POWER SYSTEM OPERATION CORPORATION LIMITED

New Delhi

Date: 02-11-2020

Subject: Amendment to detailed guidelines for assessment of ramping capability of thermal Inter-state generating stations (ISGS)

Sir / Madam,

In compliance with Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations, 2019, detailed guidelines for assessment of ramping capability of thermal Inter-state generating stations were formulated by NLDC, which were published on 28th February 2020 after considering feedback from stakeholders.

After the operationalization of the provisions of the regulations and the detailed guidelines, feedback has been received from thermal generating stations regarding practical constraints in achieving the assessment threshold specified in the guidelines. These mainly stem from the mathematics of converting a physical 15-minute ramping to 15-minute average MW used for the purpose of scheduling and settlement.

Accordingly, it is proposed to amend the guidelines in order to recognize the difficulties being faced by generating stations. The following amendments in the guidelines are proposed:

Clause 4(5) of the guidelines would be replaced as below:

> *"5) Number of blocks D, E and F shall be calculated as follows:*
>
> *D - Number of time blocks during the computation period when the scheduled ramp rate is greater than or equal to 1%/min in the net injection schedule.*
>
> *E - Number of blocks in which the ISGS has achieved ramp rate greater than or equal to scheduled ramp rate, out of the blocks in which the scheduled ramp rate is greater than or equal to 1%/min in the net injection schedule. E is a subset of D.*
>
> *F - Number of blocks in which the ISGS has achieved ramp rate greater than or equal to 1%/min, out of the blocks in which the scheduled ramp rate is greater than or equal to 1%/min in the net injection schedule. F is a subset of D.*
>
> ***The blocks where there is change in direction of scheduled ramp rate, i.e. from ramp up to ramp down or vice versa, shall not form part of D.***
>
> *While calculating E, for the blocks where the scheduled ramp in preceding block was zero, ~~or in the opposing direction,~~ if the ramp in actual generation is greater than or equal to 50% of scheduled ramp rate, that block shall be counted in E (i.e. ISGS shall be considered to have achieved scheduled ramp rate in that block).*
>
> *Similarly, while calculating F, for the blocks where the scheduled ramp in preceding block was zero, ~~or in the opposing direction,~~ if the ramp in actual generation is greater*

than or equal to 0.5%/min, that block shall be counted in F (i.e. ISGS shall be considered to have achieved 1%/min in that block).

The blocks in which no units are on-bar (i.e. zero DC on bar) and the blocks in which the schedule is less than technical minimum (i.e. start-up or shutdown) shall not form part of D, E and F."

Clause 4(6) of the guidelines would be replaced as below:

*"6) As the actual generation is unlikely to exactly match the scheduled generation in each block, because of inherent randomness of physical systems, tolerance of ~~5%~~ **10%** in ramp rate is allowed while measuring the actual generation and counting the blocks E and F. For example, if the scheduled ramp rate in a block is 100 MW and measured actual ramp rate is ~~95 MW~~ **90 MW**, the generator would be considered passed in that block."*

Under clause 4(11), the following text would be appended:

"For the blocks where the scheduled ramp rate in the preceding block is zero, AARR shall incorporate twice the actual ramp rate (expressed in %/min) achieved in such blocks."

Changes in ramp calculation logic in the scheduling software of RLDCs/NLDC is also under modification in view of feedback received from generating stations over practical considerations of averaging ramp over a 15-minute block in schedule. Analysis of simulated schedules has indicated that the number of blocks where scheduled ramp would be 1%/min or greater would reduce by considerable margin after implementation of this logic. Accordingly, the minimum threshold of number of blocks considered for assessment would commensurately need to be changed. Amendment in the guidelines on this aspect would be taken up at a later date after observing the actual performance of the modified logic.

A copy of the guidelines with the proposed changes marked is enclosed as annexure. **Suggestions/feedback** on these proposed amendments to the guidelines for assessment of ramping capability of thermal ISGS **may kindly be forwarded to feedback-ramp@posoco.in by 16th November 2020**.

