising from the historical operating profile of the unit, including past operating regimes, ageing, and prevailing O&M practices; and

(ii) Additional damage attributable to the current flexible operation regime.

It is highlighted that in many cases, critical equipment and components were already operating close to their failure threshold prior to the commencement of flexible operation. With the introduction of flexible operation—particularly when carried out using conventional control systems without advanced flexibilisation solutions—the rate of life consumption increases, resulting in earlier manifestation of failures. Accordingly, pre-existing damage and degradation must be duly accounted for, and failures should not be attributed exclusively to flexible operation.

It was further stated that while flexible operation inherently results in higher life consumption compared to base-load operation, such impacts can be effectively controlled and mitigated if thermal generating units are suitably upgraded and made capable for flexible operation through the implementation of advanced control and retrofit solutions. The relatively faster deterioration presently being observed was attributed to the fact that flexibilisation is being undertaken without deployment of comprehensive flexibilisation solution packages.

The OEM (BHEL) also cautioned that several generating units are currently operating in flexible mode without implementation of requisite technical solutions, which is likely to result in premature equipment failures and reduced plant life. It was emphasized that merely achieving compliance with CEA's minimum technical load regulations is not sufficient unless accompanied by corresponding technical measures to address the broader implications of flexible operation.

The OEM (BHEL) further observed that new tenders and technical specifications are largely focused only on meeting CEA's regulatory requirements, without incorporating provisions to address the full spectrum of issues associated with flexible operation. In this context, BHEL recommended that solutions required for enabling safe and sustainable flexible operation should be explicitly incorporated into standard technical specifications and tender documents, both for retrofitting of existing units and for new thermal power projects.

The OEM (BHEL) expressed that the damages and stresses associated with flexible operation can be significantly mitigated through appropriate retrofitting and control modifications to enable stable 40% MTL operation.

With respect to the operational data furnished by NTPC, the OEM noted that the data pertains only to Farakka Unit-2 and Jhajjar Unit-3. Farakka Unit-2 is an aged unit operating beyond its original design life of 25 years, and therefore ageing-related effects on critical components, particularly boiler pressure parts, are expected and need to be considered while analysing the data.

Preliminary examination of the data indicated excursions in boiler outlet and turbine inlet steam parameters beyond recommended limits, both during ramping conditions as well as during steady load operation, suggesting that factors such as operational control, equipment condition, and O&M practices may also be contributing to component stress.

Further, the failure instances shared by NTPC for its fleet across a few stations were observed to exhibit mixed trends, and no uniform or conclusive inference could be drawn from the information provided. The correlation between failures and load ramping, as indicated by NTPC, could not be established based on the statistical analysis made available. Similarly, attribution of the majority

of Boiler Tube Leakages (BTLs) exclusively to flexible operation could not be conclusively established on the basis of the data submitted.

2.7 Data analysis of NTPC units

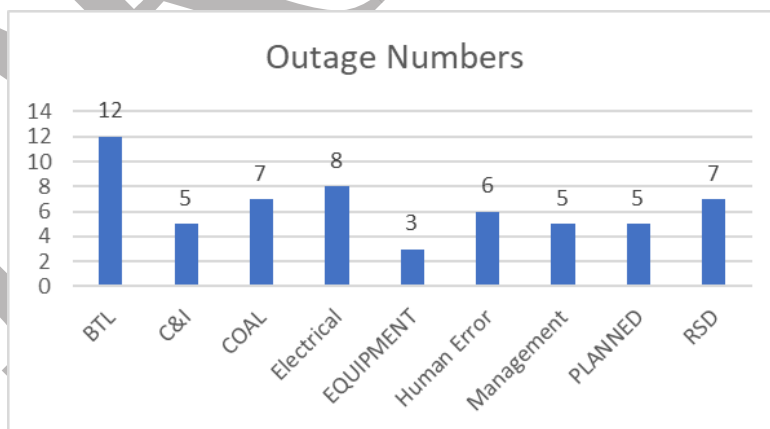
CEA and Intertek jointly analyzed operational/ technical data of Farakka Unit-2 (210 MW) and Jhajjar Unit-3 (210 MW), as received from NTPC.

- 2.7.1 The Farakka unit-2 of capacity 210 MW is about 39 years old which has almost completed its useful life. The preliminary analysis of operational data shows that generation losses at Farakka Thermal Power Station over the last five years were attributable to a total of 58 outage events, comprising 12 Boiler Tube Leakages (BTL), 6 shutdowns due to human error, 5 Control & Instrumentation (C&I) related issues, 5 planned outages, and the remaining outages arising from electrical, mechanical, and other operational causes. The analysis further indicated that the observed ramp rates at Farakka TPS remained conservative, generally within 0.5% per minute across most operating blocks.

Categorization of outage events based on cold start, warm start and hot start:

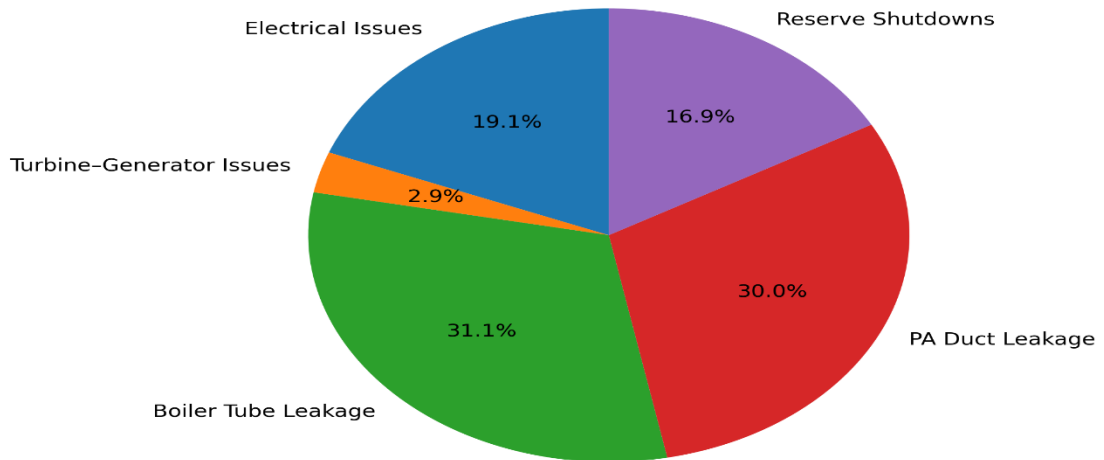
Cold	Warm	Hot
21	14	23

Types of outage events and their occurrences:

