# Power System Operation Corporation Ltd.

**National Load Despatch Center (NLDC), New Delhi**

**दिनांक: 30 June 2022**

**सेवा में,**

All the Stakeholders

**विषय:** Extension of date for Public stakeholder Consultation on Draft Detailed Procedure on interim methodology for estimation of reserves

**संदर्भ:** Central Electricity Regulatory Commission (CERC) (Ancillary Services) Regulations, 2022

**महोदय/महोदया,**

CERC (Ancillary Services) Regulations, 2022 have been notified on 31st January, 2022 which would come into force from a date to be notified subsequently by the Hon'ble Commission.

The draft interim detailed procedure, formulated by NLDC, as the Nodal Agency has been floated for stakeholder consultations on 24 May, 2022. The aforesaid detailed procedure is also placed on the POSOCO website at https://posoco.in/documents/consultation-papers/

The last date for submission of stakeholder suggestions/feedback on the above said draft interim detailed procedure for the estimation of reserve requirements to ancillary@posoco.in is, hereby, extended from 30th June, 2022 to **15th July, 2022**.

**सधन्यवाद,**

**भवदीय,**

30/06/22

**(देबाशिस दे)**

**कार्यकारी निदेशक**

**संलग्न** – Draft Detailed Procedure on Estimation of Reserves

# Power System Operation Corporation Ltd.

## Nodal Agency - National Load Despatch Centre (NLDC)

# Detailed Procedure

# For

# Estimation of the Requirement of

# Secondary Reserve Ancillary Service (SRAS)

# and

# Tertiary Reserve Ancillary Service (TRAS)

# at Regional Level

*Prepared in Compliance to Central Electricity Regulatory Commission (Ancillary Services) Regulations, 2022*

***Revision (-1) dated 20th May 2022 (w.e.f xx-xx-2022)***



***Draft For Stakeholder Consultation***

## 1.0 Preamble

1.1 Indian grid has met a demand over 207 GW through both inter-state and intra-state resources.

1.2 Every entity shall undertake all appropriate measures to maintain it's drawal/injection as per schedule. Each control area has to follow certain Frequency Response Performance (FRP) criteria, as may be specified in Indian Electricity Grid Code (IEGC), in order to maintain frequency within the IEGC stipulated band under normal operating conditions.

1.3 The objective of Ancillary Services in Indian power system is to maintain the grid frequency close to 50 Hz, and restoration of the national grid frequency within the allowable band as specified in the IEGC and for relieving congestion in the transmission network, to ensure smooth operation of the power system, and safety and security of the grid.

1.4 Adequate reserves are required to be maintained in a distributed manner with both the regional entities at the regional level and at the State level for each state control area as per the IEGC or the State Grid Code as the case may be.

1.5 The Nodal Agency i.e. National Load Despatch Centre (NLDC) shall, in coordination with Regional Load Despatch Centres (RLDCs) and State Load Despatch Centres (SLDCs), estimate the quantum of requirement of Secondary Reserves for SRAS and Tertiary Reserves for TRAS at the regional level after factoring in the reserves for each state control area, for such period and based on such methodology as specified in the IEGC and publish the same on its website.

1.6 There would be assessment of reserves on year ahead basis, quarter ahead basis week-ahead basis, day ahead basis and intra-day basis.

1.7 This procedure provides an interim methodology for estimation of reserves in accordance with Regulation 6(1) of the Central Electricity Regulatory Commission

(CERC) (Ancillary Services) Regulations, 2022, hereinafter referred to as the "AS Regulations".

1.8 There are various basis and methodologies that could be adopted for assessment of reserves. Few of those are outlined as follows:

1.8.1 99 Percentile of the Area Control Error of the respective control area.

1.8.2 Net demand forecast error

1.8.3 Variability in Net demand forecast error

1.8.4 Variability in Net demand

In the interim, to begin with, Nodal Agency would consider the 99 Percentile of the Area Control Error of the respective control area as the basis for the assessment of reserves for SRAS and TRAS. The other methodologies would also be explored parallelly by the Nodal Agency. If any improved methodology for assessment is evolved over the due course, the same would be incorporated in the Detailed Procedure subject to approval by the Central Commission.

1.9 All the words and expressions used in the Procedure shall have the same meaning as assigned to them in various CERC Regulations.

## 2.0 Objective

2.1 The objective of this procedure is to lay down the roles and methodology to be followed for estimation of quantum of reserves for SRAS and TRAS to be followed by the Nodal Agency i.e. NLDC in coordination with RLDCs and SLDCs.

## 3.0 Definitions

3.1 **'Reference contingency'** means the maximum positive power deviation occurring instantaneously between generation and demand and considered for dimensioning of reserves.

3.2 All the words and expressions used in the Procedure shall have the same definition as assigned to them in various CERC Regulations.

## 4.0 Scope

4.1 The procedure shall be applicable to all entities as provided in the AS regulations, 2022.

## 5.0 Roles

5.1 Nodal Agency i.e. NLDC shall, in coordination with RLDCs and SLDCs, estimate the quantum of requirement of SRAS & TRAS on year ahead basis, quarter ahead basis, week-ahead basis, day ahead basis and real-time basis as per the methodology specified in subsequent sections.

5.2 SLDCs shall furnish data in the stipulated formats to the Nodal Agency for estimation of the quantum of requirement of SRAS & TRAS.

5.3 SLDC shall maintain reserves as estimated by Nodal Agency or as per the estimation carried out by the SLDC in accordance with the IEGC or State Grid Code, as the case may be.

## 6.0 Reserves in Indian Power System

6.1 There shall be different types of reserves, as specified in the IEGC and AS regulations, such as primary, secondary and tertiary for the purpose of frequency control and regulating Area Control Error. The reserves shall be deployed by each control area as per the IEGC and the applicable AS regulations:

6.1.1 Provision for primary response shall be mandatory.

6.1.2 Secondary reserves shall be deployed through a regulated mechanism.

6.1.3 Tertiary reserves shall be procured through the market and deployed

6.2 The deployment of reserves is broadly distinguished on the basis of the time of initiation and duration of response as tabulated in Table-1 below:

| Reserve | Start of activation | Full Availability/ deployment | Ability to sustain the full deployment |
|---|---|---|---|
| Primary Response* | Instantaneous as soon as frequency crosses the dead band | <= 30 sec | Up to 5 min |
| Secondary control Reserve | >= 30 sec | <= 15 Min | Up to 30 min or till replaced by Tertiary Reserves |
| Tertiary control Reserve | Usually > 15 Min to 1 hour | | |

*Table 1: Reserves and their activation*

## 7.0 Area Control Error (ACE)

7.1 "Area Control Error" or "ACE" means the instantaneous difference between a control area's net actual interchange and net scheduled interchange, taking into account the effects of frequency bias and correction of measurement errors.

7.2 The Area Control Error (ACE) for each control area would be calculated at all the load despatch centres based on telemetered values and external inputs as per the below formula:

**ACE = (Ia - Is) - 10 * Bf * (Fa - Fs) + Offset**

Ia = Actual net interchange in MW (positive value for export)

Is = Scheduled net interchange in MW (positive value for export)

Bf = Frequency Bias Coefficient in MW/0.1 Hz (negative value)

Fa = Actual system frequency in Hz

Fs = Schedule system frequency in Hz (default 50 Hz)

Offset = Provision for compensating errors such as measurement error; default value zero.

7.3 The detailed methodology to be followed by Nodal Agency for calculation and monitoring of Area Control Error (ACE) is attached at **Annexure – 1**. The ACE shall be worked out for each state and region.

7.4 ACE is 'positive' means that the control area has surplus generation and the control area's internal generation has to be backed down. ACE is 'negative'

means the control area is in deficit and the control area's internal generation has to be increased. All the frequency control interventions shall be in the direction to drive ACE towards zero.

## 8.0 Estimation of Reserves

8.1 CERC vide its order dated 13th October, 2015 in the matter of Petition no. 11/SM/2015 envisaged loss of complete power station as a credible contingency for maintaining primary reserve. The most credible reference contingency for maintaining primary reserve, presently considered in the Indian power system, is the outage of the largest power plant or sudden load throw-off of 4500 MW.

8.2 The data for assessment of the reserves capacity requirement for SRAS and TRAS shall be furnished to the Nodal Agency by respective SLDCs pertaining to their state control areas as per following timelines.

8.2.1 Year Ahead Basis – For reserve estimation for the next financial year (FY+1), the data for the previous calendar year shall be furnished by 15th January of the current financial year (FY) **(Format – RAS1).**

***(Illustration: If the assessment is being carried out for FY 2022-23, the data for the period 1st Jan 2021 to 31st December 2021 has to be provided by 15th January, 2022)***

8.2.2 Quarter Ahead Basis – For reserve estimation of the next quarter (Q+1) , the data for the similar quarter (Q-3) of the previous year shall be furnished by 15th day of the first month of current quarter (Q)**(Format – RAS2)**

***(Illustration: If the assessment is being carried out for Q2 of FY 2022-23 i.e. 01st July – 30th September, 2022, the data for Q2 of FY 2021-22 i.e. 01st July – 30th September 2021 has to be provided by First Month of Q1 of FY 2022-23 i.e. 15th April, 2022)***

8.3 In case of non-availability of data from SLDCs as mentioned above, the data available at RLDCs/Nodal Agency shall be used to estimate the quantum of reserves requirement.

