

Low Carbon Power Generation Transition: Policy & Regulation

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MARCH 9th, 2017



NITI AAYOG, NEW DELHI



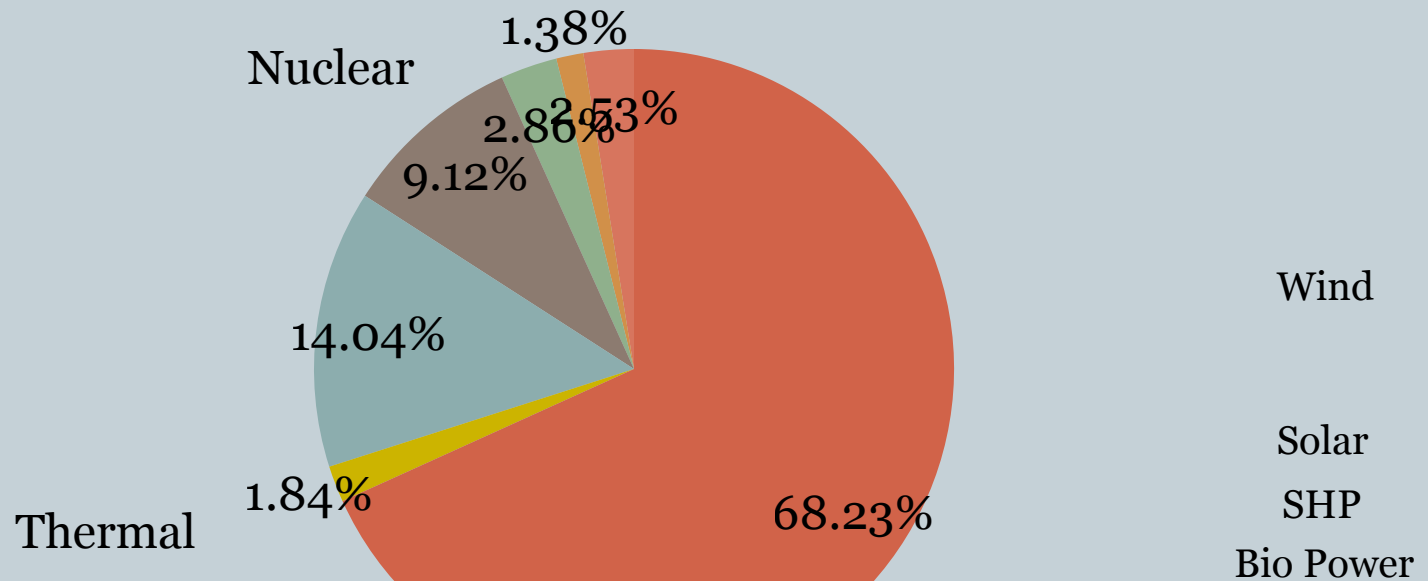
केन्द्रीय विद्युत विनियामक आयोग
CENTRAL ELECTRICITY REGULATORY COMMISSION



India: Generation Overview

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- Total Installed Capacity of ~315 GW
- Renewable Energy (RE) Capacity of 50 GW (more than 15% of installed capacity), as on January 31, 2017



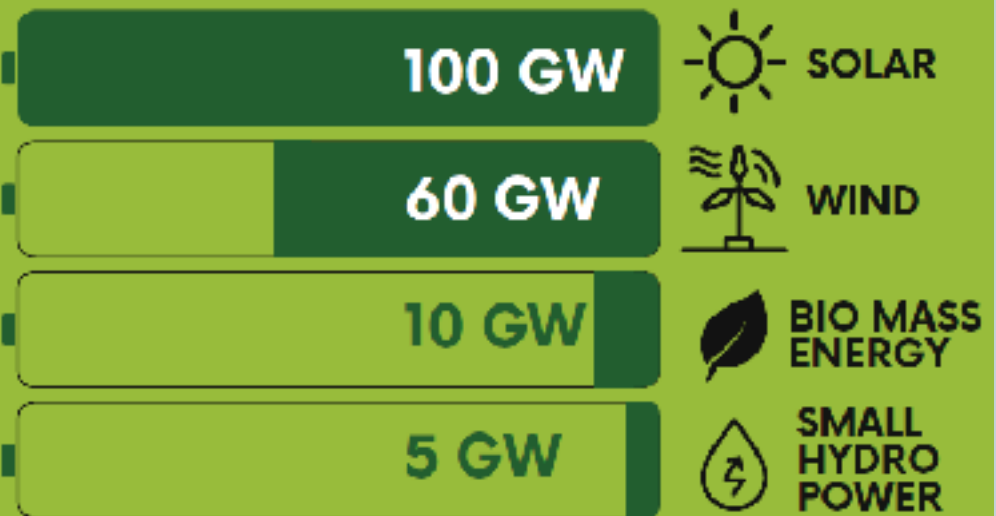
India enacted the National Action Plan on Climate Change (NAPCC) & Jawaharlal Nehru National Solar Mission (JNNSM) in 2009-2010

Renewable Energy Goals by 2022

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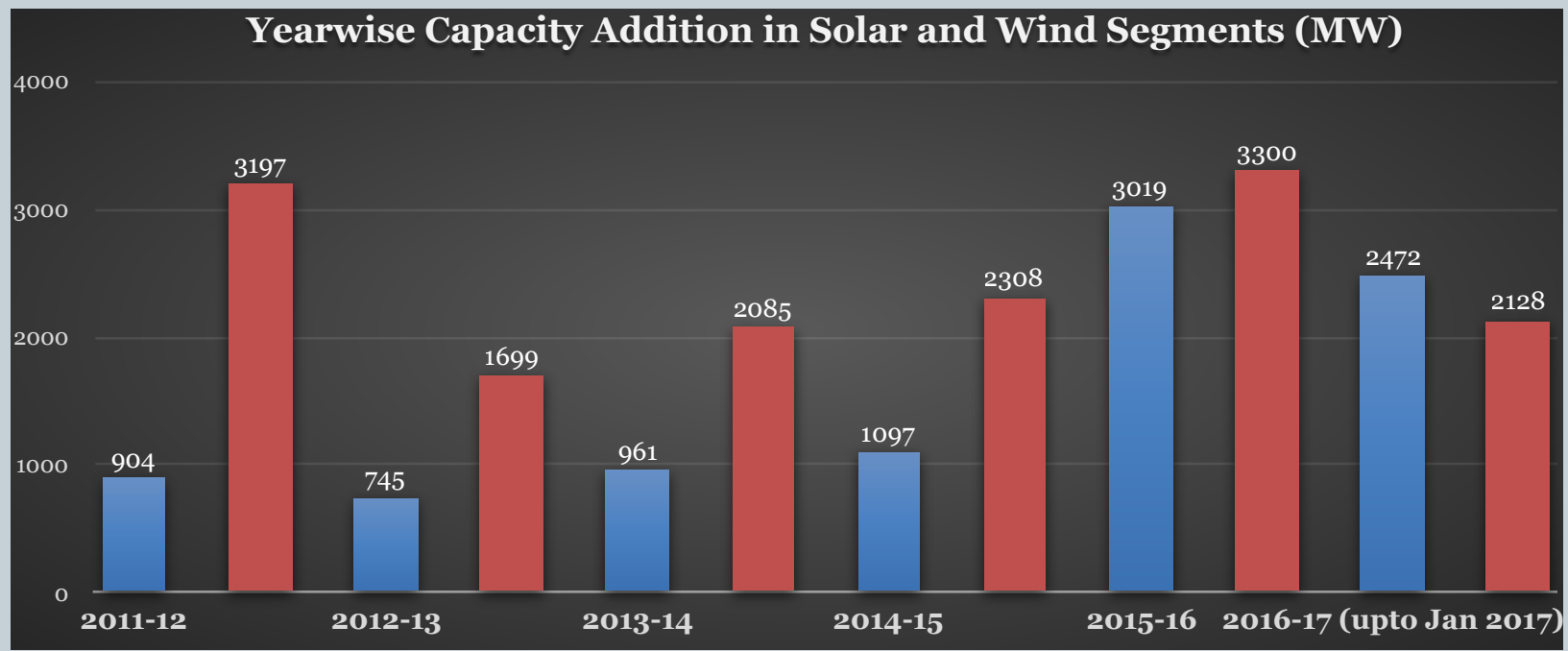
- India has set a target of reaching 175 GW of Renewable Energy capacity by 2022 (from the present level of 50 GW ~ 15% of total capacity)

