Regulatory and Policy Framework in the Indian Power Sector : Load Despatchers Perspective

Power System Operation and Deviation Settlement Mechanism

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DISCLAIMER :

The opinions expressed in this presentation are those of the presenter and do not necessarily represent the official views of the Grid Controller of India Limited (formerly POSOCO)

Dimensions of Indian Power System & Bulk Electricity Market

~454 GW
generation capacity

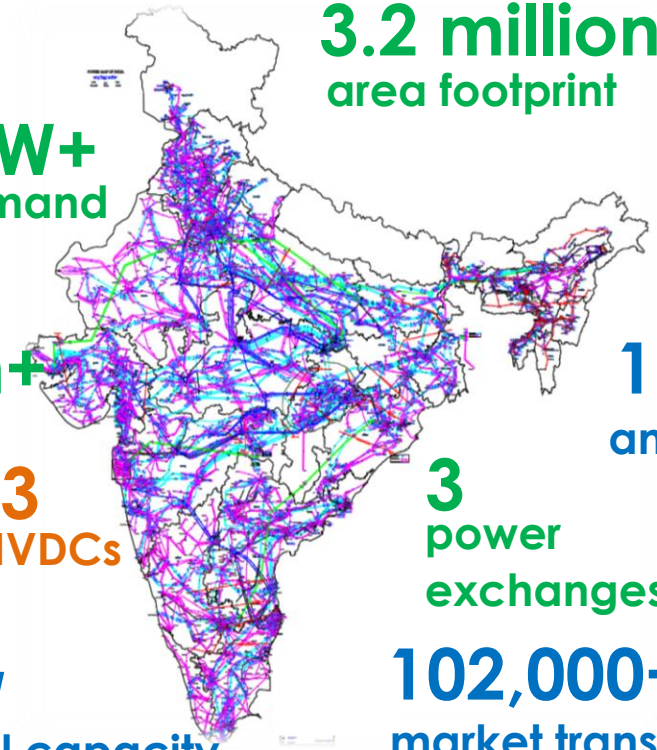
250 GW+
peak demand

> 5 TWh
daily energy met

481326 ckm+
EHV transmission

~202 GW
renewables
(including large Hydro)

~ 112 GW
inter-regional capacity



13
HVDCs

3
power exchanges

102,000+
market transactions

3.2 million km²
area footprint

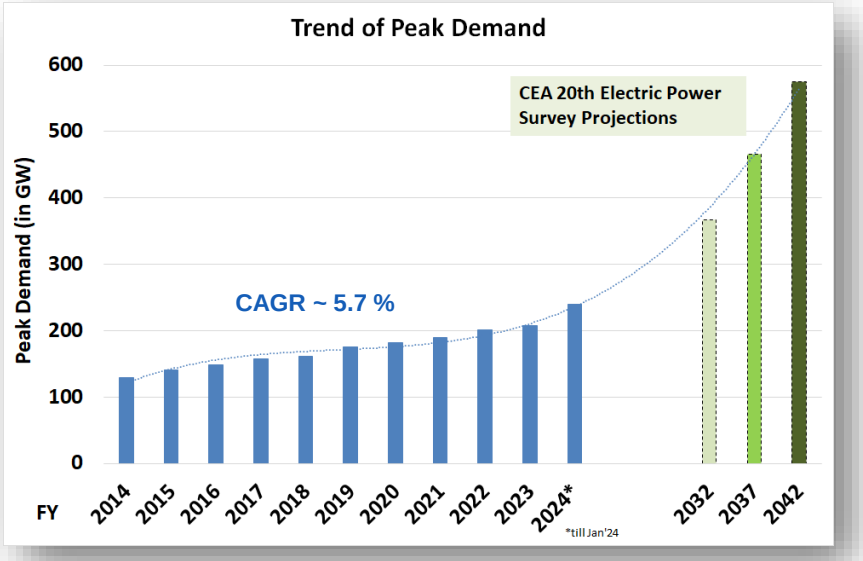
1.4 Billion+
people served

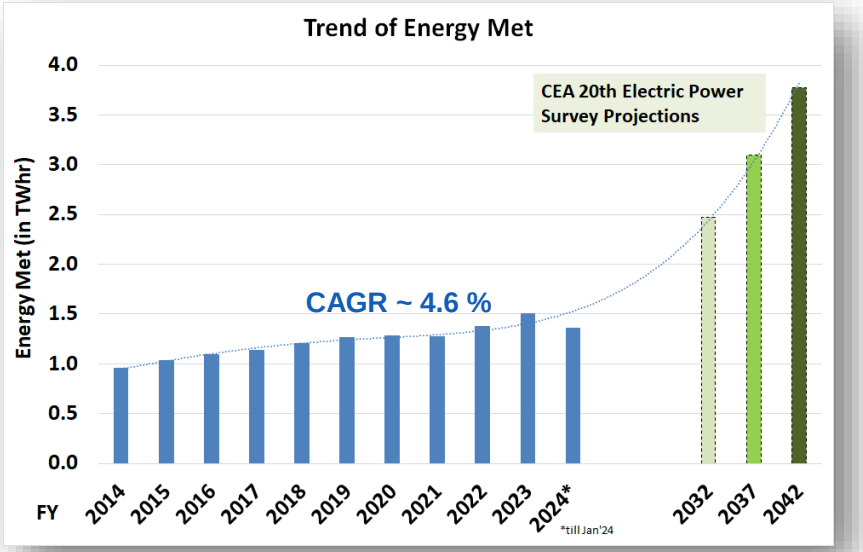
4.5 GW+
international exchanges

160 TWh+
annual market trades

6000+
market participants

Growth Story…looking back to leap forward…



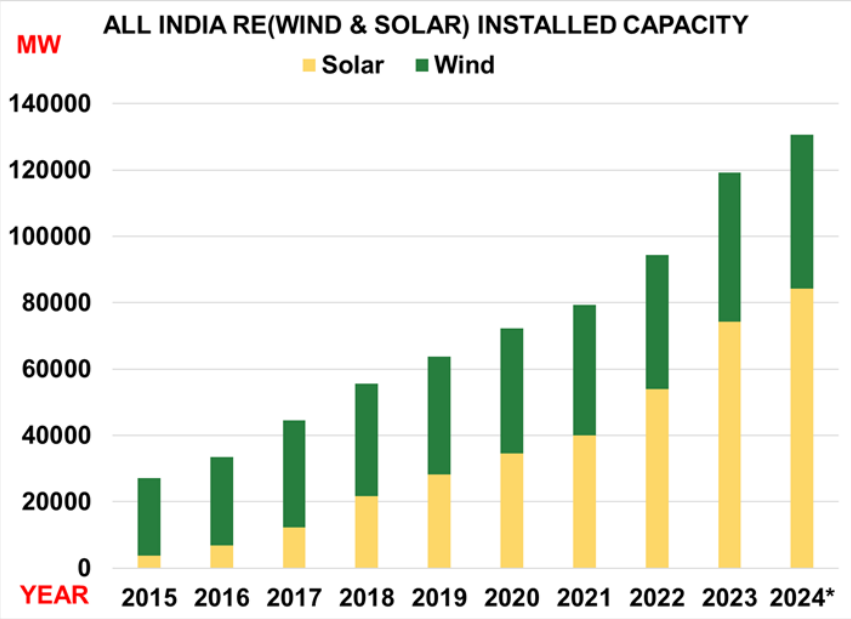


Drivers for Future Growth (Gen-Z loads)

- Electric Cooking
- Electric Vehicles
- Electrolyzers
- Data Centres
- Space Cooling

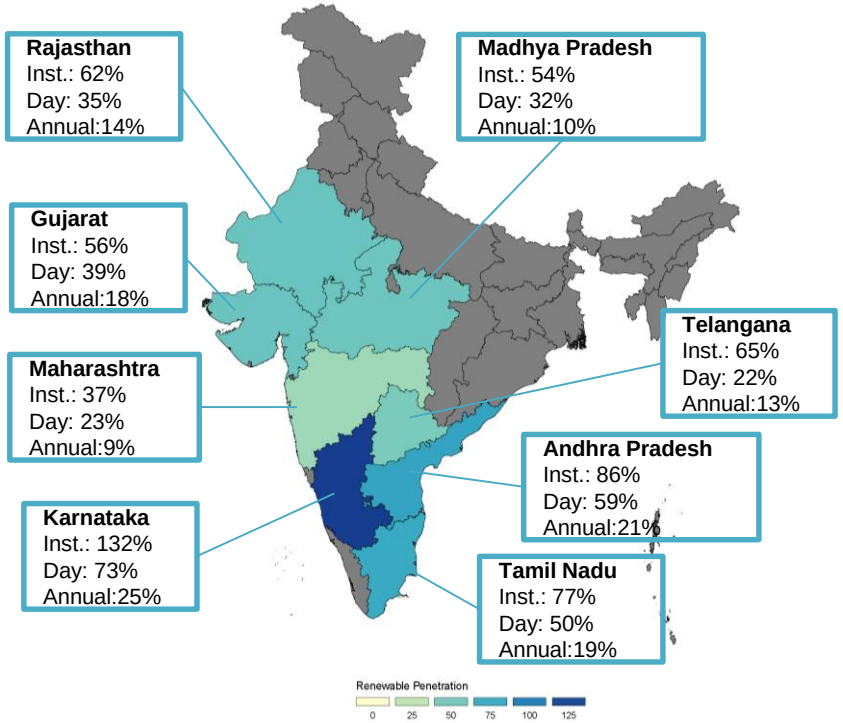
\+ Decarbonization Goals

India's Journey with Renewables



*** Till June 2024**
Source: CEA Installed Capacity Report (data as on June 2024)
https://cea.nic.in/installed-capacity-report/?lang=en

Maximum Wind + Solar penetration in instantaneous MW and energy (day/year) terms – FY 2023-24



