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

Date: 21.08.2026

विषय: कोयला आधारित ताप विद्युत संयंत्रों हेतु रैम्प दर अनुपालन रूपरेखा एवं अनुसूचन (शेड्यूलिंग) कार्यप्रणाली पर केंद्रीय विद्युत प्राधिकरण (CEA) की रिपोर्ट - के संबंध में।

Subject: CEA Report on Ramp Rate Compliance Framework and Scheduling Methodology for Coal-Based Thermal Power Plants – reg.

With the increasing integration of renewable energy into the Indian power system, coal-based thermal power plants are required to provide enhanced operational flexibility through operation at minimum technical load and compliance with prescribed ramp rate requirements. In this context, a report has been prepared by the Central Electricity Authority (CEA), through a series of stakeholder consultations held under the Chairmanship of Principal Chief Engineer-II with representatives from NTPC, GRID-India, BHEL, DVC, RVUNL, Adani Power and other stakeholders, by examining the practical challenges associated with ramp rate compliance, scheduling methodology, Deviation Settlement Mechanism (DSM) implications and equipment stress during flexible operation.

The enclosed report consolidates the technical deliberations, key observations and recommendations emerging from these discussions, and is circulated for information, wider dissemination and appropriate consideration by all thermal generating companies in their operational planning and future flexibility initiatives.

Digitally signed by
Surata Ram
Date: 27-08-2026
13:28:32

(सुरता राम / Surata Ram)
Chief Engineer (TPRM), CEA

Copy to: All Genclos/NLDC/RLDCs/RPCs

Copy to: 1. Chairperson, CEA 2. Principal Chief Engineer-II, CEA

3. IT & Procurement, CEA-with a request to upload on CEA website.

Report

On

Ramp Rate compliance framework

And

Scheduling Methodology for the coal-based power plant

Date: 21st August 2026

Background:

A meeting was held on 11th March 2026 at 03:00 PM under the Chairmanship of PCE-II, CEA in Manthan Hall, Sewa Bhawan, New Delhi to deliberate upon issues relating to ramp rate compliance and scheduling methodology in the context of flexible operation of coal-based thermal power plants. The meeting was attended by representatives from NTPC Limited, Damodar Valley Corporation, Bharat Heavy Electricals Limited, Rajasthan Rajya Vidyut Utpadan Nigam Limited, Grid Controller of India Limited and Adani Power Limited. List of participants is enclosed as Annexure-I

At the outset, PCE-II welcomed the participants and highlighted that with the increasing penetration of renewable energy in the grid, the requirement for flexibility from thermal power plants has significantly increased. He emphasized that ramp rate capability and scheduling practices should remain aligned with the regulatory provisions so that grid balancing requirements are met while ensuring that it is technically feasible and safe for the operation of thermal generating units. He then invited the participants to share their perspectives.

Discussion

GRID-INDIA

Representatives from Grid-India made a presentation on ramp rate treatment in inter-state scheduling and highlighted the growing requirement of system flexibility in view of increasing renewable energy integration. It was stated that thermal generating stations play an important role in providing balancing support to the grid by offering ramping capability for managing variability in generation and demand.

GRID-INDIA explained the regulatory framework governing ramp rate provisions. Reference was made to the relevant provisions under the Tariff Regulations issued by the Central Electricity Regulatory Commission, wherein ramp rate performance of thermal generating stations has been linked with return on equity. As per Clause 30(2) of the Tariff Regulations, 2019, with effect from 1 April 2020, the rate of return on equity is reduced by 0.25% in case of failure to achieve the ramp rate of 1% per minute. Further, an additional return on equity of 0.25% is allowed for every incremental ramp rate of 1% per minute achieved over and above the base ramp rate of 1% per minute, subject to a ceiling of 1.00%. It was informed that detailed guidelines for ramp rate measurement and assessment were issued by NLDC in February 2020 and subsequently revised in December 2020 after incorporating feedback received from thermal generating stations. Ramp rate computation for the control period 2019-24 has been carried out in accordance with these guidelines.

GRID-INDIA further explained the current scheduling methodology wherein generating stations declare their ramp-up and ramp-down capabilities for scheduling. These ramp limits are considered while preparing generation schedules, and beneficiary requisitions are moderated, wherever feasible, to ensure that schedules remain within the declared ramping limits. It was stated that ramp rate constraints are taken into account during schedule preparation in order to maintain grid security and operational feasibility.

NTPC

Representatives from NTPC highlighted certain operational and commercial challenges faced by thermal generating stations in meeting ramp rate requirements under the present assessment methodology. It was explained that ramp rate assessment is presently based on the change in average generation between two consecutive 15-minute time blocks. However, the ramping process in thermal generating units inherently involves different stages including boiler response time, active ramping phase and stabilization phase. During the boiler response and stabilization phases, the change in generator output may be negligible even though the ramping process has already been initiated.

