Regulatory Governance Framework in the Indian Power Sector

Evolution and Emerging Landscape for Ancillary Services

25th July 2025

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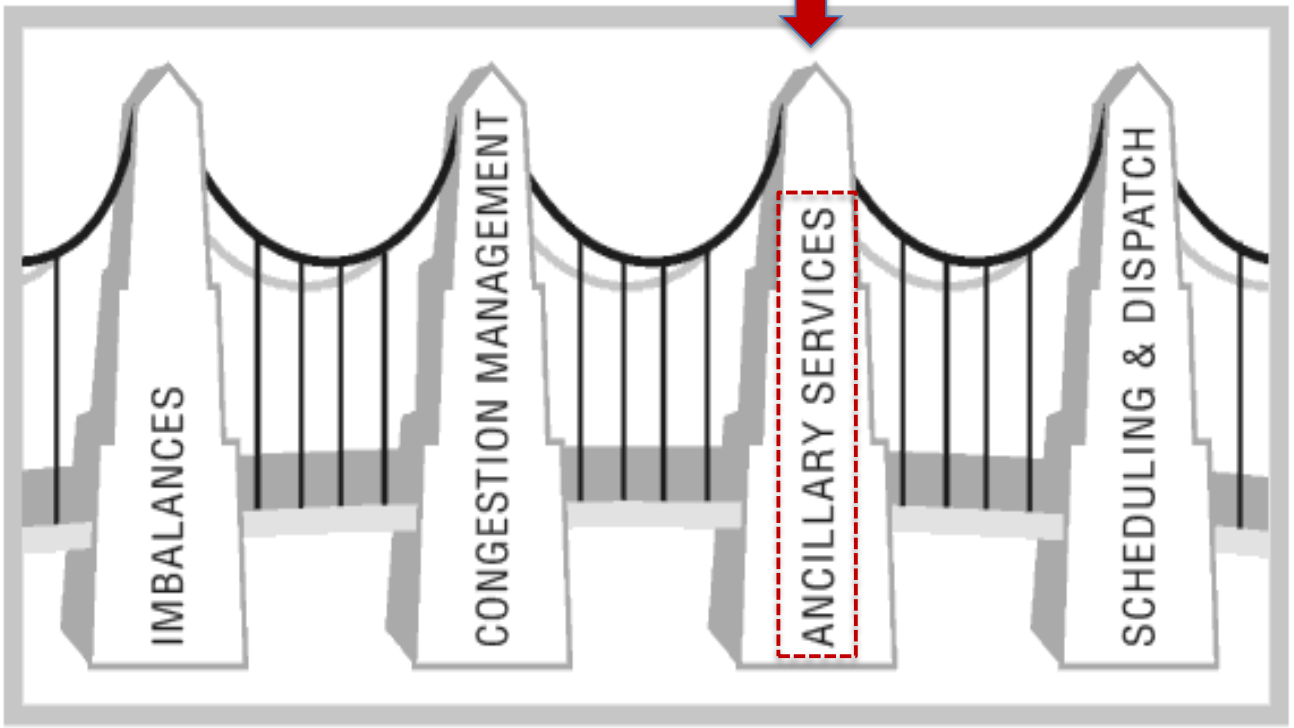
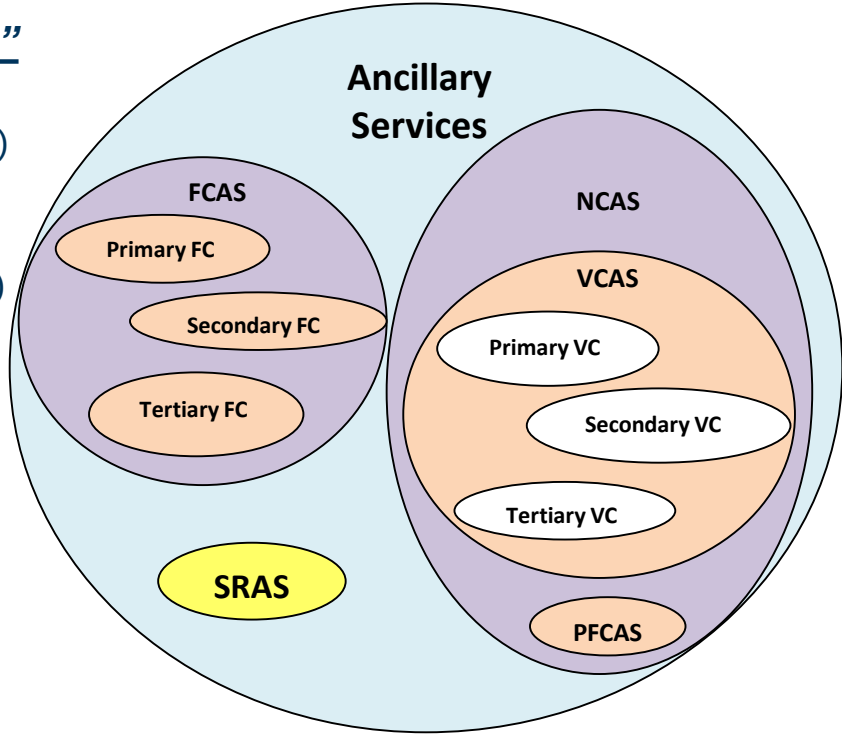
A key Pillar of Electricity Market Design – "Ancillary Service"



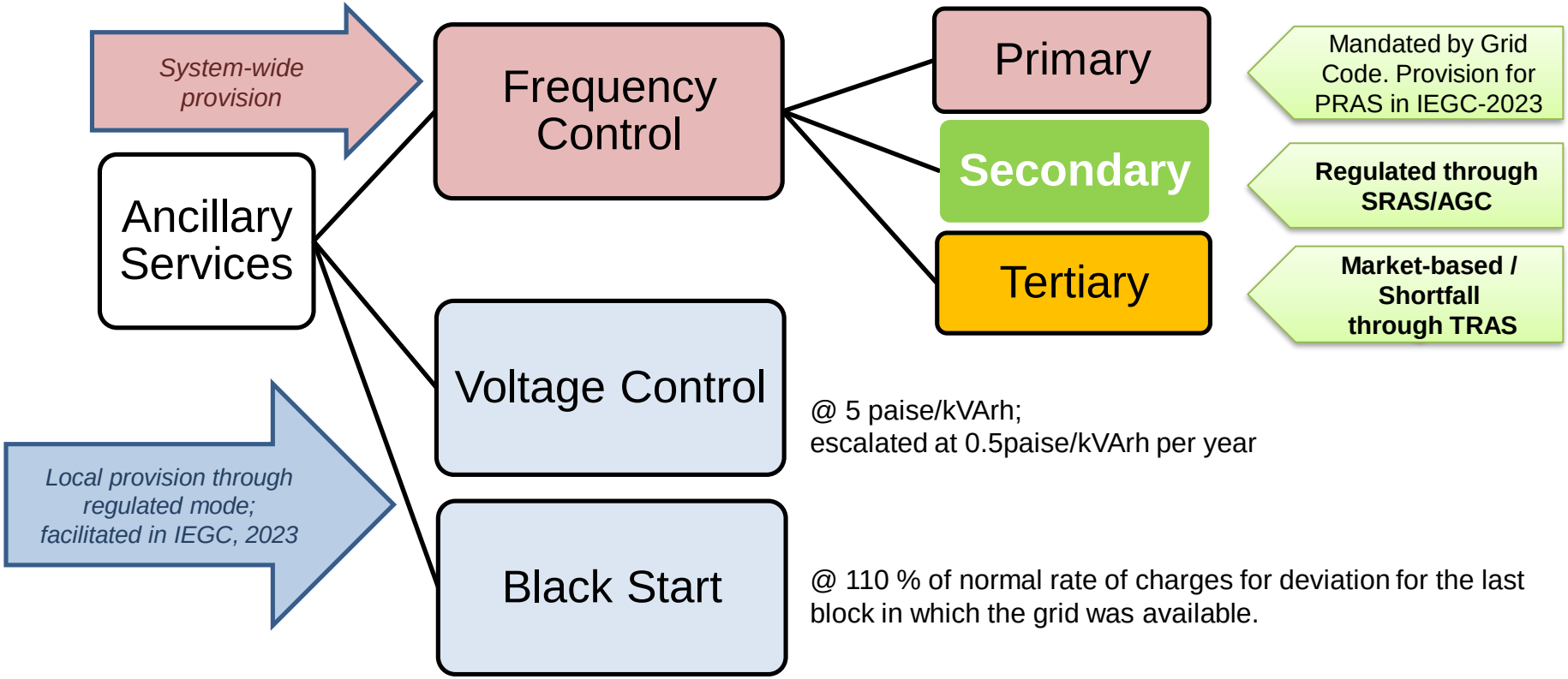
Sally Hunt – Book 'Making Competition Work in Electricity'

Introduction – Ancillary Services

- **Ancillary services consist of *“value-added services”* required for**
  - Maintaining generation and load balance (frequency control)
  - Maintaining voltage and reactive power support (voltage control)
  - Emergency preparedness (system restart & stability control)
- **Necessary for maintaining power quality, reliability and security of the grid**
- **Ancillary services can be provided by**
  - Generators
  - Distribution Utilities
  - Transmission operators
- **Ancillary services despatched by system operator**
  - Maintaining generation and transmission reserves
  - Need to define, measure and pay for services (regulated/market)