8.4 Week-ahead, Day-Ahead and Real-Time Basis – Nodal Agency would use the data available with RLDCs/Nodal Agency.

8.4.1 For weekly reserves requirement computation for the next week (W+1), data for the past four weeks (W-1, W-2, W-3, W-4) and same week (W+1) of the last year shall be used.

8.4.2 For the day ahead reserve estimation, last seven days data shall be used.

8.4.3 For real time reserve estimation, the estimated day ahead reserve requirement, availability of reserves on day ahead basis, real time system conditions, load/RE forecast, load generation balance, weather, contingencies, congestion and other related parameters shall be used.

**Secondary Reserves**

8.5 The estimation of secondary reserve capacity requirement, on regional basis and state basis, shall be carried out by Nodal Agency as per the following methodology:

8.5.1 The positive (Up Reserve) and negative (Down Reserve) secondary reserve capacity requirement on regional basis would be computed as 99 percentile of negative and positive ACE respectively of that region for year ahead, quarter ahead and week ahead.

8.52 The 99 percentile of the positive and negative ACE of each state control shall be computed and aggregated at regional level. This shall be scaled using 99 percentiles of the regional ACE to factor diversity at regional level. The scaled values of 99 percentile of the state ACE shall be used to arrive at the reserve requirement at Inter-state and Intra-state levels.

8.5.3 The drawl by the respective state and its internal-generation at the time of peak demand during the period under consideration shall be used for

apportionment of the reserve requirement. The intra state reserves shall be in proportion to the contribution of internal generation at the time peak demand. The Inter-state reserves shall be in proportion to the drawl from the grid at the time of peak demand.

8.5.4 The state level requirement shall be aggregated to arrive at the regional and all India reserve requirement.

8.6 The all-India total of positive (and negative) secondary reserves capacity requirement on regional basis shall be equal to the reference contingency or secondary reserve capacity requirement as computed above, whichever is higher. If the all-India reserve requirement is less than the reference contingency such additional reserves shall be considered in the regional requirement.

**Tertiary Reserves**

8.7 The estimated quantum of tertiary reserve requirement at regional level would be considered equal to the secondary reserve requirement at regional level as computed above.

8.8 The estimated quantum of tertiary reserve requirement at state level would be considered equal to the sum of secondary reserve requirement at state level and 50 % of the largest unit size in the respective state control area.

**Day-Ahead Assessment of Requirement of Reserves for SRAS and TRAS**

8.9 The Nodal Agency shall use the methodology outlined above for assessment of the reserve requirement for SRAS and TRAS on day-ahead.

**Real Time Assessment of Requirement of Reserves for SRAS and TRAS**

8.10 For real time reserve estimation, the estimated day ahead reserve requirement, availability of reserves on day ahead basis, real time system conditions, load/RE forecast, load generation balance, weather, contingencies, congestion, and other related parameters shall be used.

## 9.0 Information Dissemination

9.1 The requirement of SRAS and TRAS reserves on year ahead, quarterly and week-ahead basis would be displayed and updated on the Nodal Agency website.

9.2 The reference contingency shall be declared by Nodal Agency by 31st January before the start of each financial year **(Format – RAS3)**. The review of reference contingency may be done by the Nodal Agency, any time after the declaration, during the financial year. Accordingly, the figures of reference contingency would be revised and updated on the Nodal Agency website.

***(Illustration: The reference contingency for financial year 2023-24 would be declared by 31st January, 2023)***

9.3 The assessment of the reserves capacity requirement for SRAS and TRAS on Year Ahead Basis would be declared by Nodal Agency by 25th January of the current year **(Format – RAS4)**

***(Illustration: The reserve requirement for SRAS and TRAS in financial year 2023-24 would be declared by 25th January, 2023)***

9.4 The assessment of the reserves capacity requirement for SRAS and TRAS on Quarterly Basis would be declared by Nodal Agency by last day of the first month of the current quarter **(Format – RAS5)**

***(Illustration: The reserve requirement for SRAS and TRAS in quarter July – September, 2022 would be declared by 30th April, 2022)***

9.5 The assessment of the reserve capacity requirement for SRAS and TRAS for the succeeding week would be declared by Nodal Agency by Thursday of the preceding week **(Format – RAS6)**

***(Illustration: The reserve requirement for SRAS and TRAS in Week-10 of FY 2022-23 would be declared by Thursday of Week–9 of FY 2022-23)***

9.6 The summary of reserve requirement on year-ahead, quarter-ahead and week-ahead would be published on Nodal Agency website **(Format – RAS7).**

9.7 The status of data received by the nodal agency from various sources and static data such as peak demand of the state, internal generation, frequency bias etc. shall also be published on the nodal agency website.

## 10.0 Revision of the procedures

Notwithstanding anything contained in this Procedure, NLDC/RLDCs may take appropriate decisions in the interest of System Operation. Such decisions shall be taken under intimation to CERC and the procedure shall be modified/amended with the approval of the CERC, as necessary.

## Format – RAS1

**Data for Estimation of Year Ahead Reserves**

**Following Data is to be provided by each state control area**

1. Assessment of reserves for the FY: 01.04.yyyy to 31.03.yyyy
2. Name of the state:
3. Data for the calendar: 01.01.yyyy to 31.12.yyyy
4. Data furnished (please tick the data submitted):
    a. Actual interchange of the State (10 seconds resolution), (Number of samples = 365*24*60*6 = 3153600 nos.) in excel format
    b. Frequency Response Characteristics of the State for the events posted on NLDC website (https://posoco.in/frc/)
    c. Peak Demand met
    d. Intra-State Generation (other than ISGS) at the time of peak demand

| Actual interchange of the State (10 seconds resolution) for calendar: 01.01.yyyy to 31.12.yyyy | |
|---|---|
| Date & Time (DD-MMM-YY HH:MM:SS) | Actual interchange of the State (MW) |
| 01-jan-2021 00:00:10 | 452 |
| 01-jan-2021 00:00:20 | 456 |
| 01-jan-2021 00:00:30 | 461 |
| ….. | |
| ……. | |
| 31-Dec-2021 23:59:50 | 498 |

| Frequency Response Characteristics of the State for calendar: 01.01.yyyy to 31.12.yyyy | |
|---|---|
| Event Details | Frequency Response Characteristics (MW/Hz) |
| Events 1: | 800 |
| Event 2: | 815 |
| Event 3: | 756 |

| Peak Demand and Intra-State Generation of the State for calendar: 01.01.yyyy to 31.12.yyyy | | |
|---|---|---|
| State/UT | Peak Demand met (MW) | Intra-State Generation (other than ISGS) at the time of peak demand (MW) |
| …… | | |

## Format – RAS2

**Data for Estimation of Quarter Ahead Reserves**

**Following Data is to be provided by each state control area**

1. Assessment of reserves for the FY: 01.mm.yyyy to 31.mm.yyyy
2. Name of the state:
3. Data for the Quarter: 01.mm.yyyy to 31.mm.yyyy
4. Data furnished (please tick the data submitted):
    a. Actual interchange of the State (10 seconds resolution), (Number of samples = 120*24*60*6 = 1036800 nos.) in excel format
    b. Frequency Response Characteristics of the State for the events posted on NLDC website (https://posoco.in/frc/)
    c. Peak Demand met
    d. Intra-State Generation (other than ISGS) at the time of peak demand

| Actual interchange of the State (10 seconds resolution) for the Quarter: 01.mm.yyyy to 31.mm.yyyy | |
|---|---|
| Date & Time (DD-MMM-YY HH:MM:SS) | Actual interchange of the State (MW) |
| 01-Apr-2021 00:00:10 | 452 |
| 01-Apr-2021 00:00:20 | 456 |
| 01-Apr-2021 00:00:30 | 461 |
| ….. | |
| ……. | |
| 31-June-2021 23:59:50 | 498 |

| Frequency Response Characteristics of the State for the Quarter: 01.mm.yyyy to 31.mm.yyyy | |
|---|---|
| Event Details | Frequency Response Characteristics (MW/Hz) |
| Events 1: | 800 |
| Event 2: | 815 |
| Event 3: | 756 |

| Peak Demand and Intra-State Generation of the State for Quarter: 01.mm.yyyy to 31.mm.yyyy | | |
|---|---|---|
| State/UT | Peak Demand met (MW) | Intra-State Generation (other than ISGS) at the time of peak demand (MW) |
| …… | | |

**Format – RAS3**

## Reference contingency for Indian Power System

| Date: 31 January 2023 | Revision No. | |
|---|---|---|
| | | |
| **Applicable for FY 2023-24** | | |
| | | |
| **Reference Contingency for generation loss (MW)** | **4500** | |
| | | |
| **Reference Contingency for load loss (MW)** | **4500** | |