**INCREASE OVERALL
RENEWABLE
CAPACITY BY
MORE THAN 5 TIMES
FROM 32 GW IN 2014
TO 175 GW BY 2022**



Over 8 GW of Solar & 11.5 GW of Wind capacity added in last 5 yrs

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Source: MNRE

Technology	Installed capacity as on January 31, 2017 (in MW)
Wind Power	28,871
Solar Power	9,235
Bio Power	8,182
Small Hydro Power	4,341

Policy & Regulatory Support for RE in India

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Support for RE Development

Introduced by CERC & most states for all RE Technologies

Various support mechanisms under National Solar Mission

Most States have formulated Policies to provide impetus to RE generation

Key Instrument for success of wind installations, available for solar and bio-power

Feed-in Tariff

State RE Policies

Renewable Purchase Obligation (RPO)

Renewable Energy Certificate

Accelerated Depreciation

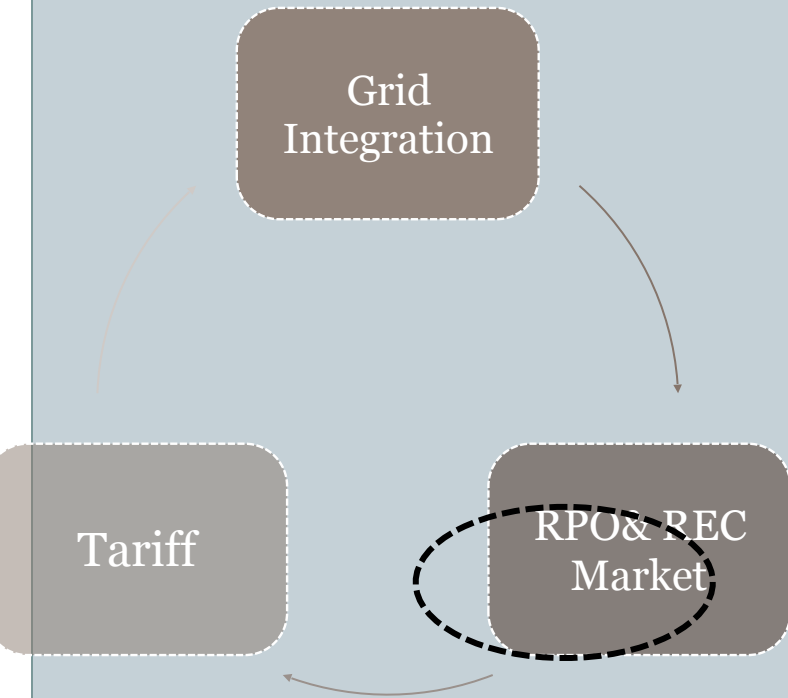
Viability Gap Funding

Mandated by EA 2003 and National Tariff Policy

Mechanism introduced to fulfill RPO and enable separate sale of green attribute of renewable power

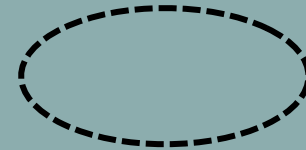
Regulatory interventions to catalyze transition to Renewables

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Grid integration

- Forecasting & Scheduling
- Ancillary Services
- Transmission
- Increasing flexibility of power system



Scheduling, Forecasting & Commercial Settlement

(Framework for solar & wind generators)

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- Most renewable capacity connected to the State Transmission Network; must-run status
- All PPAs are single part tariff, based on actual generation => did not incentivize generators to invest in forecasting & scheduling
- Framework issued by CERC in August 2015 lays the foundation for sustainable integration of RE sources
 - Bringing RE generators in alignment with existing commercial framework opens the entire country as a market for them
- System operators will now have visibility into how much solar & wind power is expected on the grid in a time-block*
- Model Regulations for States in October 2015 (Karnataka has finalized, seven states in draft stage).

* Indian grid operates on 15-min despatch; 96 time-blocks in a day

Renewable Energy Management Centers (REMCs)

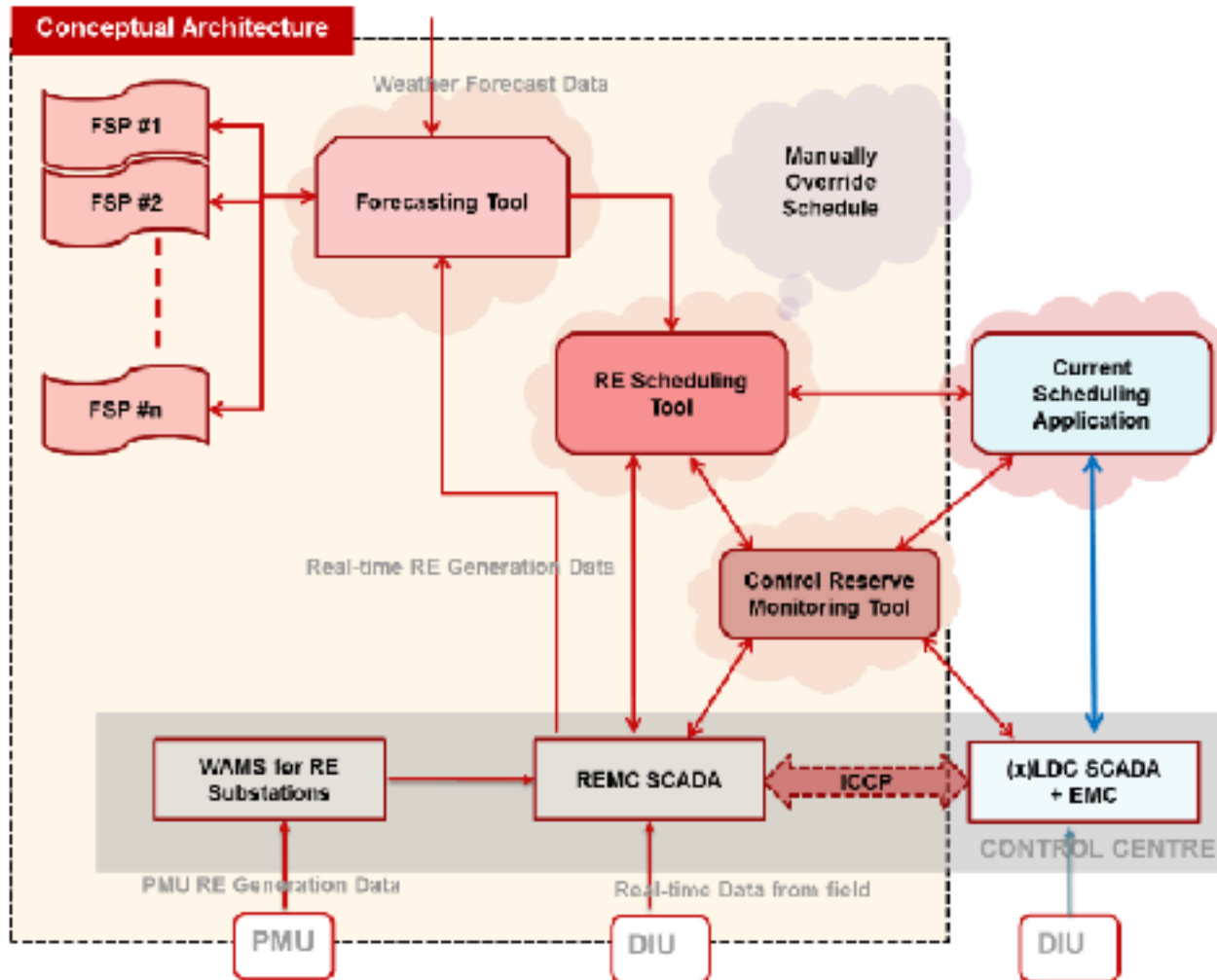
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Renewable Energy Management Centers (REMCs) to be established at Regional & State Load Despatch Centers