Ancillary Services in India - Types



Ancillary Services – Legal and Regulatory Framework

National Electricity Policy, 2005 (5.2.3)

- Need to create adequate reserve capacity margin
- Spinning reserve of at least 5%, at national level to ensure grid security, quality and reliability of power supply

Tariff Policy, 2016 (7.4)

- Norms and framework for ancillary services, including the method of sharing the charges
  - To support power system or grid operation for maintaining power quality, reliability and security of grid.
- Adoption of norms & framework for ancillary services by states

CERC (Indian Electricity Grid Code) Regulations, 2023

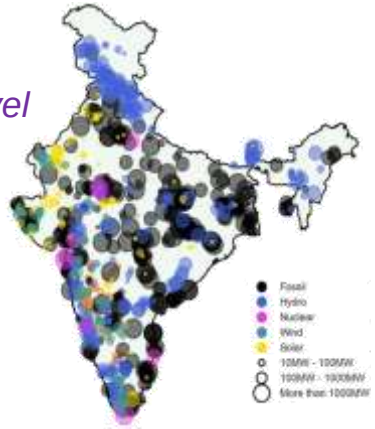
- "*…Ancillary Services in relation to power system operation, means the services necessary to support the grid operation in maintaining power quality, reliability and security of the grid and includes Primary Reserve Ancillary Service, Secondary Reserve Ancillary Service, Tertiary Reserve Ancillary Service, active power support for load following, reactive power support, black start and such other services as defined in these regulations;…*"

Ancillary Services – Evolution over the years

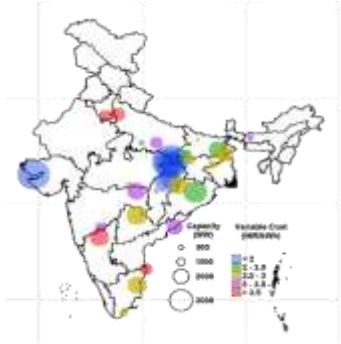
Future….

Voltage Control Ancillary Service
Black-start Ancillary Service
Ancillary Services at intra-state level

Tertiary Reserve Ancillary Service (TRAS), **Jun-2023**
Secondary Reserve Ancillary Service (SRAS), **Dec-2022**



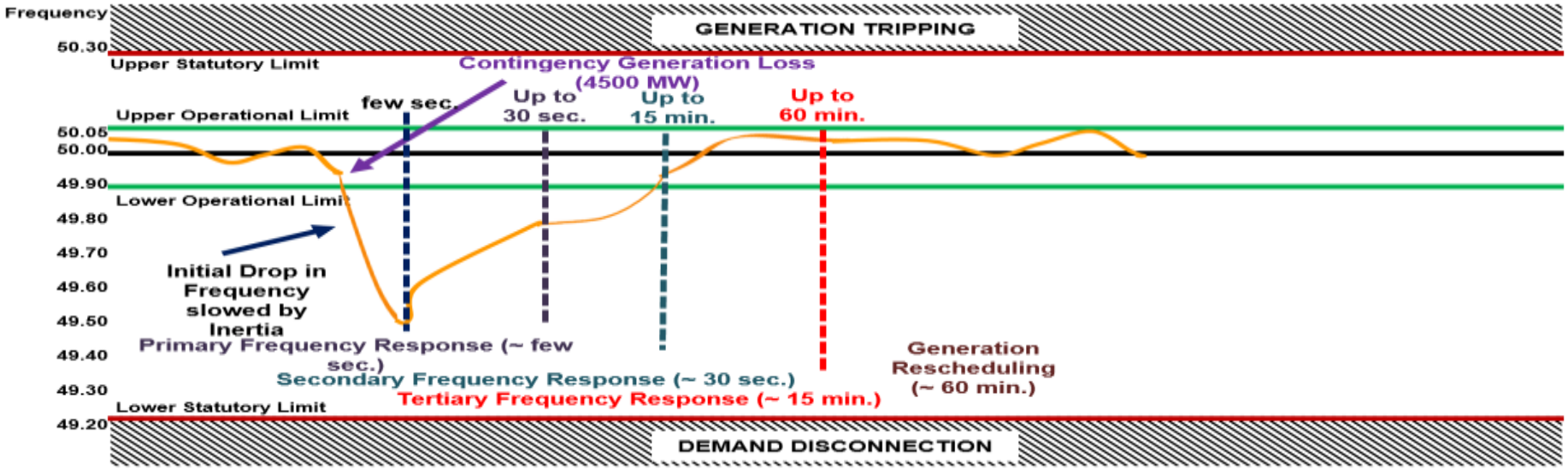
Hydro as Fast Response Ancillary Services, **Jul-2018**
AGC Pilot Operationalization, **Jan-2018**
IEGC (Fifth Amendment) Regulations, **Apr-2017**



Reserve Regulation Ancillary Services (RRAS), **Apr-2016**
Roadmap to Operationalise Reserves in the country, **Oct-2015**
Ancillary Services Operations Regulations, **Aug-2015**

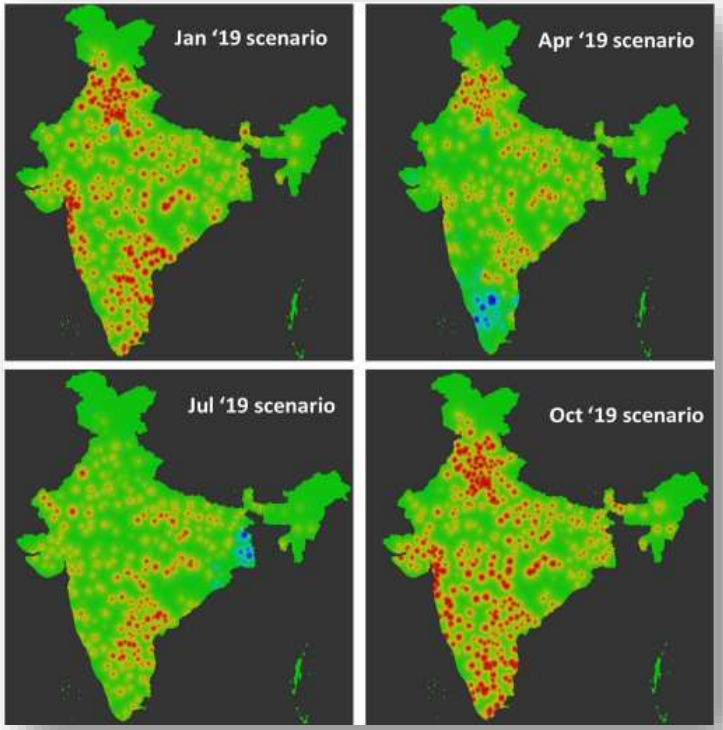
Indian Electricity Grid Code (IEGC) Regulations, **Apr-2010**

Role of Ancillary Service in System Balancing



Reserve	Start of activation	Full Availability/ deployment	Ability to sustain the full deployment	Providers
Primary Response (Automatic)	Instantaneous after frequency crosses dead band	Within 45 sec	5 min	All generators, Energy Storage
Secondary Reserve Ancillary Service (Automatic)	Within 30 sec	Within 15 Min	30 min or till replaced by Tertiary Reserves	All generators, Energy Storage, DR
Tertiary Reserve Ancillary Service (Manual)	Within 15 Min		60 min	All generators, Energy Storage, DR

Voltage Control Ancillary Services (VCAS)



- Voltage control strategy in regulated mode
  - Mandatory support from grid connected generators.
  - Charges for reactive drawal / exchanges, depending on the voltage conditions (outside band of 0.97 to 1.03 p.u.)
- Need to bring in a different approach
  - 500 GW RE by 2030
- Procedure on Dynamic reactive power reserve assessment as per IEGC, 2023 in place
- Need for suitable compensation mechanism
  - Dynamic Var Support
  - Synchronous condenser operation of hydro
  - Var support from RE during no generation period

Reactive power is like chlorophyll for the GREEN future

CERC Ancillary Services Regulations 2022

Objective and Identified Ancillary Services

- Provide mechanism for procurement, deployment and payment of Ancillary Services at regional and national level
  - Using Administered as well as market based mechanisms
- Maintaining grid frequency close to 50 Hz and restoring frequency within allowable band
- Relieve congestion in transmission network
- Ensure smooth operation of the power system, and safety and security of the grid

Primary Reserve Ancillary Service (PRAS)	Secondary Reserve Ancillary Service (SRAS)	Tertiary Reserve Ancillary Service (TRAS)	Other Ancillary Services as specified in Grid Code, including •Voltage Control Ancillary Service •Black Start Ancillary Service

Regulations and Procedures – SRAS and TRAS

Central Electricity Regulatory Commission (Ancillary Services) Regulations, 2022.

