Ministry of Power
Government of India

Report of the
Technical Committee
on
Large Scale Integration of Renewable Energy, Need for Balancing, Deviation Settlement Mechanism (DSM)
and
associated issues



April, 2016

Table of Contents

List of Annexures

List of Figures

Constitution of the Technical Committee

1. Shri Devendra Chaudhry, Special Secretary, M/o. Power – **Chairman (till 15th June, 2015)**
2. Chairperson, Central Electricity Authority **(Officiating Chairman from 16th June, 2015)**
3. Joint Secretary (Trans.), Ministry of Power
4. Joint Secretary, Ministry of New & Renewable Energy
5. Principal Secretary (Energy), Tamil Nadu
6. Principal Secretary (Energy), Gujarat
7. Principal Secretary (Energy), West Bengal
8. Principal Secretary (Energy), Rajasthan
9. CEO, POSOCO
10. Chief Operating Officer, CTU (PGCIL)
11. Joint Chief(RA), CERC
12. Director (PG), Ministry of Power - **Convener & Secretary**

Special Invitees:

1. Representative from IMD, Ministry of Earth Sciences (MoES)
2. Member (Hydro), CEA, MoP
3. Representative from NIWE, MNRE
4. Representative from NISE, MNRE
5. Representative from GIZ, Germany
6. Representative from E&Y Consultants
7. Representatives from NTPC, State GENCOs and Private GENCOs

Executive Summary

"You can't cross the sea merely by standing and staring at the water."
- Rabindranath Tagore

The country has set an ambitious target of adding 175 GW of renewable generation capacity by 2022. In order to integrate such high penetration of renewables into the grid, effectively, several actions have to be taken such as bringing flexibility in the conventional generation, frequency control, maintaining generation reserves, introduction of ancillary services, forecasting, scheduling, deviation settlement mechanism, balancing mechanism, robust data telemetry and communication systems, establishment of Renewable Energy Management Centres (REMCs), augmentation and strengthening of Transmission system as well as compliance to Regulations & Standards by renewable generation . The Technical Committee for "Large Scale Integration of Renewable Energy, need for balancing, Deviation Settlement Mechanism (DSM) and associated issues", based on detailed deliberations with different stakeholders and analysis, recommends the following action points:

1. Appropriate Regulatory Framework for handling Inter-State Deviations especially for Large and High RE Penetration States

The deviation limits for inter-state and intra-state entities, especially for Large and High RE Penetration States, stipulated by the Appropriate Commission, may take into account the stakeholder's concerns and international best practices. The regulatory framework for intra-state deviation, metering, accounting and settlement mechanism amongst the different entities including renewables must be in place and implemented at state level in 2016. Subsequently, say by 2017, deviation price may be linked to market linked mechanism with suitable price discovery process.

2. Forecasting and Scheduling

Forecasting (both Load, RE generation as well as Net Load) is essential for ensuring resource adequacy during operation and grid security. Suitable regulatory framework for Forecasting, Scheduling and Imbalance Settlement for RE generators at both inter-state and intra-state level needs to be in place. Such a framework at inter-state level has already been put into place by the Central Commission and be used as a reference for intra-state framework. Aggregators should be introduced to coordinate with several RE generators and be responsible for scheduling, real time operation and settlement of imbalances with the State/Regional Pool and RE generators.

3. Deployment of Reserves

Generation reserves need to be identified in advance and kept available all the time for the system operator to maintain grid reliability and security. Necessary incentives to the generator may be provided for maintaining and deploying the reserves. To begin with, a framework for identification and utilising of generation reserves available with regulated generators may be implemented. Subsequently, say by March, 2017, evolution to a market based framework may be done for efficient provision of all types of reserves across India.

4. Transmission System Augmentation and Strengthening

There is need for augmenting the transmission corridors from renewable rich states with coordinated transmission planning. Use of power electronic devices like SVCs, STATCOMs etc. for reactive power control also needs a thrust. Technical Standards for RE generation incorporating features such as Low Voltage Ride Through (LVRT), High Voltage Ride Through (HVRT), frequency

thresholds for disconnection from the grid, active and reactive power regulation by RE generators also become important and needs to be notified at the earliest.

5. Ancillary Services

Ancillary Services need to be put in place as complementary support services for reliable operation of the electricity grids. Ancillary Services provide a framework for operationalizing the spinning reserves and the modalities of scheduling, metering and settlement of the reserves. It would address congestion management issues and facilitate optimization at Regional & National Level and thereby facilitate integration of renewables too. Ancillary services are being implemented at the inter-state level and a similar framework needs to be implemented in the States.

6. Balancing Requirements

A coordinated multilateral despatch model has been implemented in India. Each DISCOM /SLDC is required to commit adequate generating resources to meet the anticipated load and RE generation. The States need to forecast and ensure adequacy of generation on a day-ahead basis. A balanced portfolio needs to be demonstrated and maintained at state level in different time frames.

7. Frequency Control

With the increasing interconnections size and interchanges between areas, proper frequency regulation brings out the need for primary control supplemented by secondary control and tertiary control. A regulatory framework and roadmap including suitable compliance monitoring and enforcement mechanisms may be put in place.

8. Harnessing and Incentivizing Flexibility

Flexibility in existing fleet of conventional generation as well as Pumped Storage Plants, Demand Side Management may be utilized for meeting changing load profile and maintaining system stability. Regulatory intervention is required to incentivize flexibility of conventional generation. Flexibility requirements should encompass the minimum and maximum generation level as well as the ramp up / down rates. The introduction of Flexible Generation Planning and Flexible Generation Obligation may be explored in the future.

9. Market Design Enhancements

There is need for more frequent market clearing in power exchanges e.g. multiple iterations in Day-Ahead segment and new products e.g real time markets, flexibility markets, capacity markets etc.

10. Communication in Power Sector

A regulatory framework for communication in power sector including smooth real time data transfer between the RE pooling stations and the SLDC/REMC is to be implemented say by March, 2017. REMCs at State, Regional and National level may be co-located with respective LDC and integrated with real time measurement and information flow. Also, provision for control signals from REMC directly to the renewable generator also needs to be made available.

11. Capacity Building of LDCs particularly in RE Rich States

System Operators need to have the required skill sets for planning, operating, maintaining and governing power systems with increasing shares of renewables. Reputed institutions and development agencies in India and abroad may be engaged so as to develop suitable training programmes with international experts, benchmark with international best practices and enable exposure to developed power systems around the world.

Action Plan

S.No.	Required Action	Action By	Time Line
1	Load Forecasting as per IEGC Section 5.3 ***(Already Started at NLDC/RLDCs)***	All States	01st June, 2016
2	Demonstration of Adequacy of Balanced Portfolio	All States / SLDCs	
3	Regulatory Framework for Intra-State Settlement System and Imbalance Handling Mechanism ***(Already implemented at inter-state level in 5 states)***	FOR / SERCs / SLDCs	01st July, 2016
4	Regulatory Framework for Forecasting of Renewable Generation and Scheduling and Implementation at ***inter-state level*** ***(Regulatory Framework already in place)***	CERC, NLDC, RLDCs, RE Generators, REMC	Implemented w.e.f 01st Nov., 2015
5	Regulatory Framework for Forecasting of Renewable Generation and Scheduling including Aggregators and Implementation at ***intra-state level*** ***(FOR Model Regulations notified in November, 2015, States of MP, Rajasthan, Karnataka, Tamil Nadu, Odisha, Jharkhand floated draft regulations)***	SERCs / FOR / MNRE, SLDCs, RE Generator, REMCs	01st June, 2016
6	Regulatory Framework for Reserves ***(Framework at inter-state level has already been specified by CERC on 13th Oct 2015)***	SERCs	01st June, 2016
7	Regulatory Framework for Ancillary Services Operation, **(Implementation of Ancillary Services at Inter-state level done)**	CERC, RPCs, NLDC, RLDCs	15th April, 2016
8	Implementation of Frequency Response (Primary Response). ***(Roadmap already provided by CERC on 13th Oct 2015)***	CERC All Generators	01st June., 2016
9	Regulatory Framework for Secondary Response (AGC) ***(Roadmap already provided by CERC on 13th Oct 2015)***	CERC, SERCs	01st April, 2017
10	Technical Standards and Protection Requirements for Renewables such as LVRT, FRT, etc. & implementation	CEA, CTU, STUs, RE Generators	01st June, 2016
11	Market Design – Frequent clearing, more opportunities, New entities (Aggregators) **(FOR Model Regulations notified in November, 2015 provide for Qualified Coordinating Agency (QCA) at state level)**	MNRE, CERC	01st June, 2016
12	Regulatory Framework for Communication in Power Sector, Availability of Real Time Data at the SLDCs/RLDCs/NLDC particularly of RE generators	CERC, RE Generators, SLDCs, POSOCO	01st June, 2016
13	Implementation of Renewable Energy Management Centres (REMCs)	CTU, STU, SLDCs, RLDCs, NLDC	01st April, 2017
14	Standards and Regulatory Framework for incentivizing "Flexibility" in Conventional Generation ***(CERC IEGC Fourth Amendment Regulations regarding Technical Minimum Schedule for operation of Central Generating Stations and Inter-State Generating Stations notified on 06th April, 2016)***	CEA, CERC	01st May, 2016
15	Capacity Building of SLDCs particularly in RE Rich States	FOLD, POSOCO, States	Ongoing

Background and Deliberations

Economic growth, fast paced urbanization, rise in per capita consumption coupled with electricity access to all are some of the factors which contribute to the increase in the total demand for electricity in India which is now over 1 trillion units per year. Renewable energy is increasingly becoming an integral part of the solution to fulfill the nation's energy needs. Under the National Wind Resource Assessment programme, National Institute of Wind Energy (NIWE) and State Nodal Agencies (SNA) have assessed the potential for wind power generation for grid interaction at about 1,02,788 MW taking sites having wind power density greater than 200 W/sq. m at 80 m hub-height with 2% land availability in potential areas for setting up wind farms @ 9 MW/sq. km. About 5,000 trillion kWh per year of solar energy is incident over India's land area with most parts receiving 4-7 kWh per sq. m per day. National Institute of Solar Energy (NISE) has calculated the State wise solar potential in the country estimated at about 748 GWp. The Wind and Solar Energy Potential in India assessed by NIWE & NISE respectively is depicted in Figure 1 below:

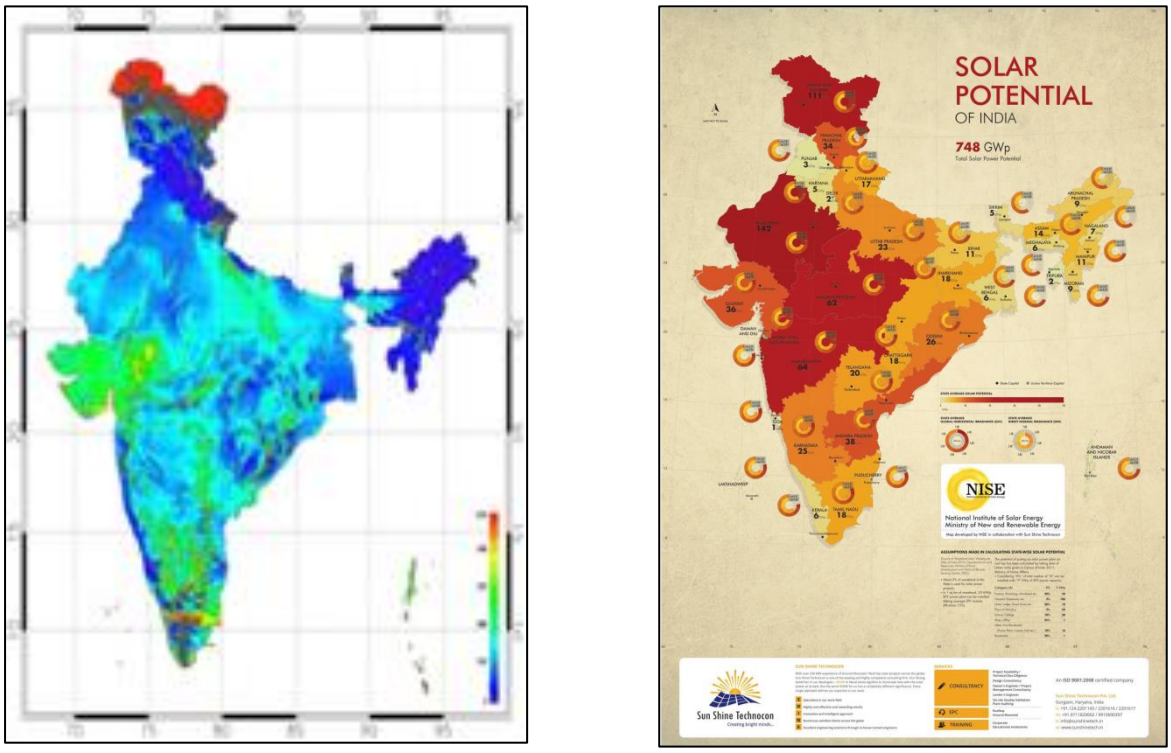


Figure 1 - Wind and Solar Energy Potential in India (Source: MNRE)

At present, out of a total All India installed capacity of 288 GW, the installed capacity of renewable energy sources in India is about 39 GW. The source wise break-up of the renewable energy sources installed capacity is depicted in the Figure 2 below.

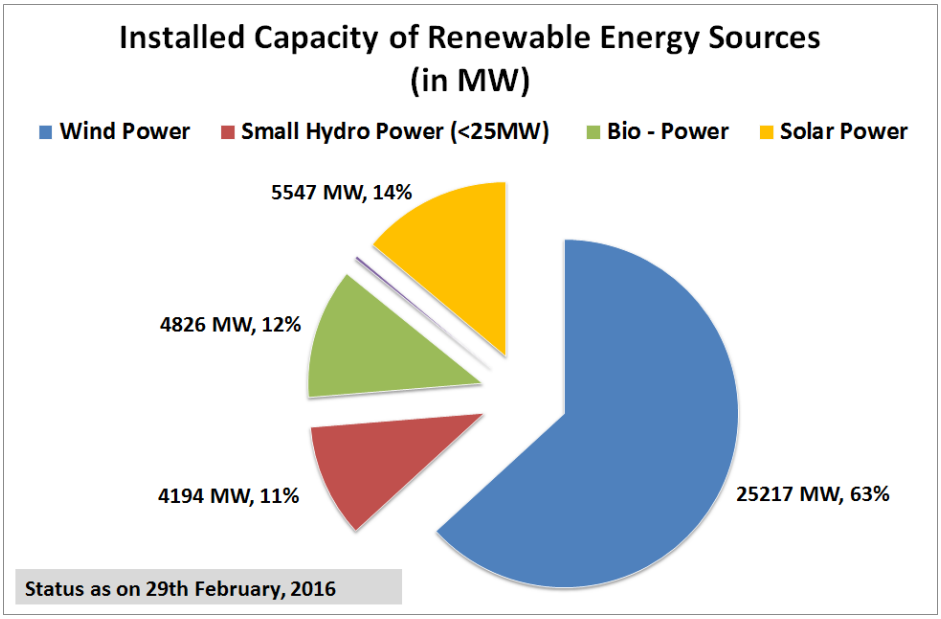


Figure 2 - Breakup of All India Renewable Energy Installed Capacity

Under the National Solar Mission, solar power capacity is targeted at 100 GW by 2022. The target will principally comprise of 40 GW Rooftop and 60 GW through Large and Medium Scale Grid Connected Solar Power Projects. Further, Government of India (GoI) has rolled out a scheme for development of Solar Parks and Ultra Mega Solar Power Projects which envisages setting up at least 25 Solar Parks and Ultra Mega Solar Power Projects targeting over 20 GW of installed capacity within a span of 5 years starting from 2014-15. Based on the proposals received, till date, 27 solar parks of aggregate capacity 18.4 GW has been envisaged in 21 States. 60 GW total wind capacity is targeted by the year 2022.

In the Power Ministers' Conference held on 9-10 April, 2015 at Guwahati with States/UTs, the issues pertaining to large scale Integration of Renewables were discussed. After discussions, it was decided to constitute a Technical Committee to consider various issues relating to large scale integration of renewable generation like spinning reserves, flexible generation, need for pumped storage and peaking hydro stations, balancing requirements, Ancillary Service, transmission system augmentation & frequency control etc. States had raised the issues regarding 150 MW volume limit on deviation, same limits for large and small states, Variability of Renewables and balancing mechanisms. Also, RE Generators raised the issues regarding curtailment by SLDCs because of inability to absorb large quantities of RE, evacuation issues and forecasting & scheduling. In pursuance of the above, Ministry of Power, vide OM No. 11/11/2015-PG dated, 20th April 2015 (Copy at Annex – I) constituted a Technical Committee for "Large Scale Integration of Renewable Energy, need for balancing, Deviation Settlement Mechanism (DSM) and associated issues".

Subsequently, Hon'ble Minister of State (IC) for Power, Coal and New & Renewable Energy took a meeting on 19th June, 2015 regarding Large Scale Integration of Renewable Energy, Need for Balancing, Deviation Settlement Mechanism (DSM) particularly with reference to 150 MW limits, Regional Grids and associated issues. In the meeting, there was convergence, as deliberated by the Technical Committee, that for large scale integration of

renewables requires, amongst other things, forecasting, flexible power systems, markets, spinning reserves, frequency control and imbalance handling mechanism. At the state level also, there is a need to forecast load & generation, balance the portfolio, keep generation reserves and put in place intra-state imbalance handling mechanism. The following technical requirements are important at all levels for integrating large quantities of RE generation in the Indian grid.

i. Robust transmission services to ensure that RE generation backing down is minimal.

ii. Adherence to Grid Standards and Regulations by RE generators.

iii. Load forecasting at DISCOM, SLDC, RLDC and NLDC levels.

iv. RE generation forecasting at pooling station, groups of Pooling Stations, SLDCs, RLDCs and NLDC levels.

v. Establishment of REMCs at SLDC, RLDC and NLDC level with full real time data availability from RE sources including forecast data.

vi. Need for primary, secondary and tertiary generation reserves

vii. Ancillary Services framework at inter state and intra state level to operationalize the

reserves.

viii. Primary, secondary and tertiary frequency control

ix. Automatic Generation Control (AGC) to implement secondary control on a regional basis.

x. More flexibility from conventional generation fleet comprising coal, gas and hydro.

xi. More flexible resources like pumped storage hydro resources in the country.

It is further reiterated that the requirements at S.no iii), and vi) to xi) are required irrespective of RE generation but are still missing in the Indian landscape.

1. Spinning Reserves

Reliable operation of large electricity grids like that of India necessitates that reserves in generation are available in the system all the time to handle contingencies in the grid. The reserves have to be identified in advance, kept available and deployed immediately in real time at the instance of the System Operator. Necessary incentives to the generator may be made for maintaining and deploying these reserves. Reserves could be spinning or non-spinning reserve; however deployment time of these reserves is a crucial factor. 0-10 minutes is the typical norm for deployment of spinning reserves. Generation reserves are further more relevant in the context of intermittent generation like wind / solar.

The total quantum of reserves and its segregation into primary, secondary and tertiary reserves is extremely important in the context of balancing. As stated above, the National Electricity Policy of 2005 mentioned 5% spinning reserve. With 275 GW generating capacity existing as on date and nearly 150 GW peak demand, the quantum of reserves has been estimated at about 4 GW of primary reserve, 3.6 GW of secondary reserve and 7 GW of other reserves. In this regard, CERC has provided a Roadmap to Operationalize Reserves in the country vide Order dated 13th Oct 2015 in Suo Motu Petition No. 11/SM/2015. This quantum would be required irrespective of the penetration of RE generation. The key question is whether the reserve requirement would go up or down and if so by what quantum as the RE penetration level increases in line with the 175 GW RE capacity target of Government of India by 2022.

As the provision of reserves is yet to be notified in any of the Regulations by the ERCs, an impression that reserves are required only for RE integration may be incorrect. The spinning reserve requirement may be attributed to a host of factors such as unit outages, transmission line trippings, weather related uncertainities forecast errors etc. An analysis of the hourly load variability and net load variability was done by POSOCO for the state of Gujarat for the three year period based on data provided by SLDC Gujarat. The same is graphically indicated in Figure 3 below.

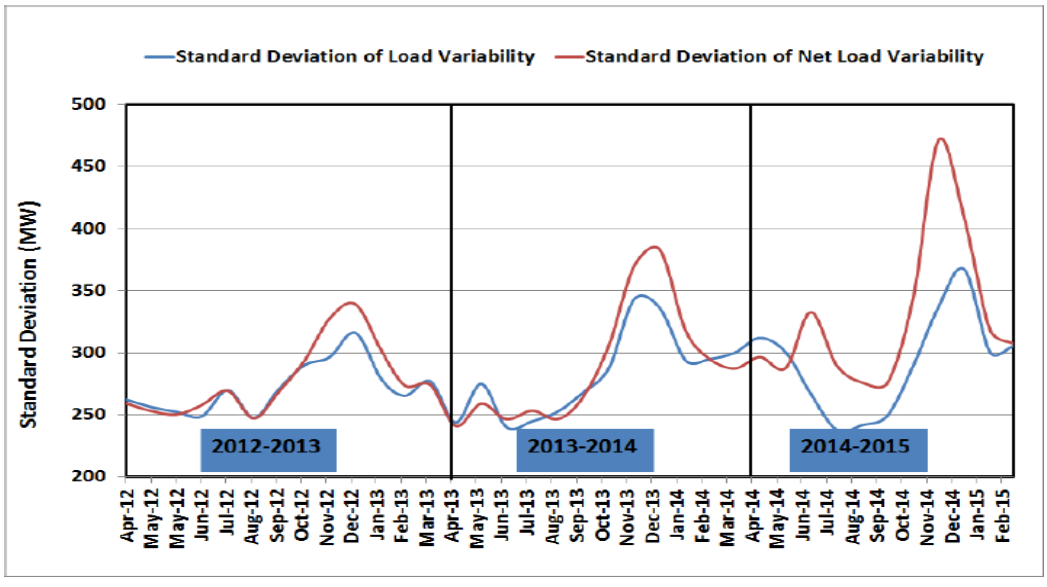


Figure 3 - Standard deviation (σ) of the hourly load variability and net load variability of Gujarat

It is observed from literature available that the standard deviation (σ) of the hourly load variability is a useful parameter to estimate the reserves and 3σ is the estimated quantum of tertiary or load following reserves required to handle the variability. The difference in standard deviation of the load and net load variability suggests that reserve requirement has gone by at least 150 MW for the state of Gujarat over the last three years. The same analysis might need to be extrapolated in 2021-22 scenario considering addition of RE sources and the load pattern.

A similar analysis at the All India level might be currently possible only for the load variability considering that accurate hourly data for RE is not available on an All India basis. (Gujarat by virtue of implementation of intra state Availability Based Tariff or ABT has at least high quality metered data for wind and solar).

In the analysis by POSOCO for 2014-15, it was observed that the standard deviation of the hourly variability for All India load was of the order of 2350 MW which suggests a tertiary or load following reserve of at least 7000 MW (3 times the standard deviation). The standard deviation has increased from 1960 MW in 2009-10 to 2350 MW in 2014-15 (increase of 400 MW) suggesting the change in load curve. A similar exercise for the net load (load less RE generation) may be useful which would indicate the need for additional reserves, if any, considering the RE penetration levels at present level as well as requirement by 2022.

When analyses show that additional investments in flexibility are required to ensure the reliability of the system at high shares of VRE, the specific performance requirements are key for the identification of the most suitable technologies, and should be included in the simulations used for decision making. Depending on the existing demand and energy mix, system flexibility can be increased through options that act on the supply side (i.e., generation technologies that can be started-up, shut-down, and controlled to adjust power output quickly and frequently without having major impact on the equipment's life), on the demand side (i.e., by making adjustments to the demand, for example through demand response management supported by smart-grid technologies), or on both supply and demand using storage technologies.

Flexible generators, such as reservoir hydropower plants or modern gas turbines and combined cycles, and demand response can quickly adjust power supply and demand, respectively, to compensate for changes in VRE output. Storage can shift generation or load as necessary to fill the gap between VRE generation and demand.

2. Ancillary Services

In an electricity grid, the basic services are power generation, energy supply and power delivery from the producer to the consumer. Some system services such as frequency and voltage control come inherently with these services. However to complement reliable operation of the electricity grids and provision of these basic services, certain support services are very much required. These support services are known as 'ancillary services' and are basically procured and pressed into service by the System Operator. Sally Hunt in her book titled" Making Competition Work in Electricity", mentioned that the four pillars as per Figure 4 below, must work together for a vibrant electricity market.

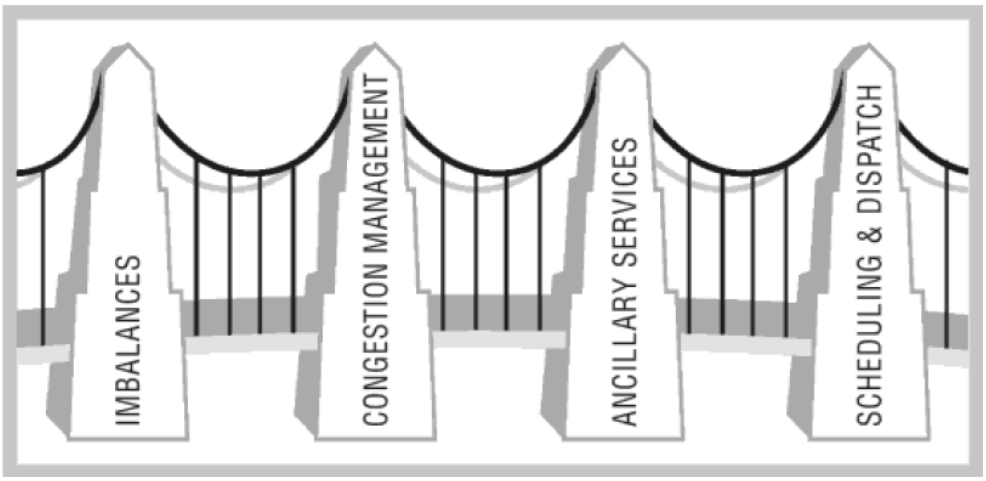


Figure 4 - Four Pillars of Market Structure

CERC Draft Ancillary Services Operations Regulations, 2015 were floated for stakeholder consultations on 01st May, 2015. A public hearing on the draft regulations was held on 12th June, 2015. The Regulations have since been notified on 19th August 2015 and need to be operationalized at the earliest. NLDC would be the nodal agency for implementing this Regulation through the RLDCs. Statement of Reasons (SoR) was issued by CERC on 17th September, 2015. NLDC floated Draft Detailed Procedure For CERC Ancillary Services Operations for stakeholder consultations on 29th September, 2015. Stakeholder Workshops were conducted in every region to discuss the draft and obtain the suggestions/comments of stakeholders, after which the draft procedures have been submitted for approval of CERC. The Detailed Procedure for Ancillary Services Operations has been approved by CERC in March, 2016. The Ancillary Services are expected to be rolled out for implementation by April 2016.

3. Load Forecasting and Generation Despatch

In order to deal with variability of renewable generation forecasts are crucial for resource adequacy during operation and grid security. Forecasting is an essential pre-requisite for scheduling of the RE generation. There is a need for both centralized and de-centralized forecasting systems. The centralized forecast is done by concerned System Operator primarily for grid security. The de-centralized forecast done by respective RE generator essentially for scheduling and this has commercial implications for the RE generator.

It is well recognized that while fixing the deviation limits, the size of the state and the quantum of renewable generation the state is having, also needs to kept in consideration. However, as large quantum of RE Generation is going to be integrated with the grid, keeping in view the security of the grid, the Forecasting and Scheduling for RE Generators is a key pre-requisite.

The granularity of forecast should be with a 15 – minute resolution so that it can be seamlessly integrated with existing scheduling and despatch framework. CERC IEGC, 2010-Regulations 5.3(e) stipulate estimation of demand at SLDC for daily operational use for each 15 minutes block.

Also, in this direction, CERC, vide order in the suo-motu petition No. 11/SM/2015 dated 13th October, 2015, has issued the roadmap to operationalize reserves in the country. A regulated framework has been provided for identification and utilising of spinning reserves and implemented with effect from 1st April, 2016 till 31st March, 2017. Also, it is envisaged that a market based framework is required for efficient provision of secondary reserves from all generators across the country for implementation by 1st April, 2017.

4. Imbalance Handling and Settlement

In the Indian Power System, as per Grid Code, action by control areas is mandated to control inter-change by changing generation and load. If there is surplus / shortage for a longer period, entity can change requisition from Generating Stations. States also have the option to procure power through intra-day contingency contract from the market. A mechanism to facilitate integration of RE and to handle imbalances was introduced by CERC as "RRF Mechanism" in 2010 (IEGC 2010 Regulation 6.5.23). However, jurisdiction issues raised by intra-state RE generators and implementation difficulties led to suspension of commercial part of RRF Mechanism in 2014 by CERC. CERC has specified volume limits under the Deviation Settlement Mechansim, 2014. The relevant provisions are as follows:

"…7. Limits on Deviation volume and consequences of crossing limits

(1)The over-drawals / under drawals of electricity by any buyer during a time block shall not exceed 12% of its scheduled drawal or 150 MW, whichever is lower, when grid frequency is „49.70‟‟Hz and above" Provided that no overdrawal of electricity by any buyer shall be permissible when grid frequency is "below 49.70 Hz"….

(2)The under-injection / over-injection of electricity by a seller during a time-block shall not exceed 12% of the scheduled injection of such seller or 150 MW, whichever is lower when frequency is „„„49.70 Hz and above‟‟ Provided that – (i) no under injection of electricity by a seller shall be permissible when grid frequency is "below 49.70 Hz" and no over injection of electricity by a seller shall be permissible when grid frequency is "50.10 Hz and above". …"

The respective state utilities may not lean on the system to take care of all load / generation changes in their system. There is a need for robust imbalance settlement mechanism. Every state is responsible for balancing within its own control area. Each state should assess its balancing capacity.

It is cautioned that, in extreme scenario, if all state utilities of a region start erring in one direction, it will lead to skewed scenario and stress the Inter-Regional tie lines flows leading to critical levels and threat to the security of the grid. It is re-emphasized that the large deviations besides causing severe transmission constraints and endangering Grid Security may also render it difficult to control the large deviations during contingency, as manual action takes time to control drawal from grid and hence may put the grid to risk. It is a fact that large deviations would undermine grid security and secure and reliable grid operation is of paramount importance.

Special provisions for handling deviations by RE generation under the CERC Framework on "Forecasting, Scheduling & Imbalance Handling for Renewable Energy (RE) Generating

Stations based on wind and solar have been incorporated at Inter-State Level. Only few states have implemented intra-state imbalance settlement mechanism. There is a need for intra-state Deviation Settlement mechanism in all the states. The committee is of the view that once the CERC Regulations at the inter-state level are in place, a model Regulation for SERCs could be made by CERC and the matter may be taken up in the next meeting of the Forum of Regulators (FOR). A need was also felt for study of the reasons for deviation in all the states with regard to variation in actual demand, variation in Conventional Generation availability and variability of RE Generation. In this direction, the Model Regulations, were subsequently deliberated in the 50th Meeting of FOR held at Pune in September 2015 and subsequently finalized. The Model Regulations on Forecasting, Scheduling and Deviation Settlement of Wind and Solar Generating Stations at the State Level (2015) are available on the website of Forum of Regulators (FOR). The draft regulations based on the Model Regulations have been formulated by states of Madhya Pradesh, Rajasthan, Odisha, Karnataka, Jharkhand and Tamil Nadu.

5. Frequency Control

The frequency of the All India grid is remaining within the band of 49.90 – 50.05 Hz for about 55 % of the time for the last six months. The Frequency Response Characteristics (FRC) for All India Grid is about 6000-6500 MW/Hz. There are statutory provisions for primary response in the Indian Electricity Grid Code (IEGC), 2010 with exemption to nuclear, CCGT, canal based hydro etc. The speed droop setting is between 3 to 6%. The frequency profile and fluctuation from 2004 onwards is depicted in Figures 5 and 6 respectively.

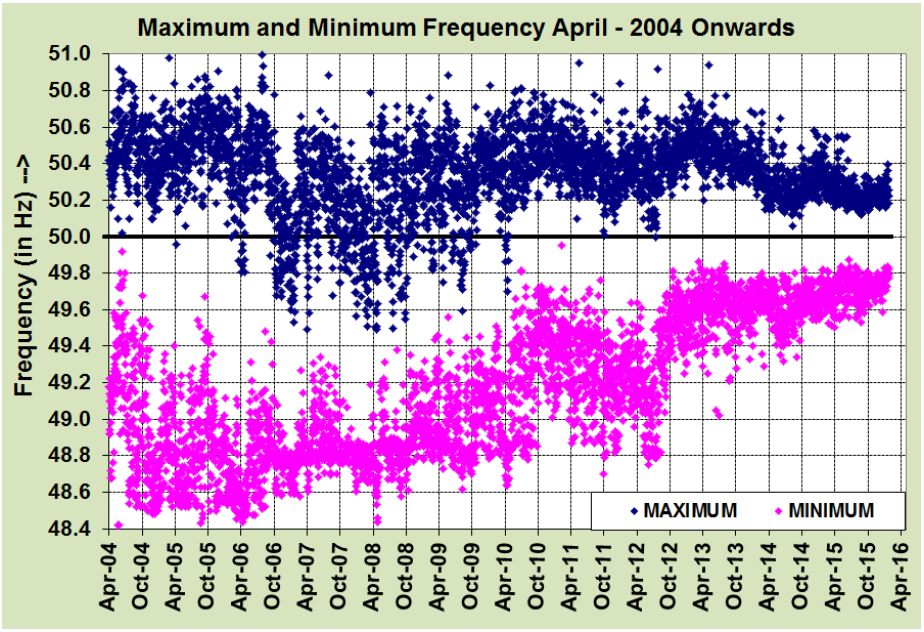


Figure 5 - Frequency Profile 2004 Onwards

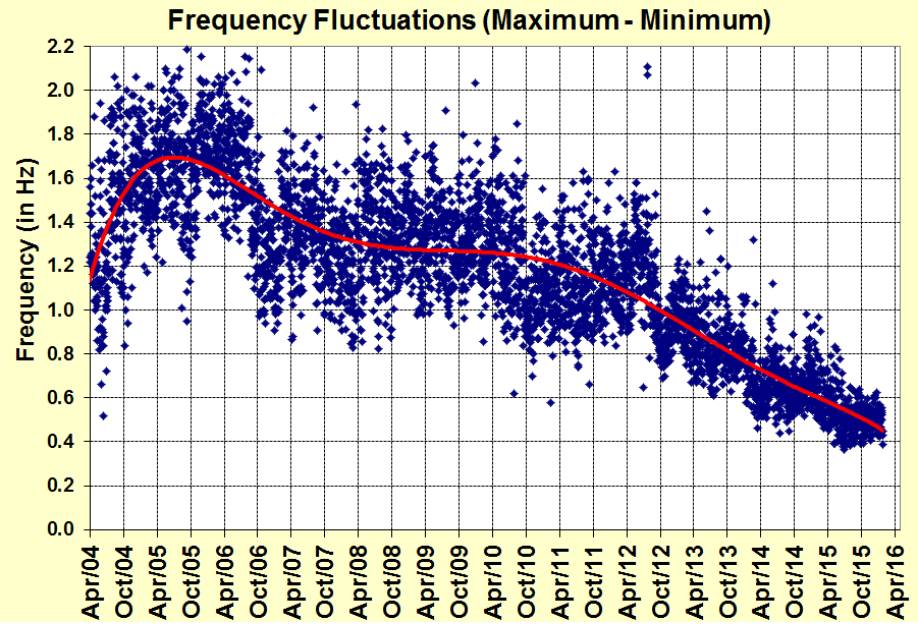


Figure 6 - Frequency Fluctuations 2004 onwards

Frequency Variation Index (FVI) is the performance index representing the degree of frequency variation, from the nominal value of 50.00 Hz, over a specified period of time. The formula for calculation of FVI is as follows:

$$FVI = 10 \times \frac{\sum_{i=1}^{N} (f_i - 50)^2}{N}$$

Where: fi : Actual frequency in Hz at ith time period.

N : Number of measurements over the specified period of time.

The FVI plot of the synchronized National Grid from January – 2014 onwards is depicted in Figure – 7 below:

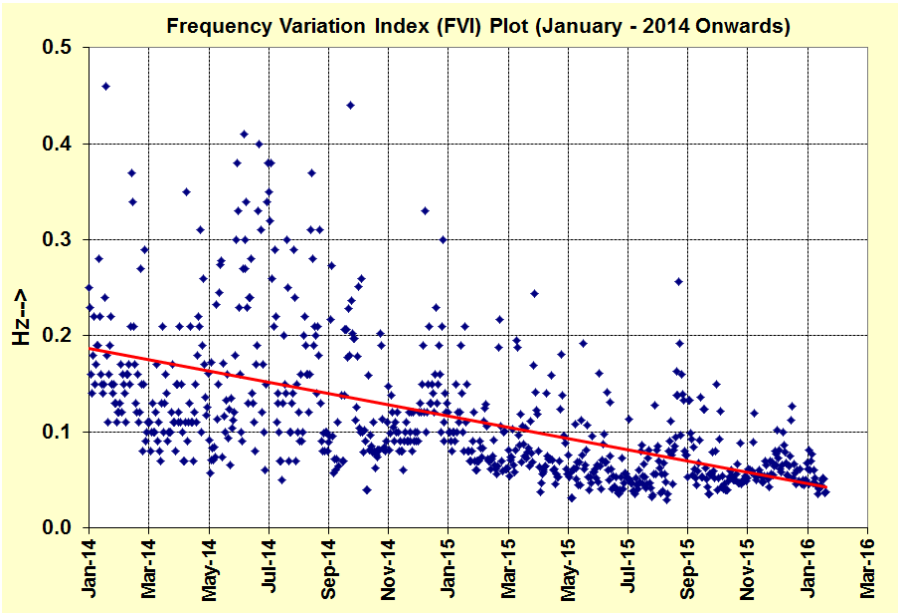


Figure 7 - FVI Plot of National Grid from January-2014 Onwards

There may be a roadmap for introduction of secondary control in India - manual mode to start with and graduate to automatic control in due course of time. In tertiary control, re-scheduling of generation through a notice 60-90 minutes in advance is done along with short term bilateral trades for the same day and load management. Primary control by governors is absolutely necessary to maintain frequency within strict limits. As the interconnections grow to subcontinent size and interchanges between areas increase, the primary control by governors has to be supplemented by secondary control (AGC) using tie-line bias. Direct primary and secondary control keep frequency and schedules within acceptable ranges for reliability.

Also, in this direction, CERC, vide order in the suo-motu petition No. 11/SM/2015 dated 13th October, 2015, has issued the roadmap to operationalize reserves in the country. A regulated framework has been provided for identification and utilising of spinning reserves and implemented with effect from 1st April, 2016 till 31st March, 2017. Also, it is envisaged that a market based framework is required for efficient provision of secondary reserves from all generators across the country for implementation by 1st April, 2017.

In 2014, a pilot project for testing of primary response had been done by Solvina International. It had carried out testing of primary response of five units in India, under a contract with Power Grid /POSOCO. The five units that were tested for Primary Frequency Response of governors were at:

a) NHPC Chamera (1 unit of 180 MW) (13th-15th Oct 2014)
b) THDC Tehri (1 unit of 250 MW) (19th-22nd Oct 2014)
c) NTPC Dadri (1 unit of 490 MW) (15th-18th Nov 2014)
d) NTPC Dadri (1 unit of 210 MW) (19th-21st Nov 2014)
e) PPCL Bawana (1 unit of 216 MW) (24th Nov 2014)

The test results and recommendations are as follows:

Unit / Test	FGMO	RGMO	Islanding (FGMO)
Dadri II (490MW)	Expected beavior 196MW/Hz, 15-85s	-	Stable f-control but unstable process
Dadri I (210MW)	Expected behavior, but maybe too reponsive 84MW/Hz, 3-8s	-	Unstable f-control and process
Bawana (216MW)	Expected behavior 110MW/Hz, 5-10s	-	Not tested due to inability to arrange test input
Chamera (180MW)	As Expected 60 MW/Hz, 10-60s	OK, meets grid code	Stable, can manage large load change (>10%)
Tehri, (250MW)	Expected behavior but gate feedback causes nonlinear load response. *50-250MW/Hz, (125)* 100-200s	Works but not as intended in some cases	Stable, can manage large load change (>10%)

Recommendations for Plants

- Phase out RGMO
- Implement PI(D) Frequency control (FGMO) with droop integrated with Load control.
- ”Power Feedback” in normal operation for predictable response
- ”Gate Feedback” in islanding for best possible stability
- Make sure process is optimally stable

Recommendations for Testing

- For Primary response in normal operation, step response tests should be carried out to get the magnitude and time constant
- For islanding, either online ”simulator testing” or real life full scale tests should be considered. Nothing else is sufficient.
- For checking of the participation in frequency control, the generated power and frequency can be used for verification
- Any testing should be carried out by an independent party

Recommendations for Grid Control

- Work out clear Grid Code for Primary Control response and for testing of the same. The requirements should be based on the unique circumstances in India.
    - Grid topology
    - Grid bottlenecks
    - Generation mix,
    - Geograpical distribition
    - ”Design base” contingencies
    - Market aspects

The secondary control may be implemented at regional level in manual mode to start with and graduating to Automatic Generation Control. A Committee constituted by CERC having different technical experts is examining the issue of primary response and is expected to submit its report shortly.

6. Flexible Generation

Large 660 MW, 800 MW and 1000 MW sets being introduced in India. With changing load profile, flexibility in the existing fleet of conventional generation is to be used to facilitate integration of renewable. As more RE generating capacity is added, increasingly different net load shape takes place. Net load—the total electric demand in the system minus RE generation—represents the demand that must be met with other, dispatchable sources such as thermal, natural gas, hydropower, and imported electricity from outside the system. A sample All India Load & Net Load Curve (known internationally as Duck Curve) considering minimum 20 GW of Solar Generation is depicted in Figure 8 below:

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

For ramp up/ramp down rates, the Indian Electricity Grid Code (IEGC) clause 5.2 (i) states that *'The recommended rate for changing the governor setting, i.e. supplementary control for increasing or decreasing the output (generation level) for all generating units, irrespective of their type and size, would be one (1.0) percent per minute or as per manufacturer's limits. However if frequency falls below 49.7 Hz, all partly loaded generating units shall pick up additional load at faster rate, according to their capability'*

CEA (Technical Standards for Construction of Electrical Plant and Electric Lines) Regulations, 2010 Part B S no 7 (4) for coal fired stations states that *'The design shall cover adequate provision for quick start up and loading of the unit to full load at a fast rate. The unit shall have minimum rate of loading or unloading of 3% per minute above the control load (i.e. 50% MCR).'*

Draft Central Electricity Regulatory Commission (Indian Electricity Grid Code) (Fourth Amendment) Regulations, 2015 had been notified vide public notice No. L-1/18/2010-CERC dated 02nd July, 2015 which laid out provisions for Technical Minimum Schedule for operation of Generating Stations. The relevant provisions are quoted as follows:

"…6.3B – Technical Minimum Schedule for operation of Generating Stations

1. The technical minimum schedule for operation in respect of ISGS shall be 55% of MCR loading of unit/units of generating stations.

2. A generating station may be directed by concerned RLDC to operate below 85% but at or above the technical minimum schedule on account of grid security or due to the less schedule given by the beneficiaries

3. Where the generating station regulated by this Commission is directed by the concerned RLDC to operate at technical minimum schedule, the generation station may be

compensated subject to the prudence check by the Commission in due consideration of average unit loading based on forced outages, planned outages, PLF, generation at generator terminal, energy sent out ex-bus, number of start-stop, secondary fuel oil consumption and aux energy consumption etc on an application filed by the generating company duly supported by relevant data verified by RLDC/SLDC.

Provided that in case of coal/lignite based stations, following station heat rate degradation shall be considered for the purpose of compensation:

S.No.	Unit loading as a % of Installed Capacity of the Unit	Increase in SHR (for supercritical units) (%)	Increase in SHR (for sub-critical units) (%)
1	85-100	Nil	Nil
2	75-84.99	1.25	2.25
3	65-74.99	2	4
4	55-64.99	3	6

Provided further where the scheduled generation falls below the technical minimum schedule, the generating station shall have the option to go for reserve shut down and in such cases start up fuel cost over and above 7 start/ stop in a year. shall be considered as additional compensation:

Provided also that in case of gas based station compensation shall be decided based on the characteristic curve provided by the manufacturer and after prudence check of the actual operating parameters of Station Heat Rate, Auxiliary Energy Consumption, etc.:

Provided also that compensation so worked out by the Commission after prudence check shall be borne by the entity who has caused the plant to be operated at technical minimum. The name of the entity shall be mentioned in the order to be issued by the Commission.

4. In case of generating stations not regulated by the Commission, generating company shall have to factor above provisions in their PPAs for sale of power in order to claim compensations for operating at the technical minimum schedule.

5. The generating companies shall keep the record of the emission levels from the plant due to part load operation and submit a report for each year to the Commission by 31st May of the year.

6. NLDC in consultation with RLDCs/SLDCs, generating companies, beneficiaries and buyers of all regions at RPC forums, shall prescribe a Operating Procedure which shall be followed in certain specific grid conditions such as sudden load throw off or unit tripping significantly endangering grid security, identifying generating stations based on merit order despatch/ stacking to be backed down in such contingencies for each region."

The figures quoted by typical generators to RLDCs for the purpose of scheduling are as under:

a) Ramagundam 500 MW unit .....24 MW per 15 minute time block (works out to 3.2 MW

per minute; 48 MW divided by 15 minutes much lower than even the conservative IEGC limit of 5 MW per minute)

b) Simhadri 500 MW.....29 MW per 15 minute time block (approx 4 MW per minute)

c) Sipat 660 MW unit .....4 MW per minute

d) Sasan 660 MW.....5.3 MW per minute

e) CGPL Mundra 830 MW unit .....8 MW per minute.

It is observed that there is a disparity in the ramp rates indicated by generators vis-à-vis the values specified in the CEA Standards. The reasons for the same needs to be technically examined and resolved including the issue of 'technical minimum'. The All India Daily Maximum - Minimum of Thermal Generation and Hydro Generation from April - 2012 Onwards is depicted in Figures 9 & 10 respectively.

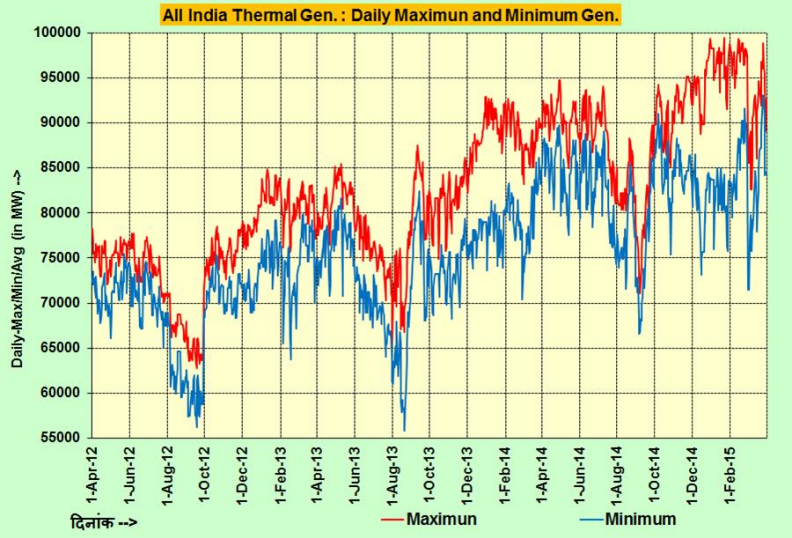


Figure 9 - All India Daily Maximum - Minimum of Thermal Generation April - 2012 Onwards

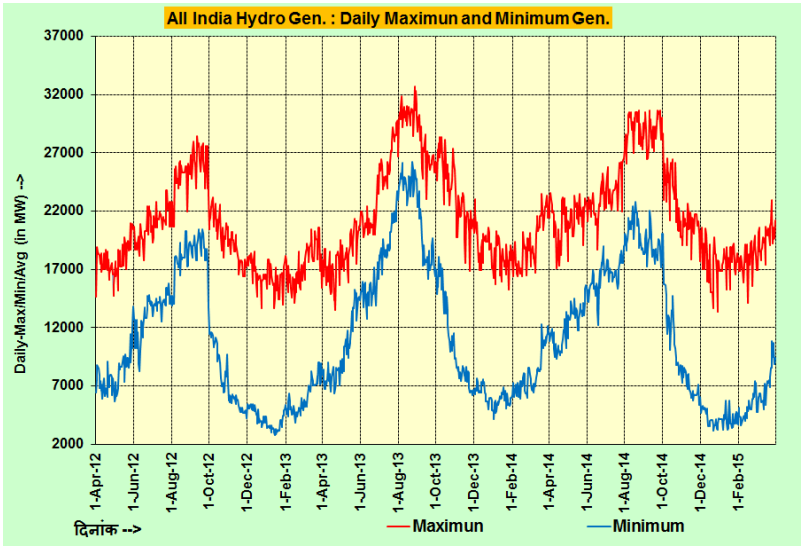


Figure 10 - All India Maximum - Minimum of Hydro Generation from April-2012 Onwards

Pumped Storage Plants also play an important role as flexible generation resource in providing peaking power and maintaining system stability. Reservoir based Hydro power plants provide the peaking power requirement. CEA Report on Large Scale Grid Integration: At present 9 pumped storage schemes with aggregate installed capacity of 4785 MW are in operation in the country. Out of these, only 5 No. of plants with aggregate installed capacity of 2600 MW are being operated in pumping mode. At present, two Pumped Storage Plants with aggregate installed capacity of 1080 MW are under construction in India. 63 sites identified for pumped storage plants (PSP) with total potential of about 96,500 MW. Typical 3-D Generation Plot of Kadamparai (Tamil Nadu) Pumped Hydro Station operation is depicted in Figure – 11.

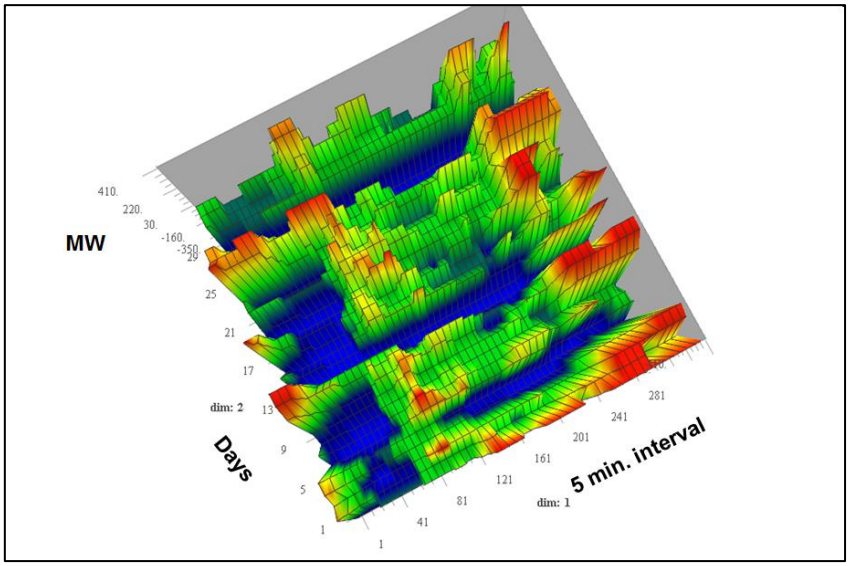


Figure 11 - Typical 3-D Generation Plot of Kadamparai (Tamil Nadu) Pumped Hydro Station

Regulatory support is required to incentivize flexibility of conventional generation sources for meeting Net load. The regulations should compensate the conventional generator for partial operation and start up and stop costs so that it can flex the generation. CEA Standard Technical Features for 660MW/800 MW Sets recommended technical minimum of 40% and two shifting of machines was envisaged.

POSOCO vide Communication dated 17th Sept., 2015 to Secretary CERC & CEA submitted a Detailed Report on need for Regulations and Standards in respect of 'flexibility' of generating units to accommodate higher penetration of Renewable Energy (RE) sources.