- Technical assistance by GIZ (€2 M) to PowerGrid (implementation lead) on Conceptual Design of REMCs, including network management
- REMC Control Center comprises of following modules:
 - REMC SCADA
 - Forecasting Tool
 - RE Scheduling Tool
 - Control Reserve Monitoring Tool
 - WAMS for RE Substations

Conceptual Architecture of REMC

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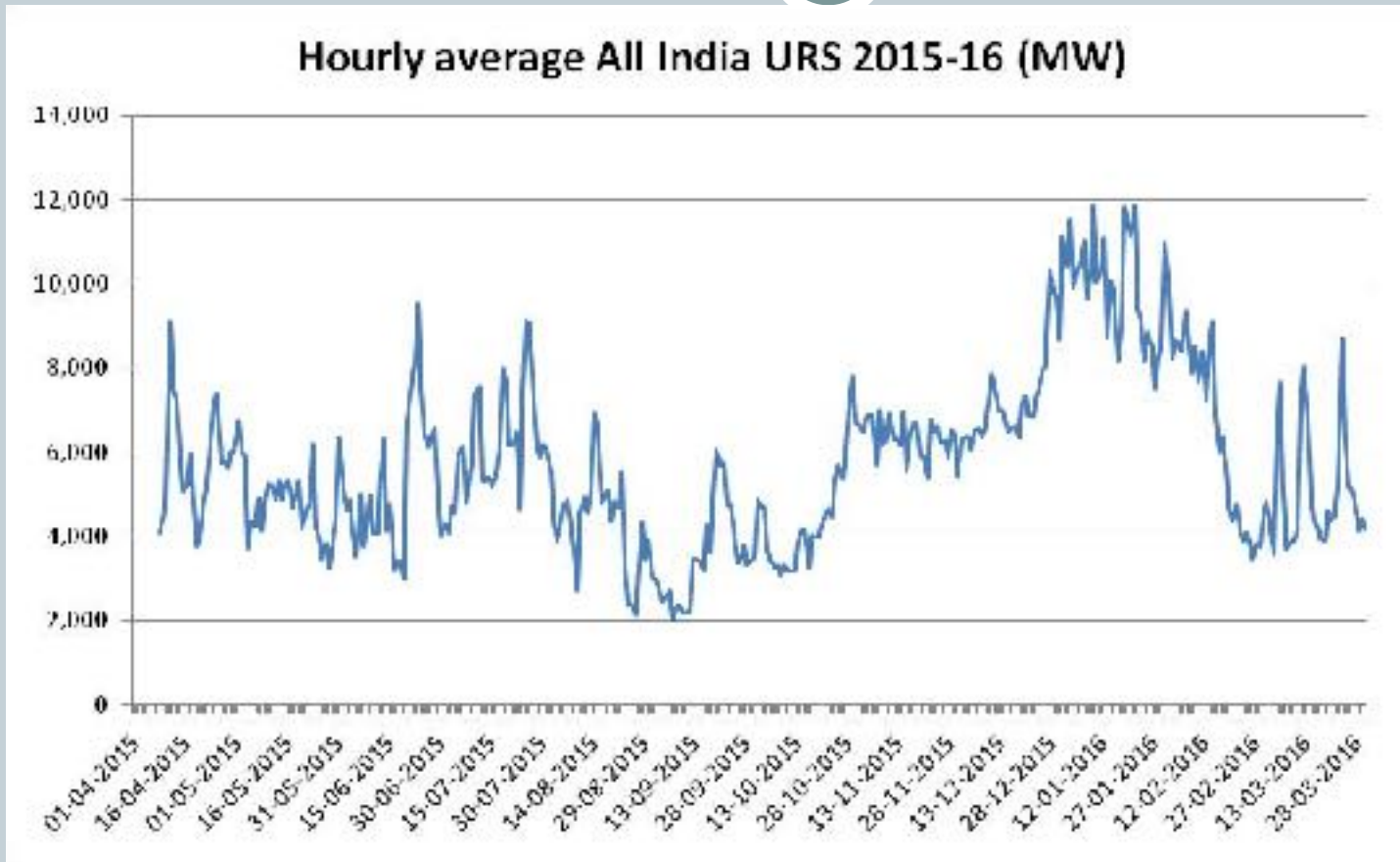
Ancillary Services Regulation

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- Operationalized in April 2016*
- NLDC, through RLDCs, operates Ancillary Services
- Objective: to restore the grid frequency to desired level (frequency control) and to relieve congestion in the transmission network
- Triggering criteria:
 - Extreme weather forecasts and/or special day;
 - Generating unit or transmission line outages;
 - Trend of load met & frequency;
 - Excessive loop flows leading to congestion.