NTPC submitted that due to these inherent operational characteristics, generating units often ramp at instantaneous rates higher than the stipulated average ramp rate in order to achieve the required block-average ramp rate. As a result, the effective ramp rate observed on a 15-minute block-average basis may not accurately reflect the actual ramping behaviour of the unit.

NTPC further highlighted that the difference between scheduled generation and actual generation during the ramping process result in deviation in all ramp time blocks and gets eliminated only in the time block with no ramp. Such deviation between scheduled generation and actual generation may attract charges under the Deviation Settlement Mechanism governed by the Central Electricity Regulatory Commission. It was therefore stated that generators may be exposed to DSM charges during ramping even when the unit is operating within its technical ramping capability.

NTPC also highlighted that frequent cyclic scheduling patterns such as V-type, W-type and M-type ramping trajectories can impose mechanical and thermal stresses on boiler and turbine components due to repeated ramp-up and ramp-down instructions within short time intervals.

NTPC suggested that ramp rate assessment methodology may be reviewed to better capture the actual ramping behaviour of thermal generating units, and that ramp rate evaluation could consider the active ramping phase using higher-resolution SCADA/AGC data rather than relying solely on 15-minute block-average measurements.

Other GENCOs (DVC/ADANI/RRVUNL) present in the meeting also raised the similar issue pertaining to ramp rate assessment methodology, scheduling practices and associated operational constraints. A clarification w.r.t to nature of ramp rate (average/instantaneous) as mentioned in CEA Flexible operation regulation was also sought by the GENCOs.

2nd meeting was held on 8th May 2026 at 03:00 PM under the Chairmanship of PCE-II, CEA in Manthan Hall, Sewa Bhawan, New Delhi to deliberate upon issues relating to ramp rate compliance and scheduling methodology in the context of flexible operation of coal-based thermal power plants. The meeting was attended by representatives from Bharat Heavy Electricals Limited and Grid Controller of India Limited. List of participants is enclosed as Annexure-II.

At the outset, PCE-II welcomed the participants and requested that all participants continue the discussion on the ramp rate compliance framework and scheduling methodology for coal-based power plants.

Discussion

GRID-INDIA

Representatives from Grid-India made a presentation on ramp rate treatment in inter-state scheduling and highlighted the growing requirement of system flexibility in view of increasing renewable energy integration. It was stated that thermal generating stations play an important role in providing balancing support to the grid by offering ramping capability for managing variability in generation and demand.

GRID-INDIA explained the regulatory framework governing ramp rate provisions. Reference was made to the relevant provisions under the Tariff Regulations issued by the Central Electricity Regulatory Commission, wherein ramp rate performance of thermal generating stations has been linked with return on equity. As per Clause 30(2) of the Tariff Regulations, 2019, with effect from 1 April 2020, the rate of return on equity is reduced by 0.25% in case of failure to achieve the ramp rate of 1% per minute. Further, an additional return on equity of 0.25% is allowed for every incremental ramp rate of 1% per minute achieved over and above the base ramp rate of 1% per minute, subject to a ceiling of 1.00%. It was informed that detailed guidelines for ramp rate measurement and assessment were issued by NLDC in February 2020 and subsequently revised in December 2020 after incorporating feedback received from thermal generating stations. Ramp rate computation for the control period 2019-24 has been carried out in accordance with these guidelines.

GRID-INDIA further explained the current scheduling methodology wherein generating stations declare their ramp-up and ramp-down capabilities for scheduling. These ramp limits are considered while preparing generation schedules, and beneficiary requisitions **are** moderated, wherever feasible, to ensure that schedules remain within the declared ramping limits. It was stated that ramp rate constraints are taken into account during schedule preparation in order to maintain grid security and operational feasibility.

BHEL

Following are the views of BHEL on subject of implementation of load ramps in the grid as discussed during the Meeting on 08.05.2026 amongst CEA, NLDC & BHEL:

- Load ramp rate implementation in the grid is being done by grid operators (NLDC etc.) assuming instantaneous load change response of thermal units.
- Currently, load change is being given by the grid as a step load change commencing at the start of any block (Figure 1). Such sudden load change/ increase is not realistically possible as time is required for achieving the load change (Figure 2).

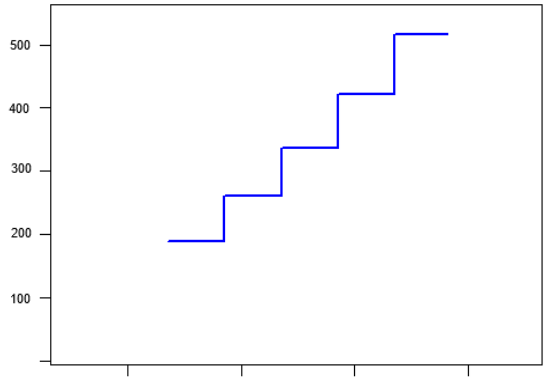

Figure 1: Step load change being mandated in the grid over several blocks continuously

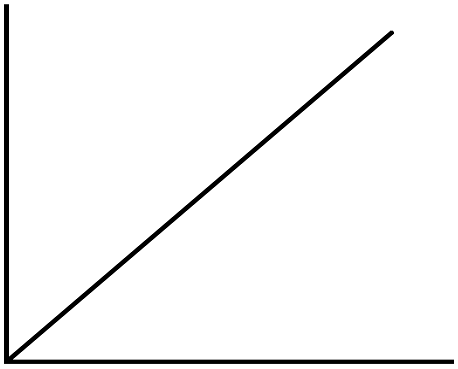

Figure 2: Linear load change that can ideally be expected from a thermal set, simplified for understanding as actual nature of load change will be in the form of a curve

- Actual response of a thermal set for load ramp is as per Figure 3.