7. Market Design Enhancements

The present power exchange provides only one opportunity for buying and selling on day-ahead basis. More frequent market clearing as well as new products such as real time markets (i.e the opportunity to buy and sell power about two hours ahead) may provide a platform for selling surplus power or buying power when in deficit. 5 % reserve capacity in generating plants as per the National Electricity Policy may be useful for providing liquidity in the electricity market. CERC order dtd. 08.04.2015 on extended market session in Power Exchanges provided for operation of 24x7 intraday/contingency market for same day and

next day delivery. The same has been implemented by the Power Exchanges (PX) since 20th July 2015; however the same is yet to be exploited in a major way by the market players.

It has been observed that in case of renewable energy generation, particularly in case of Wind Turbine Generators (WTGs), the ownership is quite fragmented and large capacity of WTGs is owned by small investors. In an earlier order, Hon'ble CERC has recognized the need of a nodal entity at the connection point, which shall be responsible for coordinating with SLDC/RLDC on behalf of all the developers/generators. Hence, a separate Institutional Entity e.g. RE Aggregators / Qualified Scheduling Entity (QSE) may be required to be put in place, which is recognized under regulatory framework and could be qualified/certified/registered with System Operator to undertake various activities associated with scheduling/commercial settlement/de-pooling/communication/data consolidation and management and co-ordination etc. Suitable definition may be incorporated in the appropriate regulations including Grid Code.

8. Transmission Augmentation

It has been recognized by the transmission planners that in view of the short gestation period of RE plants, the transmission has to lead generation and would require upfront investment. There is a need for transmission corridors for evacuation of power from RE – rich states through the established process of coordinated transmission planning. The approval process of transmission scheme involves stages like Standing Committee, CERC regulatory approval, RPC, Section 68, MoP/Empowered committee approval etc. In case of transmission scheme of RE, a single window approval procedure may be adopted to facilitate speed up the implementation.

In India we have the advantage of a large grid integrated by high capacity transmission corridors. CERC Grant of Regulatory Approval for execution of Inter-State Transmission Scheme to Central Transmission Utility Regulations, 2010. CEA and CTU planned "Green Corridors" in the states of Tamil Nadu, Gujarat, Rajasthan, Karnataka, Andhra Pradesh, Maharashtra, Himachal Pradesh and Jammu & Kashmir. MoP, MNRE collaboration with GIZ, KfW, Germany for the inter-state and intra-state schemes for evacuation of power from wind and solar projects. Green Energy Corridors – I report was submitted by PGCIL to the MNRE.

Under the technical assistance component of the Green Energy Corridor project GIZ, Germany has prepared draft reports on Forecasting, Scheduling, Balancing and on Renewable Energy Management Centres (REMCs) as one of the deliverables. The Green Energy Corridor project is under implementation in the 8 States namely Andhra Pradesh, Gujarat, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Tamil Nadu. The issues discussed in the report are critical for grid integration of large scale renewable power.

Reactive Power Planning, particularly the use of Power Electronic Devices (PEDs) like Static Var Compensators (SVCs), STATCOMs also become important from the viewpoint of having a flexible power system.

Apart from the above requirements, CEA Standards for RE generation incorporating features such as Low Voltage Ride Through (LVRT), High Voltage Ride Through (HVRT), frequency thresholds for disconnection from the grid, active and reactive power regulation by RE generators also become important and needs to be notified at the earliest.

9. Renewable Energy Management Centres (REMCs)

Renewable Energy Management Centres (REMCs) at State, Regional and National level may be co-located with respective Load dispatch centers (LDC) and integrated with real time measurement and information flow. There may be a hierarchical connection between the state Load Dispatch Centre, Regional Load Dispatch Centre and National Load Dispatch Centre. The REMC may have following functions:

i. Forecasting of RE generation in jurisdiction area on day-ahead, hour-ahead, week-ahead, month-ahead basis.
ii. Real time tracking of generation from RE sources
iii. Geo-spatial visualization of RE generation
iv. Close coordination with respective LDC for RE generation and control for smooth grid operation.
v. Single source information repository and coordination point for RE penetration.
An ideal dataset, including any local weather data, may be required from the RE generators for the purpose of forecasting RE generation. Such a list and its inclusion in the appropriate Regulations would greatly facilitate availability of data and enable forecasts at REMC level. For the purpose of forecasting of RE generation, information of all the solar park/wind farms in terms of static data like lat/long of each turbine, hub height, turbine type, inverter etc., real time generation/weather data (developer SCADA), historical generation data may be required.

It would also enable in identifying the areas where the Indian Meteorological Department (IMD) may be involved and necessary capacity building exercises may be undertaken. RTU along with suitable communication infrastructure at all RE pooling station/Point of Common Coupling (PCC) is needed for visibility as well as forecasting of RE generation. The respective state utilities may expedite the installation of RTU & Communication system at RE pooling station/PCC.

10. First Meeting of the Technical-Committee

The First meeting of the Technical Committee was held at 1200 hrs on 27th April, 2015 at Ministry of Power, New Delhi. The copy of the minutes of the First Meeting of the Technical Committee held on 27th April, 2015 is placed at Annex – II. The gist of discussions held in the meeting is as under:

a) It was emphasized that spinning reserves may be defined in the Act, Policy, Grid Code as well as factored in the Planning process. Joint Chief (RA), CERC stated that provisions of primary response have already been stipulated in IEGC, 2010 and therefore, requirement of reserves is mandated by CERC. CEO (POSOCO) stated that

short term solution may be to identify the reserves in the existing plants and spell out the quantity on daily basis to respective LDC. JS (JA), MoP stated that suitable amendments in the Act and Policy are being proposed by the Ministry of Power in respect of spinning reserves.

b) On a query from Chairman, Joint Chief (RA), CERC stated that there were reservations from State Utilities on implementation of Ancillary Services with the major fear being that it would lead to operation of costly plants leading to rise in electricity prices at retail level. Chairman mentioned that Spinning Reserves are implemented through Ancillary Services.

c) The representative of Rajasthan state utility highlighted the challenge of RE generation variability. It entailed surrender of Central Sector allocated power alongwith huge over-drawal/under-drawal due to sudden variation in RE generation. Chairman stated that RE generation should not be backed down. CEO (POSOCO) stated the need for ramping up/down of the conventional generation. It was highlighted that the CEA Standard Technical Features for 660MW/800 MW Sets recommended technical minimum of 40% and two shifting of machines was envisaged.

d) JS (MNRE) raised the issue of mismatch between forecast and actual RE generation and therefore, a need for review of band specified in the draft CERC proposed framework. Joint Chief (RA), CERC clarified that besides the issue of band, 16 revisions i.e. One revision every 1.5 hr has been proposed thereby providing flexibility in revision of schedule more closer to the real time. Both Wind and Solar generators must forecast and schedule for market access.

e) Chairman sought clarification as to why state utilities are not being able to square off in 1.5 hr with 16 revisions. The representative of Rajasthan State Utility attributed the challenge to the forecasting and absence of cooperation from intra-state RE generators. JS (MNRE) stated that GETCO had managed to persuade RE generators in Gujarat to provide data. In Tamil Nadu, IWEA is coordinating with NIWE to provide forecast data to SLDC.

f) Chairman highlighted the need for both centralized and de-centralized forecasting. Chairman directed POSOCO to prepare doable action plan for introduction of forecasting, RE forecasting models adopted world-wide and extent of responsibility for both RE generation and load forecasting.

g) POSOCO stated that statistical analysis of deviations of RE-rich states had been presented in FOR meeting on 27th June, 2014. It was found out that the maximum correlation for deviation from schedules was due to the variation in load, followed by conventional generation changes and minimum correlation to the variation in RE generation. Therefore, the deviations are attributable more to factors other than variation in RE generation. Only few states have Intra-state imbalance settlement mechanism. There is need for intra-state Deviation Settlement mechanism in all the states.

h) CEO (POSOCO) stated that recently a pilot project for testing of primary response had been done and the report of the same has been submitted to CERC. The secondary control may be implemented at regional level in manual mode to start

with and graduating to Automatic Generation Control. Joint Chief (RA), CERC stated that a Committee constituted by CERC having different technical experts is examining the issue of primary response and is expected to submit its report shortly.

i) The issue of increasingly different net load shape as more RE capacity is added was highlighted. Net Load which is total electric demand in the system minus RE generation represents the demand that must be met with other despatchable sources. Hence, flexible generation like Pumped Storage Plants is required to provide peaking power and maintaining system stability.
j) JS (JA), MoP mentioned that possibly there is need to consider Pumped Storage Plants as RE generation as it emerged in the Conference of Power and Mines/NRE Ministers of States/UTs. Chairman mentioned the need for introduction of Flexible Generation Planning and Flexible Generation Obligation (FGO) in the future.
k) JS (MNRE) suggested that issues related to REMC & Control Equipment may be included in the scope of work of the Technical Committee. JS (JA), MoP mentioned that funding of REMC was proposed through budgetary support of Government of India; however, the same could also be funded through Power System Development Fund (PSDF).
l) Chairman highlighted the importance of market design enhancement and transmission augmentation as crucial for large scale RE grid integration.

11. Second Meeting of the Technical-Committee

The second meeting of the committee was held on 9th May 2015 at 09:00 hours in Vidyut, Bhawan, Jaipur, Rajasthan. The copy of the minutes of the Second Meeting of the Technical Committee held on 09th May, 2015 is placed at Annex – III. The gist of discussions held in the meeting is as under:

a) Mainly discussion was held on the issue of communication of Data from RE Generators to the SLDCs. Regulations on Communication in power sector may be evolved by CERC.
b) SLDCs/CEA/CTU/POSOCO/developers have to come out with a long term solution and an intermediate solution through leveraging the existing facilities. CEA would also come out quickly with their DPR for below 132 kV communication system.
c) MNRE would explore whether the communication system up to 132 kV and below 132 kV up to 33 kV could be funded as part of the GEC project and central funding may be earmarked.
d) GIZ and E&Y would try to incorporate the above features in their REMC report due in August 2015.
e) A committee headed, by, Principal Secretary, Energy, Government of Rajasthan and having members from SLDC Rajasthan. Secretary RERC, CEA, CTU, POSOCO, Director MNRE and representative from developers would evolve a framework for smooth real time data transfer between the wind/solar pooling stations and the State Load Despatch Centre (SLDC).
f) The developers also expressed the need for a forecasting mechanism. The developers stated that they needed 15-minute forecasts as scheduling is on a 15-

minute block basis at the Load Despatch Centre level. It was decided that MNRE in consultation with developers, NIWE, SLDCs and POSOCO would work out the modalities for transmission of data from energy meters to SLOCs.

g) It was decided that IMD would explore the possibility of 15-minute basis forecast for the next day.
h) Scheduling of solar projects was also discussed. It was decided that Joint Secretary, MNRE in consultation with IMO, GIZ, E&Y, developers and the state utilities of TN/Rajasthan/Andhra/Telangana/Gujarat/Madhya Pradesh would look at the policy level interventions required to acquire capability of solar generation forecasting considering that it would be a greenfield area for the country.
i) As regards, balancing resources to handle variability of wind generation, POSOCO through a brief presentation stated that the minimum to maximum load ratio was reducing over the years and thermal backing down had increased. POSOCO stated that the draft Ancillary Services Regulation brought out by CERC on 1st May, 2015 provided an opportunity for balancing. It was decided that Shri Pankaj Batra, CEA would chair a Committee having members from CEA (Hydro wing), MNRE, GIZ, Rajasthan DISCOMs, Rajasthan GENCO and developers to examine the balancing requirements on account of variability and fulfilling the same.
j) The Chairman stated that three (3) main issues had emerged in the meeting and requested that the different areas such as policy making, regulatory, planning and system operation be examined for the following three areas:
    i. Real time data and communication from RE generators to LDCs
    ii. Forecasting and Scheduling
    iii. Balancing Resources & mechanism

12. Third Meeting of the Technical-Committee

The third meeting of the Technical Committee was held at 1200 hrs on 13th May, 2015 at Ministry of Power, New Delhi. The copy of the minutes of the Third Meeting of the Technical Committee held on 13th May, 2015 is placed at Annex – IV. The gist of discussions held in the meeting is as under:

a) An Implementation Committee under Sh Pankaj Batra, Chief Engineer (CEA) would be set up comprising members from states, POSOCO and POWERGRID as members for overseeing implementation of the recommendations of the Technical Committee.
b) Backing down to 60% of installed capacity for a coal fired power station would lead to 5 paise/kWh increase in energy charges due to poorer Heat rate. CEA has separately worked out the reserves requirement and flexibility required from conventional power fleet.
c) A committee under RVPN would study the feasibility of introducing storage systems at GENCO level itself and submit its report within 15 days.
d) Rajasthan and Gujarat would send the developer and owner wise list of solar and wind generators in their respective state to the Committee.

e) Sh Pankaj Batra, Chief Engineer CEA would look into the harmonization of regulations at the interstate and intra state level and development of market to make the process of RE integration sustainable.
f) SLDC Gujarat would work out the 'communication' system requirements for getting real time data from the generators to SLDCs through the Data Concentrators at the STU substations.

13. Fourth Meeting of the Technical-Committee

The fourth meeting of the Technical Committee was held at 1200 hrs on 13th May, 2015 at Ministry of Power, New Delhi. The copy of the minutes of the Fourth Meeting of the Technical Committee held on 27th May, 2015 is placed at Annex – V. The gist of discussions held in the meeting is as under:

a) Chairman emphasized the need for implementation of Reserves Requirement and Balancing Resources for RE Integration. POSOCO presented a draft base paper on the Reserves Requirements for Indian Power System.
b) Chief Engineer (RA), CEA submitted that, at present, about 14,000 MW of gas capacity as spinning reserves has been identified. He also suggested that, based on the original 12th Plan projections for RE capacity addition, about 4300 MW i.e. 10 % of the projected capacity may be used for balancing RE. It was also deliberated that there is a policy requirement from Ministry of Petroleum & Natural Gas (MoP&NG) for increasing the present permissible variation of 20 % in the gas pipeline further to accommodate the flexibility in gas fired stations for balancing requirements.
c) GIZ is working with Rajasthan Utilties regarding analysis of balancing requirements, hourly wind/solar generation data and hourly conventional generation data. It was suggested that more flexible conventional generation to rum upto 50 % is needed along with demand response and pumped storage plants. It was also mentioned that, in the mid-term, regional balancing may be facilitated through regulatory framework.
d) CEO (POSOCO) stated that short term solution may be to identify the reserves in the existing plants by scheduling conventional generation upto only 95 % of the Installed Capacity and balance 5 % may be kept as spinning reserve.
e) It was agreed that CEA shall finalize the document on Reserves Requirement and Balancing Resources for RE Integration based on the inputs received so far and as per the discussion held in this meeting.
f) ED (NLDC) presented an interim report on the communication requirements covering the basic details towards infrastructure requirements, technological developments and implementation plan. Chairman directed CEA to coordinate with Gujarat and Rajasthan Utilities to prepare a model data and communication framework for RE integration at intra-state level to be replicated across the country.
g) On a query from Chairman, representative from Rajasthan Utility stated that interim solution may be GPRS communication but long term solution is OPGW communication. Chairman suggested that a long term solution is needed to address the data and communication issues at intra-state level for RE integration. The

funding of the infrastructure on the pattern of Green Energy Corridors (GEC) may be done from PSDF and NCEF. GIZ representative stated that OPGW based communication is the long term solution.

h) POSOCO presented a draft base paper on the Forecasting, Scheduling and Deviation Settlement Mechanism for RE Generation and Load. CEO (POSOCO) mentioned that two stages of forecasting is needed i.e. one at LDC level and other at generator level. It was discussed that ensemble forecasts are preferable as due to large number of forecasts, the error is reduced. PGCIL representative stated that GIZ report on REMC is awaited so that tendering process may be initiated for REMC.

i) Chairman queried on the responsibility of the forecast. He stated that there is a need for aggregator at the generator level. Due to multiplicity of forecast providers, a government entity may provide the forecasting service and be responsible for it. LDCs may enter into an agreement with NIWE or any other agencies for forecasting services. JC (RA), CERC clarified that as REMC are envisaged as a part of LDC, which itself is a government entity. GIZ representative explained that in Germany, TSO acts as the aggregator and enters into contract with 4 or 5 different forecasting service providers. PGCIL representative highlighted that aggregator must be responsible for scheduling and commercial settlements. Any commercial implication may be borne by the aggregator. The grid operator may be responsible from the grid security perspective.

j) Chairman directed CEA representative to coordinate with all the members and finalize the documents on the issues raised in the meeting. CEA shall also prepare a draft note on Technical Committee Recommendations for RE Integration for presentation to the Sec(P) in the next meeting.

14. Meeting taken by Hon'ble MoS(IC) for Power, Coal and NRE on 19th June, 2015 regarding Large Scale Integration of Renewable Energy, Need for Balancing, Deviation Settlement Mechanism (DSM) particularly with reference to 150 MW limits, Regional Grids and associated issues

The copy of the gist of discussion of the Meeting taken by Hon'ble MoS(IC) for Power, Coal and NRE on 19th June, 2015 regarding Large Scale Integration of Renewable Energy, Need for Balancing, Deviation Settlement Mechanism (DSM) particularly with reference to 150 MW limits, Regional Grids and associated issues is placed at Annex – VI. The salient points are as follows:

a) Hon'ble Minister of State (IC) for Power, Coal and New & Renewable Energy chaired the meeting. JS (JA), MoP welcomed all the participants and in the opening remarks mentioned the context of the presentation being made. She mentioned that 150 MW limits under the DSM Regulations of CERC, integration of renewables, balancing at regional grids level etc. had been raised as issues during the Power Minister's Conference held at Guwahati. It was mentioned that CERC had introduced the RRF mechanism to facilitate integration of RE and to handle imbalances in 2010. However, jurisdiction issues raised by intra-state RE generators and implementation difficulties led to suspension of commercial part of RRF Mechanism in 2014 by CERC.

b) JS (JA), MOP also mentioned that the following actions have been initiated to address the concerns raised in the Power Minister's Conference held at Guwahati:
    i. A Committee had been constituted by the MOP on Large Scale Integration of Renewables, Balancing and Deviation Settlement Mechanism (DSM). Four meetings of the Committee had taken place so far and there were interactions with various stakeholders such as CEA, CTU, wind developers, state utilities, generators, etc. The report of the Committee is under finalization.
    ii. Initiatives have been taken by the MOP for implementation of the Renewable Energy Management Centers (REMCs) and GIZ, the consultant is in the process of finalizing the report.
    iii. CERC has notified draft Regulations on the "Framework for Forecasting, Scheduling and Imbalance Handling for Renewable Generating Stations based on Wind and solar at Inter-State level" on 31st March 2015 and "Ancillary Services Operations" on 1st May 2015. Public Hearing on both Regulations was held on 12th June 2015 and the final Regulations are to be notified by CERC in due course
c) JS (JA), MOP requested POSOCO to make a presentation on the relevant issues. The presentation by POSOCO highlighted the need for frequency control, handling deviations, balancing of renewables and the way forward. It was recognized that deviation or imbalance handling mechanism is an essential pillar for large grids & applicable to all States (load serving entities) and Generation – conventional as well as renewable generation. The concept of deviation rates (earlier known as UI charges) was introduced by CERC with the ABT (Availability Based Tariff) mechanism in the year 2000 and the deviation limits and price vector is being specified by CERC at the inter-state level from time to time. So far, eight refinements have been made by CERC on the deviation price vector.
d) Hon'ble MoSP (IC) stated that while fixing the deviation limits, the size of the state and the quantum of renewable generation the state is having, also needs to kept in consideration. However, as large quantum of RE Generation is going to be integrated with the grid, keeping in view the security of the grid, the Forecasting and Scheduling for RE Generators in non-negotiable. He asked all stakeholders present including the wind generators to mutually cooperate and resolve the present issues.
e) Secretary CERC mentioned that in this direction the Draft Framework for Forecasting, Scheduling and Imbalance Handling for Renewable Generating Stations at Inter-State level has been notified by CERC on 31st March 2015 and subsequent to receipt of the comments from different stakeholders, the public hearing has also been held on 12th June 2015. It was further clarified that the CERC jurisdiction is on inter-state matters and to address this issue within the state boundaries, framework shall have to be brought-in in the states also by the respective SERCs. CE(RA), CEA highlighted that harnessing more and more renewables being the national mission, extra commercial burden on account of renewables, entirely by RE-rich state utilities may not be desirable and hence any mechanism brought on this subject needs to be conducive from their angle also. Hon'ble MoSP (IC) requested CERC to finalize

Framework for Forecasting, Scheduling and Imbalance Handling for Renewable Generating Stations at Inter-State level within a month. In order to extend the applicability of this mechanism in the states also, the possibility of MOP giving a advisory to SERCs in this regard was also deliberated. After deliberations, finally it emerged out that once the CERC Regulations at the inter-state level are in place, a model Regulation for SERCs could be made by CERC and the matter may be taken up in the next meeting of the Forum of Regulators (FOR).

f) Representative of the wind developers mentioned that there were difficulties in regards to forecasting and scheduling at individual level and there was a need for introducing the concept of Aggregators who can take up this role. All the developers agreed to provide forecast and schedule to the concerned entity at the intra-state level as well as at inter-state level. Further, they also mentioned the need for proper commercial mechanism for handling deviations within the State.

g) JS, MNRE agreed to the role of Aggregators and emphasizing the importance of scheduling and forecasting, mentioned the efforts made in Tamil Nadu where the wind developers and NIWE have cooperated for implementation of forecasting and scheduling. A similar initiative is also being taken up in Gujarat.

h) Secretary, MNRE mentioned that Government has a very ambitious plan with a target of 165,000 MW of wind and solar integration. It is essential that a proper Regulatory Framework forecasting, scheduling and imbalance settlement is put in place both at the inter-state and intra-state level to facilitate integration of large scale renewables.

i) Hon'ble MoSP (IC) desired that Model Regulations on Forecasting, Scheduling and Imbalance Handling for Renewable Generating Stations at Intra-state level may be formulated by Forum of Regulators for adoption by SERCs. Hon'ble MoSP (IC) directed Ministry of Power to give a communication to all the state utilities regarding Load Forecasting mandated as per CERC Grid Code Regulations, 2010. All the state utilities/SLDCs may begin load forecasting within 3 months.

j) On the issue of balancing at state/regional grids level, it was explained that in India based on the principles of federal structure and jurisdictional issues, a typical coordinated multilateral despatch Model has been adopted, wherein each state control area is required to maintain a balance between its demand and supply alongwith handling surplus and deficit. It was emphasized that balanced portfolio needs to be demonstrated and maintained by all state utilities in different time frames. The need for intra-state deviation and settlement mechanism amongst the different entities in each state was recognized. It was highlighted that only five states namely Delhi, Gujarat, Madhya Pradesh, Maharashtra and West Bengal have implemented intra-state Deviation Settlement Mechanism and the need for implementation of intra-state Deviation Settlement Mechanism in all the states was emphasized.

k) It was also explained that Frequency Control is necessary to balance generation and demand in real time operation. Frequency control is important for Grid Security as system frequency indicates the health of the system. Frequency control is vital as frequency fluctuations have a direct impact on voltage fluctuations and may also

lead to uncontrolled transmission flows. Further, operation within the mandated frequency band is also essential for equipment safety. It was stated that the operational frequency band in India is 49.90 – 50.05 Hz and the system remains 60 – 65 % of time within the band which needs to be further improved through Primary and Secondary control and reserves etc.

l) The concerns of the state utilties regarding 150 MW volume limit on deviation, same limits for large and small states, and variability of renewables and balancing issues were discussed. RE Generators also expressed concern regarding curtailment of RE by the SLDCs because of inability to absorb large quantities of RE, evacuation issues and the challenges they envisage towards forecasting and scheduling of their generation.

m) It was stated that concerns of smaller states were addressed through CERC order (Petition No. RP/06/2014 dated 20th January, 2015) in which relaxation to all the sellers/buyers whose schedule is less than 400 MW has been provided with deviation limit of 48 MW across the board..

n) In this regard in the presentation made by POSOCO it was highlighted that each state being a "control area" is mandated to forecast its Load, RE and Conventional generation and balance its load and generation, including import from grid. It was cautioned that, in extreme scenario in case all state utilities of a region start erring in one direction, it will lead to skewed scenario and stress the Inter-Regional tie lines flows leading to critical levels and threat to the security of the grid..

o) It was emphasized that as stipulated under CERC regulations, in case of deviations the zero crossing in 3 Hours (12 time blocks) is essential in order to ensure that the states do abide by the given limits of over-drawal/under-drawal.

p) It was re-emphasized that the large deviations besides causing severe transmission constraints and endangering Grid Security may also render it difficult to control the large deviations during contingency, as manual action takes time to control drawal from grid and hence may put the grid to risk. Furthermore, the volume limits also incentivize stakeholders for implementing better controls, load forecasting in all time horizons, frequency control through primary control (FGMO), Secondary control (AGC) and Tertiary controls as well as by planning for Reserves. Internationally, the limits on deviation are much more stringent e.g. FERC Order 890 (USA) specifies a maximum of 7.5% or 10 MW deviation limit.

q) The effect of deviations on Transmission Reliability Margin was also deliberated and it was mentioned that Reliability margins are essential for secure operation with transmission outages, unit trippings and taking care of deviations. Hon'ble MoSP (IC) took note of the fact that large deviations would undermine grid security and stated that secure and reliable grid operation is of paramount importance..

r) MD, GETCO highlighted the issue of 150 MW deviation limit being too low for a large state like Gujarat. He also raised the issue of penalizing of the state utility on the under-drawal even when frequency is above 50.1 Hz. The representative of Tamil Nadu state utility highlighted the challenge of RE generation variability stating that this resulted in huge over-drawal/under-drawal due to sudden variation in RE generation and there were commercial implications as per the DSM Regulations on

the State. The representative of Rajasthan expressed the view that for a large state of their size as well as having large quantum of renewables, at times the value of deviations could be high. He further mentioned that DSM limits are important and suggested keeping an outer band of around 250 MW on either side to contain the deviations.

s) Hon'ble MoSP (IC) queried on the flexibility of the renewable rich states to manage and balance renewables and the overall framework towards addressing this issue. JS (JA) stated that ultimately regulatory intervention is required for addressing the issue of balancing as well as any reconsideration towards deviation volume limits. Hon'ble MoSP (IC) suggested formulation of different bands of deviation volume in which states may be placed according to size of the state and level of penetration of RE in the state. A need was also felt for study of the reasons for deviation in all the states with regard to variation in actual demand, variation in Conventional Generation availability and variability of RE Generation.

t) Regarding the issue of balancing in a larger area and advantages thereof, It was highlighted that balancing over larger area is already in place with states already revising the schedules from ISGS at one hour notice within and across the regions (about 20-25 revisions daily). To further enhance this, the need for real time markets, multiple iterations, enhancing the flexibility of conventional generation and Ancillary Services was also highlighted. Secretary, CERC stated that CERC Order on Extended Market Session on Power Exchanges in respect of operation of 24x7 intraday/contingency markets has been notified. Power Exchanges would commence operation of round the clock intraday/contingency market shortly. The need for more frequent clearing in Collective market was also emphasized.

u) It was also stated that Ancillary Services is an essential pillar for reliable and secure operation of the grid and it also facilitates renewable integration. Ancillary Services will facilitate optimization at Regional & National Level by the RLDCs/NLDC and thereby facilitate integration of RE also. In this regard it was clarified by Secretary, CERC that CERC has already floated the draft Ancillary Services Operation Regulations and the stakeholder consultation process is completed with the public hearing held on the 12th June 2015.

v) It was explained that the provisions for Reserves already exists in National Electricity Policy 2005 which mandates 5 % Spinning Reserves at National Level. The Draft Electricity (Amendment) Bill, 2014 has provisions that the generating stations shall be required to maintain a specified capacity of spinning reserve for the grid safety and security. Chief (Engg.), CERC stated that provisions of primary response have already been stipulated in IEGC, 2010 and this needs to be enforced. MoP Technical Committee on Large Scale Integration of Renewables, Balancing and DSM had extensive deliberations on Power Reserves Requirement in Indian Power System. Also, CERC has constituted a committee chaired by Member (Technical), CERC for formulating Regulations on Reserves.

w) Hon'ble MoSP(IC) mentioned that under the scheme for utilization of Gas based power generation capacity the gas based generation may be explored as a source of spinning reserve. Hon'ble MoSP (IC) emphasized that suitable compensation

mechanisms also have to be in place for pumped storage plants. He further emphasized, that adequate mechanisms and incentive may also be provided so that intra-state generating stations, for example, Koyna in Maharashtra, are also able to provide reserves as and when required. He also suggested that NTPC stations should provide reserves. Regarding banking arrangements, Hon'ble MoSP stated that some states may not be willing and hence, suitable mechanisms for operation of reserves may be put in place.

x) Hon'ble MoSP (IC) directed that action points given may be taken up in a time bound manner. Hon'ble MoSP (IC) stated that availability of adequate generation is a benchmark for any developed country. Therefore, there is a need to change our attitude towards renewables and go extra mile to facilitate grid integration of renewables and increase competitiveness of the RE generation without penalizing the RE-rich states. The next meeting is to be scheduled to be held at the end of July**.**

15. Fifth Meeting of the Technical-Committee

The fifth meeting of the Technical Committee was held at 1100 hrs on 18th September, 2015 at CEA, New Delhi. The copy of the minutes is placed at Annex – VII. The gist of discussions held in the meeting is as under:

a) Chairperson, CEA chaired the meeting. Sh. Ghanshyam Prasad, Director-OM, MoP recapitulated the work done by the Technical Committee and requested POSOCO to make a presentation on the draft report which was circulated by Ministry of Power on 04th September, 2015 to all the members.

b) ED, NLDC gave a brief presentation on the draft report. JS, MNRE stated that Indian Space Research Organization (ISRO) may also be involved in obtaining weather data and forecasting. She mentioned that India Meteorological Department (IMD) may not have enough data and therefore, it may be better to take data from ISRO, especially Gujarat. She also mentioned that Hon'ble MoS (P) also opined the same in a recent conference.

c) Director-OM, MOP informed that during recently conducted meeting of JCC (Joint coordination committee between MOP & MNRE), it was decided that technical specifications for REMC shall be prepared by POSOCO in consultation with PGCIL and the States.

d) JS, MNRE informed that GIZ has been asked to prepare State-specific detailed technical specifications for REMC, in addition to the draft generalized technical specification that has been submitted by GIZ. In this regard, it was suggested that POSOCO may take forward the detailed specification prepared by GIZ and improve upon & implement the same.

e) On the issue of volume limits of deviation, under Deviation Settlement Mechanism (DSM), JS, MNRE emphasized that it is imperative that states first implement intra-state DSM and then, may seek review of deviation volume limits.

f) With reference to the recommendations in regard to forecasting, it was suggested that RE rich states may do area/zone-wise forecasting of RE generation and aggregate the same and forward to the respective Regional Load Despatch Centres (RLDCs). The representative from Gujarat mentioned that, based on their experience so far, RE generation forecasting may be specified to be state-wise rather than area/zone wise.

g) In this regard, JS, MNRE advised Gujarat to consult the agencies involved in forecasting in Tamil Nadu, as it was learnt that are getting very good results. She further mentioned that till appropriate regulations and systems are notified, there may be some mechanism to address the deviation of RE generation with respect to forecast/schedule. Adviser – RE, CERC emphasized that dormant pumped storage plants may be revived and made operational at the earliest.

h) It was suggested that action plan for intermediate stage shall be mentioned, apart from final deliverables. Ms. Anjuli Chandra, CE, CEA suggested that recommendations regarding voltage control may also be included. It was suggested that weather related data also to be sent by RE Generators along with other data. CEA suggested that CTU/STU may ensure compliance of standards.

16. Sixth Meeting of the Technical-Committee

The sixth and final meeting of the Technical Committee was held at 1100 hrs on 16th October, 2015 at Ministry of Power, New Delhi. The copy of the minutes is placed at Annex – VIII. The gist of discussions held in the meeting is as under:

a) Sh. Major Singh, Chairperson, CEA chaired the meeting. Sh. Ghanshyam Prasad, Director-OM, MoP recapitulated the work done by the Technical Committee and requested POSOCO to explain the salient features and recommendations of the draft report which was circulated by Ministry of Power on 12th October, 2015 to all the members.

b) The representative of POSOCO gave a brief overview of the draft report covering the recommendations of the Technical Committee under various areas such as:

a) Framework for Forecasting of load and RE generation, Scheduling, Monitoring and Imbalance Handling of RE generators

b) Need for Reserves and Flexibility of resources to balance variability of load and RE generation

c) Ancillary Services Framework

d) Availability of Real Time Data at SLDCs/RLDCs/NLDC

e) Standards and Protection Requirements

f) Renewable Energy Management Centres (REMCs)

c) It was mentioned that the comments of CTU, CEA and Gujarat were received. However, only CTU comments could be incorporated as the comments of CEA and Gujarat Utility were received only few days back.

d) JS, MOP enquired about the status of inter-state and intra-state RE regulatory framework. It was mentioned that CERC has introduced a regulatory framework for RE generators connected at the inter-state level through amendments in the Indian Electricity Grid Code (IEGC) and the Deviation Settlement Mechanism (DSM) Regulations on 7th Aug 2015. These amendments come into effect from 1st November 2015 and the RE generators connected at the inter-state level would become responsible for forecasting, scheduling and settlement of deviations from the schedule.

e) Adviser-RE, CERC mentioned that the Forum of Regulators (FOR) deliberated the framework proposed for wind and solar projects at the intra-State level. The Forum, further directed the FOR Secretariat to evolve draft Model Regulations related to implementation of the framework by SERCs / JERCs, based on the broad principles as presented by CERC. The Model Regulations, as approved by Chair, FOR are under finalization by the FOR Secretariat and would be circulated to the States for consideration/adoption.

f) JS, MNRE mentioned that cabinet note for DISCOMs package is under process and therefore, intra-state RE framework may be made mandatory in order to avail the special provisions in the package. Adviser-RE, CERC mentioned that CERC may issue an advisory to the Ministry of Power and, through Forum of Regulators, to all the states. She also mentioned that incentives maybe given to state utilities for handling deviations due to RE generation. JS, MOP observed that finance is available only from Power system Development Fund (PSDF), which was however, limited in nature. .

g) JS(JA) mentioned that in order to maintain grid discipline, RE framework may be made mandatory for all the states by 01st April, 2016. It was also decided that an advisory from the Ministry of Power would be issued to all the states to have intra-state RE framework by 01st April, 2016.

h) CE(GM), CEA suggested that definition of “RE-rich” state may be clarified in the report as the state with 20 % or more RE capacity of the entire installed generation capacity. JS, MNRE suggested the removal of “RE-rich” term and wanted RE framework in all the states irrespective of RE penetration. Adviser-RE, CERC also supported the suggestion of JS, MNRE. It was decided that the term “RE-rich” would be removed and all the states would be mandated to put in place proper RE framework irrespective of RE penetration. It was also decided that FOR would issue the Model RE framework regulations by end of October, 2015.

i) The representative of POSOCO mentioned that CERC, vide order in the suo-motu petition No. 11/SM/2015 dated 13th October, 2015 has issued the roadmap to

operationalize reserves in the country. Also, in this direction, Draft Central Electricity Regulatory Commission (Indian Electricity Grid Code) (Fourth Amendment) Regulations, 2015 had been notified on 02nd July, 2015 which laid out provisions for Technical Minimum Schedule for operation of Generating Stations. A public hearing was held on 19th August, 2015. Further, POSOCO vide Communication dated 17th Sept., 2015 to Secretary, CERC & Secretary, CEA provided Detailed Report on Regulations and Standards in respect of 'flexibility' of generating units to accommodate higher penetration of Renewable Energy (RE) sources.

j) Adviser-RE, CERC mentioned that the IEGC amendments are expected to be notified soon by CERC. It was decided that CERC may endeavor to issue the amendments before the end of October, 2015. She also mentioned that Regulatory framework is being evolved for identification and utilizing of spinning reserves and implemented with effect from 1st April, 2016 till 31st March, 2017. In the long term, a market based framework may be evolved for efficient provision of secondary reserves from all generators across the country.

k) JS, MOP ,mentionted that CEA should compute the financial implication for provision of reserves through automated control and necessary software & communication requirements. The representative of CEA informed that CEA Construction Standards are in the process of revision including flexibility requirements. JS, MNRE highlighted the need for having proper compliance framework. Adviser-RE, CERC clarified that irrespective of renewables, secondary control through AGC may be mandated to all generators.

l) JS, MOP enquired about the progress of Ancillary Services Operations. The representative of POSOCO informed that the final CERC Regulations on Ancillary Services Operations, 2015 haves been notified on 19th August 2015. The draft Detailed Procedure for Ancillary Services Operations has been floated by the Nodal Agency (NLDC) for stakeholder consultations on 29th September, 2015. After incorporating suggestions, it will be placed before CERC for approval. It was mentioned that the Ancillary Services are expected to be operationalized by 31st December, 2015.

m) On the issue of volume limits of deviation raised by some states having large penetration of RE, Adviser-RE, CERC mentioned that CERC DSM regulations are under discussion and review. .

n) With reference to the recommendations in regard to communication framework, it was informed that CERC had constituted a Task Force, in April, 2015, for inputs to frame the draft Regulations for communication systems in power sector. As it was close to 6 months since formation, CERC was asked to expedite the Task Force report submission by the end of October, 2015.

o) Regarding Standards and Protection Requirements, it was decided that a system for compliance monitoring of the same may be put in place by the Appropriate Commission at the state level.

p) On the issue of REMCs, JS, MNRE informed that GIZ has been asked to prepare State-specific detailed technical specifications for REMC, in addition to the draft generalized technical specification that has been submitted by GIZ. In this regard, COO(CTU) informed that the consultant had completed the survey and starting from October, 2015 end, they will provide the state-wise DPRs to PGCIL in a progressive manner after the approval of the respective states. JS, MOP asked POSOCO to request the NREL team for their observations on the DPR for REMCs on which comments have been invited by MNRE. .

q) The representatives from West Bengal and Tamil Nadu informed that they would provide written comments on the draft report. JS, MOP informed that Power Ministers conference is scheduled on 05th & 06th Nov., 2015 and therefore, the final report for approval may be submitted to the MOP at the earliest. She also desired that status report on the action points may also be given along with responsible agencies and deadlines.

Stakeholder Concerns and Recommendations

1. Concerns of State Utilities & RE Generators

i. Volume Limits on Inter-State Deviations especially for Large and High RE Penetration States

ii. Deviation Settlement Mechanism at Intra-State Level

iii. Handling Variability of Renewable Generation

iv. Inter-State and Intra-State Transmission System Augmentation and Strengthening

Recommendations

a. Appropriate Regulatory Framework for handling Inter-State Deviations especially for Large and High RE Penetration States

Mechanism to handle deviations is an essential part of the regulatory framework to ensure delivery of power in a secure and reliable manner. The deviation limits for inter-state transmission, stipulated by the Central Commission, may take into account the stakeholder concerns and international best practices.

- **Present Status** – CERC had organized multiple stakeholder meetings on the issue of DSM on 04th September, 2015, 11th September, 2015 and 28th September, 2015. POSOCO has given comprehensive feedback to CERC on the DSM Mechanism and the impact on the States. This issue was also discussed in the 49th Meeting of Forum of Regulators at Ahmedabad held from 26th – 28th July, 2015. The forum desired that CERC may look into the concerns raised in the context of the present limit of 150 MW or 12% (whichever is lower) of the schedule for over drawl / under drawl.
- **Responsible Agency** – CERC
- **Timeframe of Implementation** - 01st July, 2016

b. Regulatory Framework for Intra-State Settlement System and Imbalance Handling Mechanism

Deviations from schedule for all intra state entities including the RE generators connected at a Pooling point and Deviation Settlement Mechanism (DSM) charges would be applicable as notified by the appropriate ERC. Special Energy Meters (SEMs) to facilitate metering, accounting and settlement would need to be placed at all the required locations so that the actual energy can be metered for the purpose of imbalance accounting.

- **Present Status** - Implemented at intra-state level only in 5 states
- **Responsible Agencies** – FOR, SERCs, SLDCs, STU, intra-state entities
- **Timeframe of Implementation** - 01st July, 2016

c. Regulatory Framework for Forecasting and Scheduling of Renewable Generation, Aggregators and Implementation at intra-state level

A White Paper on Forecasting and Scheduling of Renewable Energy (RE) and Load in India is placed at **Annex – IX**. At intra-state level many embedded RE generators have come up. It is

therefore, suggested that the respective State Electricity Regulatory Commissions (SERCs) of all states to formulate a similar RE framework for forecasting, scheduling and despatching of RE generators at intra-state level based on Model Regulations notified by FOR.

- **Present Status** - Already discussed in 50th Meeting of FOR held at Pune. The Model Regulations on Forecasting, Scheduling and Deviation Settlement of Wind and Solar Generating Stations at the State Level (2015) are available on the website of Forum of Regulators (FOR). The draft regulations based on the Model Regulations have been formulated by states of Madhya Pradesh, Rajasthan, Odisha, Karnataka, Jharkhand and Tamil Nadu.
- **Responsible Agencies** – FOR, SERCs, SLDCs, RE Generators
- **Timeframe of Implementation** - 01st June, 2016

d. Forecasting by all RE Generators / SLDCs

All states may do an area/zone-wise/pooling-station wise forecast of RE generation (wind/solar) within the state, aggregate the same or do the entire state RE forecast and forward to RLDCs who in turn would forward the values to NLDC for the purpose of system security. NLDC/RLDCs have operationalized CERC Renewable Energy framework with effect from 1st Nov 2015 at the inter-state level. The same needs to be adopted by the States under the RE framework by the respective SERC.

- **Present Status –** CERC has introduced a regulatory framework for RE generators connected at the inter-state level through amendments in the Indian Electricity Grid Code (IEGC) and the Deviation Settlement Mechanism (DSM) Regulations on 7th August 2015. Regulatory Framework already in place at the inter-state level and implemented with effect from 1st November 2015. The RE generators connected at the inter-state level would become responsible for forecasting, scheduling and settlement of deviations from the schedule.
- **Responsible Agency –** SLDCs, RE Generators
- **Timeframe of Implementation –** 01st June, 2016

e. Regulatory Framework for Reserves

CERC Roadmap to Operationalize Reserves in the country along with Report of the Committee on the Spinning Reserve have been notified on 13th October, 2015 (Copy placed at **Annex – X**). The Appropriate Commission may come out with Regulations on maintaining of generating reserves at the State Level. Such Regulations would be consistent with the National Electricity Policy stipulations and the CERC Roadmap for Reserves notified on 13th October 2015. Considering 5% Spinning Reserves are to be kept as advised in the National Electricity Plan (NEP), approximately 14500 MW are to be kept as Reserves. There is need to determine the distribution of this quantum of reserves amongst primary, secondary and tertiary category in line with the CERC roadmap for implementation of reserves, which has been brought out on 13th October 2015. SERCs are required to put into place a similar framework at the State level.

- **Present Status** - Framework at inter-state level has been specified by CERC on 13th Oct 2015 and this is under implementation.
- **Responsible Agency** – CERC, SERCs, NLDC, RLDCs, SLDCs, All Generators

- **Timeframe of Implementation** - 01st June, 2016

f. Market Design – Frequent clearing, more opportunities, New entities (Aggregators)

Aggregated Forecasting and scheduling at Pooling Station level needs to be done by suitable aggregators on behalf of the RE generators. These schedules would form the reference for working out the deviations in actual operation and imbalance payments. The aggregator or Qualified Scheduling Entity (QSE) would be a duly approved agency by the appropriate ERC, with a clear line of responsibility and fee structure at the Pooling Station level.

- **Present Status** - The CERC had vide order dated 8th April 2015 directed the Power Exchanges to operationalize 24 x 7 extended market session. Both the Power Exchanges have implemented the same with effect from 20th July 2015.
- **Responsible Agency** – MNRE, CERC, SERC
- **Timeframe of Implementation** - 01st June, 2016

g. Inter-State and Intra-State Transmission System Augmentation and Strengthening

Robust transmission services to ensure that RE generation backing down is minimal. With the short gestation period of RE generation, transmission has to lead generation. There is need for transmission corridors from states with high penetration of renewables alongwith coordinated transmission planning. In case of transmission scheme of RE, a single window approval procedure may be adopted to facilitate speed up the implementation. Reactive Power Planning, particularly the use of Power Electronic Devices (PEDs) like Static Var Compensators (SVCs), STATCOMs also become important from the viewpoint of having a flexible power system.

- **Present Status** –
  i. CEA and CTU planned "Green Corridors" in the states of Tamil Nadu, Gujarat, Rajasthan, Karnataka, Andhra Pradesh, Maharashtra, Himachal Pradesh and Jammu & Kashmir. MoP, MNRE collaboration with GIZ, KfW, Germany for the inter-state and intra-state schemes for evacuation of power from wind and solar projects.
  ii. Under the technical assistance component of the Green Energy Corridor project GIZ, Germany has prepared draft reports on Forecasting, Scheduling, Balancing and on Renewable Energy Management Centres (REMCs) as one of the deliverables. The Green Energy Corridor project is under implementation in the 8 States namely Andhra Pradesh, Gujarat, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Tamil Nadu.
- **Responsible Agency** – MNRE, CEA, CTU, SLDCs, State Utilities
- **Timeframe of Implementation** – 01st April, 2017

2. Concerns of System Operators

i. Load Forecasting
ii. Demonstration of Adequacy & Balanced Portfolio
iii. Implementation of Frequency Response

iv. Ancillary Services implementation

v. Flexibility in conventional generation

vi. Technical Standards and Protection Requirements for Renewables

vii. Regulatory Framework for Communication in Power Sector

viii. Implementation of Renewable Energy Management Centres (REMCs)

ix. Capacity Building of SLDCs/ RLDCs/NLDC

Recommendations

a. Load Forecasting as per IEGC Section 5.3

Load forecasting on 15-minute block basis at state, region and National level by the appropriate Load Despatch Centres (LDCs) duly considering weather parameters and other factors. Within the state, each DISCOM would be responsible for load forecasting and submitting the same to SLDC**.**

- **Present Status –** Being done by NLDC and all five RLDCs and SLDCs of Southern Region, Western Region, Northern Region (except J&K) and North Eastern Region.
- **Responsible Agency –** All State Utilities
- **Timeframe of Implementation –** 01st June, 2016

b. Demonstration of Adequacy & Balanced Portfolio

Each DISCOM/SLDC shall commit adequate generating resources to meet the anticipated load and RE generation. SLDCs shall publish the day-ahead adequacy figures on the respective websites.

- **Present Status –** The need for forecasting and demonstrating a balanced portfolio was emphasised in the 15th meeting of the Forum of Load Despatchers (FOLD) held on 3rd August 2015
- **Responsible Agency –** All State Utilities, SLDCs
- **Timeframe of Implementation –** 01st June, 2016

c. Implementation of Frequency Response (Primary Response)

IEGC mandates that all generators provide primary frequency response for secure and reliable operation of the grid. Generators have been expressing difficulties in providing primary response. The Central Regulator needs to strictly enforce the provisions of the grid code in this regard.

- **Present Status –**
  - **i.** In view of the difficulties expressed by the generators, CERC vide office order dated 24.09.2014 constituted a Committee under the Chairmanship of Sh A. Velayutham, Ex-Member, MERC.
  - **ii.** The Committee held three meetings on 3rd Nov 2014, 21st Nov 2014 and 16th March 2015. The draft report has been circulated to the Committee members on 26th Aug 2015 for comments by 2nd Sep 2015.

- **Responsible Agency –** CERC, SERCs, All Generators
- **Timeframe of Implementation –** 01st June, 2016

d. Regulatory Framework for Secondary Response (AGC)

Secondary Response (AGC) has hitherto been absent by design in the Indian power system. However, with the synchronous integration of the regional grids, the Indian power system has now become a 'large grid'. AGC is an essential requirement for secure and reliable operation of large grids.

- **Present Status –** Roadmap for implementation already provided by CERC on 13th Oct 2015
- **Responsible Agency –** CERC, SERCs, All Generators, SLDCs, RLDCs, NLDC
- **Timeframe of Implementation –** 01st April, 2017

h. Regulatory Framework for Ancillary Services Operation

CERC has notified regulations on Ancillary Services Operations, 2015 on 13th August 2015. SERCs may come out with similar Regulations at the State level.

- **Present Status** - Already notified on 19th August 2015. Procedures are under finalization for implementation. Stakeholder workshops were held in all the regions by POSOCO from 14th – 20th October, 2015. The detailed procedure for Ancillary Services Operations has been approved by CERC.
- **Responsible Agency** – CERC, RPCs, NLDC, RLDCs, SLDCs, All Regional Entity Generators
- **Timeframe of Implementation** – 15th April, 2016

e. Standards and Regulatory Framework for incentivizing "Flexibility" in Conventional Generation

The requirement of fast responding 'Flexible Generation' is emerging. In case of higher penetration of Renewables - besides reserves, a large portion of the overall generation might require to be flexible to follow the high ramps of the Renewable generation. Flexibility is a key attribute to be defined by Regulations in terms of start/stop, ramp up/ramp down, Maximum and Minimum generation levels etc. Pumped storage schemes need to be encouraged suitably for this purpose. POSOCO vide Communication dated 17th Sept., 2015 to Secretary CERC & CEA provided submitted a Report on need for Regulations and Standards in respect of 'flexibility' of generating units to accommodate higher penetration of Renewable Energy (RE) sources.

- **Present Status –**
  - **i.** On the 2nd July 2015, CERC issued draft amendment to the Indian Electricity Grid Code (IEGC) regarding technical minimum for thermal power stations. The draft amendment prescribed a figure of 55% of the capacity as technical minimum with generators being compensated in terms of Heat Rate for operating at levels below 85% of capacity of unit. Based on comments by the different stakeholders, a public hearing was held on 19th Aug 2015. The amendments are expected to be notified soon by CERC.

ii. POSOCO vide Communication dated 17th Sept., 2015 to Secretary CERC & CEA provided Detailed Report on Regulations and Standards in respect of 'flexibility' of generating units to accommodate higher penetration of Renewable Energy (RE) sources.

- **Responsible Agency –** CEA, CERC, SERCs
- **Timeframe of Implementation –** 01st May, 2016

f. Technical Standards and Protection Requirements for Renewables such as LVRT, FRT, etc. & implementation

CEA has formulated various regulations such as CEA Measures of Safety and Electricity Supply Regulations, 2010, CEA Technical Standards for Connectivity of the Distributed Generation Resources Regulations, 2013 and CEA Installation and Operation of Meters' Amendment Regulation 2014. All the RE generators, both wind and solar, must follow the CEA standards and protection requirements for ensuring secure and reliable operation of the grid. Considering the Govt. of India plans for Solar generation, Standards like LVRT/FRT compliance, active power control etc. for Solar generation may also be introduced by CEA as part of the Technical standards for Connectivity to the Grid. A system for compliance monitoring of the same may be put in place by the Appropriate Commission.

- **Present Status –**

  i. All wind turbines connected at 66 kV and above are required to comply with the Low Voltage Ride Through (LVRT) or Fault Ride Through (FRT) capability. This needs to be ensured at the connection stage itself by the CTU/STU.

  ii. For older machines not complying with the LVRT requirements, there must be a mandate through Regulations for retrofits, wherever possible. CEA is expected to issue certain amendments to the Regulation to avoid any ambiguity.

  iii. Similar provisions for LVRT/FRT as well as frequency limits need to be made for solar also considering the large capacity addition expected in the coming years.

- **Responsible Agency –** CEA, CERC, SERCs, CTU, STUs, SLDCs, All RE Generators
- **Timeframe of Implementation –** 01st June, 2016

g. Regulatory Framework for Communication in Power Sector, Availability of Real Time Data at the SLDCs/RLDCs/NLDC particularly of RE generators

A Framework for smooth real time data transfer between the wind / solar pooling stations and the State Load Despatch Centre is placed at **Annex – XI**. The Appropriate Commissions may come out with Regulations on communication which could clearly outline the responsibilities of each entity towards facilitating flow of real time information from the Pooling Station to Control Centre. The respective STU/SLDC shall ensure provision of RTU at all RE pooling station/Point of Common Coupling(PCC) along with suitable communication infrastructure from pooling station to the control centre at all RE pooling station/Point of Common Coupling(PCC) for real time monitoring/measurement visibility as well as forecasting of RE generation. Respective States may expedite installation of RTU & Communication system at RE pooling station/PCC, wherever it is not available.