## Format RAS4

| SRAS and TRAS Reserve requirement for year 2022-23 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| State/UT | Actual 99 Percentile Negative ACE (MW) | Actual 99 Percentile Positive ACE (MW) | Scaled 99 Percentile Negative ACE (MW) (a) | Scaled 99 Percentile Positive ACE (MW) (b) | Max. Demand met (c) | Internal Gen. at the time of max demand (d) | Drawl from ISTS (e=c-d) | State Internal Generation/ State Maximum Demand (f=d/c) | State drawl from ISTS/ State Maximum Demand (g=e/c) | Secondary Reserves in ISGS (h=a*g) | Secondary Reserves at Regional Level (sum of reserves in all states of the region as given in "h") | Secondary Reserves within state (i=a*f) | Tertiary Reserves in ISGS (j = h) | Tertiary Reserves within state (k = i) | Largest Unit Size of internal generation (l) | Total Tertiary Reserves within state (m=k + 0.5*l) |
| Punjab | 307 | 505 | 125 | 310 | 13431 | 6014 | 7417 | 0.45 | 0.55 | 69 | | 56 | 69 | 56 | 700 | 406 |
| Haryana | 411 | 443 | 167 | 272 | 12120 | 2953 | 9167 | 0.24 | 0.76 | 126 | | 41 | 126 | 41 | 660 | 371 |
| Rajasthan | 730 | 735 | 296 | 451 | 15696 | 9701 | 5995 | 0.62 | 0.38 | 113 | | 183 | 113 | 183 | 660 | 513 |
| Delhi | 156 | 273 | 63 | 168 | 7305 | 645 | 6660 | 0.09 | 0.91 | 58 | | 6 | 58 | 6 | 216 | 114 |
| Uttar Pradesh | 658 | 847 | 267 | 520 | 24795 | 12302 | 12493 | 0.50 | 0.50 | 135 | 725 | 133 | 135 | 133 | 660 | 463 |
| Uttarakhand | 200 | 198 | 81 | 122 | 2318 | 812 | 1506 | 0.35 | 0.65 | 53 | | 28 | 53 | 28 | 76 | 66 |
| UT Chandigarh | 45 | 76 | 18 | 47 | 426 | 0 | 426 | 0.00 | 1.00 | 18 | | 0 | 18 | 0 | 0 | 0 |
| Himachal Pradesh | 165 | 173 | 67 | 106 | 1955 | 675 | 1280 | 0.35 | 0.65 | 44 | | 23 | 44 | 23 | 100 | 73 |
| UT Jammu & Kashmir | 296 | 260 | 120 | 160 | 2743 | 240 | 2503 | 0.09 | 0.91 | 110 | | 11 | 110 | 11 | 150 | 86 |
| **NR state Sum** | 2968 | 3510 | 1205 | 2154 | | | | | | | | | | | | 2091 |
| **Northern Region** | 1205 | 2154 | | | | | | | | | | | | | | |
| West Bengal | 319 | 336 | 237 | 201 | 9316 | 6800 | 2516 | 0.73 | 0.27 | 64 | | 173 | 64 | 173 | 500 | 423 |
| Bihar | 364 | 381 | 270 | 228 | 6868 | 400 | 6468 | 0.06 | 0.94 | 255 | | 16 | 255 | 16 | 250 | 141 |
| Odisha | 281 | 336 | 209 | 201 | 6008 | 3903 | 2105 | 0.65 | 0.35 | 73 | 398 | 136 | 73 | 136 | 600 | 436 |
| Jharkhand | 154 | 164 | 114 | 98 | 1718 | 394 | 1324 | 0.23 | 0.77 | 88 | | 26 | 88 | 26 | 210 | 131 |
| DVC | 272 | 273 | 202 | 163 | 3487 | 5638 | -2151 | 1.62 | -0.62 | -125 | | 327 | -125 | 327 | 600 | 627 |
| Sikkim | 57 | 48 | 42 | 29 | 132 | 0 | 132 | 0.00 | 1.00 | 42 | | 0 | 42 | 0 | 0 | 0 |
| **ER state Sum** | 1447 | 1538 | 1075 | 921 | | | | | | | | | | | | 1757 |
| **Eastern Region** | 1075 | 921 | | | | | | | | | | | | | | |
| Maharashtra | 547 | 625 | 424 | 404 | 25644 | 16595 | 9049 | 0.65 | 0.35 | 149 | | 274 | 149 | 274 | 660 | 604 |
| Gujarat | 657 | 594 | 509 | 384 | 19431 | 10416 | 9015 | 0.54 | 0.46 | 236 | | 273 | 236 | 273 | 800 | 673 |
| Madhya Pradesh | 488 | 607 | 378 | 392 | 15917 | 5991 | 9926 | 0.38 | 0.62 | 236 | | 142 | 236 | 142 | 660 | 472 |
| Chhattisgarh | 232 | 232 | 180 | 150 | 4870 | 2172 | 2698 | 0.45 | 0.55 | 100 | 829 | 80 | 100 | 80 | 500 | 330 |
| UT Dadra Nagar Haveli | 56 | 33 | 43 | 21 | 888 | 0 | 888 | 0.00 | 1.00 | 43 | | 0 | 43 | 0 | 0 | 0 |
| UT Daman Diu | 39 | 22 | 30 | 14 | 369 | 0 | 369 | 0.00 | 1.00 | 30 | | 0 | 30 | 0 | 0 | 0 |
| Goa | 45 | 41 | 35 | 26 | 698 | 0 | 698 | 0.00 | 1.00 | 35 | | 0 | 35 | 0 | 0 | 0 |
| **WR States Sum** | 2064 | 2154 | 1598 | 1392 | | | | | | | | | | | | 2079 |
| **Western Region** | 1598 | 1392 | | | | | | | | | | | | | | |
| Andhra Pradesh | 571 | 442 | 302 | 265 | 11472 | 5319 | 6153 | 0.46 | 0.54 | 162 | | 140 | 162 | 140 | 800 | 540 |
| Tamil Nadu | 609 | 641 | 322 | 384 | 16846 | 7624 | 9222 | 0.45 | 0.55 | 176 | | 146 | 176 | 146 | 600 | 446 |
| Karnataka | 587 | 535 | 311 | 320 | 14367 | 9354 | 5013 | 0.65 | 0.35 | 108 | | 202 | 108 | 202 | 800 | 602 |
| Kerala | 183 | 191 | 97 | 114 | 4284 | 1519 | 2765 | 0.35 | 0.65 | 62 | 620 | 34 | 62 | 34 | 130 | 99 |
| UT Puducherry | 35 | 60 | 19 | 36 | 452 | 0 | 452 | 0.00 | 1.00 | 19 | | 0 | 19 | 0 | 0 | 0 |
| Telangana | 391 | 418 | 207 | 250 | 13688 | 7561 | 6127 | 0.55 | 0.45 | 93 | | 114 | 93 | 114 | 800 | 514 |
| **SR State Sum** | 2376 | 2287 | 1257 | 1369 | | | | | | | | | | | | 2202 |
| **Southern Region** | 1257 | 1369 | | | | | | | | | | | | | | |
| Assam | 111 | 111 | 72 | 87 | 2132 | 340 | 1792 | 0.16 | 0.84 | 60 | | 11 | 60 | 11 | 50 | 36 |
| Meghalaya | 41 | 39 | 27 | 31 | 391 | 114 | 277 | 0.29 | 0.71 | 19 | | 8 | 19 | 8 | 42 | 29 |
| Tripura | 59 | 60 | 38 | 47 | 327 | 172 | 155 | 0.53 | 0.47 | 18 | | 20 | 18 | 20 | 21 | 31 |
| Manipur | 25 | 26 | 16 | 20 | 244 | 0 | 244 | 0.00 | 1.00 | 16 | 154 | 0 | 16 | 0 | 0 | 0 |
| Mizoram | 16 | 23 | 10 | 18 | 144 | 54 | 90 | 0.38 | 0.63 | 6 | | 4 | 6 | 4 | 6 | 7 |
| Nagaland | 20 | 30 | 13 | 24 | 153 | 14 | 139 | 0.09 | 0.91 | 12 | | 1 | 12 | 1 | 8 | 5 |
| Arunachal Pradesh | 34 | 42 | 22 | 33 | 162 | 0 | 162 | 0.00 | 1.00 | 22 | | 0 | 22 | 0 | 0 | 0 |
| NER State Sum | 306 | 331 | 198 | 260 | | | | | | | | | | | | 108 |
| **North-Eastern Region** | 198 | 260 | | | | | | | | | | | | | | |
| All India | 5333 | 6096 | 5333 | 6096 | | | | | | | | | 2726 | | | 8237 |
| | | | | | | | | | | Total Tertiary Reserves Requirement in India | 10963 | | | | | |