Gazette Notification Statement of Reasons

Notification - effective date 05.12.2022 --- SRAS

Notification - effective date 01.06.2023 --- TRAS

CERC orders on implementation aspects

Introduction of AS contracts Expansion of scope

Detailed Procedure for Secondary Reserve Ancillary Services (SRAS) – Dec 2022 - Link

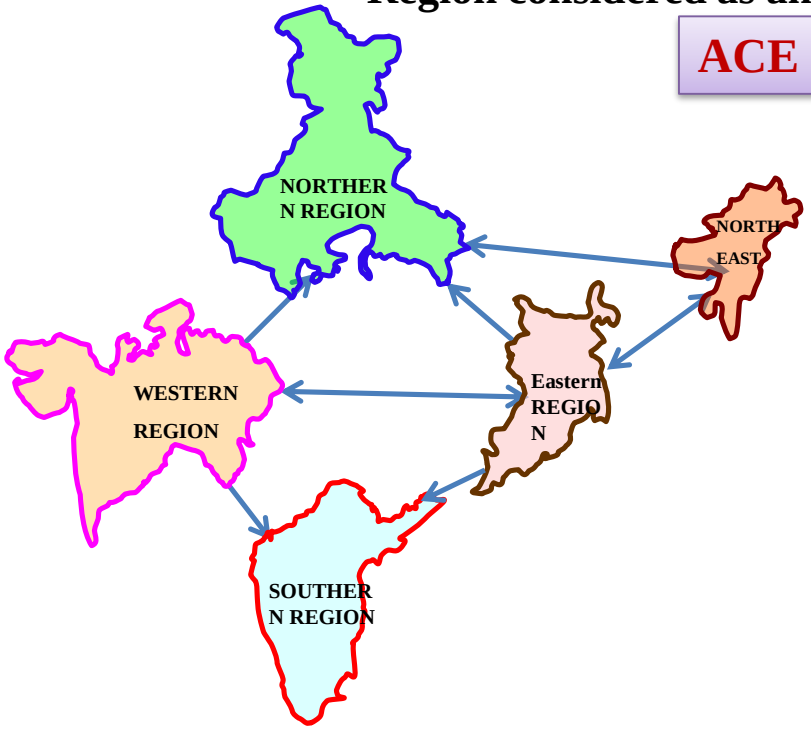
Detailed Procedure for Tertiary Reserve Ancillary Services (TRAS) – April 2023 – Link

Central Electricity Regulatory Commission (Indian Electricity Grid Code) Regulations, 2023 – Link

Procedure for Assessment and Procurement of Reserves – IEGC 2023 – Link

Area Control Error (ACE) Calculation

Region considered as an Area for secondary control



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

- Ia = Actual net interchange in MW (positive for export)
- Is = Scheduled net interchange in MW (positive 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
- ACE positive means area is in surplus and its internal generation has to back down
- ACE negative means area is in deficit and its internal generation has to increase

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

Balancing Reserves Dimensioning (2025-26)

Type of reserve	Inter-state level (MW)	Intra state level (MW)	Total All India level (MW)
Secondary	6672	4958	11630
Tertiary	6672	10638	17310
Total	**13344**	**15596**	**28940**

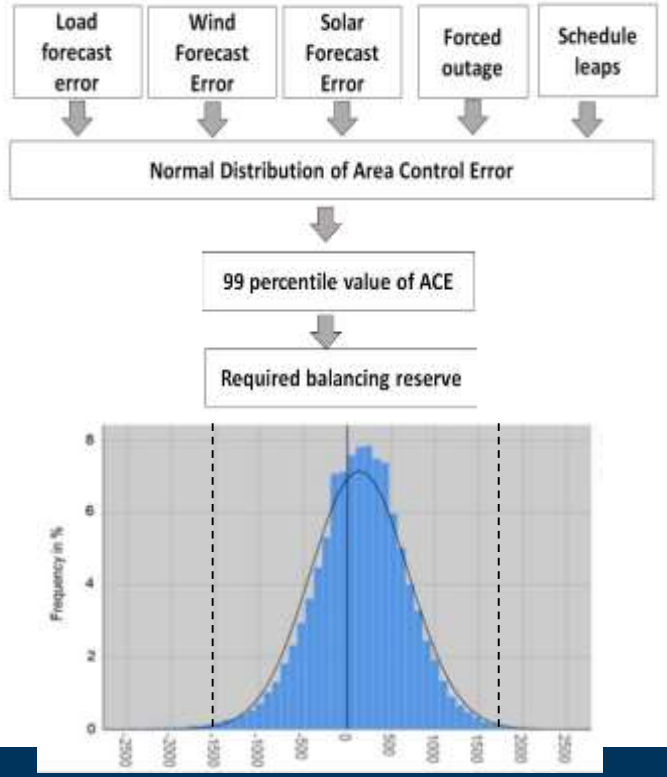
Reference contingency for 2025-26 (**7000 MW** (for Solar hours) / **4500 MW** (for non- Solar hours)) published on NLDC website

Reserve Estimation, Planning and Procurement

- Nodal Agency (NLDC) to estimate the quantum of requirement of SRAS and TRAS at the regional level in coordination with RLDCs and SLDCs and publish on its website
  - after factoring in the reserves for each state control area
  - based on such methodology specified in the Grid Code

- Requirement of quantum of SRAS and TRAS to be re-assessed on day-ahead basis

Basis of Estimation



Planning for Reserves

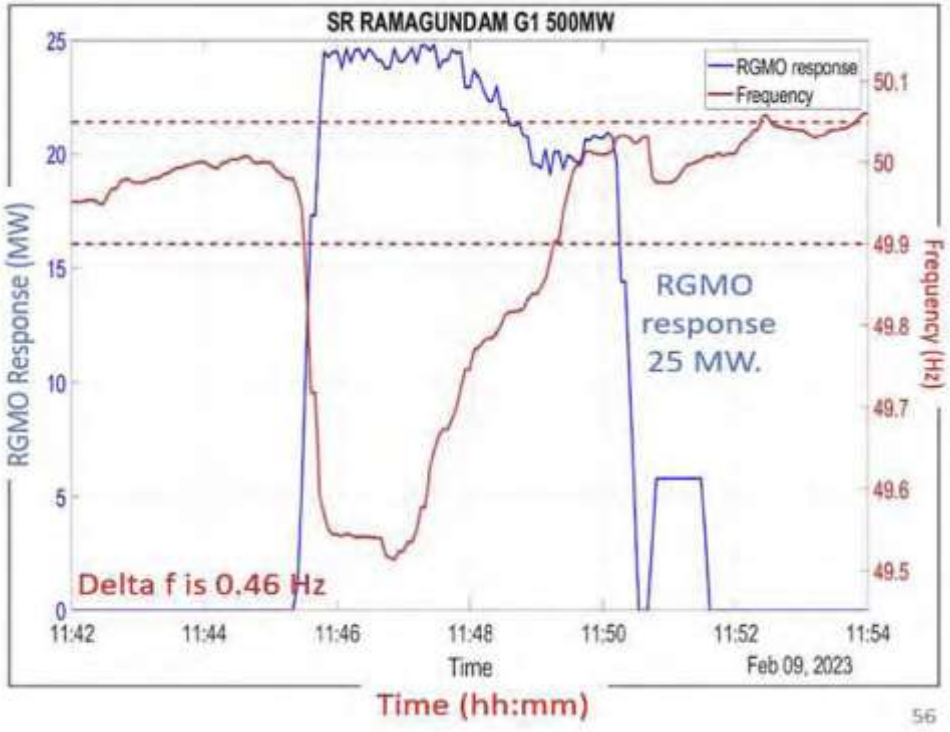
Year- Ahead	Resource Adequacy/LGBR
Three Day - Ahead	Operational planning/Unit Commitment

Procurement of Reserves

Day- Ahead	Day Ahead Procurement (DAM - AS)
Intra - Ahead	Incremental Procurement (RTM - AS)

https://cercind.gov.in/Regulations/Order_SRAS%20TRAS.pdf

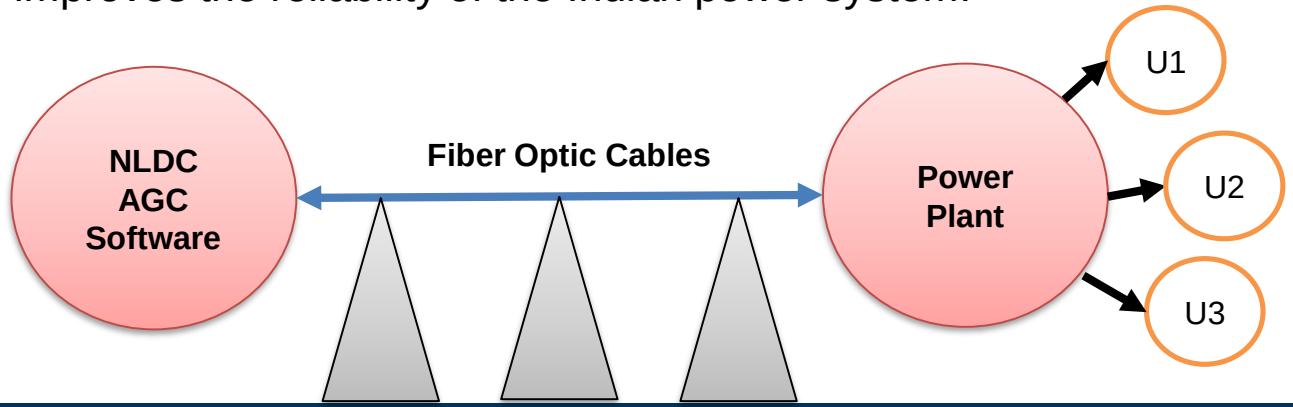
Primary Frequency Control



- Response from governor is automatically driven.
- Third-party assessment of ~ 240 generating units carried out coordinated by RLDCs/NLDC.
- Presently mandated as per Grid Code
- Primary Response as an Ancillary Service – **a future option in light of high RE penetration**
- RE and Energy Storage to provide Primary Response

SRAS/Automatic Generation Control (AGC) in Brief

- Automatic and supplementary control mechanism, 24x7
  - To control frequency and tie-line flows
- Several signals exchanged with generators every 4 seconds
- AGC helps replenish the exhausted primary reserves
  - Be ready for any next contingency
- Efficient and automatic frequency control during high RE periods
- AGC improves the reliability of the Indian power system.