- **Present Status –**

  i. CERC had vide office order dated 22nd April 2015 constituted a Task Force headed by Ms Neerja Mathur, ex-Chairperson CEA for inputs to frame the draft Regulations for communication systems in power sector.

  ii. The Task Force has held two meetings on 8th May 2015 and 6th July 2015 and is expected to submit its report shortly. MOM of 06th July, 2015 meeting were issued by CERC.

- **Responsible Agency –** CERC, SERCs, RE Generators, SLDCs, RLDCs
- **Timeframe of Implementation –** 01st June, 2016

h. Implementation of Renewable Energy Management Centres (REMCs)

Renewable Energy Management Centres (REMCs) are needed at State, Regional and National level co-located with respective Load Despatch Centres (LDC). Also, commensurate communication & IT infrastructure is needed with adequate resilience and redundancy. There is requirement of different skill sets for personnel manning REMCs and Load Despatch Centres. Interfacing is needed with Indian Metrological Department (IMD) at local and global level. CEA may be designated as the coordinating agency for implementation of REMCs. REMC may have following functions:

- Forecasting of RE generation in jurisdiction area on fifteen minute ahead, hour-ahead, day-ahead, week-ahead, month-ahead basis for the purpose of system security
- Real time tracking of generation from RE sources
- Geo-spatial visualization of RE generation
- Advanced decision-making and control systems - Close coordination with respective LDC for RE generation and control for smooth grid operation
- Single source information repository and coordination point for RE penetration

- **Responsible Agency –** MNRE, CEA, CTU, STU, SLDCs, RLDCs, NLDC
- **Timeframe of Implementation –** 01st April, 2017
- **Present Status –**

  i. GiZ appointed consultants led by E&Y is preparing Detailed Project Reports along with Technical Specifications under Indo-German Technical assistance project; (As on 18th Oct'15, Survey completed for SRLDC, SLDCs of Tamilnadu, Karnataka and Andhra Pradesh; DPR under preparation for the above SLDCs/RLDC)

  ii. Survey for remaining locations (NLDC, NRLDC, WRLDC, SLDCs of Rajasthan, Madhya Pradesh and Maharashtra) scheduled to be completed by 31st Oct'15 by E&Y

  iii. DPR to be submitted by E&Y progressively by 30th Nov'15

  iv. DPR approval by respective SLDCs/RLDC/NLDC within 15 days of submission – Target 15th Dec'15

  v. NIT to be issued within 4 weeks of approval of DPRs/scope by respective SLDCs/RLDCs/NLDC by POWERGRID

  vi. CTU (PGCIL) may finalize the bidding process and call for tenders for establishment of REMCs as per Green Energy Corridors Report. GIZ has submitted draft DPR of

REMC which is yet to be finalised in consultation with SLDC/RLDC/CEA/MNRE/MOP. MNRE to coordinate for its finalisation and acceptance by stakeholders so that tenders by CTU (PGCIL) may be initiated.

i. Capacity Building of LDCs particularly in RE Rich States

- **Timeframe of Implementation –** Ongoing Activity
- **Present Status –**

i. CERC, POSOCO and NREL USA organized a workshop on RE integration on 9th June 2015 at NLDC, New Delhi which was attended by senior officials from MOP, MNRE and CERC. Participation was extensive covering POWERGRID, NLDC, RLDCs and SLDCs.

ii. As part of kick-starting the MoU between POSOCO and IMD signed on 18th May 2015, a kick-off meeting of DG IMD, CEO POSOCO and senior officials from IMD, RLDCs/NLDC was held on 15th July 2015 at New Delhi. It was decided to take the interactions forward at regional level also where the SLDCs and IMD's regional centers would be involved.

iii. A special training on Wind Energy Technology was conducted at Chennai for NLDC/RLDCs/SLDC engineers by POSOCO through NIWE/NPTI from 13th to 18th July 2015.

iv. Regional workshops with IMD were held at SRLDC Bengaluru on 31st July 2015 and at WRLDC Mumbai on 24th August 2015, NRLDC, Delhi on 15th Sep 2015. These workshops have paved the way for data exchange between these organizations for load forecasting as well as RE generation forecasting.

v. As part of the USAID's Greening the Grid (GtG) program in collaboration with Ministry of Power, a four day program on RE integration and modelling using PLEXOS software is being held at NLDC, New Delhi from 1st to 4th Sep 2015.

vi. A 3-4 day boot camp involving experts from different parts of the world is expected to be organized shortly. The topics to be covered have already been identified and the Forum Of Load Despatchers (FOLD) members have been advised of the same in its meeting on 3rd Aug 2015.

vii. A training programme for all SLDCs on familiarization of PLEXOS software was organized by USAID in association with POSOCO at NRLDC, Delhi from 01st – 04th September, 2015.

viii. Apart from the above, regular training programs are being conducted at NPTI under the System Operator certification process. 4th Basic System Operator Certification Exam for NLDC/RLDC/SLDCs is being conducted on 01st Nov., 2015 by NPTI.

Annexure - I

No.11/11/2015–PG
Government of India
Ministry of Power
Shram Shakti Bhawan, Rafi Marg, New Delhi-110 001

Dated, 20th April 2015

To,

As per distribution list.

Subject: Constitution of a Technical Committee for "Large Scale Integration of Renewable Energy, need for balancing, Deviation Settlement Mechanism (DSM) and associated issues".

Sir,

I am directed to say that during the Power Ministers' Conference held on 9-10 April, 2015 at Guwahati with States/UTs, the issues pertaining to large scale Integration of Renewables were discussed.

2. After discussions, it was decided to constitute a Technical Committee under the chairmanship of Shri Devendra Chaudhry, Special Secretary, Ministry of Power to consider various issues relating to large scale integration of renewable generation like spinning reserves, flexible generation, need for pumped storage and peaking hydro stations, balancing requirements, Ancillary Service, transmission system augmentation & frequency control, etc.

3. The proposed framework on "Forecasting, Scheduling & Imbalance Handling for Renewable Energy Generating Stations based on wind and solar at Inter-State Level" issued by CERC vide Public Notice No.1/14/2015-Reg.Aff.(FSDS)/CERC dated 31st March, 2015 shall also be kept in view by the Committee.

4. Accordingly, the Technical Committee is constituted with the following composition:

1. Shri Devendra Chaudhry, Special Secretary, M/o. Power - Chairman
2. Chairperson, Central Electricity Authority
3. Joint Secretary (Trans.), Ministry of Power
4. Joint Secretary, Ministry of New & Renewable Energy
5. Principal Secretary (Energy), Tamil Nadu
6. Principal Secretary (Energy), Gujarat
7. Principal Secretary (Energy), West Bengal
8. Principal Secretary (Energy), Rajasthan
9. CEO, POSOCO
10. Chief Operating Officer, CTU (PGCIL)
11. Joint Chief(RA), CERC
12. Director (PG), Ministry of Power - Convener & Secretary

....2/-

5. The Committee may co-opt any other member, as deemed fit. The Committee shall meet once in a week and submit its Report within a month. The first meeting of the Committee shall be held at 12.00 Noon on 27.04.2015 . You are, therefore, requested to attend the meeting in NPMC Room, 2nd Floor, Shram Shakti Bhavan, New Delhi.

(Jyoti Arora)
Joint Secretary (Trans.)
Tele: 011-2371 0389

To

1. Chairperson, CEA, New Delhi.
2. Joint Secretary, MNRE, New Delhi
3. Principal Secretary (Energy), Tamil Nadu
4. Principal Secretary (Energy), Gujarat
5. Principal Secretary (Energy), West Bengal
6. Principal Secretary (Energy), Rajasthan
7. CEO, POSOCO, New Delhi.
8. Chief Operating Officer (COO), CTU (PGCIL)
9. Jt. Chief(RA), CERC, New Delhi

Copy to Sr PPS to SS (DC)/ JS(Trans) / Director (PG)/ US (PG).

Annexure - II

F.No.11/11/2015-PG
Government of India
Ministry of Power

Shram Shakti Bhawan, Rafi Marg,
New Delhi, May 1, 2015

To

1. Chairperson, Central Electricity Authority
2. Joint Secretary (Trans.), Ministry of Power
3. Joint Secretary, Ministry of New & Renewable Energy
4. Principal Secretary (Energy), Tamil Nadu
5. Principal Secretary (Energy), Gujarat
6. Principal Secretary (Energy), West Bengal
7. Principal Secretary (Energy), Rajasthan
8. CEO, POSOCO
9. Chief Operating Officer, CTU (PGCIL)
10. Joint Chief(RA), CERC
11. Director (PG), Ministry of Power - Convener & Secretary

Subject: Minutes of the meeting of Technical Committee on Large Scale Integration of Renewable Energy, Need for Balancing, Deviation Settlement Mechanism (DSM) and associated chaired by Special Secretary, MOP on 27.04.2015.

Sir,

I am directed to forward herewith the minutes of the meeting taken by Special Secretary(DC), Ministry of Power on 27.04.2015 on the subject mentioned above for information and necessary action at your end.

(Sanjeev Jain)
Under Secretary to the Govt. of India
Telefax: 011-23730264

Copy to:

- Sr. PPS to SS(DC)/ PPS to JS(Trans.)/ PS to Director(PG), MoP, Shram Shakti Bhawan, New Delhi

Minutes of the First Meeting of Technical Committee on Large Scale Integration of Renewable Energy, Need for Balancing, Deviation Settlement Mechanism (DSM) and associated issues held on 27th April, 2015 at 12.00 PM in NPMC Conference Room, 2nd Floor, Ministry of Power, Shram Shakti Bhawan, Delhi

The list of participants is enclosed at Annex-I.

Shri Devendra Chaudhry, Special Secretary, Ministry of Power chaired the meeting. JS (JA), MoP recapitulated the discussion in the Conference of Power and Mines/NRE Ministers of States/UTs held at Guwahati on 9th - 10th April, 2015 wherein some of the states raised the issues related to balancing, Deviation Settlement Mechanism (DSM) and draft CERC Proposed Framework on "Forecasting, Scheduling & Imbalance Handling for Renewable Energy (RE) Generating Stations based on wind and solar at Inter-State Level. Accordingly, this technical committee has been constituted.

2. Chairman welcomed the members of the committee and initiated the discussion. He stated that Terms of Reference of the Technical Committee may be drawn up at the earliest.

3. The following issues were discussed:

a) Spinning reserves need to be identified in advance and kept available all the time. Spinning reserves have been defined in the draft amendments to the Electricity Act, 2003 and needs to be covered both in Tariff Policy and CERC Regulations.
b) Ancillary Services (AS) are complementary support services needed for reliable operation of the electricity grids. Regulatory intervention is needed for implementation of Ancillary Services in Indian Electricity Market. Ancillary Services (AS) provides a framework for operationalizing the spinning reserves and the modalities of scheduling, metering and settlement of the same.
c) Forecasting (both Load, RE generation as well as Net Load) is essential for ensuring resource adequacy during operation and grid security. It is a pre-requisite for scheduling of Renewable Energy (RE) generation.
d) There is a need for robust intra-state imbalance settlement mechanism.
e) With the increasing interconnections size and interchanges between areas, proper frequency regulation brings out the need for primary control supplemented by secondary control and tertiary control. There is need for Automatic Generation Control (AGC) so that secondary control is effective.
f) Flexibility in existing fleet of conventional generation as well as Pumped Storage Plants may be utilized for meeting dynamic load profile. Regulatory intervention is required to incentivize flexibility of conventional generation sources. Flexibility requirements should encompass the minimum and maximum generation level as well as the ramp up and ramp down rates.
g) There is need for market design enhancements with more frequent market clearing and new products such as real time markets.
h) With the short gestation period of RE generation, transmission has to lead generation. There is need for transmission corridors from RE – rich states with coordinated transmission planning.

4. Chairman emphasized that the realization of this wish list should be within six months. The report of the technical committee may be prepared after seeking the views of all the stakeholders. The recommendations should be implementable in a time bound manner.

5. It was emphasized that spinning reserves may be defined in the Act, Policy, Grid Code as well as factored in the Planning process. Joint Chief (RA), CERC stated that provisions of primary response have already been stipulated in IEGC, 2010 and therefore, requirement of reserves is mandated by CERC. CEO (POSOCO) stated that short term solution may be to identify the reserves in the existing plants and spell out the quantity on daily basis to respective LDC. JS (JA), MoP stated that suitable amendments in the Act and Policy are being proposed by the Ministry of Power in respect of spinning reserves.

6. CERC was requested to take up parallel actions to bring in spinning reserves and to propose changes in the regulations after stakeholder consultations within 3 months. In light of fast pace of RE addition, Chairman directed CEA to submit a report within 15 days after due consultation with POSOCO/States Utilities on the following:

a) Identification of present and future spinning reserve capabilities in Coal, Gas and Hydro Plants alongwith the cost of carrying these.
b) Identification of MoU route based, Competitively Bid based and Merchant based plants for reserve capacities with sensitivity analysis.

(Action Point: CEA (GM & IRP Divisions), State Utilties, POSOCO , Timeframe: Within 15 days)

7. On a query from Chairman, Joint Chief (RA), CERC stated that there were reservations from State Utilities on implementation of Ancillary Services with the major fear being that it would lead to operation of costly plants leading to rise in electricity prices at retail level. Chairman mentioned that Spinning Reserves are implemented through Ancillary Services. Chairman requested Joint Chief (RA), CERC to fast-track the consultation process so that regulations on Ancillary Services may be notified by 01st August, 2015. **(Action Point: CERC , Timeframe: 01st August, 2015)**

8. The representative of Rajasthan state utility highlighted the challenge of RE generation variability. It entailed surrender of Central Sector allocated power alongwith huge over-drawal/under-drawal due to sudden variation in RE generation. Chairman stated that RE generation should not be backed down. CEO (POSOCO) stated the need for ramping up/down of the conventional generation. It was highlighted that the CEA Standard Technical Features for 660MW/800 MW Sets recommended technical minimum of 40% and two shifting of machines was envisaged.

9. JS (MNRE) raised the issue of mismatch between forecast and actual RE generation and therefore, a need for review of band specified in the draft CERC proposed framework. Joint Chief (RA), CERC clarified that besides the issue of band, 16 revisions i.e. One revision every 1.5 hr has been proposed thereby providing flexibility in revision of schedule more closer to the real time. Both Wind and Solar generators must forecast and schedule for market access.

10. Chairman sought clarification as to why state utilities are not being able to square off in 1.5 hr with 16 revisions. The representative of Rajasthan State Utility attributed the challenge to the

forecasting and absence of cooperation from intra-state RE generators. JS (MNRE) stated that GETCO had managed to persuade RE generators in Gujarat to provide data. In Tamil Nadu, IWEA is coordinating with NIWE to provide forecast data to SLDC.

11. Chairman highlighted the need for both centralized and de-centralized forecasting. Chairman directed POSOCO to prepare doable action plan for introduction of forecasting, RE forecasting models adopted world-wide and extent of responsibility for both RE generation and load forecasting.
(Action Point: POSOCO , Timeframe: 15th May, 2015)

12. POSOCO stated that statistical analysis of deviations of RE-rich states had been presented in FOR meeting on 27th June, 2014. It was found out that the maximum correlation for deviation from schedules was due to the variation in load, followed by conventional generation changes and minimum correlation to the variation in RE generation. Therefore, the deviations are attributable more to factors other than variation in RE generation. Only few states have Intra-state imbalance settlement mechanism. There is need for intra-state Deviation Settlement mechanism in all the states. Chairman directed POSOCO to send the presentation to Rajasthan State Utility. Chairman also directed JS (MNRE) to arrange for communication through Secretary (MNRE) to concerned RE rich states to attend all the meetings of the Technical Committee.
(Action Point: MNRE, POSOCO, State Utility , Timeframe: Before next meeting)

13. CEO (POSOCO) stated that recently a pilot project for testing of primary response had been done and the report of the same has been submitted to CERC. The secondary control may be implemented at regional level in manual mode to start with and graduating to Automatic Generation Control. Chairman directed that NTPC, State Gencos and 4 Private Gencos may be called to attend the second meeting of the Technical Committee. Joint Chief (RA), CERC stated that a Committee constituted by CERC having different technical experts is examining the issue of primary response and is expected to submit its report shortly.
(Action Point: CERC , Timeframe: Before next meeting)

14. The issue of increasingly different net load shape as more RE capacity is added was highlighted. Net Load which is total electric demand in the system minus RE generation represents the demand that must be met with other despatchable sources. Hence, flexible generation like Pumped Storage Plants is required to provide peaking power and maintaining system stability.

15. JS (JA), MoP mentioned that possibly there is need to consider Pumped Storage Plants as RE generation as it emerged in the Conference of Power and Mines/NRE Ministers of States/UTs. Chairman mentioned the need for introduction of Flexible Generation Planning and Flexible Generation Obligation (FGO) in the future. On being asked about ToD Tariff implementation, Joint Chief (RA), CERC stated that 20 states have implemented at High Voltage (HV) level; however further implementation at the domestic level was beset with challenges. Chairman requested CEA to conduct a study to assess present and potential flexibility of coal and gas fired stations as well as hydro stations and submit report within 15 days on the technical and commercial aspects.
(Action Point: CEA, CERC , Timeframe: Within 15 days)

16. JS (MNRE) suggested that issues related to REMC & Control Equipment may be included in the scope of work of the Technical Committee. JS (JA), MoP mentioned that funding of REMC was proposed through budgetary support of Government of India; however, the same could also be funded through Power System Development Fund (PSDF).

17. Chairman highlighted the importance of market design enhancement and transmission augmentation as crucial for large scale RE grid integration. **(Action Point: CERC, PGCIL, POSOCO)**

18. Based on the above discussions, the action points are as follows:

1) The following may be invited as special invitees
   i. Representative from IMD, Ministry of Earth Sciences (MoES)
   ii. Member (Hydro), CEA, MoP
   iii. Representative from NIWE, MNRE
   iv. Representative from NISE, MNRE
   v. Representative from GIZ, Germany
   vi. Representative from E&Y Consultants
   vii. Representatives from NTPC, State GENCOs and 4 Private GENCOs for 2nd meeting
2) CERC to suo-motu propose changes in the regulations after stakeholder consultations within 3 months as per proposed amendments in the Act and Policy regarding spinning reserves.
3) CEA to submit a report within 15 days on
   i. Identification of present and future spinning reserve capacities in Coal, Gas and Hydro Plants including cost of carrying and supplying spinning reserve.
   ii. Identification of MoU based, Competitively Bid based and Merchant based plants for participation in spinning reserve capacities with sensitivity analysis.
4) CERC to notify regulations on Ancillary Services by 01st August, 2015.
5) POSOCO to submit a doable action plan within 15 days for introduction of forecasting in India considering the present status, analyzing RE forecasting models adopted world-wide and extent of responsibility for both RE generation and load by REMC/SLDC/RLDC/NLDC.
6) POSOCO to send the FOR meeting presentation to Rajasthan State Utility.
7) MNRE to arrange for communication through Secretary (MNRE) to concerned RE rich states to attend all the meetings of the Technical Committee.
8) CEA to conduct a study to assess present and potential flexibility in coal and gas fired stations as well as hydro stations and submit report within 15 days on the technical and commercial aspects.

19. The Second Meeting be scheduled at Jaipur on 09th May, 2015 at 1000 hrs. The meeting venue and logistics will be coordinated by RRVPNL (Rajasthan State Utility).The meeting ended with thanks to the Chair.

****

Annex – I

List of participants

1. Sh. Devendra Chaudhary, Special Secretary, Ministry of Power – **Chairman**
2. Ms. Jyoti Arora, JS (Trans.), Ministry of Power
3. Ms. Varsha Joshi, JS, MNRE
4. Sh. Ghanshyam Prasad, Director(PG), Ministry of Power
5. Sh. Sanjeev Jain, Under Secretary, Ministry of Power
6. Sh. Major Singh, Chairperson, CEA
7. Sh. S.K. Soonee, CEO, POSOCO
8. Ms. Seema Gupta, COO, CTU (PGCIL)
9. Sh. Sushanta Chatterjee, Joint Chief (RA), CERC
10. Sh. Dinesh Chandra, Chief Engineer (GM), CEA
11. Sh. Ramesh Kumar, Chief Engineer (IRP), CEA
12. Sh. B.L. Jakhar, Chief Engineer, RDPPC, Rajasthan
13. Sh. S.R. Narasimhan, AGM, POSOCO
14. Ms. Vineeta Aggarwal, Asst. GM, PGCIL
15. Sh. K.V.N. Pawan Kumar, Sr. Engr., POSOCO

Annexure - III

F.No.11/11/2015-PG
Government of India
Ministry of Power

Shram Shakti Bhawan, Rafi Marg,
New Delhi, May 20th 2015

To

1. Chairperson, Central Electricity Authority
2. Joint Secretary (Trans.), Ministry of Power
3. Joint Secretary, Ministry of New & Renewable Energy
4. Principal Secretary (Energy), Tamil Nadu
5. Principal Secretary (Energy), Gujarat
6. Principal Secretary (Energy), West Bengal
7. Principal Secretary (Energy), Rajasthan
8. CEO, POSOCO
9. Chief Operating Officer, CTU (PGCIL)
10. Joint Chief(RA), CERC
11. Director (PG), Ministry of Power - Convener & Secretary
12. All Special invitees. (as per list)

Subject: Minutes of the meeting chaired by Special Secretary, MOP on 09.05.2015 on Large Scale Integration of Renewable Energy, Need for Balancing, Deviation Settlement Mechanism (DSM) and associated issues.

Sir,

I am directed to forward herewith the minutes of the meeting taken by Special Secretary(DC), Ministry of Power on 09.05.2015 on the subject mentioned above for information and necessary action at your end.

Girish Kr

(Girish Kumar)
Section Officer (PG)
Telefax: 011-23730264

Copy to:

Sr. PPS to SS(DC)/ PPS to JS(Trans.)/ PS to Director(PG), MoP, Shram Shakti Bhawan, New Delhi

Minutes of the 2nd meeting held under the chairmanship of Special Secretary(MOP) on Large Scale Integration of Renewable Energy, Need for Balancing, Deviation Settlement Mechanism (DSM) and associated issues.

1. 2nd meeting of the committee was held under the chairmanship of Special Secretary, Ministry of Power on 9th May 2015 at 09:00 hours in Vidyut Bhawan, Rajasthan to discuss the Large Scale Integration of Renewable Energy, Need for Balancing, Deviation Settlement Mechanism (DSM) and associated issues. The list of participants is at Annexure-I Various issues were discussed and the following decisions were taken

2. As regards to the communication of Data from Generators to the SLDC is concerned, the following need to done quickly so that the things can move forward.

i) CEA, CTU and POSOCO would hold discussions so that the required set of Regulations on communication could be quickly brought in by CERC.

ii) SLDCs/CEA/CTU/POSOCO/developers have to come out with a long term solution and an intermediate solution through leveraging the existing facilities. CEA would also come out quickly with their DPR for below 132 kV communication system.

iii) MNRE would explore whether the communication system up to 132 kV and below 132 kV up to 33 kV could be funded as part of the GEC and Central funding earmarked.

iv) GIZ/E&Y would try to incorporate the above features in their REMC report due in August 2015.

v) A Committee headed by Principal Secretary, Energy Government of Rajasthan and having members from SLDC Rajasthan, Secretary RERC, CEA(Sh Pankaj Batra), CTU (Seema Gupta), POSOCO (Sh V K Agrawal), Director MNRE and representative from developers would evolve a framework for smooth real time data transfer between the wind/solar pooling stations and the State Load Despatch Centre (SLDC).

(Target: First draft by 18th May 2015 and report within two weeks.)

3. The developers also expressed the need for a forecasting mechanism. The developers stated that they needed 15-minute forecasts as scheduling is on a 15-minute block basis at the Load Despatch Centre level.

It was decided that MNRE in consultation with developers, NIWE, SLDCs and POSOCO would work out the modalities for transmission of data from energy meters to SLDCs within a week.

(Target: 16th May 2015)

4. **It was decided that IMD would explore the possibility of 15-minute basis forecast for the next day.**

A Committee headed by Principal Secretary, Energy Government of Rajasthan and having members from SLDC Rajasthan, NIWE, CEA (Sh PankajBatra), POSOCO (Sh V K Agrawal) and Director MNRE will evolve a framework for forecasting and scheduling of wind generators recognizing the fact that the latter would be wholly responsible for the same and the impact of deviations from the schedule.

(Target 17th May 2015)

5. Scheduling of solar projects was also discussed.

It was decided that Joint Secretary, MNRE in consultation with IMD, GIZ, E&Y, developers and the state utilities of TN/Rajasthan/Andhra/Telangana/Gujarat/Madhya Pradesh would look at the policy level interventions required to acquire capability of solar generation forecasting considering that it would be a green field area for the country.

(Target 18th May 2015)

6. As regards, balancing resources to handle variability of wind generation, POSOCO through a brief presentation stated that the minimum to maximum load ratio was reducing over the years and thermal backing down had increased.

POSOCO stated that the draft Ancillary Services Regulation brought out by CERC on 1st May 2015 provided an opportunity for balancing.

It was decided that Shri Pankaj Batra, CEA would chair a Committee having members from CEA (Hydro wing), MNRE, GIZ, Rajasthan DISCOMs, Rajasthan GENCO and developers to examine the balancing requirements on account of variability and fulfilling the same.

(Target 20th May 2015)

7. The Chairman stated that three (3) main issues had emerged in the meeting and requested that the different areas such as policy making, regulatory, planning and system operation be examined for the following three areas:

i. Real time data and communication from RE generators to LDCs
ii. Forecasting and Scheduling
iii. Balancing Resources & mechanism

The sub-groups highlighted above would look at these issues and submit their report. Similar discussion would be held with the states of Gujarat, Tamilnadu, Andhra Pradesh and Telangana.

The meeting ended with a vote of thanks to the Chair.

****

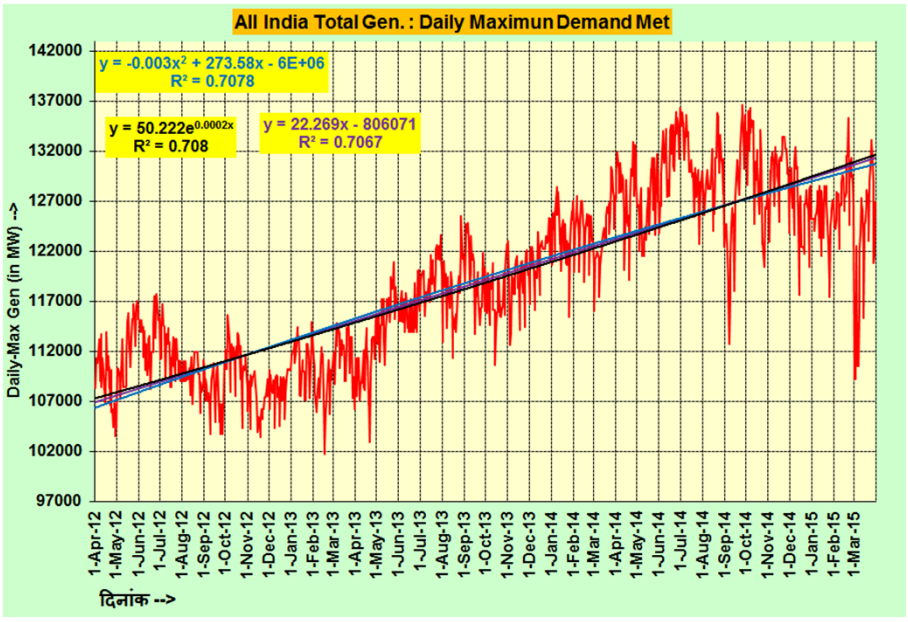
Annexure-I

List of Participant

1. Shri Devendra Chaudhry, Special Secretary, MoP - **in chair**
2. Shri Ghanshyam Prasad, Director, MoP
3. Shri Vijay Menghani, Director, CEA
4. Shri Ishan Sharan, Director, CEA
5. Shri K.N Garg, Member(Hydro), CEA
6. Shri Pankaj Batra, Chief Engineer, CEA
7. Shri S.K Soonee, CEO, POSOCO
8. Smt Seema Gupta, COO (CTU), POWERGRID
9. Shri V.K Agrawal, E.D, POSOCO
10. Shri S.R Narasimhan, Addl. GM, NLDC, POSOCO
11. Shri H.K Chawla, DGM, POSOCO
12. Shri K. Muralikrishna, DGM,WRLDC, POSOCO
13. Shri D.L Jakhar, CE, RDPPC
14. Shri G.K. Sharma, Secretary, RERC
15. Shri U.D Khan, Joint Secretary, Energy
16. Shri Anurag , MD, Jaipur
17. Shri Ajay Mathur, XEn (PP) RDPPC
18. Shri Alok Pareek, TA to CE (RDPPC), Jaipur
19. Shri A.K Arya, SE; RVPNL, Jaipur
20. Shri R.P Barwar, Director (Operation), Jaipur
21. Shri S.K Baswal, G.M, RREC
22. Shri M.M Ranna, SE (PP), RDPPC
23. Shri Manoj Gupta, ACME/AVP
24. Shri Pramod Singh, iNOX Renewable Ltd.
25. Shri Alok Gupta, INOX Wind Infra Ltd.
26. Shri R. S Pareek, Mytrah Energy(I) Ltd.
27. Shri Shailenra Singh, Mytrah Energy (I) Ltd.
28. Shre Asheeh Calla, REGEW POWERTECH
29. Shri Shanti Prasad, Ex-Chairman, RERC
30. Shri Abhishek Bhatia, Webspun Energy Pvt. Ltd.
31. Shri Narendra Mahipal, SUNEDZSON SOLAR INDIA
32. Shri B.L Sharma, Vikram Solar
33. Shri Sunil Bora, TANOT Wind Power
34. Shri Kavid Bhatt, Veer Energy
35. Shri D.K Saxena, Wellspen.
36. Shri S.C Bhan, SE, India Met Deptt.
37. Shri K. Boopathi, Head WRA, NIWE, Chennai
38. Shri K. Manoharan, SE/Solar/TANGEDCO
39. Shri Bindoo Srivastava, C/o EY Gurgaon
40. Shri Shuvendu Bose, EY
41. Shri Pradeep Vashishta, State Head, SUZLON
42. Shri Pankaj Thakkar, Solar, ALSTOM
43. Shri Abhijit Mondal, Reliance Power
44. Shri Amaresh Pandey, Sn. Manager, GAMESA Corp.
45. Dr. Winfried Damm, GiZ, Delhi
46. Shri Markus Sypior, Giz, Delhi
47. Shri Sunil Sharma, GiZ, Delhi

All India Maximum Generation Patterns

1



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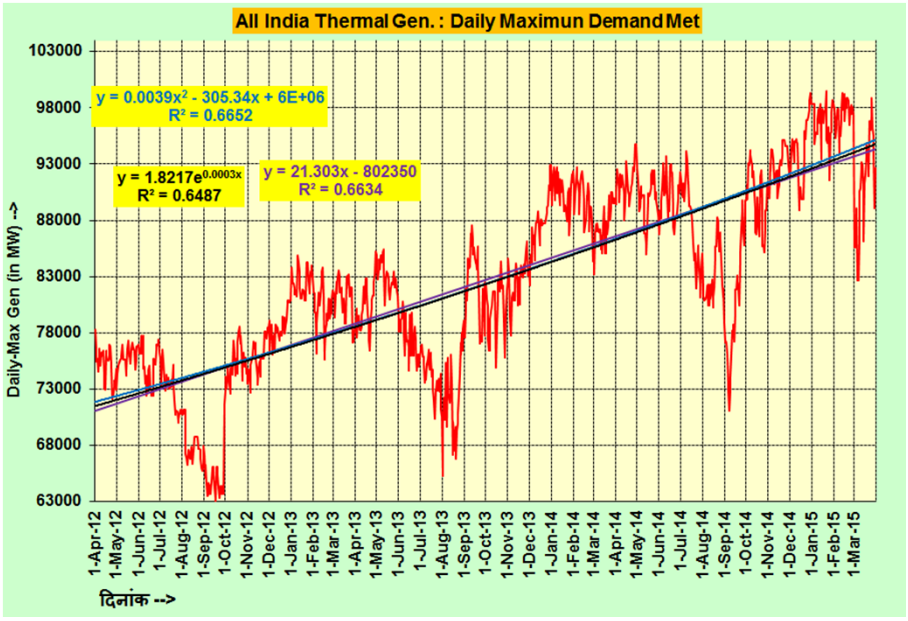
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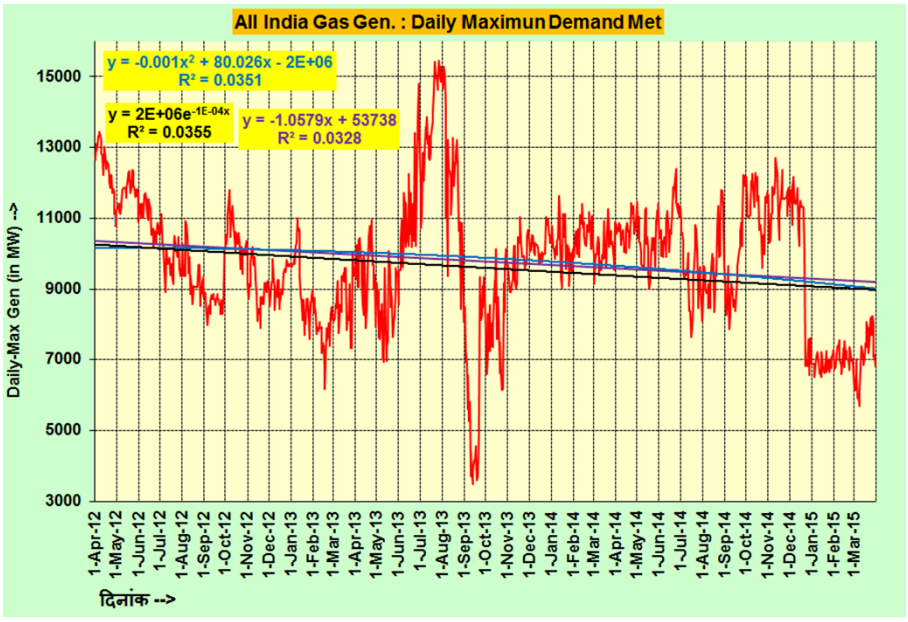
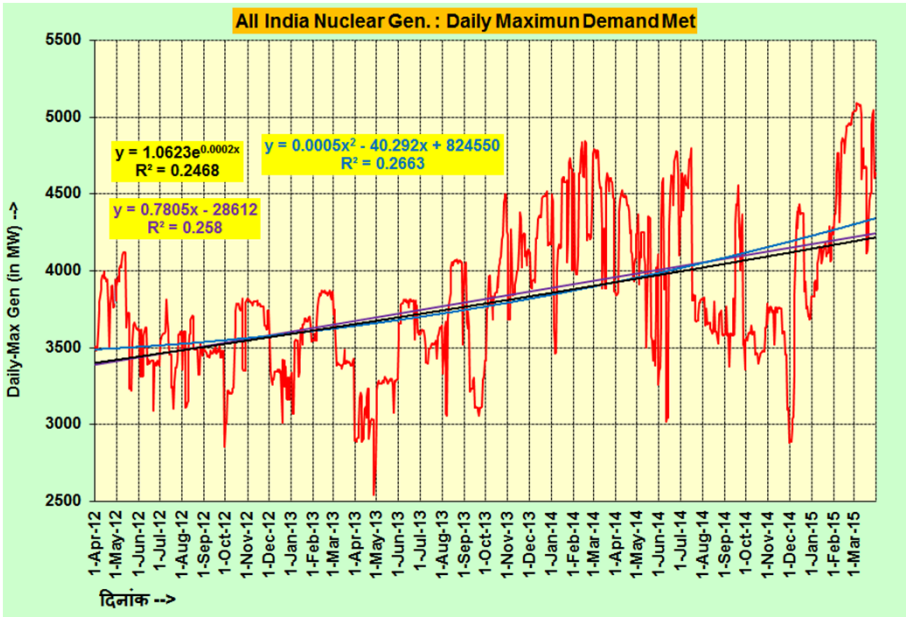
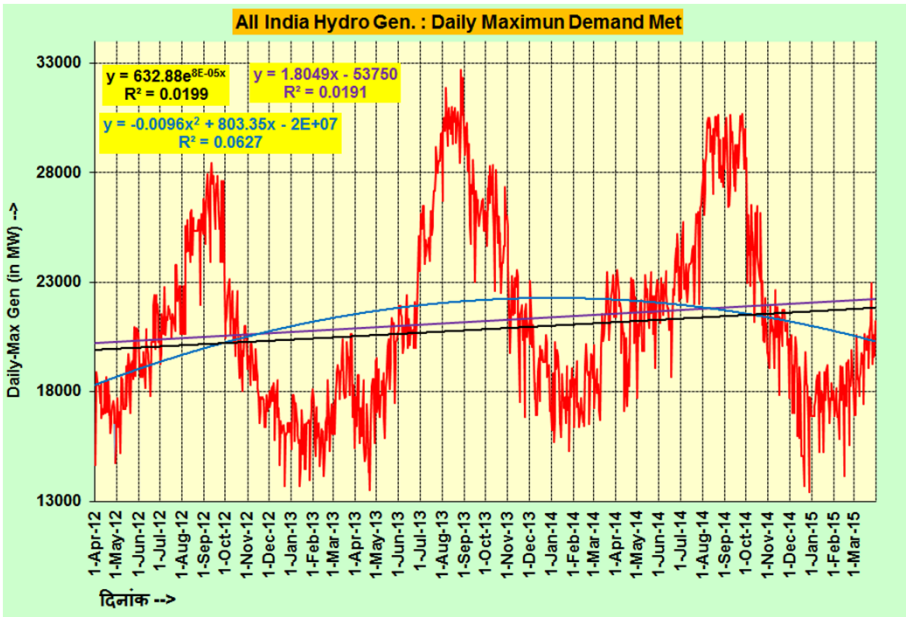

All India Gas Gen. : Daily Maximun Demand Met
y = -0.001x² + 80.026x - 2E+06
R² = 0.0351
y = 2E+06e^-1E-04x
R² = 0.0355
y = -1.0579x + 53738
R² = 0.0328
Daily-Max Gen (in MW) -->
दिनांक -->

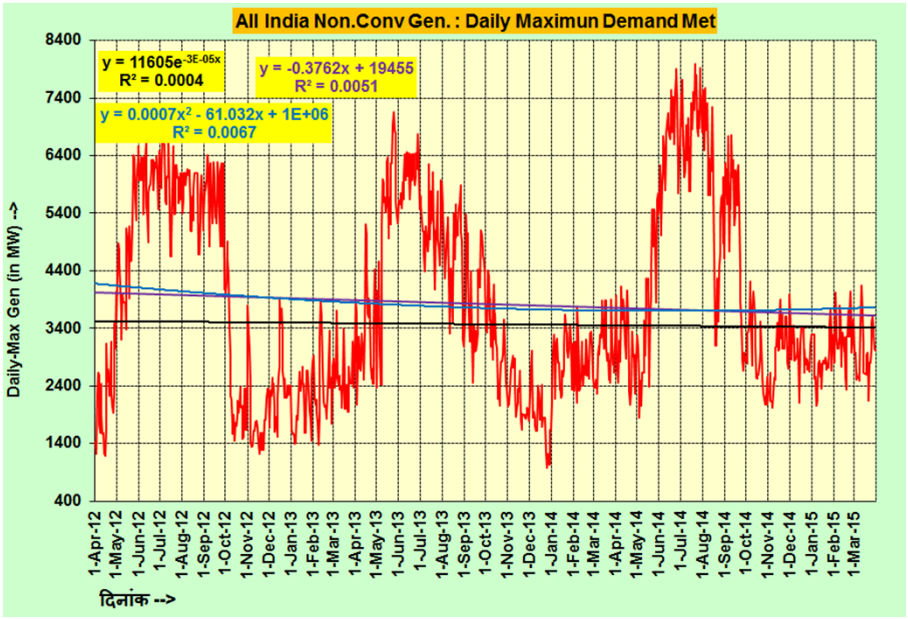
4


All India Nuclear Gen. : Daily Maximun Demand Met
y = 1.0623e^0.0002x
R² = 0.2468
y = 0.0005x² - 40.292x + 824550
R² = 0.2663
y = 0.7805x - 28612
R² = 0.258
Daily-Max Gen (in MW) -->
दिनांक -->

5


All India Hydro Gen. : Daily Maximun Demand Met
y = 632.88e^8E-05x
R² = 0.0199
y = 1.8049x - 53750
R² = 0.0191
y = -0.0096x² + 803.35x - 2E+07
R² = 0.0627
Daily-Max Gen (in MW) -->
दिनांक -->

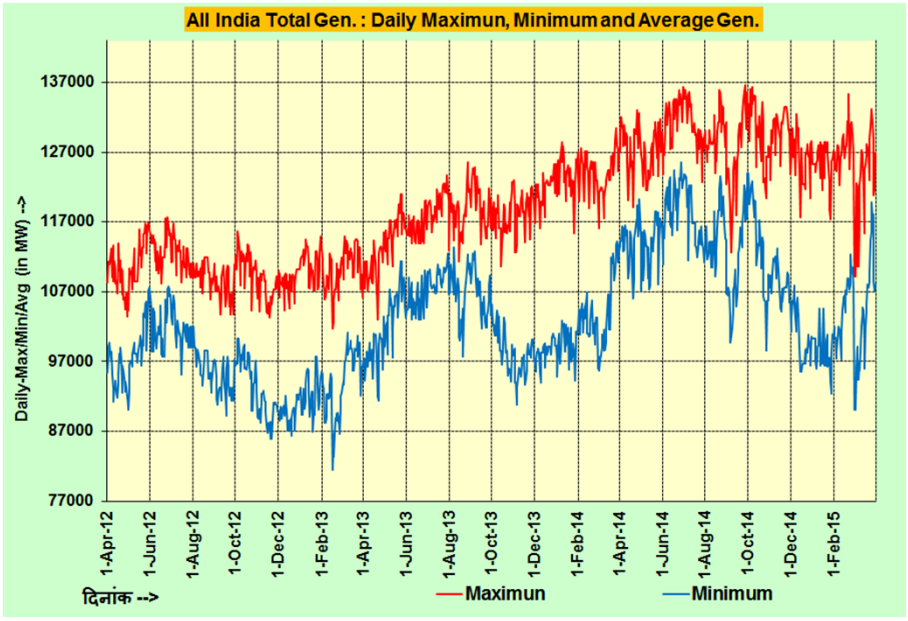
6



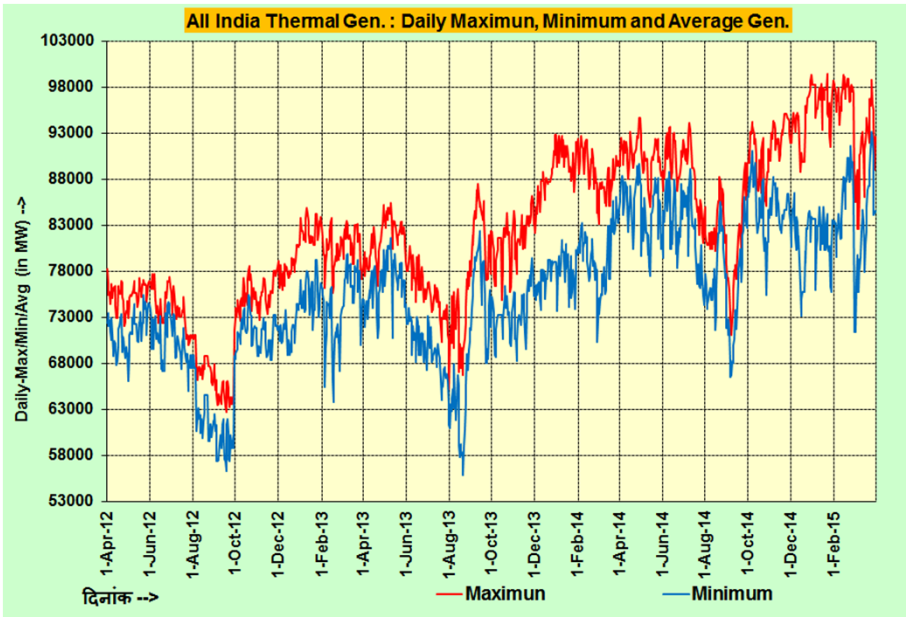
7

All India Maximum-Minimum Generation Patterns

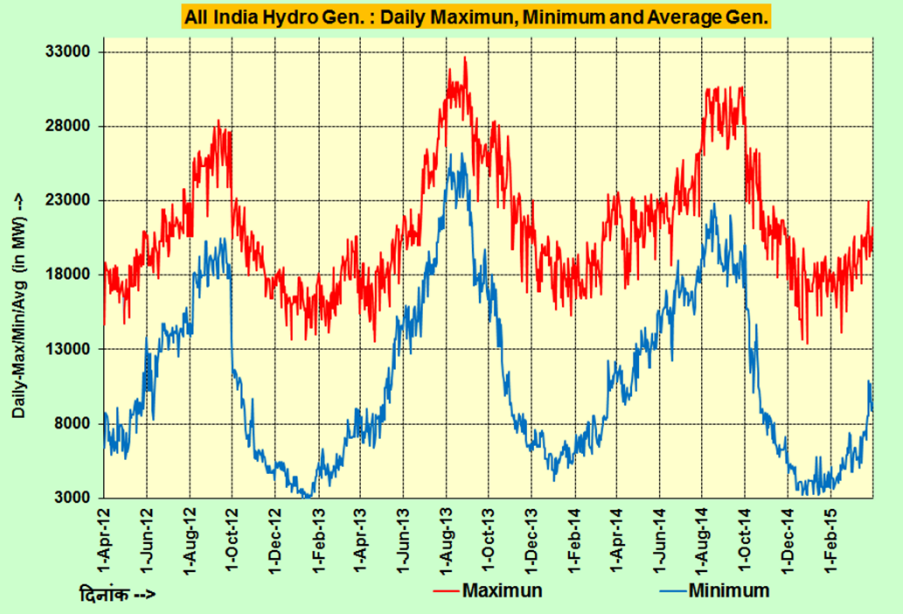
8


All India Total Gen. : Daily Maximun, Minimum and Average Gen.
Daily-Max/Min/Avg (in MW) -->
137000
127000
117000
107000
97000
87000
77000
1-Apr-12
1-Jun-12
1-Aug-12
1-Oct-12
1-Dec-12
1-Feb-13
1-Apr-13
1-Jun-13
1-Aug-13
1-Oct-13
1-Dec-13
1-Feb-14
1-Apr-14
1-Jun-14
1-Aug-14
1-Oct-14
1-Dec-14
1-Feb-15
दिनांक -->
Maximun
Minimum

9


All India Thermal Gen. : Daily Maximun, Minimum and Average Gen.
Daily-Max/Min/Avg (in MW) -->
103000
98000
93000
88000
83000
78000
73000
68000
63000
58000
53000
1-Apr-12
1-Jun-12
1-Aug-12
1-Oct-12
1-Dec-12
1-Feb-13
1-Apr-13
1-Jun-13
1-Aug-13
1-Oct-13
1-Dec-13
1-Feb-14
1-Apr-14
1-Jun-14
1-Aug-14
1-Oct-14
1-Dec-14
1-Feb-15
दिनांक -->
Maximun
Minimum

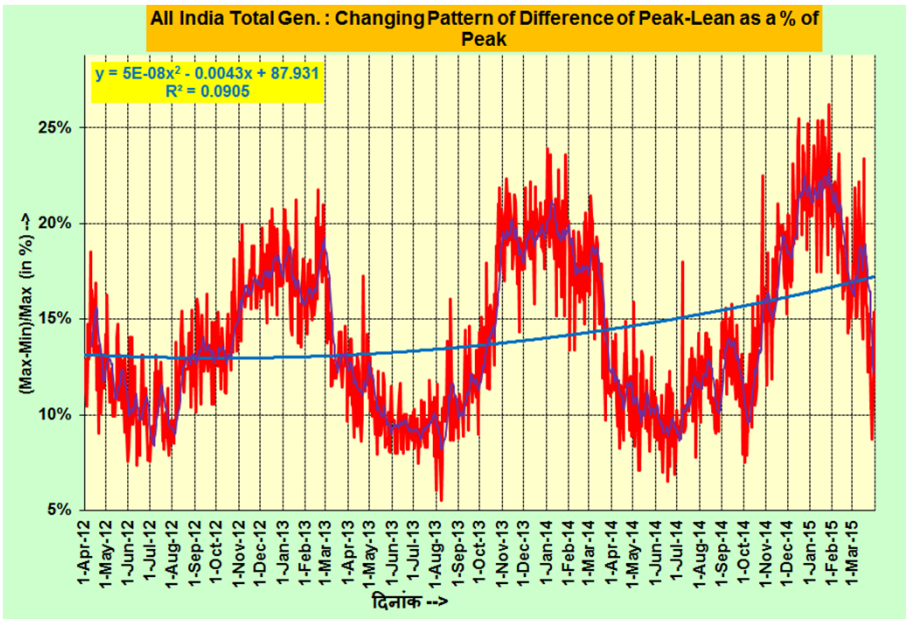
10



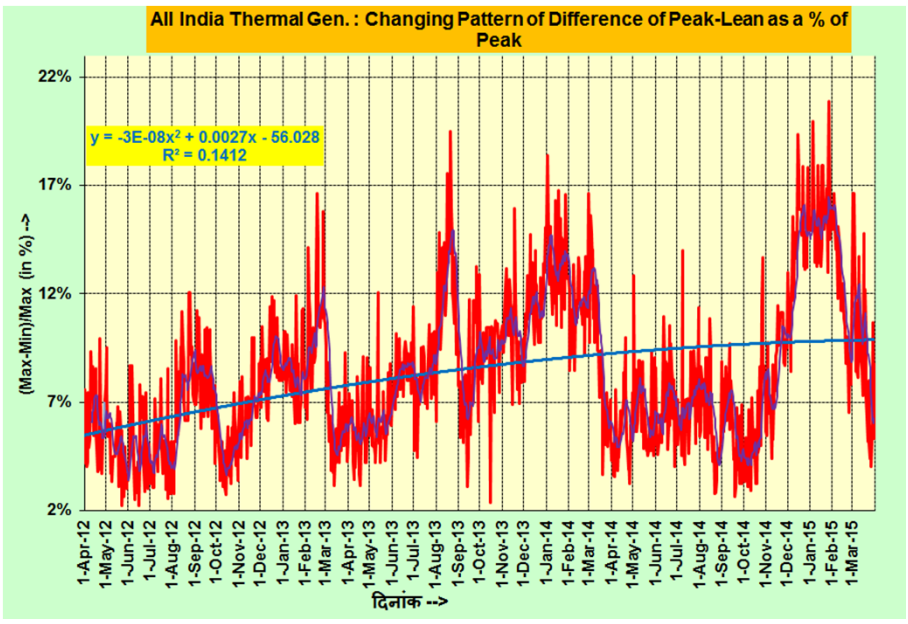
11

All India Changing generation Patterns of Diff. of Peak-Lean as a Peak

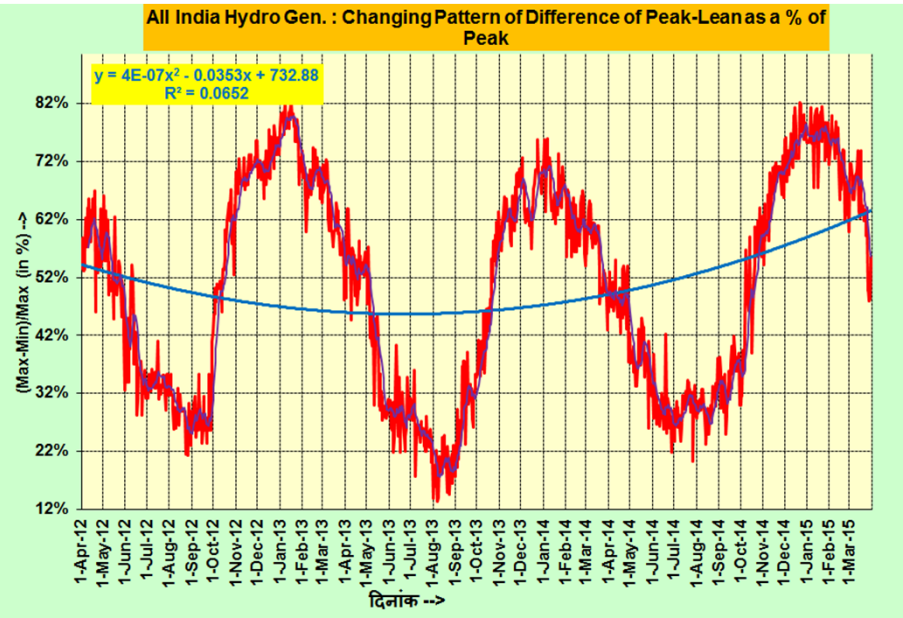
12


All India Total Gen. : Changing Pattern of Difference of Peak-Lean as a % of Peak
y = 5E-08x² - 0.0043x + 87.931
R² = 0.0905
(Max-Min)/Max (in %) -->
25%
20%
15%
10%
5%
1-Apr-12
1-May-12
1-Jun-12
1-Jul-12
1-Aug-12
1-Sep-12
1-Oct-12
1-Nov-12
1-Dec-12
1-Jan-13
1-Feb-13
1-Mar-13
1-Apr-13
1-May-13
1-Jun-13
1-Jul-13
1-Aug-13
1-Sep-13
1-Oct-13
1-Nov-13
1-Dec-13
1-Jan-14
1-Feb-14
1-Mar-14
1-Apr-14
1-May-14
1-Jun-14
1-Jul-14
1-Aug-14
1-Sep-14
1-Oct-14
1-Nov-14
1-Dec-14
1-Jan-15
1-Feb-15
1-Mar-15
दिनांक -->

