

Overview of Power Markets

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Market Design Contours

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3. Scheduling, Dispatch, and Settlement
 - *Centralised Dispatch vs Decentralised scheduling and Dispatch*
4. Congestion Management and Imbalance Settlement

Comparison of Different Markets (1/5)

Market Design Consideration	India	USA	UK	Europe
Resource Adequacy / Capacity Market	Long Term PPA	Capacity Contracts (except ERCOT)	Capacity Contract	Capacity Contract
Day-Ahead and Real Time Market Design				
Market clearing in Day Ahead Market (DAM)	Self-Scheduling outside market/Double-sided closed auction in PX	Double sided closed auction	Double sided closed auction	Double sided closed auction
Bilateral Contracts required to submit bid on exchanges?	No (Bilateral Contracts and Exchange Bids are mutually exclusive)	Mandatory (In case of bilateral contracts, volumes only bids to be submitted and they will be price takers)	Voluntary	Voluntary

Comparison of Different Markets (2/5)

Market Design Consideration	India	USA	UK	Europe
Day-Ahead and Real Time Market Design (... continued)				
Single or Multiple Exchanges	Multiple	No Exchange (ISO handles market operation)	Multiple	Multiple
Market Operation + System Operation together or separate?	Separation between Exchanges and System Operator (exchanges perform only part component of market operation)	Embedded into the function of System Operator	Separated between Exchange and System Operator	Separated between Exchange and System Operator

Comparison of Different Markets (3/5)

Market Design Consideration	India	USA	UK	Europe
Transmission Planning, Transmission Access and System Operation				
Transmission System Owner and Operator : Separate or Integrated	<u>Inter-State</u> : Separate <u>Intra-State</u> : STUs own the system. SLDC is the system operator	Owner and System Operator are separated. ISOs and RTOs are not-for-profit independent with no ownership of assets	Earlier NGET was Owner+Operator Now, NGET is Owner and NESO is Operator	<u>Netherlands, France</u> – Single Owner/Operator <u>Germany</u> – 4 System Operators with separate jurisdiction
Single or Multiple Grid Operators	Hierarchical structure at state, regional and national level for same geography. <u>National</u> – (One national and five regional) <u>State</u> – SLDCs	9 ISOs / RTOs in USA – 2/3 rd of energy is traded through ISOs/RTOs	One System Operator (NESO)	<u>Netherlands, France</u> – Single system operator <u>Germany</u> - Multiple

Comparison of Different Markets (4/5)

Market Design Consideration	India	USA	UK	Europe
Transmission Planning, Transmission Access and System Operation (... continued)				
Transmission planning	<p>For inter-state / regional network, planning by CTU and CEA</p> <p>For intra-state / regional network, planning by STU and CEA</p>	Transmission planning is done by ISO / RTO with inputs from states & LSEs	Transmission planning is done by system operator and plan is approved by the Regulator	Transmission planning is done by system operator and plan is approved by the Regulator