Highest Instantaneous RE penetration of ~33% recorded - 6th July 2024

Changing Generation Resource Mix towards 2030

All India Installed Capacity (MW)			
Resource	Mar-24	Mar-30	% Addition
Hydro	46928	53860	15%
PSP	4746	5350	13%
Small Hydro	4994	18986	280%
Solar PV	75575	292566	287%
Wind	45153	99895	121%
Biomass	10845	14500	34%
Nuclear	7480	15480	107%
Coal + Lignite	217589	251683	16%
Gas	25038	24824	-1%
Total	438348*	777144**	77%
BESS	0	41650 (5 hr)	

	2024	2030
Maximum Demand Met (GW)	250	334^
Total Generation Installed Capacity (GW)	445*	777
Non-fossil Fuel Based Generation Installed Capacity (GW)	203*	500
Wind & Solar Installed Capacity (GW)	132*	393

Source: CEA Report on Optimal Generation Capacity Mix for 2030 (Ver 2.0)
As on June 2024 as per Operational Data of Grid-India
* **As on June 2024** from CEA Installed Capacity Report
^ 20th EPS Survey by CEA

Key Provisions of Indian Electricity Grid Code, 2023 notified on 29th May, 2023

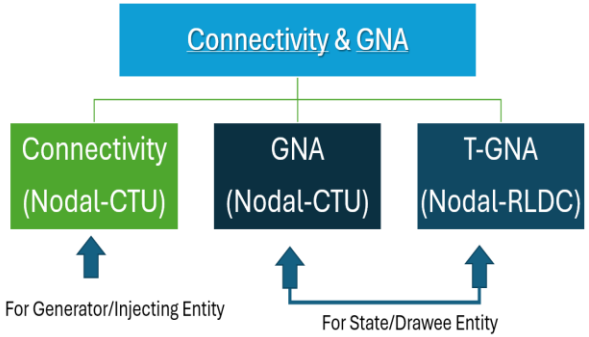
- Resource Adequacy & Resilience
- Unit Commitment and Economic Despatch
- Frequency Response Performance Assessment
- Primary, Secondary and Tertiary Reserves
- Load and Renewables Forecasting
- Reactive Power and Inertia Support
- Communication and Telemetry at RE Pooling Stations
- Compliance Verification and Periodic Testing
- Provisions for Cyber Security

Paradigm shift in Grid Code w.r.t. Transmission Access, Resource Adequacy and Scheduling

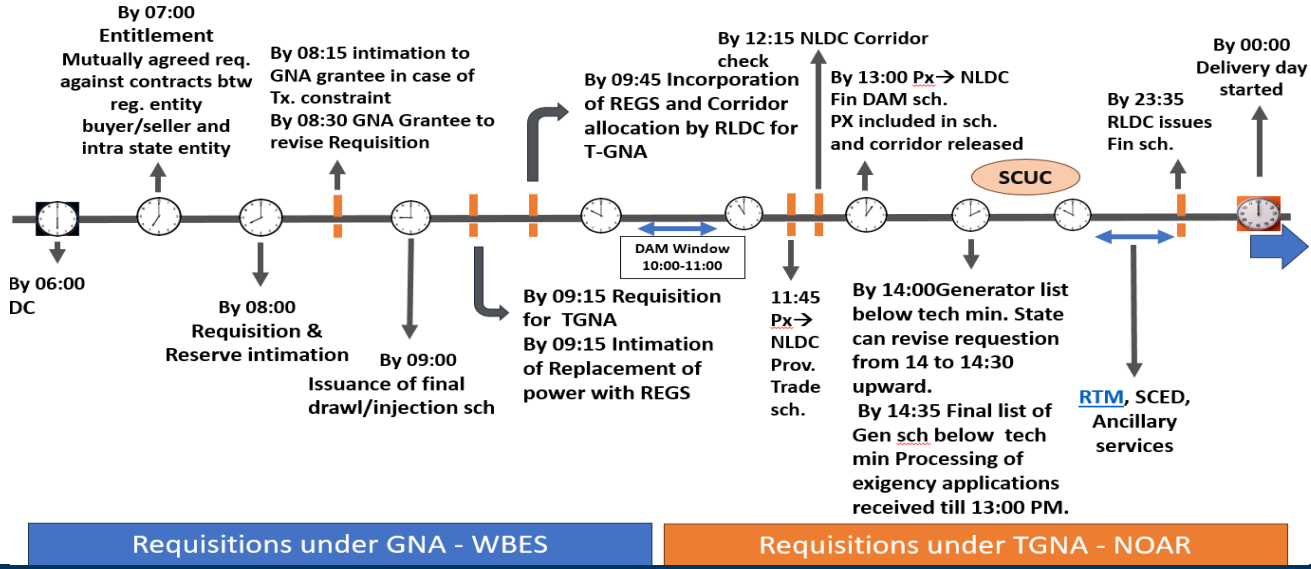
Grid Access & Scheduling Activity driving market transition

Use it or lose it !	Access and PPA delinked	Flexibility	Optimization
Market Access	Freedom & Choice	Balancing	Benefit Sharing
Payment Security – Financial Sustainability			

Grid Access – Scheduling Pre-requisite



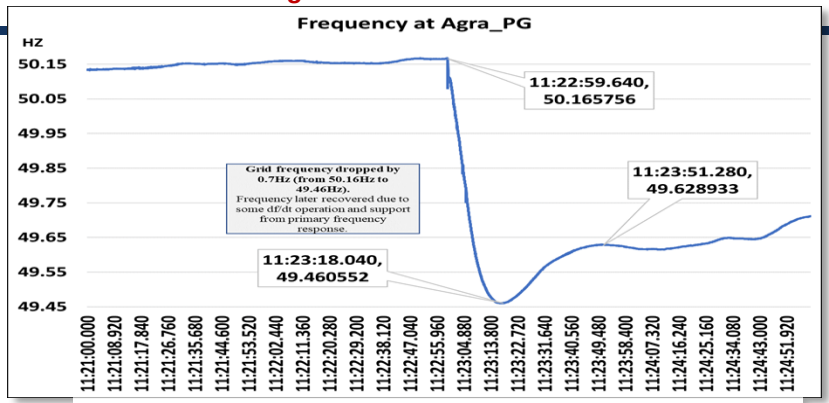
Scheduling Timeline

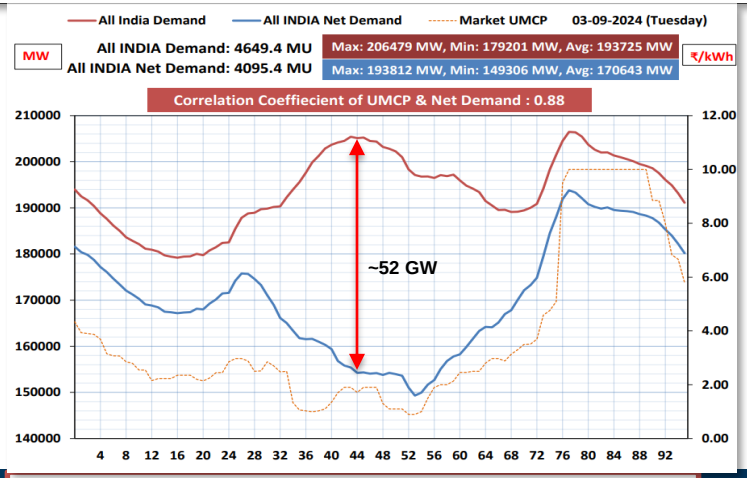


Major Operational and Planning Challenges

Renewable integration in India unique in terms of concentrated capacity addition	Possibility of large disturbance/generation loss in case of any non-compliance	Challenges in ensuring sufficient system strength in remotely located RE pockets
Lack of Black Start sources in remote RE pockets	Power quality issues due to large number of converter based devices	Low gestation period of renewables vis-à-vis transmission
Resource Adequacy concerns especially in low renewable generation periods	Increasing ramping requirement and lack of commensurate flexible generating resources	Renewable forecasting accuracy related challenges

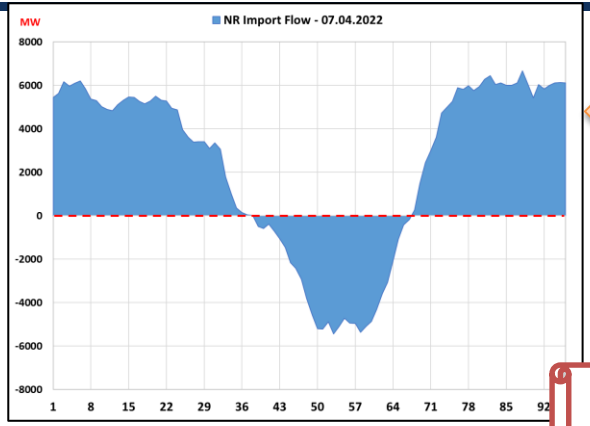
Huge RE Generation Loss





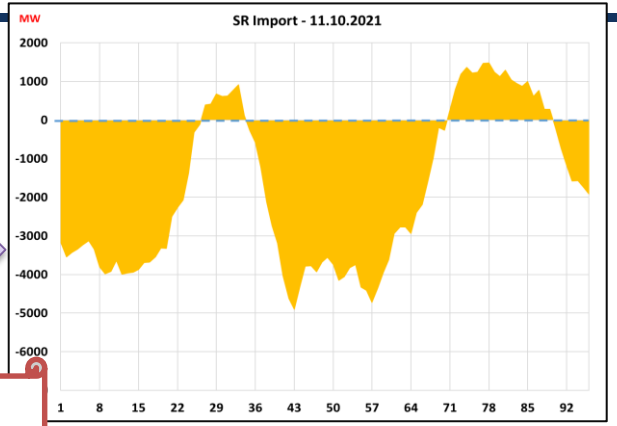
Increasing "Duck Curve" Belly !!