13


All India Thermal Gen. : Changing Pattern of Difference of Peak-Lean as a % of Peak
y = -3E-08x² + 0.0027x - 56.028
R² = 0.1412
(Max-Min)/Max (in %) -->
22%
17%
12%
7%
2%
1-Apr-12
1-May-12
1-Jun-12
1-Jul-12
1-Aug-12
1-Sep-12
1-Oct-12
1-Nov-12
1-Dec-12
1-Jan-13
1-Feb-13
1-Mar-13
1-Apr-13
1-May-13
1-Jun-13
1-Jul-13
1-Aug-13
1-Sep-13
1-Oct-13
1-Nov-13
1-Dec-13
1-Jan-14
1-Feb-14
1-Mar-14
1-Apr-14
1-May-14
1-Jun-14
1-Jul-14
1-Aug-14
1-Sep-14
1-Oct-14
1-Nov-14
1-Dec-14
1-Jan-15
1-Feb-15
1-Mar-15
दिनांक -->

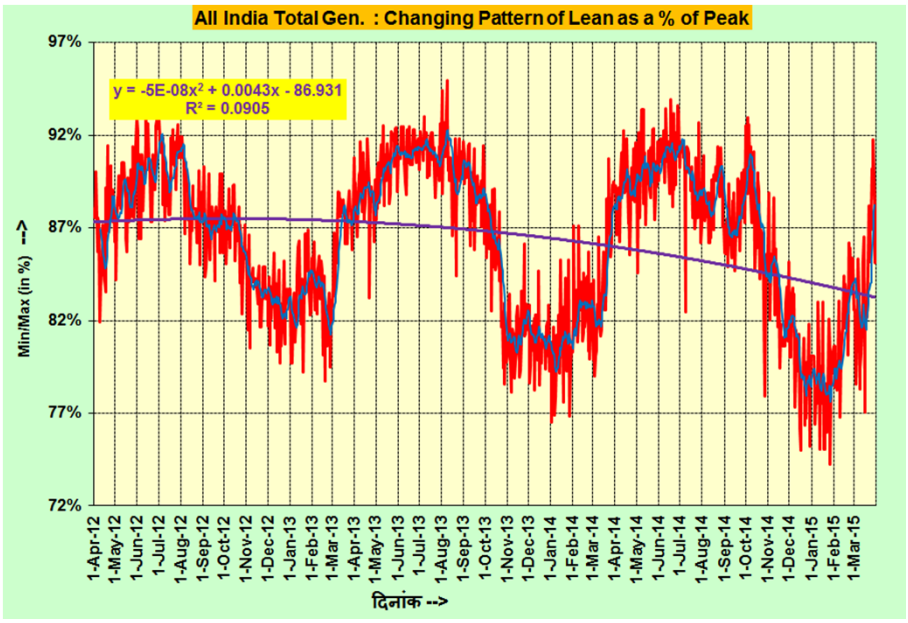
14



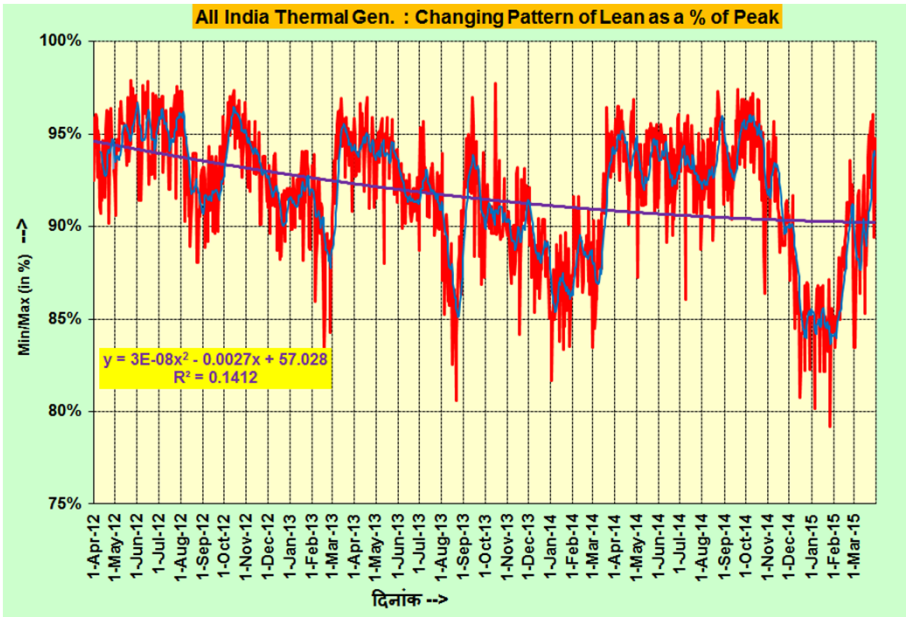
15

All India Changing generation Patterns of Lean as a Peak

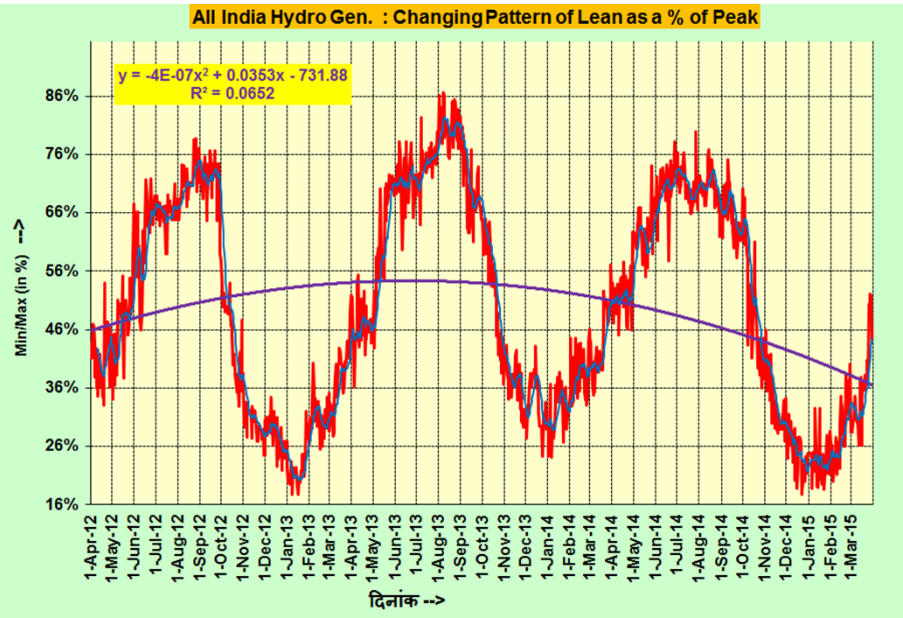
16


All India Total Gen. : Changing Pattern of Lean as a % of Peak
y = -5E-08x² + 0.0043x - 86.931
R² = 0.0905
Min/Max (in %) -->
97%
92%
87%
82%
77%
72%
1-Apr-12
1-May-12
1-Jun-12
1-Jul-12
1-Aug-12
1-Sep-12
1-Oct-12
1-Nov-12
1-Dec-12
1-Jan-13
1-Feb-13
1-Mar-13
1-Apr-13
1-May-13
1-Jun-13
1-Jul-13
1-Aug-13
1-Sep-13
1-Oct-13
1-Nov-13
1-Dec-13
1-Jan-14
1-Feb-14
1-Mar-14
1-Apr-14
1-May-14
1-Jun-14
1-Jul-14
1-Aug-14
1-Sep-14
1-Oct-14
1-Nov-14
1-Dec-14
1-Jan-15
1-Feb-15
1-Mar-15
दिनांक -->

17


All India Thermal Gen. : Changing Pattern of Lean as a % of Peak
y = 3E-08x² - 0.0027x + 57.028
R² = 0.1412
Min/Max (in %) -->
100%
95%
90%
85%
80%
75%
1-Apr-12
1-May-12
1-Jun-12
1-Jul-12
1-Aug-12
1-Sep-12
1-Oct-12
1-Nov-12
1-Dec-12
1-Jan-13
1-Feb-13
1-Mar-13
1-Apr-13
1-May-13
1-Jun-13
1-Jul-13
1-Aug-13
1-Sep-13
1-Oct-13
1-Nov-13
1-Dec-13
1-Jan-14
1-Feb-14
1-Mar-14
1-Apr-14
1-May-14
1-Jun-14
1-Jul-14
1-Aug-14
1-Sep-14
1-Oct-14
1-Nov-14
1-Dec-14
1-Jan-15
1-Feb-15
1-Mar-15
दिनांक -->

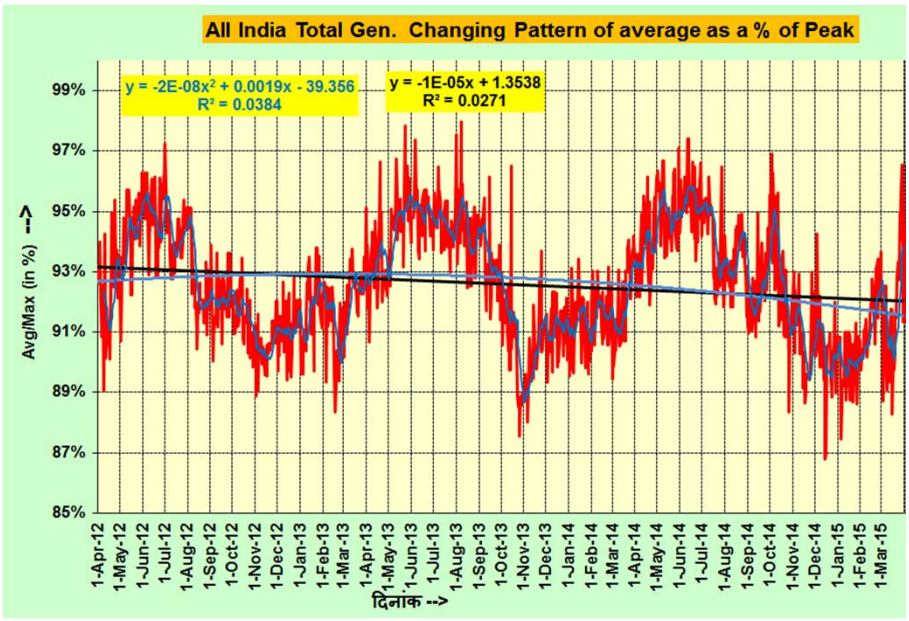
18



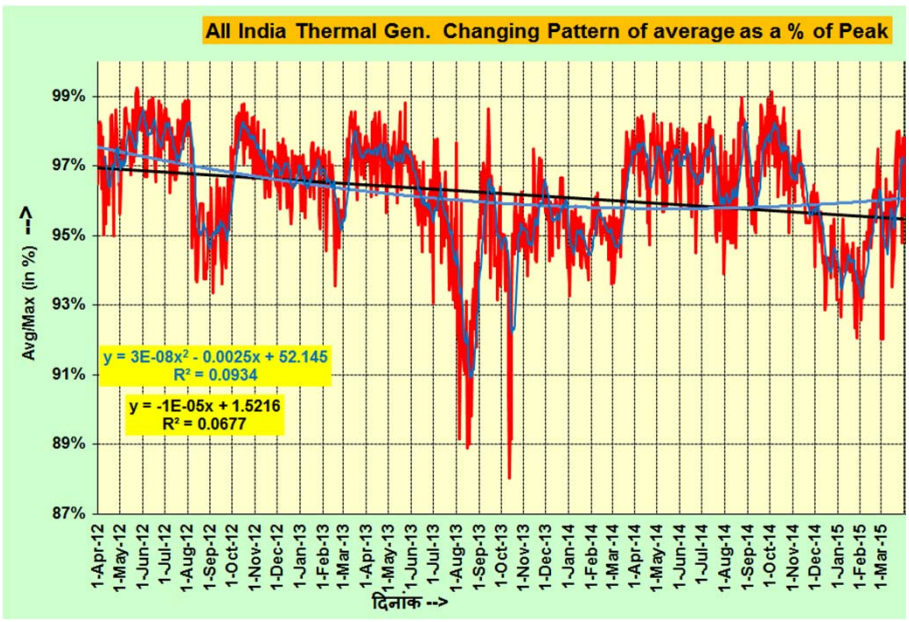
19

All India Changing generation Patterns of Average as a Peak

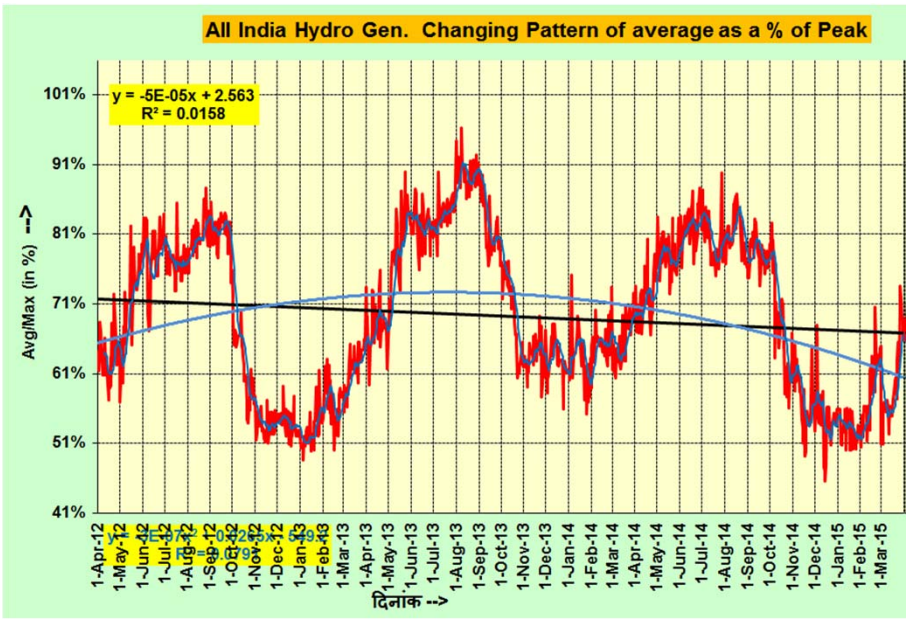
20


All India Total Gen. Changing Pattern of average as a % of Peak
y = -2E-08x² + 0.0019x - 39.356
R² = 0.0384
y = -1E-05x + 1.3538
R² = 0.0271
Avg/Max (in %) -->
दिनांक -->

21


All India Thermal Gen. Changing Pattern of average as a % of Peak
y = 3E-08x² - 0.0025x + 52.145
R² = 0.0934
y = -1E-05x + 1.5216
R² = 0.0677
Avg/Max (in %) -->
दिनांक -->

22


All India Hydro Gen. Changing Pattern of average as a % of Peak
y = -5E-05x + 2.563
R² = 0.0158
101%
91%
81%
71%
61%
51%
41%
Avg/Max (in %) -->
1-Apr-12
1-May-12
1-Jun-12
1-Jul-12
1-Aug-12
1-Sep-12
1-Oct-12
1-Nov-12
1-Dec-12
1-Jan-13
1-Feb-13
1-Mar-13
1-Apr-13
1-May-13
1-Jun-13
1-Jul-13
1-Aug-13
1-Sep-13
1-Oct-13
1-Nov-13
1-Dec-13
1-Jan-14
1-Feb-14
1-Mar-14
1-Apr-14
1-May-14
1-Jun-14
1-Jul-14
1-Aug-14
1-Sep-14
1-Oct-14
1-Nov-14
1-Dec-14
1-Jan-15
1-Feb-15
1-Mar-15
दिनांक -->

23

Annexure - IV

Third Meeting of Technical Committee on Large Scale Integration of Renewable Energy, Need for Balancing, Deviation Settlement Mechanism (DSM) and associated issues held on 13th May, 2015 at 1400 hrs in NPMC Conference Room, 2nd Floor, Ministry of Power, Shram Shakti Bhawan, Delhi

1) An Implementation Committee under Sh Pankaj Batra, Chief Engineer (CEA) would be set up comprising members from states, POSOCO and POWERGRID as members for overseeing implementation of the recommendations of the Technical Committee.

2) Backing down to 60% of installed capacity for a coal fired power station would lead to 5 paise/kWh increase in energy charges due to poorer Heat rate. CEA has separately worked out the reserves requirement and flexibility required from conventional power fleet.

3) A committee under RVPN would study the feasibility of introducing storage systems at GENCO level itself and submit its report within 15 days.

4) Rajasthan and Gujarat would send the developer and owner wise list of solar and wind generators in their respective state to the Committee.

5) Sh Pankaj Batra, Chief Engineer CEA would look into the harmonization of regulations at the interstate and intra state level and development of market to make the process of RE integration sustainable.

6) SLDC Gujarat would work out the 'communication' system requirements for getting real time data from the generators to SLDCs through the Data Concentrators at the STU substations.

Annexure - V

Record of discussion of the Fourth Meeting of Technical Committee on Large Scale Integration of Renewable Energy, Need for Balancing, Deviation Settlement Mechanism (DSM) and associated issues held on 27th May, 2015 at 2.00 PM in the Chambers of the Special Secretary, Ministry of Power, Government of India

The list of participants is enclosed at Annex-I.

A. Shri Devendra Chaudhry, Special Secretary, Ministry of Power chaired the meeting. Chairman reviewed the progress of the Sub-Groups in the following areas:

1) Implementation of Reserves Requirement and Balancing Resources for RE Integration
2) Real time data and Communication from RE generators to LDCs
3) Forecasting, Scheduling and Deviation Settlement Mechanism for RE Generation and Load

Implementation of Reserves Requirement and Balancing Resources for RE Integration

B. Chairman emphasized the need for implementation of Reserves Requirement and Balancing Resources for RE Integration. POSOCO presented a draft base paper on the Reserves Requirements for Indian Power System. It was decided that the base paper would also incorporate the reserve requirements specifically for RE Generation in RE-rich states. It was also decided that identification of specific generating stations, associated costs and implications for the stakeholders may be incorporated in the report.

C. Chief Engineer (RA), CEA submitted that, at present, about 14,000 MW of gas capacity as spinning reserves has been identified. He also suggested that, based on the original 12th Plan projections for RE capacity addition, about 4300 MW i.e. 10 % of the projected capacity may be used for balancing RE. It was also deliberated that there is a policy requirement from Ministry of Petroleum & Natural Gas (MoP&NG) for increasing the present permissible variation of 20 % in the gas pipeline further to accommodate the flexibility in gas fired stations for balancing requirements.

D. GIZ is working with Rajasthan Utilties regarding analysis of balancing requirements, hourly wind/solar generation data and hourly conventional generation data. It was suggested that more flexible conventional generation to rum upto 50 % is needed along with demand response and pumped storage plants. It was also mentioned that, in the mid-term, regional balancing may be facilitated through regulatory framework.

E. CEO (POSOCO) stated that short term solution may be to identify the reserves in the existing plants by scheduling conventional generation upto only 95 % of the Installed Capacity and balance 5 % may be kept as spinning reserve.

F. It was agreed that CEA shall finalize the document on Reserves Requirement and Balancing Resources for RE Integration based on the inputs received so far and as per the discussion held in this meeting.

Real time data and Communication from RE generators to LDCs

G. Chairman enquired about the progress of the committee to evolve a framework for smooth real time data transfer between the wind/solar pooling stations and the State Load Despatch Centre. ED (NLDC) presented an interim report on the communication requirements covering the basic details towards infrastructure requirements, technological developments and implementation plan. Chairman directed CEA to coordinate with Gujarat and Rajasthan Utilities to prepare a model data and communication framework for RE integration at intra-state level to be replicated across the country.

H. On a query from Chairman, representative from Rajasthan Utility stated that interim solution may be GPRS communication but long term solution is OPGW communication. Chairman suggested that a long

term solution is needed to address the data and communication issues at intra-state level for RE integration. The funding of the infrastructure on the pattern of Green Energy Corridors (GEC) may be done from PSDF and NCEF. GIZ representative stated that OPGW based communication is the long term solution.

Forecasting, Scheduling and Deviation Settlement Mechanism for RE Generation and Load

I. POSOCO presented a draft base paper on the Forecasting, Scheduling and Deviation Settlement Mechanism for RE Generation and Load. CEO (POSOCO) mentioned that two stages of forecasting is needed i.e. one at LDC level and other at generator level. It was discussed that ensemble forecasts are preferable as due to large number of forecasts, the error is reduced. PGCIL representative stated that GIZ report on REMC is awaited so that tendering process may be initiated for REMC.

J. Chairman queried on the responsibility of the forecast. He stated that there is a need for aggregator at the generator level. Due to multiplicity of forecast providers, a government entity may provide the forecasting service and be responsible for it. LDCs may enter into an agreement with NIWE or any other agencies for forecasting services. JC (RA), CERC clarified that as REMC are envisaged as a part of LDC, which itself is a government entity. GIZ representative explained that in Germany, TSO acts as the aggregator and enters into contract with 4 or 5 different forecasting service providers. PGCIL representative highlighted that aggregator must be responsible for scheduling and commercial settlements. Any commercial implication may be borne by the aggregator. The grid operator may be responsible from the grid security perspective.

K. Chairman directed CEA representative to coordinate with all the members and finalize the documents on the issues raised in the meeting. CEA shall also prepare a draft note on Technical Committee Recommendations for RE Integration for presentation to the Sec(P) in the next meeting.

L. Based on the above discussions, the action points are as follows:

- Representative from E&Y Consultants to be present in next meeting
- CEA to coordinate with Gujarat and Rajasthan Utilties to prepare a model data and communication framework for RE integration at intra-state level to be replicated across the country.
- GIZ to submit Green Energy Corridors - II Report to all the members of the Technical Committee
- CEA representative to coordinate with all the members and finalize the documents on the issues raised in the meeting.
- CEA shall also prepare a draft note on Technical Committee Recommendations for RE Integration for presentation to the Sec(P) in the next meeting.
- The Fifth Meeting is scheduled on 03rd June, 2015 at 1400 hrs in the NPMC Conference Room, Ministry of Power, Government of India.

M. The meeting ended with thanks to the Chair.

Annex – I

List of Participants

1. Sh. Devendra Chaudhary, Special Secretary, Ministry of Power – Chairman
2. Sh. Pankaj Batra, Chief Enginner (RA), CEA
3. Sh. Sushanta Chatterjee, Joint Chief (RA), CERC
4. Sh. S.K. Soonee, CEO, POSOCO
5. Sh. V.K. Agrawal, ED, NLDC
6. Sh. Subir Sen, GM, PGCIL
7. Sh. Ghanshyam Prasad, Director(PG), Ministry of Power – Convenor
8. Representative from Tamil Nadu
9. Representative from Rajasthan
10. Representative from Gujarat
11. Representative from MNRE
12. Representative from GIZ
13. Representative from NTPC
14. Representative from NIWE

Gist of discussion of the Meeting taken by Hon'ble MoS(IC) for Power, Coal and NRE on 19th June, 2015 regarding Large Scale Integration of Renewable Energy, Need for Balancing, Deviation Settlement Mechanism (DSM) particularly with reference to 150 MW limits, Regional Grids and associated issues.

The list of participants is enclosed at **Annex-I**.

1. Hon'ble Minister of State (IC) for Power, Coal and New & Renewable Energy chaired the meeting. Joint Secretary (JA), Ministry of Power (MoP) welcomed all the participants and in the opening remarks mentioned the context of the presentation being made. She mentioned that 150 MW limits under the DSM Regulations of CERC, integration of renewables, balancing at regional grids level etc. had been raised as issues during the Power Minister's Conference held at Guwahati. It was mentioned that CERC had introduced the Renewable Regulatory Fund (RRF) mechanism to facilitate integration of Renewable Energy (RE) and to handle imbalances in 2010. However, jurisdiction issues raised by intra-state RE generators and implementation difficulties led to suspension of commercial part of RRF Mechanism in 2014 by CERC.

2. JS (JA), MOP also mentioned that the following actions have been initiated to address the concerns raised in the Power Minister's Conference held at Guwahati:

(i) A Committee had been constituted by the MOP on Large Scale Integration of Renewables, Balancing and Deviation Settlement Mechanism (DSM). Four meetings of the Committee had taken place so far and there were interactions with various stakeholders such as CEA, CTU, wind developers, state utilities, generators, etc. The report of the Committee is under finalization.

(ii) Initiatives have been taken by the MOP for implementation of the Renewable Energy Management Centers (REMCs) and GIZ, the consultant is in the process of finalizing the report.

(iii) CERC has notified draft Regulations on the "Framework for Forecasting, Scheduling and Imbalance Handling for Renewable Generating Stations based on Wind and solar at Inter-State level" on 31st March 2015 and "Ancillary Services Operations" on 1st May 2015. Public Hearing on both Regulations was held on 12thJune 2015 and the final Regulations are to be notified by CERC in due course

3. A presentation by POSOCO was made on the relevant issues. The presentation by POSOCO highlighted the need for frequency control, handling deviations, balancing of renewables and the way forward. Copy of the presentation is enclosed at **Annex–II**. It was recognized that deviation or imbalance handling mechanism is an essential pillar for large grids &applicable to all States (load serving entities) and Generation – conventional as well as renewable generation.

4. It was stated that while fixing the deviation limits, the size of the state and the quantum of renewable generation the state is having, also needs to be kept in consideration. However, as large quantum of RE Generation is going to be integrated

with the grid, keeping in view the security of the grid, the Forecasting and Scheduling for RE Generators is non-negotiable.

5. It was decided that Ministry of Power would send a communication to all the State Utilities regarding Load Forecasting mandated as per CERC Grid Code Regulations, 2010. All the State Utilities/SLDCs may begin load forecasting within 3 months.

P.T.O

6. Representative of the wind developers mentioned that there was a need for introducing the concept of Aggregators. All the developers agreed to provide forecast and schedule to the concerned entity at the intra-state level as well as at inter-state level. Further, they also mentioned the need for proper commercial mechanism for handling deviations within the State.

7. JS, MNRE agreed to the role of Aggregators and emphasizing the importance of scheduling and forecasting, mentioned the efforts made in Tamil Nadu where the wind developers and NIWE have collaborated for implementation of forecasting and scheduling. A similar initiative is also being taken up in Gujarat. Secretary, MNRE mentioned that Government has a very ambitious plan with a target of 165,000 MW of wind and solar integration. It is essential that a proper Regulatory Framework forecasting, scheduling and imbalance settlement is put in place both at the inter-state and intra-state level to facilitate integration of large scale renewables.

8. CERC was requested to finalize Framework for Forecasting, Scheduling and Imbalance Handling for Renewable Generating Stations at Inter-State level within a month. After deliberations, finally it emerged out that once the CERC Regulations at the inter-state level are in place, a model Regulation for SERCs could be made by CERC and the matter may be taken up in the next meeting of the Forum of Regulators (FOR).

9. It was emphasized that balanced portfolio needs to be demonstrated and maintained by all state utilities in different time frames. The need for intra-state deviation and settlement mechanism amongst the different entities in each state was recognized. It was also explained that Frequency Control is necessary to balance generation and demand in real time operation. Frequency control is important for Grid Security as system frequency indicates the health of the system.

10. MD, GETCO highlighted the issue of 150 MW deviation limit being too low for a large state like Gujarat. He also raised the issue of penalizing the state utility on the under-drawal even when frequency is above 50.1 Hz. The representative of state utility highlighted the challenge of RE generation variability stating that this resulted in huge over-drawal/under-drawal due to sudden variation in RE generation and there were commercial implications as per the DSM Regulations in the State.

11. It was cautioned that, in extreme scenario in case all state utilities of a region start erring in one direction, it will lead to skewed scenario and stress the Inter-Regional

tie lines flows leading to critical levels and threat to the security of the grid. It was re-emphasized that the large deviations besides causing severe transmission constraints and endangering Grid Security may also render it difficult to control the large deviations during contingency, as manual action takes time to control drawal from grid and hence may put the grid at risk. Hon'ble MoSP (IC) took note of the fact that large deviations would undermine grid security and stated that secure and reliable grid operation is of paramount importance.

12. On the issue of flexibility of the renewable rich states to manage and balance renewables and the overall framework towards addressing this issue, JS (JA) stated that ultimately regulatory intervention is required for addressing the issue of balancing as well as any reconsideration towards deviation volume limits. It was suggested that formulation of different bands of deviation volume in which states may be placed according to size of the state and level of penetration of RE in the state. A need was also felt for study of the reasons for deviation in all the states with regard to variation in actual demand, variation in Conventional Generation availability and variability of RE Generation.

13. Regarding the issue of balancing in a larger area and advantages thereof, the need for real time markets, multiple iterations, enhancing the flexibility of conventional generation and Ancillary Services was also highlighted. It was also stated that Ancillary Services is an essential pillar for reliable and secure operation of the grid and it also facilitates renewable integration. Ancillary Services will facilitate optimization at Regional & National Level by the RLDCs/NLDC and thereby facilitate integration of RE also. It was explained that the provisions for Reserves already exists in National Electricity Policy 2005 which mandates 5% Spinning Reserves at National Level. CERC has constituted a committee chaired by Member (Technical), CERC for formulating Regulations on Reserves.

14. It was mentioned that under the scheme for utilization of Gas based power generation capacity, the gas based generation may be explored as a source of spinning reserve. Hon'ble MoSP(IC) emphasized that suitable compensation mechanisms also have to be in place for pumped storage plants. He also suggested that NTPC stations should provide reserves. Regarding banking arrangements, It was felt that some states may not be willing and hence, suitable mechanisms for operation of reserves may be put in place.

15. It was decided that action points given at **Annex – III** may be taken up in a time bound manner. The next meeting is to be scheduled to be held at end July, 2015.

16. The meeting ended with thanks to the Chair.

****

Annex – I

List of Participants

1. Sh .PiyushGoyal, Hon'ble MoSP (IC) – Chairman
2. Sh. UpendraTripathy, Secretary, MNRE
3. Ms. Jyoti Arora, JS (Trans.), Ministry of Power
4. Sh. TarunKapoor, JS, MNRE
5. Ms. Varsha Joshi, JS, MNRE
6. Sh. J. K. Jethani, Sc 'D'.MNRE
7. Ms. ShubhaSarma, Secretary, CERC
8. Sh. A.K. Saxena, Chief (Engg.), CERC
9. Ms. AnjuliChandra,CE, DPM&RE, CEA
10. Sh. PankajBatra, Chief Engineer (RA), CEA
11. Sh. K. K. Arya, CE, CEA
12. Sh. T. K. Barai, Member(Th), CEA
13. Sh. S.K. Soonee, CEO, POSOCO
14. Sh. V.K. Agrawal, ED, NLDC, POSOCO
15. Sh. S.R Narasimhan, Addl. GM, NLDC, POSOCO
16. Sh. S. C. Saxena, Asstt. GM, POSOCO.
17. Ms. Seema Gupta, COO, (CTU-Plng), PGCIL
18. Sh. R. P. Barwar, Director (Operation), RVPNL
19. Sh .Kiran. V., Mytrah
20. Sh.Kiran Nair, Mytrah
21. Sh. Kishor Nair, Welspun
22. Sh. Rajsekhar.B, IL&FS Energy
23. Sh. Shiv Nimbargi, CEO, SEMBCORP GREEN / NFRA
24. Sh. P. Rajagunanidhi, Ex-Engineer, Grid Tantranco, Chennai
25. Sh. P. R. Muralidharan, EE, Wind Power Projects, TANGEDCO , Chennai
26. Sh. K. R. Nair, Indin Wind Power Association
27. Sh. Prabhat Mishra, Renew Power Ventures
28. Sh. Ravi Arora, Sembcorp Green Intra
29. Sh. A. S. Upadhyay, Advisor, TT/M, Ministry of Railway
30. Sh. S. K. Negi, GETCO
31. Sh. MileshGogad, GE
32. Sh. A.K Arya, SE, RVPNL, Jaipur
33. Sh. P. S. Ahluwalia,Greenko Energies
34. Sh. Mahesh Vipradas,Sr. GM, Suzlon Ltd.
35. Sh. K. Boopathi, Scientist, NIWE
36. Dr.S. Gomathinayagam, DG, NIWE
37. Sh. M. Ganesan,IWPA
38. Dr. K. Balaraman, PRDC,Banglore
39. Sh. H.R. Venkatesh, PRDC,Banglore
40. Sh. J. Hammer, VESTAS
41. Dr. Rajiv Mishra, PTC India
42. Sh. O. P. Taneja, IWTMA
43. Sh. A. Tamboli,Wespum Renewed
44. Sh. Amar Variawa, Vestas Wind IndiaLtd.

Large Scale Integration of Renewables, Need for Balancing, Deviation Settlement Mechanism (DSM) particularly the 150 MW Limit and Regional Grids

19th June, 2015

Ministry of Power

1

Presentation Outline

- Context
- Need for Frequency Control
- Handling Deviations
- Balancing of Renewables
- Way Forward

2

Context

- **Deviation or Imbalance handling mechanism**
  - Essential pillar for large grids & applicable to all entities
    - States (load serving entities)
    - Generation – conventional as well as renewable generation
  - Deviation Rates
    - Introduced by CERC with ABT mechanism in 2000
    - Deviation price vector specified by CERC at the inter-state level
- **Integration of Renewables**
  - Mechanism to facilitate integration of RE and to handle imbalances introduced by CERC as "RRF Mechanism" in 2010 (IEGC 2010 Regulation 6.5.23)
  - Jurisdiction issues raised by intra-state RE generators and implementation difficulties led to suspension of commercial part of RRF Mechanism in 2014 by CERC
  - Draft Framework for Forecasting, Scheduling and Imbalance Handling for Renewable Generating Stations issued by CERC on on 31st March 2015

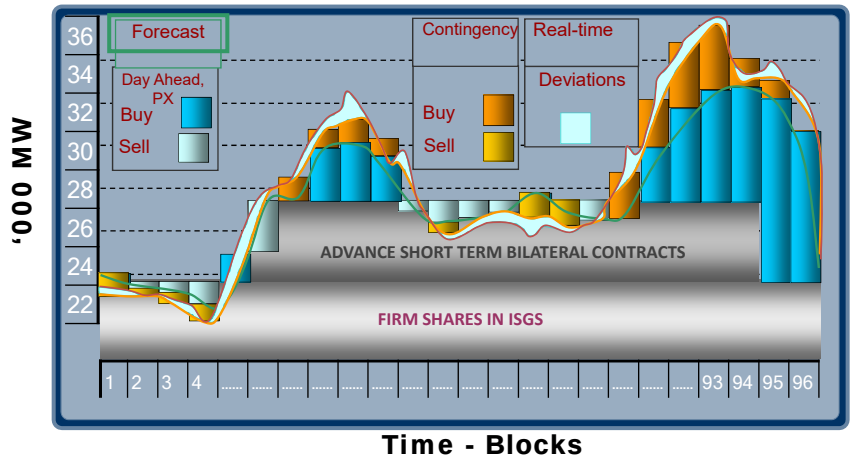
3

Actions Already Initiated

- **Power Minister's Conference**
  - Held at Guwahati on 9th April 2015
- **Committee constituted by Ministry of Power on Large Scale Integration of Renewables, Balancing and Deviation Settlement Mechanism (DSM)**
  - Four Meetings held (27th April, 9th May, 13th May, 27th May)
  - Interaction with Stakeholders including States, RE Generators, CEA, CTU, generating stations, system operators
  - Report under finalization
- **Renewable Energy Management Centers (REMCs)**
  - Initiatives for implementation taken by Ministry of Power
  - GIZ appointed as Consultant, Report under finalization
- **Draft Regulations floated by CERC**
  - Framework for Forecasting, Scheduling and Imbalance Handling for Renewable Generating Stations on 31st March 2015
  - Ancillary Services Operations Regulations on 1st May 2015
  - Public Hearing on both Regulations held on 12th June 2015
  - Final Regulations to be notified by CERC shortly

4

A Typical Despatch



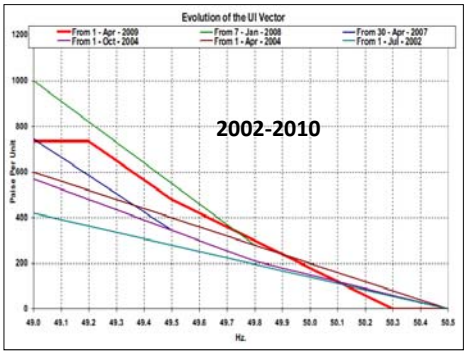
Coordinated Multilateral Model in India

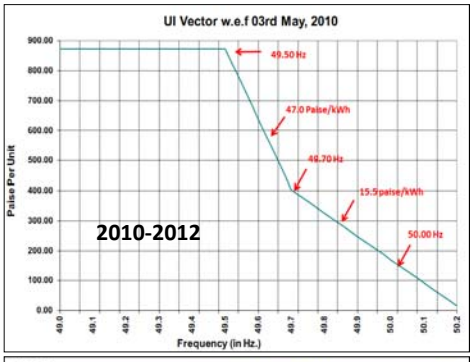
Balancing Supply and Demand

Handling Surplus and Deficit

5

Evolution of Deviation Handling Mechanism in India

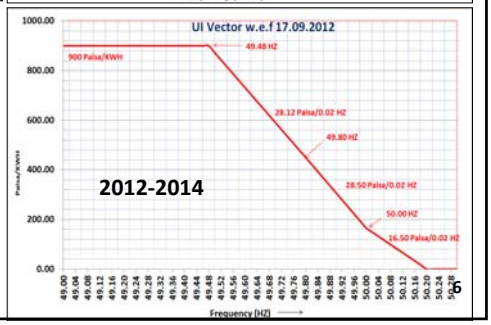




Imbalance / Deviation Mechanism

-Specified by CERC at inter-state level

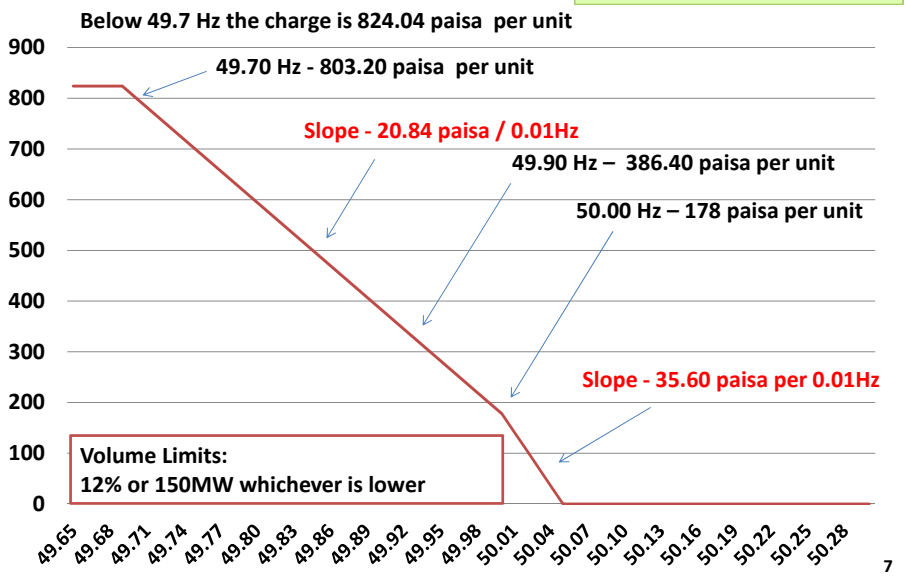
-Period review of the Deviation Price



6

Deviation Rate Vector w.e.f 17th February, 2014

IEGC Band: 49.90 – 50.05 HZ



7

Volume Limits under DSM Regulations

"…7. Limits on Deviation volume and consequences of crossing limits

(1) *The over-drawals / under drawals of electricity by any buyer during a time block shall not exceed 12% of its scheduled drawal or 150 MW, whichever is lower, when grid frequency is „49.70‟Hz and above" Provided that no overdrawal of electricity by any buyer shall be permissible when grid frequency is "below 49.70 Hz"….*

(2) *The under-injection / over-injection of electricity by a seller during a time-block shall not exceed 12% of the scheduled injection of such seller or 150 MW, whichever is lower when frequency is „„49.70 Hz and above‟ Provided that – (i) no under injection of electricity by a seller shall be permissible when grid frequency is "below 49.70 Hz" and no over injection of electricity by a seller shall be permissible when grid frequency is "50.10 Hz and above". …"*

8

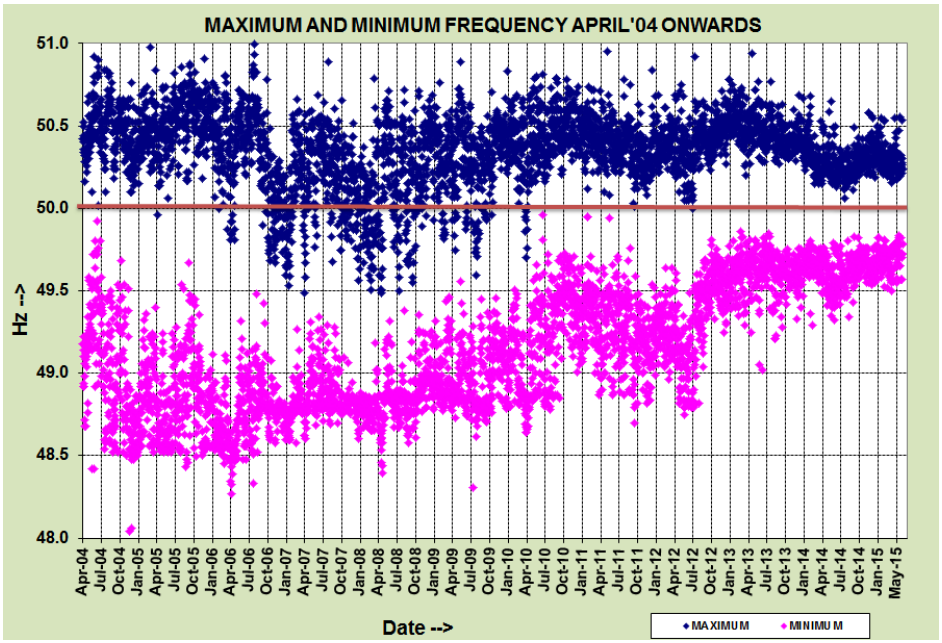
Stakeholder concerns

- **States**
  - 150 MW volume limit on deviation
  - Same limits for large and small states
  - Variability of Renewables, balancing issues
- **RE Generators**
  - Curtailment by SLDCs because of inability to absorb large quantities of RE
  - Evacuation issues
  - Forecasting and scheduling

9

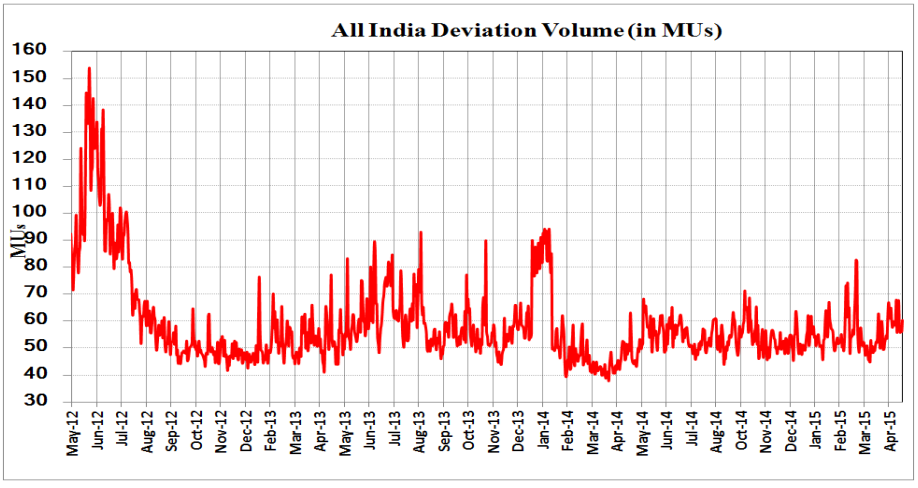
Need for Frequency Control

10



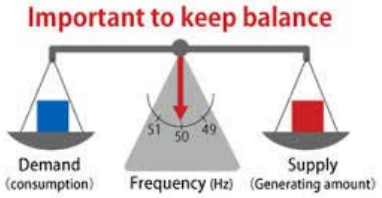
11

All India Deviation Volume



- Utilities procuring power through Bilateral and Power Exchanges
- Scheduled interchange of power is taking place

12



Frequency Fluctuations

- Frequency - Manifestation of load-generation balance
  - Low Freq: Load > generation
  - High Freq: Load < generation
- Need to balance generation and demand over all time frames.

Need for Frequency Control

Grid Security:
System frequency - Health of the system.
Increased Vulnerability

Voltage fluctuations

Uncontrolled Transmission Flows

Equipment Safety
Designed for operation within a frequency band.
Especially generation turbines.

13

International Experience

Country	Nominal Frequency (Hz)	Permissible Frequency Band (Hz)	Permissible Deviation (%)
Eastern Interconnection (USA)	60	59.95 - 60.05	± 0.083 %
Western Interconnection (USA)	60	59.856 - 60.144	± 0.24 %
Nordic Countries (Europe)	50	49.90 - 50.10	± 0.2 %
India	50	49.90 - 50.05	(-) 0.2 / (+) 0.1 %

Provisions at par with international standards regarding operational frequency band

14

Handling Deviations

15

CERC DSM Regulations 2014

- **Limits as per DSM Regulations**
  - 12% or 150 MW whichever is lower
- **Concerns of smaller states addressed**
  - CERC order (Petition No. RP/06/2014 dtd. 20th Jan. 2015)
  - Relaxation to all the sellers/buyers whose schedule is less than 400 MW
  - Deviation limit of 48 MW across the board
- **Large states/renewable rich states continue to raise concerns about 150 MW limit**

16

Control Areas & Deviations

- **Each state, a "control area", mandated to**
  - Forecast Load
  - Forecast RE
  - Balance its load and generation including import from grid
- **Deviation = Actual - Schedule**
- **Reasons for Deviations**
  - Variation in actual demand
  - Variation in Generation availability
  - Variability of RE Generation

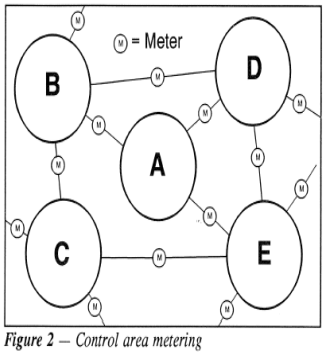
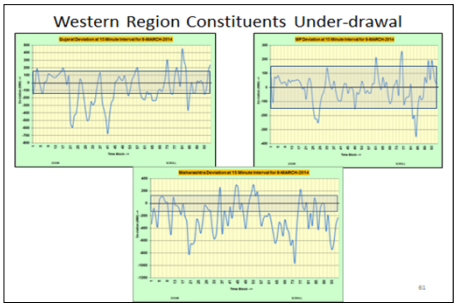


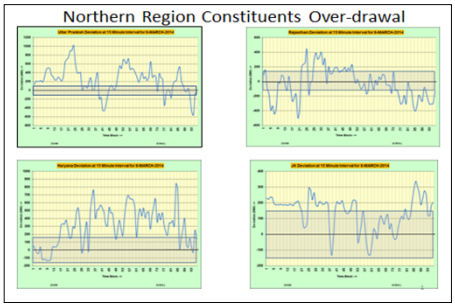
Figure 2 — Control area metering

Control Area Bounded by Meters

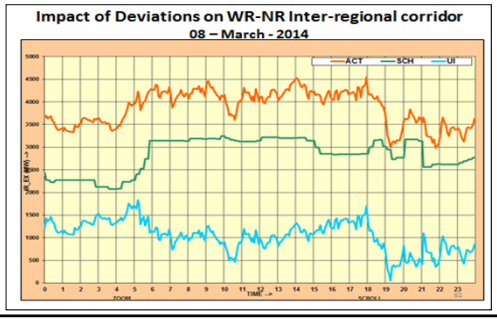
17

Extreme Scenario – All erring in one direction





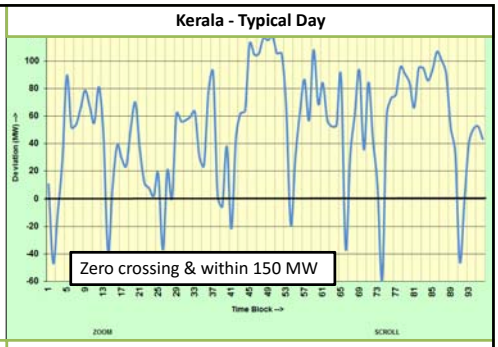
Skewed scenario stressed the IR tie lines flows leading to critical levels.

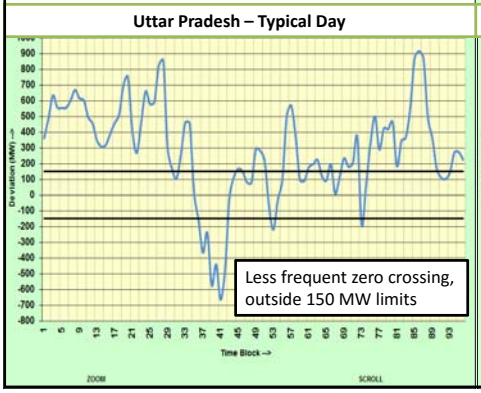


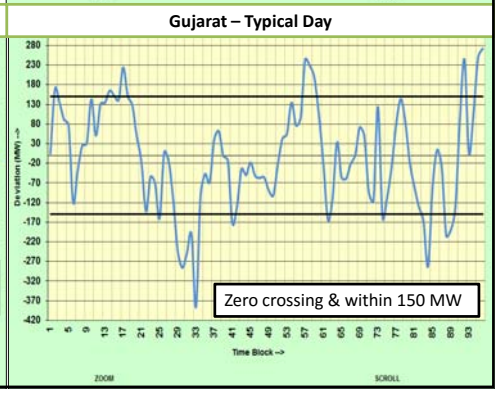
If utilities resort to persistent over-drawal / under-drawal, there is a threat of grid disturbance.

18

Zero Crossing in 3 Hours (12 time blocks) is essential







Provisions in FERC Order 890 (USA) regarding imbalances

- "imbalances of less than or equal to 1.5% of scheduled energy, or up to 2 MW be netted monthly and settled ……
- Imbalances of between 1.5% and 7.5% of scheduled energy, or between 2 and 10 MW (whichever is larger), are settled at 90% of decremental costs and 110% of incremental costs.
- Imbalances greater than 7.5% (or 10 megawatts, whichever is larger) would be settled …… Intermittent resources, however, would be settled at 90% of decremental costs and 110% of incremental costs for imbalances greater than 7.5% or 10 megawatts."