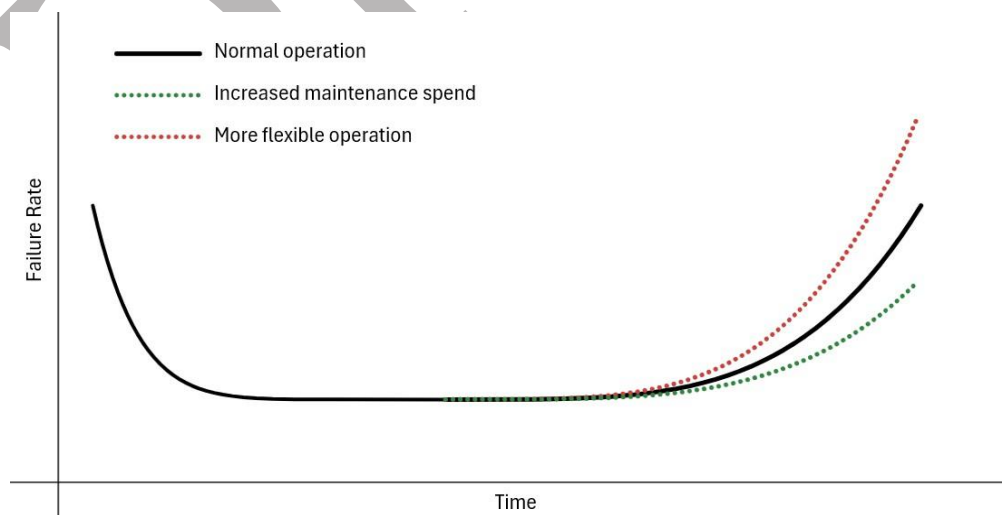


- 2.7.2 The Jhajjar Unit-3 (210 MW) is about 13 years old. Analysis of data for the last one year indicated that generation losses were primarily on account of outages due to electrical issues (32 hours), turbine-generator related issues (4.9 hours), Boiler Tube Leakages (52.3 hours), PA duct leakage (50.35 hours), and Reserve Shutdowns (28.38 hours). The ramp rates were generally conservative, within 0.5%/min, except for isolated instances.

Jhajjar Unit-3: Share of Outage Hours by Category



Units beyond their design life naturally show higher failure rates (as represented by the “bathtub curve”).



(Figure 1: Bath Tub Curve)

2.7.3 Attribution of Damage:

NTPC's analysis correlates all failures to flexible operation, ignoring other dominant causes such as:

- Frequent start-ups and shutdowns,
- Sub-optimal O&M practices
- Improper preservation or forced cooling,
- Coal quality deviation, and
- Human and procedural errors.

Evidence from global and national studies shows that thermal stress and fatigue primarily accumulate during start-up, shutdown, and tripping events — not during steady low-load operation.

2.7.4 Influence of Coal Quality and Combustion:

Poor coal quality contributes significantly to fatigue and overheating. Even during baseload operation, wide deviations from design coal parameters cause substantial thermal stress unless mitigated by blending and combustion optimization.

2.7.5 Flame Failure and Combustion Imbalance:

Several flame failures cited by NTPC occurred even at higher loads (>65%), indicating combustion imbalance rather than load-level issues. These events highlight the need for:

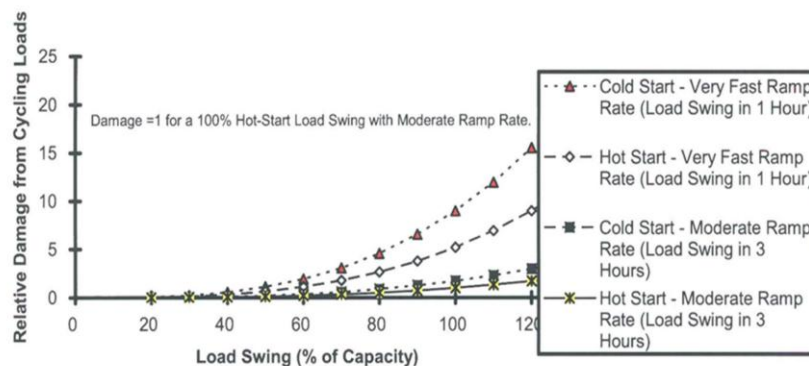
- ✓ fuel–air ratio tuning,
- ✓ burner optimization, and
- ✓ systematic fuel blending practices.

2.7.6 Impact of O&M Practices:

Increased O&M expenditure and timely maintenance substantially reduce damage rates, often below those experienced under baseload operation.

2.7.7 Start-up Severity and Operator Practices:

The USAID–Intertek “Cost of Cycling” study (NTPC Ramagundam, 2017) shows that one poorly executed start-up can cause up to **16 thermal cycles** in a single component (e.g., reheat desuperheater). Proper operator training and start-up procedures can drastically reduce this damage.



(Figure 2: Assumed Relative Damage under Cycling from Cycling Loads)

2.7.8 Both units did **not operate below 55% MTL** during normal conditions. The analysis indicated **no significant damage attributable to low-load operation** at 55% MTL or conservative ramping rates.

2.7.9 Approximately **70% of the observed issues were not due to flexible operation**, but related to **ageing, poor coal quality, or operational disturbances**. It was therefore concluded that while flexibility introduces some additional thermal stress, the existing conservative operations have not shown measurable degradation directly attributable to low-load running.