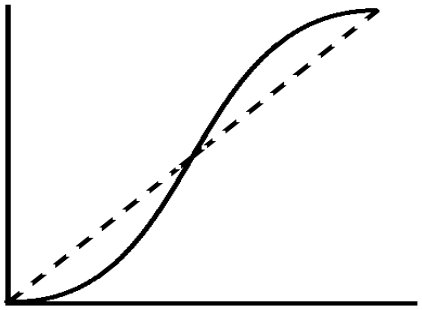

Figure 3: Actual response of a thermal unit during load ramping (Dotted line is linear load setpoint that can be ideally expected from thermal sets, solid line is actual load change of thermal set)

- Consequently, desired load during load ramping is achieved somewhere in between the block depending on load change quantum and actual load ramp rates possible. For example, consider a 500 MW set for which load ramping is to be done at 1%/minute in 67th block for two cases, as described below:

  - **<u>Case 1:</u>** load change from 300 MW to 350 MW

    Case 1 will need 10 minutes for achieving the target load and it will reach the target load in between the 67th load block (see Figure 4)

  - **<u>Case 2:</u>** load change from 300 MW to 375 MW.

    Case 2 will need 15 minutes for achieving the target load and will reach the target load by the end of the block.

  Hence, load ramping setpoint change and actual response of the unit would be as depicted in Figure 4. Accordingly, there could be different scenario of load change, depending on the magnitude of the load change and the load ramp rate.

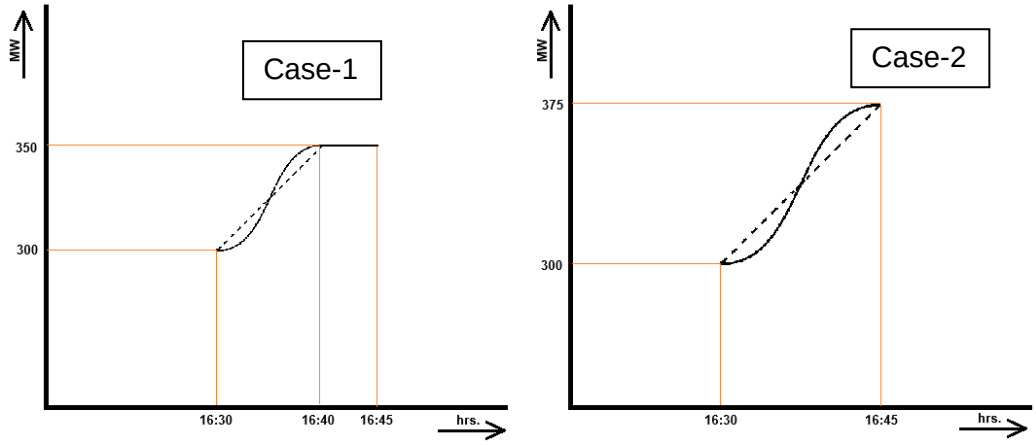

Figure 4: Actual load ramping response of a thermal set at 1%/minute for 300 MW to 350 MW in Case 1 and for 300 MW to 375 MW in Case 2 in the 67th block. (*Dotted line is linear load setpoint that can be ideally expected from thermal sets, solid line is actual load change of thermal set*)

- Due to this behaviour, there is a deviation in the actual generation from that specified by the grid over the block. To compensate the deviation in generation, utilities are going for higher quantum of load change in the same time block to achieve the generation target. This is resulting in actual load ramp rates being higher than what is required and this is putting additional stress on the thermal sets as the above ramp rates may be higher than design conditions.
- The above is primarily happening as grid is giving step load change commands.
- Further, after achieving a load ramp, in the next block itself another ramp is being given from the grid (as shown in Figure 1, which is a continuous step load change over several blocks). In the process, the unit does not have time to stabilize which is creating additional disturbances in the system and putting stress on the components. In worst case, the next load ramp is in the opposite direction in the next block, thereby putting more stress on the system.

- This issue can be mitigated if there is a block dedicated to the ramp itself, followed by stabilization blocks as shown in Figure 5.