Sd/-
(Debasis De)
Executive Director
NLDC, POSOCO

Annexure-I

Power System Operation Corporation Limited

National Load Despatch Centre

"Detailed Guidelines for Assessment of Ramping Capability"

of

Inter State Generating Stations

Prepared in Compliance

to

CERC (Terms and Conditions of Tariff) Regulations, 2019

Revision 1

~~28th February~~ xx November 2020

"Detailed Guidelines for Assessment of Ramping Capability" of Inter State Generating Stations (ISGS)

1. Introduction

1) These guidelines are being issued in compliance with the regulation 30(2)(iii) of Central Electricity Regulatory Commission (Terms and Conditions of Tariff), Regulations, 2019.

2) The objective of this document is to lay down detailed procedure for assessment /evaluation of ramping capability for

   - Reducing rate of return on equity (RoE) by 0.25% in case of failure to achieve the mandatory ramp rate of 1% per minute and
   - Providing an additional rate of return on equity of 0.25% for every incremental ramp rate of 1% per minute achieved over and above the ramp rate of 1% per minute, subject to ceiling of additional rate of return on equity of 1.00%.

3) These guidelines shall be applicable to all the regional entity coal/lignite based generators whose tariff is being determined by Central Electricity Regulatory Commission (CERC).

2. Background

With increasing penetration of renewable energy sources in the Indian power system, real-time system operation is faced with the challenge of balancing variable renewable energy. The solution requires harnessing the flexibility attributes in generation. Flexible generation, in which conventional power plants can ramp up and down quickly and efficiently and run at low output levels, is an important part of the solution.

It has been observed that wind and solar generation can create the need for more flexibility as they lead to steeper ramps, deeper turn downs, and shorter peaks in system operation. Even in the present scenario, such demands are being placed on the generation portfolio with high ramps in net load are being witnessed. With increase in RE penetration, flexibility demands are going to increase. Figure 1 shows the trend of net demand on a sample day.