***Please Note: Based on Actual Data for Illustration Purpose only***

## Format RAS5

| SRAS and TRAS Reserve requirement for Quarter 1 of year 2022-23 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| State/UT | Actual 99 Percentile Negative ACE (MW) | Actual 99 Percentile Positive ACE (MW) | Scaled 99 Percentile Negative ACE (MW) (a) | Scaled 99 Percentile Positive ACE (MW) (b) | Max. Demand met (c) | Internal Gen. at the time of max demand (d) | Drawl from ISTS (e=c-d) | State Internal Generation/ State Maximum Demand (f=d/c) | State drawl from ISTS/ State Maximum Demand (g=e/c) | Secondary Reserves in ISGS (h=a*g) | Secondary Reserves at Regional Level (sum of reserves in all states of the region as given in "h") | Secondary Reserves within state (i=a*f) | Tertiary Reserves in ISGS (j = h) | Tertiary Reserves within state (k = i) | Largest Unit Size of internal generation (l) | Total Tertiary Reserves within state (m=k + 0.5*l) |
| Punjab | 326 | 600 | 86 | 356 | 24494 | 22319 | 2175 | 0.91 | 0.09 | 8 | | 78 | 8 | 78 | 700 | 428 |
| Haryana | 458 | 629 | 120 | 373 | 11484 | 2943 | 8541 | 0.26 | 0.74 | 90 | | 31 | 90 | 31 | 660 | 361 |
| Rajasthan | 761 | 856 | 200 | 508 | 13061 | 7497 | 5564 | 0.57 | 0.43 | 85 | | 115 | 85 | 115 | 660 | 445 |
| Delhi | 156 | 292 | 41 | 173 | 6943 | 641 | 6302 | 0.09 | 0.91 | 37 | | 4 | 37 | 4 | 216 | 112 |
| Uttar Pradesh | 761 | 1062 | 200 | 630 | 27587 | 21518 | 6069 | 0.78 | 0.22 | 44 | 406 | 156 | 44 | 156 | 660 | 486 |
| Uttarakhand | 197 | 250 | 52 | 148 | 2169 | 829 | 1340 | 0.38 | 0.62 | 32 | | 20 | 32 | 20 | 76 | 58 |
| UT Chandigarh | 39 | 60 | 10 | 36 | 381 | 0 | 381 | 0.00 | 1.00 | 10 | | 0 | 10 | 0 | 0 | 0 |
| Himachal Pradesh | 163 | 174 | 43 | 103 | 1644 | 587 | 1057 | 0.36 | 0.64 | 28 | | 15 | 28 | 15 | 100 | 65 |
| UT Jammu & Kashmir | 329 | 305 | 86 | 181 | 2626 | 428 | 2198 | 0.16 | 0.84 | 72 | | 14 | 72 | 14 | 150 | 89 |
| **NR state Sum** | 3190 | 4228 | 838 | 2509 | | | | | | | | | | | | 2044 |
| **Northern Region** | 838 | 2509 | | | | | | | | | | | | | | |
| West Bengal | 365 | 423 | 326 | 221 | 9068 | 6569 | 2499 | 0.72 | 0.28 | 90 | | 236 | 90 | 236 | 500 | 486 |
| Bihar | 426 | 472 | 380 | 246 | 6045 | 387 | 5658 | 0.06 | 0.94 | 356 | | 24 | 356 | 24 | 250 | 149 |
| Odisha | 284 | 369 | 254 | 192 | 5771 | 3367 | 2404 | 0.58 | 0.42 | 106 | 589 | 148 | 106 | 148 | 600 | 448 |
| Jharkhand | 172 | 197 | 153 | 103 | 1636 | 217 | 1419 | 0.13 | 0.87 | 133 | | 20 | 133 | 20 | 210 | 125 |
| DVC | 256 | 286 | 228 | 149 | 3421 | 5603 | -2182 | 1.64 | -0.64 | -146 | | 374 | -146 | 374 | 600 | 674 |
| Sikkim | 56 | 60 | 50 | 31 | 96 | 0 | 96 | 0.00 | 1.00 | 50 | | 0 | 50 | 0 | 0 | 0 |
| **ER state Sum** | 1558 | 1807 | 1391 | 943 | | | | | | | | | | | | 1883 |
| **Eastern Region** | 1391 | 943 | | | | | | | | | | | | | | |
| Maharashtra | 594 | 580 | 591 | 440 | 26053 | 17340 | 8713 | 0.67 | 0.33 | 198 | | 394 | 198 | 394 | 660 | 724 |
| Gujarat | 660 | 627 | 656 | 476 | 19265 | 13356 | 5909 | 0.69 | 0.31 | 201 | | 455 | 201 | 455 | 800 | 855 |
| Madhya Pradesh | 433 | 659 | 431 | 500 | 11219 | 5790 | 5429 | 0.52 | 0.48 | 209 | | 223 | 209 | 223 | 660 | 553 |
| Chhattisgarh | 228 | 261 | 227 | 198 | 4820 | 2324 | 2496 | 0.48 | 0.52 | 117 | 853 | 109 | 117 | 109 | 500 | 359 |
| UT Dadra Nagar Haveli | 53 | 34 | 53 | 26 | 860 | 0 | 860 | 0.00 | 1.00 | 53 | | 0 | 53 | 0 | 0 | 0 |
| UT Daman Diu | 30 | 23 | 30 | 17 | 344 | 0 | 344 | 0.00 | 1.00 | 30 | | 0 | 30 | 0 | 0 | 0 |
| Goa | 46 | 48 | 46 | 36 | 606 | 0 | 606 | 0.00 | 1.00 | 46 | | 0 | 46 | 0 | 0 | 0 |
| **WR States Sum** | 2044 | 2232 | 2034 | 1695 | | | | | | | | | | | | 2491 |
| **Western Region** | 2034 | 1695 | | | | | | | | | | | | | | |
| Andhra Pradesh | 697 | 524 | 418 | 355 | 11573 | 5416 | 6157 | 0.47 | 0.53 | 223 | | 196 | 223 | 196 | 800 | 596 |
| Tamil Nadu | 594 | 636 | 357 | 431 | 17248 | 8017 | 9231 | 0.46 | 0.54 | 191 | | 166 | 191 | 166 | 600 | 466 |
| Karnataka | 587 | 488 | 352 | 330 | 14194 | 8712 | 5482 | 0.61 | 0.39 | 136 | 771 | 216 | 136 | 216 | 800 | 616 |
| Kerala | 180 | 178 | 108 | 120 | 4380 | 1664 | 2716 | 0.38 | 0.62 | 67 | | 41 | 67 | 41 | 130 | 106 |
| UT Puducherry | 33 | 56 | 20 | 38 | 457 | 0 | 457 | 0.00 | 1.00 | 20 | | 0 | 20 | 0 | 0 | 0 |
| Telangana | 416 | 428 | 250 | 290 | 13559 | 6227 | 7332 | 0.46 | 0.54 | 135 | | 115 | 135 | 115 | 800 | 515 |
| **SR State Sum** | 2507 | 2309 | 1504 | 1565 | | | | | | | | | | | | 2298 |
| **Southern Region** | 1504 | 1565 | | | | | | | | | | | | | | |
| Assam | 127 | 122 | 104 | 96 | 1974 | 330 | 1644 | 0.17 | 0.83 | 87 | | 17 | 87 | 17 | 50 | 42 |
| Meghalaya | 42 | 42 | 34 | 33 | 354 | 0 | 354 | 0.00 | 1.00 | 34 | | 0 | 34 | 0 | 42 | 21 |
| Tripura | 78 | 60 | 64 | 47 | 336 | 176 | 160 | 0.52 | 0.48 | 31 | | 34 | 31 | 34 | 21 | 44 |
| Manipur | 24 | 23 | 19 | 18 | 226 | 0 | 226 | 0.00 | 1.00 | 19 | 227 | 0 | 19 | 0 | 0 | 0 |
| Mizoram | 16 | 19 | 13 | 15 | 130 | 0 | 130 | 0.00 | 1.00 | 13 | | 0 | 13 | 0 | 6 | 3 |
| Nagaland | 18 | 21 | 15 | 17 | 149 | 0 | 149 | 0.00 | 1.00 | 15 | | 0 | 15 | 0 | 8 | 4 |
| Arunachal Pradesh | 35 | 51 | 28 | 40 | 145 | 0 | 145 | 0.00 | 1.00 | 28 | | 0 | 28 | 0 | 0 | 0 |
| NER State Sum | 340 | 337 | 278 | 266 | | | | | | | | | | | | 115 |
| **North-Eastern Region** | 278 | 266 | | | | | | | | | | | | | | |
| All India | 6046 | 6977 | 6046 | 6977 | | | | | | | | | 2846 | | | 8830 |
| | | | | | | | | | | Total Tertiary Reserves Requirement in India | | | 11676 | | | |