20

Why Limits on Deviation

- Large deviations cause severe transmission constraints
- Endangers Grid Security
  - To control large deviations during contingency is difficult
- Manual action takes time to control drawal from grid and puts the grid to risk in case of contingencies.
- Volume limits incentivize stakeholders for implementing better controls
  - Load forecasting in all time horizons,
  - Frequency control through primary control (FGMO), Secondary control (AGC) and Tertiary controls.
  - Reserves

21

Effect of Deviation on Transmission Reliability Margin

- Reliability margins essential for secure operation
  - Transmission outages
  - Unit trippings
  - Deviations
- Skewed scenarios
  - All constituents erring on the same side
  - Example: Say 6 out of 9 Constituents of NR overdrawing by 150 MW each, hence total deviation 900 MW
- TRM also a deciding factor for open access

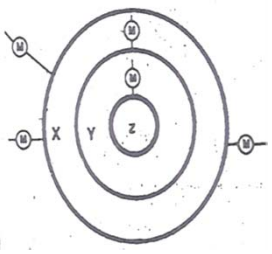
22

Balancing of RE

23

Balancing of RE & Size of Balancing Area

- **Balancing over larger area**
  - States already revising the schedules from ISGS, which are located over a larger balancing area
  - Revisions being done at 1 hour notice
  - Revisions within and across the regions (about 20-25 revisions daily)
- **Need for Real time markets**
  - More closer time frame
  - Multiple iterations
- **Other measures**
  - Enhance the flexibility of conventional generation (e.g. gas turbines, pumped storage, hydro etc.)
- **Ancillary Services**
- **Size of the balancing area**
  - Need for robust imbalance settlement mechanism



24

Ancillary Services in India

- **Ancillary Services – Fourth Essential Pillar**
  - System Support & Reliability
  - Facilitates Renewable Integration
- **First Time in Indian Electricity Market**
  - Harnessing Unrequisitioned Surplus in ISGS
  - Addressing Congestion Management Issues
  - More Economy & Efficiency in Grid Management
- **Facilitate optimization at Regional & National Level**
- **CERC Draft Regulations 1st May 2015**
  - Public Hearing 12th June 2015

25

Provisions for Reserves

- National Electricity Policy 2005
  - 5 % Spinning Reserves at National Level
- Draft Electricity (Amendment) Bill, 2014
- MOP Committee on Large Scale Integration of Renewables, Balancing and DSM
- CERC Committee for formulating Regulations on Reserves (3rd June 2015)

26

Way Forward

27

Way Forward (1 of 2)

Sr. No.	Required Action	Action By
1	Load Forecasting as per IEGC Section 5.3	States
2	Demonstration of Adequacy of Balanced Portfolio	States / SLDCs
3	Regulatory Framework for Intra-State Settlement System and Imbalance Handling Mechanism *(already implemented at inter-state level)*	SERCs / SLDCs (So far implemented in 5 states only)
4	Regulatory Framework for Forecasting of Renewable Generation and Scheduling and Implementation at ***inter-state level*** (Draft CERC regulations under process)	CERC, NLDC, RLDCs, RE Generators, REMC
5	Regulatory Framework for Forecasting of Renewable Generation and Scheduling including Aggregators (or Qualified Scheduling Entities) and Implementation at ***intra-state level,***	SERCs / FOR / MNRE, SLDCs, RE Generator REMCs
6	Regulatory Framework for Reserves	CERC, SERCs
7	Regulatory Framework for Ancillary Services Operation, Implementation of Ancillary Services	CERC NLDC, RLDCs, RPCs

28

Way Forward (2 of 2)

Sr. No.	Required Action	Action By
8	Implementation of Frequency Response (Primary Response)	All Generators
9	Regulatory Framework for Secondary Response (AGC)	CERC, SERCs
10	Technical Standards and Protection Requirements for Renewables such as LVRT, FRT, etc.	CEA, CTU, STUs, RE Generators
11	Market Design – Frequent clearing, more opportunities, New entities (Aggregators)	CERC
12	Regulatory Framework for Communication in Power Sector, Availability of Real Time Data at the SLDCs/RLDCs/NLDC	CERC, RE Generators, SLDCs, RLDCs, NLDC
13	Implementation of Renewable Energy Management Centers (REMCs)	CTU, STU, SLDCs, RLDCs, NLDC
14	Standards and Regulatory Framework for introducing “Flexibility” in Generation	CEA, CERC

29

Thank You

30

Annex – III

Action Plan

Sr. No.	Required Action	Action By	Time Line
1	Load Forecasting as per IEGC Section 5.3	All States	3 months
2	Demonstration of Adequacy of Balanced Portfolio	All States / SLDCs	
3	Regulatory Framework for Intra-State Settlement System and Imbalance Handling Mechanism *(already implemented at inter-state level in 5 states)*	FOR / SERCs / SLDCs	2 months
4	Regulatory Framework for Forecasting of Renewable Generation and Scheduling and Implementation at ***inter-state level***	CERC, NLDC, RLDCs, RE Generators, REMC	1 month
5	Regulatory Framework for Forecasting of Renewable Generation and Scheduling including Aggregators and Implementation at ***intra-state level***	SERCs / FOR / MNRE, SLDCs, REGenerator, REMCs	2 months
6	Regulatory Framework for Reserves	CERC, SERCs	3 months
7	Regulatory Framework for Ancillary Services Operation, Implementation of Ancillary Services	CERC, RPCs, NLDC, RLDCs	2 months
8	Implementation of Frequency Response (Primary Response).	CERC All Generators	1 month
9	Regulatory Framework for Secondary Response (AGC)	CERC, SERCs	6 months
10	Technical Standards and Protection Requirements for Renewables such as LVRT, FRT, etc. & implementation	CEA, CTU, STUs, RE Generators	2 months
11	Market Design – Frequent clearing, more opportunities, New entities (Aggregators)	MNRE, CERC	2 months
12	Regulatory Framework for Communication in Power Sector, Availability of Real Time Data at the SLDCs/RLDCs/NLDC particularly of RE generators	CERC, RE Generators,SLDCs, RLDCs, NLDC	3 months
13	Implementation of Renewable Energy Management Centers (REMCs)	CTU, STU, SLDCs, RLDCs, NLDC	12 months
14	Standards and Regulatory Framework for incentivizing “Flexibility” in Conventional Generation	CEA, CERC	6 months
15	Capacity Building of SLDCs particularly in RE Rich States	FOLD, POSOCO, States	3 months

Record of discussion of the Fifth Meeting of Technical Committee on Large Scale Integration of Renewable Energy, Need for Balancing, Deviation Settlement Mechanism (DSM) and associated issues held on 18th September, 2015 at CEA, New Delhi

The list of participants is enclosed at Annex-I.

Ms. Varsha Joshi, Joint Secretary (JS), MNRE chaired the meeting. Sh. Ghanshyam Prasad, Director-OM, MoP recapitulated the work done by the Technical Committee and requested POSOCO to make a presentation on the draft report which was circulated by Ministry of Power on 04th September, 2015 to all the members.

ED, NLDC gave a brief presentation on the draft report covering constitution of the Technical Committee, Terms of Reference along with meetings and action points. The various issues highlighted in the report are Spinning Reserves, Ancillary Services, Load Forecasting and Generation Despatch, Imbalance Handling and Settlement, Frequency Control, Flexible Generation, Market Design Enhancements, Transmission Augmentation and Renewable Energy Management Centres (REMCs). He also discussed about the recommendations of the Technical Committee under various areas such as:

a) Framework for Forecasting of load and RE generation, Scheduling, Monitoring and Imbalance Handling of RE generators
b) Need for Reserves and Flexibility of resources to balance variability of load and RE generation
c) Ancillary Services Framework
d) Availability of Real Time Data at SLDCs/RLDCs/NLDC
e) Standards and Protection Requirements
f) Renewable Energy Management Centres (REMCs)

JS, MNRE stated that Indian Space Research Organization (ISRO) may also be involved in obtaining weather data and forecasting. She mentioned that India Meteorological Department (IMD) may not have enough data and therefore, it may be better to take data from ISRO. She also mentioned that Hon'ble MoS (P) also opined the same in a recent conference.

Director-OM, MOP informed that during recently conducted meeting of JCC (Joint coordination committee between MOP & MNRE), it was decided that technical specifications for REMC shall be prepared by POSOCO in consultation with PGCIL and the States.

JS, MNRE informed that GIZ has been asked to prepare State-specific detailed technical specifications for REMC, in addition to the draft generalized technical specification that has been submitted by GIZ. In this regard, it was suggested that POSOCO may take forward the detailed specification prepared by GIZ and improve upon & implement the same.

On the issue of volume limits of deviation, under Deviation Settlement Mechanism (DSM), JS, MNRE emphasized that it is imperative that states first implement intra-state DSM and then, may seek review of deviation volume limits.

With reference to the recommendations in regard to forecasting, it was suggested that RE rich states may do area/zone-wise forecasting of RE generation and aggregate the same and forward to the respective Regional Load Despatch Centres (RLDCs). The representative from Gujarat mentioned that, based on their experience so far, RE generation forecasting may be specified to be state-wise rather than area/zone wise.

In this regard, JS, MNRE advised Gujarat to consult the agencies involved in forecasting in Tamil Nadu, as it was learnt that are getting very good results. She further mentioned that till appropriate regulations and systems are notified, there may be some mechanism to address the deviation of RE generation with respect to forecast/schedule. Adviser – RE, CERC emphasized that dormant pumped storage plants may be revived and made operational at the earliest.

It was suggested that action plan for intermediate stage shall be mentioned, apart from final deliverables. Ms. Anjuli Chandra, CE, CEA suggested that recommendations regarding voltage control may also be included. It was suggested that weather related data also to be sent by RE Generators along with other data. CEA suggested that CTU/STU may ensure compliance of standards.

The meeting ended with a vote of thanks to the Chair.

Annex – I

MNRE

1. Ms. Varsha Joshi, Joint Secretary
2. Ms. Veena Sinha, Director

MOP

3. Sh. Ghanshyam Prasad, Director-OM

CTU (PGCIL)

4. Ms. Seema Gupta, COO

CERC

5. Ms. Shruti M. Deorah, Adviser-RE

CEA

6. Sh. J. Bandhopadhyay, Chief Engineer – IRP
7. Sh. Dinesh Chandra, Chief Engineer – GM
8. Ms. Anjuli Chadra, Chief Engineer – RESD
9. Sh. V. Menghani, Director
10. Sh. P. Esther Kamala, Dy. Director
11. Sh. Sanatan Sarvesh, Asst. Director
12. Sh. Himanshu Upadhyay, Asst. Director

Gujarat

13. Sh. B.B. Mehta, Chief Engineer, Gujarat-SLDC

Rajasthan

14. Sh. AK Arya, Executive Engineer, Rajasthan-SLDC
15. Sh. Arvind Agarwal, Executive Engineer, RVPN

POSOCO

16. Sh. K.V.S. Baba, Executive Director, NRLDC-NLDC
17. Sh. S.R. Narasimhan, Addl. General Manager(SO), NLDC

Record of discussion of the Sixth Meeting of Technical Committee on Large Scale Integration of Renewable Energy, Need for Balancing, Deviation Settlement Mechanism (DSM) and associated issues held on 16th October, 2015 at NPMC Conference Room, Ministry of Power, New Delhi

The list of participants is enclosed at Annex-I.

Sh. Major Singh, Chairperson, CEA chaired the meeting. Sh. Ghanshyam Prasad, Director-OM, MoP recapitulated the work done by the Technical Committee and requested POSOCO to explain the salient features and recommendations of the draft report which was circulated by Ministry of Power on 12th October, 2015 to all the members.

The representative of POSOCO gave a brief overview of the draft report covering the recommendations of the Technical Committee under various areas such as:

a) Framework for Forecasting of load and RE generation, Scheduling, Monitoring and Imbalance Handling of RE generators
b) Need for Reserves and Flexibility of resources to balance variability of load and RE generation
c) Ancillary Services Framework
d) Availability of Real Time Data at SLDCs/RLDCs/NLDC
e) Standards and Protection Requirements
f) Renewable Energy Management Centres (REMCs)

It was mentioned that the comments of CTU, CEA and Gujarat were received. However, only CTU comments could be incorporated as the comments of CEA and Gujarat Utility were received only few days back.

JS, MOP enquired about the status of inter-state and intra-state RE regulatory framework. It was mentioned that CERC has introduced a regulatory framework for RE generators connected at the inter-state level through amendments in the Indian Electricity Grid Code (IEGC) and the Deviation Settlement Mechanism (DSM) Regulations on 7th Aug 2015. These amendments come into effect from 1st November 2015 and the RE generators connected at the inter-state level would become responsible for forecasting, scheduling and settlement of deviations from the schedule.

Adviser-RE, CERC mentioned that the Forum of Regulators (FOR) deliberated the framework proposed for wind and solar projects at the intra-State level. The Forum, further directed the FOR Secretariat to evolve draft Model Regulations related to implementation of the framework by SERCs / JERCs, based on the broad principles as presented by CERC. The Model Regulations, as approved by Chair, FOR are under finalization by the FOR Secretariat and would be circulated to the States for consideration/adoption.

JS, MNRE mentioned that cabinet note for DISCOMs package is under process and therefore, intra-state RE framework may be made mandatory in order to avail the special provisions in the package. Adviser-RE, CERC mentioned that CERC may issue an advisory to the Ministry of Power and, through Forum of Regulators, to all the states. She also mentioned that incentives maybe given to state utilities for handling deviations due to RE generation. JS,

MOP observed that finance is available only from Power system Development Fund (PSDF) , which was however, limited in nature.

JS(JA) mentioned that in order to maintain grid discipline, RE framework may be made mandatory for all the states by 01st April, 2016. It was also decided that an advisory from the Ministry of Power would be issued to all the states to have intra-state RE framework by 01st April, 2016.

CE(GM), CEA suggested that definition of "RE-rich" state may be clarified in the report as the state with 20 % or more RE capacity of the entire installed generation capacity. JS, MNRE suggested the removal of "RE-rich" term and wanted RE framework in all the states irrespective of RE penetration. Adviser-RE, CERC also supported the suggestion of JS, MNRE. It was decided that the term "RE-rich" would be removed and all the states would be mandated to put in place proper RE framework irrespective of RE penetration. It was also decided that FOR would issue the Model RE framework regulations by end of October, 2015.

The representative of POSOCO mentioned that CERC, vide order in the suo-motu petition No. 11/SM/2015 dated 13th October, 2015 has issued the roadmap to operationalize reserves in the country. Also, in this direction, Draft Central Electricity Regulatory Commission (Indian Electricity Grid Code) (Fourth Amendment) Regulations, 2015 had been notified on 02nd July, 2015 which laid out provisions for Technical Minimum Schedule for operation of Generating Stations. A public hearing was held on 19th August, 2015. Further, POSOCO vide Communication dated 17th Sept., 2015 to Secretary, CERC & Secretary, CEA provided Detailed Report on Regulations and Standards in respect of 'flexibility' of generating units to accommodate higher penetration of Renewable Energy (RE) sources.

Adviser-RE, CERC mentioned that the IEGC amendments are expected to be notified soon by CERC. It was decided that CERC may endeavor to issue the amendments before the end of October, 2015. She also mentioned that Regulatory framework is being evolved for identification and utilizing of spinning reserves and implemented with effect from 1st April, 2016 till 31st March, 2017. In the long term, a market based framework may be evolved for efficient provision of secondary reserves from all generators across the country.

JS, MOP, mentioned that CEA should compute the financial implication for provision of reserves through automated control and necessary software & communication requirements. The representative of CEA informed that CEA Construction Standards are in the process of revision including flexibility requirements. JS, MNRE highlighted the need for having proper compliance framework. Adviser-RE, CERC clarified that irrespective of renewables, secondary control through AGC may be mandated to all generators.

JS, MOP enquired about the progress of Ancillary Services Operations. The representative of POSOCO informed that the final CERC Regulations on Ancillary Services Operations, 2015 haves been notified on 19th August 2015. The draft Detailed Procedure for Ancillary Services Operations has been floated by the Nodal Agency (NLDC) for stakeholder consultations on 29th September, 2015. After incorporating suggestions, it will be placed before CERC for approval. It was mentioned that the Ancillary Services are expected to be operationalized by 31st December, 2015.

On the issue of volume limits of deviation raised by some states having large penetration of RE, Adviser-RE, CERC mentioned that CERC DSM regulations are under discussion and review.

With reference to the recommendations in regard to communication framework, it was informed that CERC had constituted a Task Force, in April, 2015, for inputs to frame the draft Regulations for communication systems in power sector. As it was close to 6 months since formation, CERC was asked to expedite the Task Force report submission by the end of October, 2015.

Regarding Standards and Protection Requirements, it was decided that a system for compliance monitoring of the same may be put in place by the Appropriate Commission at the state level.

On the issue of REMCs, JS, MNRE informed that GIZ has been asked to prepare State-specific detailed technical specifications for REMC, in addition to the draft generalized technical specification that has been submitted by GIZ. In this regard, COO(CTU) informed that the consultant had completed the survey and starting from October, 2015 end, they will provide the state-wise DPRs to PGCIL in a progressive manner after the approval of the respective states. JS, MOP asked POSOCO to request the NREL team for their observations on the DPR for REMCs on which comments have been invited by MNRE..

The representatives from West Bengal and Tamil Nadu informed that they would provide written comments on the draft report. JS, MOP informed that Power Ministers conference is scheduled on 05th & 06th Nov., 2015 and therefore, the final report for approval may be submitted to the MOP at the earliest. She also desired that status report on the action points may also be given along with responsible agencies and deadlines.

The meeting ended with a vote of thanks to the Chair.

Annex – I

MOP

1. Ms. Jyoti Arora, Joint Secretary
2. Sh. Ghanshyam Prasad, Director-OM

MNRE

3. Ms. Varsha Joshi, Joint Secretary

CTU (PGCIL)

4. Ms. Seema Gupta, COO

CERC

5. Ms. Shruti M. Deorah, Adviser-RE

CEA

6. Sh. Major Singh, chairperson, CEA
7. Sh. Dinesh Chandra, Chief Engineer – GM
8. Ms. Anjuli Chadra, Chief Engineer – Renewables
9. Sh. Praveen Gupta, Director,C&E

Representatives from Tamil Nadu and West Bengal

POSOCO

10. Sh. S.C. Saxena, Asst. GM
11. Sh. K.V.N. Pawan Kumar, Sr. Engr.

Annexure - IX

Forecasting and Scheduling of Renewable Energy (RE) and Load in India

Contents

1. Introduction

World over, the penetration of renewable energy generation has grown manifold in the last decade. In India also there have been a lot of policy and regulatory initiatives with an aim to facilitate promotion of renewable energy sources. As on 31st Mar 2015, the total installed capacity of renewable generation is 35777 MW [1]. Out of which Wind energy contributes 23444 MW and solar generation includes 3744 MW.

Presently, most of the renewable generation is concentrated in few states and are connected to sub-transmission level within the States. Recently, Government of India has announced the enhanced the target of solar from 20,000 MW to 1,00,000 MW by 2022 and wind to 60,000 MW [2]. RE generation depends on parameters such as wind velocity, sunshine etc. Integrating large quantum of renewable generation into grid gives rise to a number of challenges into the power system from generation to transmission to distribution to deal with increased variability and uncertainty in power system operation. As the level of renewable energy sources increases, forecasting and scheduling will play an increasingly important role in the operation of power systems. The variability of renewables can be dealt through improved forecasting techniques. When the percentage of RES becomes significant, their output generation needs to be forecasted accurately.

The purpose of this document is to discuss about the forecasting and scheduling of load and Renewables followed in short-term upto two weeks.

2. Need for Forecasting

The electricity grid is the most complex man-made system in the world. Electricity generated has to be consumed immediately and it cannot be stored in huge quantities. Generation and demand always has to be balanced to maintain the system secure. Forecasting plays a necessary and important function in all segments of power industry i.e., generation, transmission and distribution. Forecasting in power system can be divided into two categories

- Load Forecasting
- Renewable Energy Forecasting
    a. Wind Forecasting
    b. Solar Forecasting

The figure below gives the use and value of forecasting.

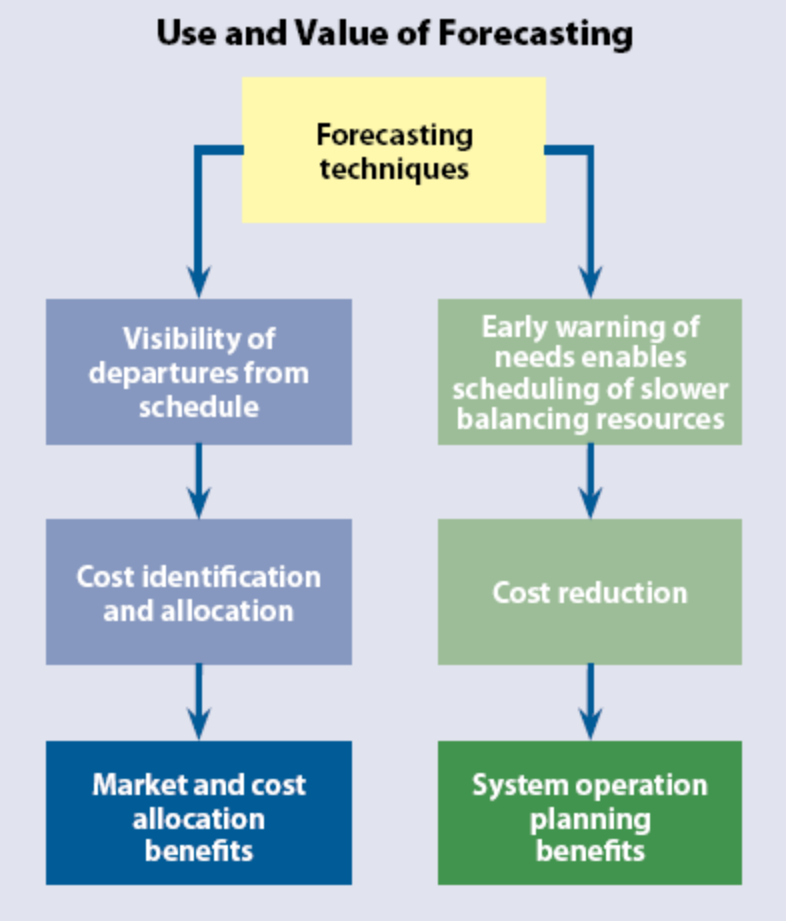


Figure-1: Use & Value of Forecasting [3]

3. Load Forecasting

Load Forecasting forms the basis for planning the power system for future and gives the information about anticipated load growth, load profiles and load distribution. Depending on the forecasting horizon, Load forecasting is classified into three different categories:

- Long Term load forecasting (above 3 years ahead forecasting)
- Medium term load forecasting (2 weeks – 3 years forecasting)
- Short term load forecasting (1 day – 2 weeks forecasting)

3.1. Need for load forecasting in power system

- Load is influenced by temperature, overall weather, dew, festivals, rainfall, hailstorms etc.
- Load changes all the time and daily load curve is a well-known pattern (Morning Peak, Evening Peak and less demand in the Mid-night)
- Load curves follow similar trends daily, weekly, on weekends, during special days.
- Long term load forecasts help in Generation and Transmission expansion planning.
- Medium term load forecasts helps in preparing the generation outage plan
- Short term load forecast also helps in solving the complex unit commitment problem and economic load dispatch problem.
- Having the day ahead load forecast results in a better scheduling of the generators and optimal use of Hydro and costly gas generation.
- Small area load forecasts help support distribution system planning.
- Absence of short term load forecast during special days like Diwali, Holi, and Independence Day etc. can be detrimental to the power system, if the resources are not kept ready to handle the event such as load crash / load peaking.

3.2. Load forecasting techniques

Different methodologies and techniques are used for load forecasting in power system [4]-[8]. These techniques are broadly classified in to following categories:

- Multiple Regression

- Exponential smoothing
- Iterative weighted least squares
- Adaptive load forecasting
- Stochastic time series
- ARMAX models based on genetic algorithms
- Fuzzy logic
- Neural networks
- Expert systems

3.3. Load Forecasting in India

- Load forecasting in India is presently being done for assessing the generation backing down requirements and ramp rate requirements etc. for special events such as Holi, Independence Day, and Diwali etc. The demand forecasts carried out by RLDCs/NLDC for such special days are based on the past generation & demand data available for the previous years and the weather forecasts given by the Indian Meteorological Department (IMD) for that particular day. These types of forecasts are extensively used in the power system operation.

- Load Despatch Centres have a system of displaying the previous day's load curve and the current day on the same graph; so some sort of similar day forecast is available to the operator.

- **Now cast (3 to 4 hours ahead):** Now casting is very important for grid operators and is done at an interval of 10-15 minutes. Here the automatic meteorological data acquisition plays a crucial role. These techniques are localized in nature to provide accurate information for real time operation.

- A pilot project has been initiated in Western Region where DISCOMs of State are involved with the development of Forecasting tool with Forecast Service Provider (FSP). The FSP will provide Short-term forecast i.e. same day forecast (Real Time), Day ahead forecast and weekly forecast for DISCOMs.

- Report on “Methods of forecasting demand for electricity” by Working Group-03 of Study Committee 37 (Power System Planning and Development), CIGRE 1987 enclosed at Annex-I gives the details about methods followed for forecasting demand by various countries.

- The report enclosed at Annex-II gives the “Impact of Republic day (26th Jan’15) on *Demand and Energy Consumption region-by-Region and at National level”.*

3.4. Ramp Forecasting

This helps in optimal scheduling of Hydro and Gas in meeting load ramp requirement. Generally, it is observed that there is highest ramp rate approx. fifteen minutes after sunset. The figure given below shows the variability of All India Demand based on the 15 minutes for last seven years.

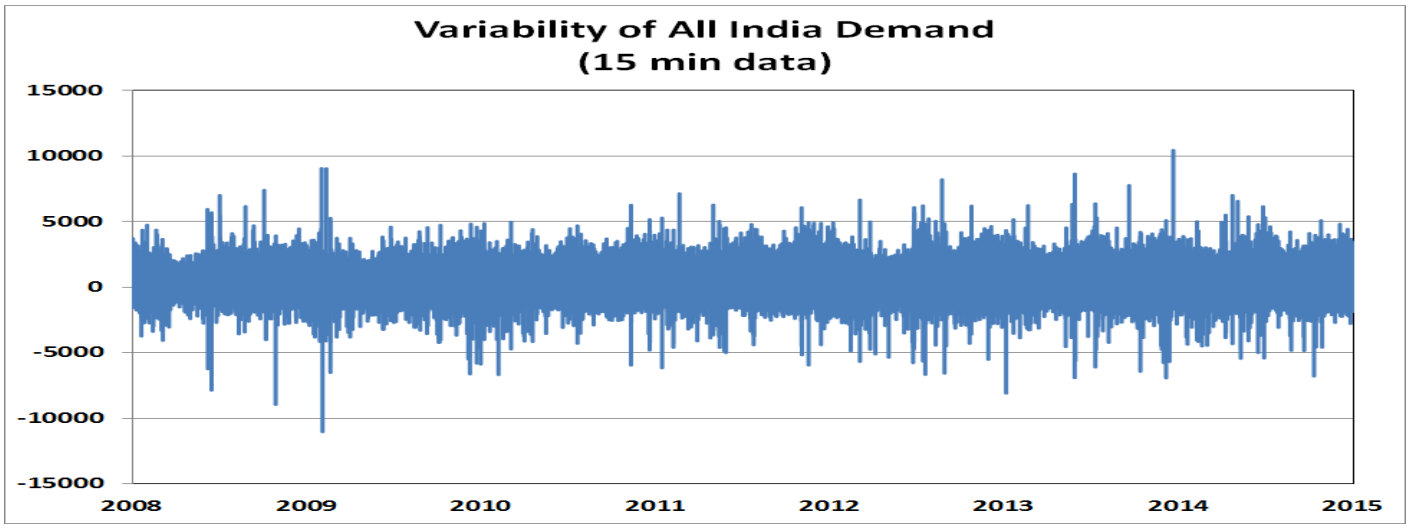


Figure-2: Variability of All India Demand

4. Renewable Energy Sources Forecasting

Renewable Energy sources forecasting plays a vital role in power system operation and planning due to its variability, intermittency and also dependency on large number of parameters such as wind speed, Insolation, humidity, clouds, sun's trajectory etc. Too high renewable forecasts results in under-scheduling of conventional generators and too low renewable forecasts results in Over-scheduling of conventional generators. Accurate forecasts help both in the system planning as well as in the system operation for taking decisions, while the inaccurate forecasts can lead to failure of equipments or even system-wide blackout. The forecasting of wind energy and solar energy requires different sets of parameters and are done separately.

Forecasting can be done in a centralised way or in a decentralised way. Centralised Forecast will give a very broad prospective, because of its huge diversity of terrain & climate. The term centralised needs to be defined, whether it is State wise or Region wise.

A. Basic requirements

- Meteorological information (wind speed, direction, temp, pressure, humidity)
- Power output of each turbine/ pooling station(Depending upon algorithm used)
- Wind turbine outage/availability information
- Plant curtailment information (including deployment instructions in MW and/or estimated MW output available if a current curtailment is lifted).

By perfect weather mapping from all the locations not only the RE can be forecasted, Load forecasting can also be linked.

B. Challenges in Forecasting:

- Data availability
- SCADA and weather till each wind turbine level
- Historical data of the above to train system
- Consistency of data

- Time taken to forecast
- Bigger the region, higher the time taken
- Mapping of transmission constraints from the forecasted wind model

C. Use of Forecasting in System Planning

Transmission Planner can develop the transmission system as per the forecast to evacuate the renewables generation without any system constraints. In case of India, 'Green Energy Corridors' report by Central Transmission Utility (CTU) gives the details about the anticipated renewables sources going to be added to grid Further, it also describes about the transmission system required for evacuating large scale integration of renewables.

D. Use of Forecasting in System Operation

- Determines the required generation dispatch
- Determines reserve capacity requirements
- Ancillary services requirement

4.1. Wind Forecasting

Different types of wind forecasting are being followed depending on the time horizon. Different Forecasting methods are given various literatures and are as follows [9-12].

- **Short Term Forecasting:** From One hour to several hours ahead
- **Medium Term Forecasting**: From several hours to one week ahead
- **Long Term Forecasting:** From one week to one year ahead

Short term forecasting is generally used for operational planning and scheduling. For near term forecasting of wind generation, the simplest method is based on the averaging of the past production values. This method act as a reference forecasting method as are easy to implement and act as benchmark while evaluating advanced forecasting method. Table-1 gives the classification of wind forecasting based on time.

Table-1: Classification of Wind Forecasting [9]

Type of forecasting	Range	Applications
Short-Term	One hour to several hours ahead	• Economic load dispatch planning • Load reasonable decisions •Operational security in electricity market
Medium-Term	Several hours to one week ahead	• Unit commitment decisions • Reserve requirement decisions • Generator online/offline decisions
Long-Term	One week to one year or more ahead	• Maintenance planning • Operation management • Optimal operating cost • Feasibility study for design of the wind farm

4.1.1. Wind Forecasting Methods

For forecasting of wind for any duration, the following approaches [9] are used:

a) Numerical Weather Prediction

The base of major forecasting technique is Numerical Weather Prediction techniques that monitor and predict weather systems in three dimensions using the physical laws that govern atmospheric motion and represent the known state of the atmosphere. Numerical weather forecast models have limitations in that small atmospheric features cannot be accurately predicted. These models were originally developed for other general weather forecasting purposes (public safety, aviation, agriculture, etc.) rather than specifically for wind and solar power forecasting.

b) Statistical Models:

Statistical models are based on empirical relationships between a set of predictor (input) and forecast (output) variables. Because these relationships are derived from a training sample of historical data that includes values of both the predictor and forecast variables, statistical models have the advantage of “learning from experience” without needing to explicitly know the underlying physical relationships.

Some of these statistical models can get quite sophisticated, finding complex multivariable and nonlinear relationships between many predictor variables and the desired forecast variable, by using advanced techniques like artificial neural networks, support vector machines and related technologies.

Today, most sophisticated wind power forecasting systems use a combination of NWP and statistical models. The basic approach is to use values from NWP models and measured data from the wind plant to predict the desired variables (e.g., hub height wind speed, wind power output, etc.) at the wind plant location. Because they can essentially learn from experience, the statistical models add value to NWP forecasts by accounting for subtle effects of the local terrain and other details that cannot realistically be represented in the NWP models themselves. But because they need to learn from historical examples, availability of historical data is a must.

c) Persistence Models:

Persistence method uses a simple assumption that the wind speed or wind power at a certain future time will be the same as it is when the forecast is made. If the measured wind speed and wind power at t are v(t) and P(t), then the forecasting wind speed and wind power at $t+\Delta t$ can be formulated as the following term:

$$v(t + \Delta t) = v(t) \quad (1)$$

$$P(t + \Delta t) = P(t)$$

The persistence method is somehow more accurate than other wind forecasting methods in ultra-short-term forecasting. But the accuracy of persistence method will degrade rapidly when with the time-scale of forecasting is increasing. Another drawback of this is major ramp events can't be predicted.

d) Hybrid Models:

The object of hybrid models is to benefit from the advantages of each model explained above and obtain a globally optimal forecasting performance. Since the information contained in the individual forecasting method is limited, hybrid method can maximize the available information, integrate individual model information and make the best use of the advantages of multiple forecasting methods thus improving the prediction accuracy. This is also known as ensemble forecasting.

The following can be concluded from the above four models.

- All over the world the major forecasting models uses similar hybrid models (NWP, Statistical and ANN), each model is unique in the way it moulds its algorithm. The more the algorithm gets trained with appropriate historical data, better accuracy evolves.
- Each of the models has its own advantages and disadvantages, the model which worked in some location and some part of the year may not go correct with other locations and time frame. So it is preferred to have multiple forecasting techniques and use the same based on experience.

4.2. Solar Forecasting

The solar energy forecasting [10] is depends on the sun's trajectory, atmospheric condition, scattering process and the characteristic of solar energy plant. Solar energy forecasting is divided in three time horizons:

- **Short Term Forecast (Up to 7 days ahead):** This information is intended for grid operator as well as for the market operator. The meteorological data estimated at a different temporal and spatial resolution over a large area is used to give more generalized perspective of solar energy forecast.
- **Long Term Forecast (For months and years):** This type of forecasts is used by the energy producers for signing of contracts with utilities/discoms.

4.2.1. Solar Forecasting Methods

Solar forecasting methods are almost similar to wind. Numerical Weather Prediction (NWP) technique is widely used method. Sky imagers near solar plants can be used to indicate approaching clouds and predict the impact the clouds will have on output. For the next few hours, successive recent satellite images have been shown to yield useful information about the direction and speed of approaching clouds and allow the position of stable clouds to be extrapolated forward into the next few hours. For longer time scales, NWP models can be used to predict clouds and solar insolation for multiple days.

5. RE Forecasting followed across the World

This section discusses the forecasting [11]-[17] done in some of the major countries having high penetration of wind/solar energy.

5.1. Denmark

Denmark has large wind farms in Western part of the country. Denmark uses Wind Power Prediction Model (WPPT), a product developed by ENFOR. It is based on the hybrid model using nonlinear statistical models and artificial intelligence. The model requires the following as inputs:

- Online wind speed measurements and direction.
- Online measurement of available production capacity
- Online measurements of wind power generation for the past few weeks
- Forecasted wind speed and direction for the next 2 days
- Forecasted availability of wind turbines

The model has a self-tuning mechanism perfecting itself as the time goes by. At the start of the new plant, the model has less accuracy. Generally, the prediction in this case is done using other units. The forecasting is done from few hours to few days. Reliable methods of ramp forecasting are also incorporated to take care of constraints. Similar philosophy is used for solar forecasting only the models are different.

5.2. Spain

Spanish regulation mandates the wind farm operators to predict the wind energy generation from their plants and penalties are imposed for inaccurate forecasting. Most of the Spanish wind farms use services of Metrological for forecasting of wind energy. It uses the statistical approach for forecasting. The model uses different global atmospheric models and the meteorological information available from satellite systems. However, for a new plant the forecasting is done based on other similar units as the wind-forecasting model is not much accurate in the beginning. However the model has an exponential learning curve and gets tuned within a month.

5.3. Australia

Australia uses wind generation forecasts 40 hrs ahead duration. If there are significant variations in real time, the wind output is limited by semi scheduling the

wind farms. The wind-forecasting model is the combination of physical and statistical models. The inputs to the model are as following:

- Wind farm location and terrain data
- Wind turbine data
- Online Power measurements
- Historical data information

5.4. New York ISO

Day-ahead schedules are used by NY ISO for planning day-ahead unit commitment decisions. These forecasts are blended with persistence schedules , weighing more heavily on persistence schedules in the nearer commitment/dispatch intervals(every 5 min) and gradually shifting weight to the forecasts as the commitment intervals look farther out in time.

5.5. Overview of Wind Power Forecasting in U.S Markets

MISO	NYISO	PJM	ERCOT	CAISO
In operation since 2008: • DA and intra-day RAC • Transmission security and outage coordination • Transmission security and peak load analysis • Indication of ramps	In operation since 2008: • Reliability assessment commitment at DA stage • RT commitment and dispatch • Ramping alert system under consideration	In operation since 2009: • DA transmission security and reserve adequacy assessments • Developing automated procedures • Specific ramp forecast	In operation since 2008: • 80% exceedance forecast used for DA planning • To be fully integrated in new nodal design, to be introduced end of 2010 • Developing ramp forecast	In operation since 2004: • Used to calculate energy schedule in RT market • Advisory role in DA market

5.6. EIRGRID Smart Grid Dashboard for Wind Generation

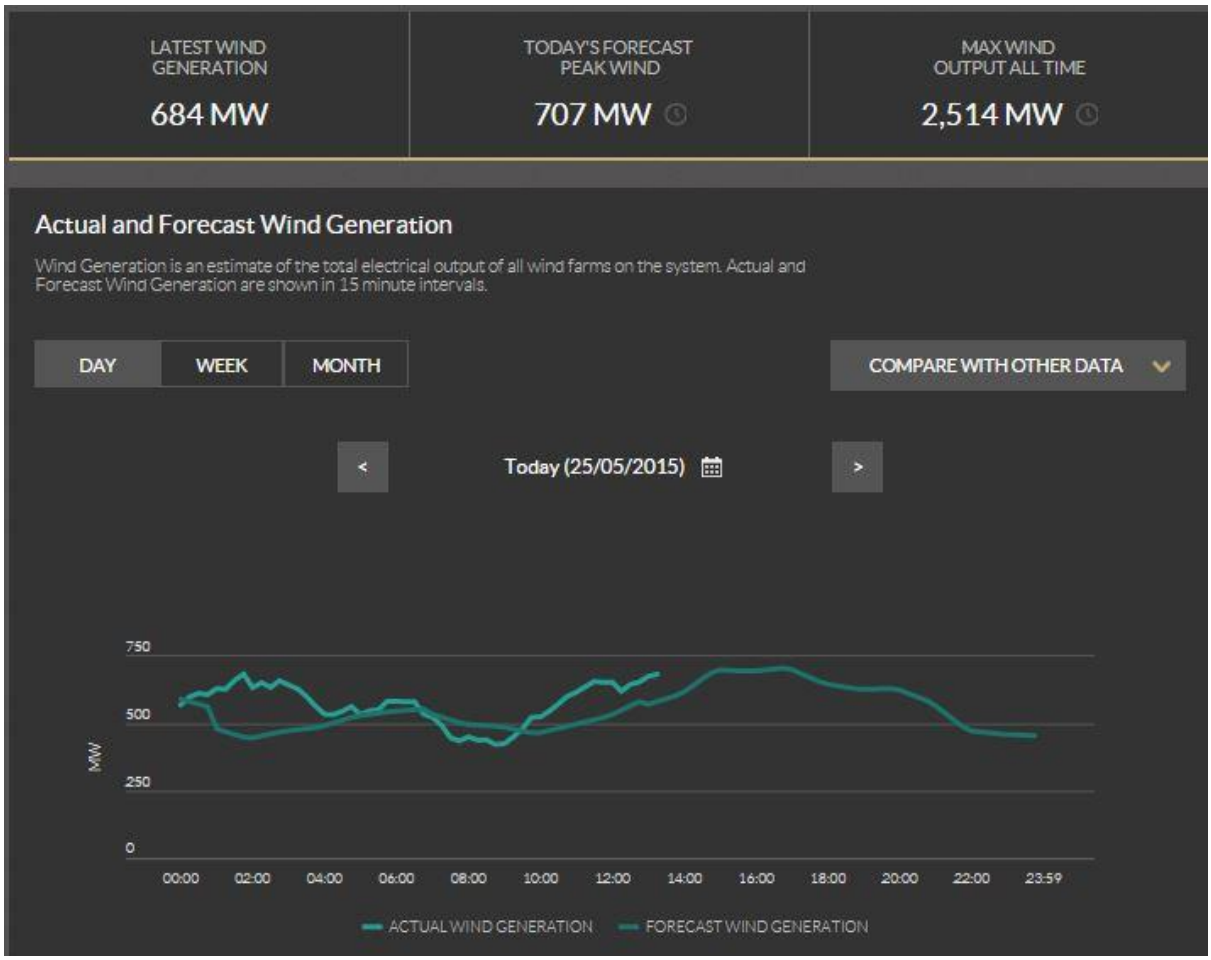


Figure-3: Dashboard displayed for Forecasted vs Actual Wind Generation on Website

6. Present RE Forecasting Methodology followed in RE rich states

6.1. Methodology in Gujarat

For wind energy forecasting, Gujarat has divided its state into 8 areas (Mundra, Okha, Jamnagar, Porbandar, Kandla, Suthri, Bhavnagar and Rajkot). Based on the wind speed and the power generation on the previous day, the wind energy forecast for the current day is calculated. The power generated from wind energy varies as a cubic function of the wind speed. Suppose P_1 and W_1 are Power generated and wind speed on previous day at 03:00 Hrs and P_2 and W_2 are the predicted power and wind speed for current day at 03:00 Hrs. the predicted power P_2 is calculated as:

$$P_2 = P_1 \left(\frac{w_1^3}{w_2^3} \right)$$

The calculation is done on hourly basis. The accuracy of forecasting is high for high wind speeds and low for low wind speeds. The wind speed data is taken from www.worldweatheronline.com.

For solar energy, Gujarat has divided its state into 16 different areas. Based on the temperature information of the previous day and the power generated, the power forecast for current day is calculated. The temperature data is taken from www.accuweather.com. However, the forecast would be more accurate if solar irradiation data is available.

$$P_2 = P_1 \left(\frac{T_2}{T_1} \right)$$

6.2. Methodology in Maharashtra

In Maharashtra, the four DISCOMs (BEST, TATA, Reliance, and MSEDCL) take generation schedule from the various renewable generators and forward the same to the Maharashtra SLDC. As such previous day generation is being taken and no methodical forecasting is being done. In case of any change in generation of renewable plants, the DISCOMs inform SLDC. Accordingly, SLDC resort to either ramping up or ramping down of the conventional generation or load shedding.

6.3. Present Methodology in Tamilnadu

Mostly Wind in Tamilnadu concentrated in four passes namely Shengottai, Aralvaimozhi, Palakkad and Kambam. Industrial Load is in Palakkad pass only. In real time also, the SLDCs do not receive data from all wind farms. At the sub-LDCs such as Erode, the operator typically manually enters the generation collected from different pooling stations once every hour. Generally, Wind forecasting is being done by wind developers. Recently, with the help of Indian Wind Power Association (IWPA) sensors & meters were installed at few locations. The data regarding wind speed, generation etc. are collected through these sensors and transferred to National Institute of Wind Energy (NIWE) for storing the data. The wind data from NIWE is further transferred to VORTEX, Sweden for tuning of forecasting models.

7. Challenges in Grid Operation due to renewables

a. The large variation in wind generation would result in

- Increase in number of Thermal generation revisions
- Large Deviation in drawal of states

To address this issue, faster revisions in ISGS are required. Further ancillary services should be developed to address such large deviations in the schedule due to variations in the renewable generation and the flexible generators participating in the ancillary services need to be identified in different areas. In addition, the pumping mode of hydro units should also be explored in accelerated manner.

b. **High ramp rates of wind & solar:** The wide variation in wind & solar due to change in wind speed & insolation need to be supported with the primary response by conventional generating units. The lack of primary response in the grid will lead to wider fluctuation in frequency with increasing renewable penetration.

c. **Telemetry of renewable generation:** The renewable generation is generally connected at low voltage transmission level; telemetry from all wind and solar generating stations is not available in most of the areas. Lack of such telemetry data results in lack of situational awareness to the real time operator regarding renewable generation.

d. **Hour boundary constraints:** Large load ramping is observed during hourly boundary which if get combined with renewable variation will pose a greater challenge to system operator. In order to maintain grid stability and parameters of the grid within their limit load ramping of 100 MW/Min should be strictly followed as per IEGC. Further, there has been constraint being observed in taking multiple hydro units outage or bringing them in service simultaneously resulting in losing the flexibility of hydro generation during hourly changeover, which should also be addressed.

e. **Specific Constraints in Renewable rich Sates**

- **Gujarat:** It has vast potential of wind in Saurashtra region. With large variation in wind generation in Saurashtra area, under certain conditions

the power flow between North Gujarat and South Gujarat could cause critical loading on the following lines in Gujarat

i. 400kV Dehgam Sami D/C
ii. 400kV Dehgam Pirana S/C
iii. 400kV Dehgam Jhanor D/C
iv. 400kV Jhanor Haldarva D/C
v. 400kV Sugen Vapi S/C

- **Maharashtra:** High voltage is observed in Wind concentrated Satara area. The lack of reactive support in the Kolhapur, Karad area in Maharashtra with high wind generation has resulted in tripping of 220 kV circuits of Goa, thus weakening the connectivity of Goa with the grid. The Kolhapur, Karad, Mapusa has already experienced islanding and complete blackout due to tripping of several lines on overvoltage on 1st March 2015. To accommodate large wind generation in these areas, the additional reactive compensation needs to be planned. Also looking at the dynamic nature of wind generation, dynamic reactive support in form of STATCOM or SVC should also be planned accordingly to cope up with the reactive power requirement.

- **Tamilnadu:** Renewables are mostly located in Tirunelveli area at 220 kV level or below. During high wind scenario, the voltages in South Tamil Nadu i.e in 400kV Udumalpet S/S, 400kV Madurai S/S, and 400kV Tirunelveli S/S are critically low. The provision for Under Voltage Load Shedding (UVLS) Relays was taken up with Tamil Nadu and the feeder list has been identified by Tamil Nadu. The UVLS scheme has to be implemented at earliest. Last year, on 02.06.14, in the 220 kV network of Tamil Nadu, 220 kV Kayathar-Tirunelveli line tripped along with other 220 kV lines due to CT blast at Kayathar end. Due to this tripping approx. 1100 MW of wind generation being evacuated through these lines also tripped. The incidents due to protection failure and inadequate transmission infrastructure at the intra-state level were observed in the past too. Therefore, there is need for augmentation and strengthening of the sub-transmission infrastructure.

8. Scheduling and Dispatch

All the power systems have their unique way in which they address the above issues depending upon the market structure and design. Sally Hunt [18] describes Scheduling and dispatch as one of the four pillars of market design.

"The trading rules that deal with the four features of electricity just mentioned are the four pillars of good electricity market design. All other aspects of market design become quite straight forward once these are in place:

1. *Imbalances;*
2. *Congestion management;*
3. *Ancillary services; and*
4. *Scheduling and dispatch.*

All these pieces must work together."

Scheduling is the assignment of generation to meet anticipated demand. Dispatch is the refinement of the scheduling process and relates to the real-time control of all generation and transmission resources that are being used and/or are available to meet demand requirements. The dispatch process recognizes the operational priorities of safety, security and economy. Dispatch aims to match demand with generation on a second by second basis, whilst maintaining tie-line flow schedules and adequate levels of operating reserve. The dispatch process also manages real-time fluctuations in system demand and the output of generators and system disturbances such as generation trips or transmission contingencies. The three important activities involved in generation scheduling are as under:

- Unit commitment
- Economic Dispatch
- Generation Control

Every country has their own mechanisms to coordinate the above activities. Sally Hunt [18] has articulated as below-

"There is no escaping this- the system operator has to schedule and dispatch. The question is how this indubitable fact should be reflected in the rules of the electricity marketplace. How does the system operator decide who should generate at any time? How are forward contracts tied to scheduling? How should financial settlements be tied to physical operations? "

8.1. Scheduling responsibility – Statutory and Regulatory provisions

The responsibility of NLDC/RLDC in India w.r.t. scheduling and dispatch as stipulated in the Electricity Act 2003 and the Indian Electricity Grid Code is quoted below:

8.1.1. Regulation 6.4.5 of the IEGC (Role of SLDC)

As per this regulation, SLDCs shall have the total responsibility for

(i) scheduling/despatching their own generation (including generation of their embedded licensees),

(ii) regulating the demand of its control area,

(iii) scheduling their drawal from the ISGS (within their share in the respective plant's expected capability)

(iv) permitting long term access, medium term and short term open access transactions for embedded generators/consumers, in accordance with the contracts and

(v) Regulating the net drawal of their control area from the regional grid in accordance with the respective regulations of the CERC.

8.1.2. Regulation 6.4.2 of the IEGC (Role of RLDC)

As per this regulation, RLDCs *shall coordinate the scheduling of the following generating stations:*

a) Central Generating Stations (excluding stations where full Share is allocated to host state),

b) Ultra-Mega power projects

c) In other cases, the control area shall be decided on the following criteria:

i. If a generating station is connected only to the ISTS, RLDC shall coordinate the scheduling, except for Central Generating Stations where full Share is allocated to one State.

ii. If a generating station is connected only to the State transmission network, the SLDC shall coordinate scheduling, except for the case as at (a) above.

……"

8.1.3. Section 4 (b) of the National Load Despatch Centre Rules, 2005

The National Load Despatch Centre shall have the total responsibility for

(b) scheduling and despatch of electricity over the inter-regional links in accordance with grid standards specified by the Authority and grid code specified by Central Commission in coordination with Regional Load Despatch Centres;

(c) Coordination with Regional Load Despatch Centres for achieving maximum economy and efficiency in the operation of National Grid…"

8.2. Key Issues and Way Forward

8.2.1. Scheduling at Intra-State level and Inter-state

Forecasting needs to be done by both RE generator and the concerned SLDCs and RLDC. The forecast by the concerned SLDC/RLDC would be from the point of grid security. The forecast by the RE generator would be RE facility centric and would form the basis of scheduling having commercial impact.

The day ahead scheduling is being done for all the generators connected to ISTS as per the Indian Electricity Grid Code on the basis of 15 minutes time blocks. At present, RLDCs are scheduling inter-state schedules & also the inter-regional schedules and NLDC is scheduling International power transfers. The scheduling activity inside that states for imbedded generators is being carried out by the concerned SLDC.

Within the state, in case of embedded generators, the RE generators would need to engage forecasting agency(ies) at decentralized level to provide schedule to the concerned SLDC. The respective SLDC may collate the schedules provided by the RE generators and give it to RLDC.

8.2.2. Need for Aggregator within the state control areas

It has been observed that in case of renewable energy generation, particularly in case of Wind Turbine Generators (WTGs) in Tamilnadu, the ownership is quite fragmented and large capacity of WTGs is owned by small investors. In an earlier

order, Hon'ble CERC has recognized the need of a nodal entity at the connection point, which shall be responsible for coordinating with SLDC/RLDC on behalf of all the developers/generators. Hence, a separate Institutional Entity e.g. Qualified Scheduling Entity (QSE) may be required to be put in place, which is recognized under regulatory framework and could be qualified/certified/registered with System Operator to undertake various activities associated with scheduling/commercial settlement/de-pooling/communication/data consolidation and management and co-ordination etc. Suitable definition may be incorporated in the appropriate regulations including Grid Code.

8.2.3. Data Telemetry and Communication Facilities

Data Telemetry and Communication Facilities with the Solar/Wind ISGS stations for all real time operations and exchange real time code for switching and shutdown etc. is vital for secure grid operation.

8.2.4. Standards and Protection Requirements

CEA has formulated various regulations such as CEA Measures of Safety and Electricity Supply Regulations, 2010, CEA Technical Standards for Connectivity of the Distributed Generation Resources Regulations, 2013 and CEA Installation and Operation of Meters' Amendment Regulation 2014. The various parameters such as harmonic current injections, Injection of DC current, Flicker, Supplying dynamically varying reactive power support, Frequency range, Voltage variation, Fault Ride Through provisions, Control active power injection set point based on the directions of the appropriate Load Despatch Centre etc. have been specified. All the RE generators both wind and solar must follow the CEA standards and protection requirements for ensuring secure and reliable operation of the grid.