Transmission Flows – Behaviour Change

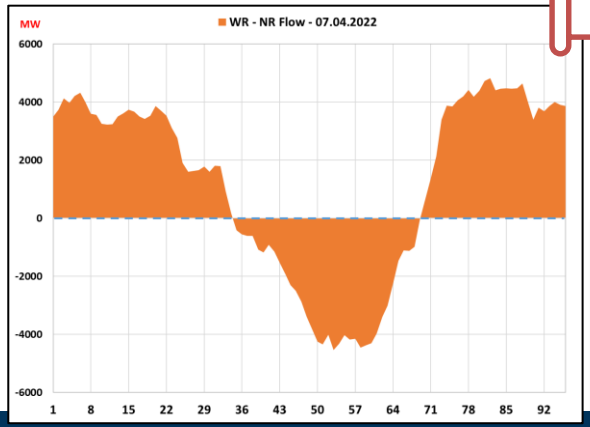


NR Import

SR Import

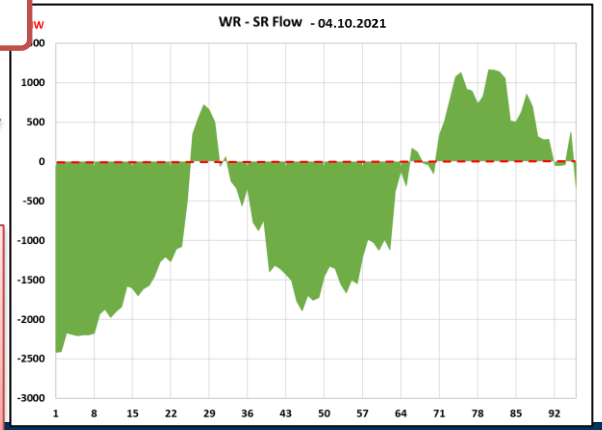


Bi-directional Flows The New Normal !!



WR -SR

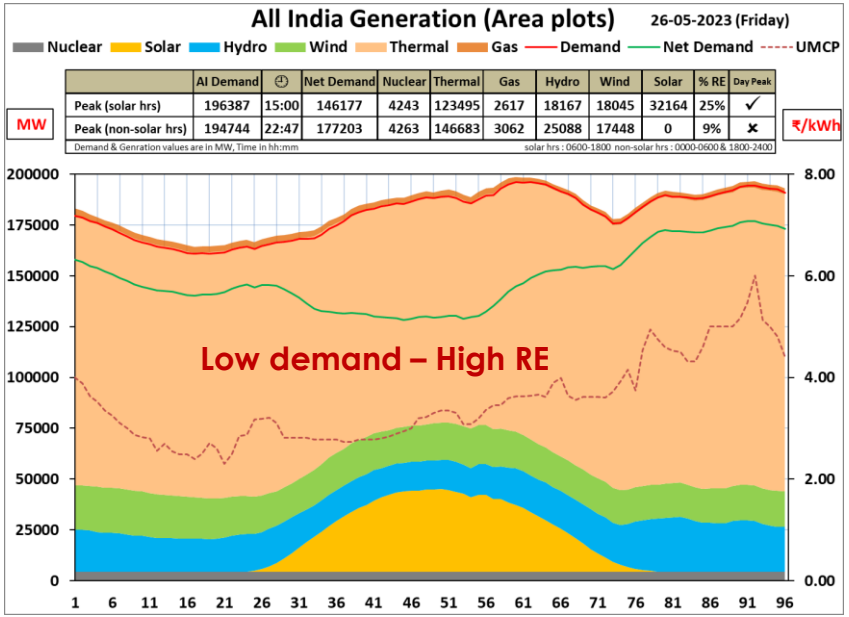
WR - NR



Large Diurnal and Seasonal Variation in IR Flows

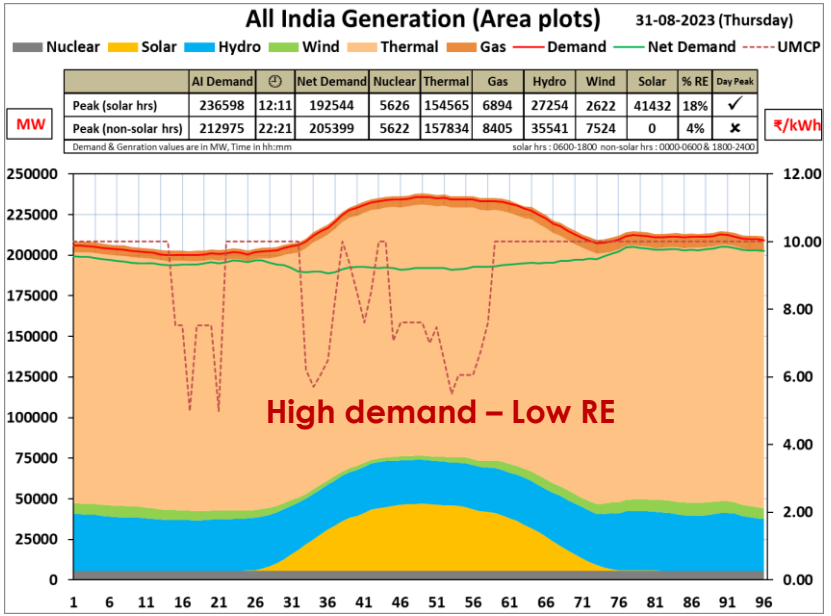
Resource Adequacy to be ensured in all Time-Frames

- Resource Adequacy Challenges due to the variability of RE
- Reserve requirements and system constraints would also vary



	AI Demand		Net Demand	Nuclear	Thermal	Gas	Hydro	Wind	Solar	% RE	Day Peak
Peak (solar hrs)	196387	15:00	146177	4243	123495	2617	18167	18045	32164	25%	✓
Peak (non-solar hrs)	194744	22:47	177203	4263	146683	3062	25088	17448	0	9%	✗

Demand & Genration values are in MW, Time in hh:mm — solar hrs : 0600-1800 non-solar hrs : 0000-0600 & 1800-2400



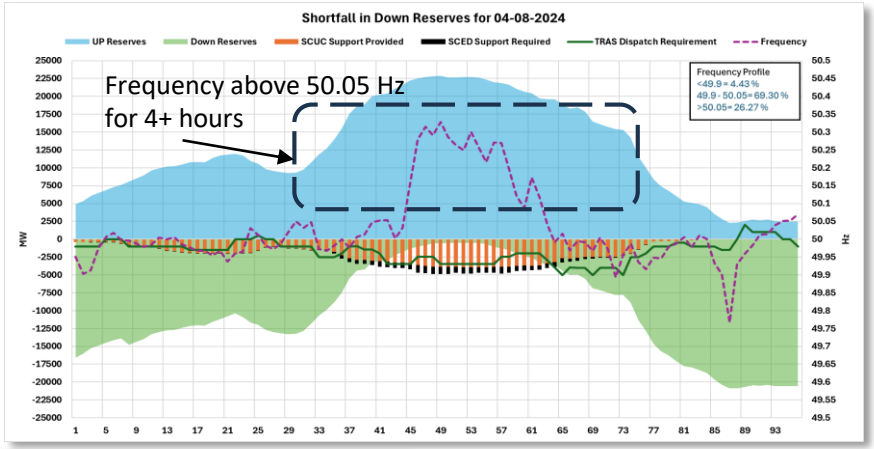
	AI Demand		Net Demand	Nuclear	Thermal	Gas	Hydro	Wind	Solar	% RE	Day Peak
Peak (solar hrs)	236598	12:11	192544	5626	154565	6894	27254	2622	41432	18%	✓
Peak (non-solar hrs)	212975	22:21	205399	5622	157834	8405	35541	7524	0	4%	✗

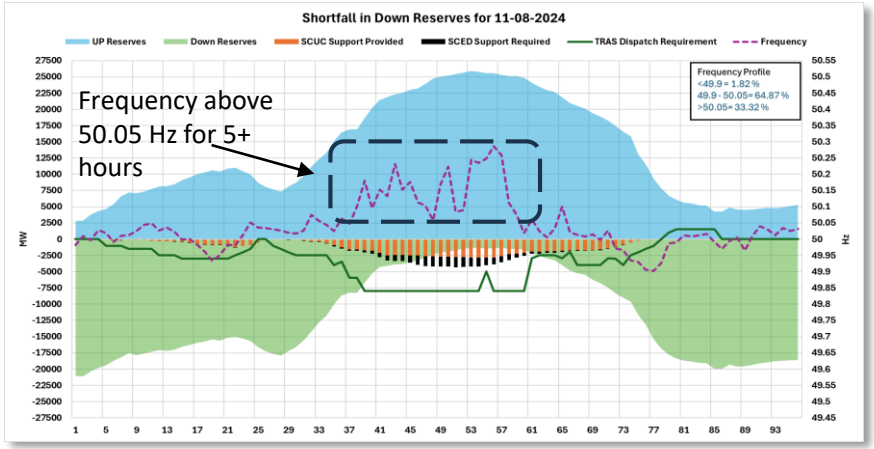
Demand & Genration values are in MW, Time in hh:mm — solar hrs : 0600-1800 non-solar hrs : 0000-0600 & 1800-2400

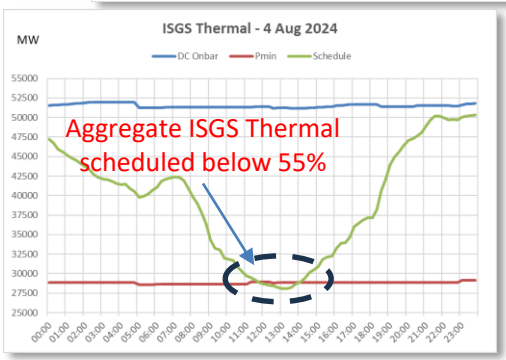
Highest Instantaneous RE penetration (in 23-24) of ~31 % was recorded on 26th May 2023