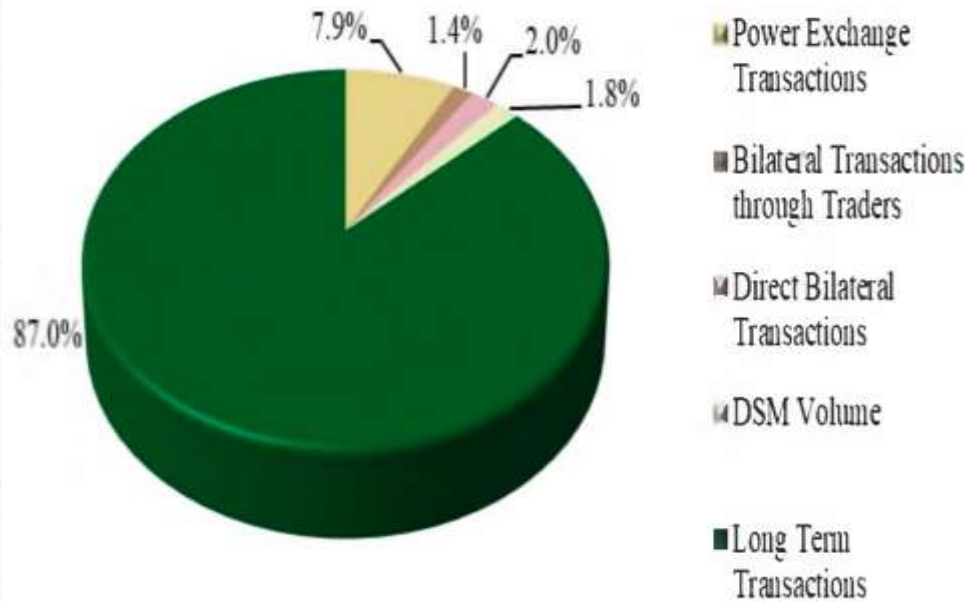
Comparison of Different Markets (5/5)

Market Design Consideration	India	USA	UK	Europe
Transmission Planning, Transmission Access and System Operation (... continued)				
Long Term Transmission Access	GNA is granted by CTU on application by users. TGNA is processed by Grid-India.	No system of GNA/TGNA prevalent for DAM. However, Transmission Access applications exist for OTC and non-exchange markets. For DAM/RTM, all Open Access approvals are given by ISO/RTO. Open Access buyers and sellers directly participate in energy market auctions on the ISO/RTO. Connectivity charges levied on Generators in most of these markets based on their connection requirements (shallow / deep connection)		
Transmission Pricing	Sharing of Transmission Charges and Losses	LMP	Zonal	Zonal
Imbalance Management				
Imbalance Management	DSM, Ancillary Services	Ancillary Services	Ancillary Services	Ancillary Services