Un-requisitioned Surplus (URS) available with Inter-state Generating Stations

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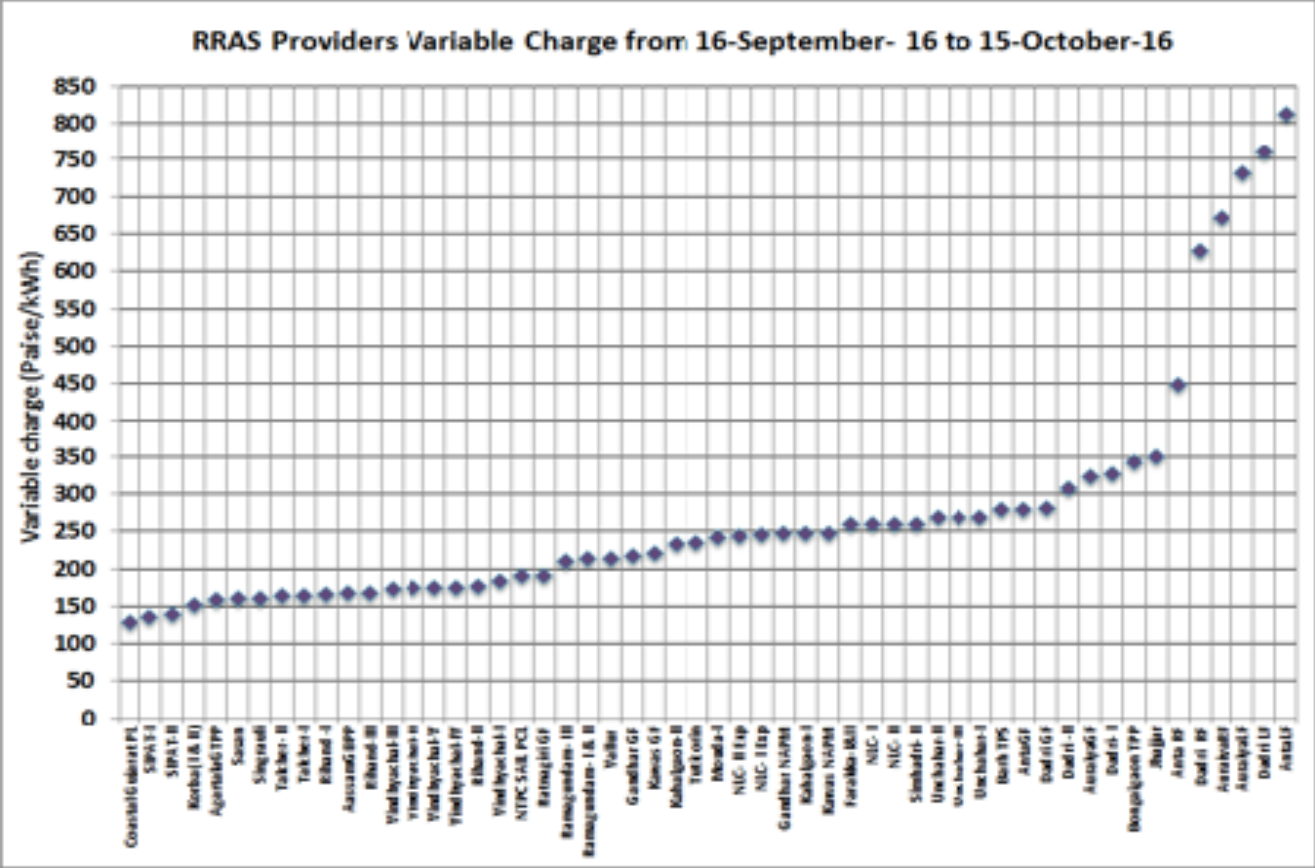
Un-requisitioned Surplus (URS) fluctuates between 2000 MW & 12,000 MW
Average URS in a time-block: 6,175 MW

Ancillary Services- Operations

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- Regulation Up: utilize un-requisitioned surplus of regional generating stations to increase supply (e.g. generator outage or transmission congestion)
- Regulation Down: instructions to decrease generation if load is lower than expected (e.g. weather changes)
- Merit order stacking, based on variable cost
- Regulated incentive to generators for participating
 - Mark-up for Regulation Up;
 - a % of variable charges for Regulation Down

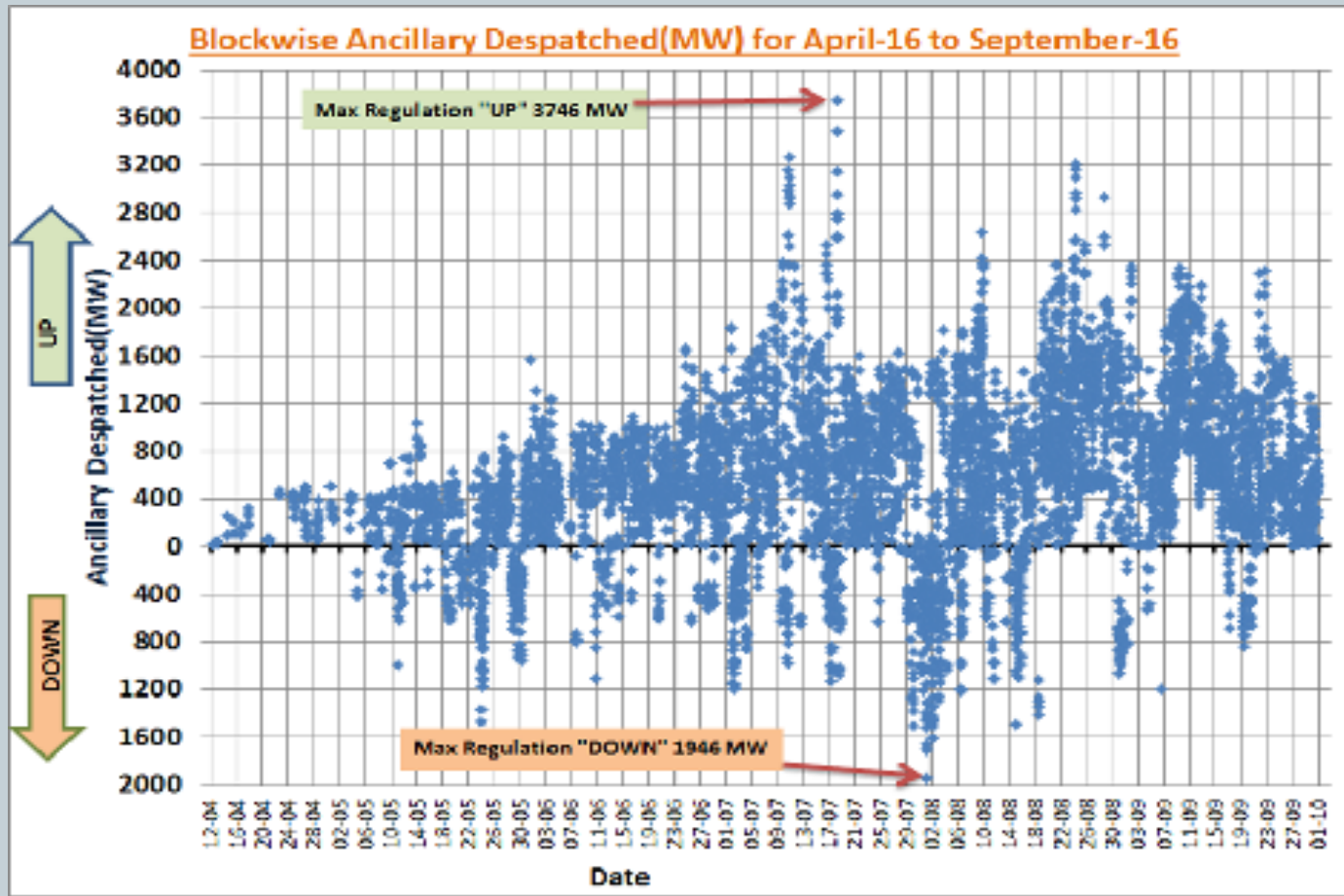
Merit order stacking based on Variable Cost



Variable Charges of RRAS Providers for the period 16 Sep'16 – 15 Oct'16

Despatch of Ancillary Services: Apr'16 to Sep'16

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Total of ~1200
RRAS instructions
by NLDC:

- 988 RRAS Up,
- 220 RRAS Down

Costs and benefits of RRAS

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Item (Apr'16 – Sep'16)	Total	Average (₹ per unit)
Regulation Up		
Energy scheduled	1253 MU	--
Total paid for RRAS Up	₹ 531 Crores	₹ 4.24
Regulation Down		
Energy scheduled	153 MU	--
Variable charges retained by RRAS providers	₹ 7.6 Crores	₹ 0.49
Variable Charges refunded to DSM Pool	₹ 22.8 Crores	₹ 1.47

- Frequency within operating band (49.90-50.05 Hz) 75 % of the time
- Average frequency most days very close to 50 Hz