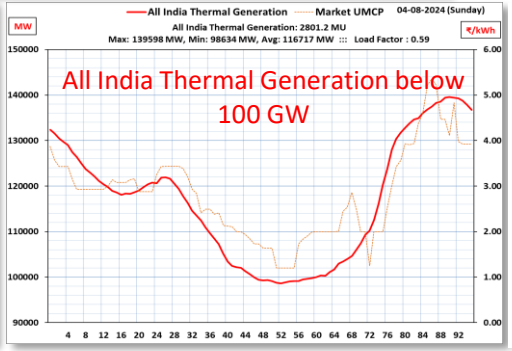
Low RE penetration during High Demand Season 31st August 2023

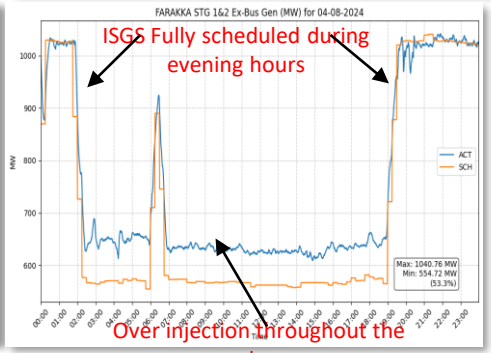
Growing need for flexibility (Case studies 4th and 11th August)

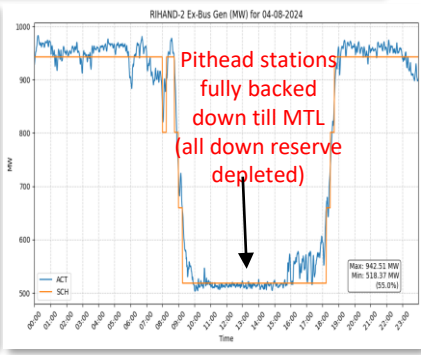












Insufficient down reserves to maintain frequency. Also, available down reserves less than MTL support req.

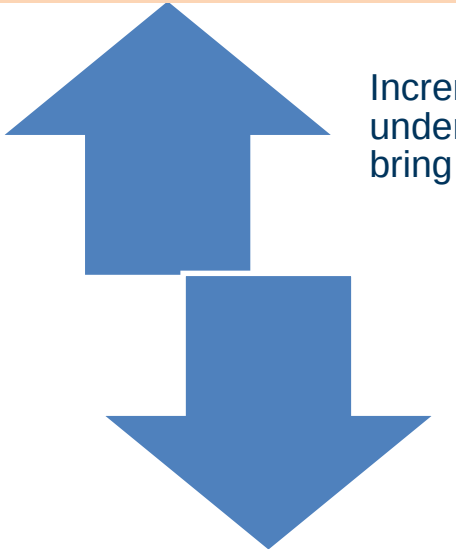
Similar pattern being observed frequently!

RE curtailment reported by some states !

Security Constrained Unit Commitment (SCUC)

Commit generating station or unit (scheduled below min. turndown level) for reserve maximization in interest of grid security on D-1 basis. If needed NLDC can carry out SCUC in D-3 basis

Applicable on: **Sec 62 generators** (mandatory) and other regional entity generators (may opt)



Incremental schedule from gen. under min. turndown level to bring sch. till the same level

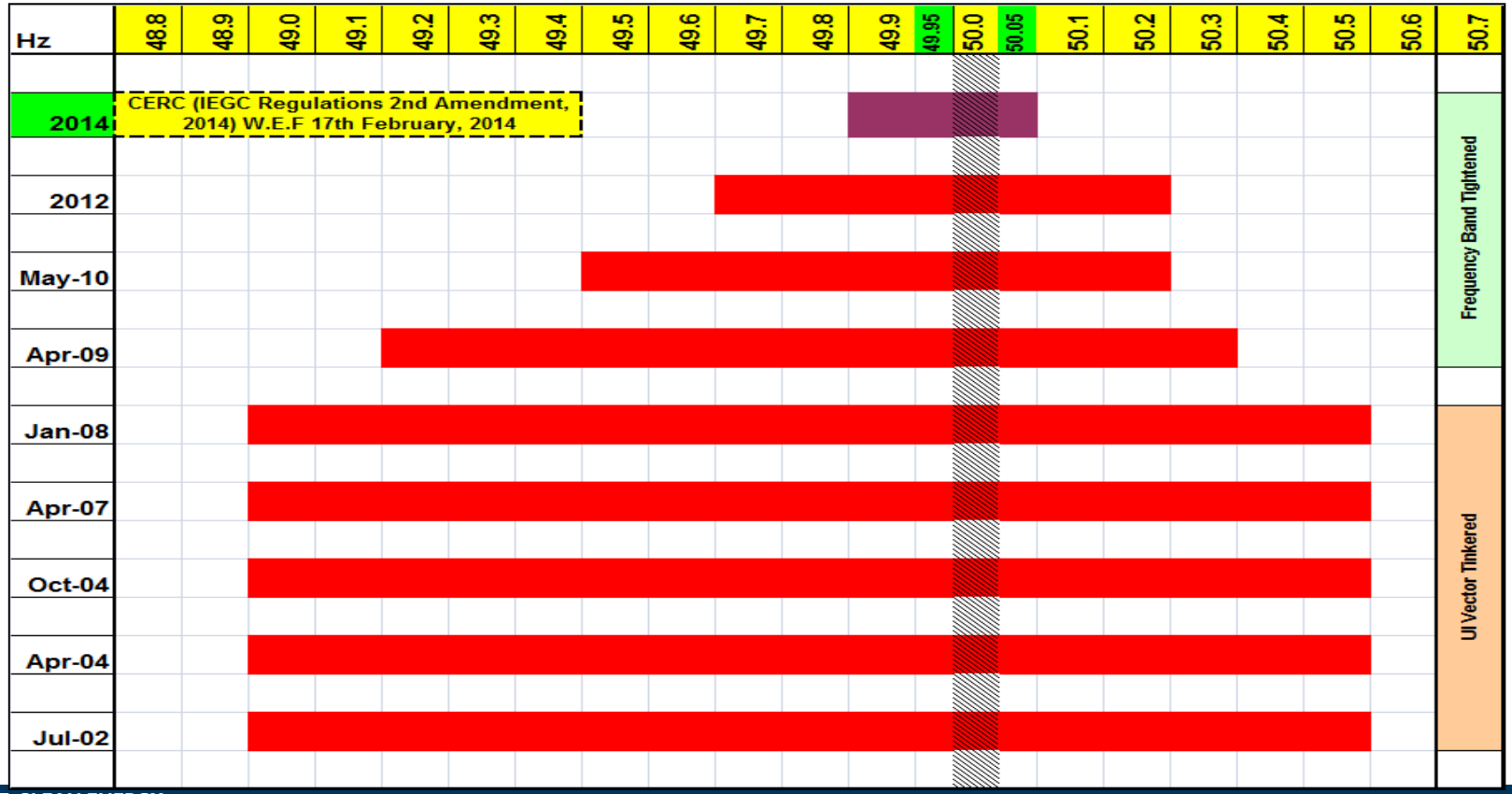
Equivalent reduction in generators till min. turndown level starting from highest VC

Conditions for deploying SCUC

Extreme variation of weather conditions	High load forecast
For Grid Security	Network Congestion


Deviation Settlement Mechanism (DSM)

Operative Frequency Band



Deviation Settlement Mechanism 2024

- Deviation charges are linked to Frequency with various slope for General Sellers & Buyers.
- **F_{band} = 49.90 Hz to 50.05 Hz**
- The charges for deviation for injection of infirm power being scheduled, the charges for deviation for such power shall be as applicable for a general seller **or WS seller, as the case may be.**
- Various **Deviation Volume limits** for Sellers and Buyers.
- Deficit in DSM Pool Account will be recovered:
  - **Up to 31.03.2025**: in the ratio of [50% in proportion to their drawal at the regional periphery] and [50% in proportion to their GNA].
  - **From 01.04.2025**: 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.

Deviation Settlement Mechanism 2024

❑ Normal Rate (NR) of charges is maximum of A, B , C

(A) the weighted average ACP (in Paise /kWh) of the Integrated-Day Ahead Market segments of all the Power Exchanges;

(B) the weighted average ACP (in Paise /kWh) of the Real Time Market segments of all the Power Exchanges;

$$(C) = \frac{1}{3}\left[\text{Weighted average ACP (in paise/kWh) of the } \textbf{Integrated-Day Ahead Market} \text{ segments of all the Power Exchanges}\right] + \frac{1}{3}\left[\text{Weighted average ACP (in paise/kWh) of the } \textbf{Real-Time Market} \text{ segments of all the Power Exchanges}\right] + \frac{1}{3}\left[\text{Ancillary Service Charge (in paise/kWh) computed based on the total quantum of } \textbf{Ancillary Services} \text{ deployed and the net charges payable to the Ancillary Service Providers for all the Regions}\right]$$

Deviation Settlement Mechanism 2024

- Changes in definition of **RE Rich State** and new definition is added & termed as "**RE Super-rich state**".
  - **'Renewable Rich State' or 'RE-rich State':** State whose combined installed capacity of solar and wind generating stations under the control area of the State is 1000 MW or more **but less than 5000 MW**.
  - **'Renewable Super Rich State' or 'RE Super-rich State':** State whose combined installed capacity of solar and wind generating stations under the control area of the State is 5000 MW or more.
- **'Contract rate'** means
  - Wind, Solar, WS Hybrid, Municipality Solid Waste (MSW) seller or such other entity
    - Rs/kWh tariff as determined or adopted or approved by the Appropriate Commission under Section 62 or Section 63 or Section 86(1)(b) of the Act
    - Price as discovered in the Power Exchange for the respective transaction, whose tariff is not determined or adopted or approved under Section 62 or Section 63 or Section 86(1)(b) of the Act, and selling power through power exchange(s),
  - For captive consumption of a captive generating plant based on renewable energy sources, the weighted average ACP of the Integrated-Day Ahead Market segments of all Power Exchanges for the respective time block
  - In case of multiple contracts or transactions including captive consumption, the weighted average of the contract rates of all such contracts or transactions