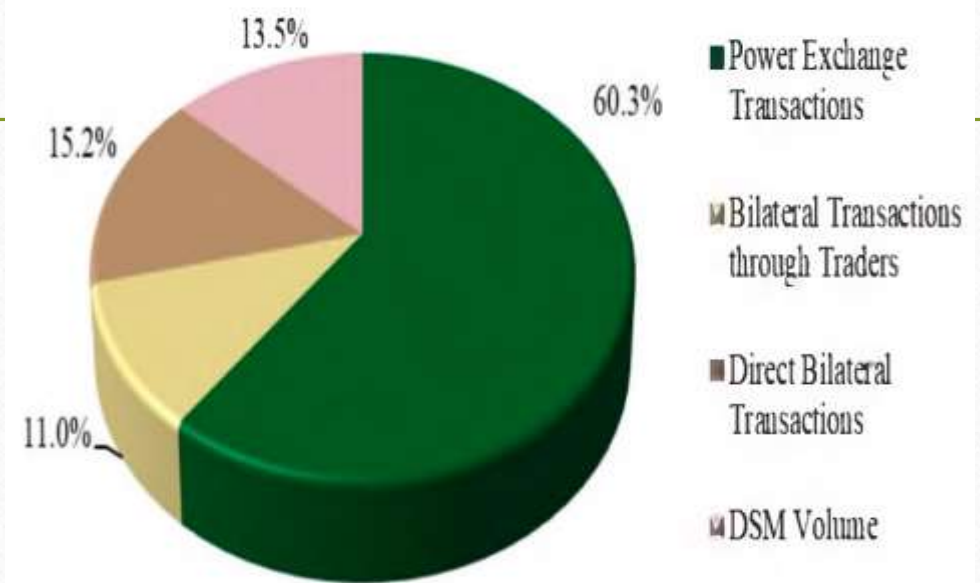
Market Design: India Case Study

Indian Electricity Market Snapshot

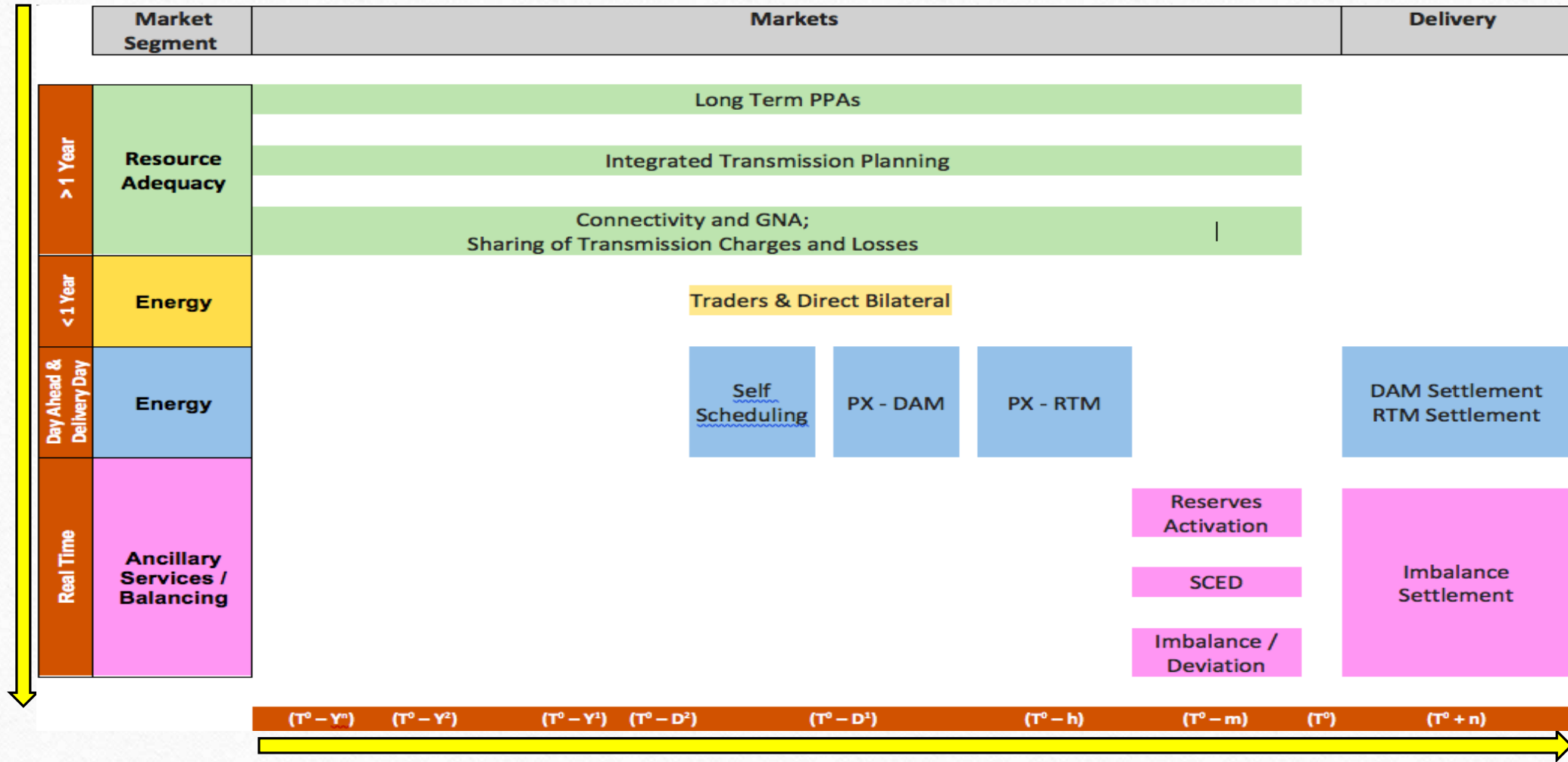
Share of Market Segments in Total Electricity Generation by Volume in FY2024-25