***Please Note: Based on Actual Data for Illustration Purpose only***

## Format RAS6

| Week-Ahead SRAS and TRAS Reserve requirement for Week 04 April to 10 April 2022 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| State/UT | Actual 99 Percentile Negative ACE (MW) | Actual 99 Percentile Positive ACE (MW) | Scaled 99 Percentile Negative ACE (MW) (a) | Scaled 99 Percentile Positive ACE (MW) (b) | Max. Demand met (c) | Internal Gen. at the time of max demand (d) | Drawl from ISTS (e=c-d) | State Internal Generation/ State Maximum Demand (f=d/c) | State drawl from ISTS/ State Maximum Demand (g=e/c) | Secondary Reserves in ISGS (h=a*g) | Secondary Reserves at Regional Level (sum of reserves in all states of the region as given in "h") | Secondary Reserves within state (i=a*f) | Tertiary Reserves in ISGS (j = h) | Tertiary Reserves within state (k = i) | Largest Unit Size of internal generation (l) | Total Tertiary Reserves within state (m=k + 0.5*l) |
| Punjab | 287 | 383 | 94 | 219 | 8631 | 4460 | 4171 | 0.52 | 0.48 | 46 | | 49 | 46 | 49 | 700 | 399 |
| Haryana | 434 | 360 | 143 | 206 | 7825 | 2294 | 5531 | 0.29 | 0.71 | 101 | | 42 | 101 | 42 | 660 | 372 |
| Rajasthan | 641 | 734 | 210 | 420 | 15992 | 9411 | 6581 | 0.59 | 0.41 | 87 | | 124 | 87 | 124 | 660 | 454 |
| Delhi | 159 | 227 | 52 | 130 | 4097 | 535 | 3562 | 0.13 | 0.87 | 45 | | 7 | 45 | 7 | 216 | 115 |
| Uttar Pradesh | 644 | 806 | 211 | 462 | 20843 | 8955 | 11888 | 0.43 | 0.57 | 121 | 591 | 91 | 121 | 91 | 660 | 421 |
| Uttarakhand | 205 | 210 | 67 | 120 | 2152 | 770 | 1382 | 0.36 | 0.64 | 43 | | 24 | 43 | 24 | 76 | 62 |
| UT Chandigarh | 27 | 92 | 9 | 53 | 215 | 0 | 215 | 0.00 | 1.00 | 9 | | 0 | 9 | 0 | 0 | 0 |
| Himachal Pradesh | 159 | 158 | 52 | 91 | 1890 | 593 | 1297 | 0.31 | 0.69 | 36 | | 16 | 36 | 16 | 100 | 66 |
| UT Jammu & Kashmir | 346 | 268 | 114 | 154 | 3004 | 228 | 2776 | 0.08 | 0.92 | 105 | | 9 | 105 | 9 | 150 | 84 |
| **NR state Sum** | 2901 | 3239 | 952 | 1856 | | | | | | | | | | | | 1972 |
| **Northern Region** | 952 | 1856 | | | | | | | | | | | | | | |
| West Bengal | 272 | 329 | 209 | 280 | 8586 | 6775 | 1811 | 0.79 | 0.21 | 44 | | 165 | 44 | 165 | 500 | 415 |
| Bihar | 285 | 297 | 219 | 252 | 5769 | 319 | 5450 | 0.06 | 0.94 | 206 | | 12 | 206 | 12 | 250 | 137 |
| Odisha | 271 | 335 | 208 | 284 | 5597 | 3260 | 2337 | 0.58 | 0.42 | 87 | 364 | 121 | 87 | 121 | 600 | 421 |
| Jharkhand | 158 | 134 | 121 | 114 | 1583 | 409 | 1174 | 0.26 | 0.74 | 90 | | 31 | 90 | 31 | 210 | 136 |
| DVC | 224 | 241 | 172 | 204 | 3563 | 5295 | -1732 | 1.49 | -0.49 | -84 | | 255 | -84 | 255 | 600 | 555 |
| Sikkim | 26 | 47 | 20 | 40 | 120 | 0 | 120 | 0.00 | 1.00 | 20 | | 0 | 20 | 0 | 0 | 0 |
| **ER state Sum** | 1235 | 1383 | 948 | 1175 | | | | | | | | | | | | 1665 |
| **Eastern Region** | 948 | 1175 | | | | | | | | | | | | | | |
| Maharashtra | 696 | 546 | 454 | 281 | 33111 | 24101 | 9010 | 0.73 | 0.27 | 123 | | 330 | 123 | 330 | 660 | 660 |
| Gujarat | 654 | 649 | 426 | 334 | 18900 | 9450 | 9450 | 0.50 | 0.50 | 213 | | 213 | 213 | 213 | 800 | 613 |
| Madhya Pradesh | 487 | 619 | 318 | 319 | 15102 | 4487 | 10615 | 0.30 | 0.70 | 223 | | 94 | 223 | 94 | 660 | 424 |
| Chhattisgarh | 215 | 208 | 140 | 107 | 5132 | 2392 | 2740 | 0.47 | 0.53 | 75 | 791 | 65 | 75 | 65 | 500 | 315 |
| UT Dadra Nagar Haveli | 80 | 35 | 52 | 18 | 910 | 0 | 910 | 0.00 | 1.00 | 52 | | 0 | 52 | 0 | 0 | 0 |
| UT Daman Diu | 66 | 28 | 43 | 14 | 364 | 0 | 364 | 0.00 | 1.00 | 43 | | 0 | 43 | 0 | 0 | 0 |
| Goa | 95 | 47 | 62 | 24 | 596 | 0 | 596 | 0.00 | 1.00 | 62 | | 0 | 62 | 0 | 0 | 0 |
| **WR States Sum** | 2293 | 2132 | 1494 | 1097 | | | | | | | | | | | | 2013 |
| **Western Region** | 1494 | 1097 | | | | | | | | | | | | | | |
| Andhra Pradesh | 588 | 380 | 446 | 225 | 12028 | 5875 | 6153 | 0.49 | 0.51 | 228 | | 218 | 228 | 218 | 800 | 618 |
| Tamil Nadu | 615 | 636 | 467 | 377 | 16766 | 6769 | 9997 | 0.40 | 0.60 | 278 | | 189 | 278 | 189 | 600 | 489 |
| Karnataka | 681 | 472 | 517 | 280 | 14859 | 9137 | 5722 | 0.61 | 0.39 | 199 | 993 | 318 | 199 | 318 | 800 | 718 |
| Kerala | 167 | 173 | 126 | 103 | 4405 | 1625 | 2780 | 0.37 | 0.63 | 80 | | 47 | 80 | 47 | 130 | 112 |
| UT Puducherry | 31 | 57 | 24 | 34 | 440 | 0 | 440 | 0.00 | 1.00 | 24 | | 0 | 24 | 0 | 0 | 0 |
| Telangana | 491 | 451 | 373 | 267 | 13882 | 7055 | 6827 | 0.51 | 0.49 | 183 | | 189 | 183 | 189 | 800 | 589 |
| **SR State Sum** | 2573 | 2169 | 1953 | 1285 | | | | | | | | | | | | 2525 |
| **Southern Region** | 1953 | 1285 | | | | | | | | | | | | | | |
| Assam | 103 | 100 | 64 | 102 | 1847 | 213 | 1634 | 0.12 | 0.88 | 56 | | 7 | 56 | 7 | 50 | 32 |
| Meghalaya | 44 | 34 | 27 | 34 | 372 | 86 | 286 | 0.23 | 0.77 | 21 | | 6 | 21 | 6 | 42 | 27 |
| Tripura | 61 | 54 | 38 | 54 | 292 | 150 | 142 | 0.51 | 0.49 | 18 | | 19 | 18 | 19 | 21 | 30 |
| Manipur | 21 | 25 | 13 | 25 | 225 | 0 | 225 | 0.00 | 1.00 | 13 | 147 | 0 | 13 | 0 | 0 | 0 |
| Mizoram | 14 | 21 | 9 | 21 | 124 | 0 | 124 | 0.00 | 1.00 | 9 | | 0 | 9 | 0 | 6 | 3 |
| Nagaland | 18 | 22 | 11 | 22 | 164 | 0 | 164 | 0.00 | 1.00 | 11 | | 0 | 11 | 0 | 8 | 4 |
| Arunachal Pradesh | 30 | 50 | 19 | 51 | 192 | 0 | 192 | 0.00 | 1.00 | 19 | | 0 | 19 | 0 | 0 | 0 |
| NER State Sum | 292 | 306 | 180 | 309 | | | | | | | | | | | | 97 |
| **North-Eastern Region** | 180 | 309 | | | | | | | | | | | | | | |
| All India | 5527 | 5722 | 5527 | 5722 | | | | | | | | | 2885 | | | 8271 |
| | | | | | | | | | | | Total Tertiary Reserves Requirement in India | | 11157 | | | |