Deviation Settlement Mechanism 2024

- ‘Reference Charge Rate’ or ‘RR’ means
  - General seller
    - Rs/ kWh energy charge as determined or adopted or approved by the Appropriate Commission whose under Section 62 or Section 63 or Section 86(1)(b) of the Act ,
    - Price as discovered in the power exchange for the respective transaction whose tariff is not determined or adopted or approved under Section 62 or Section 63 or Section 86(1) (b) of the Act, and selling power through power exchange(s),
  - Captive generating plant based on resources other than renewable energy sources, the weighted average ACP of the Integrated-Day Ahead Market segments of all the Power Exchanges for the respective time
  - For multiple contracts or transactions including captive consumption, the weighted average of the reference rates of all such contracts or transactions.
- Run-of-River Generating Station’ or ‘RoR generating station’ means a hydro generating station which does not have upstream pondage;
  - IEGC 2023 : Run-of-River Generating Station segregation : less than 3 hours pondage and more than 3 hours pondage
  - Generally, all ROR generating stations are designed with a small pondage
  - Hence, the definition can be Run-of-River Generating Station’ or ‘RoR generating station’ means a hydro generating station which does not have upstream pondage upto 3 hours to be considered

Deviation Settlement Mechanism 2024

- ‘Available Capacity' for generating station based on wind or solar or hybrid of wind solar resources, which are regional entities, is the cumulative capacity rating of wind turbines or solar inverters that are capable of generating power in a given time block;
- **Deviation in a time block for WS sellers shall be computed as follows:**

Up to 31.03.2026 :

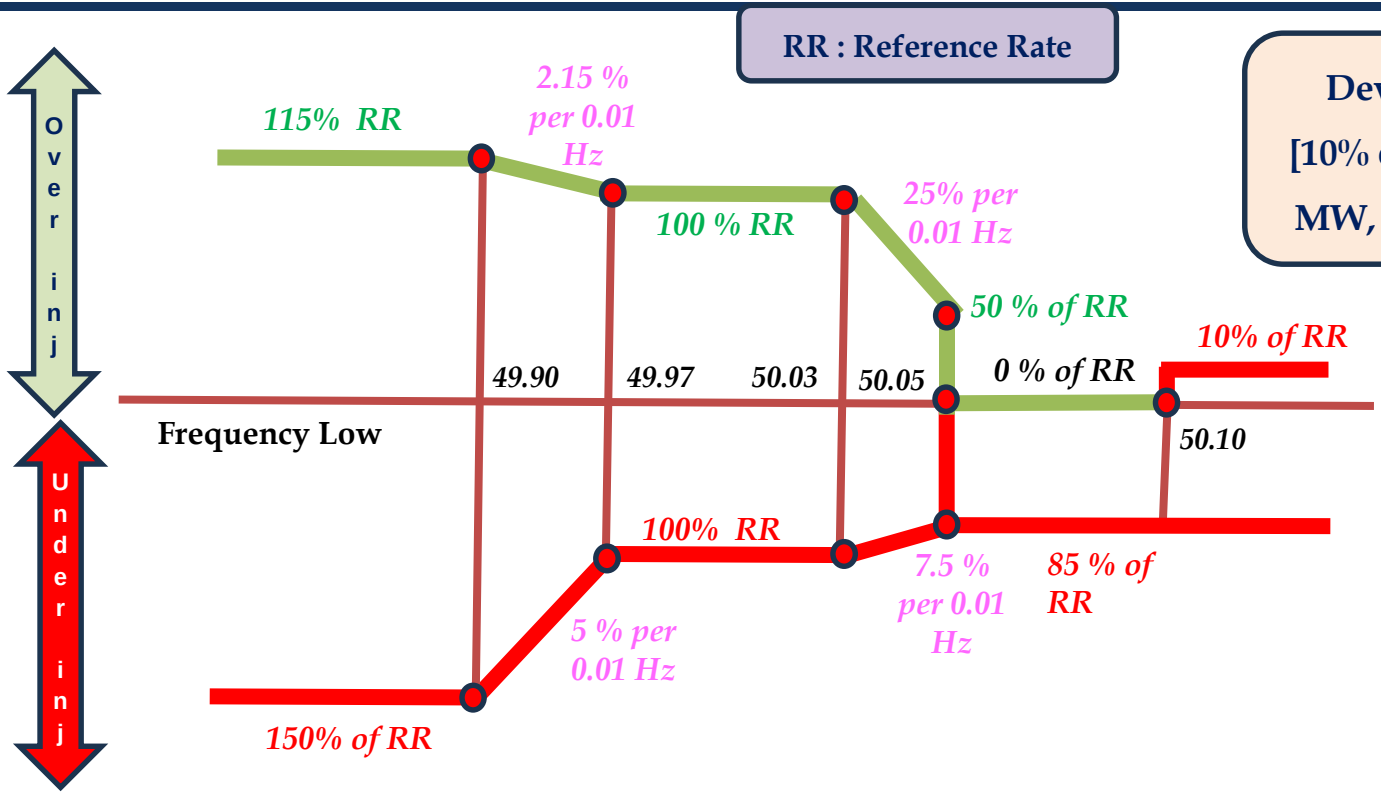
- Deviation-WS seller (DWS) (in %) = 100 x [(Actual Injection in MWh) – (Scheduled generation in MWh)] / [(Available Capacity)]

From 01.04.2026 onwards

Deviation-WS seller (DWS) (in %) = 100 x [(Actual Injection in MWh) – (Scheduled generation in MWh)] / [(X% of Available Capacity) + (100-X) % of Scheduled Generation):

Provided ‘X’ shall be stipulated by the Commission through separate order(s) after public consultation

DSM Framework for General Seller and Standalone Energy Storage System



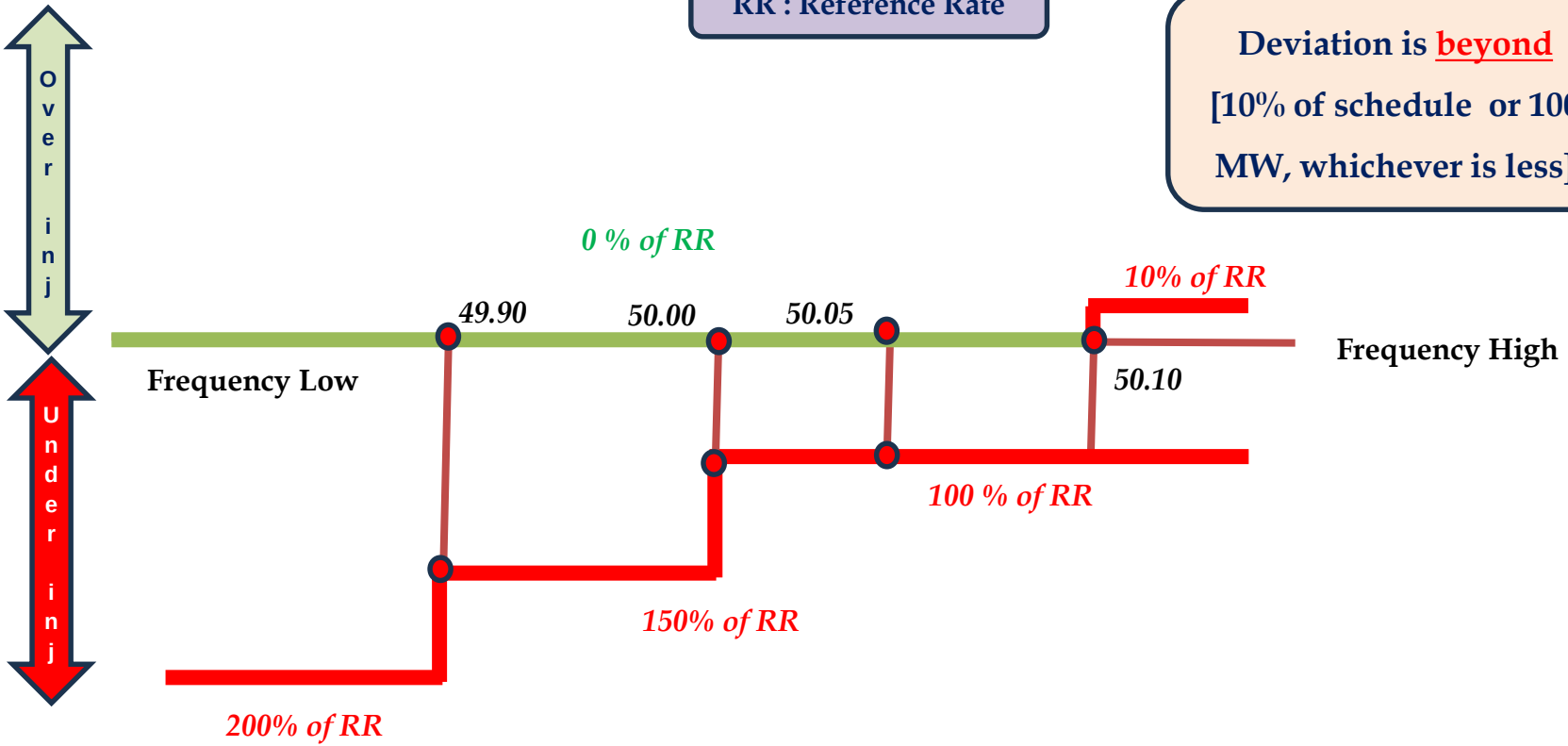
Deviation is within

[10% of schedule or 100 MW, whichever is less]