Tariff for RE Generators

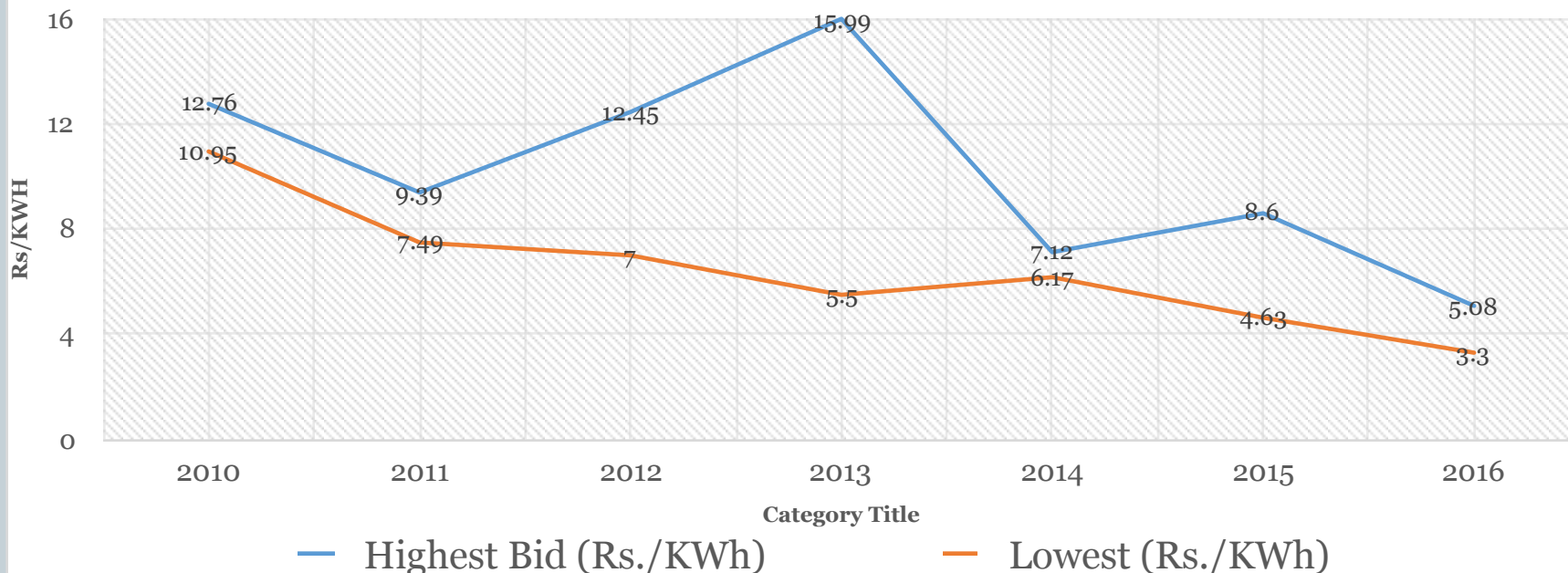
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- Solar & Wind sectors expected to be dominated by reverse auctions for price discovery
 - Small Hydro Power (SHP), Biomass power, Biogas, Biomass gasifier and Cogen: still dependent on cost-plus regulated tariff
 - Draft RE Tariff Regulations for control period 2017-2020 in public domain; public hearing 15/03/17
 - Proposed tariff design: single-part tariff with following fixed cost components
 - Interest on loan
 - Return on equity
 - Depreciation
 - Interest on working capital
 - O&M expenses
- technologies with fuel costs have a variable cost component as well

Price of utility scale solar has dropped 70% since 2010

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Trend Analysis for solar Bid results (2010-2016)



Source: MNRE

Solar Auction – Rewa Ultra Mega Solar Park

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Reference	Remarks
Location	Rewa District, Madhya Pradesh (approx. 24° 30”N & 81° 35” E)
Size	750 MW (AC Capacity), 3 projects of 250 MW AC capacity each
Technology	Solar PV with no restriction on technology/module type
Evacuation Facility	Power Grid Corporation of India (PGCIL) to construct 400/220 kV pooling substation and 400 kV transmission line at the plant site Internal evacuation of three 220/33 kV sub-stations and 220 kV transmission lines to be developed by RUMSL
Implementation Agency	Rewa Ultra Mega Solar Limited (RUMSL), a joint venture company between Solar Energy Corporation of India (SECI) and Madhya Pradesh Urja Vikas Nigam Limited (MPUVN)
Date of Auction	9-10 February 2017
Bid Results (1 st year Tariff)	Mahindra Renewables Pvt. Ltd. – Rs 2.979 per kWh (250 MW) Acme Solar Holdings – Rs 2.970 per kWh (250 MW) Solenergi Power Pvt. Ltd. – Rs 2.974 per kWh (250 MW)
Levelling Tariff (After escalation of 5 paise/unit for first 15 years)	Rs 3.30 per kWh

Wind Auction – Scheme for Setting up of 1000 MW ISTS Connected Wind Projects

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Reference	Remarks
Location	All India
Size	Eligible project capacity for bidding under the Scheme : minimum 50 MW and maximum 250 MW by a bidder
Evacuation Facility	The Wind projects shall be connected to the ISTS network, power to be procured by PTC and back to back agreements with the Discoms
Implementation Agency	Solar Energy Corporation of India (SECI)
Date of Auction	23-24 February 2017
Winning Tariff	Rs 3.46 per kWh
Bid Results	Mytrah Energy (India) Pvt. Ltd. (250 MW) Green Infra Wind Energy Limited (249.9 MW) Inox Wind Infrastructure Services Limited (250 MW) Ostro Kutch wind Private Limited (250 MW) Adani Green Energy (MP) Limited (50 MW)

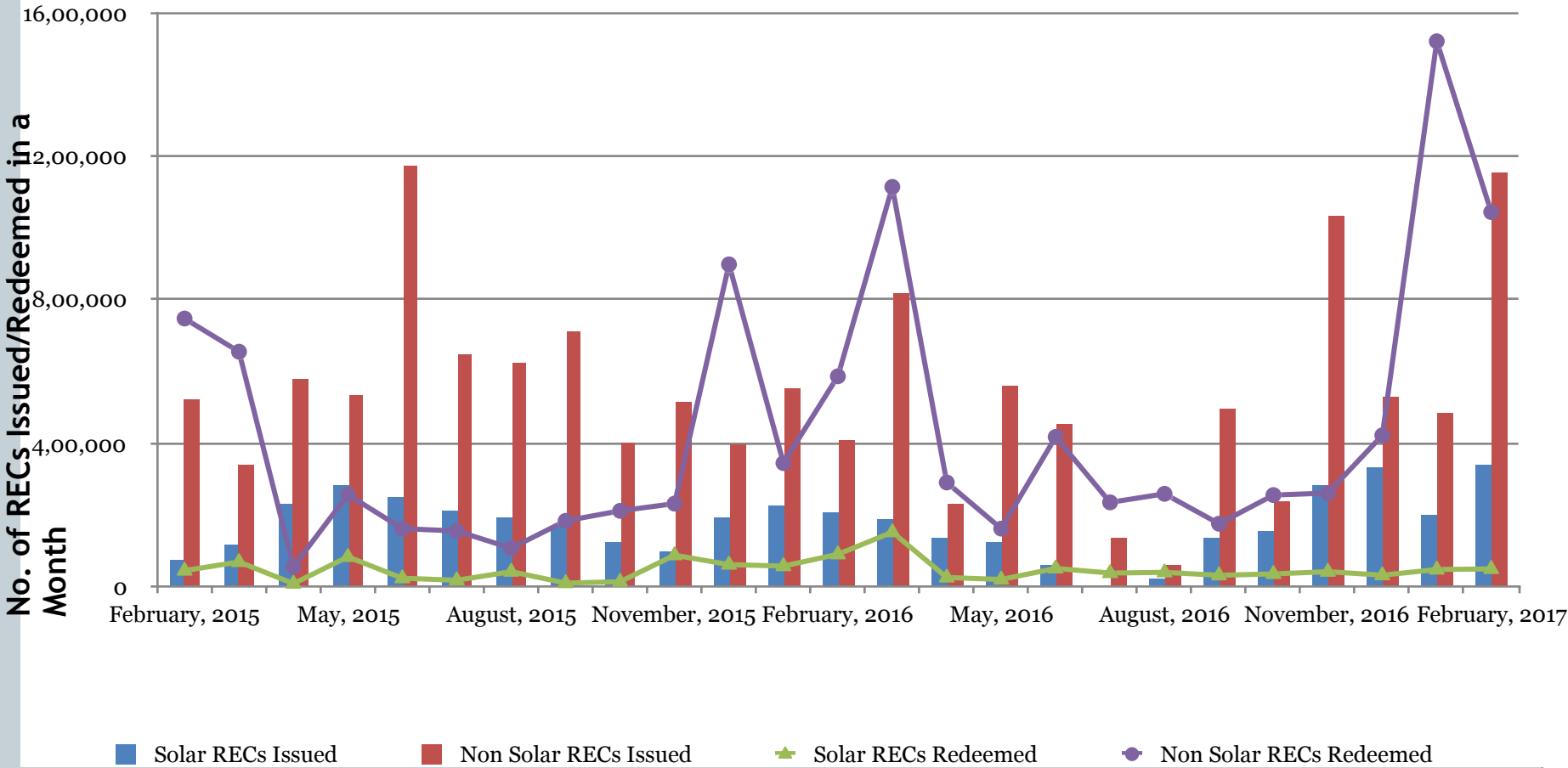
Renewable Energy Certificates (RECs)