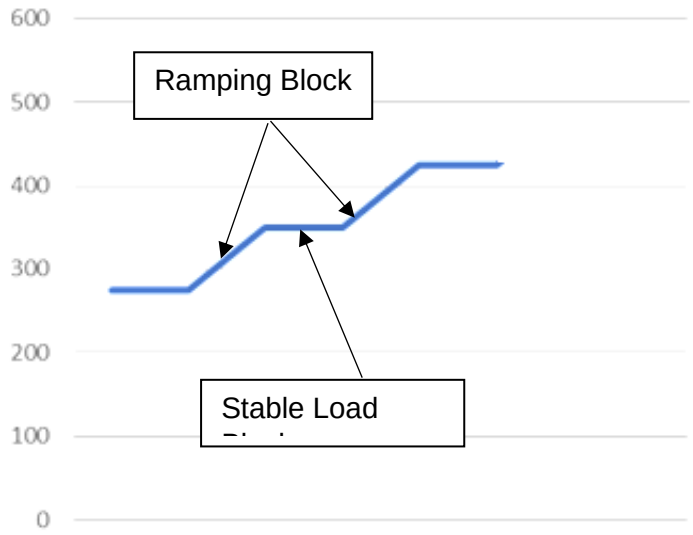

Figure 5: Suggested approach to operate grid for load ramping, stable load block in between ramping blocks

- Further, the system/ equipment design characteristics require that ramps are not given continuously over several consecutive blocks, as depicted in Figure 1. Instead load ramps can be either clubbed to be given as a single command which will continue over different blocks as per the quantum of load change and load ramp rates (Figure 6). Otherwise, load ramps can be scheduled as per the Figure 7 as it allows stable operation of unit between two ramps.

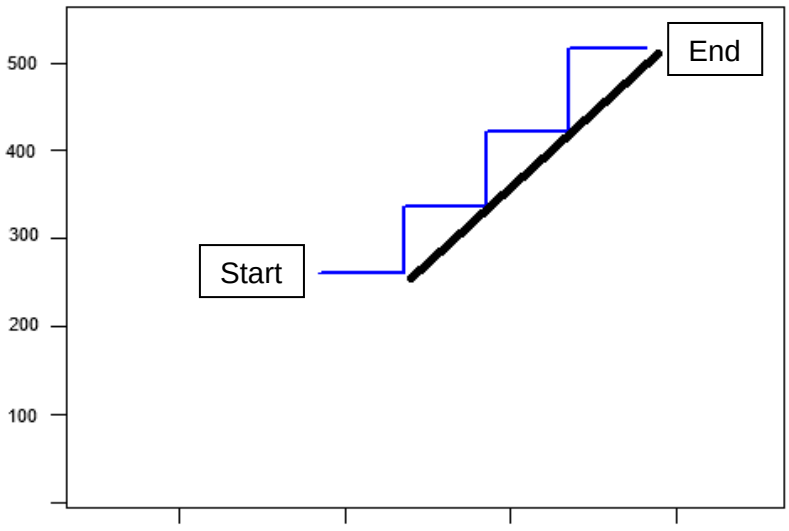

Figure 6: Single load ramp command to be given from starting to end instead of continuous step load change (Blue line: Step load change as per the existing practice of grid, Black line: Suggested load change from start to end for thermal set)

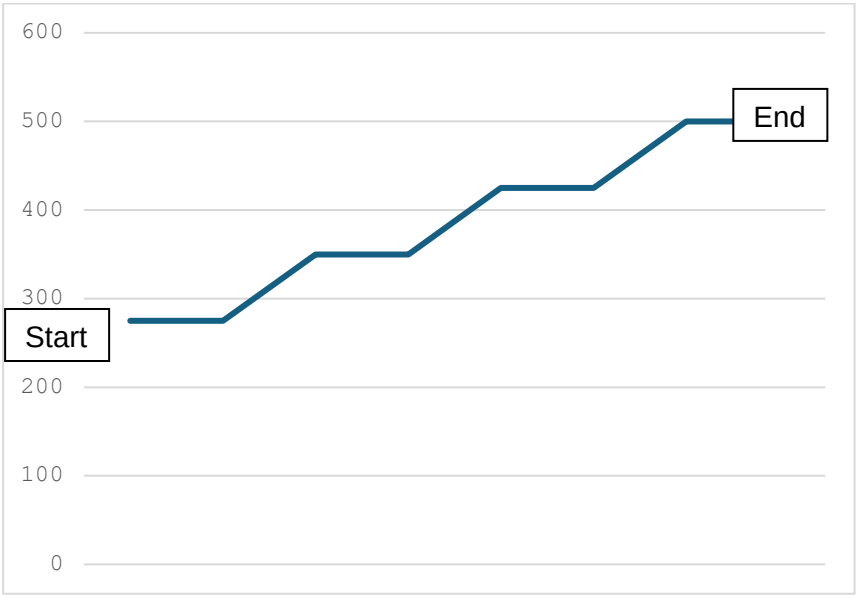

Figure 7: Staggering of load change with a stable load block in between load ramps from start to end

- Flexible Operation means load generation of thermal sets follows renewable generation during solar hours. Accordingly, in a day there should be one ramp down in the morning, followed by minimum load operation for 4-5 hours (during solar hours) and then one load ramp up in the evening, after solar hours. But currently, load variation of thermal sets is not happening in this manner and there are many additional load ramps during the day of various magnitude.
- While doing load pattern/demand analysis, grid controllers are representing the grid as an average for a day and looking for maximum and minimum. Instead, if the load pattern of one day is studied block-wise, then grid controllers can understand the number of additional load cycles that are being forced onto a thermal unit.
- These additional load cycles are due to Grid stabilizing mechanisms of AGC, SCUC, SCED etc. Ultimately, these cycles are not part of flexible operation and are detrimental for thermal units.