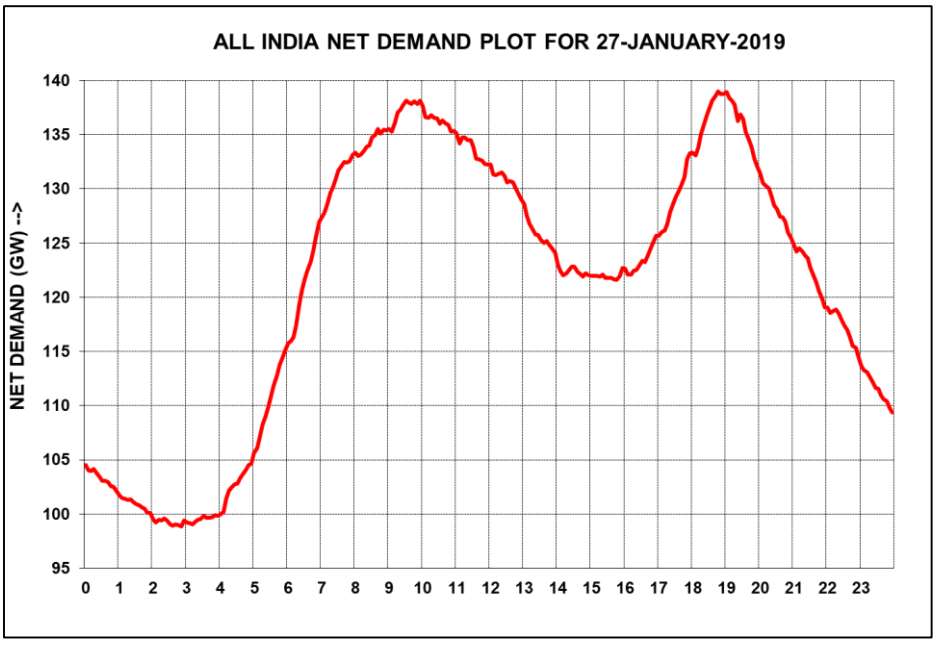


Figure 1: Plot of net demand for 27th January 2019

In this context, the role of thermal generating stations in providing the requisite flexibility in the form of ramping capability becomes highly essential. Various standards and guidelines of CEA for thermal power plants prescribe ramp capability of 3-5%/minute. Indian Electricity Grid Code (IEGC), cl 5.2 (i) stipulates that "*The recommended rate for changing the governor setting i.e., supplementary control for increasing or decreasing the output (generation level) for all generating units, irrespective of their type and size, would be one (1.0) per cent per minute or as per manufacturer's limits*"

This aspect has been recognized in CERC (Terms and Conditions of Tariff) Regulations, 2019. Proviso (iii) to clause 30 (2) in the regulations states that:

"iii. in case of a thermal generating station, with effect from 1.4.2020:

a) rate of return on equity shall be reduced by 0.25% in case of failure to achieve the ramp rate of 1% per minute;

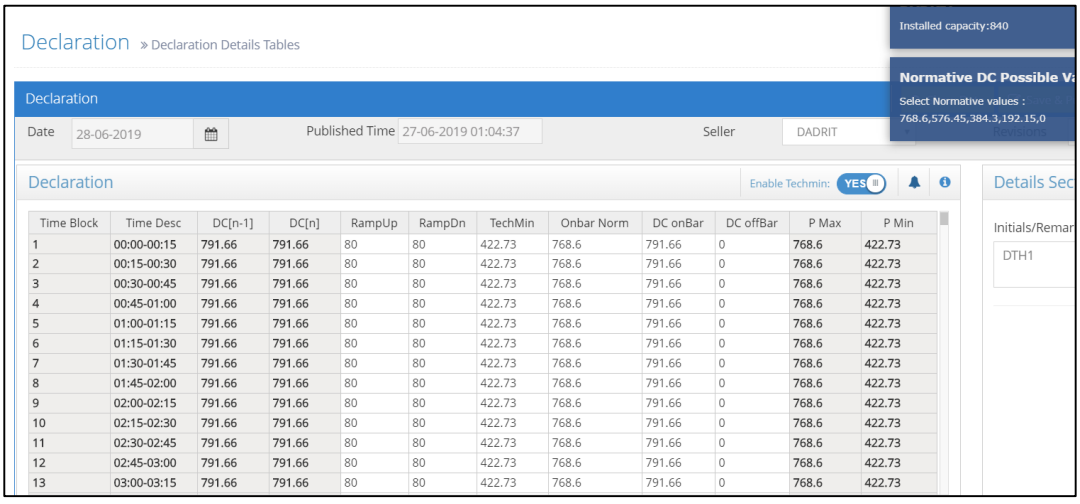
b) an additional rate of return on equity of 0.25% shall be allowed for every incremental ramp rate of 1% per minute achieved over and above the ramp rate of 1% per minute, subject to ceiling of additional rate of return on equity of 1.00%:

Provided that the detailed guidelines in this regard shall be issued by National Load Dispatch Centre by 30.6.2019."

The primary objective of these guidelines is to determine the ramping capability of coal fired generation so that they can perform load following duties well as the system wide ramp requirements increase. Once a generator exhibits reasonable ramp rates during load following on day to day basis, it would also be able to effectively participate in secondary regulation through Automatic Generation Control (AGC) as well as tertiary control and thus help in frequency control. This procedure excludes combined cycle gas power stations as they can exhibit much higher ramp rates than 1% as per the CEA Standards and considering the emphasis of the Commission's orders on coal fired stations.

3. Assessment procedure to be followed by RLDCs/NLDC

1) Generators furnish block-wise up and down ramp rates in RLDC Web Based Energy Scheduling (WBES) software in MW (up/down)/time block along with capability declaration. Figure 2 shows a sample capability declaration form where ISGS can enter the DC, On bar capacity and Ramp up/down rate.