Share of Market Segments in Short Term Transaction & DSM by Volume in FY2024-25



Indian Electricity Market Architecture



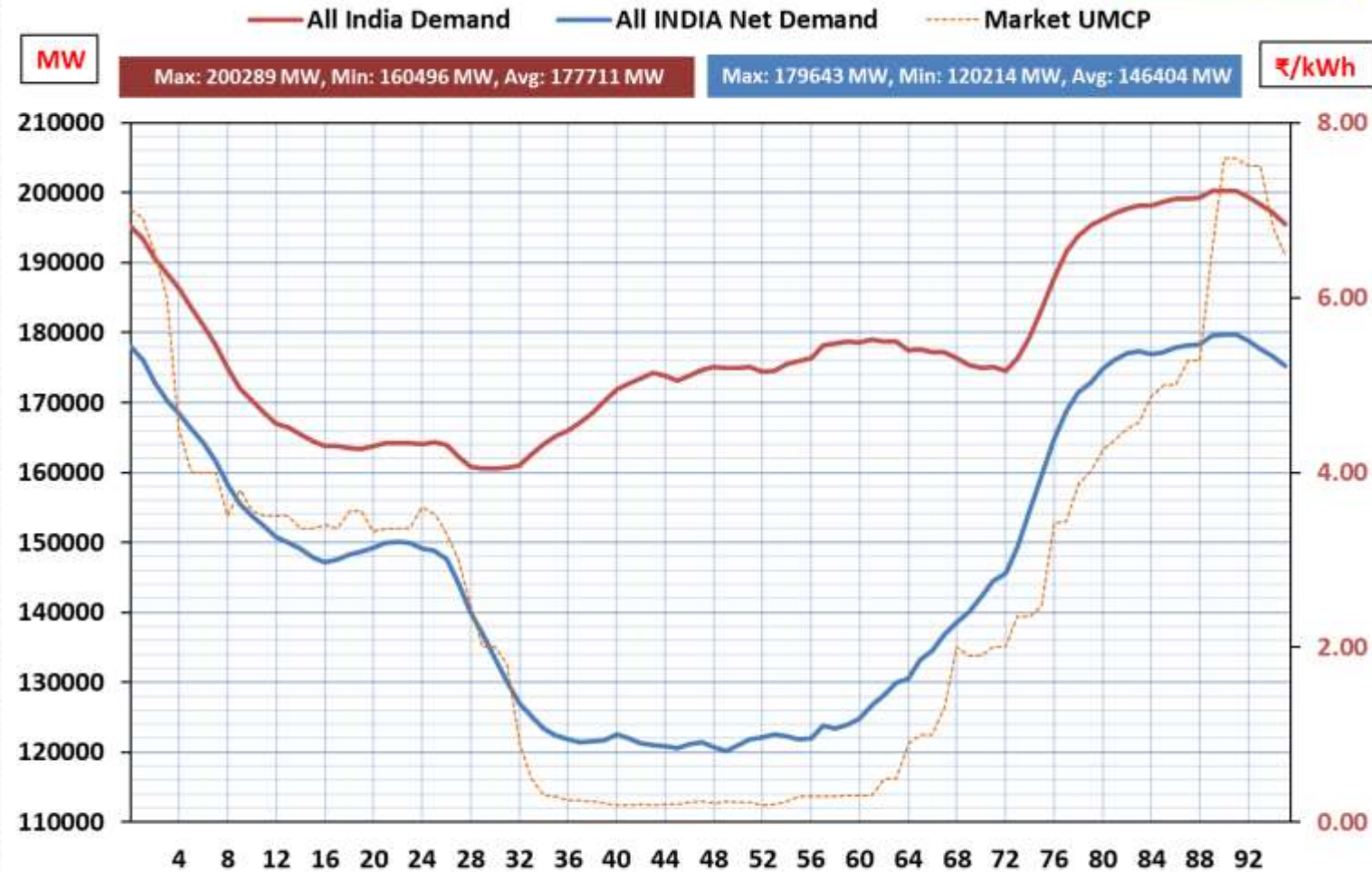
Market Design in the wake of Energy Transition