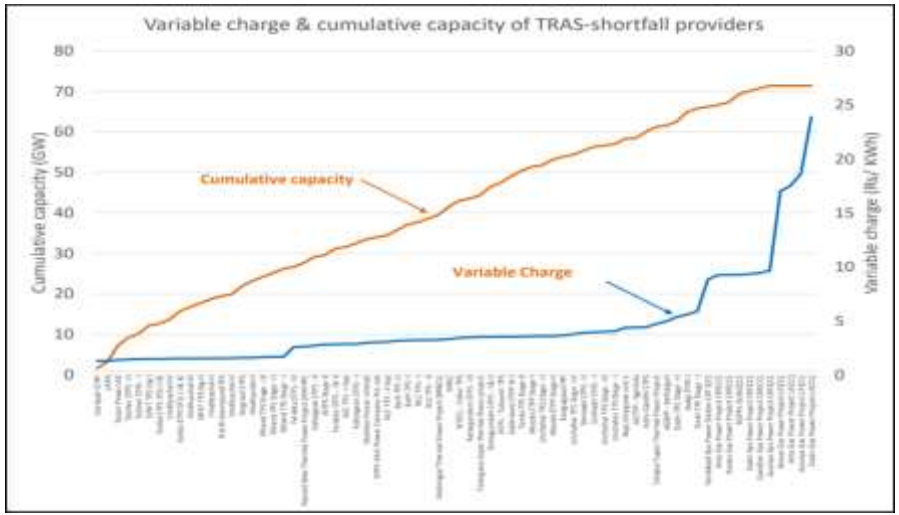


Key terms of SRAS - Custom Participation Factor

Ramp rate and Energy Charges are considered

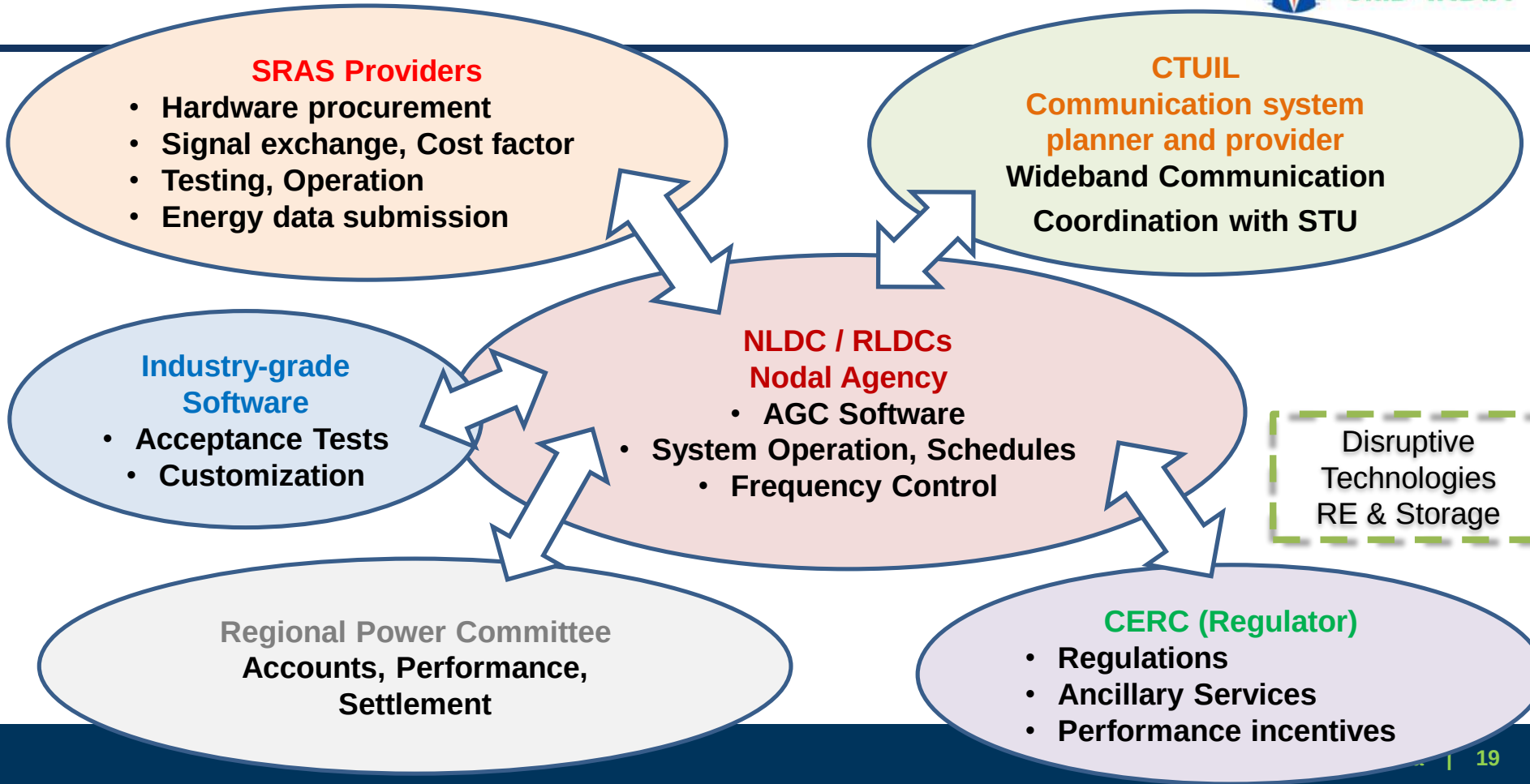
- Allocation of a part of Smoothened Area Control Error amongst different generators
- **Custom participation factor** is used
- SRAS Provider shall be selected, on regional basis, by the Nodal Agency for providing SRAS-Up or SRAS-Down based on the Custom Participation Factor.
- **Up Regulation:** The regulation component is calculated based on the normalized value in proportion to ramp rate and inversely proportional to the Cost Factor.
- **Down Regulation:** The regulation component is calculated based on the normalized value in proportion to ramp rate and the Cost Factor.