Time Block	Time Desc	DC[n-1]	DC[n]	RampUp	RampDn	TechMin	Onbar Norm	DC onBar	DC offBar	P Max	P Min
1	00:00-00:15	791.66	791.66	80	80	422.73	768.6	791.66	0	768.6	422.73
2	00:15-00:30	791.66	791.66	80	80	422.73	768.6	791.66	0	768.6	422.73
3	00:30-00:45	791.66	791.66	80	80	422.73	768.6	791.66	0	768.6	422.73
4	00:45-01:00	791.66	791.66	80	80	422.73	768.6	791.66	0	768.6	422.73
5	01:00-01:15	791.66	791.66	80	80	422.73	768.6	791.66	0	768.6	422.73
6	01:15-01:30	791.66	791.66	80	80	422.73	768.6	791.66	0	768.6	422.73
7	01:30-01:45	791.66	791.66	80	80	422.73	768.6	791.66	0	768.6	422.73
8	01:45-02:00	791.66	791.66	80	80	422.73	768.6	791.66	0	768.6	422.73
9	02:00-02:15	791.66	791.66	80	80	422.73	768.6	791.66	0	768.6	422.73
10	02:15-02:30	791.66	791.66	80	80	422.73	768.6	791.66	0	768.6	422.73
11	02:30-02:45	791.66	791.66	80	80	422.73	768.6	791.66	0	768.6	422.73
12	02:45-03:00	791.66	791.66	80	80	422.73	768.6	791.66	0	768.6	422.73
13	03:00-03:15	791.66	791.66	80	80	422.73	768.6	791.66	0	768.6	422.73

Figure 2: ISGS Capability Declaration form in WBES

2) Ramp rates furnished by the generators are considered by the RLDCs and NLDC while preparing the injection schedule. The ramp rate in injection schedule is less than or equal to the declared ramp capability. The requisitions given by the beneficiary states are summed up to get the net injection schedule for the power plant. For many power plants which are cheaper and at the bottom of the merit order stack, the requisitions could be the same and at maximum value throughout the day and even if the power plant has given a higher ramping rate, it might be rarely scheduled or utilised by the system. Likewise, whenever the requisition is such that summing up leads to a violation of the declared ramp rate by the plant, the RLDC would have to step in and revise the schedule honouring the ramp rate.
3) Actual injection is measured by interface meters or special energy meters (SEMs[1]) for each of the 15-minute time blocks. As scheduling and metering are being done on 15-minute basis at present, assessment of ramping performance shall also be on 15-minute basis. In the future, when scheduling and metering move to a shorter dispatch period such as 5 minutes, assessment of ramping performance can be carried out on such shorter period.
4) Assessment of overall ramp performance shall have the following factors:
    - Proportion of blocks (**Td**) out of total (**Tm**) in a period, in which the ramp up/down rate declared by ISGS is 1% per minute or more i.e., (**Td/Tm**)
    - No of Blocks (**D**) out of declared blocks (Td), in which ISGS is scheduled by RLDC with ramp up/down rate of ≥1 % /min
    - Proportion of blocks (**E**) out of scheduled blocks (**D**), where ISGS has achieved actual ramp up/down rate ≥ scheduled ramp rate (when it is ≥1%/min) i.e., (**E/D**)
    - Proportion of blocks (**F**) out of scheduled blocks (**D**), where ISGS has achieved actual ramp up/down of ≥1%/min when scheduled ramp rate is ≥1%/min i.e., (**F/D**)
    - Actual Average Ramp Rate (**AARR**) in the blocks when scheduled ramp rate is 1%/min or more
5) Calculation of the ramping performance of each thermal ISGS shall be carried out at the end of each month of the financial year on cumulative basis by RLDCs, which shall be certified by RPCs and published on respective RPC websites. Based on such published calculations/statement, ISGS stations shall bill respective beneficiaries on monthly basis.