- Context
 - Target of 500 GW RE by 2030
 - Share of RE - already more than 50% in capacity terms, 22% in energy terms

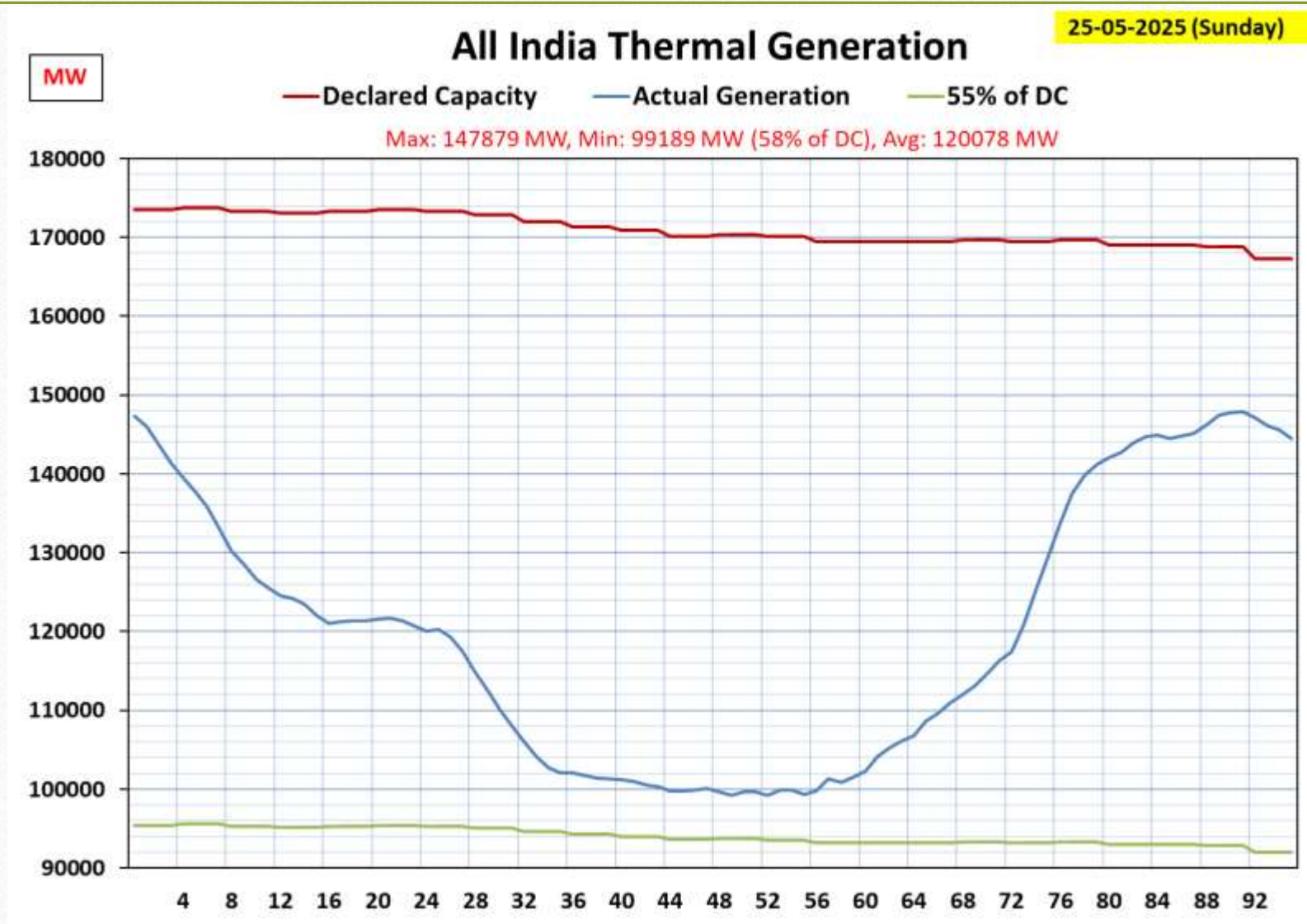
Challenges.....