SRAS (AGC) Status Update

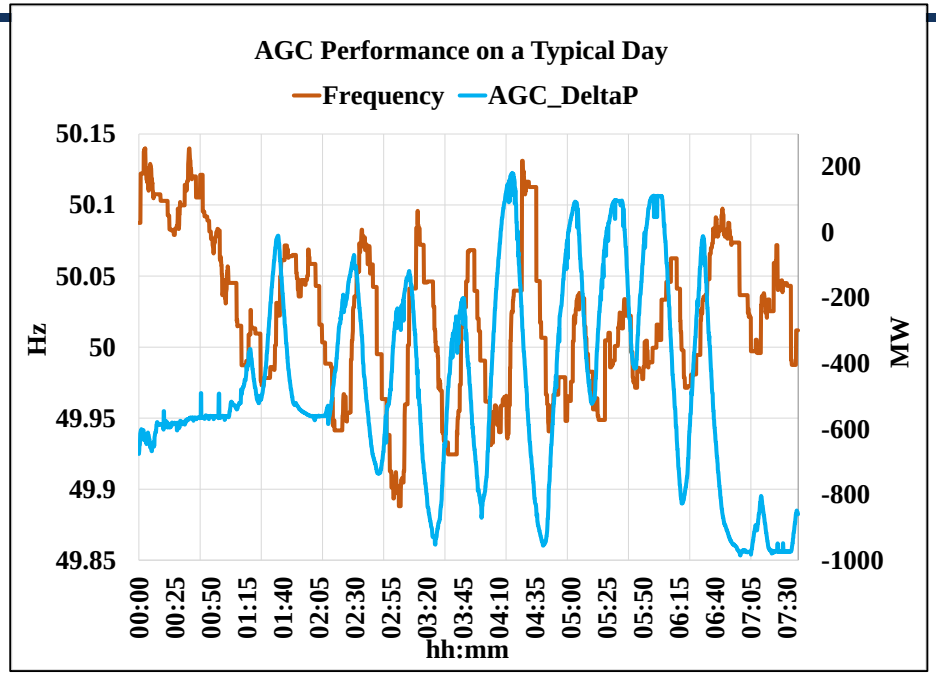


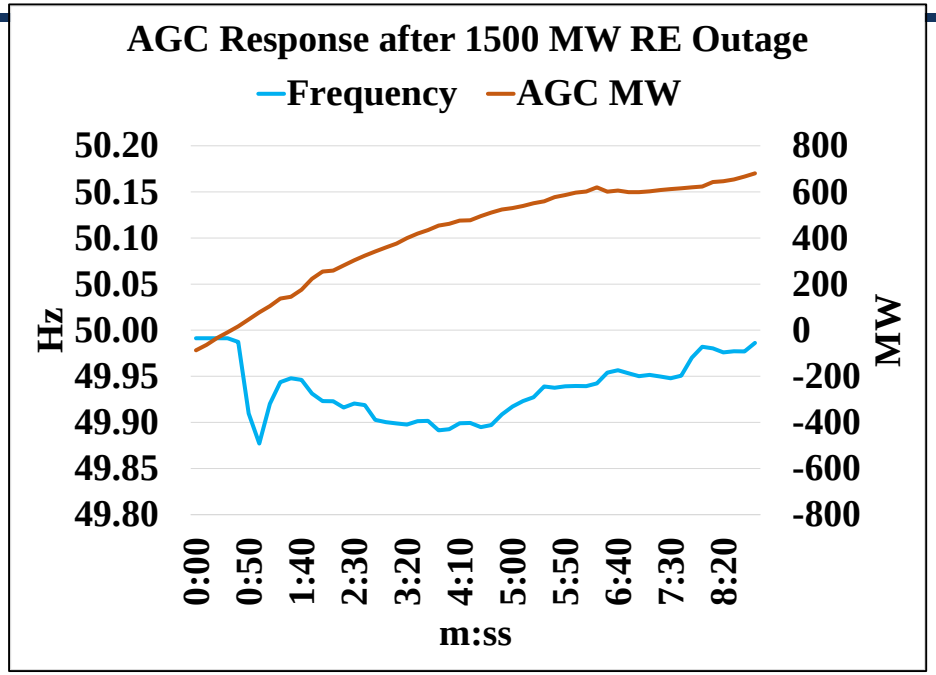
- Pan India distributed AGC
- 80 power plants, 204 units, and 75326 MW capacity under AGC
  - ~ 65.3 GW coal, ~ 6.6 GW hydro, ~ 3.2 GW gas, 180 MW solar and ~20 MW BESS
  - 24x7 operation of AGC from 20th July 2021
  - Far away plants in remote from NLDC !
    - NTPL 2760 kms, Loktak 2500 kms
- Robust communication infrastructure through optical fiber
- Signals sent from NLDC to the power plants every 4 seconds for AGC-Up or AGC-Down
- Un-despatched surplus reserves utilized in the real-time.
- Up & Down Regulation up to 2000 MW pan-India

Roles of Multiple Stakeholders in SRAS/AGC



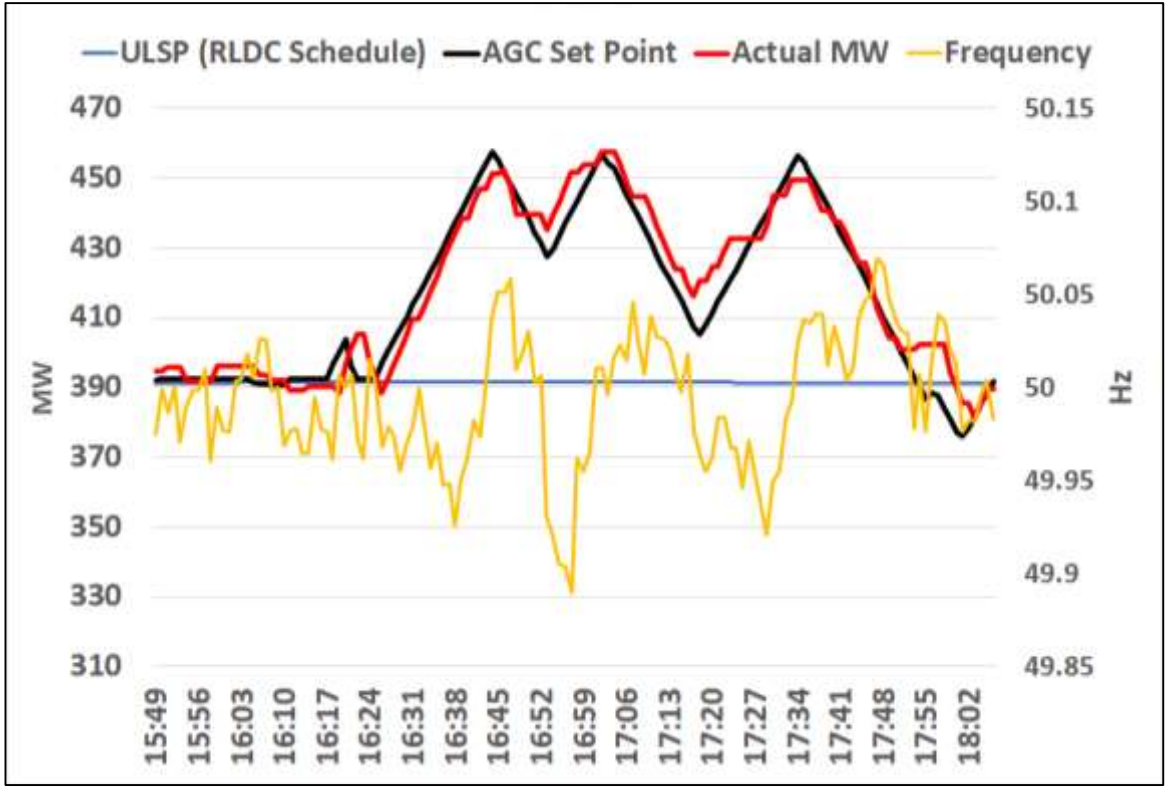
Typical Day Operation of SRAS/AGC





- 24x7 Automatic Control
- Supports high RE penetration
- Helps during contingencies

Typical Power Plant Response



Ramp rate honored, Smooth control of generation

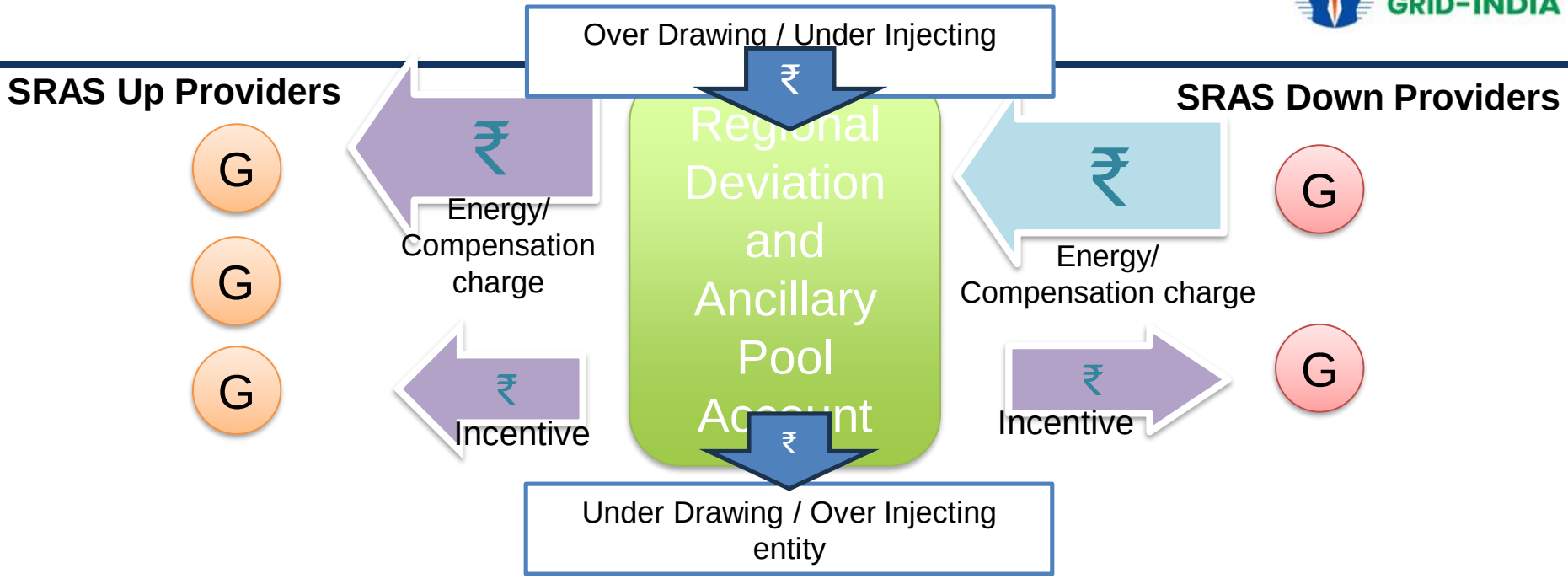
15-min DeltaP data

TB	Avg MW	MWh
TB1	24	6
TB2	20	3
TB3	-12	-3
TB4	-24	-6

5-min DeltaP data

Sub-TB	Avg MW	MWh
TB1(1)	24	2
TB1(2)	-12	-1
TB1(3)	60	5

Accounting & Settlement for SRAS/AGC



SRAS Up Providers to be paid (in case of SRAS Up) or to pay back (in case of SRAS Down) Energy/compensation charges