3rd meeting was held under the chairmanship of Principal Chief Engineer-II, CEA in Manthan Hall, CEA on 18.06.2026 at 11:00 AM. The officers of TPRM and TETD Divisions of CEA, BHEL, NTPC, RVUN, Damodar Valley Corporation (DVC), National Load Despatch Centre (NLDC), New Delhi, and Adani Power Limited (APL) participated in the meeting. The list of participants is enclosed at **Annexure-III**.

At the outset, Shri B.C. Mallick, Principal Chief Engineer-II, CEA welcomed the participants. He outlined the issues faced by generating companies when complying with ramping up and down under different loading conditions. He pointed out that to achieve the specified average ramp rate (in 15-minute block) expressed as a percentage of Maximum Continuous Rating (MCR) per minute, thermal power plant (TPP) units are actually applying a much higher ramp rate than CEA regulations require. This is done to avoid penalties for failing to meet generation targets within the 15-minute time block, especially under DSM regulations.

He raised four key concerns regarding the application of ramp rates in scheduling as reported by GENCOs. First, operation at higher ramp rates puts undue stress on the machines. Second, continuous ramping across successive time blocks without stabilization periods adversely impacts plant lifespan and health. Third, generators receive ramp-up or ramp-down directives just 12 to 15 minutes in advance, which is insufficient for smooth machine response. Finally, plants must often ramp up in one block and immediately ramp down in the next, creating an onerous burden due to sharp ramp-rate demands.

At the same time, PCE-II recognizes the complexity of the current national grid, where scheduling accounts for various factors. These include grid demand, renewable energy integration, the requirement for flexible power, the availability and flexing capability of coal-based units, the MOD, and PPAs. He emphasizes the need to operate coal-based power plants at their minimum technical load (MTL)—presently 55% and phase-wise 40%, as per CEA regulations—for the smooth integration of renewable generation into the grid. Concurrently, the health of the machinery must be maintained. Finally, he sought the views of the participants on all issues so the machine could be operated at MTL successfully.

NTPC submitted that to achieve average ramp rate of 1% per min in a time block, generators need to ramp at the rate of 2.5 to 3% per min during active ramping phase of around 5 to 7 minutes to compensate for negligible change in load during boiler response time and stabilization time. Thus, to achieve 1%/min rate, the machine needs to actually attain 2.5%/min. This way, thermal characteristics varies these many times within a single time block of 15 minutes.

NTPC also submitted that BHEL in its offer of Advanced Process Control to NTPC also offered to demonstrates ramp rate up to 3% per min for a single ramp test excluding the boiler response time & stabilization time. The relevant excerpt from BHEL's APC offer is as follows:

Further, these trials will be conducted with a minimum load change of 3% per minute for 5 minutes in a single ramp test due to manual addition and removal of mills. Sufficient stabilization time will be provided between each ramp trial. No additional and withdrawal of mills should be attempted during ramps.

All other Gencos also informed that in order to achieve 1% of units capacity per min ramping up, the unit has to attain 2.5% MW/ min, other-wise it would not be possible for the unit to achieve the MW level for the next block, yet it faces the penalty under DSM as it will not be able to meet the schedule in terms of MWh during the block under ramping.

NTPC pointed out that the ISGS and SCED units face DSM penalty during ramping in terms of DSM Regulations 2024 for deviation from scheduled generation.

NTPC pointed out that the Regulation 30(3)(iii) of the Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations, 2024 provides for that :

"iii. in the case of a thermal generating station:

a) rate of return on equity shall be reduced by 0.25% in case of failure to achieve the ramp rate as specified under Regulation 45(9) of IEGC Regulations, 2023.
b) an additional rate of return on equity of 0.125% shall be allowed for every incremental ramp rate of 0.50% per minute achieved over and above the ramp rate specified by Central Electricity Authority, subject to the ceiling of additional rate of return on equity of 1.00%:"

NTPC also added that Grid India has considered that block-wise 0.5 % MW/ min. ramp rate is deemed equivalent to 1 % MW/min ramp rate in the first ramp time block to avoid the penalty under regulation 30(3)(iii)(a). NTPC requested that the same should be extended to the provision of penalty for deviations under Central Electricity Regulatory Commission (Deviation Settlement Mechanism and Related Matters) Regulations, 2024. Grid-India informed that this has been considered only for the first ramping block and not applicable for subsequent ramping block.