Challenges posed by intermittent RE

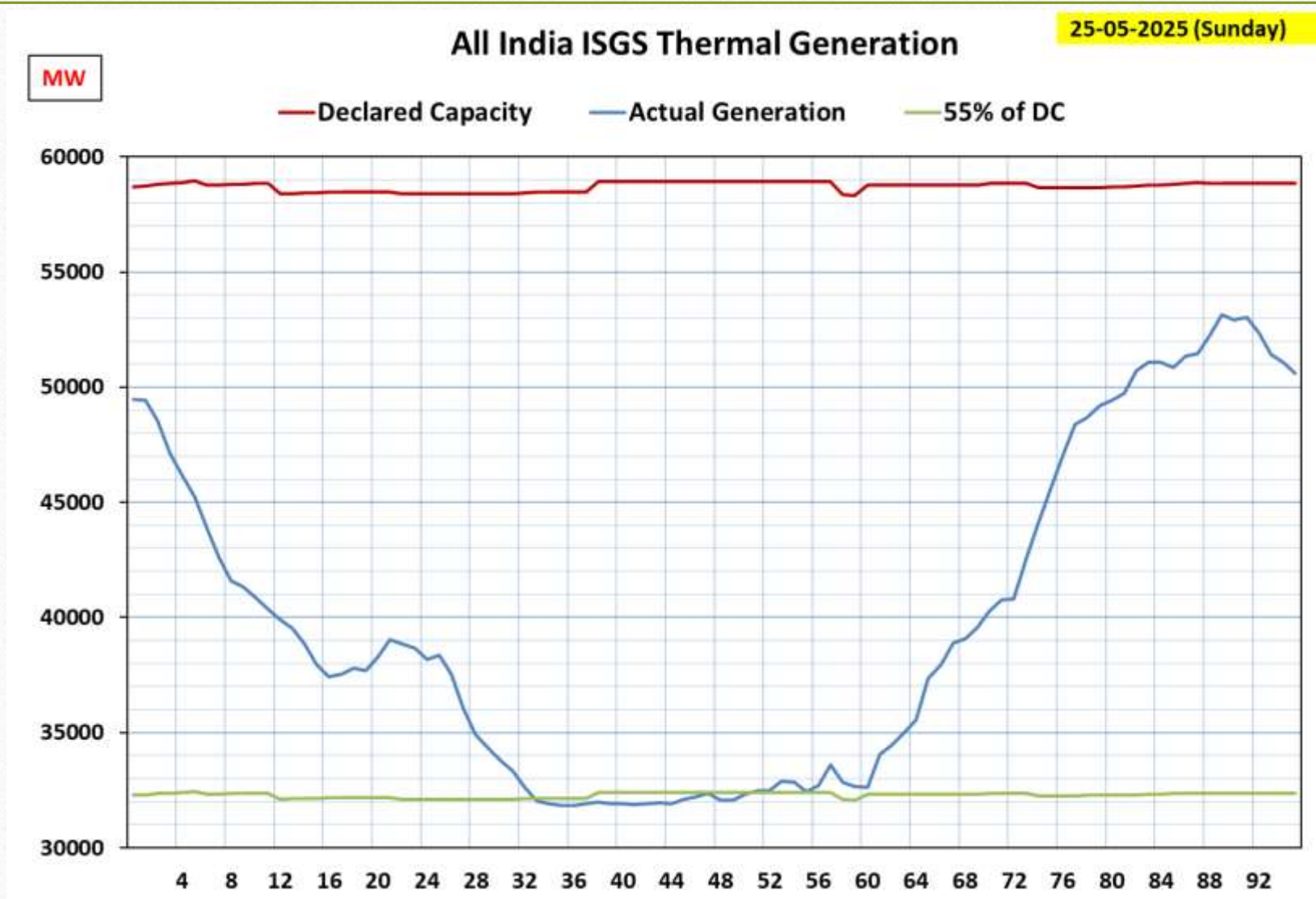
25-05-2025 (Sunday)