8.2.5. Renewable Energy Management Centres (REMCs)

Renewable Energy Management Centres (REMCs) are needed at State, Regional and National level co-located with respective Load Despatch Centres (LDC) Communication & IT infrastructure is needed with adequate resilience and

redundancy. There is requirement of different skill sets for personnel manning REMCs and Load Despatch Centres. Interfacing is needed with Indian Metrological Department (IMD) at local and global level. REMC may have following functions:

- Forecasting of RE generation in jurisdiction area on hour-ahead, day-ahead, week-ahead, month-ahead basis.
- Real time tracking of generation from RE sources
- Geo-spatial visualization of RE generation
- Advanced decision-making and control systems - Close coordination with respective LDC for RE generation and control for smooth grid operation.
- Single source information repository and coordination point for RE penetration.

9. CERC Proposed framework for RE Integration at Interstate level

9.1. Background

Government of India has ambitious plan by 2020 for installing solar capacity of 1,00,000 MW and Wind capacity of 65,000 MW. The plans for 25 Nos. of Ultra-Mega Solar Power Projects in 12 States (each 500 MW to 1000 MW capacity) have been formulated. The details are as follows:

- Gujarat (750 MW), MP (1500 MW), Telangana (1000 MW), AP (1500 MW), Karnataka (2000 MW), UP (370 MW), J&K (7500 MW), Rajasthan (3000 MW)
- Total Inter-State Capacity envisaged: 17, 620 MW

9.2. Proposed Framework

In order to facilitate the large scale integration of renewables at ISTS in the grid with regard to forecasting, scheduling & imbalance handling, CERC has come out with the new framework. Extracts from CERC's proposed methodology for forecasting, scheduling and imbalance handling of wind and solar generators are given below:

9.2.1. Forecasting Methodology:

Wind / Solar energy generation is uncertain and variable but uncertainty and variability can and should be minimized to the extent possible through proper forecasting. In the earlier framework provided in the IEGC, the wind energy generators were mandated to undertake forecasting and scheduling subject to pre-specified tolerance limit. The solar energy generation being at its infancy was not subjected to commercial impact on account of deviation from schedule. Over the period, however, we have gained experience on solar front as well. In fact, solar is considered equally, if not more firm than wind. As such, both wind and solar energy generation are being brought under the requirement of forecasting and scheduling. Accuracy of forecasts can be increased inter alia by maximizing geographic diversity in wind / solar energy generation as the errors in forecasts tend to offset each other, the larger the number of generators covered and broader the area included in the forecasts. In order to maximize the accuracy of forecasts, meteorological models must incorporate maximum possible data about as many wind / solar energy generators as possible in as high a resolution (spatial and temporal) as possible, which has to be provided on a mandatory basis by all wind / solar energy generators whose scheduling is done by RLDCs as specified in the grid code.

Forecasting is an essential pre-requisite for scheduling of the wind/solar generation. Forecasting needs to be done by both the wind/solar generator and the concerned RLDC. While the forecast by the concerned RLDC would be more with the objective of secure grid operation, the forecast by the wind / solar energy generator would be windfarm/solar facility centric and would form the basis of scheduling. Appropriate use of forecast for scheduling is also expected to reduce commercial impact for the wind and solar energy generators. It is understood that the Renewable Energy Management Centers (REMCs) are being established and these would be equipped with advanced forecasting tools. The wind/solar energy generator may choose to utilize its own forecast or the forecast given by REMC/concerned RLDC. However, any commercial impact on account of scheduling based on the forecast would be borne by the wind/solar energy generator. It would also be prudent to have multiple forecast providers (both for REMC/RLDC & wind/solar energy generators) for better confidence levels/lower forecast errors.

9.2.2. Scheduling Methodology:

The wind/solar generators at the inter-state level whose scheduling is done by the RLDCs, would be scheduled like any other generator and would be paid as per scheduled generation and not actual generation. Considering the fact that wind/solar generation is intermittent and variable in nature and also taking into account the fact
that accuracy of forecast improves as we move closer in time, the wind/solar energy generator would be allowed more opportunities to revise the schedule. There may be a maximum of 16 revisions for each fixed one and half hour time slot starting from 00:00 hours during the day (as against 8 revisions currently allowed as per IEGC 2010).

The wind/solar energy generators may transact power through long-term, medium term and short-term trades. Some of the wind/solar energy generators may also transact power through short term trades. Revisions are allowed for bilateral transactions but no revision of trades discovered through collective transactions in the Power Exchange(s) is possible.

9.3. Similar Framework at State Level

The proposed CERC framework is for forecasting, scheduling and despatch of RE generators at Inter-State level. This would pave the way forward for RE generators to participate in open electricity markets. This framework delinks the deviations of RE generators from frequency and therefore, RE generators would receive the payment in accordance with the schedule and treated like any other conventional generator.

However, at intra-state level many embedded RE generators have come up and are facing transmission constraints for evacuation of their power. It is therefore, imperative upon the respective State Electricity Regulatory Commissions (SERCs) of RE rich states to formulate a similar RE framework for forecasting, scheduling and despatching of RE generators at intra-state level.

10. Road Map for Forecasting and Scheduling of Renewable Energy (RE) and Load

10.1. Forecasting

Forecasting is an essential pre-requisite for scheduling of the RE generation. Forecasting needs to be done by both the RE generator and the concerned System Operator i.e. SLDC at the State level and RLDC at the Regional level. The forecast by the RE generator would be wind-farm/solar facility centric and would form the basis of scheduling. This forecast is also expected have a commercial impact for the RE generator. The forecast by the concerned System Operator would be more with the objective of secure grid operation. Renewable energy management Centres (REMC) are being established and these would be equipped with advanced forecasting tools. The REMC/System Operator may provide forecast to the RE generators also, if required, with the condition that any commercial impact because of the forecast would be borne by the RE generator. It would also be prudent for an institution like REMC to have multiple forecast providers for better confidence levels.

10.2. Scheduling

The day ahead scheduling is being done for all the generators connected to ISTS as per the Indian Electricity Grid Code on the basis of 15 minutes time blocks. At present, RLDCs are scheduling inter-state schedules & also the inter-regional schedules and NLDC is scheduling International power transfers. The scheduling activity inside that states for imbedded generators is being carried out by the concerned SLDC.

Within the state, in case of embedded generators, the RE generators would need to engage forecasting agency (ies) at decentralized level to provide schedule to the concerned SLDC. The respective SLDC may collate the schedules provided by the RE generators and give it to RLDC. The RE generators at the inter-state level would be scheduled like any other generator. Considering the fact that RE generation is intermittent and variable in nature and also factor in the forecast errors, the RE generator may be allowed more opportunities to revise its schedule.

Some of the RE generators may also transact power through short term trades. The revisions are allowed for bilateral transactions but no revision of trades discovered through collective transactions in the Power Exchange(s) is possible. Hence, the preferable mode in the short term would be bilateral transactions and they may be discouraged to go through the collective route. Further, special provisions regarding revision of bilateral transactions by RE generators would need to be considered & necessary provisions be made to facilitate revisions in short time frame.

10.3. Imbalance Handling

Deviations from schedule are bound to occur for the RE generator and these would be treated in the same manner as for any other entity and DSM charges would be applicable. SEMs to facilitate metering, accounting and settlement would need to be placed.

10.4. RE framework at Intra-state level

At intra-state level, many embedded RE generators have come up and are facing transmission constraints for evacuation of their power. It is therefore, imperative upon the respective State Electricity Regulatory Commissions (SERCs) of RE rich states to formulate a RE framework for forecasting, scheduling and despatching of RE generators at intra-state level.

10.5. Need for Aggregator within the state control areas

It has been observed that in case of renewable energy generation, particularly in case of Wind Turbine Generators (WTGs) in Tamil Nadu, the ownership is quite fragmented and large capacity of WTGs is owned by small investors. In an earlier order, Hon'ble CERC has recognized the need of a nodal entity at the connection point, which shall be responsible for coordinating with SLDC/RLDC on behalf of all the developers/generators. Hence, a separate Institutional Entity e.g. Qualified Scheduling Entity (QSE) may be required to be put in place, which is recognized under regulatory framework and could be qualified/certified/registered with System Operator to undertake various activities associated with scheduling/commercial settlement/de-pooling/communication/data consolidation and management and co-ordination etc. Suitable definition may be incorporated in the appropriate regulations including Grid Code.

10.6. Data Telemetry and Communication Facilities

Data Telemetry and Communication Facilities with the Solar/Wind ISGS stations for all real time operations and exchange real time code for switching and shutdown etc. is vital for secure grid operation.

10.7. Standards and Protection Requirements

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injection set point based on the directions of the appropriate Load Despatch Centre etc. have been specified. All the RE generators both wind and solar must follow the CEA standards and protection requirements for ensuring secure and reliable operation of the grid.

10.8. Renewable Energy Management Centres (REMCs)

Renewable Energy Management Centres (REMCs) are needed at State, Regional and National level co-located with respective Load Despatch Centres (LDC) Communication & IT infrastructure is needed with adequate resilience and redundancy. There is requirement of different skill sets for personnel manning REMCs and Load Despatch Centres. Interfacing is needed with Indian Metrological Department (IMD) at local and global level. REMC may have following functions:

- Forecasting of RE generation in jurisdiction area on hour-ahead, day-ahead, week-ahead, month-ahead basis.
- Real time tracking of generation from RE sources
- Geo-spatial visualization of RE generation
- Advanced decision-making and control systems - Close coordination with respective LDC for RE generation and control for smooth grid operation.
- Single source information repository and coordination point for RE penetration.

10.9. Ancillary Services

Renewable energy generation is variable in nature (diurnal & seasonal) and implementation of Ancillary Services would facilitate integration of renewable energy generation in the country. Ancillary Services will certainly help in controlling the variability of renewable generation, presently concentrated in certain parts of the country, however other suitable mechanisms like more frequent market clearing products are required. Also, Grid scale Storage system e.g. Pumped Storage Plants can be one of the alternative ancillary service handling grid integration issues associated with renewable sources of energy.

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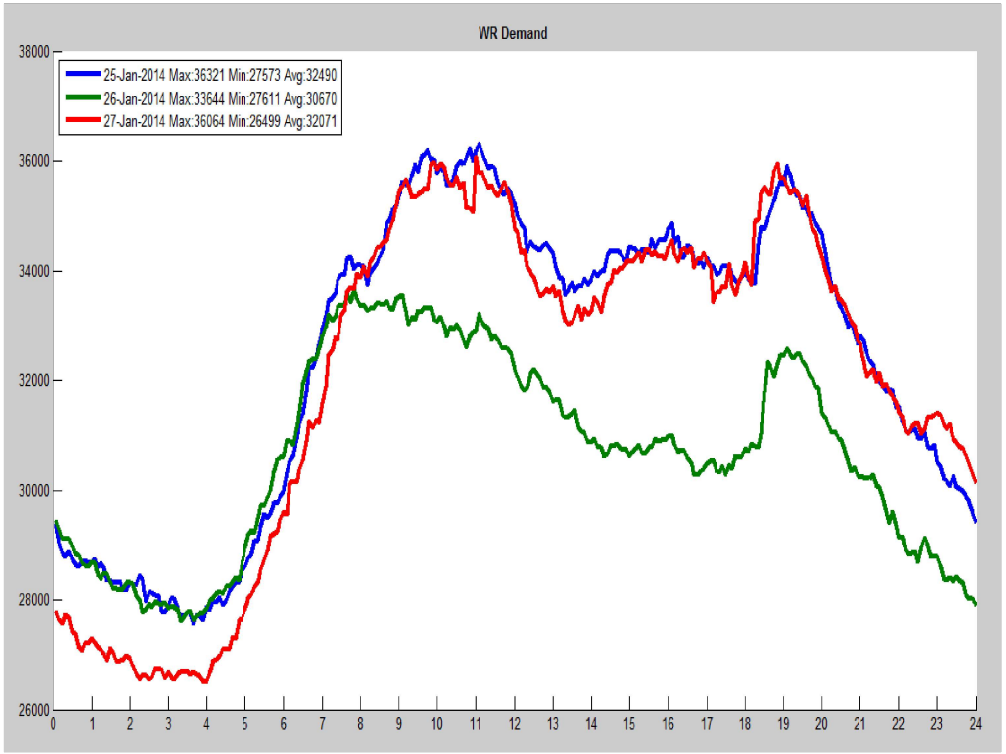
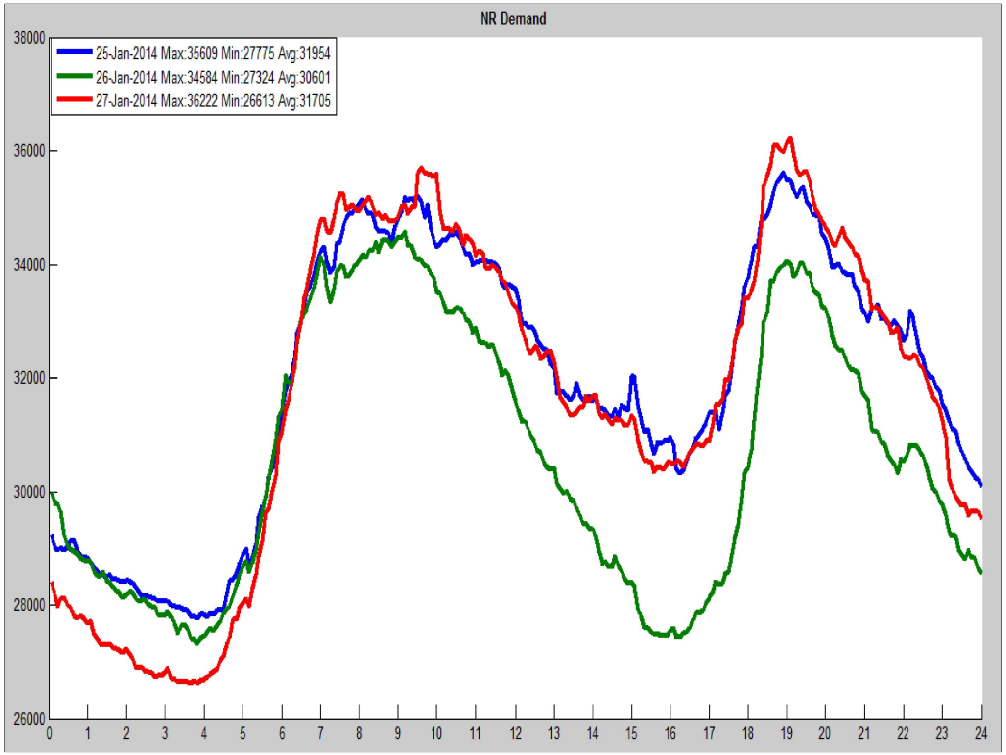
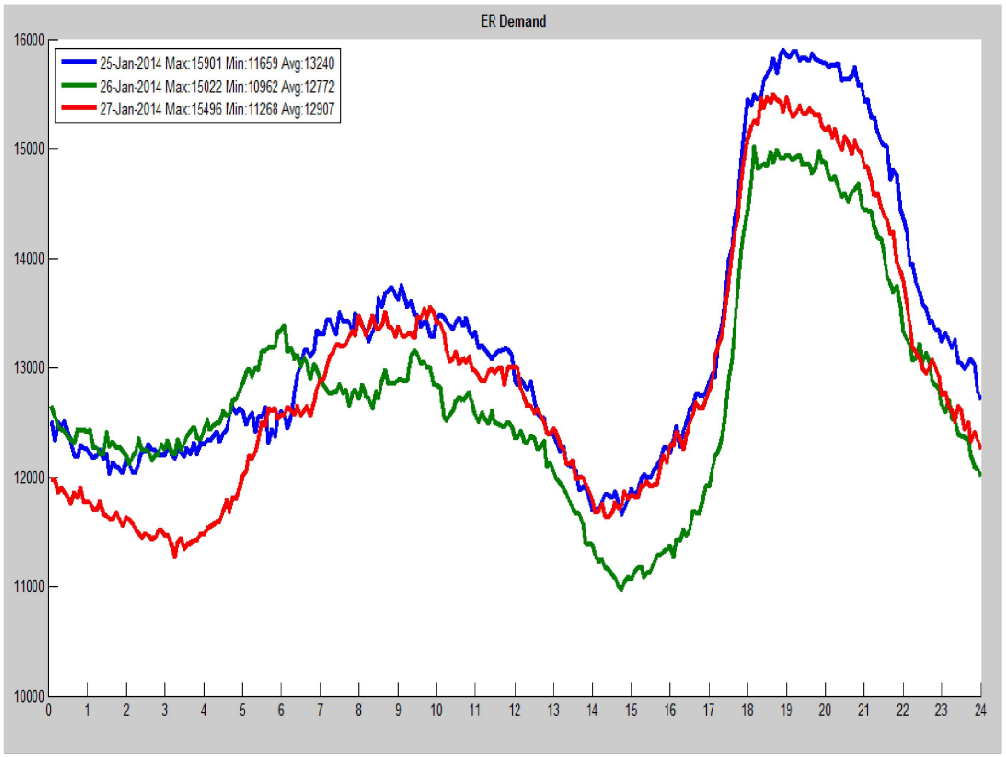
Republic Day- 2014



Annex-II

Load Forecast for Republic Day 2015

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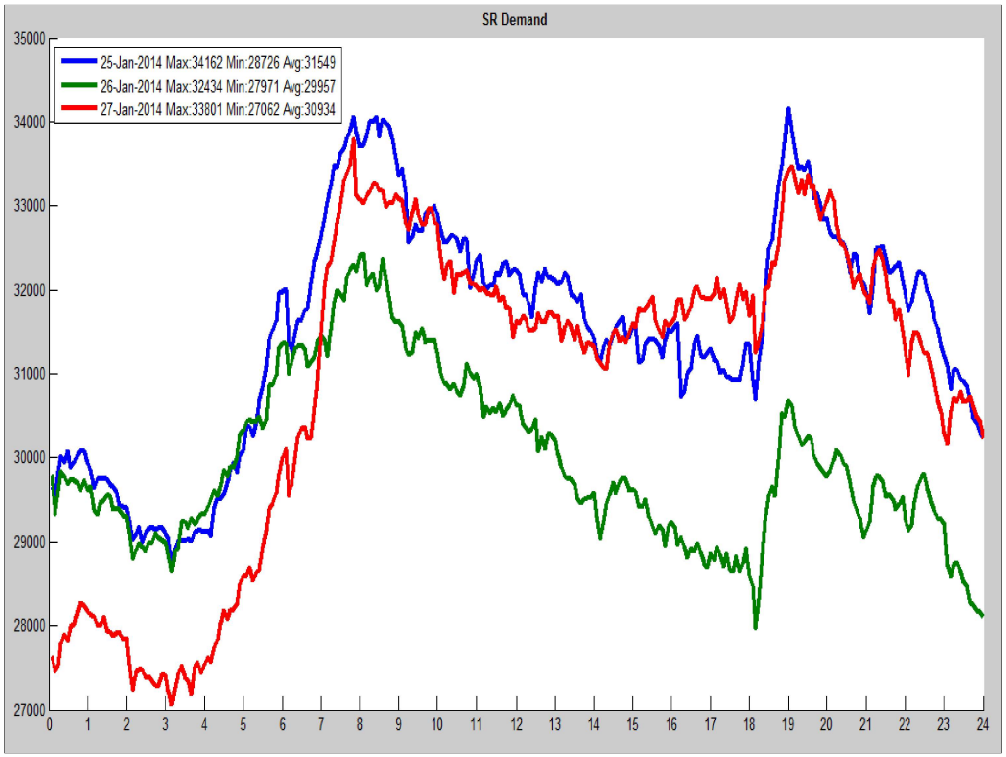
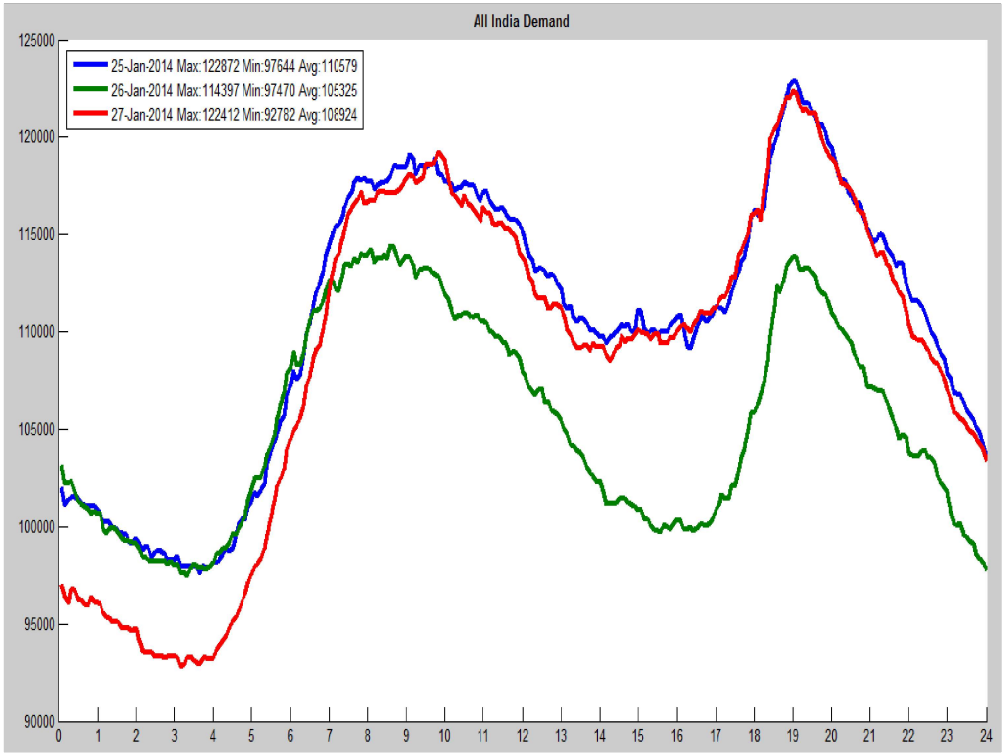
26-Jan-2014 Max:15022 Min:10962 Avg:12772
27-Jan-2014 Max:15496 Min:11268 Avg:12907


SR Demand
25-Jan-2014 Max:34162 Min:28726 Avg:31549
26-Jan-2014 Max:32434 Min:27971 Avg:29957
27-Jan-2014 Max:33801 Min:27062 Avg:30934


All India Demand
25-Jan-2014 Max:122872 Min:97644 Avg:110579
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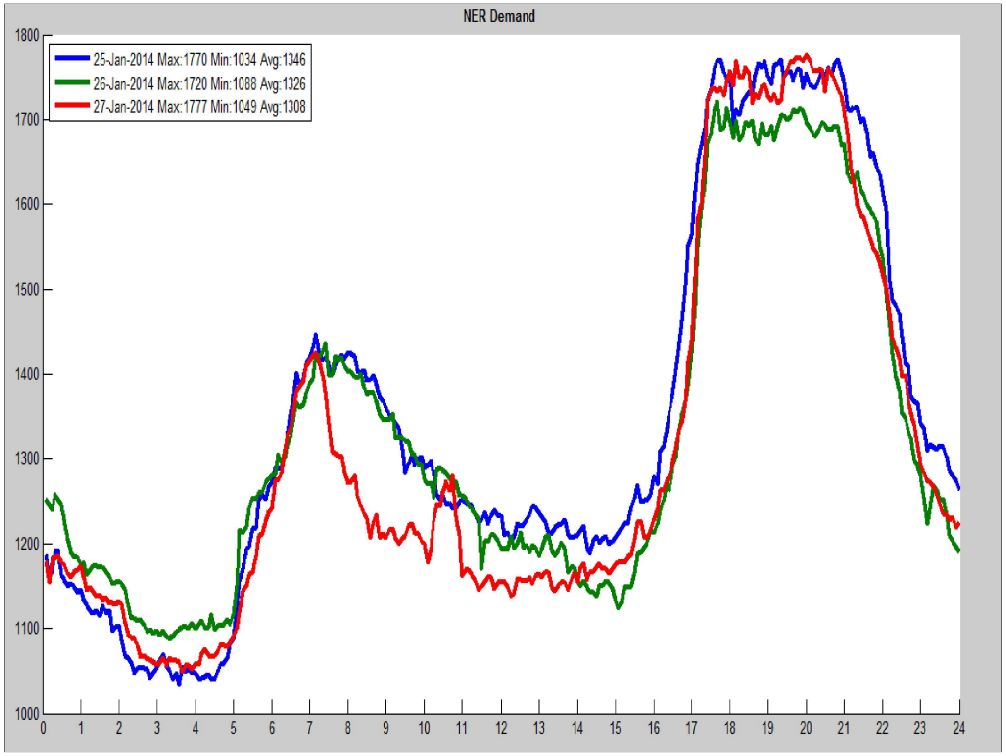
27-Jan-2014 Max:122412 Min:92782 Avg:108924


NER Demand
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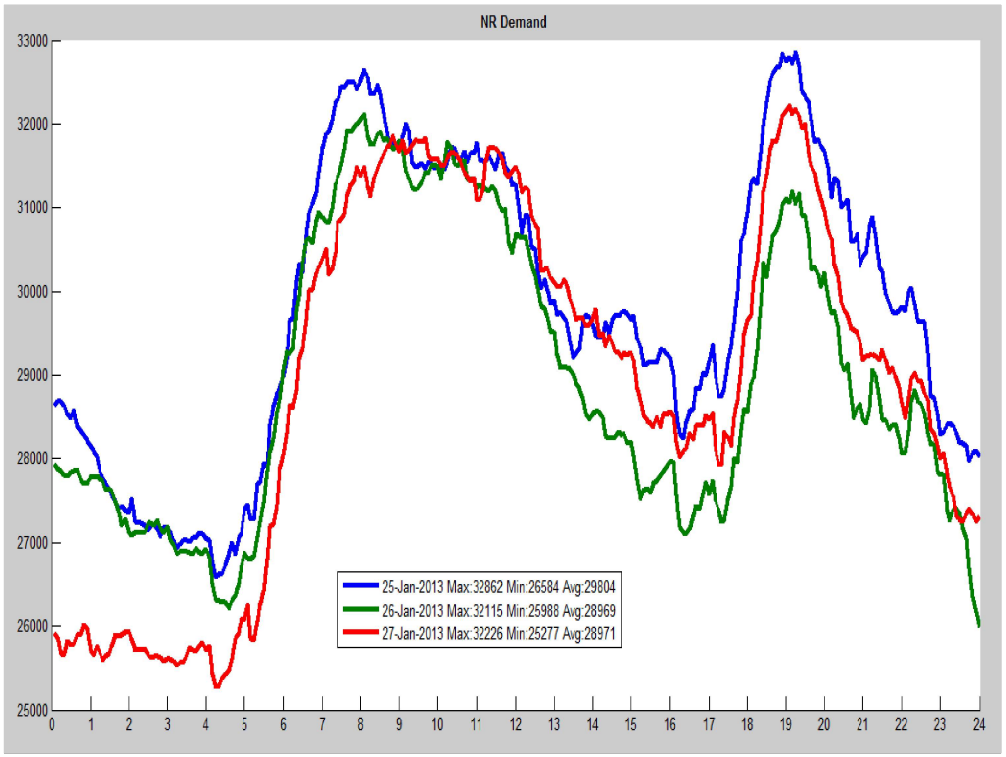
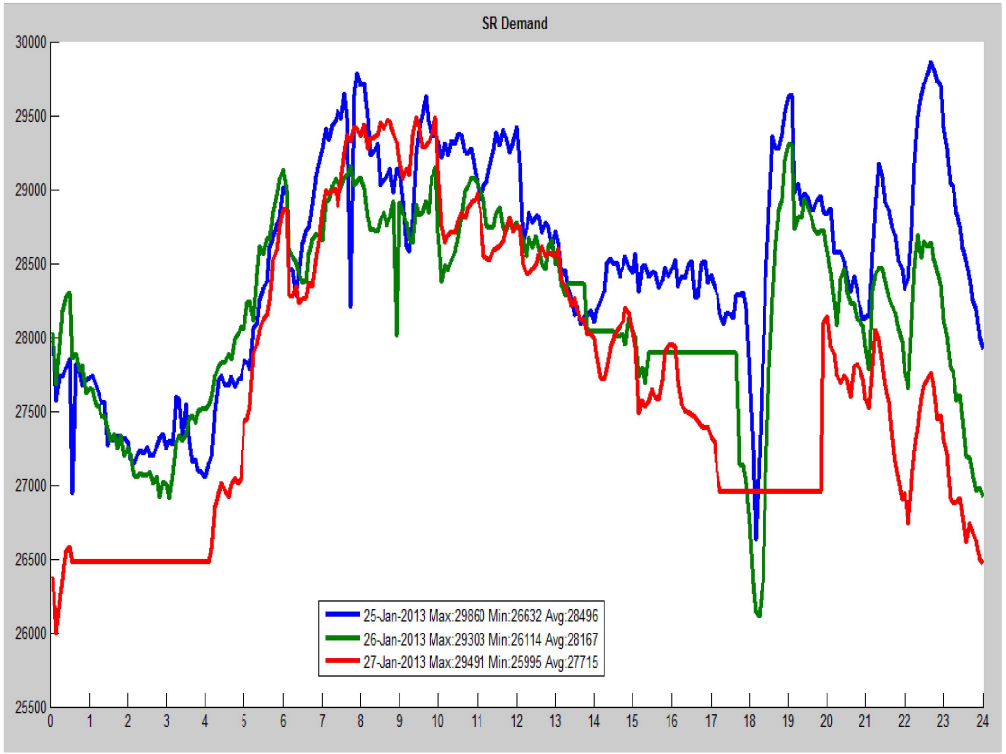
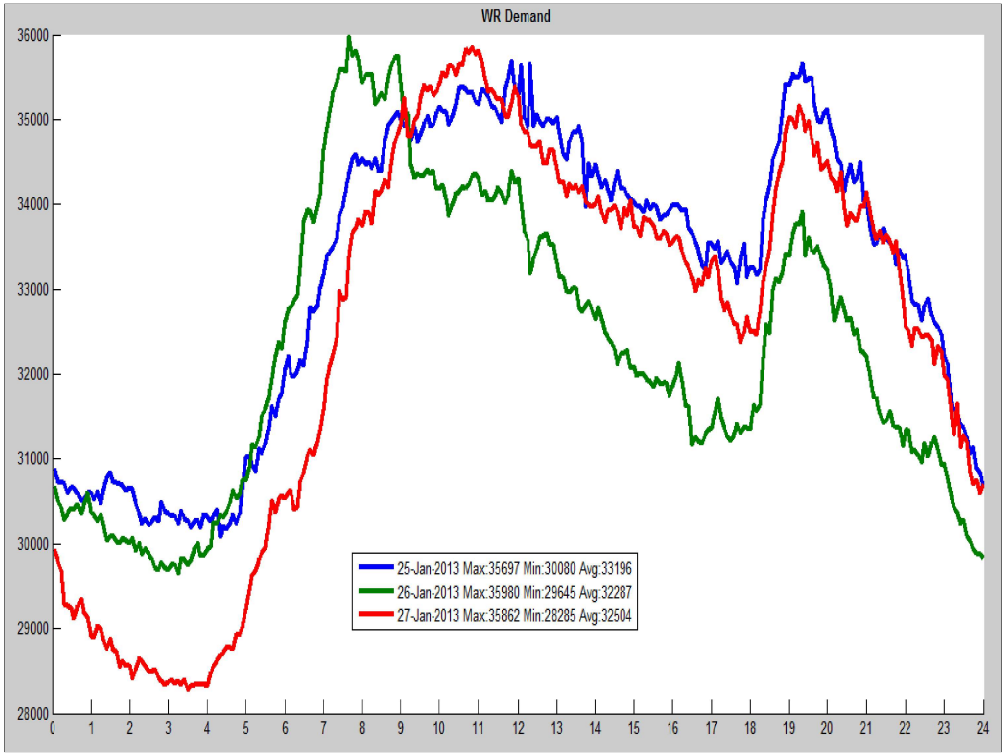
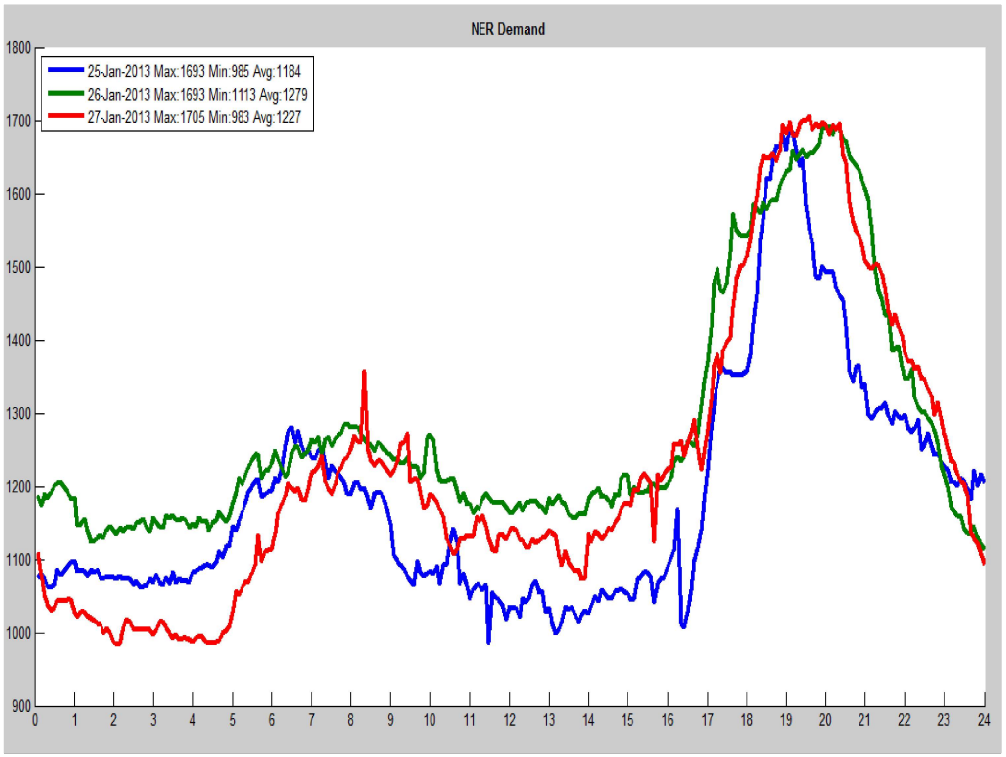
27-Jan-2014 Max:1777 Min:1049 Avg:1308

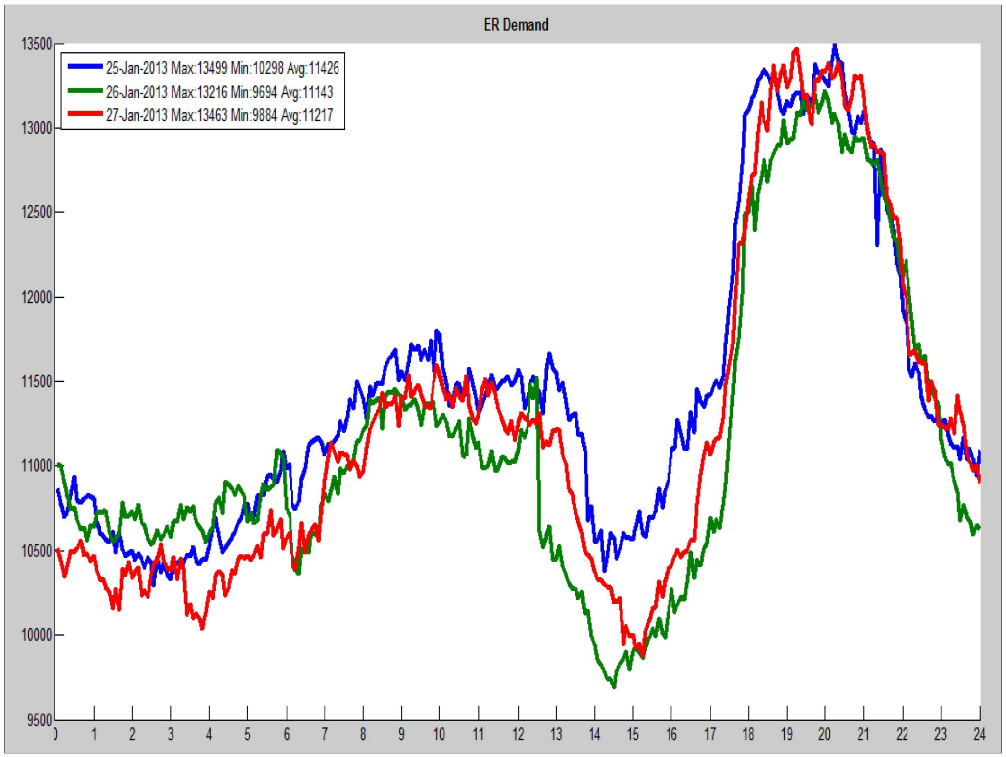


Republic Day-2013

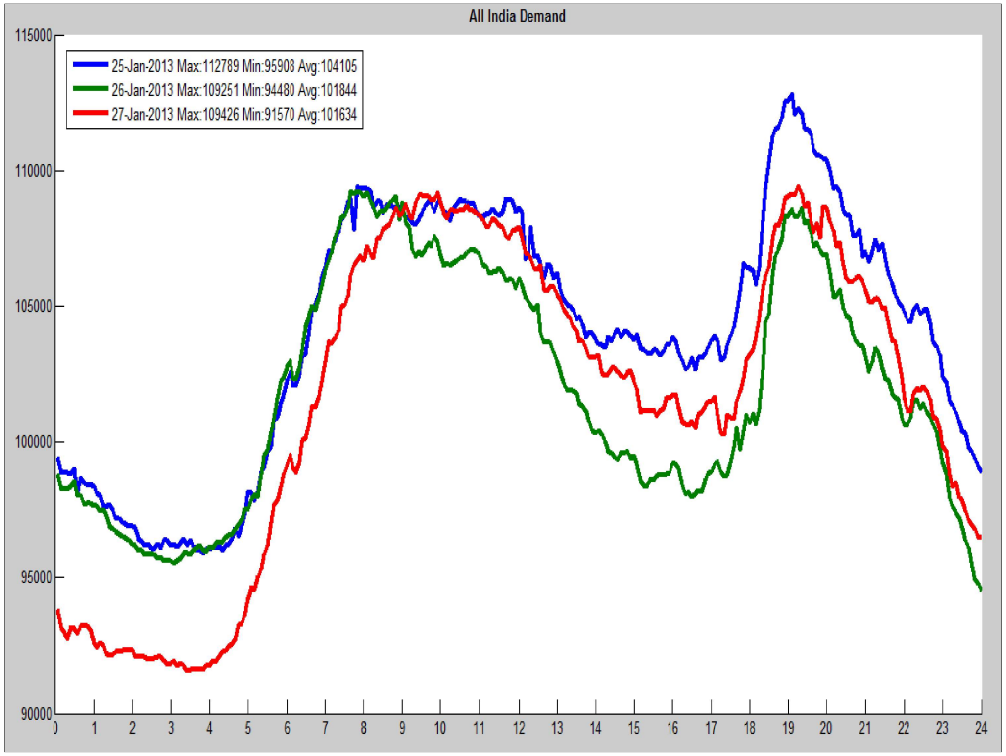


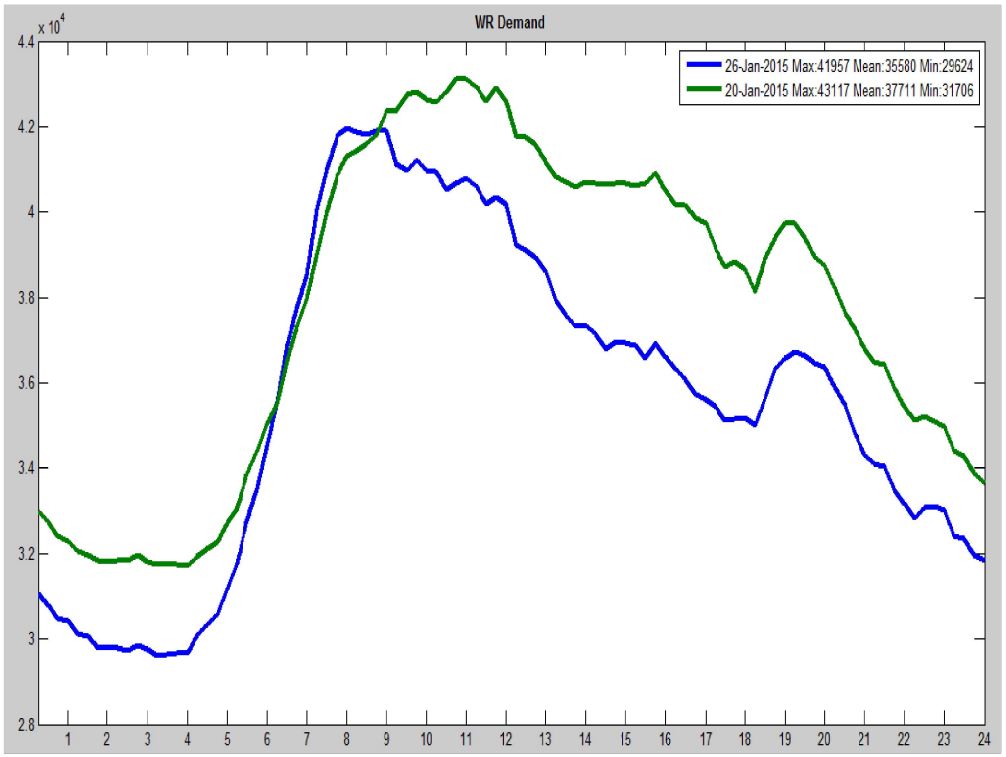


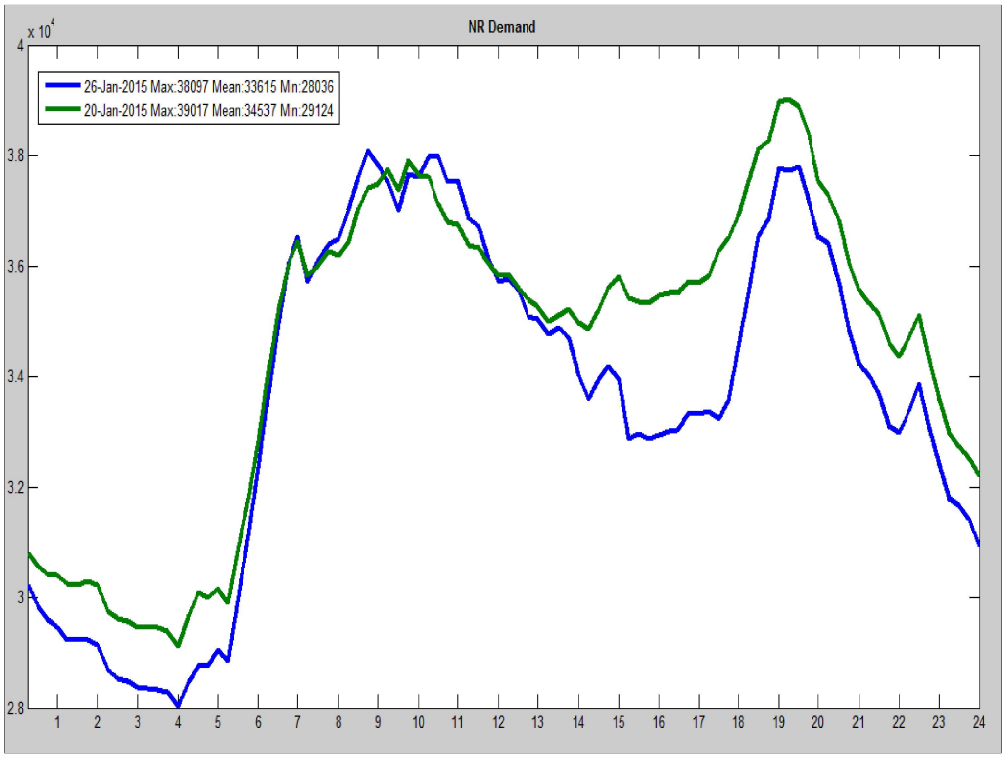


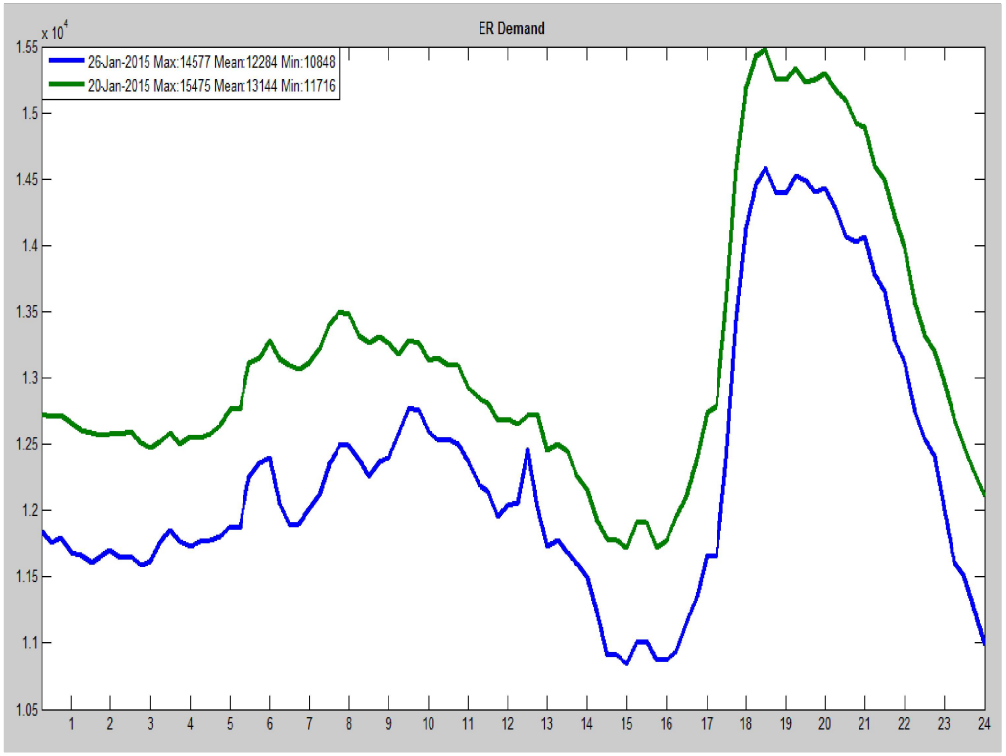


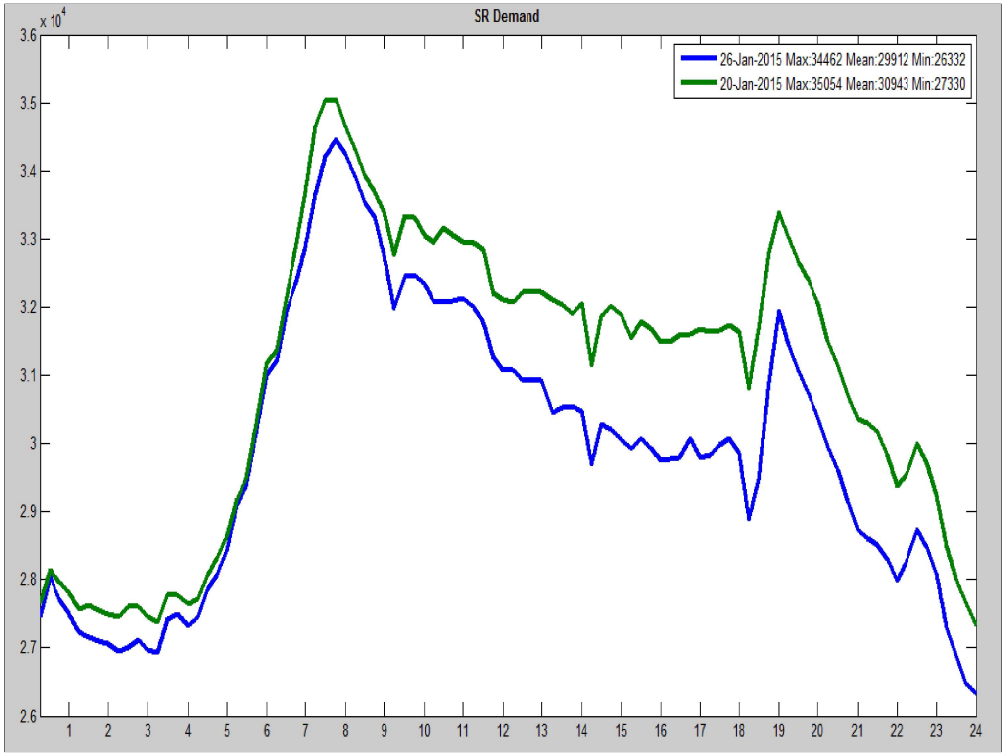
26-Jan-2015
(Predicted Load)




WR Demand
x 10^4
26-Jan-2015 Max:41957 Mean:35580 Min:29624
20-Jan-2015 Max:43117 Mean:37711 Min:31706


NR Demand
x 10^4
26-Jan-2015 Max:38097 Mean:33615 Mn:28036
20-Jan-2015 Max:39017 Mean:34537 Mn:29124