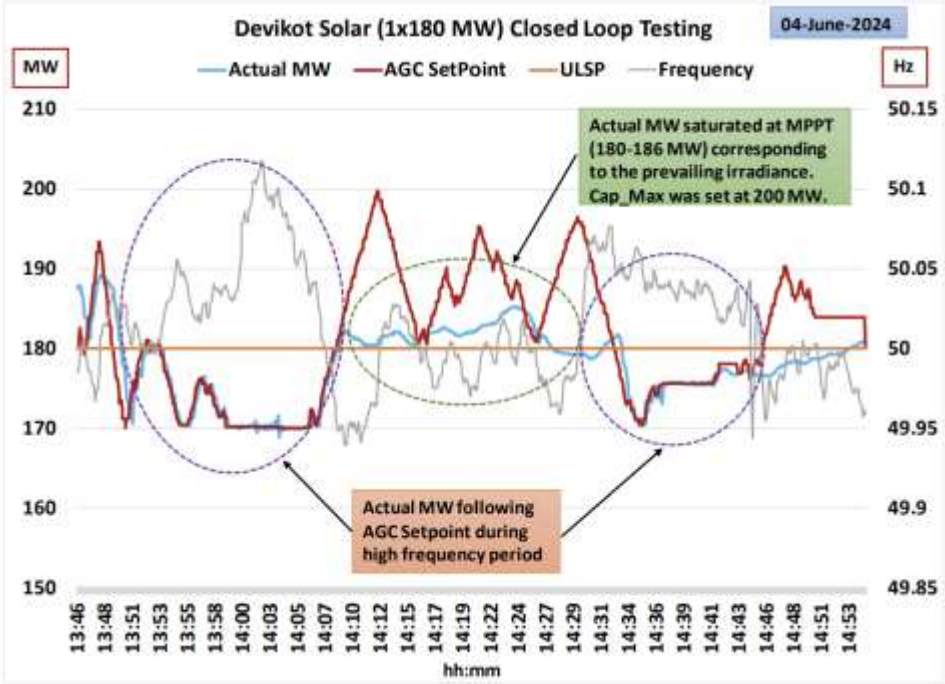
- Corresponding to net energy despatched under SRAS Up or Down
- Using 15-min SCADA MWh

SRAS Up and Down Providers are eligible for incentive based on performance:

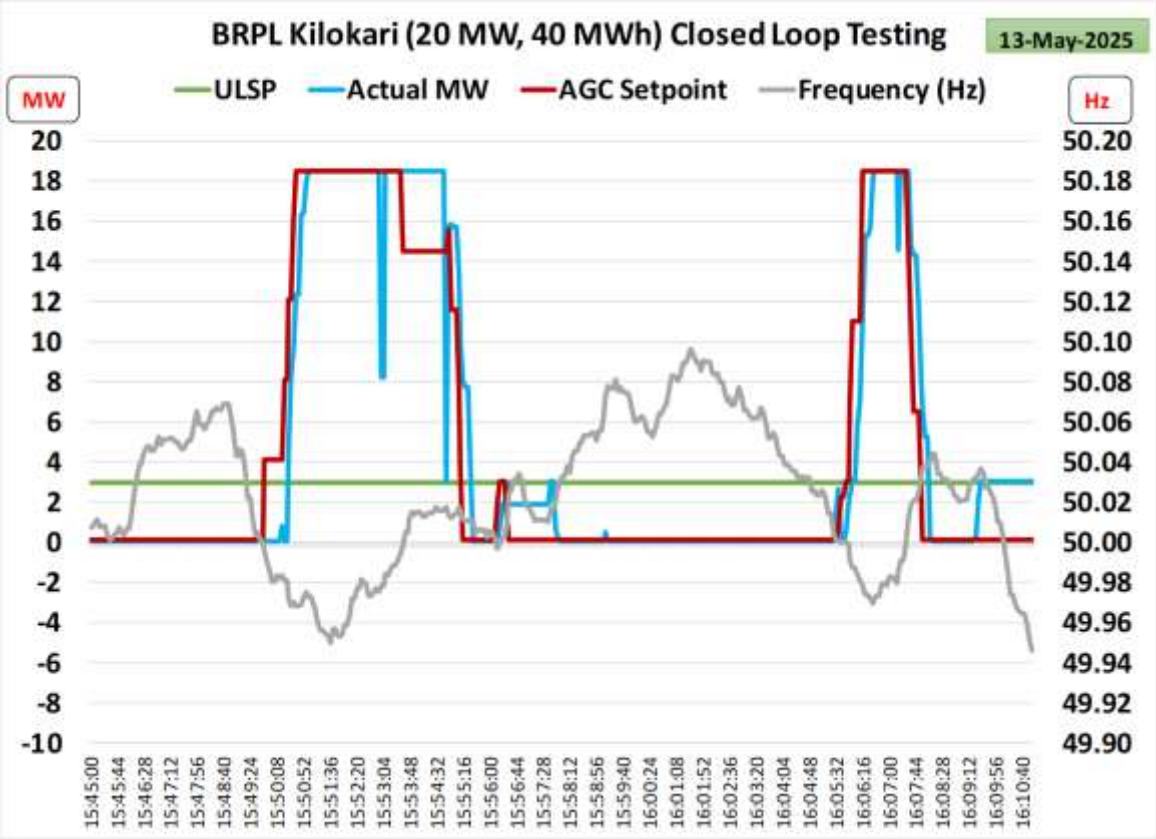
Incentive between 0 - 50 paisa/kWh for every **5-min AGC Up/down MWh (using SCADA)**

AGC Pilot project at Devikot Solar (180 MW)

- With high RE penetration, frequency control during high solar periods is a challenge
- Flexibility attributes needed from thermal power plants
- Down regulation to Solar plants may be needed
- Efficient curtailment mechanism based on grid requirements
- Signal list ready
  - Sensitizing stakeholders
  - More pilots



AGC Pilot with BESS



Statistics on AGC/SRAS

Chronic shortage of both Up reserves (non-solar) and Down reserves (solar)

July 2021 – March 2025

Sno	Title	Value
1	Maximum Up Regulation MW	1751 MW
2	Maximum Down Regulation MW	2231 MW
3	Total Up Regulation MU; (a)	5974 MU
4	Total Down Regulation MU; (b)	(-) 14520
5	Total MU energy (+) delivered/ (-) absorbed; (a) + (b)	(-) 8546 MU
6	Total mileage; (c) = |a| + |b|	20494 MU
7	Total Mark-up/incentive disbursed	₹983 Cr
8	Maximum MW contribution during contingency	1400 MW
9	Maximum ramp contribution during contingency	283 MW/min

Tertiary Reserves Ancillary Services (TRAS)

Introduced through Ancillary Services Regulations, 2022

Transition from regulated RRAS to market-based TRAS w.e.f. 1st June 2023

System operator can procure reserves from the TRAS-DAM and/or TRAS-RTM markets to enhance the availability of tertiary spinning reserves

- Generating stations at inter/intra state level including energy storage and demand response eligible to participate
- Dispatch from procured reserves based on real-time system conditions
- 169 providers with 141 GW capacity registered to provide TRAS through market

Provision of TRAS dispatch under shortfall from Sec 62/other willing generators or all generators under emergency conditions

- 77 generating stations with 83 GW capacity providing TRAS-Shortfall
- Variable cost range upto Rs 35/kWh (Open cycle Liquid fuel)/Rs.24/kWh (Combined cycle liquid fuel)

82 Generator with a capacity of 44.48 (IPP+RE) are under the consideration for dispatch under TRAS Emergency

In-house design and development of market clearing engine, dispatch engine and reserve assessment software

Procurement of TRAS

Overall up & down reserve requirement on day-ahead basis calculated by using 99th percentile of 10-second Area Control Error (ACE) for each time block for last 7 days

Reserves likely to be available in Sec 62 plants estimated as minimum available up & down reserves in each block in last 7 days

- Subtracted from the overall reserve requirement

Reserves procurement quantum apportioned between DAM and RTM in a fixed ratio

- Ratio to be reviewed from time to time based on quantum of bids received in Power Exchanges

Up & down reserves quantum so obtained becomes TRAS reserve requirement for DAM

Incremental reserves requirement from RTM factors in the actual reserves available in Sec 62 plants, and actual cleared reserves quantum from DAM

Automated by default. Manual intervention by exception.