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- REC mechanism instituted to overcome resource variation across States- for RPO compliance.
- Recognizes the green attribute of renewable power; enables RE generator to sell at brown power rate and sell green attribute separately
- RECs issued by central agency NLDC based on actual metered generation of RE power
- RE generators can sell these certificates to obligated entities (utilities/ open access consumers) who need to fulfil their RPO
- RECs compensated at a market determined price (@power exchanges) within a price band (floor and forbearance price) determined by CERC
- Floor & forbearance price move with the solar and non-solar tariffs and Average Power Purchase Cost (APPC) of the States

Enforcement of RPO has been challenging

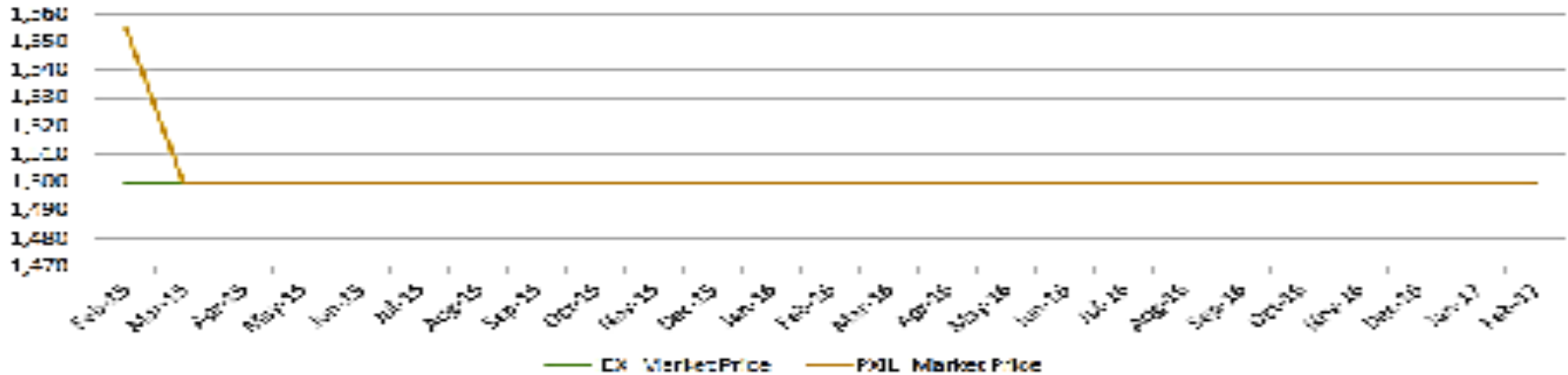
REC Market Trends – Last 2



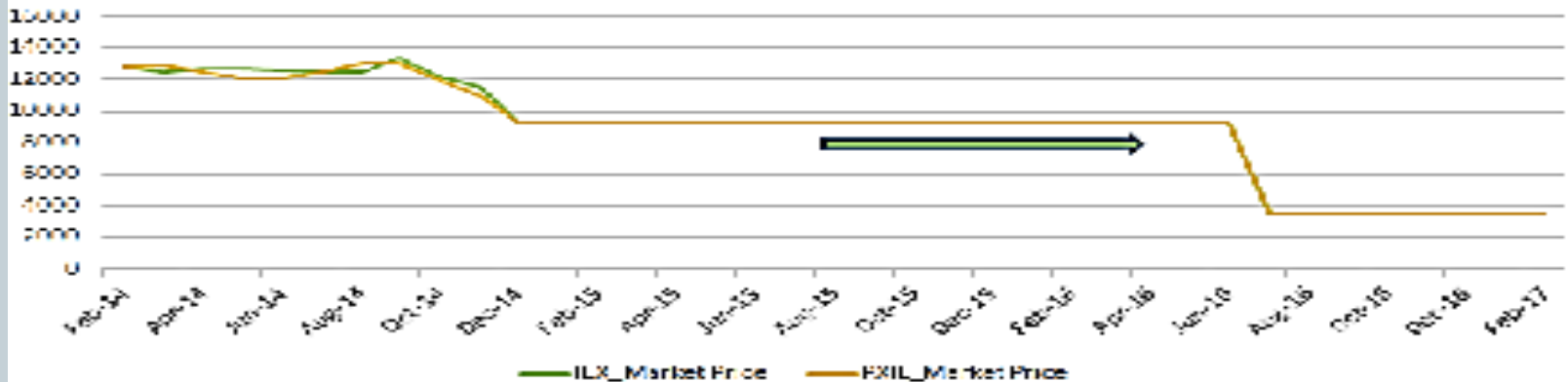
Market clearing happens at the floor price

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Non-Solar Market Clearing Price



Solar Market Clearing Price



With UDAY (Ujwal DISCOM Assurance Yojana)- power sector reform to revamp DISCOMs- RPO compliance to get a boost

Source: REConnect, IEX, PXIL

The Roadmap to achieve RE Targets

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Large scale
integration of
wind & solar