2.7.10 Mode-Specific Damage Categorization:

For accurate assessment, NTPC was requested to provide mode-wise data under:

- steady full-load operation,
- continuous low-load operation,
- ramping operation,
- start-ups (post-tripping and post-outage),
- forced cooling, and
- poor coal quality scenarios.

NTPC was further requested on 15.10.2025 to share operational/technical data of any other units where damages occurred due to flexible operation. However, till the finalization of report (14.01.2026) they have not shared any data to the Committee.

2.8 Feasibility study for 2-shift operation

Keeping in mind the present grid scenario and curtailment of large quantity renewable generation the committee decided to carry out the feasibility study for 2-shift operation at smaller size old unit preferably less of equal to 210 MW of age more than 35 years. Accordingly, NTPC, DVC and Mahagenco were requested to offer a unit each to examine viability of two shift operation, potential damage to the unit, retrofits/capex. requirement, tariff impact etc.

Despite four Committee meetings, multiple written requests, and communications from CEA, Grid India, and CERC, NTPC has not nominated any unit for pilot two-shift operation trials. Grid India, in consultation with CERC, had identified ten NTPC units suitable for such trials to establish a scientific compensation methodology, but NTPC has not confirmed any for study. Similarly, DVC and Mahagenco also have not identified/ offered any such unit for feasibility studies.

2.9 Conclusion:

1). **Operational/ technical data analysis:**

The data shared by NTPC so far is limited to two units and cannot be extrapolated to the entire NTPC fleet. Averaging fleet-wide failures is not a scientifically valid approach, as units differ in age, operating history, maintenance standards, coal quality etc. Units beyond their design life naturally show higher failure rates (as represented by the “bathtub curve”). Based on available data and empirical evidence, it is confirmed that no significant damage has been observed that can be attributed directly to low-load operation (at 55% MTL and conservative ramp rates). The principal sources of accelerated wear and tear remain improper start-up/shutdown procedures, Human & procedural errors, poor combustion management etc.

Therefore, the focus should be on measures implementation for achieving 40% Minimum Technical Load (MTL) in consultation with OEM/main plant (BTG) manufacturer /BTG designer, improving operational discipline, and training of plant operators to manage cycling efficiently, rather than associating damage solely with flexible operation.

2). **Measures implementation**

The damages and stresses associated with flexible operation (below 55%) can be significantly mitigated through appropriate retrofitting and control modifications. The generating utilities shall conduct detailed study/tests for finding the most optimal solutions to improve the flexibility of plants as the measures required are unit specific and shall depend on the level of flexibilisation. It is also advised to refer CEA’s report **“Flexibilisation of coal-based power plants”**- a roadmap for achieving 40% Technical Minimum Load (MTL) published in 2023.

3). **Reluctance of NTPC in pilot study for 2-shift operation:**

a. **CERC’s direction for conducting 2-shift operation pilot study:**

On the direction of CERC, NLDC identified candidate units and communicated the same to NTPC vide letter dated 22.05.2025, requesting confirmation of unit readiness for 2-shift operation and submission of start-up cost data for hot and warm starts. However, NTPC, vide its letter dated 13.06.2025, sought exemption from

participation in the proposed pilot study, citing technical and operational constraints, reliability concerns, and the comparatively higher efficiency and environmental performance of its units.

b. The Committee's request for identification of a unit:

The committee also requested NTPC number of times to identify an old unit of capacity 210 MW for 2-shift operation pilot study/test. However, they are reluctant and no response has been received since 1st meeting held on 02.07.2025 till finalization of the report.

4). Pilot study for 2-shift operation

In view of the present grid scenario and curtailment of large quantity renewable generation it is essential to carry out the feasibility study for 2-shift operation at smaller size old units preferably less or equal to 210 MW of age more than 35 years. The pilot study includes examination/tests of unit for viability of two shift operation (to understand technical & operational constraints if any and reliability of 2-shifting), then potential damage (life consumption) to the unit, retrofits/capex. requirement, tariff impact etc.

This continued non-availability of pilot units has hindered progress on examination of feasibility, empirical validation of damage mechanisms, delayed formulation of a regulatory compensation framework etc. for two-shift operation.



सत्यमेव जयते

भारत सरकार

Government of India

विद्युत मंत्रालय

Ministry of Power

केन्द्रीय विद्युत प्राधिकरण

Central Electricity Authority

तापीय परियोजना नवीनीकरण एवं आधुनिकीकरण प्रभाग

Thermal Project Renovation & Modernization Division

No. CEA/TPRM/2 SHIFT/2025/982-992

Dated 15.07.2025

विषय: Minutes of the Meeting of the Committee to Examine wear & tear, O&M, and Plant Lifespan implications of Two-Shift Operations in Thermal Power Plants held on 02.07.2025 under the Chairmanship of PCE-II, CEA.

Reference is invited to the Meeting of the Committee to Examine wear & tear, O&M, and Plant Lifespan implications of Two-Shift Operations in Thermal Power Plants held on 02.07.2025 under the Chairmanship of PCE-II, at 03:30 PM at Manthan Hall, 2nd Floor, CEA, Sewa Bhawan. The minutes of the meeting are enclosed herewith for further information and action.

This issues with the approval of Competent Authority.

Pravir Kumar

Director, TPRM

To:

1. Sh. Bikash Chandra Mallick , PCE-II , CEA
2. Sh. Surata Ram, CE, TPRM, CEA
3. Sh. Pravir Kumar, Director, TPRM, CEA
4. Sh. SK Pandey, CGM, DVC
5. Sh. Partha Nag, CGM, NTPC
6. Sh. S Bhattacharya, GM, BHEL
7. Sh. KV Singh, Sr. Manager, BHEL

8. Sh. Sanju Kumar Yadav, DGM, NTPC
9. Sh. Akhileshwar Maurya, DGM, NTPC
10. Sh. R. Sahoo, GM, WBPDC
11. Sh. Manoj Kumar Agarwal, Executive Director, NRLDC, GRID INDIA
12. Sh. Nitin Yadav, DGM, GRID INDIA
13. Sh. AK Sinha, Technical Director, Intertek
14. Sh. Ripu Bhanjan Singh, USISPF

Minutes of the Meeting of the Committee to Examine wear & tear, O&M, and Plant Lifespan implications of Two-Shift Operations in Thermal Power Plants held on 02.07.2025 under the Chairmanship of PCE-II, CEA.