***Please Note: Based on Actual Data for Illustration Purpose only***

**Format RAS7**

# Summary of Reserve Requirement

| | Year-Ahead | | | | | | Quarter-Ahead | | | | | | Week-Ahead | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Secondary Reserves | | | Tertiary Reserves | | | Secondary Reserves | | | Tertiary Reserves | | | Secondary Reserves | | | Tertiary Reserves | | |
| State/UT | Within ISGS | Within state | Total | Within ISGS | Within state | Total | Within ISGS | Within state | Total | Within ISGS | Within state | Total | Within ISGS | Within state | Total | Within ISGS | Within state | Total |
| Punjab | 69 | 56 | 125 | 69 | 406 | 475 | 8 | 78 | 86 | 8 | 428 | 436 | 46 | 49 | 94 | 46 | 399 | 444 |
| Haryana | 126 | 41 | 167 | 126 | 371 | 497 | 90 | 31 | 120 | 90 | 361 | 450 | 101 | 42 | 143 | 101 | 372 | 473 |
| Rajasthan | 113 | 183 | 296 | 113 | 513 | 626 | 85 | 115 | 200 | 85 | 445 | 530 | 87 | 124 | 210 | 87 | 454 | 540 |
| Delhi | 58 | 6 | 63 | 58 | 114 | 171 | 37 | 4 | 41 | 37 | 112 | 149 | 45 | 7 | 52 | 45 | 115 | 160 |
| Uttar Pradesh | 135 | 133 | 267 | 135 | 463 | 597 | 44 | 156 | 200 | 44 | 486 | 530 | 121 | 91 | 211 | 121 | 421 | 541 |
| Uttarakhand | 53 | 28 | 81 | 53 | 66 | 119 | 32 | 20 | 52 | 32 | 58 | 90 | 43 | 24 | 67 | 43 | 62 | 105 |
| UT Chandigarh | 18 | 0 | 18 | 18 | 0 | 18 | 10 | 0 | 10 | 10 | 0 | 10 | 9 | 0 | 9 | 9 | 0 | 9 |
| Himachal Pradesh | 44 | 23 | 67 | 44 | 73 | 117 | 28 | 15 | 43 | 28 | 65 | 93 | 36 | 16 | 52 | 36 | 66 | 102 |
| UT Jammu & Kashmir | 110 | 11 | 120 | 110 | 86 | 195 | 72 | 14 | 86 | 72 | 89 | 161 | 105 | 9 | 114 | 105 | 84 | 189 |
| West Bengal | 64 | 173 | 237 | 64 | 423 | 487 | 90 | 236 | 326 | 90 | 486 | 576 | 44 | 165 | 209 | 44 | 415 | 459 |
| Bihar | 255 | 16 | 270 | 255 | 141 | 395 | 356 | 24 | 380 | 356 | 149 | 505 | 206 | 12 | 219 | 206 | 137 | 344 |
| Odisha | 73 | 136 | 209 | 73 | 436 | 509 | 106 | 148 | 254 | 106 | 448 | 554 | 87 | 121 | 208 | 87 | 421 | 508 |
| Jharkhand | 88 | 26 | 114 | 88 | 131 | 219 | 133 | 20 | 153 | 133 | 125 | 258 | 90 | 31 | 121 | 90 | 136 | 226 |
| DVC | -125 | 327 | 202 | -125 | 627 | 502 | -146 | 374 | 228 | -146 | 674 | 528 | -84 | 255 | 172 | -84 | 555 | 472 |
| Sikkim | 42 | 0 | 42 | 42 | 0 | 42 | 50 | 0 | 50 | 50 | 0 | 50 | 20 | 0 | 20 | 20 | 0 | 20 |
| Maharashtra | 149 | 274 | 424 | 149 | 604 | 754 | 198 | 394 | 591 | 198 | 724 | 921 | 123 | 330 | 454 | 123 | 660 | 784 |
| Gujarat | 236 | 273 | 509 | 236 | 673 | 909 | 201 | 455 | 656 | 201 | 855 | 1056 | 213 | 213 | 426 | 213 | 613 | 826 |
| Madhya Pradesh | 236 | 142 | 378 | 236 | 472 | 708 | 209 | 223 | 431 | 209 | 553 | 761 | 223 | 94 | 318 | 223 | 424 | 648 |
| Chhattisgarh | 100 | 80 | 180 | 100 | 330 | 430 | 117 | 109 | 227 | 117 | 359 | 477 | 75 | 65 | 140 | 75 | 315 | 390 |
| UT Dadra Nagar Haveli | 43 | 0 | 43 | 43 | 0 | 43 | 53 | 0 | 53 | 53 | 0 | 53 | 52 | 0 | 52 | 52 | 0 | 52 |
| UT Daman Diu | 30 | 0 | 30 | 30 | 0 | 30 | 30 | 0 | 30 | 30 | 0 | 30 | 43 | 0 | 43 | 43 | 0 | 43 |
| Goa | 35 | 0 | 35 | 35 | 0 | 35 | 46 | 0 | 46 | 46 | 0 | 46 | 62 | 0 | 62 | 62 | 0 | 62 |
| Andhra Pradesh | 162 | 140 | 302 | 162 | 540 | 702 | 223 | 196 | 418 | 223 | 596 | 818 | 228 | 218 | 446 | 228 | 618 | 846 |
| Tamil Nadu | 176 | 146 | 322 | 176 | 446 | 622 | 191 | 166 | 357 | 191 | 466 | 657 | 278 | 189 | 467 | 278 | 489 | 767 |
| Karnataka | 108 | 202 | 311 | 108 | 602 | 711 | 136 | 216 | 352 | 136 | 616 | 752 | 199 | 318 | 517 | 199 | 718 | 917 |
| Kerala | 62 | 34 | 97 | 62 | 99 | 162 | 67 | 41 | 108 | 67 | 106 | 173 | 80 | 47 | 126 | 80 | 112 | 191 |
| UT Puducherry | 19 | 0 | 19 | 19 | 0 | 19 | 20 | 0 | 20 | 20 | 0 | 20 | 24 | 0 | 24 | 24 | 0 | 24 |
| Telangana | 93 | 114 | 207 | 93 | 514 | 607 | 135 | 115 | 250 | 135 | 515 | 650 | 183 | 189 | 373 | 183 | 589 | 773 |
| Assam | 60 | 11 | 72 | 60 | 36 | 97 | 87 | 17 | 104 | 87 | 42 | 129 | 56 | 7 | 64 | 56 | 32 | 89 |
| Meghalaya | 19 | 8 | 27 | 19 | 29 | 48 | 34 | 0 | 34 | 34 | 21 | 55 | 21 | 6 | 27 | 21 | 27 | 48 |
| Tripura | 18 | 20 | 38 | 18 | 31 | 49 | 31 | 34 | 64 | 31 | 44 | 75 | 18 | 19 | 38 | 18 | 30 | 48 |
| Manipur | 16 | 0 | 16 | 16 | 0 | 16 | 19 | 0 | 19 | 19 | 0 | 19 | 13 | 0 | 13 | 13 | 0 | 13 |
| Mizoram | 6 | 4 | 10 | 6 | 7 | 13 | 13 | 0 | 13 | 13 | 3 | 16 | 9 | 0 | 9 | 9 | 3 | 12 |
| Nagaland | 12 | 1 | 13 | 12 | 5 | 17 | 15 | 0 | 15 | 15 | 4 | 19 | 11 | 0 | 11 | 11 | 4 | 15 |
| Arunachal Pradesh | 22 | 0 | 22 | 22 | 0 | 22 | 28 | 0 | 28 | 28 | 0 | 28 | 19 | 0 | 19 | 19 | 0 | 19 |
| **Region-wise and All-India** | | | | | | | | | | | | | | | | | | |
| **Northern Region** | 725 | 480 | 1205 | 725 | 2091 | 2816 | 406 | 433 | 838 | 406 | 2044 | 2449 | 591 | 361 | 952 | 591 | 1972 | 2563 |
| **Western Region** | 829 | 769 | 1598 | 829 | 2079 | 2908 | 853 | 1181 | 2034 | 853 | 2491 | 3344 | 791 | 703 | 1494 | 791 | 2013 | 2804 |
| **Southern Region** | 620 | 637 | 1257 | 620 | 2202 | 2822 | 771 | 733 | 1504 | 771 | 2298 | 3069 | 993 | 960 | 1953 | 993 | 2525 | 3518 |
| **Eastern Region** | 398 | 677 | 1075 | 398 | 1757 | 2155 | 589 | 803 | 1391 | 589 | 1883 | 2471 | 364 | 585 | 948 | 364 | 1665 | 2028 |
| **North-Eastern Region** | 154 | 44 | 198 | 154 | 108 | 262 | 227 | 51 | 278 | 227 | 115 | 342 | 147 | 33 | 180 | 147 | 97 | 243 |
| All India | 2726 | 2607 | 5333 | 2726 | 8237 | 10963 | 2846 | 3200 | 6046 | 2846 | 8830 | 11676 | 2885 | 2642 | 5527 | 2885 | 8271 | 11157 |

***Please Note: Based on Actual Data for Illustration Purpose only***

**Annexure I**

National Load Despatch Centre
Power System Operation Corporation Limited

# Guideline for Calculation and Monitoring of Area Control Error

This document provides the detailed guidelines to be uniformly adopted by the NLDC, RLDCs, SLDCs, and REMCs for measurement, calculation, monitoring, and archival of Frequency, Tie-Line Flows, Frequency Bias, Metering Errors, and Area Control Error (ACE). ACE is an important parameter which depicts the health of the power system. This document enables uniform notation for ACE, thereby allowing all the load despatch control rooms pan India to pass on information about this grid security aspect with one another.