ER Demand
x 10^4
26-Jan-2015 Max:14577 Mean:12284 Min:10848
20-Jan-2015 Max:15475 Mean:13144 Min:11716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x 10^4
26-Jan-2015 Max:34462 Mean:29912 Min:26332
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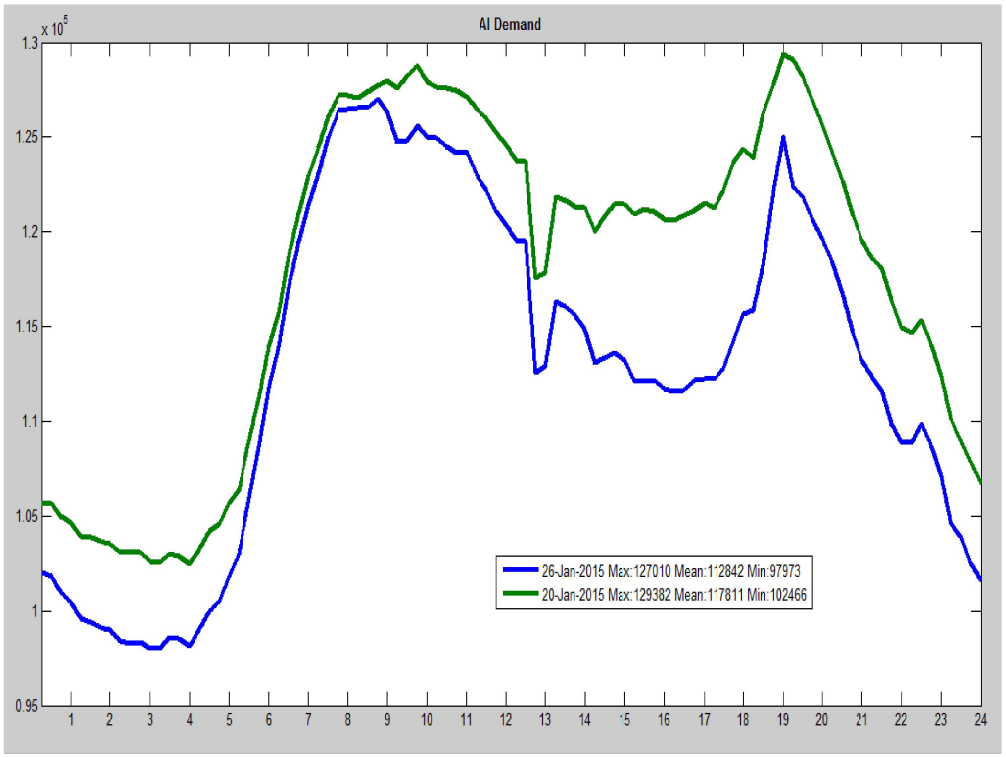
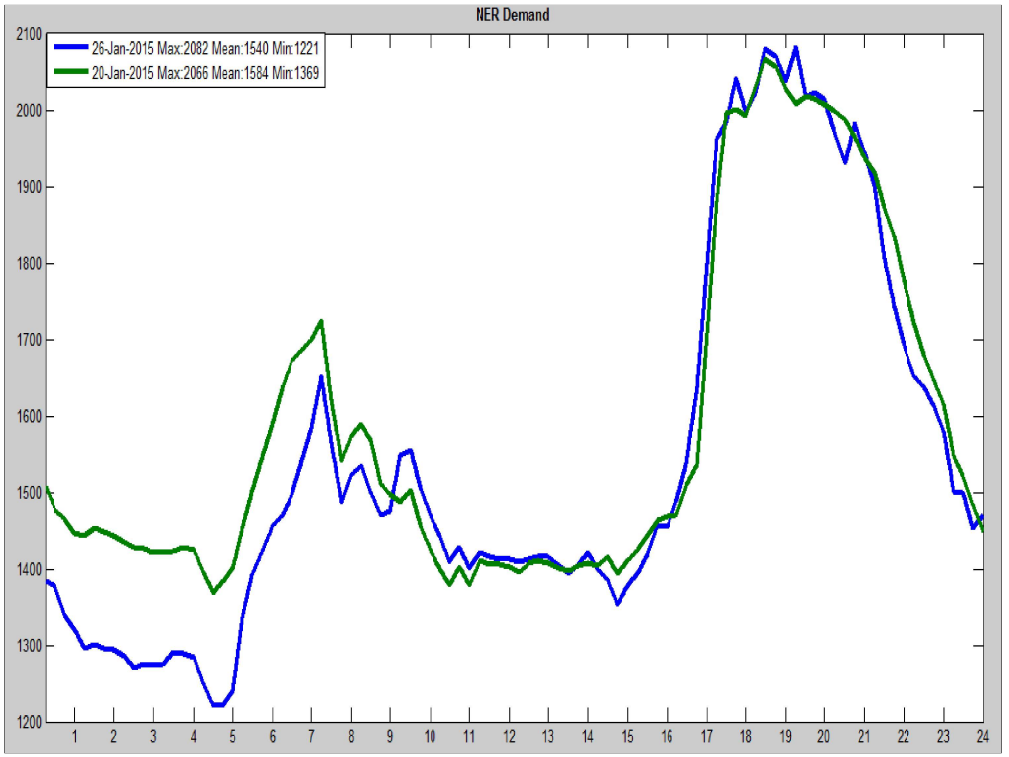
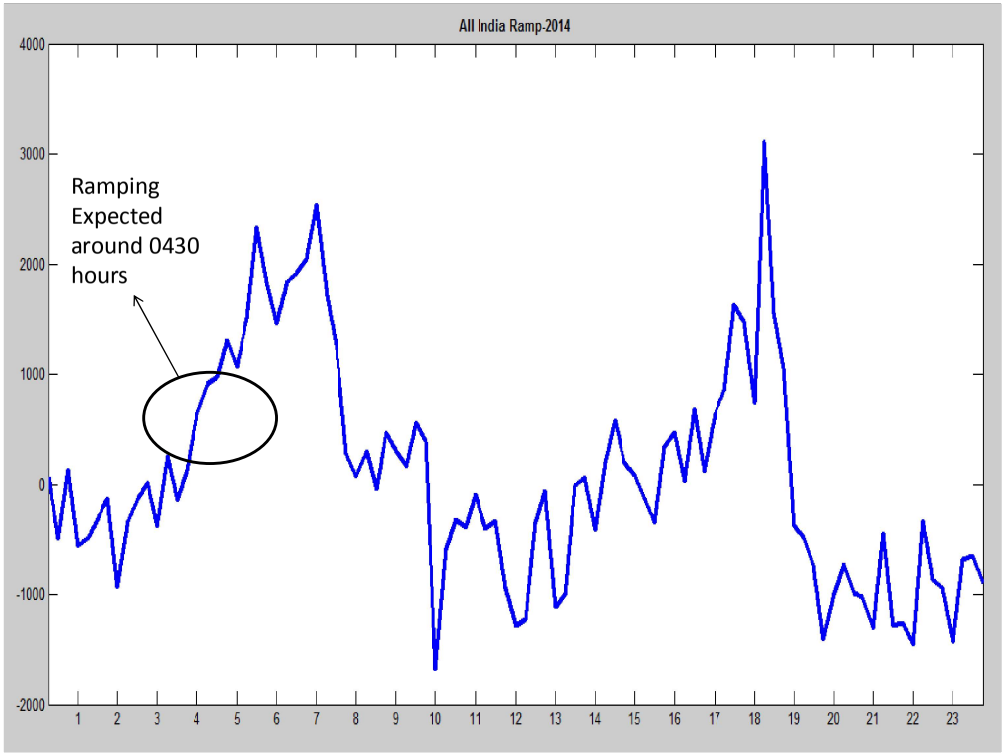
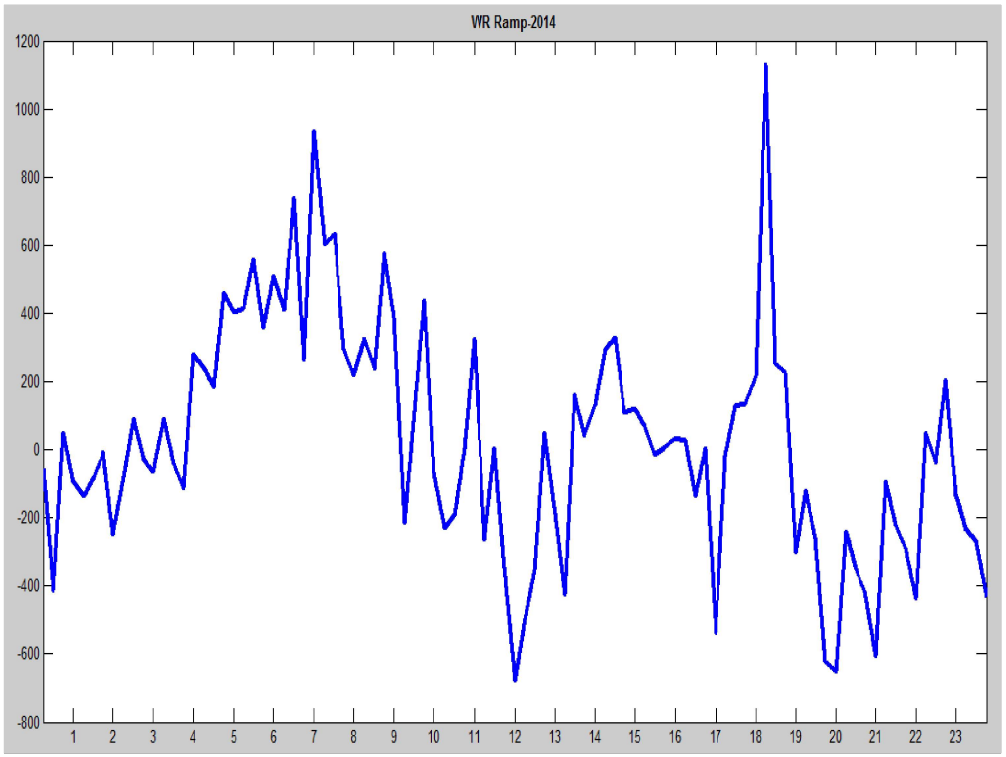
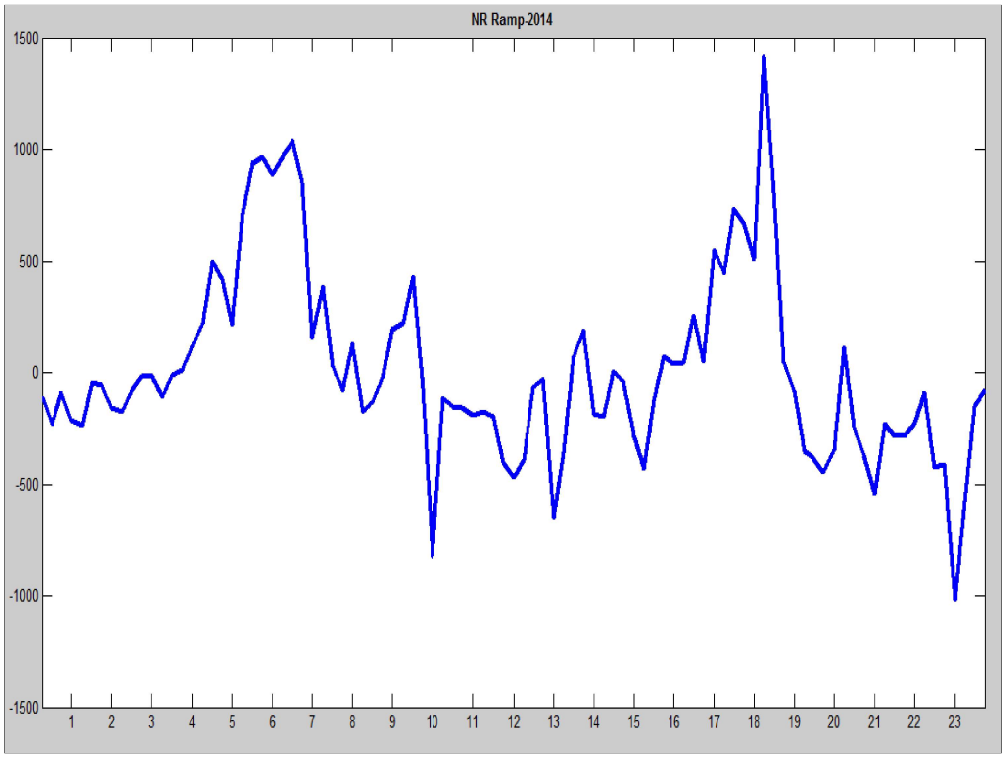






Ramp Rate-27 Jan'2014


WR Ramp-2014
1200
1000
800
600
400
200
0
-200
-400
-600
-800
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23


NR Ramp-2014
1500
1000
500
0
-500
-1000
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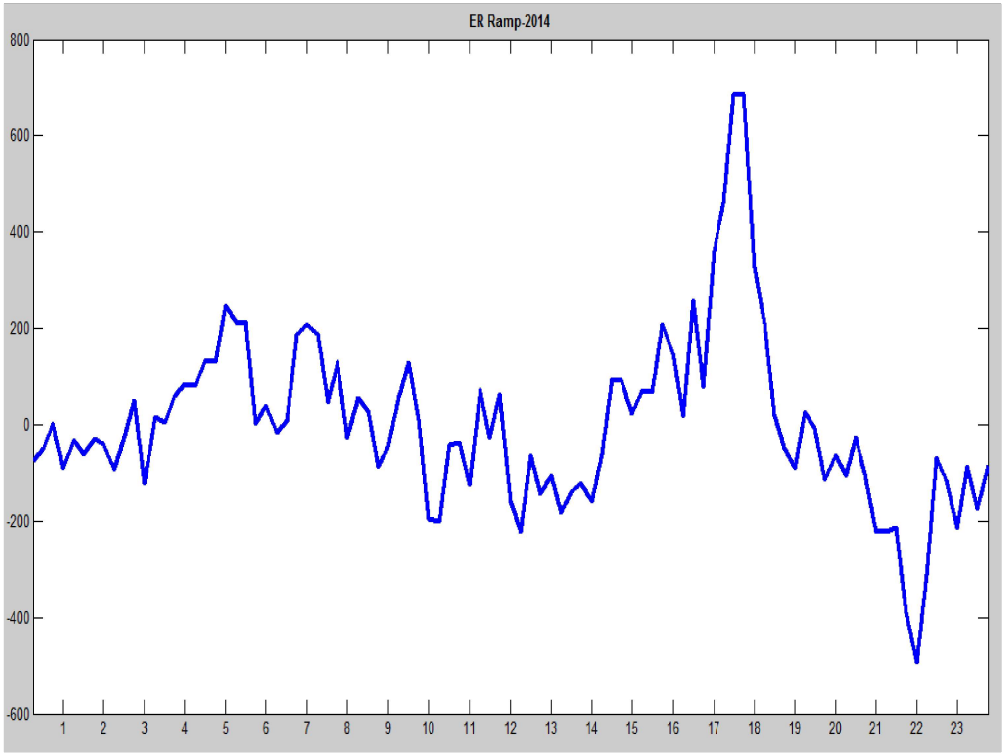
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23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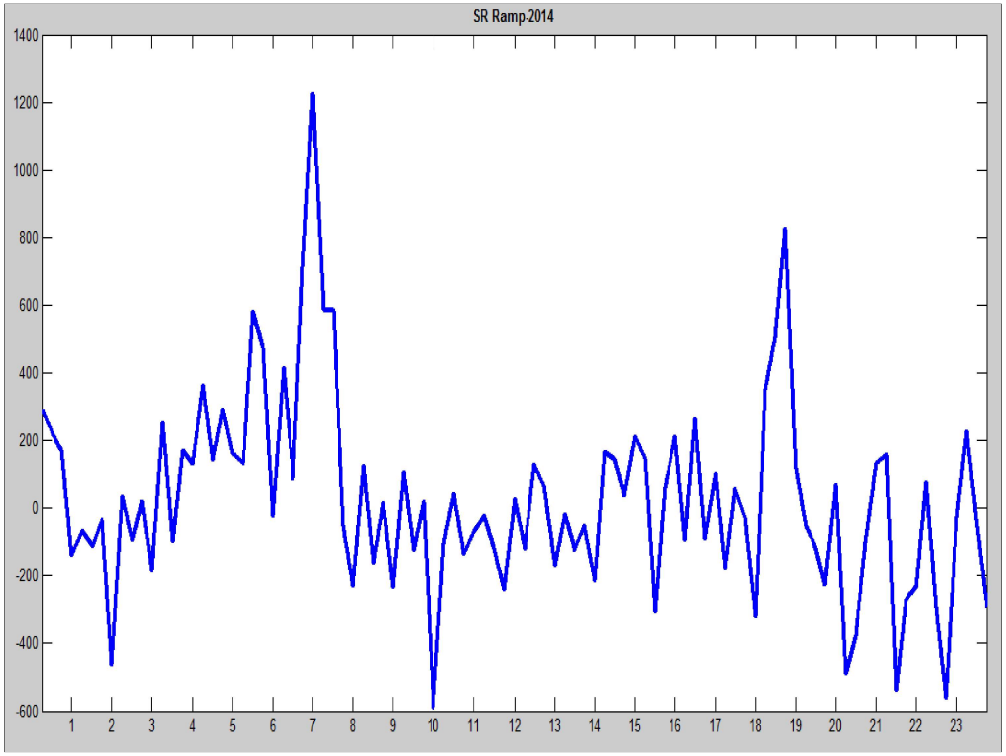
600
400
200
0
-200
-400
-600
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23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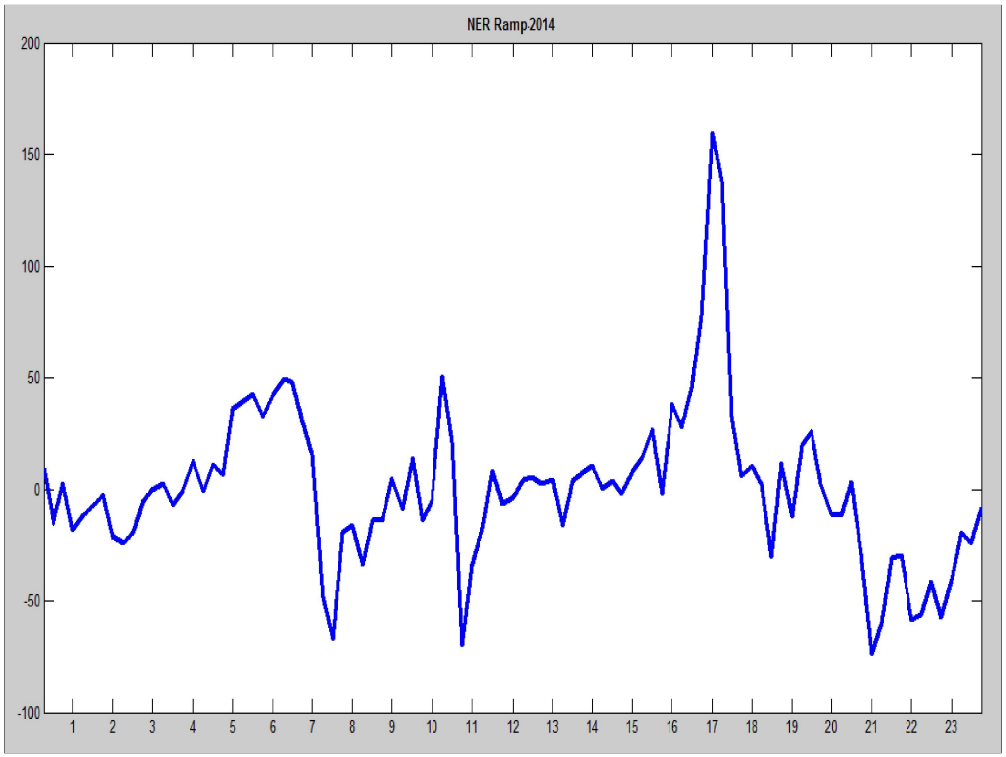
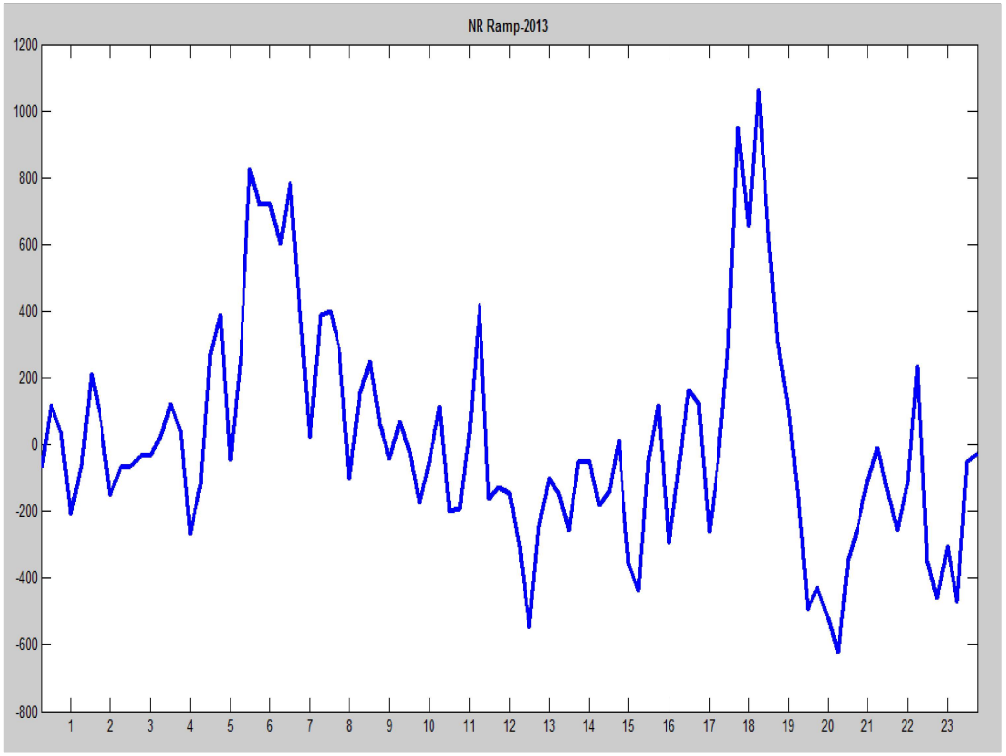
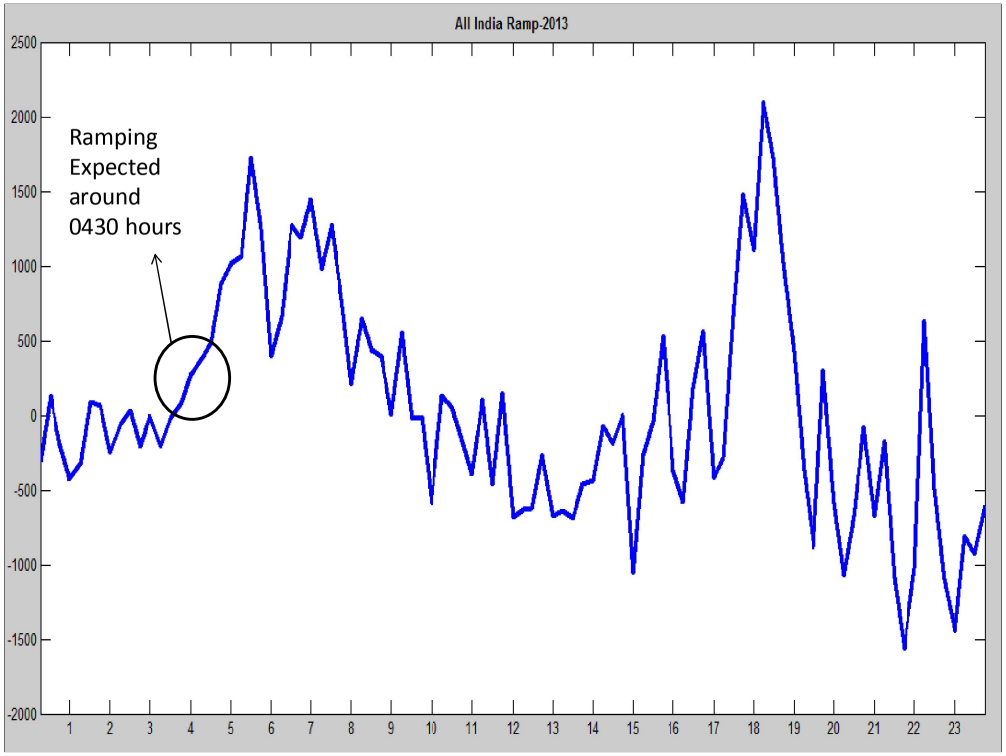
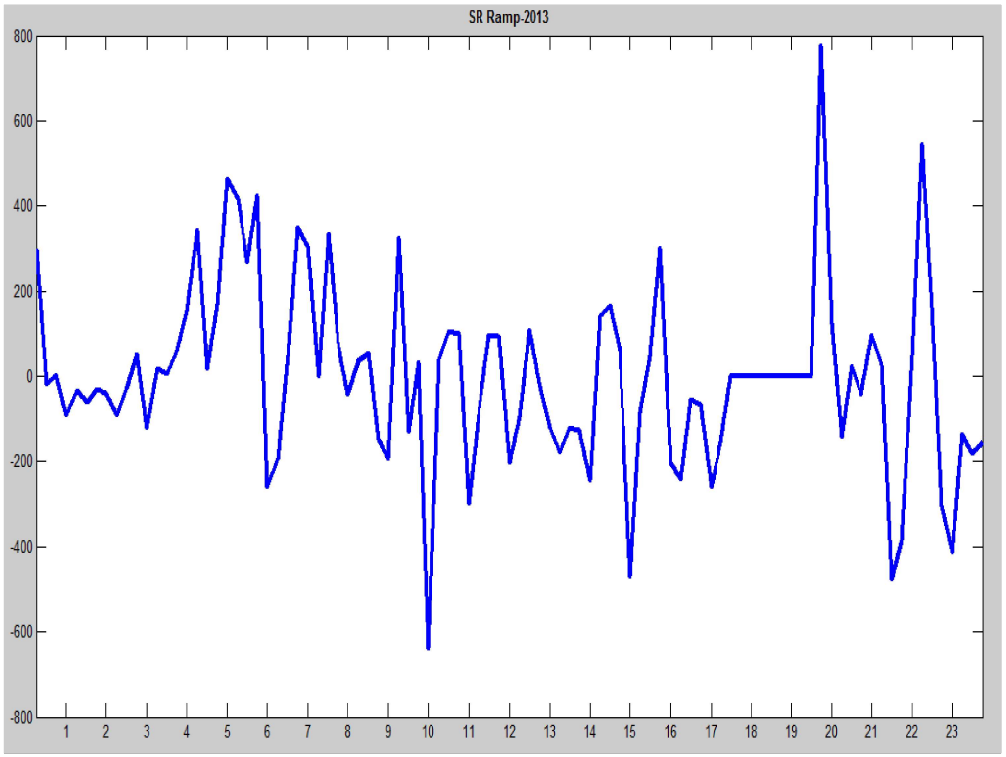
1400
1200
1000
800
600
400
200
0
-200
-400
-600
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

Ramp Rate-27 Jan’2013





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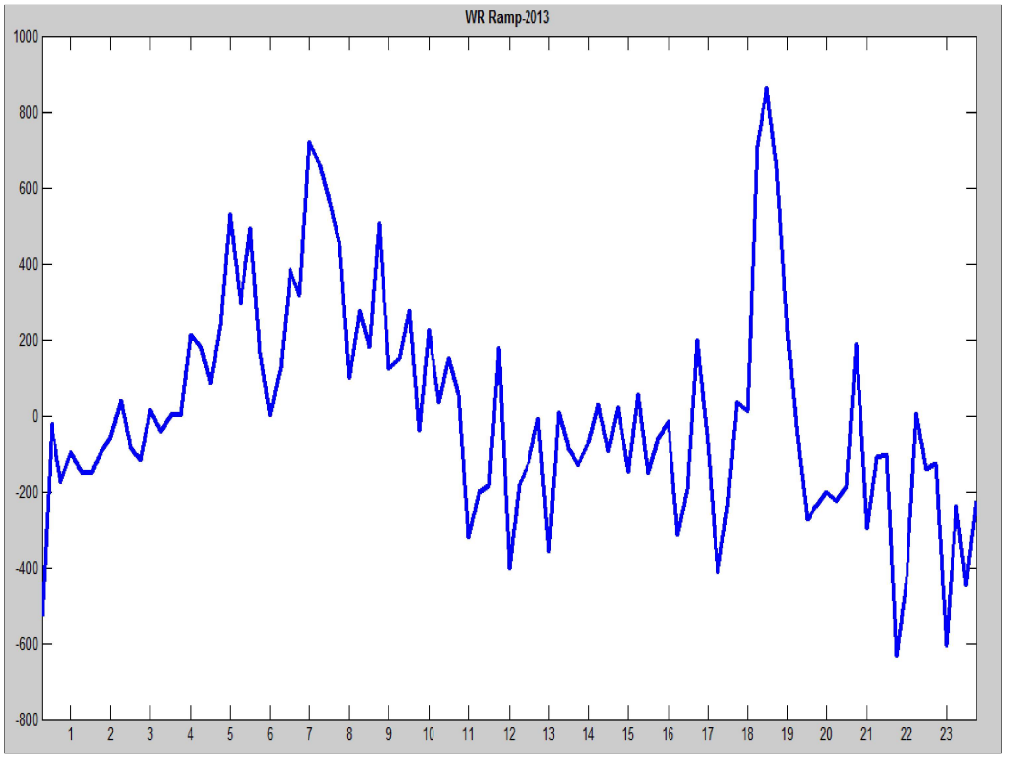
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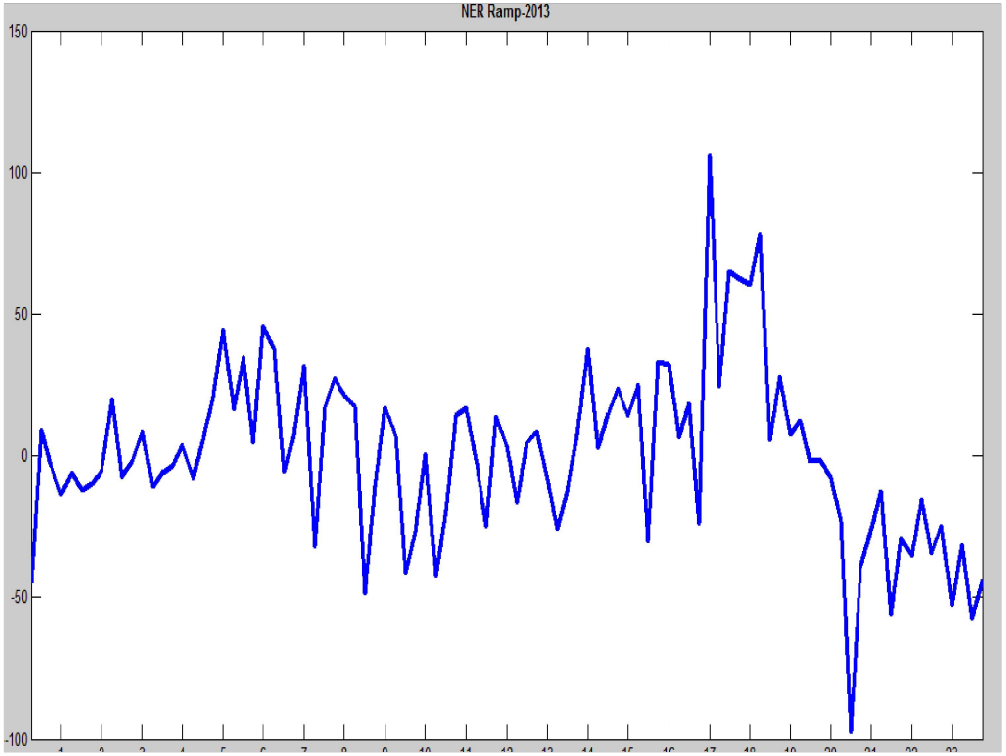
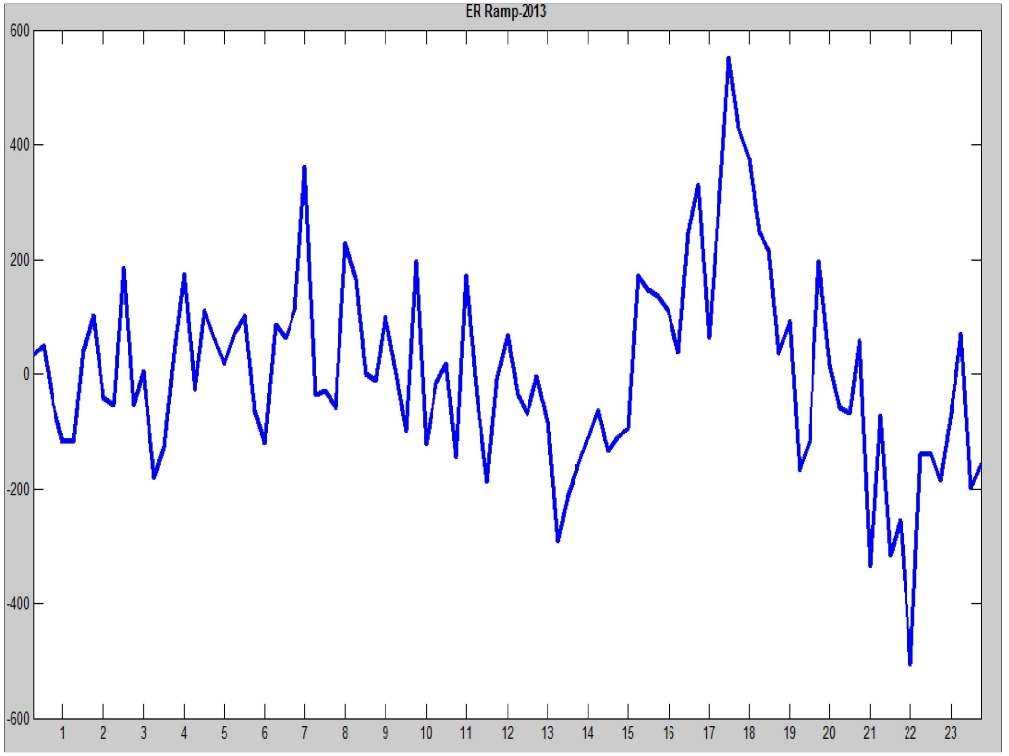

NER Ramp-2013


ER Ramp-2013

Weather Forecast

Region	Weather
All India	Normal with Mild Showers at Places
NR	Mild Shower
WR	Hazy Sun
SR	Sunny
ER	Sunny
NER	Hazy Sun

Region	% Energy Back Down for 26th Jan 2015
All India	0.16
NR	2.79
WR	0.97
SR	-0.78
ER	1.56
NER	1.01

* All figures are with respect to day Energy demand

	Predicted Demand on 26th January 2015					
Blocks	All India	NR	WR	SR	ER	NER
1	101995	30215	31053	27459	11846	1384
2	101818	29848	30778	28041	11753	1377
3	100956	29582	30489	27725	11796	1340
4	100426	29465	30427	27501	11681	1321
5	99598	29236	30139	27231	11664	1295
6	99391	29225	30069	27162	11603	1301
7	99118	29238	29800	27102	11655	1295
8	99004	29131	29780	27073	11698	1294
9	98408	28696	29797	26952	11643	1285
10	98238	28521	29740	27015	11658	1271
11	98344	28477	29850	27117	11588	1276
12	98024	28366	29760	26968	11620	1275
13	97973	28342	29624	26935	11767	1275
14	98568	28331	29645	27422	11852	1291
15	98541	28282	29673	27493	11770	1289
16	98105	28036	29678	27332	11732	1283
17	99080	28456	30097	27464	11763	1250
18	100001	28764	30338	27849	11777	1221
19	100488	28766	30562	28081	11806	1222
20	101851	29058	31183	28435	11879	1242
21	102992	28856	31786	29098	11872	1337
22	105706	29939	32701	29380	12252	1393
23	108671	31127	33524	30222	12356	1425
24	111760	32350	34537	31026	12393	1457
25	113967	33716	35545	31212	12052	1471
26	117061	34981	36861	31931	11885	1498
27	119429	36051	37741	32339	11902	1539
28	121409	36538	38541	32893	12023	1584
29	123019	35725	40073	33665	12113	1651
30	124978	36068	41011	34204	12347	1565
31	126389	36394	41786	34462	12487	1488
32	126492	36475	41957	34240	12494	1523
33	126533	37002	41866	33916	12385	1535
34	126519	37583	41815	33543	12260	1500
35	127010	38097	41909	33331	12372	1470
36	126321	37845	41913	32760	12400	1475
37	124763	37531	41119	31979	12577	1549
38	124821	37015	40985	32450	12771	1556
39	125604	37664	41205	32462	12757	1505

	Predicted Demand on 26th January 2015					
Blocks	All India	NR	WR	SR	ER	NER
40	125021	37609	40979	32345	12593	1470
41	124936	37969	40949	32066	12528	1443
42	124474	37998	40530	32071	12540	1409
43	124179	37517	40669	32091	12500	1427
44	124201	37549	40784	32131	12370	1401
45	122996	36860	40566	31995	12198	1421
46	122191	36710	40197	31772	12141	1415
47	121091	36113	40347	31257	11959	1413
48	120432	35725	40175	31067	12039	1412
49	119575	35766	39235	31080	12056	1409
50	119484	35558	39102	30915	12466	1413
51	112565	35093	38934	25129	12033	1417
52	112894	35030	38613	26168	11726	1416
53	116293	34757	37915	30457	11777	1404
54	116044	34892	37565	30528	11678	1394
55	115578	34691	37324	30556	11595	1406
56	114796	34023	37349	30481	11500	1421
57	113088	33591	37131	29691	11226	1400
58	113349	33937	36796	30288	10913	1386
59	113630	34191	36950	30204	10911	1354
60	113206	33965	36920	30060	10848	1379
61	112127	32877	36860	29930	11003	1395
62	112115	32970	36586	30068	11013	1420
63	112147	32879	36949	29930	10872	1457
64	111690	32944	36617	29765	10867	1455
65	111562	33016	36323	29774	10933	1489
66	111638	33029	36081	29795	11155	1539
67	112173	33334	35742	30080	11349	1637
68	112204	33329	35621	29794	11660	1799
69	112226	33370	35423	29826	11656	1961
70	112742	33240	35126	29980	12386	1984
71	114308	33566	35170	30078	13438	2041
72	115682	34540	35179	29849	14131	1998
73	115871	35513	35006	28893	14455	2024
74	118228	36529	35607	29481	14577	2080
75	122206	36865	36329	32905	14392	2070
76	125040	37778	36562	34948	14398	2039
77	122397	37735	36713	31426	14529	2082
78	121875	37790	36637	31064	14485	2017

Predicted Demand on 26th January 2015						
Blocks	**All India**	**NR**	**WR**	**SR**	**ER**	**NER**
79	120691	37164	36465	30744	14399	2024
80	119635	36523	36361	30401	14433	2014
81	118451	36411	35912	29973	14280	1972
82	116668	35695	35459	29604	14066	1932
83	114697	34841	34798	29132	14026	1983
84	113208	34230	34299	28739	14065	1945
85	112369	34030	34111	28616	13785	1902
86	111613	33673	34055	28518	13651	1806
87	109882	33100	33514	28313	13281	1743
88	108870	32983	33161	27978	13111	1692
89	108902	33394	32826	28301	12749	1651
90	109839	33873	33067	28743	12543	1638
91	108650	33074	33114	28477	12408	1612
92	107093	32425	33024	28083	12005	1579
93	104618	31796	32414	27308	11612	1501
94	103924	31682	32368	26883	11500	1499
95	102574	31422	31973	26486	11260	1453
96	101534	30924	31829	26332	10986	1470

CENTRAL ELECTRICITY REGULATORY COMMISSION
NEW DELHI

Petition No. 11/SM/2015

Coram:
Shri Gireesh B. Pradhan, Chairperson
Shri A.K. Singhal, Member
Shri A.S. Bakshi, Member
Dr. M.K. Iyer, Member

Date of Order: 13.10.2015

In the matter of
Roadmap to operationalise Reserves in the country

ORDER

The Electricity Act, 2003 entrusts on the Central Commission important responsibilities inter-alia of regulating the inter-State transmission of electricity, specifying grid code and also enforcing standards with respect to quality, continuity and reliability of service by licensees. Laying down of framework for effective and secure grid operation is thus one of the most important mandates of the Commission. The Central Commission has taken initiatives towards this end through regulations on Indian Electricity Grid Code and Deviation Settlement Mechanism and related matters. The Commission has also issued direction from time to time for enforcing grid discipline.

2. Over the period, reliance of the utilities on the grid for meeting their short term energy demand was increasing. This caused serious threat to grid security. The Commission, therefore, tightened the operating band of grid frequency and made deviation charges stringent enough to discourage the utilities from deviation from their schedule. This has started yielding the desired results in terms of operation of the grid

closer to 50 Hz. The Commission has reiterated time and again that un-scheduled inter-change (UI) mechanism cannot be used as platform for meeting the energy demand of the utilities. Last mile imbalances are inevitable, but for this reliance on grid is not desirable. This need be planned for, and adequate reserves need be contracted to address such last mile imbalances.

3. The National Electricity Policy (NEP) mandates that adequate reserves may be maintained to ensure secure grid operation:

> "5.2.3 In order to fully meet both energy and peak demand by 2012, there is a need to create adequate reserve capacity margin. In addition to enhancing the overall availability of installed capacity to 85%, a spinning reserve of at least 5%, at national level, would need to be created to ensure grid security and quality and reliability of power supply."

4. However, creation of adequate system reserve margin and spinning reserves at national level has not yet materialised. In furtherance to the provisions relating to the requirement of Spinning Reserves in the Electricity Act, 2003, National Electricity Policy and Tariff Policy, and to facilitate-large scale integration of renewable energy sources, balancing, deviation settlement mechanism and associated issues, CERC constituted a Committee vide letter No, 25/1/2015/Reg. Aff. (SR)/CT.RC dated 29th May 2015, under the chairmanship of Shri A.S. Bakshi, Member CERC, to examine the technical and commercial issues in connection with Spinning Reserves and evolve suggested regulatory interventions in this context.

5. The Committee submitted its final report to the Commission on 17th September 2015 (annexed as Annexure-I). Major findings of the Committee are as under:

(a) Spinning Reserves are required to be maintained of requisite quantum depending upon the grid conditions. Operation at constant frequency target of 50.0 Hz with constant area interchange should be the philosophy adopted.

(b) The Spinning Reserve may be maintained, to start with at the regional level in a distributed manner.

(c) The respective RLDC should be the Nodal agency at the regional level and NLDC at the country level.

(d) Each region should maintain secondary reserves corresponding to the largest unit size in the region and tertiary reserves should be maintained in a de-centralized fashion by each state control area for at least 50% of the largest generating unit available in the state control area. This would mean secondary reserves of 1000 MW in Southern region; 800 MW in Western regions; 800 MW in Northern region; 660 MW in Eastern region and 363MW in North-Eastern region (total approx. 3600 MW on an All India basis). Primary reserves of 4000 MW should be maintained on an All India basis considering 4000 MW generation outage as a credible contingency. The same should be provided by generating units in line with the IEGC provisions.

(e) The reserve requirement may be estimated by the nodal agency on day-ahead basis along with day ahead scheduling of all available generating stations.

(f) Implementation of AGC is necessary along with reliable telemetry and communication. The AGC may be planned to be operationalised in the power system from 1.4.2017.

(g) It is essential that load forecasting is done at each DISCOM level, at each SLDC/State level and each RLDC/Regional level and finally at NLDC/country level.

(h) It is also essential to forecast the generation from renewable sources of energy by the generators, and similarly by the DISCOMs, by the SLDCs and by the RLDCs.

(i) To start with a regulated framework in line with the Ancillary Services Regulations may be evolved for identification and utilising of spinning reserves and implemented with effect from 1.4.2016. This framework may continue till 31.3.2017.

(j) The reserves at the regional level, should be assigned to specific identified generating station or stations duly considering the various technical and commercial considerations including energy charges of the generating stations. The nodal agency should be empowered to identify the ISGS irrespective of type and size of the generating station for providing spinning reserve services and it should be mandatory for such generating stations to provide spinning reserve services.

(k) The nodal agency may have the option of carrying such reserves on one or more plants on technical and commercial considerations and may withhold a part of declared capacity on such plants from scheduling. It could be in terms of % of declared capacity or in MW term as deemed fit.

(l) A framework as specified in the Central Electricity Regulatory Commission (Ancillary Services Operations) Regulations, 2015 may be followed for the Spinning Reserve Services as well. The Central Electricity Regulatory Commission (Ancillary Services Operations) Regulations, 2015 may be amended to incorporate the necessary changes in this regard.

(m) Going forward, a market based framework may be put in place from 1st April 2017 for achieving greater economy and efficiency in the system. A detailed study is required to be carried out before the market mechanism on spinning reserves is put in place. It is suggested that the NLDC be directed to commission study through a consultant in the context and submit a proposal to the Commission for approval.

The Commission has carefully considered and accepted the findings of the Committee.

6. One of the important components of ensuring grid reliability includes achieving adequacy of supply and maintaining the load-generation balance. This poses a challenge to grid operators on various time-scales: on a daily level as weather varies, for example, on an hourly level as load varies during the day, and on sub-hourly/time-

block level as there are errors in forecasting of load or unplanned outages of generating units or transmission lines. Sudden disturbances in the Power System can initiate a steep fall or rise in the frequency of the Power System, which can be detrimental to the Power System operation, if not contained immediately. Thus, to ensure 24x7 power supply and grid reliability, grid operators must have access to reserves at different locations and factoring transmission constraints, the system operators should be able to increase or decrease power supply on the grid at any time of the day.

7. Three types of reserves are generally considered depending on the timeline of initiation and functional need. Primary control refers to local automatic control available in all conventional generators, which delivers reserve power negatively proportional to frequency change. Such immediate automatic control is implemented through turbine speed governors, in which the generating units respond quickly to the frequency deviation as per droop characteristic of the units. However, this response to arrest frequency drop or rise lasts for short period of up to 30 seconds - 15 minutes, within which secondary control should come into play should the contingency last longer than that. IEGC section 5.2(i) specifies a provision for primary reserves, as under:

> "The recommended rate for changing the governor setting, i.e., supplementary control for increasing or decreasing the output (generation level) for all generating units, irrespective of their type and size, would be one (1.0) per cent per minute or as per manufacturer's limits. However, if frequency falls below 49.7Hz, all partly loaded generating units shall pick up additional load at a faster rate, according to their capability."

However, this has not been adhered to fully by the generators.

8. Secondary control involves Automatic Generation Control (AGC) which delivers reserve power in order to bring back the frequency and the area interchange programs to their target values. For AGC, units as well as load dispatch centres have to be equipped with necessary communication infrastructure, as it involves sending automated control signals from the LDC to the generator based on grid conditions. AGC has been absent in the Indian power system. Very commonly, this results in 'load shedding' by DISCOMs in case generation is lagging load. The Indian power sector was beset with scarcity for a long time; however, now the scenario is changing and margin for reserves is feasible. With a large interconnected grid meeting a peak load of over 145 GW, both primary and secondary controls are essential components for reliable grid operation.

9. Tertiary control refers to manual change in the dispatching and unit commitment in order to restore the secondary control reserve, as loss of generator may cause a system contingency that lasts for several hours.

10. Traditionally, imbalance handling on the Indian grid has been done through the Unscheduled Interchange (UI) or the Deviation Settlement Mechanism (DSM) framework, in which the frequency-linked UI rate gave a signal to the grid participants to correct for instantaneous frequency deviations. However, it led to use not meant for, and further grid indiscipline besides stress/constraints in the transmission network. While measures like tightening of the operating grid frequency band and provision for deterrent deviation charges, have been resorted to and this has resulted in improvement of grid operation, the Commission feels that the power system operation in

the country still needs to mature further. Even now States have been deviating from schedule substantially. For instance, in 2014-15, Rajasthan deviated in the range of (+) 1202 to (-) 1324; UP in the range of 1613 to (-) 2291; Karnataka in the range of 945 to (-) 787 etc.; Tamil Nadu in the range of 546 to (-) 990; Gujarat in the range of 1174 to (-) 1162. These are not only undesirable but also a cause of serious concern. The DSM Regulations provide for a periodic review of the DSM rates and the Commission directs the Staff to undertake a review of the same and submit a proposal for consideration of the Commission.

11. The Commission would like to underscore that grid does not generate electricity and as such cannot be relied upon for meeting energy needs. Reserves and reserves alone can address this and the earlier the stakeholders realise this, the better it is for safe and secure system operation. Reserves assume greater significance additionally in the wake of the goal of integration of large scale variable renewable energy sources. With increasing penetration of variable and intermittent RE generation, flexible generation such as pumped storage hydro plants are needed. There is a need for more flexibility in the operation of conventional generation plants also and flexibility needs to be quantified, measured and duly compensated for. The Commission has already made a beginning in this direction by proposing amendment to the Indian Electricity Grid Code (IEGC) in respect of 'technical minimum' which is expected to be notified shortly. 'Ramp up' and 'ramp down' rates are other important parameters for flexibility which would gradually be introduced through Regulations.

12. The grid operator would now be required to undertake planning exercise to meet Net Load, which is defined as: Net load = Load – RE power. This quantum must be met with conventional generation with adequate flexibility at every point in time. To even begin an exercise of planning for ongoing load-generation balance, load forecasting is essential. It is also necessary to ensure conventional generators to generate as per the schedules. Forecasting and scheduling of solar and wind generating stations is the next critical step for the grid operators to estimate the amount of RE power they can anticipate to be injected into the grid, on a day-ahead and hour-ahead basis. Thus, the variability that can be predicted in the forecasts must be accounted for in planning flexible generation as well as tertiary reserves day-ahead and hour-ahead. Furthermore, balancing the uncertainty of RE power on a continuous basis necessitates a streamlined process for deploying spinning reserves. This would be effectively balancing the forecasting error in net load.

13. The Commission notified Central Electricity Regulatory Commission (Ancillary Services Operations) Regulations, 2015 on 19th August 2015 with the objective of utilizing un-requisitioned surplus in ISGS. These regulations are a first step towards the entire gamut of Ancillary Services, starting with tertiary frequency control services. Applicable to regional entities, the regulations outline a framework for both Regulation Up and Regulation Down service by Reserves Regulation Ancillary Services (RRAS) providers. NLDC along with RLDC, operating as the nodal agency, shall call for these services in varying situations, such as extreme weather events, loss of generating unit

or transmission line outage, load-generation imbalance, etc. The RRAS providers shall be paid from the Regional DSM Pools.

14. Furthermore, the Commission notified the Order on Extended Market Session on Power Exchanges on 8th April, 2015, and the power exchanges started operating extended hours for intra-day products by end of July. The trading window is now open round-the-clock for delivery of power on the same day, with a 3-hour delivery time-frame. This can enable to significantly correct for intra-day imbalances in a proactive manner, and not passively rely on the grid for the same. It is expected that the Distribution Control Centres (DCCs) of DISCOMs also operate in a 24 x 7 manner to reap the advantages from these extended market sessions. Depending on the market needs, there is a need for newer products in the electricity market to provide more opportunities to the participants to balance their portfolio. The Commission directs the staff to examine this aspect of market design and submit a proposal for consideration of the Commission.

15. It is also expected that with provision for reserves and harnessing the same through 'controls', the inter area power flows would be manageable and help in optimizing the Transmission Reliability Margin (TRM). This would benefit all stakeholders to a great extent.

16. In due recognition of the above factors, the Commission would like to chart out a road map for introduction of reserves in the country. Accordingly, the Commission directs as under:

(a) For reliable and secure grid operation, to maintain continuous load-generation balance, to counter generation outages as well as unexpected load surges or crashes, and for large scale integration of variable renewable power, it is essential for the grid operators to have access to distributed Spinning Reserves which are dispatched taking due care of transmission constraints whenever required.

(b) The Commission reiterates the need for mandating Primary Reserves as well as Automatic Generation Control (AGC) for enabling Secondary Reserves.

(i) All generating stations that are regional entities must plan to operationalise AGC along with reliable telemetry and communication by 1st April, 2017. This would entail a one-time expense for the generators to install requisite software and firmware, which could be compensated for. Communication infrastructure must be planned by the CTU and developed in parallel, in a cost-effective manner.

(ii) On the other hand, National/Regional/State Load Dispatch Centres (NLDC/RLDCs/SLDCs) would need technical upgrades as well as operational procedures to be able to send automated signals to these generators. NLDC /RLDCs and SLDCs should plan to be ready with requisite software and procedures by the same date.

(iii) The Central Commission advises the State Commissions to issue orders for intra-state generators in line with this timeline as AGC is essential for reliable operation of India's large inter-connected grid.

(c) To start with, a regulated framework in line with the Ancillary Services Regulations would need be evolved for identification and utilising of spinning reserves and implemented with effect from 1st April, 2016. This framework may continue till 31st March, 2017. This may only include generating stations regulated by CERC, which could be started off with a manual process for secondary reserves. The NLDC/POSOCO is directed to submit a detailed procedure in this regard for approval by the Commission within one month from the issue of this Order. The amendments required in various Regulations issued by the Commission would also need to be indicated. As the Renewable Energy (RE) penetration levels increase in the coming years, the impact on the quantum of reserves would need to be separately studied and provided for through further amendments.

(d) In the long term, however, a market based framework is required for efficient provision of secondary reserves from all generators across the country. For this, NLDC/POSOCO is directed to commission a detailed study through a consultant and suggest a proposal to the Commission for implementation by 1st April, 2017, giving due consideration to the experience gained in the implementation of Spinning Reserves w.e.f. 1st April, 2016.

(e) The States must undertake separate scheduling and energy accounting of all generating and load entities. Deployment of DSM framework shall greatly prepare the State to differentiate between and attribute deviations caused due to various entities involved. Recording of this data shall also give the State grid operator much needed clarity on which entities are responsible for schedule deviations, and to what extent.

(f) Load forecasting must be undertaken by all DISCOMs. Combined with DSM, it is the foundation on which strong and reliable grid management can be built.

(g) In order to ensure reliable and secure operation of the grid, in addition to compliance to standards and regulations, adequate defense mechanisms such as Under Frequency Relays (UFRs), df/dt (rate of change of frequency), System Protection Schemes (SPS), etc. must be put in place and which also need to be periodically reviewed and checked for healthiness.

17. The petition is disposed of in terms of the above directions.

sd/-	sd/-	sd/-	sd/-
(Dr. M.K. Iyer)	**(A. S. Bakshi)**	**(A.K. Singhal)**	**(Gireesh B. Pradhan)**
Member	**Member**	**Member**	**Chairperson**

ANNEXURE – I

REPORT OF

THE COMMITTEE

ON SPINNING RESERVE

September 17, 2015

CENTRAL ELECTRICITY REGULATORY COMMISSION NEW DELHI

ACKNOWLEDGEMENT

This report has been finalized with the support of several stakeholders. The Committee is thankful to all of them and places on record the contribution made by each one of them. We would like to make a special mention of Shri S R Narasimhan, Shri S C Saxena, Shri S S Barpanda of POSOCO and Ms Shruti Deora of CERC for their active involvement and painstaking efforts in helping the Committee in finalizing its recommendations

INDEX

Executive Summary

The most important responsibility of the Power System operators is to maintain reliability of the Power System. The maintenance of Load - Generation balance is one important aspect of reliability. There are a number of uncertainties associated with Power System. There is an increasing penetration of Renewables (both Wind and Solar) in the country, and considering the fact that their generation output can vary unexpectedly, it poses more challenges in the operation of Indian Power system and creation of system reserves becomes much more desirable. Therefore, the committee is of the view that spinning reserves are required to be maintained of requisite quantum depending upon the grid conditions.