Meeting Introduction:

At the outset, PCE-II welcomed all the members of the Committee. After a brief introduction of all the participants, the Chair, PCE-II, initiated the meeting by explaining background leading to formation of the committee. PCE-II later invited Grid India to update present grid scenario and implementation of CEA's flexible operation regulation, 2023. Thereafter invited NTPC and other members for further discussion to elaborate on low load operation requirement for grid balancing and the damages due to low load.

Deliberations:

1. **GRID INDIA:** GRID-India confirmed that most Inter-State Generating Stations (ISGSs) and several State generating stations are operating at the 55% Technical Minimum Load (TML), while others are constrained by commercial—not technical—reasons. GRID-India emphasized the growing operational challenge from the duck curve caused by mid-day RE surplus and steep evening ramp (~60 GW). It was also stressed that state grid codes must align with CEA's "Flexible Operation of Coal-based Thermal Power Units Regulations, 2023," and financial mechanisms for SHR degradation, auxiliary power rise, and oil use must be embedded in tariff regulations (2024–29). Achieving India's target of 500 GW RE and 50% non-fossil energy by 2030 hinges on enhancing grid flexibility through flexible thermal operations, BESS, PSPs, and improved ramping capabilities. The Grid India representative highlighted the prevailing situation in the Indian power grid. **In the month of May-2025, frequency remained almost 20% of the time above the IEGC band** and persistently hovered above the band during solar hours for almost 4hrs from 12hrs window (06:00-18:00hrs). **On typical day of 25 May 2025 despite of reducing the thermal fleet of the country till 58% and backing down of IPP thermal generation till 55% & 10 GW of solar generation through TRAS Emergency down dispatch, still frequency touched to 50.48Hz, which is cause of concern for safe and secure grid operation.** Grid-India also informed that some of the units like Shree Cement (30% of DC), Rajpura (50% of DC), Talwandi Sabo (50% of DC), Adani-Raigarh (45% of DC), Mahan (45% of DC) are already going below 55%. Shree Cement plant in Northern Region is merchant plant and it is generating around 45MW (30%) during solar hours and 150MW (full capacity) during non-solar hours. Grid-India representative further stated that all India demand ramp requirement is 250- 300MW/minute and on special days it reached up to 500MW/minute, all India diurnal demand variation is ~75GW. It can be clearly observed that net demand evening ramp was around 60GW, which was met through thermal ramp of ~50GW and hydro ramp of ~10GW. Therefore all options for flexibilization need to be ensured such as, thermal flexibility in terms of 40% MTL, higher ramp rate and two shift operation, as these are essential for supporting a rapidly evolving power system with high levels of variable renewable energy integration.

In reference to the present terms of this committee, GRID-INDIA apprised to the Committee that CERC vide order dated 29th March 2025 in suo-motu petition No. 2/SM/2025, has asked to conduct a pilot for 2 shift operation of thermal generating stations and NLDC to identify list of candidate thermal units (section 62, rail feed, preferably >500MW). Accordingly, NLDC has

identified the candidate units for two shift operation of thermal generating station and communicated to NTPC vide its letter dated 22nd May 2025. NTPC was requested to confirm readiness of units identified and share the relevant information such as start-up costs for hot/warm start for each of the units. In response NTPC has requested to exempt from participating in the proposed pilot study on two-shift operation citing technical and operational constraints, reliability concerns, and the higher efficiency and environmental performance of NTPC units vide their letter dated 13th June 2025. Grid-India representative further highlighted that as per CERC order the pilot project for two shift operation is required to be carried out and incentive during this period is also specified by CERC. The pilot project will help in true assessment of wear & tear of m/cs, increased O&M expenses etc, so that a suitable compensation mechanism can be designed and implemented.

GRID-INDIA representative informed that Central Electricity Authority (CEA) has also envisaged requirement of two shift operations in future and accordingly provided provision of this requirement in technical specifications of Sub-critical Thermal Power Projects in September 2008 and also in Standard Technical Features for BTG System for Supercritical 660/800 MW thermal units,” issued by CEA in July 2013.

Conducting a pilot for two-shift operation will enable the committee to assess wear and tear impacts, identify an appropriate compensation mechanism, and address other related concerns. It is, therefore, essential to initiate the pilot at the earliest, to facilitate implementation of two-shift operations on selected units within the next two years.

2. **NTPC:** Representative of NTPC informed members that all its units are running at 55% MTL but not going below it. More than 5000 MW is under USD. NTPC further submitted that it is witnessing increased cases of BTL because of thermal fatigue due to running at low load. NTPC submitted that for Grid balancing and minimising damages, multiple ramp up/down per day per unit should be avoided. He further informed that a similar committee has also been constituted by CERC for identifying units from ISGS utility under Section 62 of 500 MW Capacity for 2 shift operation pilot tests. NTPC further informed that NTPC as a group member of Sub-Group of Technical Experts constituted by CERC have presented NTPC Strategy in lowering the Minimum Turn down Level upto 55%.
3. **DVC:** Representative of DVC informed the committee that all its units were running at 55% MTL except Raghunathpur TPS (Chinese make). He further informed that Ball & Tube mills units too are running at 50% MTL on a regular basis after retrofits as per the recommendation of CEA Committee.
4. **WBPDC:** Representative of WBPDC stated that all units are capable to run up to 55%, but running at higher loads (mostly 70-%) due to schedule commitment and 70% is the MTL as specified by WBSERC. No damage is observed in units.
5. **MSPGCL:** Representative from MSPGCL submitted that MSPGCL is regularly running its units at 55% but facing much fluctuation in Schedule.
6. **PCE-II** informed generating utilities present in the meeting that increased BTL, flame failure etc may be due to not following standard operation procedure (SOP). CEA already circulated SOP for operating at 55% load in the year 2023 where CEA suggested mandatory training for Power Plant operators. Training details was also included in SOP which was prepared in association with NPTI. All the issues as mentioned by utilities shall be reduced once operators are provided training and they follow standard operation procedure (SOP).