**Table of the Contents**

## 1. Formula of Area Control Error (ACE)

The Area Control Error (ACE) for each control area[1] would be calculated at all the load despatch centres based on telemetered values and external inputs as per the below formula[2].

**ACE = (Ia - Is) - 10 * Bf * (Fa - Fs) + Offset**

Ia = Actual net interchange in MW (positive value for export)

Is = Scheduled net interchange in MW (positive value for export)

Bf = Frequency Bias Coefficient in MW/0.1 Hz (negative value)

Fa = Actual system frequency in Hz

Fs = Schedule system frequency in Hz (default 50 Hz)

Offset = Provision for compensating errors such as measurement error; default value zero.

In the above formula, ACE has three components as below.

1. Interchange deviation component **(Ia-Is)**
2. Frequency deviation component -**10*Bf*(Fa-Fs)**
3. Offset or Metering Error

Sign convention adopted for interchange MW values is, positive value for export and negative value for import. Bf is a negative value. System Frequency (Fa) is a positive value, close to the National Reference Frequency[3] of 50 Hz.

ACE is positive means that the control area has surplus generation and the control area's internal generation has to be backed down. ACE is negative means the control area is in deficit and the control area's internal generation has to be increased. ACE has to be driven towards zero for better frequency control and grid security.

[1] *Control Area means an electrical system bounded by interconnections (tie lines), metering and telemetry which controls its generation and/or load to maintain its interchange schedule with other control areas and contributes to regulation of frequency as specified;*
Definition from the Report of the Expert Group: Review of Indian Electricity Grid Code, January 2020. https://cercind.gov.in/2020/reports/Final%20Report%20dated%2014.1.2020.pdf

[2] Formula as given in the Report of the Expert Group: Review of Indian Electricity Grid Code, January 2020.

[3] Defined in the Report of the Expert Group: Review of Indian Electricity Grid Code, January 2020.

## 2. Measurement of Frequency

System frequency is an important input for calculating ACE. Typically, ACE is used for taking generation increase/decrease actions using the below applications

a. Secondary frequency control through AGC
b. Tertiary frequency control through RRAS
c. Monitoring and manual generation rescheduling

All the above three applications operate in the time frame of a few seconds to several minutes. Hence it should suffice that the system frequency signal is captured using a sampling time of a few seconds for calculation of ACE.

Suggested sampling time for frequency: 4 seconds, i.e., take a fresh frequency data point every four seconds.

### 2.1. Choosing the master list of redundant frequency sources

The frequency signal taken should be free from noise. To ensure the same, the signals from such stations shall be selected as the frequency sources, whose historical data is proven to be at least 99.9% noise-free in the past three months. To identify noise, the frequency data of different stations shall be plotted in a time series graph. The graph should be free from spikes. Choose 10 such stations to act as redundant frequency sources in ACE calculation. This list may be reviewed quarterly.

### 2.2. Location of redundant frequency sources and host server

For the applications a, b, and c, mentioned above, frequency source from any geographic location should serve the purpose as the time range of interest is in seconds. Typically, in time frame of a few seconds, all the electromagnetic transients and most of the electromechanical transients usually get damped and settled[4]. Hence, stations from different geographic locations can be chosen as redundant frequency sources. Having a mix of at least 10 redundant frequency sources from SCADA and URTDSM (PMU) is advised. Frequency data from URTDSM server are generally imported into SCADA[5] for the purpose of ACE calculation.

### 2.3. Algorithm for selecting the Primary Frequency Source

The ACE calculation program can look at the quality tags of all the redundant signals and choose one of the signals as the primary source. In case the quality of

[4] For applications b & c, as the dispatches are time block-wise, there is no need of consideration about frequency oscillations. For AGC, oscillations in ACE are further smoothened by the exponential moving average filters and the PI controller (low pass filter) which are typically part of the AGC software. The integration time in AGC is in generally between 10s -120s and hence the electromechanical oscillations and any noise get further damped.

[5] PMUs are not available on all the tie-lines. Hence calculating ACE is recommended through SCADA.

the primary frequency source becomes 'suspect', then the next signal with 'good quality tag' shall be selected as the primary frequency source automatically. This logic may be developed into the calculation program gradually, if not immediately.

Algorithm outline:

Initialize Primary Freq= 50 Hz

Initialize K=1

Initialize J=1

Initialize Flag = Good

Call Subroutine-A

Subroutine-A ()

Select the Kth frequency signal in the list as 'primary' and read its quality tag.

If the quality tag is good, set J=1, exit Subroutine-A and GOTO Subroutine-B.

If, J=11, Primary Freq = 50 Hz, exit Subroutine-A and GOTO Subroutine-B.

Else, K=K+1, J=J+1 and Call Subroutine-A.

End Subroutine-A ()

Subroutine-B ()

While Flag = Good

Read the quality tag of the Kth signal at time t

If the quality tag is good, t=t0+4s, Flag=Good

Else Flag = Bad

End While

GOTO Subroutine-A

End Subroutine-B

## 3. Measurement of Tie-Line Flows

### 3.1. Actual Tie-Line Flows

Actual tie-line flows shall be sampled every 4 seconds[6] similar to frequency and shall be used in the ACE calculation. Say, the data is acquired only every 12s by the SCADA because of delays[7], the ACE calculation program shall repeat the data thrice in those 12s. Some Tie-Line flows have the problem of becoming suspect often. Such data should be identified and rectified immediately by following up with site/substation. Every tie-line flow can be obtained from 3 different sources viz.,

i. Primary Side (choose the Metering End as per IEGC)
ii. Secondary Side (side other than the Metering End as per IEGC)
iii. State Estimator output

Primary side data shall be normally used for ACE calculation. In case the quality of the primary side becomes 'suspect', then let the ACE calculation program automatically choose the secondary side. If flow at both the ends goes suspect, use the state estimator output. If the state estimator is not running, replace the suspect data manually with 'last good value', rather than retaining garbage value. Information of manual interventions shall be monitored, carried forward and updated frequently in every shift. Sign convention adopted for interchange MW values is, positive value for export and negative value for import.

Note that all the tie-lines should be accounted for, while calculating the Net Actual Tie-Line Flow (Ia), i.e., algebraic sum of the flows. If any of the tie-lines is non-observable, the data of the same can be replaced with a fixed value as informed by site/substation telephonically to the control room.

### 3.2. Scheduled Tie-Line Flows

The Net Scheduled Tie-Line Flow (*Is*) of a control area should generally be the output of a scheduling software program, from which the data is imported into SCADA for all the 96-time blocks. ACE is calculated using the net tie-line flow, and path-wise scheduled flows are algebraically added based on direction.

Net Scheduled Tie-Line Flow of the control area can be calculated every time block by adding the algebraic sum of scheduled MW export contracts (from the control

[6] At NLDC, the tie line flow acquisition delay (around 10s) includes the delay introduced while acquiring data from RLDCs through ICCP, apart from the delay in acquiring tie line data from RTUs to the RLDCs. For other RLDCs/control areas, delay (~ 5s) is mainly introduced in acquiring tie line data from RTUs to the RLDCs. However, this data acquisition timing has to be improved further by all the control areas.

[7] Higher updation time as well as non-simultaneity can lead to inconsistent frequency response assessment and incorrect ACE calculations. Ideal would be to have PMUs on all inter-regional lines to begin with, followed by all inter-state tie lines.

area to all the other control areas; positive values) and the scheduled MW import contracts (to the control area from all the other control areas; negative values) and the MW sum of resultant of the virtual entities. In line with the tie-line flow convention, sign convention for TRAS Up regulation is positive, TRAS Down is negative. Note that for ACE calculation, we are interested in the net control area values, and not the path-wise values.

For example, if a particular control area imports 2000 MW from the other control areas through tie-lines, exports 500 MW to the other control areas through tie-lines, RRAS Up of 200 MW is dispatched and SCED Down of 100 MW is dispatched. Then Is = -2000+500+200-100 = -1400 MW for that time block.

Note that the Net Scheduled Tie-Line Flow value shall be always less than the Export Available Transfer Capability (ATC) and greater than the Import ATC value.

## 4. Assessment of Frequency Bias

The 2017 IEEE Task Force Report[8] on "Measurement, Monitoring, and Reliability Issues Related to Primary Governing Frequency Response," recommends using Frequency Response Characteristic (FRC) calculated after the power and frequency transients have settled, for the Frequency Bias Coefficient (Bf) used in the ACE equation. A sample size of twenty (20) FRC events has been deemed adequate for estimating the frequency response characteristic to rule out human error. Several other references[9] also have been studied, which support the IEEE Task Force Report recommendations.