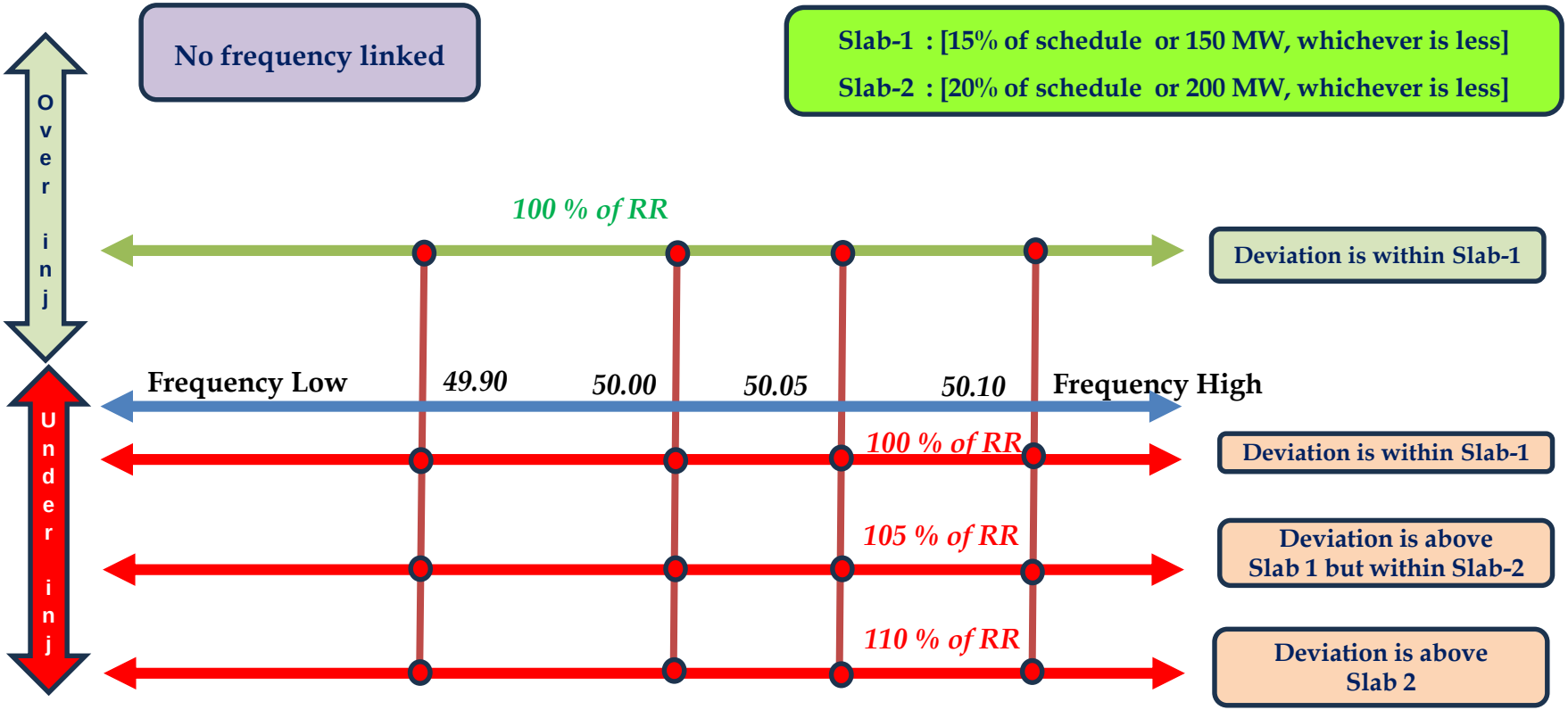
DSM Framework for General Seller and Standalone Energy Storage System

RR : Reference Rate

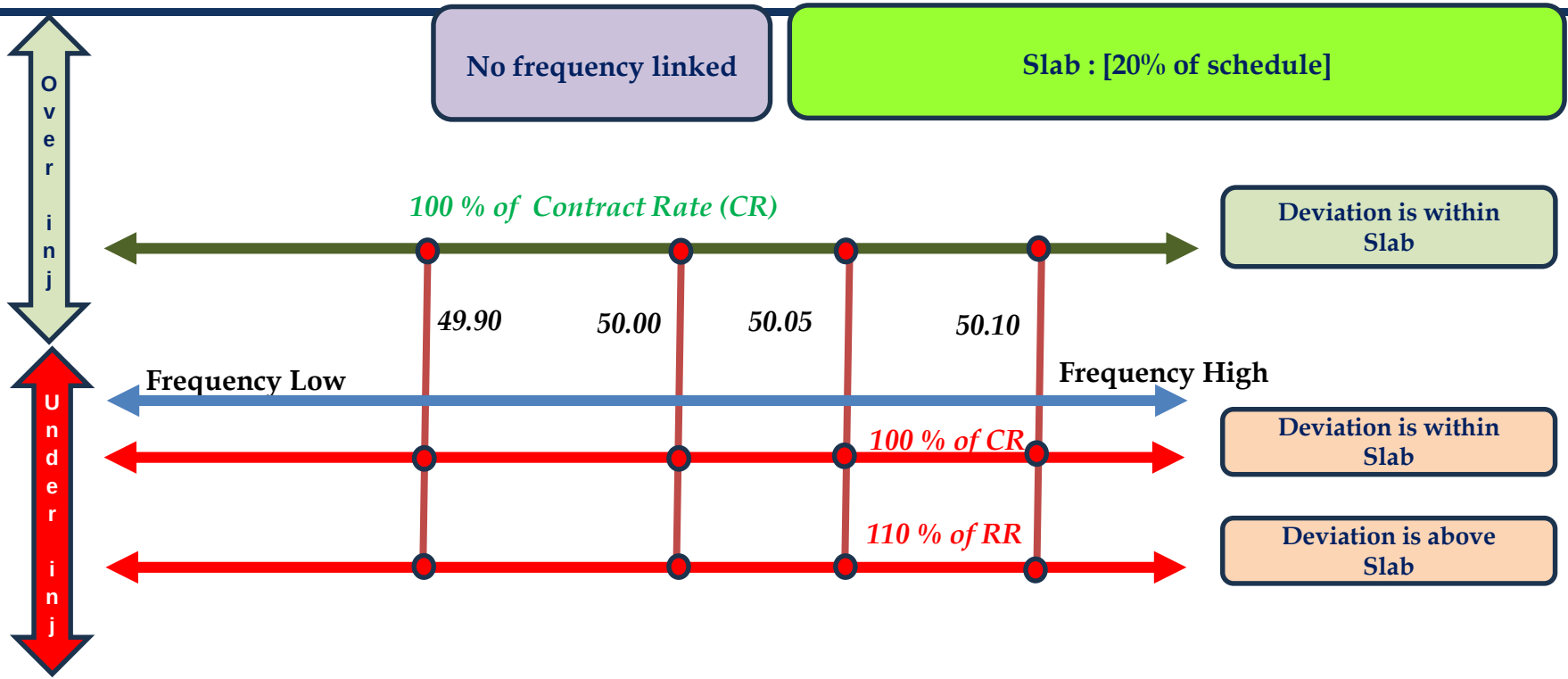
Deviation is beyond [10% of schedule or 100 MW, whichever is less]