Regional
balancing

Intra-day trades
at 24x7
exchange

Ancillary
services in the
State

SEMs, Data,
process, tech
upgrades, process

State gener:
flexing &
balancing

Frequent
schedule
revisions, closer
to dispatch

Scheduling &
deviation
accounting of
ALL generators

THANK YOU

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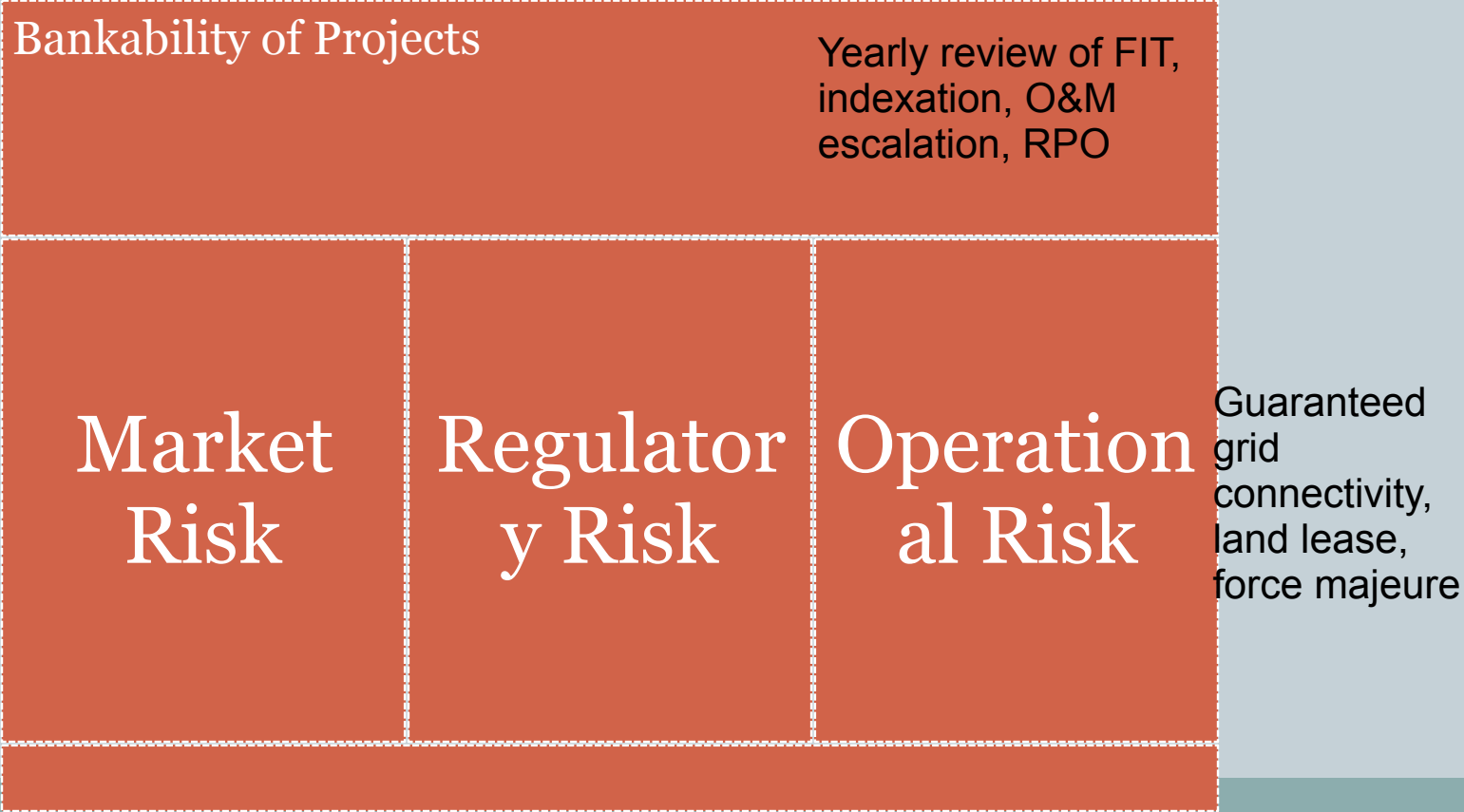
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APPENDIX

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Improving bankability of RE projects

Indian Government & Regulators have worked hard to reduce risk for RE projects



Grid Operation Challenge: the Duck Curve

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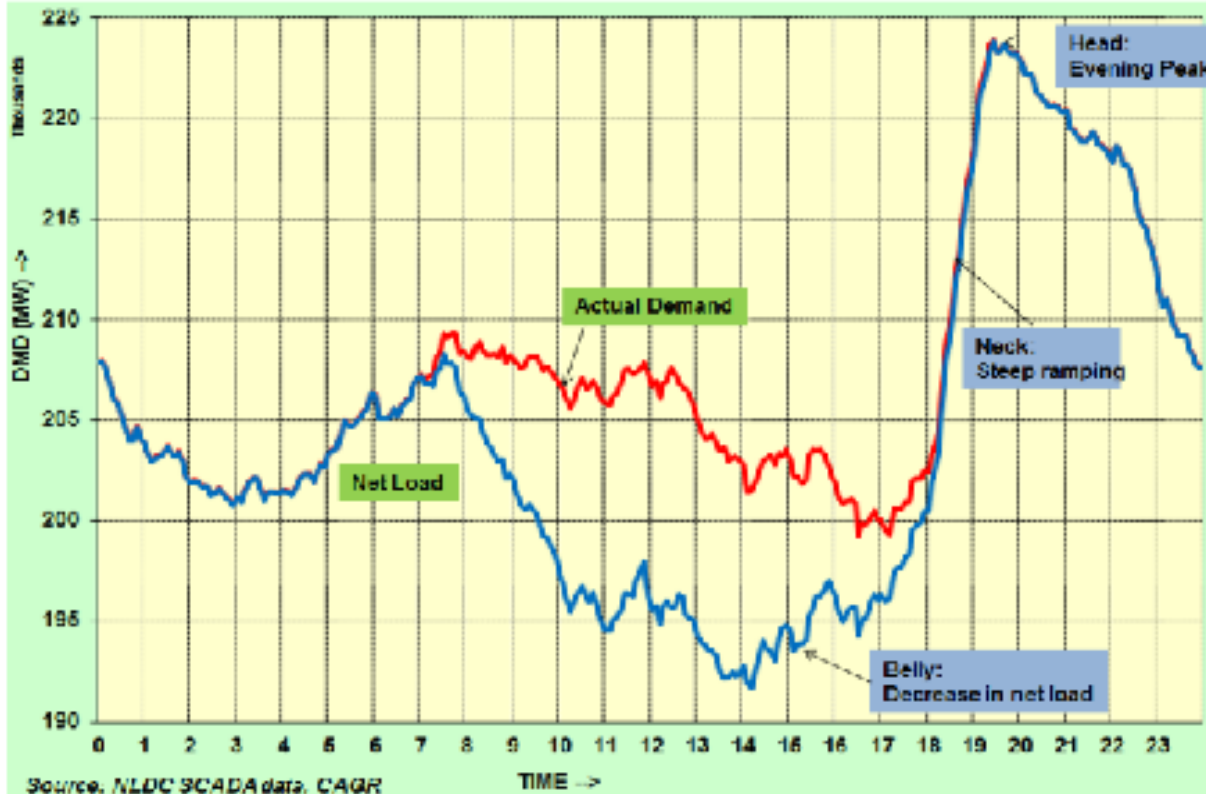


Figure 8 - Expected All India Duck Curve (Sample 20 GW of Solar Generation)

- Enhanced flexibility of coal plants
- Fast ramping gas plants
- Storage solutions such as pumped hydro

Greening the Grid: despatch modeling study to simulate grid operation in 2022
Participants: NREL, LBNL, NLDC, RLDCs, sponsored by USAID

Flexibility of Power System for Balancing

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- Flexing of coal plants: technical minimum now 55% (CERC Amendment to Grid Code in April 2016)
 - Generators are compensated for degradation in Station Heat Rate through increased energy charges
- Pumped storage present capacity: ~4800 MW (only half is being operated in pumping mode)
- Gas plants installed capacity: ~25,330 MW (Operating at very low PLF)