Representative of APL informed that schedule of an upcoming time block is known only 8 to 10 minutes before the block in which ramping up/down is required.

NLDC informed that the schedule of inter state generators are prepared by RLDCs. Intra state generators are being scheduled by their concerned SLDC and further only their inter state transactions are scheduled as per their PPA and mutually agreed schedule with buyers through RLDCs. Further for IPPs, the schedules are prepared based on the PPAs and mutually agreed schedule with their buyers and/or their market transactions. These IPP are despatched under Ancillary services (shortfall category) based on the consent provided by them to NLDC. The Ramp rate declared by the IPPs is considered despatch under Ancillary Services. For section 62 generators having share allocations, the schedule is prepared based on requisitions received from their Beneficiaries and the time block wise Ramp Up and Down rate declared by the power plant. Further as per Grid Code, thermal stations are mandated to provide 1% ramp rate per minute. Further CEA Flexible Operation of Coal based Thermal Power Generating Units Regulations, 2023 mandate the coal based thermal power generating units shall have ramp rate capability of minimum three percent per minute for their operation between seventy percent to hundred percent of maximum continuous power rating and shall have ramp rate capability of minimum two percent per minute for their operation between fifty-five percent to seventy percent of maximum continuous power rating. The schedule is prepared based on the requisitions provided by beneficiaries, sale in DAM/RTM, SCUC,SCED and Ancillary services. Plants participating in SCED are able to get their final dispatch schedule 30 minutes before the start of time block and plants getting dispatch under Ancillary services are able to get the schedule 15 minutes before the start of the block. Further with the implementation of SCED since April'2019, most of the power plants having low and high variable charge are

generally get dispatch at constant schedule with minimal changes in schedule. Only mid-merit plants get changes in schedules, which is based on the ramp rate declared by the power station.

Further, as a result of operation of SCED, there is reduction in the number of time blocks where plants need to ramp as per schedule, as well as the ramping quantum in MW. This aspect has been documented in the Detailed Feedback Report on SCED Pilot. During April-December 2019, number of schedule changes reduced by 29% and cumulative MW quantum of schedule changes reduced by 42% on aggregate basis as a result of SCED.

Further NLDC informed that the deviation in schedule is calculated based on the energy recorded in the SEM and schedule energy (not on the Schedule MW).Plants can accordingly start increasing or decreasing their generation from any point one time block in advance in such a way that plant is able to achieve its actual energy close to schedule energy in the next block to avoid any deviation liability. Further the deviation with respect to schedule by the power station during the change in schedule is already acknowledged in DSM regulation and accordingly DSM charges are payable/receivable for deviations up to 10% or 100 MW as per their Variable charges.

In this regard, DVC said that the machine should run sustainably rather than gaining DSM pool charges.

BHEL stated that ramp instruction has been given to the generators plant-wise. Thus, each ramp instruction per time block may be implemented to the TPP units alternatively. NLDC clarified that schedules are prepared on a plant-wise basis and not on a unit-wise basis. Accordingly, any unit-wise allocation of ramping within a plant needs to be managed by the generating station.

PCE-II opined that technical ramping feasibility, the minimum number of unit ramp-ups and ramp-downs, and the subsequent impact on plant life must be considered during merit order dispatch scheduling. He further noted that during the flexible operation of thermal power plant (TPP) units, repeated high boiler ramp rates on the same machine primarily elevate the risk of tube leakage. BHEL stated that Merit order despatch needs to change, although, consumer can get relatively costlier power but O&M cost will be reduced and machine life will be extended.

NLDC informed that major part of the schedule is prepared based on the beneficiary's requisition. The Beneficiaries are different plant wise. NLDC moderates the schedule of section 62 and plants participating in SCED and Ancillary services based on the Un-requestion surplus available and margin available above technical minimum and ramp rate declared by the plant.

The PCE-II asked all OEM(s) and GENCO(s) to specify the maximum number of time blocks allowable for continuous ramping up at 1% MW/min, and how many time blocks should pass before a stabilization period is introduced.

Upon this, RVUN representative drew attention of the participants to the IEGC provision of Tests prior to declaration of Commercial Operation under Regulation 24(3)(b)(ii) and 24(3)(b)(ii) of IEGC 2023 where stabilisation period of 30 minutes is mandated between two steps which provide for :

"(ii) Ramp-up from fifty five (55) percent of MCR to MCR at a ramp rate of at least one (1) percent of MCR per minute, in one step or two steps (with stabilization period of 30 minutes between two steps), and sustained operation at MCR for one (1) hour."

"(iv) Ramp-down from MCR to fifty five(55) percent of MCR at a ramp rate of at least one (1) percent of MCR per minute, in one or two steps (with stabilization period of 30 minutes between two steps)."

Extending his logic from above, RVUN representative requested that on the above line, where the ramp rate is 1% MW/min, a stabilization period of at least 1 time block should be given after ramping up for 2 time blocks continuously to allow for smooth mill addition to ramp up generation to the desired level.