4. Ramping Performance Evaluation Methodology – Detailed Procedure

1) Generator shall declare its ramp up rate (MW/Block) and ramp down rate (MW/Block) for each of the 96 time blocks to the concerned RLDCs for the purpose of scheduling on day ahead basis, and with subsequent revisions during the course of the day. This will be referred as "Declared Ramp Up Rate" and "Declared Ramp Down Rate".

   Td - The number of blocks in which both declared ramp up rate and declared ramp down rate are 1%/minute or greater (i.e. 15% of ex-bus generation corresponding to MCR per time block) shall be counted as "**Td**"

   Tm - The total number of time blocks in the period of computation shall be counted as "**Tm**". The blocks in which no units are on-bar (i.e zero DC on-bar) and the blocks in which the schedule is less than technical minimum (i.e. start-up or shutdown) shall not form part of "**Td**" and "**Tm**".

[1] Assessment of actual ramp performance can be done based on SCADA data as well. However, reliance on SCADA data has several issues – latency, non-simultaneity and data communication issues. As SEM data has universal acceptance for accounting and settlement, the injection recorded by SEMs will be considered for assessment of actual ramp performance

2) These ramp rates shall be considered while providing injection schedules to the generator. The final implemented schedule shall serve as the basis for computation. Impact of Automatic Generation Control (AGC) shall be incorporated in the schedule. 15-minute average AGC MW shall be added to the final implemented schedule. The change in injection schedule for each time block shall be referred as *Scheduled Ramp Rate (SRR).*

   Scheduled Ramp Rate$_t$ = (Net Injection Schedule$_t$ – Net Injection Schedule$_{t-1}$)
   Net Injection Schedule$_t$ = Final injection Schedule$_t$ + AGC MW$_t$,
   Where t is the time block
   and AGC MW is the 15-minute average of (AGC setpoint – Unit Load Setpoint)

3) The actual ramp rate achieved by the generator shall be assessed based on 15 minute SEM Data. Actual ramp rate provided in MW / block, is the difference in recorded average injection (AG) between successive time blocks.
   Actual Ramp Rate$_t$ = (Actual ex bus Avg Gen$_t$ – Actual ex bus Avg Gen$_{t-1}$)
   Where t is the time block

4) Proportion (**Td/Tm**) signifies the readiness of the generator to support the grid in terms of ramping performance and it represents the ability to ramp up or down except during times of exigencies, breakdowns and other conditions. Considering these exigencies, threshold for Td/Tm has been kept at 0.85.

5) Number of blocks D, E and F shall be calculated as follows:

   D - Number of time blocks during the computation period when the scheduled ramp rate is greater than or equal to 1%/min in the net injection schedule.

   E - Number of blocks in which the ISGS has achieved ramp rate **greater than or equal to scheduled ramp rate**, out of the blocks in which the scheduled ramp rate is greater than or equal to 1%/min in the net injection schedule. **E** is a subset of **D**.

   F - Number of blocks in which the ISGS has achieved ramp rate **greater than or equal to 1%/min**, out of the blocks in which the scheduled ramp rate is greater than or equal to 1%/min in the net injection schedule. **F** is a subset of **D**.

   The blocks where there is change in direction of scheduled ramp rate, i.e. from ramp up to ramp down or vice versa, shall not form part of D.

   While calculating E, for the blocks where the scheduled ramp in preceding block was zero, ~~or in the opposing direction,~~ if the ramp in actual generation is greater than or equal to 50% of scheduled ramp rate, that block shall be counted in E (i.e. ISGS shall be considered to have achieved scheduled ramp rate in that block).

   Similarly, while calculating F, for the blocks where the scheduled ramp in preceding block was zero, ~~or in the opposing direction,~~ if the ramp in actual generation is greater than or equal to 0.5%/min, that block shall be counted in F (i.e. ISGS shall be considered to have achieved 1%/min in that block).

   The blocks in which no units are on-bar (i.e. zero DC on bar) and the blocks in which the schedule is less than technical minimum (i.e. start-up or shutdown) shall not form part of D, E and F.