Challenges posed by intermittent RE

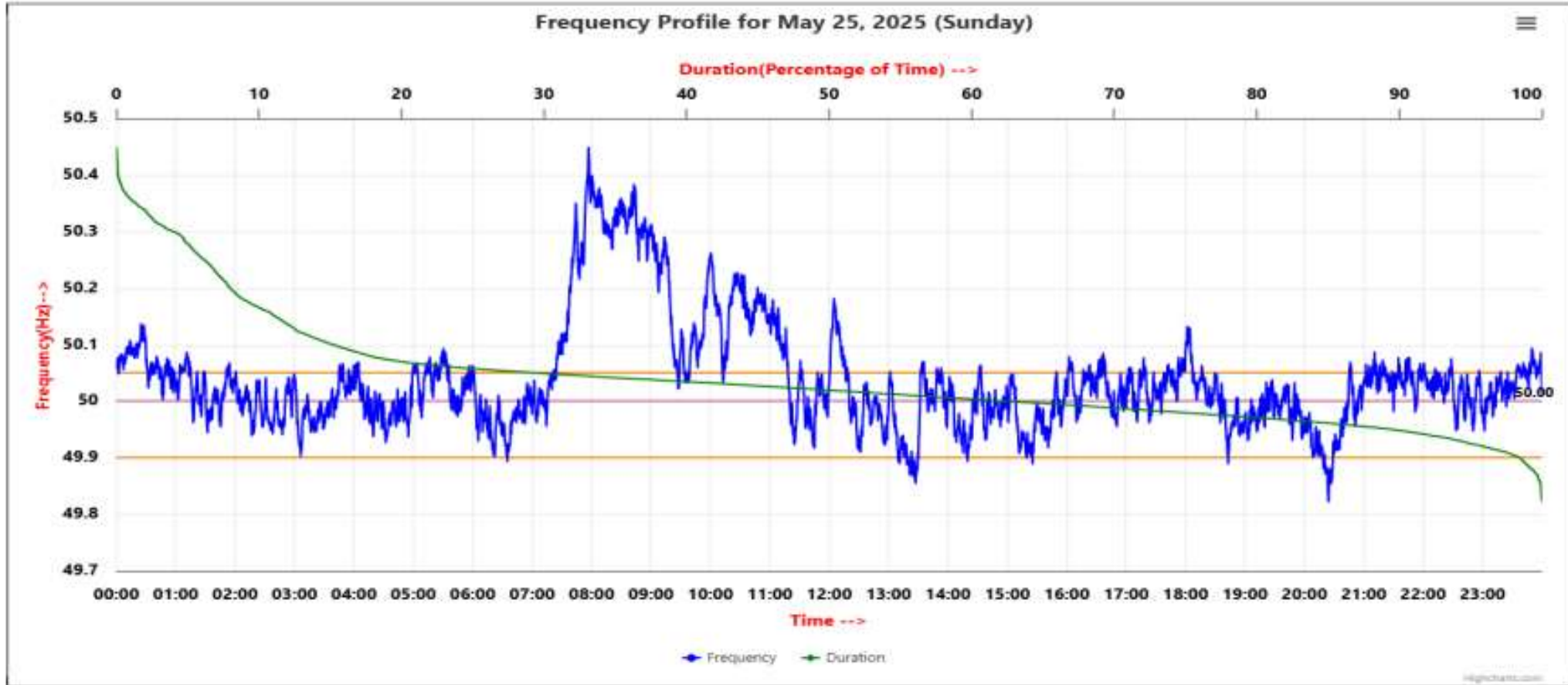


Challenges posed by intermittent RE



Challenges posed by intermittent RE

Sunday-High Frequency Operation (low demand, bad weather)