Transmission Planning & Support

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- ADB is lending \$1 Billion to PowerGrid or the Central Transmission Utility (CTU) for strengthening transmission infrastructure between southern & western regional grids
- Green Energy Corridors (GEC)- Phase I & Phase II- conceptualized to strengthen transmission network
 - 765 kilovolt (kV) and 400 kV high voltage transmission lines, sub-stations, HVDC terminals, etc
- GEC I: RE Capacity envisaged - about 33 GW (in 12th plan) ; ~INR 40,000 crores (~USD 6 billion)
- GEC II: connectivity for solar parks ~8 GW already under planning
- In 13th Plan (2017-2022): investment of INR 120,000 crores envisaged

- Tariff Policy 2016: Inter-state transmission charges & losses to be waived for solar & wind projects commissioned by 2022

Scheduling, Forecasting & Commercial Settlement

(Framework for solar & wind generators)

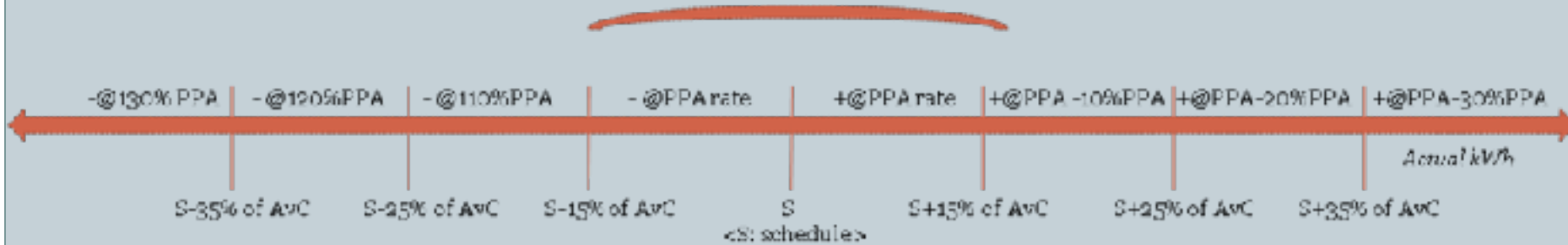
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- System Operator shall forecast from grid security perspective
- RE generators, independently or through Qualified Coordinating Agency (QCA)*, shall forecast & submit schedule which'll form the basis for commercial settlement, on a day-ahead basis
- Due to the infirm nature of these sources, more flexibility provided w.r.t schedule
- Incentive to improve forecasting- deviation charges outside a tolerance band, which could be tightened over time
- Bringing RE generators in alignment with existing commercial framework opens the entire country as a market for them

* Within States, forecasting & scheduling at the pooling station level

Deviation Settlement Framework for Regional Entities

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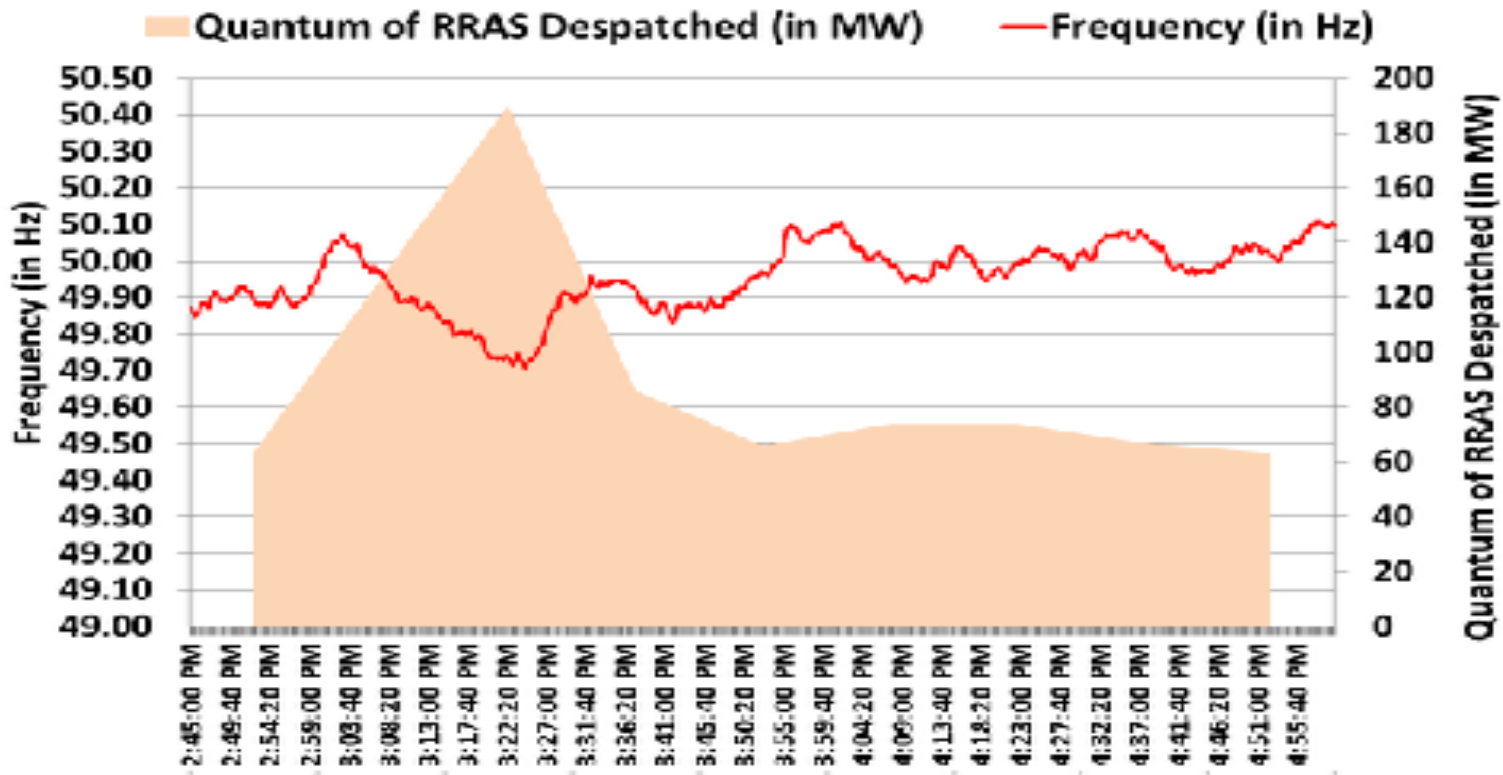
- Error definition: $[(\text{Actual generation} - \text{Scheduled generation}) / \text{Available Capacity}] \times 100$
- Payment as per schedule @PPA Rate
- Deviation Settlement within tolerance band (+/- 15%):
 - Receipt from/payment to pool @PPA rate (i.e. in effect, payment as per actuals)
- Beyond 15%, a gradient band for deviation charges is proposed as follows:

<i>Abs Error (% of AvC)</i>	<i>Deviation Charge</i>
15%-25%	10% of PPA rate
25%-35%	20% of PPA rate
>35%	30% of PPA rate

- 16 revisions allowed, one for every one-and-half-hour block, effective from 4th time-block.

Example of RRAS in Action:
Outage of HVDC Mundra – Mohindergarh Pole

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- Event Date: 28th April, 2016, Event Time: 1434 Hrs
- DM water leakage in valve hall, TTC/ATC of WR-NR corridor reduced from 7450 MW/6950 MW to 6200 MW/5700 MW
- RRAS despatch : 14:45 To 17:00 hrs, Regulation UP - 300 MW
- Effect of RRAS: Frequency improvement