6) As the actual generation is unlikely to exactly match the scheduled generation in each block, because of inherent randomness of physical systems, tolerance of ~~5%~~10% in ramp rate is allowed while measuring the actual generation and counting the blocks **E** and **F**.

For example, if the scheduled ramp rate in a block is 100 MW and measured actual ramp rate is ~~95 MW~~90 MW, the generator would be considered passed in that block.

7) Proportion (**E/D**) signifies the percentage in terms of number of blocks in which the ISGS has achieved its scheduled ramp rate, out of the total blocks when it is scheduled by RLDC to ramp at 1%/min or more. This proportion is used, while qualifying for the admissibility of additional RoE as per Tariff Regulations.

8) Proportion (**F/D**) signifies the percentage in terms of number of blocks in which the ISGS has achieved ramp rate of at least 1%/min, out of the total blocks when it is scheduled by RLDC to ramp at 1%/min or more. This proportion is used to check for failure to meet mandatory 1% ramp rate, while imposing reduction of RoE by 0.25% as per Tariff Regulations.

9) Considering that ISGS may not always be able to follow the scheduled ramp due to requirement of taking in/cutting out mills, tripping of auxiliaries or other exigencies, passing threshold for ratios E/D and F/D has been kept at 0.75.

10) In order to ensure that ISGS have sufficient opportunity to demonstrate ramping capability, change in RoE shall be effected only when the number of blocks in which the scheduled ramp rate is 1%/min or greater is more than the threshold of 60 blocks per month (i.e. 2 blocks per day) for evaluating E/D, or 90 blocks per month (i.e. 3 blocks per day) for evaluating F/D.

11) **Actual Average Ramp Rate (AARR)** is the average of actual ramp rate in the blocks when the scheduled ramp rate is 1%/min or greater (i.e. D), expressed in %/min. For the blocks where the scheduled ramp rate in the preceding block is zero, AARR shall incorporate twice the actual ramp rate (expressed in %/min) achieved in such blocks.

12) Flowchart indicating the steps involved in the calculation is enclosed at Annexure-I.

5. Determination of additional RoE/reduction in RoE

1) These calculations shall be done at the end of each month of the financial year on cumulative basis (with period of calculation "**M**" taken suitably in the methodology), by RLDCs. Here, "**M**" is the number of months in the period of calculation.
2) A statement of summary of calculations shall be prepared by respective RLDCs and certified by RPCs, at the end of each month of the financial year on cumulative basis, which shall indicate the ramping performance evaluation of each coal/lignite ISGS based on the metrics specified in these guidelines along with recommendation for change in rate of return of equity. The statement shall be posted on RPCs' websites for information of all stakeholders.
3) Determination of change in percentage of RoE shall be done as below:

   (i) If the proportion **Td/Tm < 0.85 → reduction in RoE by 0.25%**

   (ii) If **Td/Tm ≥ 0.85**

   (a) Check for additional RoE

   If number of blocks **D < 60*M → no additional RoE.**

   If **D ≥ 60*M** and proportion **E/D < 0.75 → no additional RoE.**

   If **D ≥ 60*M** and proportion **E/D ≥ 0.75,** then

Additional RoE (%) = (Greatest Integer (AARR) – 1)*0.25%,

Subject to ceiling of additional rate of RoE of 1.00%

(b) Check for reduction in RoE

If number of blocks **D < 90*M → no reduction in RoE.**

If **D ≥ 90*M** and proportion **F/D ≥ 0.75 → no reduction in RoE.**

If **D ≥ 90*M** and proportion **F/D < 0.75 → reduction in RoE by 0.25%**

4) Based on the above statement of ramping performance evaluation, each ISGS shall bill or adjust the RoE % separately on monthly basis from beneficiaries according to the revised rate of return of equity.
5) Sample calculation sheet for illustrative purposes is enclosed at Annexure-II.

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