Other Key Implementation Features of TRAS

Separate high price segments for TRAS-DAM and TRAS-RTM

- Clearing and settlement of separate price segments handled with single TRAS requirement
- UMCP for TRAS UP & Pay as bid for TRAS Down

Uniform clearing price for TRAS-Up and Pay-as-bid clearing for TRAS-Down

Option to carry forward uncleared quantum from IDAM to TRAS-DAM

Expansion of ambit to cover advance procured reserves and intra-state resources under TRAS-Shortfall

Demutualized operations through separate teams for various responsibilities

- Reliability and reserve assessment, market clearing, despatch of reserves in real time
- NOAR implementation, Scheduling, accounting, settlement, MIS, IT hardware/software support

TRAS Emergency provision

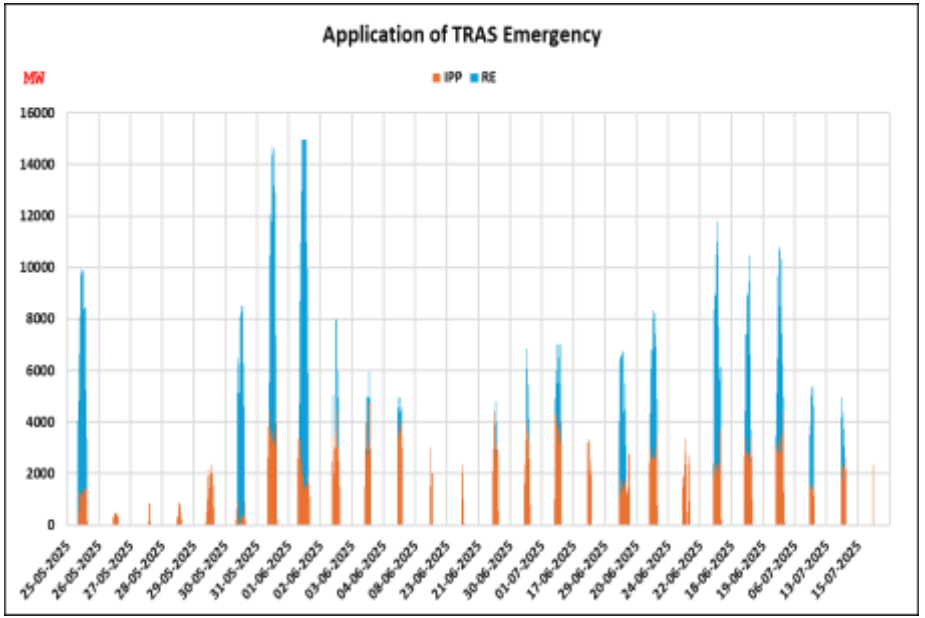
- As per the CERC (Ancillary Services) Regulations, 2022, under emergency conditions, the Nodal Agency (NLDC) may instruct any generating station to provide Ancillary Services.

Quote

20(6) In case the Nodal Agency requires any generating station to provide Ancillary Services to meet the emergency conditions for reasons of grid security as per the provisions of the Grid Code, such generating station shall be compensated at the rate of the energy charge as determined under Section 62 of the Act or adopted under Section 63 of the Act, or at the rate of the compensation charge declared by the AS provider, as the case may be.

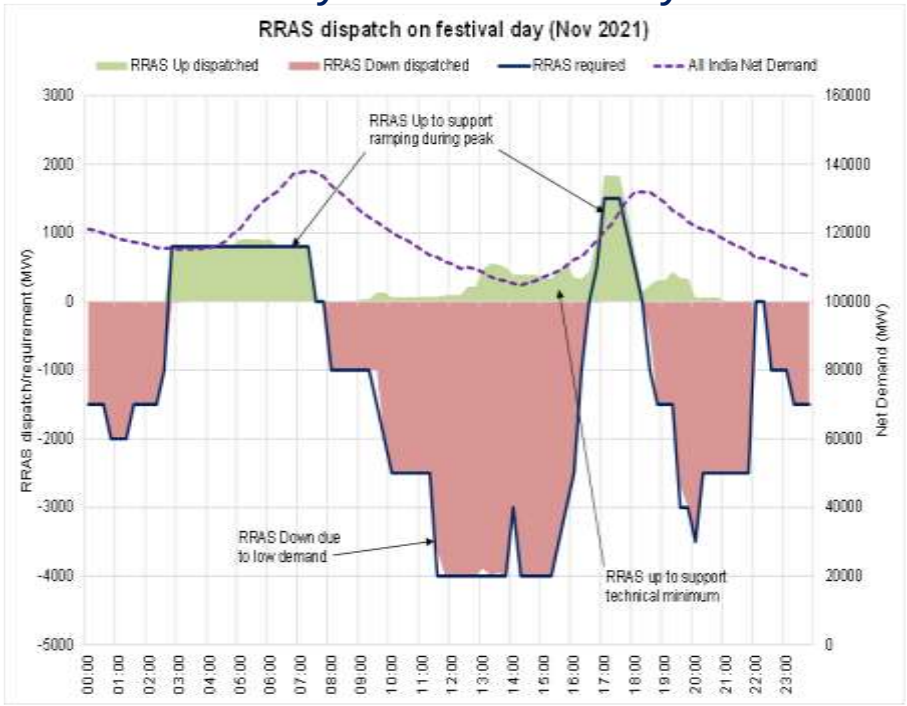
Unquote

- TRAS EM Down instructions being issued to Regional Thermal IPP Generators and **Regional RE Generators**

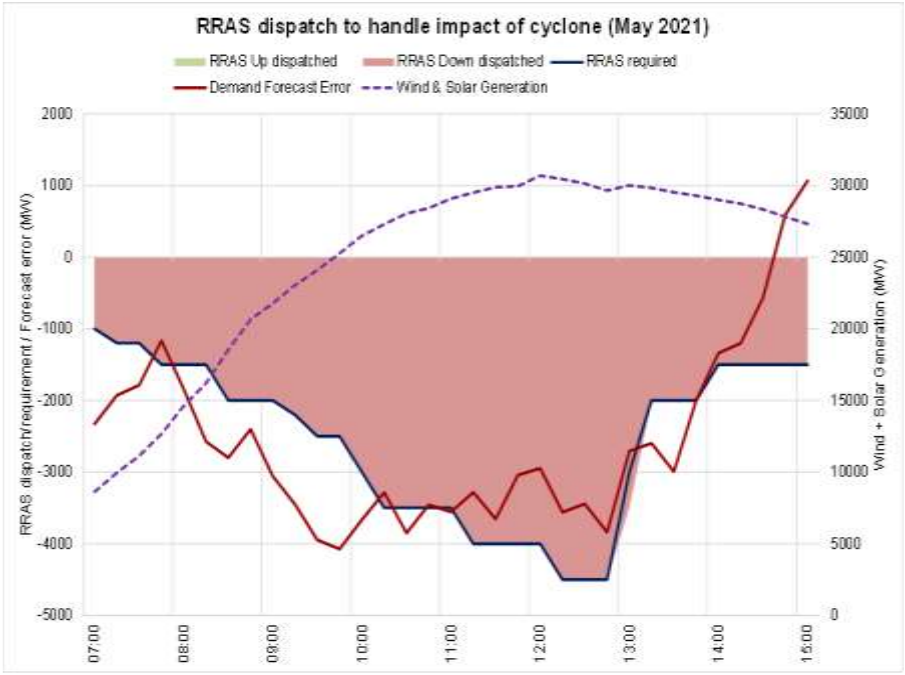


Case study on application of Tertiary Reserve Ancillary Service

Case Study 1 : Festival Day



Case Study 2 : Cyclone Tauktae Impacted Day



- Extremely Severe Cyclonic Storm
- High Wind after Landfall
- Low Demand
- Regulation Down Applied

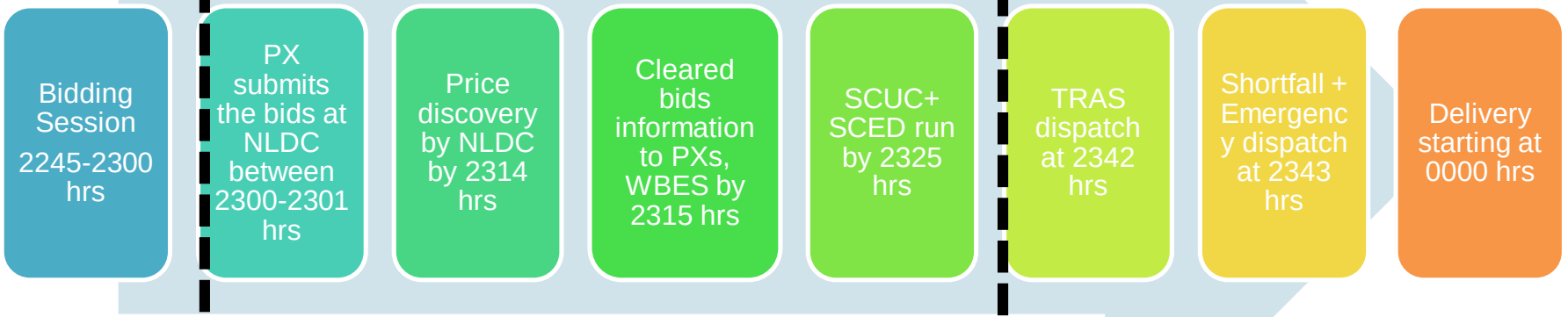
Timelines for SCED, TRAS and Shortfall Dispatch