7. **BHEL:** Representatives from BHEL submitted that even though damages are being observed while following flexible operation regime, such damages may not entirely be attributable to flexible operation. The damages observed have two components, first due to past operating history of the unit (operating regime, O&M practices etc.) and other due to flexible operation regime. The damages as observed are mainly because equipment/ components were close to threshold of failure before flexing started and with onset of flexing because of comparatively higher rate of life consumption early failure has occurred (as flexing is done with existing controls, without advanced solutions being implemented). Therefore, damage prior to flexing also needs to be accounted instead of attributing the failure to flexible operation alone. It was further highlighted that flexible operation regime will consume more life of the equipment than normal (base load) operating regime but the same can be controlled and mitigated if thermal units are made capable for flexible operation with implementation of advanced control solutions. The faster rate of deterioration being presently observed during flexible operation can be attributed to flexibilization of units without implementation of Flexibilisation solutions package. It was further suggested that a comprehensive study for ascertaining the damages, purely attributable to flexible operation needs to be carried out.
8. **INTERTEK:** Representative from Intertek informed that damage modelling has been carried out by Intertek in various units. According to which 70% of the damages was not due to flexible operation and a comprehensive study for the same needs to be carried out.
9. PCE-II asked all generating utilities if they feel increased BTL, flame failure etc. technically due to low load operation, identify units and submit data for damage modelling study.
10. DVC representative stated that they have not informed anywhere officially that operation at 55% load damages unit.

Decisions:

1. NTPC to submit technical data as per attached format so as to evaluate/quantify the damages due to flexible operation within 10 days from the date of meeting.
2. Intertek asked to share a data template with NTPC and committee members for better and requisite data capturing to quantify the damages due to flexible operation

List of Participants:

1. Sh. Bikash Chandra Mallick , PCE-II , CEA
2. Sh. Surata Ram, CE, TPRM, CEA
3. Sh. Pravir Kumar, Director, TPRM, CEA
4. Sh. SK Pandey, CGM, DVC
5. Sh. Partha Nag, CGM, NTPC
6. Sh. S Bhattacharya, GM, BHEL
7. Sh. KV Singh, Sr. Manager, BHEL
8. Sh. Sanju Kumar Yadav, DGM, NTPC
9. Sh. Akhileshwar Maurya, DGM, NTPC
10. Sh. R. Sahoo, GM, WBPDC
11. Sh. Manoj Kumar Agrawal, Executive Director, NRLDC, GRID-INDIA
12. Sh. Nitin Yadav, DGM, GRID INDIA
13. Sh. AK Sinha, Technical Director, Intertek

14. Sh. Ripu Bhanjan Singh, USISPF



सत्यमेव जयते

भारत सरकार

Government of India

विद्युत मंत्रालय

Ministry of Power

केन् ट्रेडि विद्युत प्राधिकरण

Central Electricity Authority

तापीय परियोजना नवीनीकरण एवं आधुनिकीकरण प्रभाग

Thermal Project Renovation & Modernization Division

No. CEA/TPRM/2 SHIFT/2025/982-992

Dated 08.09.2025

विषय: Minutes of the Meeting of the Committee to Examine wear & tear, O&M, and Plant Lifespan implications of Two-Shift Operations in Thermal Power Plants held on 19.08.2025 under the Chairmanship of PCE-II, CEA.

Reference is invited to the Meeting of the Committee to Examine wear & tear, O&M, and Plant Lifespan implications of Two-Shift Operations in Thermal Power Plants held on 19.08.2025 under the Chairmanship of PCE-II, at 03:30 PM at Manthan Hall, 2nd Floor, CEA, Sewa Bhawan. The minutes of the meeting are enclosed herewith for further information and action.

This issues with the approval of Competent Authority.

Pravir Kumar

Director, TPRM

To:

1. Sh. Surata Ram, CE, TPRM, CEA
2. Sh. Pravir Kumar, Director, TPRM, CEA
3. Sh. SK Pandey, CGM, DVC
4. Sh. S Bhattacharya, GM, BHEL
5. Sh. KV Singh, Sr. Manager, BHEL
6. Sh. Manas Kapoor, DGM, NTPC

7. Sh. Sanju Kumar Yadav, DGM, NTPC
8. Sh. Sumit Pandey, DGM, NTPC
9. Sh. Somara Lakara, NRLDC, GRID-INDIA
10. Sh. Nitin Yadav, DGM, GRID INDIA
11. Sh. AK Sinha, Technical Director, Intertek
12. Sh. Rajiv Patil, ED, MAHAGENCO
13. Sh. Bhupender Sharma, Sri Cements
14. Sh. Jaysinh Jadeja, Adani Power
15. Sh. Tanmay Vyas, Adani Power

Minutes of the Meeting of the Committee to Examine wear & tear, O&M, and Plant Lifespan implications of Two-Shift Operations in Thermal Power Plants held on 19.08.2025 under the Chairmanship of PCE-II, CEA.