<49.7	<49.90	<49.97	49.7-49.8	49.8-49.9	49.9-50.0	50.0-50.1	50.1-50.2	49.90-50.05	49.7-50.2	49.97-50.03	50.05-50.1	>50	>50.03	>50.05	50.2	<49.95	49.95-50.05	49.90-49.95
0.0	1.54	19.32	0.0	1.54	35.93	47.3	7.25	68.87	92.01	37.38	14.36	62.53	43.3	29.59	7.99	10.43	59.98	8.89

Market Design in the wake of Energy Transition

- Paradigm shift in market design....

Handling power system operation challenges with greater penetration of intermittent RE

- problem of ever dipping belly of the duck curve
- focus on resource adequacy
 - to ensure procurement of right resource mix and consequently
 - to avoid under-utilisation of resources as at present
- contracting structure – a rethink –
 - separate contracting for peak load and
 - contracting for flexible resources for managing ramping requirements.

Future Market Design

Encouraging flexible resources (India does not have the luxury of flexible resources such as gas). Hence....

-
- Thermal flexing (minimum turndown level 55%/40%, incentivizing ramping through compensation and incentive)
 - Mandating states (through Grid Code) to maintain reserves (primary, secondary and tertiary) – incentives and penalties
 - Storage - BESS and PSP – Demand creation through national target, Energy Storage Obligation (ESO), and other incentives (fiscal, transmission charge waiver)
 - Demand Response/Demand Flexibility – framework of Demand Flexibility Purchase Obligation in State regulations
 - Aggregator/Virtual Power Plant (VPP) – Future negawatt support to grid
 - Ancillary Services – further incentive under contemplation - for flexible resources to participate in primary, secondary, and tertiary ancillary services

Transmission planning, access, and pricing

- Traditional approach needs a rethink to address the emerging realities of generation resources and electricity use.
- Focus on
 - optimum utilization of the transmission assets (solar and non-solar hour connectivity and access),
 - right kind of pricing signal for generation siting, and
 - greater flexibility in use and trade of transmission rights.

Market design: a rethink

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- System operation and market operation need greater coordination than at present.
 - Ongoing Debates
 - centralized dispatch based market (merged power system operation and market operation – SCUC/SCED) vs
 - decentralized scheduling and dispatch based market (as at present in India) and
 - distributed digitalized market (DEG, peer-to-peer trade)
 - New products –
 - Capacity Contract, VPPA, CfD, Carbon Credits, Electricity Derivatives

Distribution Sector

- Discom viability is key – primary source of revenue that sustains upstream generation, transmission, and trading/market
- Focus on improving performance of discoms
- **Retail sale competition**
 - in consumer interest.

Future Market Design

Summary.....

- Future Market Design with focus on
 - **Grid integration** of intermittent RE (SCUC, SCED, Ancillary Services etc)
 - Harnessing **flexible resources** (including **demand flexibility**) and **DRE** – Minimum Turndown Level for thermal, Time of Use Tariff, Demand Flexibility Purchase Obligation, Demand Response, Aggregation/Virtual Power Plant, Peer-to-Peer Trade, Digital Energy Grid
 - **Resource adequacy** – scientific demand forecasting, planning reserve margin, optimum and least cost power procurement, RA enforcement
 - **Transmission** - planning, optimization, access, and pricing
 - Redesigning **system operation and market operation** – centralized vs decentralized dispatch! Innovative products – VPPA, CfD, Capacity Contract, Electricity Derivative
 - Ensuring **Viability of Distribution** – Improving performance and retail sale competition

Thank you

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