NLDC informed that the referred clause in the Grid Code pertains to tests conducted prior to the declaration of commercial operation. Such provisions are not covered under the applicable clauses of the Procedure for Scheduling and Despatch for Inter-State Transactions under the Grid Code. NLDC further reiterated that neither the CEA Flexible Operation Regulations nor the CERC Regulations presently provide for any stabilization period while scheduling generating stations. If such a requirement is considered necessary, it may be introduced through an appropriate regulatory amendment.

To mitigate the impact of same unit getting subjected to frequent ramp up and down same day and sometimes ramp reversal in the continuous time blocks, PCE-II suggested that ramp scheduled should be rotated between some pool of units/ plants instead strictly as per Merit Order so that the stresses exposure to the TPPs could be alleviated and the burden of stress is shared among larger pool of units for the better health of the TPPs. NLDC observed that schedules are prepared on a plant-wise basis rather than unit-wise. Accordingly, if rotation of ramping among individual units is desired, the same may be managed by the respective generating stations.

DVC, APL and NTPC were also supported the same view in this regard.

After detailed deliberation and discussions, the following conclusions have been reached:

1. Flexible power is essential for integrating renewable energy into the grid, and it can be provided by operating coal-based power plants at their minimum technical load (MTL). Therefore, the objective is to operate these plants at MTL of 55% or less (down to 40%) in accordance with CEA Regulations, while ensuring minimal wear and tear on the equipment.

2. Frequent, high-magnitude ramping—rather than low-load operation—is the primary cause of severe wear and tear in coal-fired power plants. Because coal units are increasingly being used for fine grid balancing, they ramp up and down constantly. When these load ramps occur consecutively, the unit lacks sufficient time to stabilize. This creates additional system disturbances and stresses critical components. Furthermore, an immediate counter-ramp in the next scheduling block compounds this mechanical stress.

3. The difference between scheduled generation and actual generation during the ramping process remains in all ramp time blocks and gets eliminated only in the time block with no ramp. Such deviation between scheduled generation and actual generation may attract charges under the Deviation Settlement Mechanism governed by the Central Electricity Regulatory Commission, i.e. generators may be

exposed to DSM charges during ramping even when the unit is operating within its technical ramping capability.

4. As per the proposal of NLDC, if a power plant starts increasing or decreasing its generation from any point, one time block in advance, it may be able to achieve its actual energy close to the scheduled energy in the next block to avoid deviation liabilities. However, this proactive ramping may result in excess or less generation (MWh) in the previous block, which could attract charges under the Deviation Settlement Mechanism, thus not recommended.

5. Due to inherent limitations of thermal sets ramping (up/down), generation cannot follow side route (vertically upward) of schedule generation block. Instead, it follows diagonal route of schedule generation block. Thus, there will always be a difference between schedule and actual generation. There is a possibility of difference of fifty percent between schedule and actual generation, if steady ramp rate is applied.

6. To compensate the deviation in generation, utilities are going for higher quantum of load change in the same time block (even more than 3% per minute) to achieve the generation target/ avoid DSM. This results in actual load ramp rates exceeding recommended limits, putting additional stress on the thermal sets by surpassing their design conditions.

7. To achieve an average ramp rate of 1% per minute in a 15-minute block, utilities are giving higher ramp command (up to 2.5 %) in the load range of 70% to 55%. As boiler has its inertia & existing control systems are not designed for such ramp rates, the resultant is often uncontrolled or uneven higher ramp rates between 0.5% to 2.5%, in the 55-70% load band. This approach for ramping is technically undesirable, because when higher ramp rates, say 3% will be required, utilities would target 4% to 5% ramp rate. According to CEA regulations, a ramp rate capability of 2% per minute is prescribed when the machine load is between 55% and 70% and a 3% per minute capability is prescribed between 70% and 100%. LDC's are currently giving ramp rates limited to 1% (as per current norms) to utilities. However, if the actual ramp rate is restricted to 2% per minute in the load range of 55%–70%, the generating unit will achieve average ramp rate of around 0.8% per min (in present conditions without retrofits/control system tuning) against the required average ramp rate of 1% per minute in a 15-min time block. Therefore, such a restriction will expose the generator to financial implications arising from non-achievement of the prescribed ramp rate, in addition to the deviation related charges under the applicable DSM Regulations.
8. According to the CEA Regulations, the ramp rate between 40% and 55% load shoud be kept within 1% per minute, while the average ramp rate in a 15-minute generation schedule may not be achievable more than 0.5% per minute (in present conditions without retrofits/control system tuning). Similiarly average ramp rate in a 15-minute generation schedule may not be achievable more than 1.2% per minute for MTL between 70% and 100% load in present conditions without retrofits/control system tuning.

9. In cases where Load ramps require spread over several time blocks due to the magnitude of load change, the same may be implemented as:
    a. By single ramp command to achieve the target load where utilities need to develop capability for mills cut-in & cut-out without operator intervention (implementation of mill scheduler) – Before implementation of this solution a pilot study regarding the same is suggested.
    b. By multiple ramp command ensuring stable load block between two load ramps.