Meeting Introduction:

At the outset, **PCE-II** welcomed all the members of the Committee. Following a brief introduction of all participants, the Chair initiated the meeting by inquiring about the **status of data submission by NTPC**, as decided in the previous meeting on 02.07.2025 by 10 days

Deliberations:

1. **NTPC:** The representative from NTPC informed the Committee that data collection is currently underway. They highlighted that the template shared by Committee was exhaustive and detailed, making the data compilation process time-consuming. NTPC requested Committee to share a simplified template comprising only critical data points. PCE-II advised NTPC to submit the data at the earliest.
2. **GRID INDIA:** The GRID INDIA representative stressed the urgency of NTPC's data submission, emphasizing that timely data is essential to assess actual damages due to low load operations. It was also noted that, to accommodate increased Renewable Energy (RE) integration, both 40% Minimum Technical Load (MTL) and two-shift operations need to run simultaneously.
3. **SRI CEMENT:** The representative from SRI CEMENT shared that their unit, operating with a CFBC boiler using normal coal, is regularly running at 30% without any retrofitting. PCE-II requested SRI CEMENT to submit relevant technical data for committee review.
4. **MAHAGENCO:** The representative submitted that all units are currently running regularly at 55%. He further submitted that running in two-shift operations are more damaging compared to continuous operation at 40% MTL.
5. **ADANI:** Representative of ADANI informed that all its units are running at 55%. No issue in running a unit at 55% MTL but facing impacts during cyclic loading. He further raised the issue of requirement of higher ramp rates (actual/real time) to meet the demand of ramp rates as per Flexible operation Regulations (Average).
6. **BHEL:** Representative of BHEL informed that units are operating in flexible operation mode without implementation of solutions. This is damaging the equipment life and will result in premature failures. Implementing the solutions will mitigate the damage to equipment. Further, utilities are focusing only on meeting CEA regulations and not on addressing all the issues associated with Flexible Operation. New tenders are also focusing only on meeting CEA's regulation only. Hence, solutions to address Flexible Operation issues should be made part of standard specifications.
7. **Special Invitee INTERTEK:** Intertek submitted the observation that damages due to flexible operation arises mostly during startup/shutdown and ramping.
8. **PCE II** opined that damages due to operation at 55% are unlikely. Even damages can be reduced by few retrofits at 40% MTL. PCE II requested committee for conducting a feasibility study regarding two-shift operation to Examine wear & tear, O&M, and Plant Lifespan implications of Two-Shift Operations of 210 MW size old units.

Decisions:

1. NTPC to submit technical data as per the updated format within 10 days from the date of the meeting, to facilitate evaluation and quantification of damages due to flexible operation.

2. CEA & Intertek to circulate an updated and simplified data template to NTPC and other committee members to ensure accurate data collection.
3. NTPC & DVC to identify one unit each of 210 MW units with age greater than or equal to 40 years for Pilot test of 2 shift operation.

List of Participants:

16. Sh. Bikash Chandra Mallick , PCE-II , CEA
17. Sh. Surata Ram, CE, TPRM, CEA
18. Sh. Pravir Kumar, Director, TPRM, CEA
19. Sh. SK Pandey, CGM, DVC
20. Sh. S Bhattacharya, GM, BHEL
21. Sh. KV Singh, Sr. Manager, BHEL
22. Sh. Manas Kapoor, DGM, NTPC
23. Sh. Sanju Kumar Yadav, DGM, NTPC
24. Sh. Sumit Pandey, DGM, NTPC
25. Sh. Somara Lakara, NRLDC, GRID-INDIA
26. Sh. Nitin Yadav, DGM, GRID INDIA
27. Sh. AK Sinha, Technical Director, Intertek
28. Sh. Rajiv Patil, ED, MAHAGENCO
29. Sh. Bhupender Sharma, Sri Cements
30. Sh. Jaysinh Jadeja, Adani Power
31. Sh. Tanmay Vyas, Adani Power



भारत सरकार

Government of India

विद्युत मंत्रालय

Ministry of Power

केन्द्रीय विद्युत प्राधिकरण

Central Electricity Authority

तापीय परियोजना नवीनीकरण एवं आधुनिकीकरण प्रभाग

Thermal Project Renovation & Modernization Division

No. CEA/TPRM/2 SHIFT/2025/ 1218-1229

Dated 06.11.2025

विषय: Minutes of the Meeting of the Committee to Examine Wear & Tear, O&M, and Plant Lifespan Implications of Two-Shift Operations in Thermal Power Plants Held on 15th October, 2025 (Wednesday) at 03:30 PM Manan Hall, 9th Floor, Sewa Bhawan, CEA, R.K. Puram, New Delhi.

Reference is invited to the Meeting of the Committee to Examine wear & tear, O&M, and Plant Lifespan implications of Two-Shift Operations in Thermal Power Plants held on 15.10.2025 under the Chairmanship of PCE-II, at 03:30 PM at Manan Hall, 9th Floor, CEA, Sewa Bhawan. The minutes of the meeting are enclosed herewith for further information and action.

This issues with the approval of Competent Authority.

For, Sakil Ahmad

Rohit Yadav

Deputy Director, TPRM

To:

1. Shri B.C Mallick , PCE-II , CEA
2. Shri Surata Ram , CE , TPRM , CEA
3. Shri Rohit Yadav , DD , TPRM , CEA

4. Shri Vikalp Saini , AD ,TPRM, CEA
5. Shri S Bhattacharya , BHEL
6. Shri Nitin Yadav , NRLDC , Grid India
7. Shri Sunil Kumar Pandey , DVC
8. Shri Somara Lakra , NRLDC , Grid India
9. Shri Partha Nag , NTPC
10. Shri Shailendra Singh , NTPC
11. Shri Sanju Kumar Yadav , NTPC
12. Shri Anjan Kumar Sinha, Intertek

Dated 08.11.2022

RE: CEATPRM SHIFTS 12.15 - 12.30

1. The minutes of the Meeting of the Committee to Examine Work & Load, CEA and Power
Lithium Implications of Two Shift Operations in Thermal Power Plants
Held on 08.11.2022 (Wednesday) at 09.30 AM
Main Hall, 9th Floor, Secretariat, CEA, New Delhi.

Reference is invited to the Meeting of the Committee to Examine Work & Load, CEA and Power
Lithium Implications of Two Shift Operations in Thermal Power Plants held on 12.10.2022 under the Chairmanship
of PCE-II at 09.30 AM at Main Hall, 9th Floor, CEA, Secretariat. The minutes of the meeting are

enclosed herewith for further information and action.

This issue with the approval of Competent Authority.