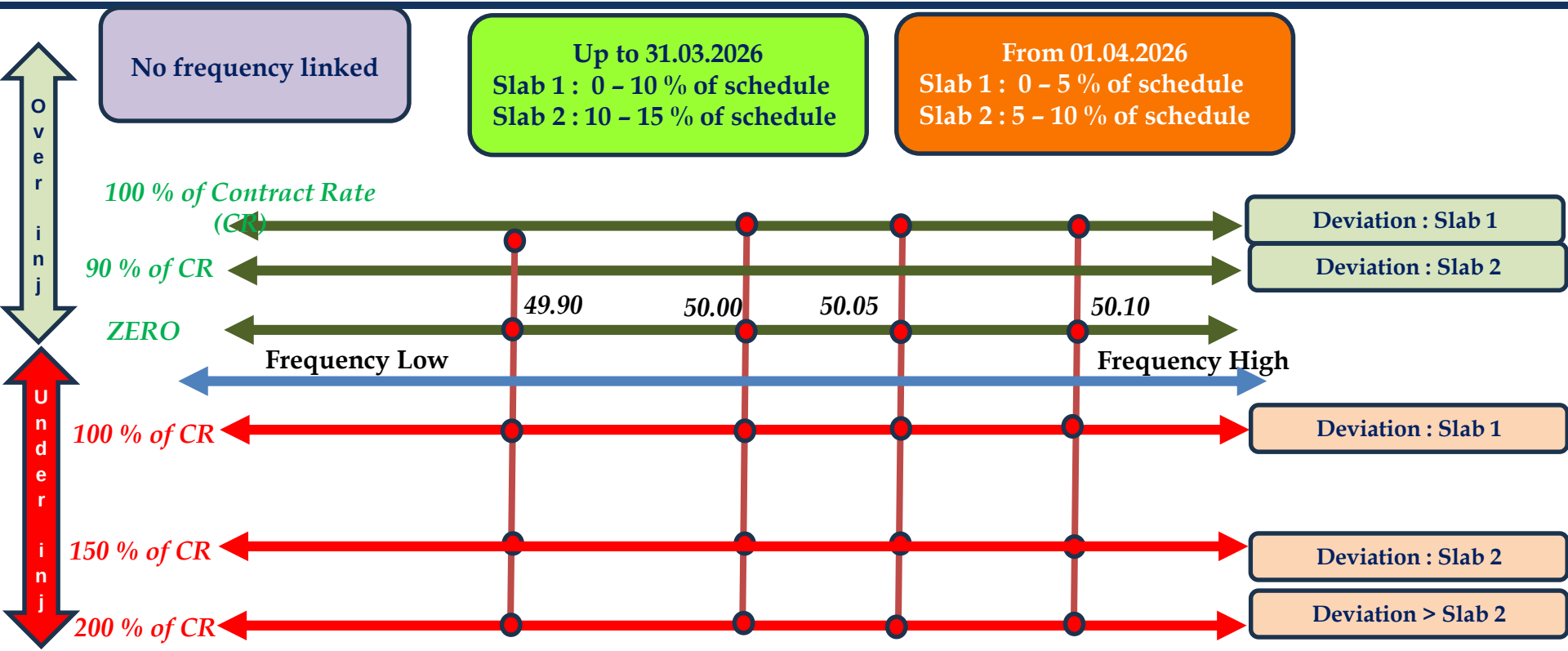
DSM Framework for Run of the River



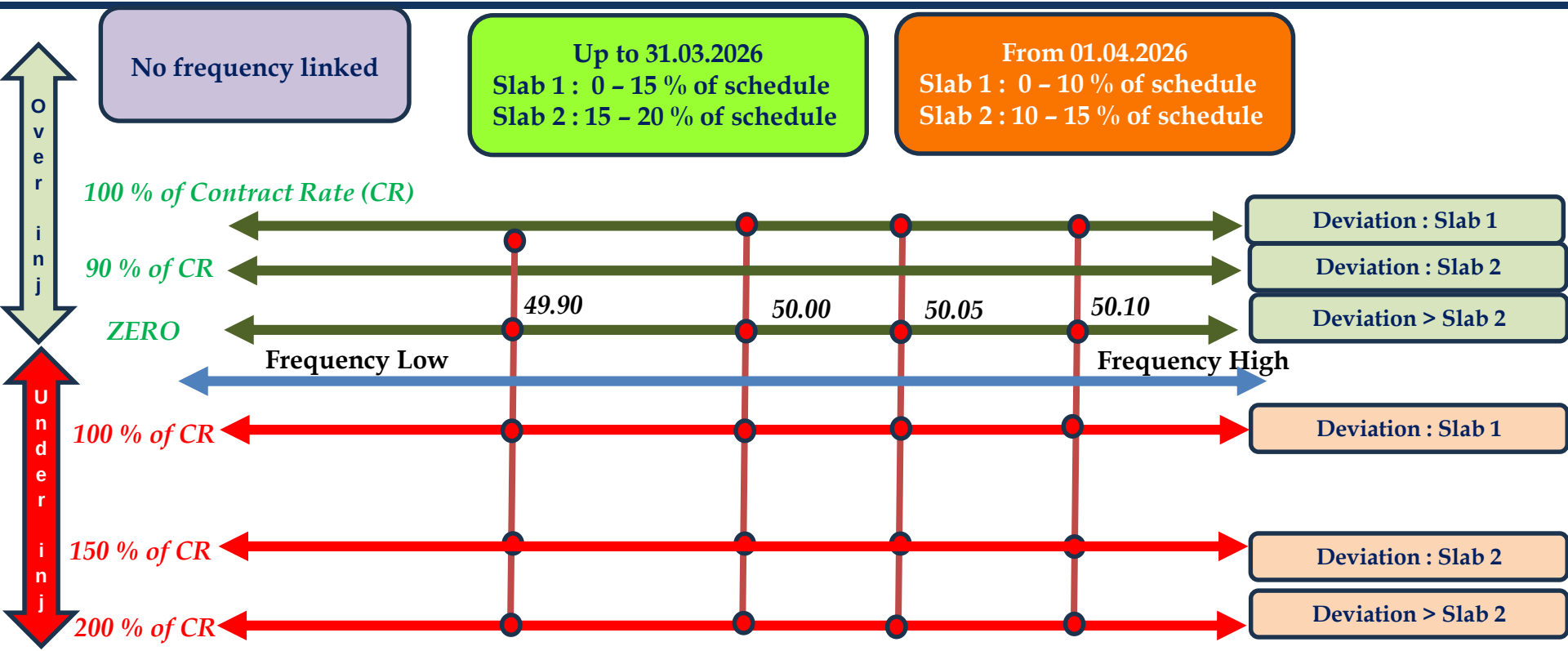
DSM Framework for Municipal Solid Waste Generation



DSM Framework for Solar and Hybrid of Wind Solar Generators



DSM Framework for Wind Generators



DSM Framework for Wind, Solar and Hybrid of Wind Solar Generators : QCA

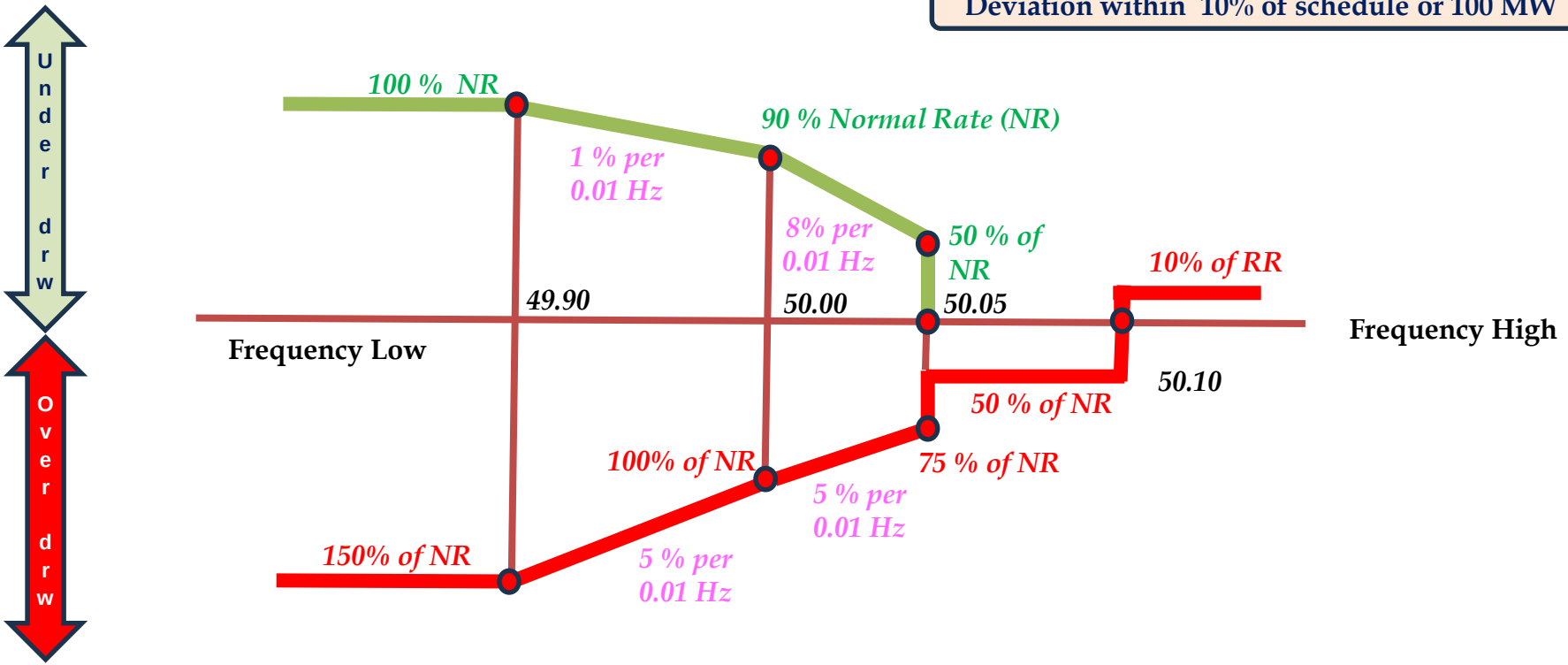
- Contract rate for the purpose of deviation shall be equal to the weighted average of the contract rates of all individual Wind, Solar seller(s) opting for aggregation at the pooling station
- Available Capacity shall be equal to the cumulative capacity rating of wind turbines or solar inverters that are capable of generating power in a given time block
- Depooling of deviation charges for Wind, Solar seller(s) connected to the pooling station shall be as per the methodology mutually agreed upon between the QCA and such individual Wind, Solar seller(s)
- Charges for Deviation, in respect of an ESS co-located with WS Seller(s) connected at the same interconnection point, shall be as follows:
  - Deviation as per WS seller : when solar, wind or hybrid of wind-solar seller is injecting
  - Deviation as per general seller : when ESS component is only injecting or drawing and WS component has zero schedule
- Charges for Deviation, in respect of standalone ESS shall be as follows:
  - Deviation as per WS seller
  - Over drawal shall be treated as under injection and under drawal shall be treated as over injection

Volume Limit : Different Buyer Category

Buyer Category	Slab 1	Slab 2	Slab 3
Buyer with schedule more than 400 MW and the RE-rich State	10% of schedule or 100 MW	15% of schedule or 200 MW	above 15% of schedule or 200 MW
Buyer with a schedule less than 400 MW	20% of schedule or 40 MW	above 20% of schedule or 40 MW	above 20% of schedule or 40 MW
Buyer being RE-rich State 1000 MW < RE capacity < 5000	200 MW	200 MW to 300 MW	above 300 MW
Buyer being Super RE-rich State 5000 MW < RE capacity	250 MW	250 M Wto 350 MW	above 350 MW