For time block 0000-0015 hrs

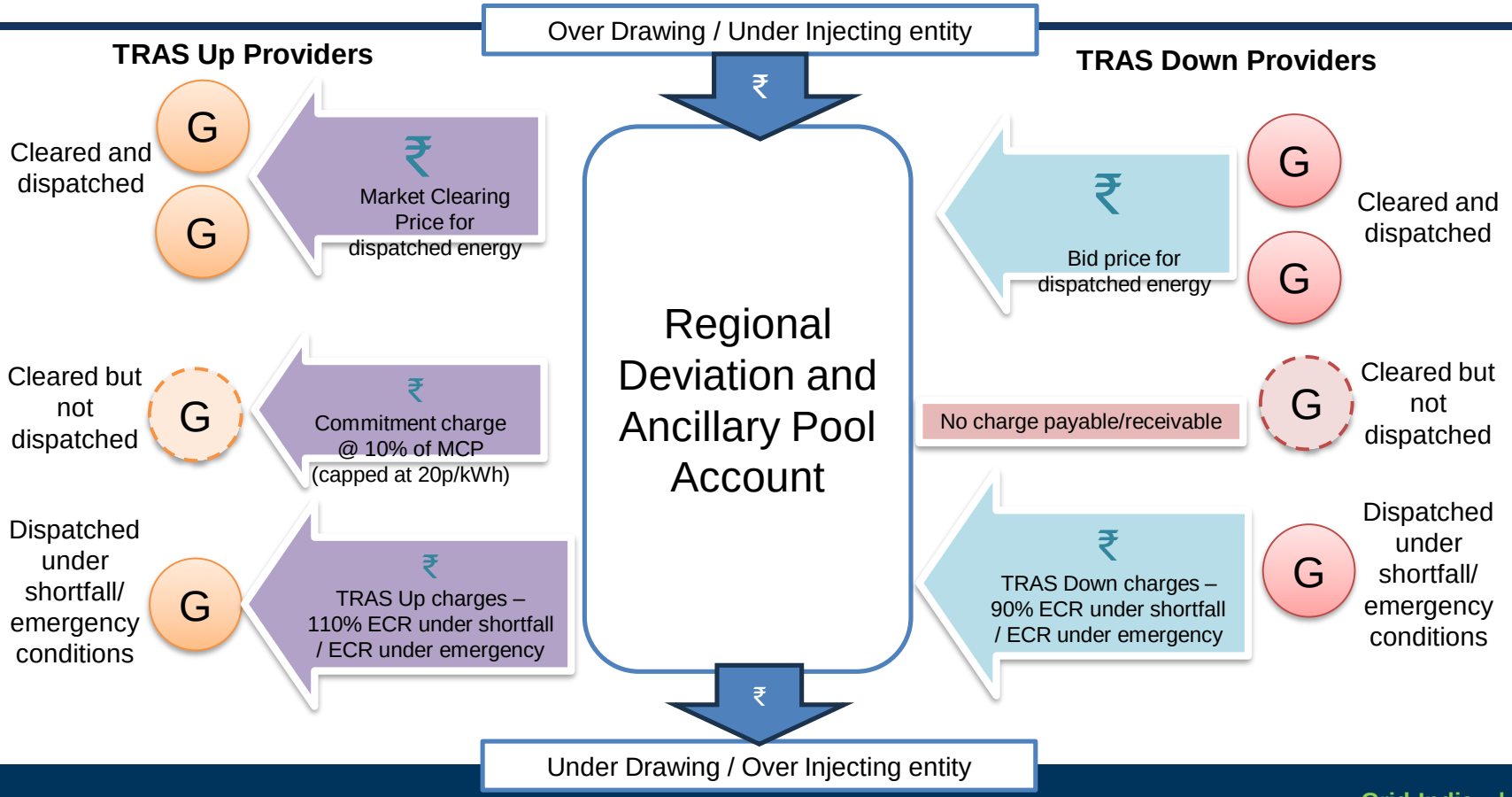
Gate closure for schedule revision

Communication of TRAS-Up & Down Reserve Requirement through API

System operator's TRAS dispatch input by 2340 hrs



Accounting & Settlement for TRAS



Mechanism for Recovery of Ancillary Charges: Normal Rate (NR) of Charges for Deviations

Normal Rate for a time-block shall be **equal to the highest of the A, B & C**:

A. Weighted average ACP (in Paise /kWh) of the I-DAM segments of all the PX;

B. Weighted average ACP (in Paise /kWh) of the RTM segments of all the PX;

C. Sum of
   - 1/3 [Weighted average ACP (in paise/kWh) of the I-DAM segments of all the PX];
   - 1/3 [Weighted average ACP (in paise/kWh) of the RTM segments of all the PX]; and
   - 1/3 [Ancillary Service (AS) Charge (in paise/kWh) computed based on the total quantum of AS deployed and the net charges payable to the AS Providers for all the Regions].

In case of non-availability of ACP for any time block on a given day, ACP for the corresponding time block of the last available day shall be considered.

Payment and Settlement modalities for Reactive Energy – As per IEGC-2023

Modalities of VAr Charges -

To discourage VAr drawals by regional entities, VAr exchanges with ISTS shall be priced as follows:

1. The regional entity pays for VAr drawl when voltage is below 97%
2. The regional entity gets paid for VAr return when voltage is below 97%.
3. The regional entity gets paid for VAr drawl when voltage is above103%.
4. The regional entity pays for VAr return when voltage is above 103%.

The charge for VArh shall be at the rate of 5 paise/kVArh. This rate shall be escalated at 0.5 paise/kVArh per year thereafter, unless otherwise revised.

As per IEGC-2023, Regional Entity Generators, Synchronous Condensers are also eligible for Reactive energy Payments to/from DSM & Ancillary Service Pool Account

Handling Deficit in the DSM Pool Account (DSM Regulation-2024)

- **In case of deficit in the Deviation and Ancillary Service Pool Account of a region:**

  First: the surplus amount available in the D&AS Pool Accounts of all **other regions** shall be used for settlement of payment.

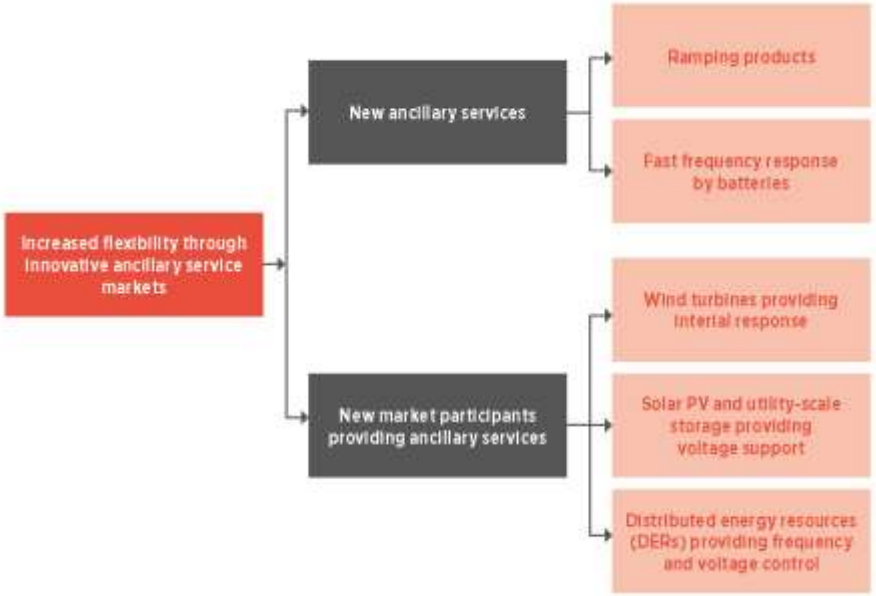
  Second: Provided that in case the surplus amount in the D&AS Pool Accounts of all other regions is not sufficient to meet such deficit, the balance amount shall be recovered from the **drawee DICs**

  – for the period from the date of effect of these regulations till **31.03.2026,** in the ratio of **[50% in proportion to their drawl at the ISTS periphery] and [50% in proportion to their GNA];** and

  – **from 01.04.2026**, **in the ratio of the shortfall of reserves allocated by NLDC to such DICs** in accordance with the **detailed procedure** to be issued in this regard by the NLDC with the **approval of the Commission.**

https://cercind.gov.in/Regulations/Approved-Procedure-deficit-DSM-Pool.pdf

Future: Innovative Ancillary Services by Renewables



Source: IRENA (2019), *Innovation landscape brief: Innovative ancillary services*, International Renewable Energy Agency https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Innovative_ancillary_services_2019.pdf?la=en&hash=F3D83E86922DEED7AA3DE3091F3E49460C9EC1A0

Ramping Capability or Flexible Capacity

- Ramp its real-power output at a specified ramp-rate
- Provide regulation up/down service

Voltage Control

- Provide reactive power support in various modes
  - Control a specified voltage schedule
  - Operate at a constant power factor
  - Produce a constant level of MVAR
  - Provide controllable reactive support (droop setting)
  - Capability to provide reactive support at night

Frequency Control

- Provide frequency response for low frequency and high frequency events
- Control the speed of frequency response
- Provide fast frequency response to arrest frequency decline

Future: Development of Battery Energy Storage Systems as Ancillary Service Provider

- VGF Scheme of up to 40% of capital cost for BESS shall be provided by the Central Government for **development of 4,000 MWh of BESS capacity (Target revised to 13200 MWh)**
- VGF 2nd Scheme with support of ₹ 18 Lakhs per MWh shall be provided by the Central Government for **development of 30 GWh of BESS capacity.**
  - Scheme shall be fully funded through PSDF.
- **"BESS Balancing Pool (BBP)"** to be established **for covering surplus/deficit revenues from BESS projects**.
- Revenues include proceeds from **sale of energy** discharged from the BESS, while expenditure includes **fixed costs** to BESS developers, expenses related to input **energy costs, and BIA trading margins**.
- **Grid-India** designated as **BESS Nodal Agency** (BNA) to oversee the BESS balancing pool
- **NVVN & SECI** identified as BIAs which will be responsible **for securing discharge of power from BESS** during the pre-declared high-demand and **stress hours**.

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