For large scale integration of RE and minimize the adverse impact of low load operation following are the **Recommendations**:

1. Avoid consecutive ramp-up and ramp-down of the same units or plants; instead, select a group of units for ramp-up and another group of units for ramp-down. Ramping schedules should be rotated among a pool of units or plants rather than assigned strictly according to the Merit Order. This will alleviate the stress exposure of individual TPPs and share the burden among a larger pool of units to preserve the overall health of the plants.

2. A set of power plants shall ramp down to the Minimum Technical Load (55% or 40%) in the morning when solar generation increases, followed by minimum load operation during solar hours and then load ramp up in the evening when solar generation declines, or sufficient stabilization time shall be provided before change in direction of ramp. The Merit Order Despatch (MOD) may be reviewed, if necessary, to adopt the above recommendations. This will reduce the O&M costs of power plants and extend their operational life.

3. Instead of using the thermal fleet for fine grid balancing, the same may be done from other sources, such as hydro power plants, gas power plants, pump storage plants, and, BESS.

4. As thermal sets ramp up in diagonal manner, they cannot give a step ramp/ change in load. Therefore, while ramping up/down, a new concept called ramping block should be introduced. In such a block, the target load will be achieved at the end of the block & generation in the block will be about 50% less/ more than scheduled generation. It is recommended to multiply 0.5 with schedule generation of 15-minute block when raping (up/down) to avoid penalty (DSM) due to less generation during ramping up and excess generation during ramping down.

5. Introduce stable-load (stabilization) blocks between ramping blocks to allow the unit to stabilize before the next ramp command which will reduce the O&M costs of power plants and extend their operational life.

6. Utility shall adopt proper control or tune existing control system so that average ramp rate of 1% per minute in a 15-minute block is achieved in between 55% and 70%, resulting in a maximum machine ramp rate of 2% per minute. For loads between 70% and 100% an average scheduled ramp rate of 1.5% per minute in a 15-minute block may be adopted. Similarly, an average ramp rate of 0.5% per minute 15-minute block should be adopted for loads between 55% and 40% resulting in a maximum machine ramp rate of 1% per minute.

7. For fine grid balancing sufficient battery storage at certain specific locations may be installed.

8. It is also recommended to carryout the requisite modification or changes in the respective regulatory framework to give effect to the recommendations.

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Annexure-I

List of Participants in 1st meeting:

1. Sh. BC Mallick, PCE-II, CEA
2. Md. Anwar, Director, TPRM
3. Sh. Rohit Yadav, Dy. Director, TPRM
4. Sh. Vikalp Saini, Asst. Director, TPRM
5. Sh. Jaysinh Jadeja, Adani Power
6. Sh. Pratyush Lenka, L&T
7. Sh. Rajiv Goyal, Head (Power trading), Adani Power
8. Sh. Mayur Sinh Gohil, DGM Adani Power
9. Sh. Ian Rabello, SIEMENS
10. Sh. Umang Swaroop, SIEMENS
11. Sh. Vivek Rastogi, DVC
12. Sh Ashis Kumar Dab, DVC
13. Sh. Mukesh Saini, AD, TETD
14. Sh. Nilesh Dangayach, NTPC
15. Sh. Nishant Bansal, NTPC
16. Sh. Dr. Vikram Singh, EEC
17. Sh Arvind Shukla, SE, RRVUNL
18. Sh P Dhariwal, RRVUNL
19. Sh. Anupam Kumar, Grid India
20. Sh. Manoj Kumar Agarwal, ED, Grid India

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List of Participants in 2nd meeting:

1. Sh. BC Mallick, PCE-II, CEA
2. Md. Anwar, Director, TPRM
3. Sh. Rohit Yadav, Dy. Director, TPRM
4. Sh. Vikalp Saini, Asst. Director, TPRM
5. Shri S. Bhattacharya, BHEL
6. Shri KV Singh, BHEL
7. Shri Saif Rehman, Grid India
8. Shri Nitin Yadav, Grid India

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Annexure-III

List of participants in 3rd meeting

1. Shri B.C. Mallick, Principal Chief Engineer- the Chair
2. Shri Surata Ram, Chief Engineer, CEA
3. Shri Md. Anwar, Director
4. Shri Vikalp Saini, AD, CEA
5. Shri Sakil Ahmad, AD, CEA
6. Shri Mukesh Saini, TETD
7. Shri Nilesh Dangayan, NTPC LTD.
8. Shri Nishant Bansal, NTPC LTD.
9. Shri P. Dhariwal, RVUN
10. Shri S. Bhattacharya, BHEL
11. Shri Vivek Rastogi, DVC
12. Shri Ashish Kumar Dab, DVC
13. Shri Rajesh Ohali, Adani Power Ltd.
14. Shri Mayursinh Gohil, Adani Power Ltd.
15. Shri Anupam Kumar, NLDC, Grid-India

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