For Sd/-

Rohit Yadav

Deputy Director, TPRM

To:

1. Shri B.C. Malik, PCE-II, CEA
2. Shri Sumit Ran, CE, TPRM, CEA
3. Shri Rohit Yadav, D.D., TPRM, CEA

Minutes of the Meeting of the Committee to Examine Wear & Tear, O&M, and Plant Lifespan Implications of Two-Shift Operations in Thermal Power Plants Held on 15th October, 2025 (Wednesday) at 03:30 PM Manan Hall, 9th Floor, Sewa Bhawan, CEA, R.K. Puram, New Delhi

1. Introduction

The 3rd meeting of the Committee constituted to examine *Wear & Tear, O&M, and Plant Lifespan implications of Two-Shift Operations in Thermal Power Plants* was held under the Chairmanship of **PCE-II, CEA** on **15th October, 2025** at **03:30 PM** in **Manan Hall, Sewa Bhawan, CEA, New Delhi**. The list of participants is attached as Annexure-I

At the outset, **PCE-II** welcomed all the participants. He informed the members that at last NTPC has shared data on 07.10.2025 which was requested in 1st meeting held on 02.07.2025. CEA and INTERTEK jointly analyzed the data and the preliminary report is ready for discussion. He also explained the agenda of the meeting which was as under:

1. Identification of one unit each of 210 MW capacity with age more than or equal to 40 years for pilot test/study of two-shift operation by NTPC and DVC, as decided in the previous meeting.
2. Analysis of data submitted by NTPC of 2 units viz., NTPC Farakka (210 MW) and NTPC Jhajjar (210 MW) (dated 08.10.2025).
3. Standard specifications and tender requirements for flexible operation (40% MTL) of coal-based generating units.

2. Deliberations

2.1 CEA and Intertek informed that after preliminary analysis of the data submitted by NTPC, it was observed that generation losses at Farakka TPS during the last 5 years to inter alia due to the recorded Reserve Shutdowns(7) (RSD), human error(6), Boiler Tube Leakage (BTL)(12), C&I issues(5), Electrical(8), other equipment & Operations issues (8) and five were planned outages(a total of 58 outages). The observed ramp rates remained conservative (within 0.5% in most operating blocks). Outages types includes cold (21), warm (14), Hot (23). The report is enclosed as Annexure.

The Farakka unit has not operated below 55% during normal load reduction (except for start-ups/Shutdown). A conservative ramp rate of <0.5% has been maintained throughout, except in a few blocks. There has been no parametric variation, apart from the existing liabilities.

No significant damages is attributable to low load operation (during the existing flexible operation@55 % and conservative ramp rate of 0.5%. The unit has is part of NTPC's ageing fleet (39 years). And the life of equipment consumed due to ageing, can be reclaimed through R&M.

Representative from Intertek also pointed out that CFBC units and IPPs need to be studied for generation losses during low load operation..

2.2 NTPC stated that units across all States need to achieve 55% MTL compliance so that the operational burden of flexibilisation is not concentrated solely on NTPC stations. NTPC agreed to submit additional operational data of units experiencing frequent ramp-up and ramp-down cycles to facilitate further analysis of wear and tear patterns associated with frequent low-load and frequent high-ramping conditions.

2.3 DVC informed that no unit of 210 MW capacity with age greater than or equal to 40 years is presently available for pilot testing of two-shift operation, as the older units are currently undergoing ESP upgradation activities.

2.4 Grid India informed that NTPC has been given the operational choice to either run selected units at 40% load or operate them under Reserve Shut Down (RSD) conditions. It was highlighted by BHEL and Intertek that operation at 40% load is expected to be significantly less damaging than repeated RSD cycles. Grid India further suggested that analysis may also be extended to Independent Power Producers (IPPs), such as Shree Cement, which have been operating units at around 30% load regularly.

2.5 Mahagenco was requested by PCE-II to nominate one suitable unit for pilot testing of two-shift operation. Mahagenco informed that the matter will be deliberated internally, and a suitable unit will be identified and communicated shortly. It was also conveyed that frequent backing-down cycles in some Mahagenco units have led to operational challenges and maintenance issues. Mahagenco will also provide data of backing down in the given format, if required.

2.6 BHEL expressed that the damages and stresses associated with flexible operation can be significantly mitigated through appropriate retrofitting and control modifications to enable stable 40% MTL operation.

2.7 Intertek, Grid India and BHEL expressed that there should be a guideline for standard specifications and tender requirements for flexible operation (40% MTL) of coal-based generating units for the new builds/incoming capacity.

3. Action Points

- (i) **NTPC** to submit detailed operational data of units having frequent ramp-up and ramp-down cycles for further analysis to assess wear and tear under low-load and high-ramp conditions within 10 days from the meeting.
- (ii) **CEA and Intertek** to prepare and submit a **comprehensive analysis report** on wear and tear patterns based on NTPC's data, including observations on equipment degradation and maintenance trends.
- (iii) **Mahagenco** to **identify and nominate one unit** suitable for pilot testing of two-shift operation and inform CEA accordingly and will also provide the data of backing down in

the given format, if required, for analysis of the data for impact of frequent ramping and low load operation on plant life.

- (iv) Data may be obtained from Shree Cement which is operating at below 40% MTL for analysis.
- (v) BHEL/NTPC/DVC/MAHAGENCO to prepare standard specification and tender requirements for flexible operation (40% MTL) for new upcoming TPPs.

4. Conclusion

The Chair emphasized that as analysis of Farakka TPS and Jhajjhar TPS data shows no significant damages is attributable to flexible operation, the pilot study on 2-Shift operation needs to be conducted before operating any unit under 2-Shift operation. Further, the pilot Study shall be conducted in aged unit around 35-40 years of age and unit size of 200/210 MW as decided in the previous meeting.

The assessment of two-shift operation must be supported by sufficient operational data to quantify the wear and tear impacts accurately.

The meeting concluded with a vote of thanks to the Chair.