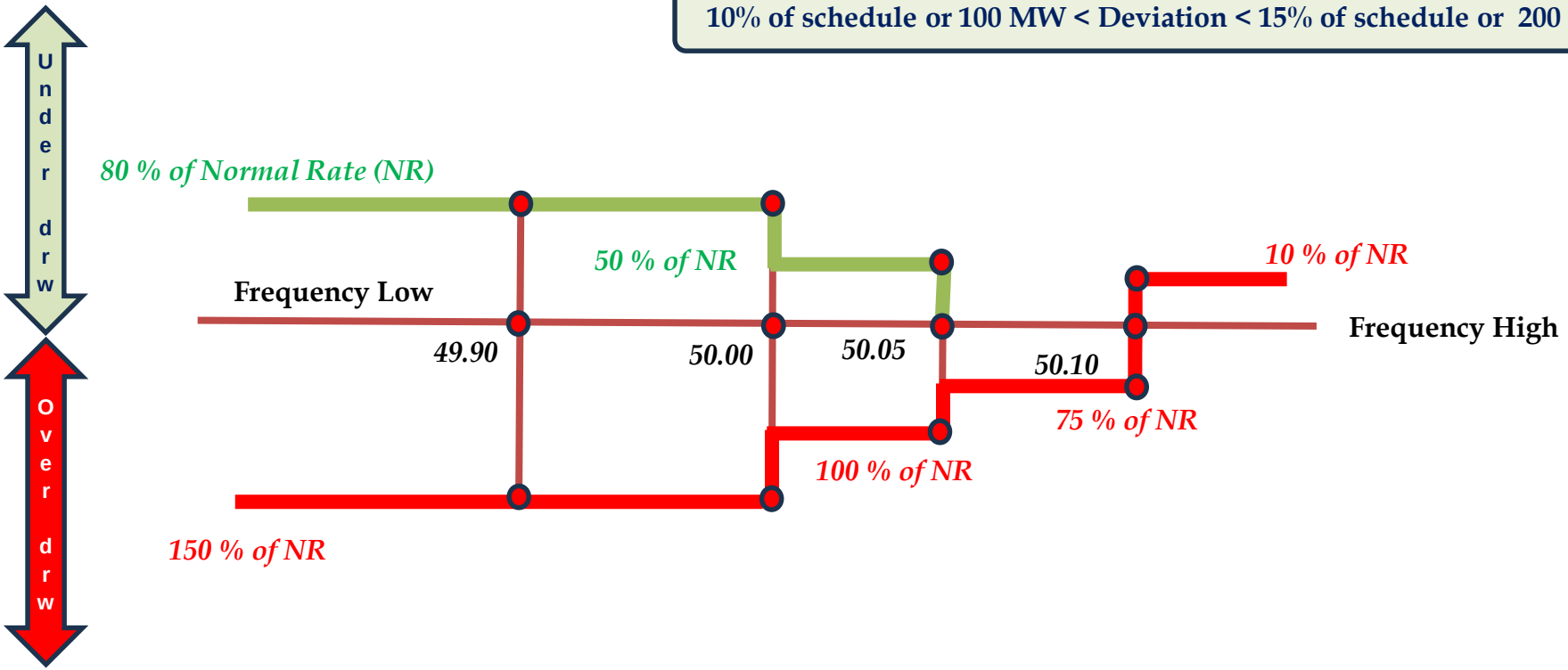
DSM Framework for Buyer

Deviation within 10% of schedule or 100 MW



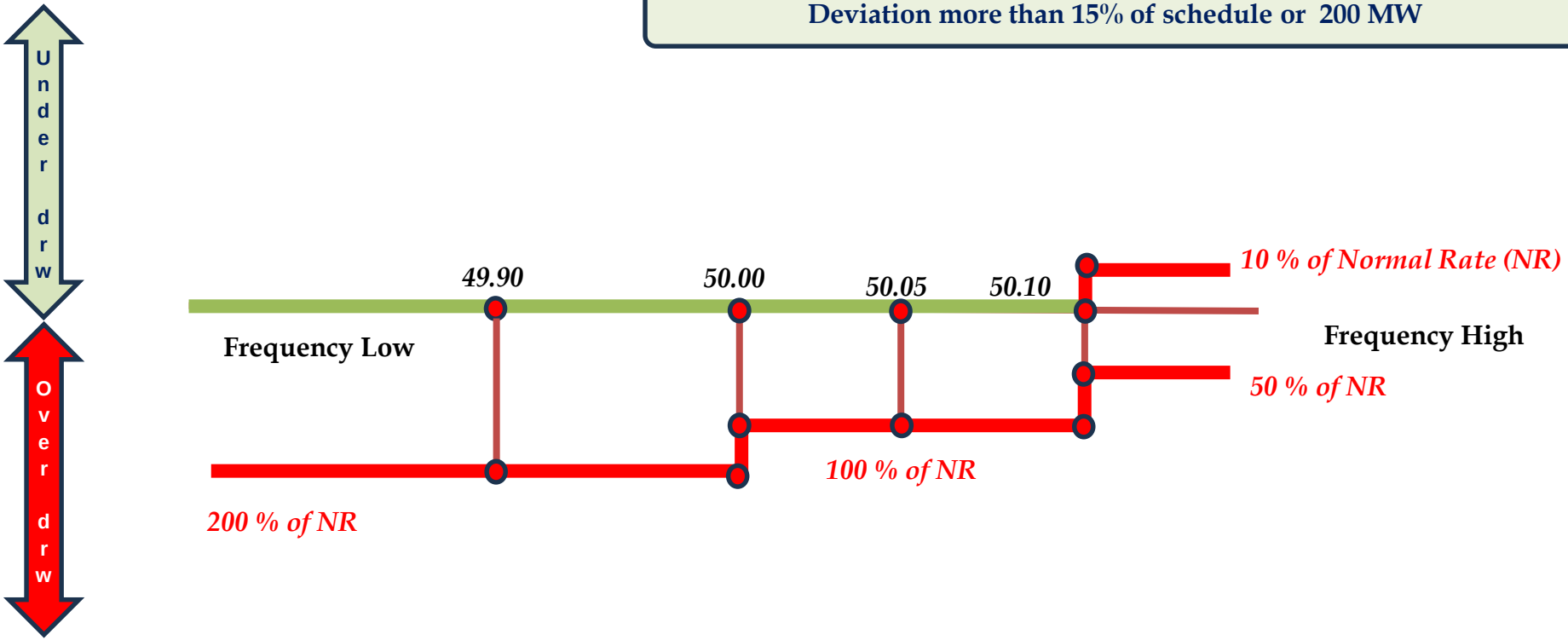
DSM Framework for Buyer

10% of schedule or 100 MW < Deviation < 15% of schedule or 200 MW



DSM Framework for Buyer

Deviation more than 15% of schedule or 200 MW

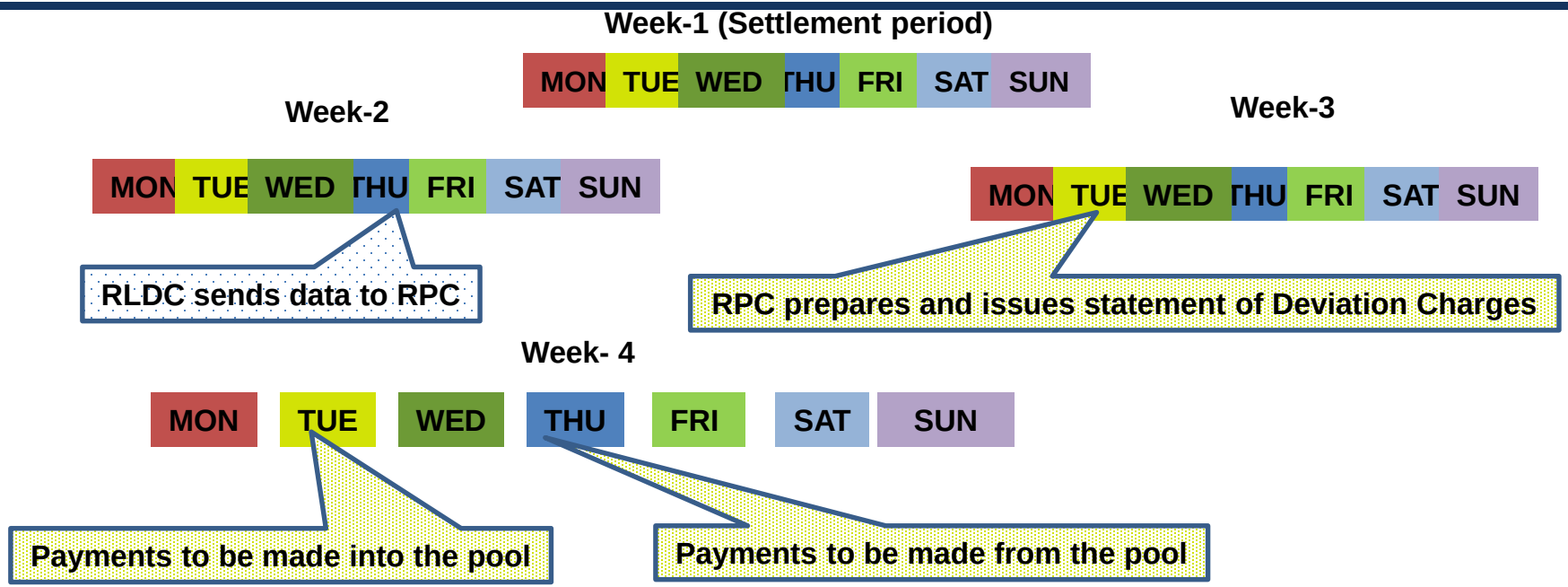


Deviation Settlement Mechanism pool

❑ Deficit in the Deviation and Ancillary Service Pool Account :

- ❖ DSM Pool Accounts of other regions shall be used for settlement of payment
- ❖ If 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 31.03.2025, in the ratio of [50% in proportion to their drawal at the regional periphery] and [50% in proportion to their GNA];
  - ➢ from 01.04.2025, 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.

Deviation Charges Timelines



- Payments received beyond 7 days will attract simple interest @ 0.04% per day.
- Defaulters to open LC equal to 110 % of its average payable weekly liability of previous year.
- LC to be encashed for defaulters and LC to be recouped by 3 days
- Surplus amount from deviation account to be transferred to PSDF fund on half yearly basis

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