FRC computation procedure has been clearly provided in the draft IEGC 2020[10]. A sample template for FRC assessment is enclosed as Annexure-I.I. FRC shall be computed for every control area for all events involving a sudden 1000 MW or

[8] IEEE Task Force Report. 2017. "Measurement, Monitoring, and Reliability Issues Related to Primary Governing Frequency Response," Technical Report PES-R-24, October. https://resourcecenter.ieee-pes.org/publications/technical-reports/PESTECRPTGS0001.html

[9] J. L. Willems, "Sensitivity Analysis of the Optimum Performance of Conventional Load-Frequency Control," in IEEE Transactions on Power Apparatus and Systems, vol. PAS-93, no. 5, pp. 1287-1291, Sept. 1974, doi: 10.1109/TPAS.1974.293852. https://ieeexplore.ieee.org/document/4075491

NERC, Frequency Response Standard Background Document. November, 2012. https://www.nerc.com/pa/Stand/Project%20200712%20Frequency%20Response%20DL/Bal-003-1-Background_Document-Clean-2013_FILING.pdf

P. Kundur, Power System Stability and Control, Chapter 11, McGraw-Hill, New York, 1994.

[10] Report of the Expert Group: Review of Indian Electricity Grid Code, January 2020. https://cercind.gov.in/2020/reports/Final%20Report%20dated%2014.1.2020.pdf

more load/generation loss or a step change in frequency by 0.10 Hz. All these FRC values shall be archived along with date, time and reasons of the event.

### 4.1. Bf value assessment

In the calculation of ACE, the value of Frequency Bias Coefficient in MW/0.1 Hz (negative value) shall be based on median Frequency Response Characteristic during previous financial year of each region. Median[11] value of the past 20 events would be used for updating the FRC. The occurrence of these 20 events is actually expected to cover the entire previous year, thereby subsuming the seasonality aspect of load and generation. Bf value shall be declared by the Nodal Agency.

### 4.2. Bf update timing

The Bias (Bf) value may be updated in the ACE calculations at the LDCs, once in every quarter[12] on the 24$^{th}$ day of the month after the completion of the previous quarter. For example, update the Bias (Bf) value on 25th July, after the completion of the quarter April – June. The updated Bf value in SCADA shall also be shared continuously through ICCP bottoms up, from SLDCs to RLDCs, and from RLDCs to NLDC for all the relevant control areas. An offline all India compilation in Excel/DB may be maintained by NLDC for all the control areas.

## 5. Measurement of Metering Errors - OFFSET

Typically, the accuracy level of the SCADA Remote Terminal Unit (RTU) is 0.5%. Also, there is a chance of error in the instrumentation and communication. Inherent latency and non-simultaneous reporting of SCADA might also cause metering error. Hence, while calculating ACE using the RTU metered tie-line flows, there is a probability of metering errors corrupting the actual value. OFFSET shall be used if such a metering error has been established using long-term data/statistical analysis.

In case of un-observable tie-line flows, where it is not feasible to replace the actual tie line flow data manually, OFFSET can be used to substitute the tie-line flow with correct sign convention. Information of manual interventions shall be monitored, carried forward and updated frequently in every shift. Sign convention adopted for interchange MW values is, positive value for export and negative value for import.

## 6. Calculation of ACE

[11] The median is a better choice as the FRC value is susceptible to a small number of extreme values, or outliers. These outliers are possible when incorrect information regarding the exact quantum of load/generation lost in the control area is received for an FRC event.

[12] The literature studied and mentioned in 6,7 suggests updating the bias values once in a year for practical power systems. However, due to the developing nature of Indian power system, authors of this report suggest a quarterly update.

With the above data, ACE may be calculated every 4 seconds, i.e., refresh the value of ACE every 4 seconds. The formula, techniques and details have already been mentioned in the earlier sections.

## 7. Archival of different parameters

It is important to archive the individual parts of the ACE into a database every 4 seconds. That means, apart from the calculated ACE, Interchange deviation (Ia-Is), Frequency deviation (Fa-Fs), Frequency Bias (Bf) and Offset shall also be separately archived in the database every 4 seconds. This is necessary to build and calculate what-if scenarios for reserve estimation, forecasting, etc.

## 8. Monitoring of ACE and Suggested Corrective Actions

All the control rooms of the control areas shall prominently monitor ACE, apart from the tie-line deviation and frequency deviation.

ACE is positive means that the control area has surplus generation and the control area's internal generation has to be backed down. ACE is negative means the control area is in deficit and the control area's internal generation has to be increased. All the frequency control interventions shall be in the direction to drive ACE towards zero. ACE remaining in the same direction for several minutes without crossing zero is a strong indicator that the frequency control interventions have to be kicked in.

## 9. Calculating ACE for Regional Entity Control Area

Each Regional entity power station is a control area by itself. ACE for a regional entity power plant can also be worked out separately for the purpose of monitoring. The bias would depend on the number of units on bar (40% of capacity on bar per Hz assuming 5% droop plus a small load response from the unit auxiliaries). When there are fragmented control areas and virtual power plants operated from a single control center, this aspect assumes importance.

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**Annexure-I.I**

## Sample Template for Frequency Response Characteristic Calculation

**Frequency Response Characteristic Calculation for All India based on NLDC SCADA Data**

**EVENT:** As reported at 16:02 Hrs on 11th June 2021, 220 kV Akal-Bhu -1&2 tripped due to snapping of B-phase jumper which resulted into 1200MW wind generation loss and 300MW solar generation loss in Northern region. At the same time, 400kV Barmer-Jaisalmer-1&2 also tripped due to over voltage after tripping of wind and solar generation.It appears that two events happen in quick succesession, total generation loss of around 1500 MW as per reported region has been considered for FRC calculation.

| S No | Particulars | Dimension | NR | ER | WR | NER | SR | Nepal | Bhutan | #Bangladesh | Combined cross border | All India |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Actual Net Interchange before the Event (16:02:30) | MW | 11313 | -5678 | -8306 | 21.2 | 1850 | 109 | 1241 | 1039 | 2390 | 164388 |
| 2 | Actual Net Interchange after the Event (16:03:50) | MW | 12241 | -6128 | -9200 | -21.5 | 1469 | 105 | 1241 | 1038 | 2384 | 164088 |
| 3 | Change in Net Interchange (2 - 1) | MW | 928 | -451 | -895 | -42.7 | -381 | -4 | -1 | -1 | -6 | -300 |
| 4 | Generation Loss (+) / Load Throw off (-) during the Event | MW | 1500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1500 |
| 5 | Control Area Response (3 - 4) | MW | -572 | -451 | -895 | -43 | -381 | -4 | -1 | -1 | -6 | -1800 |
| 6 | Frequency before the Event | HZ | 50.09 | 50.09 | 50.09 | 50.09 | 50.09 | 50.09 | 50.09 | 50.09 | 50.09 | 50.09 |
| 7 | Frequency after the Event | HZ | 50.00 | 50.00 | 50.00 | 50.00 | 50.00 | 50.00 | 50.00 | 50.00 | 50.00 | 50.00 |
| 8 | Change in Frequency (7 - 6) | HZ | -0.090 | -0.090 | -0.090 | -0.090 | -0.090 | -0.090 | -0.090 | -0.090 | -0.090 | -0.090 |
| 9 | Frequency Response Characteristic (5 / 8) | MW/Hz | 6353 | 5007 | 9939 | 475 | 4233 | 47 | 6 | 11 | 64 | 20000 |
| 10 | Net System Demand met before the Event | MW | 57737 | 18219 | 47210 | 2249 | 38974 | -- | -- | -- | -- | -- |
| 11 | Internal Generation before the Event (10 - 1) | MW | 46424 | 23897 | 55516 | 2228 | 37124 | -- | -- | -- | -- | -- |
| 12 | Ideal load response assuming 4% per Hz (0.04*Row 10) | MW/Hz | 2309 | 729 | 1888 | 90 | 1559 | -- | -- | -- | -- | -- |
| 13 | Ideal generator response assuming 5% droop.....40% per Hz (40% of Row 11) | MW/Hz | 18570 | 9559 | 22206 | 891 | 14849 | -- | -- | -- | -- | -- |
| 14 | Composite ideal response (12 + 13) | MW/Hz | 20879 | 10287 | 24095 | 981 | 16408 | -- | -- | -- | -- | -- |
| 15 | Percentage ideal response | % | 30.4% | 48.7% | 41.2% | 48.4% | 25.8% | -- | -- | -- | -- | -- |

(*) - Data may be constant/suspected during the event
Note: +ve exchange=> import ; (-)ve exchange => export

# Flow of 132kv Surjamani-comilla D/c is included in Bangladesh interchange,

Total Generation All India

| | |
|---|---|
| Total Change in (MW) | 1500 |
| **FRC for NEWS GRID (dp/df) MW/Hz** | **16667** |
| **Power Number (net change in MW/maximum change in frequency )** | **8824** |

| Source Wise Generation (MW) | GAS | HYDRO | NUCLEAR | Thermal | WIND | SOLAR |
|---|---|---|---|---|---|---|
| | 4834 | 22342 | 5088 | 98676 | 20669 | 12686 |

| | |
|---|---|
| Percentage of non responsive generation(nuclear+ wind+ solar as a percentage of total generation) | 23.40% |