ANNEXURE

List of Participants:

1. Shri B.C Mallick , PCE-II , CEA
2. Shri Surata Ram , CE , TPRM , CEA
3. Shri Rohit Yadav , DD , TPRM , CEA
4. Shri Vikalp Saini , AD , TPRM, CEA
5. Shri S Bhattacharya , BHEL
6. Shri Nitin Yadav , NRLDC , Grid India
7. Shri Sunil Kumar Pandey , DVC
8. Shri Somara Lakra , NRLDC , Grid India
9. Shri Partha Nag , NTPC
10. Shri Shailendra Singh , NTPC
11. Shri Sanju Kumar Yadav , NTPC
12. Shri Anjan Kumar Sinha , Intertek

Analysis of Data for Flexible operation

Farakka Unit 2 Outage(4.5 years data), Operational Data- 2 months August/September 2025

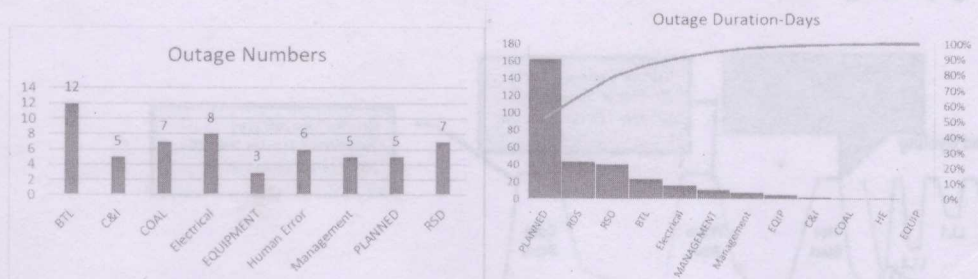


Figure 1: Outages Numbers & Duration

Table 1: Outages type

cold	warm	Hot
21	14	23

The unit has not operated below 55% during normal load reduction (except for start-ups/ Shutdown). A conservative ramp rate of <0.5% has been maintained throughout, except in a few blocks. There has been no parametric variation, apart from the existing liabilities.

CONCLUSION: No significant damages is attributable to low load operation (during the existing flexible operation@55 % and conservative ramp rate of 0.5%. The unit has is part of NTPC's ageing fleet (39 years). It may be noted that as per the EPRI's bathtub curve(see Figure 2), the EFOR increases with significant ageing. And the life of equipment consumed due to ageing, can be reclaimed through R&M.

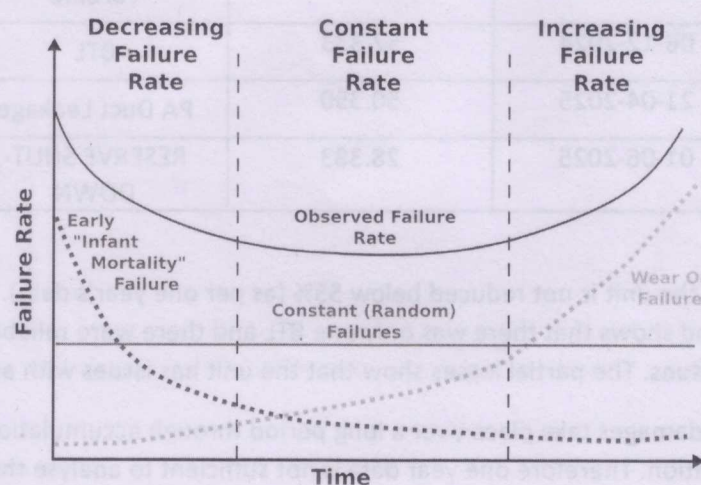


Figure 2: Bath-tub curve - a reliability model used in engineering and by organizations like the Electric Power Research Institute (EPRI) to represent the failure rate of products or components over their lifespan.

The damages in the unit (as per the last 5 years of data provided) is because of the outages. The outages reflect the loss of reliability and a need to focus on capacity building/retraining(as visible from 6 human errors).

It may be noted that start-ups/Shutdowns are much more damaging than load following and conservative ramping. (See Figure 3)

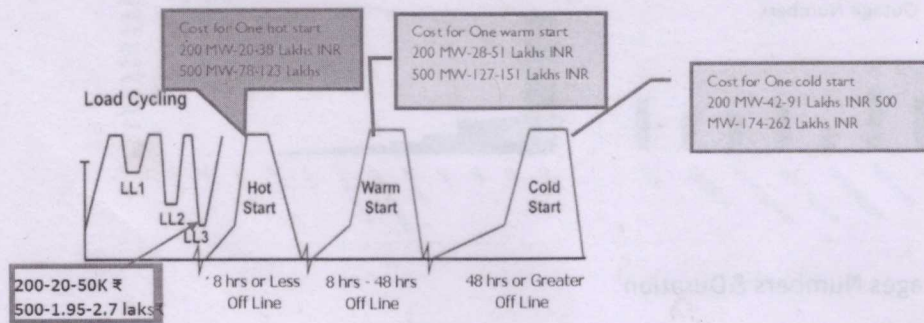


Figure 3: Comparative costs of damages on different modes of flexible operation

The units had undergone 21 cold starts, 14 warm starts, and 23 hot starts.

APCPL-JHAJJAR UNIT 3

Data from July 24 to July 25

Table 2: Jhajjar U3 Outages

Date	Duration (hour)	ROOT CAUSE
07-10-2024	32.900	Electrical
13-11-2024	32.350	Electrical
14-11-2024	4.950	Turbine
06-12-2024	52.333	BTL
21-04-2025	50.350	PA Duct Leakage
01-06-2025	28.383	RESERVE SHUT-DOWN

The minimum load of the unit is not reduced below 55% (as per one year's data). The list of outages is shown in table 2, and shows that there was only one BTL and there were reliability issues due to electrical and other issues. The partial losses show that the unit has issues with ash evacuation.

However, equipment damages take place over a long period through accumulation of damages on every damaging operation. Therefore one year data is not sufficient to analyse the damages and make conclusions.

Final Conclusion: There is no significant damage due to flexible operation @55% MCR load.