The philosophy of operation at constant frequency target of 50.0 Hz with constant area interchange may be adopted in the interest of grid security and reliability. However, in India, the creation of adequate system reserve margin and spinning reserve of 5% at national level has not yet materialized. It is observed that in India, primary response is mandated through the IEGC, but the actual response is much less than the ideal response or the desired response. One important reason behind this inadequate response is the generators not keeping sufficient Reserves from their maximum capacity. Other reasons for non-compliance could be technical difficulties at the power plant level.

Secondary control is implemented, in multi utility power pools, through an automatic generation control scheme operated centrally taking into account both frequency deviation and area wise tie-line power flow deviations through a combined Area Control Error (ACE= $\Delta P_{tie} + k \Delta f$). Secondary control has not been implemented in India as yet. To implement secondary control, some infrastructure is needed. Units have to be wired under AGC (Automatic Generation Control) and both sides communication between control room and generators has to be provided. AGC (Automatic Generation Control) software is needed to implement and handle the calculations, as this is an automatic process. The committee is of the view that

implementation of AGC is necessary along with reliable telemetry and communication. The AGC may be planned to be operationalized in the Indian power system from 01st April, 2017.

After exhaustive literature review, the committee had come across various terminologies, in the context of reserves, prevalent worldwide with different meanings. The Indian Electricity Grid Code (IEGC), 2010 provides the definition which includes primary reserve also as the spinning reserves. Therefore, the committee is of the view that suitable amendment in IEGC, 2010is required modifying the definition of spinning reserve and definition of primary reserve is made separately. The committee recommends that the definition of Spinning Reserve in IEGC, 2010may be modified as *"The spinning reserve means "the capacity which can be activated on decision of the system operator and which is provided by devices which are synchronized to the network and able to effect the change in active power."*

Renewable forecast and renewable scheduling form the basis for calculating the Power Reserve needed with respect to Renewable. CERC through Forum of Regulators (FOR) has strongly emphasized States to operationalize a similar framework for the intra-state RE generators. This will ensure that SLDCs as well as RLDCs have visibility into net load that must be met through conventional generators and spinning reserves.

In terms of National Electricity policy, spinning reserves at 5% of the Installed Generation Capacity of around 272 GW works out as 13600 MW. Using the Demand data of 7 years from 2008 to 2015, variability of All India Demand taking the hourly and 15 minute variations of the All India Demand met was studied. The variability and the statistical index of 3σ suggests a tertiary reserve of at least 7000 MW and secondary reserves of the order of 2500 MW. Therefore, the committee recommends that the spinning Reserve may be maintained, to start with, at the regional level. The respective RLDC shall be the Nodal agency at the regional level and NLDC at the country level. Each region should maintain secondary reserve corresponding to the largest unit size in the region and Tertiary reserves should be maintained in a de-centralized fashion by

each state control area for at least 50% of the largest generating unit available in the state control area.

The committee also had detailed deliberations on the question of which of the stations may carry these spinning reserves. To start with, it is felt that the spinning reserves may be carried on the ISGS regulated by CERC and for the present, UMPP and other competitive bid projects may be kept out of this. Nevertheless, a framework needs to be evolved which provides clear guidelines for determination of quantum of spinning reserve, identifying the generating units, decide the compensation for the generators, energy accounting and its requisite commercial settlement by a nodal agency. The respective RLDCs and the NLDC may be the nodal agencies for the respective region and the country as a whole.

The nodal agency may be empowered to identify the ISGS irrespective of type and size of the generating station for providing spinning reserve services and it should be mandatory for such generating stations to provide spinning reserve services. The committee recommends that the reserve requirement may be estimated by the nodal agency on day-ahead basis along with day ahead scheduling of all available generating stations. It is essential that load forecasting is done at each DISCOM level, at each SLDC/State level and each RLDC/Regional level and finally at NLDC/country level. It is also essential to forecast the generation from renewable sources of energy by the generators, by the DISCOMs, by the SLDCs and by the RLDCs. The committee is of the view that no generating unit may be earmarked exclusively as reserves. Rather the margins available on part loaded generating units may be the reserve actuated through different means. (primary, secondary or tertiary). Further, the scheduling limit as a percentage of Declared Capability (DC), might need to be done for the power station so that margins are available for secondary and tertiary control.

The committee is of the opinion that a framework as specified in the CERC (Ancillary Services Operations) Regulations, 2015 may be followed for the Spinning Reserve Services as well. CERC (Ancillary Services Operations) Regulations, 2015 may

be amended to incorporate the necessary changes in this regard. In the meantime, to start with, the committee proposes that the regulated framework in line with the Ancillary Services Regulations may be evolved for identification and utilising of spinning reserves and implemented with effect from 1.4.2016. This framework may continue till 31st March, 2017. Thus, going forward, a market based frame work may be put in place from 1st April 2017 for achieving greater economy and efficiency in the system. A detailed study may be required to be carried out before the market mechanism on spinning reserves is put in place. It is suggested that POSOCO may be directed to commission study through a consultant in this context and submit a proposal to the CERC for approval.

Chapter – I

Background

1. BACK GROUND

1.1 Para 5.2.3 of the National Electricity Policy (NEP) mandates that adequate reserves may be maintained to ensure secure grid operation. The same is reproduced below:

> *"5.2.3 In order to fully meet both energy and peak demand by 2012, there is a need to create adequate reserve capacity margin. In addition to enhancing the overall availability of installed capacity to 85%, a spinning reserve of at least 5%, at national level, would need to be created to ensure grid security and quality and reliability of power supply."*

1.2 However, the creation of adequate system reserve margin and spinning reserve of 5% at national level has not yet materialised. However, with the large capacity augmentation during 11th and 12th plans, it is felt that it is high time that such reserves were created.

2. Constitution of Committee to draft CERC Regulations on Spinning Reserves

2.1 In furtherance to the provisions relating to the requirement of spinning reserves in the Electricity **Act,** 2003, National Electricity Policy and Tariff Policy, and to facilitate-large scale integration of renewable energy sources, balancing, deviation settlement mechanism and associated issues, CERC constituted a **Committee** vide letter No, 25/1/2015/Reg. Aff. (SR)/CT.RC dated 29th May 2015 **with** the following composition to go into the technical and commercial issues in connection with the Spinning Reserves and evolve a base paper including the suggested regulatory interventions in the form of **regulations** of **amendments** to the existing regulations, in this context.

1. **Shri A.S.Bakshi, Member, CERC**	**Chairperson**
2. Smt. Shubha Sarma, Secretary, CERC	Member
3. Shri S.K.Soonee, CEO, POSOCO	Member
4. Shri S.C.Srivastava, JC (Engg,), CERC	Member
5. Shri H.T.Gandhi, JC (Fin), CERC	Member
6. Representative of CEA	Member
7. Representative of NTPC	Member
8. Representative of Pvt. Gencos. (to be co-opted by the Committee)	Member
9. DR. Sushanta K Chatterjee, JC (RA), CERC	Member-Secretary

2.2 The Committee was asked to *inter alia* consider the relevant provisions of the National Electricity Policy, Tariff Policy, the provisions contained in the Electricity Act, 2003 and to examine, analyze and draft regulations on spinning reserves.

2.3 The Committee was allowed to co-opt any other expert as deemed fit. The Committee was to draft regulations within three weeks from the date of issue of the notification.

2.4 The Committee held its first meeting on 3rd June 2015 and decided to invite representatives from IPPs, CPSUs and State generating companies as special invitees in the next meeting for wider consultation and seek their valuable opinion on creating a desirable framework for Spinning Reserves for power system operation in India. The following persons were invited as special invitees or to depute a suitable person for the meeting:

1. Shri Anil Sardana, CEO& Managing Director, M/s. Tata Power Company Ltd., Mumbai, Maharashtra
2. Shri Anil Dhirubhai Ambani, Managing Director, M/s. Reliance Power, Mumbai, Maharashtra
3. Shri Vineet S. Jain, M/s. Adani Power Limited, Ahmedabad, Gujarat
4. Shri Jinal Mehta, Director, M/s. Torrent Power Limited, Ahmedabad, Gujarat
5. Shri R.S.T. Sai (Additional charge of Chairman & Managing Director) NHPC, Faridabad
6. Shri R.S.T. Sai, Chairman & Managing Director, THDC India Limited, Uttrakhand
7. Shri L.Chuaungo, Chairman& Managing Director, GUVNL, Gujarat
8. Shri Kalai Selvan, (Incharge of Managing Director), TANTRANSCO, Tamil Nadu

9. Shri Sanjay Malhotra, Chairman& Managing Director, RVPN, Rajasthan
10. Shri N.S. Nigam, Chairman & Managing Director, WBSEDCL, West Bengal
11. Shri K.V. Eapen, Chairman & Managing Director, APDCL, Assam

2.5 The Committee held its second meeting on 23rd June 2015 and deliberated on various technical and commercial issues associated with creation of spinning reserves at length.

2.6 The Committee held its 3rd meeting on 10th September 2015 and deliberated on some key issues and future road map.

3. Necessity of Reserves including Spinning Reserves

3.1 The most important responsibility of the Power System operators is to maintain reliability of the Power System [2] [3]. Maintenance of Load - Generation balance is one important aspect of Reliability. There are a lot of uncertainties associated with Power System. Historically from the Power System statistics, it has been observed that large generators and transmission lines can and do suddenly fail.

3.2 In the forecasting and scheduling part of the Power System Load, there are a lot of uncertainties associated with rainfall, humidity, temperature, thunder storms, and other weather related uncertainties. Also natural calamities, special days like festivals and celebrations affect the demand met of the Power System, and differ from that of the forecasted load demand.

3.3 There is an increasing penetration of Renewables (both Wind and Solar) in the country, and considering the fact that their generation output can vary unexpectedly, it poses more challenges in the operation of Indian Power system and creation of system reserves becomes much more desirable.

3.4 The sudden disturbances in the Power System can initiate a steep fall or rise in the frequency of the Power System, which can be detrimental to the Power System operation, if not contained immediately. The immediate arrest of the sudden fall or rise of the frequency of the Power System also needs Real Power reserves which respond almost instantaneously with the frequency change, popularly referred to as 'Primary response from the generators'. In the absence of Primary Control Response, such disturbances will have to be handled by automatic load disconnection, which is undesirable.

3.5 Amidst all these uncertainties, it is very important to have different 'Real Power Reserves' in the Power System. Keeping planned Reserves all the time will result in increased reliability of the Power System. Optimal use of Reserves can lead to overall economy, enhanced Security, improved Frequency, better power quality and these reserves can be used as counter flows for congestion management etc. The use of Spinning Reserves includes control of inter-area interchanges.

4. Type of Reserves

4.1 There are three levels of reserve deployment mechanisms generally accepted in the Frequency control System depending on the time line and the distinct functional need of initiation of the Reserves. They are:

4.2 Primary control: local automatic control available in all conventional generators, which delivers reserve power in the negative proportion of any frequency change. Immediate automatic control implemented through turbine speed governors, in which the generating units respond quickly to the frequency deviation as per droop characteristic of the units. Input signal for this control is system frequency which is locally available at the generating station. Most of immediate response comes from coal based thermal units running on part load with primary control. But this is available for a few seconds/minutes only. Hydro units on part load can also provide primary response. Primary control is for providing immediate support to correct imbalance which lasts for short period of up to 30 seconds - 15 minutes, within which secondary control should come into play so as to push generation of units providing primary control reserves back to their scheduled values thereby restoring back the availability of primary control margins for subsequent real time deviations.

4.3 In India, primary response is mandatory through the IEGC, but the actual response is much less than the ideal response or the desired response. One important reason behind this inadequate response is the generators not keeping sufficient Reserves from their maximum capacity. Other reasons for non-compliance could be technical difficulties and no existing penalties for defaulters.

4.4 Secondary control: centralized control area wise automatic control which delivers reserve power in order to bring back the frequency and the area interchange programs to their target values. In doing so, the delivered primary control reserves are restored on those machines. Secondary control is implemented, in multi utility power pools, through an automatic generation control scheme operated centrally taking into account both frequency deviation and area wise tie-line power flow deviations through a combined Area Control Error (ACE= $\triangle P_{tie}$+k $\triangle$f). Secondary control signals are generated at control centres (RLDCs or SLDCs) as the frequency deviates from the target value and transmitted to generating stations/units for responding with desired change in generation. Secondary control provides for restoration of primary control reserves and is to be available in 30 seconds to 15 minutes. Hydro units, gas units and coal units engaged in secondary control provide for required secondary support.

In case of a single control area, the secondary control would have only maintaining target frequency as the objective while in case of multiple control areas, the secondary control would have both maintaining target frequency and the area interchange schedules as the objective.

4.5 Secondary control has not been implemented in India as yet. To implement Secondary control, some infrastructure is needed. Units have to be wired under AGC (Automatic Generation Control) and both sides communication between control room and generators has to be provided. AGC (Automatic Generation Control) software is needed to implement and handle the calculations, as this is an automatic process.

4.6 Tertiary control: manual change in the dispatching and unit commitment in order to restore the secondary control reserve, to manage eventual congestions, and to bring back the frequency and the interchange programs to their target if the secondary control reserve is not sufficient. Tertiary control therefore, refers to rescheduling of

generation to take care of deviations in a planned manner during real time operation and leads to restoration of primary control and secondary control reserve margins.

4.7 The general response time of reserves is given below

Reserve	**Start**	**Full availability**	**End**
Primary reserve	Immediate	< 30 s	>15 min
Secondary Control reserve	> 30 s	<15min	As long as required or till replaced by Tertiary Reserves
Tertiary control reserve	Usually > 15 min to Hours		

5. Definition of Spinning Reserve

5.1 In the context of reserves, various terminologies are prevalent worldwide with different meaning. Some of them are:

i. Fast tertiary reserve available within 15 minutes
ii. Complementary tertiary reserve available within 30 minutes
iii. Delayed or term reserve
iv. Minutes reserve/Hours reserve/Emergency reserve
v. Dynamic Reserve
vi. Regulating Reserve
vii. Operating Reserve
viii. Reserve beyond 30 minute
ix. Primary Reserve/Secondary Reserve
x. Spinning Reserve
xi. Quick Start Reserve
xii. Contingency Reserve
xiii. Replacement Reserve
xiv. Supplemental Energy

xv. Standing Reserve

xvi. Fast Start

xvii. Warming and Hot Standby

5.2 YannRebours et.al. [1] illustrates the difficulties associated with the definitions of reserve services. Many authors use the term "Spinning Reserve" without defining it because they assume that its meaning is obvious and unambiguous. A partial survey of the literature produces very different definitions:

- Hirst and Kirby [1]: "generators online, synchronized to the grid that can increase output immediately in response to a major outage and can reach full capacity within 10 minutes ":
- Wood and Wallenberg [2]: the total synchronized capacity, minus the losses and the load;
- Zhu, Jordan and Ihara [3]: "the unloaded section of synchronized that is able to respond immediately to serve load, and is fully available within ten minutes ";
- British Electricity International [4]: "the additional output which a part-loaded generating plant is able to supply and sustain within 5 minutes. This category also includes pumped-storage plant [...] operating in the pumping mode, whose demand can be disconnected within 5 minutes ";
- UCTE [6]: tertiary reserve available within 15 minutes "that is provided chiefly by storage stations, pumped-storage stations, gas turbines and by thermal power stations operating at less than full output (responsibility of the TSO) ";
- NERC [7]: "Unloaded generation that is synchronized and ready to serve additional demand".

5.3 The Indian Electricity Grid Code (IEGC) provides the following definition of Spinning Reserve:

"Spinning reserve means part loaded generating capacity with some reserve margin that is synchronized to the system and is ready to provide increased generation at short notice pursuant to despatch instructions or instantaneously in response to a frequency drop."

5.4 It may be seen that the definition in IEGC include primary reserve also as the spinning reserves.

5.5 In the Indian context, simple and easy to relate and administer definitions could be thought of initially. The spinning reserves could be defined as ***"the capacity which can be activated on decision of the system operator and which is provided by devices which are synchronized to the network and are able to effect a change in the active power."***

5.6 This would however, require amendment in IEGC modifying the definition of spinning reserve and insertion of definition of primary reserve separately.

Chapter – II

Technical & Commercial Aspects of Reserves

6. Reserves – Technical and Commercial Aspects

6.1 Reserves are a necessity. It is pertinent to note that, majority of the turbines in the Indian Power System are steam turbines and their off-frequency capability is within a band constrained by design specifications. Operation of Power System at low frequency is also not good for the health of the equipment associated with Power Systems, particularly sensitive loads. Frequency of the Power System can influence the life of all the turbines connected to it at the same time. Frequency should remain close to 50 Hz in a Power System. Load curtailment might also become necessary during a sustained under-frequency operation, despite Un-Requisitioned Surplus being available during some time blocks. Uncontrolled frequency deviation might result in the operation of under frequency load shedding schemes. It may also lead to the isolation of certain areas and influence the service obligation to the loads. All these have an indirect commercial impact. The cost incurred because of a load curtailment needs to be compared with investment requirement on reserves. The 'Real Power Reserves' are offered / commercially settled as an 'Ancillary Service' in the Power Markets in many countries [10] and their costs are decided by the market players. Reference [10] provides information regarding the pricing of Ancillary Services, different costs and intricacies involved.

7. International Practices

7.1 Internationally, large systems like UCTE (Europe)which includes Belgium, France, Germany, the Netherlands, Spain; PJM, California and Great Britain all carry Primary, Secondary and Tertiary control reserves. In majority of the systems, the full availability of the Primary control reserves happens within 30s. Great Britain has a regulation of 10s time for primary response for full availability and 30s time for secondary response to get

initiated. 100% of the primary reserve is deployed for a deviation of ± 200 mHz in case of UCTE, ± 167 mHz in case of Belgium.

7.2 In majority of the systems, the full availability of the Secondary control reserves varies from 5 min. in case of Germany & PJM to 10 min. in case of Belgium and CAISO to 15 min. in case of UCTE. "Fast" tertiary control reserve is deployed within 15 minutes in majority of the systems. In PJM and CAISO, it is 10 min. "Slow" tertiary control reserve is deployed after more than 15 minutes. In France and PJM, the full availability is within 30 min. Germany and CAISO have time of 1 hr.

7.3 In order to maintain reliability of supply of power system and to deal with load forecast errors, generator forced outages and for balancing variable generation from renewable energy sources, viz. wind and solar generation, the practice in many countries is to ensure availability of generation capacity and resources at all times in excess of peak demand to be met and maintaining sufficient reserve margin through regular monitoring and assessment.

7.4 Reserve margin is the difference of expected available generation capacity and expected peak demand in absolute terms, and is expressed as a percentage of expected peak demand. Therefore, a reserve margin of 10% would mean that an electric system has excess capacity to the extent of 10% of expected peak demand.

7.5 Each fall NERC issues an annual Long-Term Reliability Assessment that presents a ten-year outlook addressing issues related to the reliability of the bulk power system. NERC also issues Summer and Winter Short-Term Reliability Assessments in May and October, respectively, that present estimates for the upcoming peak demand season. These assessments highlight reserve margin estimates.

7.6 The reserve requirement in various countries is as follows:

Table 1: Calculation of spinning reserve requirements in different systems [1]

Country	Calculation of the amount of Spinning Reserve
UCTE	$\sqrt{10L_{maxzone} + 150^2} - 150$
Belgium	UCTE rules. Currently at least 460 MW by generators
France	UCTE rules. Currently at least 500 MW by generators
The Netherlands	UCTE rules. Currently at least 300 MW by generators
Spain	Between $3\sqrt{L_{max}}$ and $6\sqrt{L_{max}}$
California	50% * $\max(5\%\ P_{hydro} + 7\%\ P_{othergeneration}; P_{largestcontingency}) + P_{non-firmimport}$
PJM	1.1 % of the Peak + Probabilistic calculation on typical days and hours

Where

L_{max}: Maximum Load of the System during a given period

$L_{maxzone}$: Maximum load of the UCTE control area during a given period

P_{hydro}: Scheduled generation from Hydro generation

$P_{othergeneration}$: Scheduled generation from resources other than hydro electric

$P_{largestcontingency}$: Value of Power imbalance due to the most severe contingency

$P_{nonfirmimport}$: Total of all the interruptible imports

7.7 Grid operators already have techniques for managing the variability of demand and generation on the system through reserves. Reserves are utilised for diverse purposes across multiple timescales. The impact of wind integration on reserve requirements is a current area of interest for integration studies and power system operators. Variability and uncertainty are not unique to wind generation; similar characteristics exist in aggregate electric demand and supply resources and have always posed challenges for power system operators. Future loads cannot be perfectly predicted, loads and generator outputs can vary substantially in different time frames, and large power system equipment can fail at any given time without notice. Power system operators procure different amounts and types of operating reserves to

compensate for these characteristics in order the types of operating reserves can be differentiated by the type of event they respond to, the timescale of the response and the direction (upward or downward) of the response. Power system operators secure different amounts and types of operating reserves in order to serve load reliably and keep the system frequency stable.

A. United States

7.8 Both NERC and NERC subregions detail how much a balancing area will require of each type of operating reserve on its system [5]. For instance, the NERC BAL-002 standard requires that a balancing authority or reserve sharing group maintain at least enough contingency reserve to cover the most severe single contingency. For the western interconnection, this is extended by a proposal by WECC to state that the minimum amount of contingency reserve should be the greater of the most severe single contingency or the sum of 3% of the balancing area load and 3% of the balancing area generation. Detailed specifications of contingency reserve requirements, including the amount of spinning compared to supplemental reserve, are established by each Regional Reliability Organization. Regions typically require at least half of the contingency reserve to be spinning. In some areas that currently have high penetrations of wind power like the Electric Reliability Council of Texas (ERCOT), the forecasted wind power output is considered when making regulating and other types of operating reserve requirements.

B. Europe

7.9 In Europe, broad guidelines are given by the former TSO groupings such as Nordel and the Union for Coordination of Transmission of Electricity (UCTE), now part of the European Network for Transmission System Operators for Electricity (ENTSO-E). ENTSO-E defines reserve in three categories; primary, secondary and tertiary control [8]. Primary control is activated when system frequency deviates by ±20 mHz from the set point value and the entire reserve carried must be fully deployed, if the frequency deviation so demands, within 30 seconds. The purpose of primary control is to limit the deviation of system frequency following a system event. Secondary control consists of units controlled by Automatic Generation Control (AGC) and fast starting units. These are engaged 30 seconds after a contingency event and must be fully operational within 15 minutes. This category of control attempts to restore the frequency to its nominal value and reduce the area control

error. Primary control reserves are required from ENTSO-E members based on their share of network use for energy production Secondary control reserves are required from members of ENTSO-E in proportion to the maximum of yearly load in their region.

C. Spain

7.10 The Spanish system uses four types of reserves: primary, secondary, tertiary and deviation. Primary control reserve is mandatory in the Spanish system, being a non-paid service operated by all the generation units in the regular regime. Generators with primary regulation operate with a reserve margin of 1.5% [10]. Secondary regulation is a market-driven service, which is provided by licensed units on automatic generation control (AGC) [10]. The Spanish TSO, Red Eléctrica de España (REE), procures as much as ±1,500 MW of the secondary regulation reserve to balance its system in real-time in the Spanish system, tertiary reserve requirements are expected to be higher with increasing penetrations of wind power generation in the power system. In addition to primary, secondary and tertiary regulation, an additional reserve of active power called deviation reserves can be used. Deviation reserve helps to balance large differences (> 300 MWh) between scheduled generation and forecasted demand.

D. The Netherlands

7.11 The Netherlands are represented within ENTSO-E by the Dutch TSO TenneT. TenneT is required to maintain minimum values of primary and secondary reserve. Based on 2008 load data, the Netherlands is also responsible for 300- MW secondary reserves.

E. Denmark

7.12 The Danish Power System is part of both the Organization for the Nordic Transmission System Operators (Nordel) and the Union for the Co-ordination of Transmission and Electricity (UCTE).

F. Ireland

7.13 The Irish system is a relatively small and isolated power system, and has a more granular approach to its definition of reserve [14]. There are five main types of reserves including: regulating, operating, replacement, substitute, and contingency reserves.

G. Quebec

7.14 Hydro Quebec requires six broad categories of reserves: stability reserves, 10-minute operations reserve, 30-minute operations reserve, energy balancing reserves, frequency regulation reserves and load following reserves. Stability or spinning reserve, typically 1000 MW, represents 60% of the largest single loss of generation. The 10-minute reserves also typically operate at 1000 MW and consist of non-firm sales, interruptible load and a large portion of stability reserves. 30- minute reserves, typically about 500 MW, represent 50% of the second most severe single loss of generation. Energy balancing reserves vary from 1500 MW in the day-ahead time frame (1200 MW in the summer) to 500 MW in real-time two hours ahead. ; however, the introduction of wind generators did not change the required quantity of contingency reserves.

7.15 In New York, the study evaluated 3,300 MW of wind power on the 33,000-MW peak load NYISO system. The study concluded that no incremental contingency reserves would be needed since the largest single severe contingency would not change.

7.16 In Minnesota, the study evaluated 15, 20, and 25% wind energy as a percentage of total annual demand (3441 MW, 4582 MW, and 5688 MW on a system with a peak demand of roughly 20,000 MW). Similar to New York, it was concluded that there would be no impact on the contingency reserve requirement with the added wind penetrations.

7.17 The first procedure of the study was to determine the contingency reserves required. As many previous US studies have done, these assumed the current rule and determined that the largest contingency was not affected by the large amounts of wind generation. One and a half times the single largest hazard in each operating region determined the amount of contingency reserves for that region.

Chapter – III

Reserves: Policy and Regulatory Framework in India

8. Facilitative Regulatory Framework in India

8.1 Section 79 (4) of the Electricity Act 2003 provides that in discharge of its function, the Central Commission shall be guided by the National Electricity Policy, National Electricity Plan and the tariff policy published under section 3.

8.2 Section 79 (1)(i) of the Electricity Act 2003 empowers Central Commission to specify and enforce the standards with respect to quality, continuity and reliability of service by licensees.

8.3 Section 79 (1) (h) of the Electricity Act 2003 empowers Central Commission to specify Grid Code having regards to Grid Standards.CERC IEGC regulations, 2010 defines the Spinning reserves as **part loaded generating capacity with some reserve margin that is synchronized to the system and is ready to provide increased generation at short notice pursuant to despatch instruction or instantaneously in response to a frequency drop.**

8.4 National Electricity Policy, 2005 envisages 5 % Spinning Reserves at national level. The relevant extracts are quoted as below:

> *"5.2.3 In order to fully meet both energy and peak demand by 2012, there is a need to create adequate reserve capacity margin. In addition to enhancing the overall availability of installed capacity to 85%, a spinning reserve of at least 5%, at national*

level, would need to be created to ensure grid security and quality and reliability of power supply."

8.5 The Para 1.2 of the tariff policy states as follows:

"1.2. The National Electricity Policy has set the goal of adding new generation capacity of more than one lakh MW during the 10th and 11th Plan periods to have per capita availability of over 1000 units of electricity per year and to not only eliminate energy and peaking shortages but to also have a spinning reserve of 5% in the system. Development of the power sector has also to meet the challenge of providing access for electricity to all households in next five years."

8.6 One of the objectives of the Tariff Policy is to promote competition, efficiency in operations and improvement in quality of supply.

8.7 The Tariff Policy also states that the real benefit of competition would be available only with the emergence of appropriate market conditions. Shortages of power supply would need to be overcome. It further states that the accelerated growth of generation capacity sector is essential to meet the estimated growth in demand. Adequacy of generation is also essential for efficient functioning of power markets. At the same time, it is to be ensured that the new capacity addition should deliver electricity at most efficient rates to protect the interests of consumers.

8.8 Standing Committee on Energy in its report on Electricity (Amendment) Bill, 2014 observed that any generating company establishing a generating station after a date as notified may be required to build and maintain a spinning reserve of such capacity as may be specified by the Authority from time to time.

8.9 The draft Electricity (Amendment) Bill, 2014, inter alia, proposes: to amend section 7 of the Electricity Act, 2003 to provide for maintenance of spinning reserve of certain capacity by the generating company. The relevant extracts are quoted as below:

> *"…..Provided that any generating company establishing a power plant may be required by the system operator to build and maintain a spinning reserve of such capacity as may be notified by the Central Government from time to time:*
>
> *…..Explanation.—For the purposes of sub-section (1), the expression ''spinning reserve'' means the backup capacity of a generating station which shall be made available on the directions of the system operator, within a time limit as may be notified by the Central Government, to maintain grid safety and security…."*

8.10 The Working Group on Power for 12th Plan recommended spinning reserves to facilitate for grid stability at the regional level to accommodate the infirm renewable energy injection into the grid.

8.11 The relevant extract from IEGC, from the section 5.2(i) is quoted as below:

> *"The recommended rate for changing the governor setting, i.e., supplementary control for increasing or decreasing the output (generation level) for all generating units, irrespective of their type and size, would be one (1.0) per cent per minute or as per manufacturer's limits. However, if frequency falls below 49.7Hz, all partly loaded generating units shall pick up additional load at a faster rate, according to their capability."*

8.12 Central Electricity Regulatory Commission notified Central Electricity Regulatory Commission (Ancillary Services Operations) Regulations with the following objective

> *"The objective of these regulations is to restore the frequency level at desired level and to relieve congestion in the transmission network."*

8.13 However, the aforesaid regulations seek to use only the un-requisitioned surplus of the generating stations regulated by CERC. This does not necessarily guarantee availability of generation capacity when the system operator really needs it on real time. There is thus a need for providing a regulatory framework, for creating adequate provisioning of the system reserves including spinning reserves in India.

Chapter – IV

Reserves: Implementation Framework for India

9. Indian Power Sector Scenario today and in future

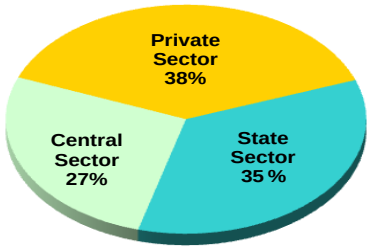
9.1 India has an Installed Capacity of 2, 72,503 MW as on 31.5.2015. The Fuel wise and sector wise break up is as follows:

Fuel-wise & Sector-wise Capacities

Fuel wise break-up (MW)

Thermal	1,89,313	69.4%
Coal	1,65,258	60.6%
Gas	23,062	8.4%
Diesel	993	0.4%
Hydro	41,632	15.4%
Nuclear	5,780	2.1%
Renewable	35,778	13.1%
TOTAL	2,72,503	100.0%

Sector wise break-up (MW)



(As on 31.05.2015, captive generation is not included in total)

(Source-CEA)

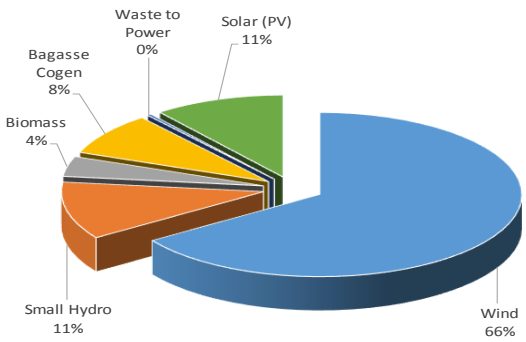
Total generation in 2014-15 : 1048.402* BU

4

9.2 The Capacity of Grid connected Renewable Energy sources are of the order of 35777 MW as on 31.5.2015. The break up is as follows:

Grid Connected RE Generation Capacities (as on 31.05.2015)

Renewable Energy	Capacity in MW
Wind Power	23444.00
Small Hydro Power	4055.36
Biomass Power & Gasification	1410.20
Bagasse Cogeneration	3008.35
Waste to Power	115.08
Solar Power (SPV)	3743.97
Total	35776.96



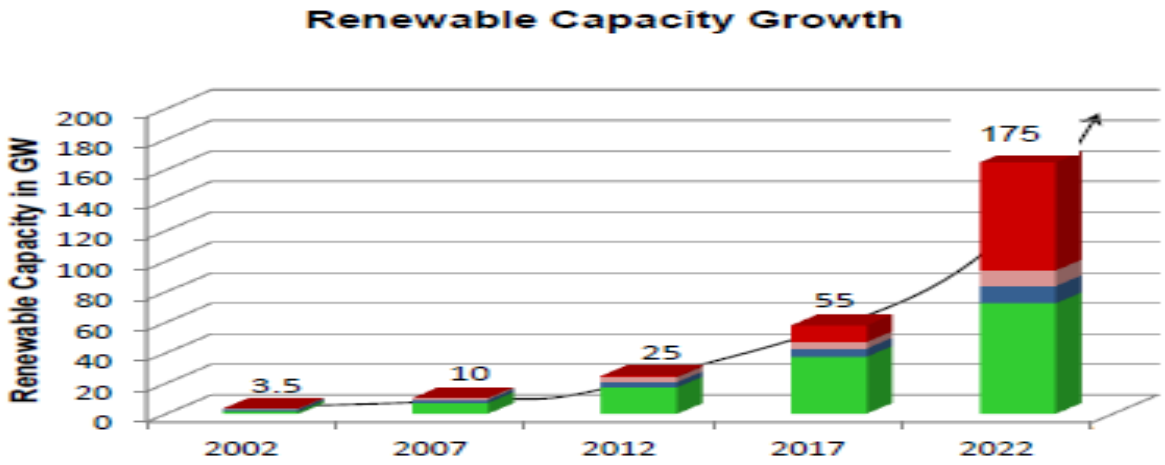
Renewable Energy (MW)

Source: Ministry of New and Renewable Energy

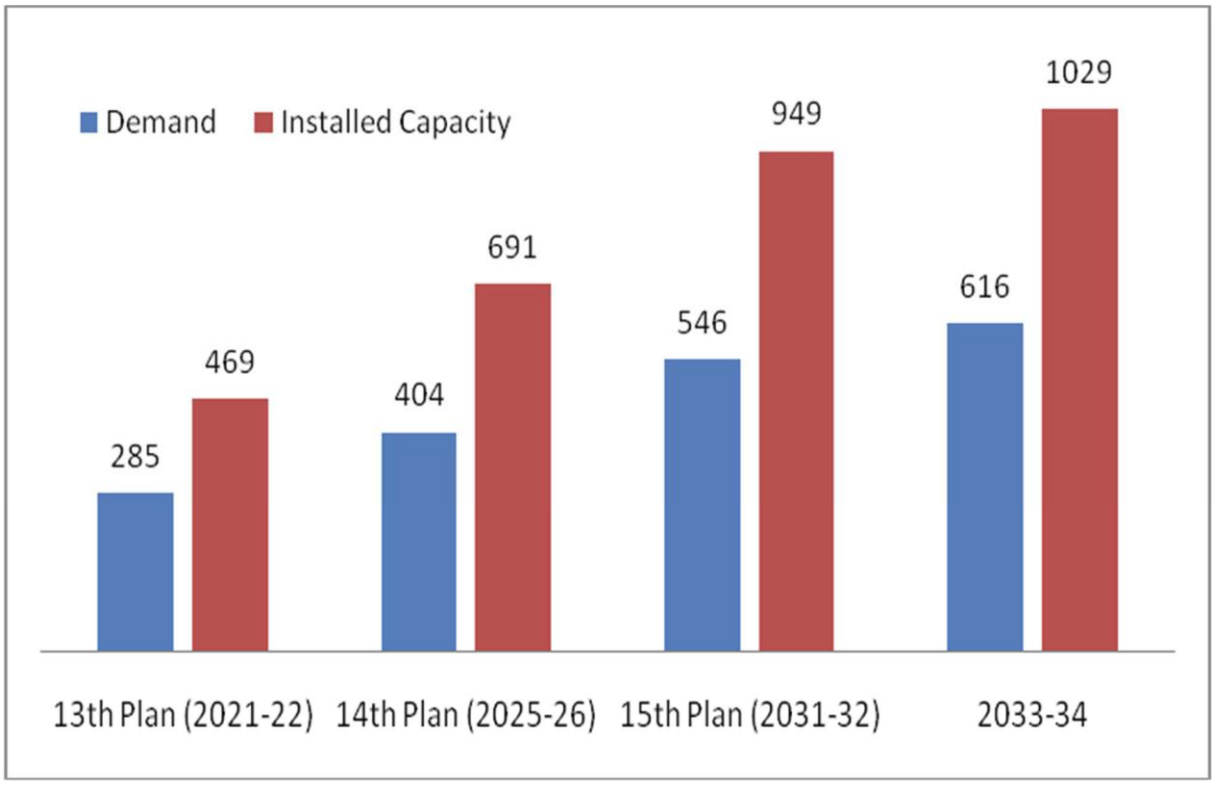
9.3 The Government has rolled out a scheme for development of Solar Parks and Ultra Mega Solar Power Projects on 12th December 2014 which envisages setting up at least 25 Solar Parks and Ultra Mega Solar Power Projects targeting over 20,000 MW of solar power installed capacity within a span of 5 years starting from 2014-15. The solar parks will have suitable developed land with all clearances, transmission system, water access, road connectivity, communication network, etc. This scheme will facilitate and speed up installation of grid connected solar power projects for electricity generation on a large scale.

9.4 The Union Cabinet on 17th June 2015 gave its approval for stepping up of India's solar power capacity target under the Jawaharlal Nehru National Solar Mission (JNNSM) by five times, reaching 1,00,000 MW by 2022. The target will principally comprise of 40 GW Rooftop and 60 GW through Large and Medium Scale Grid Connected Solar Power Projects. With this ambitious target, India will become one of the largest Green Energy producers in the world, surpassing several developed countries.

9.5 The expected capacity growth in Renewable Energy Sources is as depicted below:



9.6 The expected Installed Capacity and demand by the end of 13 Plan and after is as follows based on 20 year perspective transmission plan of CEA:



Power Supply Position

9.7 The Actual power supply position of the Country since the end of 7th Plan to End of 11th Plan and during 12thplan is as presented in the Table below:

Table: 2 Power Supply position from the end of 7thPlan to March 2015

PERIOD	PEAK DEMAND (MW)	PEAK MET (MW)	PEAK DEFICIT/ SURPLUS (MW) (- / +)	PEAK DEFICIT/ SURPLUS (%) (- / +)	ENERGY REQUI-RMENT (MU)	ENERGY AVAIL-ABILITY (MU)	ENERGY DEFICIT/ SURPLUS (MU) (- / +)	ENERGY DEFICIT/ SURPLUS (%) (- / +)
7th PLAN END	40385	33658	-6727	-16.7	247762	228151	-19611	-7.9
8th PLAN END	63853	52376	-11477	-18.0	413490	365900	-47590	-11.5
9th PLAN END	78441	69189	-9252	-11.8	522537	483350	-39187	-7.5

10th PLAN END	100715	86818	-13897	-13.8	690587	624495	-66092	-9.6
11th PLAN END	130006	116191	-13815	-10.6	937199	857886	-79313	-8.5
2012-13	135453	123294	-12159	-9	995557	908652	-64840	-8.7
2013-14	135918	129815			1002257	959829		
2014-15	148166	141160	-7006	-4.73	1068943	1030785	-38158	-3.57

Source: CEA

As can be seen above, the actual energy and peak shortages in the year 2014-15have come down to 4.73% and 3.57% respectively.

Demand Projection

9.8 As per the 18th Electric Power Survey (EPS) Report, the anticipated energy requirement and peak load at the end of the 12th and 13th Plans are as follows:

	12th Plan end (2016-17)	**13th Plan end (2021-22)**
Peak Load (MW)	**199,540**	**283,470**
Energy Requirement (MU)	**1354,874**	**1904,861**

Source :18th EPS Report

9.9 As per the 18th EPS, by the end of the year 2016-17, the anticipated energy and peaking shortage in the country are expected to be wiped out based on the anticipated new generating capacity addition of 88537 MW during the 12th Plan.

9.10 The Indian power sector scenario in the last five years is as follows:

Sl. No.	**Particulars**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**
1	Installed Capacity (MW)	159398.00	173626.00	199877.03	223344.00	243028.95	267637.35
	% Increase		8.93	15.12	11.74	8.81	10.13

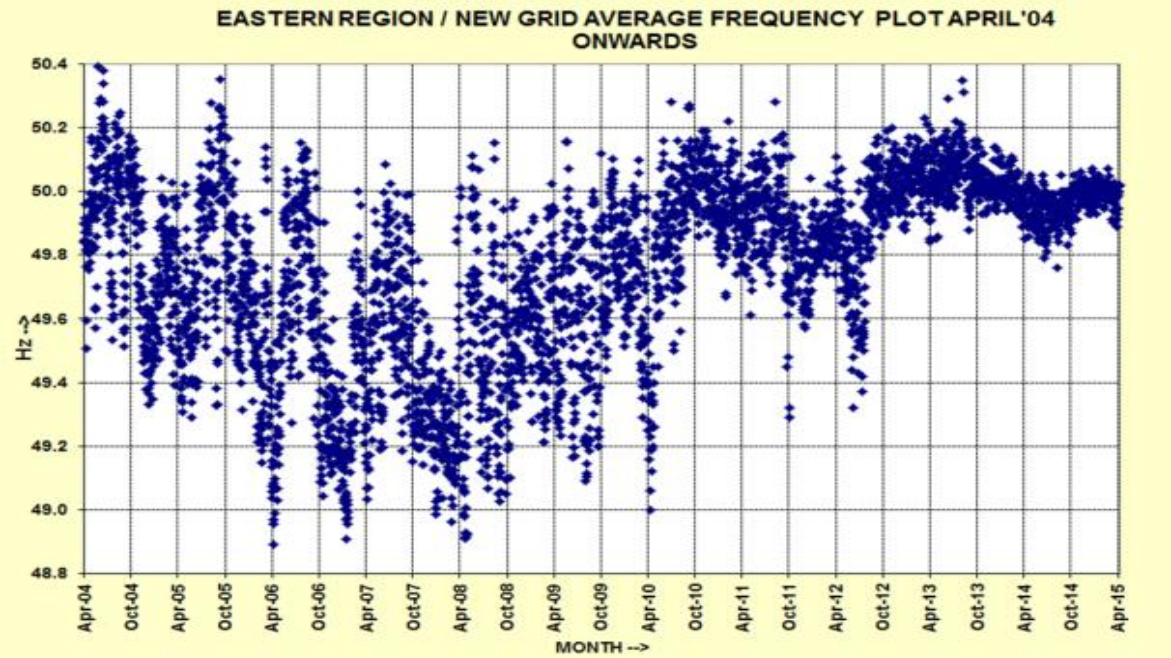
2	Capacity Addition (MW)		14228.00	26251.03	23466.97	19684.95	24608.40
3	Generation (BU)	771.55	811.143	876.89	912.056	967.15	1048.403
	% Increase		5.13	8.11	4.01	6.04	8.40
4	Energy Requirement (MU)	8,30,594	8,61,591	9,37,199	9,95,557	10,02,257	10,68,943
	% Increase		3.73	8.78	6.23	0.67	6.65
5	Energy Available (MU)	7,46,644	7,88,355	8,57,886	9,08,652	9,59,829	10,30,785
	% Increase		5.59	8.82	5.92	5.63	7.39
6	Peak Demand (MW)	1,19,166	1,22,287	1,30,006	1,35,453	1,35,918	1,48,166
	% Increase		2.62	6.31	4.19	0.34	9.01
7	Peak met (MW)	1,04,009	1,10,256	1,16,191	1,23,294	1,29,815	1,41,160
	% Increase		6.01	5.38	6.11	5.29	8.74
8	PLF of thermal units (%)	77.5	75.07	73.32	69.95	65.6	64.46
	% Increase		-3.14	-2.33	-4.60	-6.22	-1.74
9	Coal consumption (mt)	367	387	417.56	454.6	489.4	531.48
	% Increase		5.45	7.90	8.87	7.66	8.60

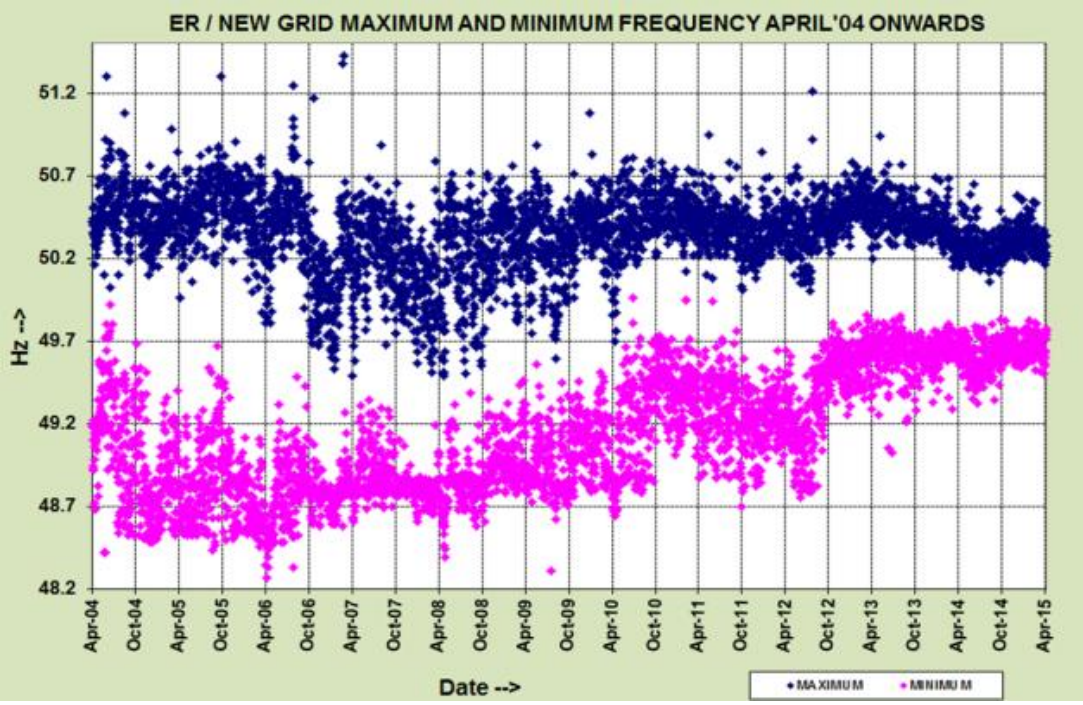
9.11 It may be seen that all India PLF for the thermal plants has gone down from 77.5% in 2009-10 to 64.46% in 2014-15; a drop of about 13%. The increase in demand has not been commensurate with the capacity addition. A capacity of only 100-110 GW of thermal capacity out of total capacity of coal and gas based generation as on 31.5.2015 of 188320.03 MW contribute to the peak demand of 140-145 GW and a significant amount of thermal capacity is under reserve shutdown due to low demand. As such enough generating capacity is available as reserves. When the National Electricity Policy was formulated in 2005 mandating reserves we did not have enough spare capacity and reserves were perceived as a 'luxury'. This is no longer the case.

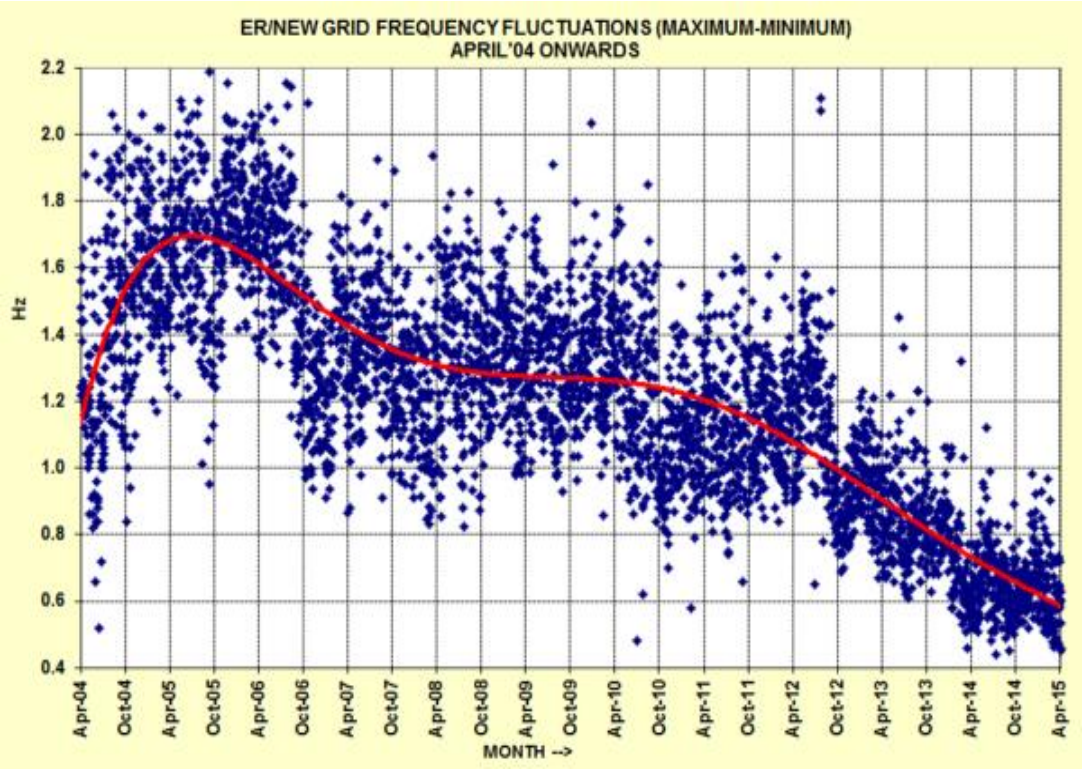
In this back drop, there appears to be no problem in creation of spinning reserves now. As such, spinning reserves of requisite quantum are required to be maintained.

10. Frequency Profile in India

10.1 There is marked improvement in the frequency profile of India and grid frequency remaining close to 50 Hz most of the time. This is evident from the following graphs depicting frequency profile since 2004:







The operating grid frequency band has been narrowed to 49.90 Hz to 50.05 Hz but on many occasions grid frequency touches 49.7 Hz on lower side and more than 50.2 Hz on the upper size. **It is felt that time has come to move towards constant frequency operation of grid at nominal frequency of 50 Hz.** Considering the multiple control areas in the Indian grid, this would require adoption of control philosophy of frequency control as well as net area interchange controls termed as 'secondary control'. However, this would be difficult without Automatic Generation Control (AGC) and therefore, to start with spinning reserve may be operationalised manually.

11. Additional Reserve Requirement on account of renewables

11.1 Solar and Wind qualify separately as they have high inherent output variability and less predictability amongst all the renewables. Because of this, Solar and Wind generation technologies are often referred to as Variable Renewable Energy (VRE) [11].

11.2 Renewables add Power generation to the grid but they contribute only negligible inertia to the grid. Considering the factors of low inertia addition and variability in the Power generation output of the renewables, all the three Power Reserves (Primary, Secondary and Tertiary) are needed in case of renewables also.

11.3 Renewable forecast and renewable scheduling form the basis for calculating the Power Reserve needed with respect to Renewables. Better the forecasts and scheduling, lower would be the requirement of reserves. Reserve estimation on account of renewables would mean computing 3σ values for variability of load as well as net load for different seasons besides extrapolating the same to 2020 and beyond to have an idea of how the reserve requirement would vary over time.

11.4 Several studies are available for different systems indicating the incremental change in the quantum of reserves with increase in RE penetration. Such studies would have to be understood in the context of the respective system size, RE penetration levels along with wind/solar combination and the forecast errors involved. The studies however, do not suggest high additional requirements of spinning reserve on account of renewables.

12. Estimation of reserves requirement in the Indian grid.

12.1 In terms of National Electricity policy, spinning reserves at 5% of the Installed Generation Capacity of around 272 GW works out as 13600 MW. This would include primary control reserves, secondary control reserves and tertiary control spinning reserves.

12.2 Using the Demand data of 7 years from 2008 to 2015 some statistics have been derived by POSOCO. Variability in Demand is the average demand met of the present hour or 15 minute time block minus average demand met of the past hour or 15 minute time block. Figure 3

and Figure 4 give the plots of variability of All India Demand taking the hourly and 15 minute variations of the All India Demand met.

Figure 3: MW Variability of All India Demand (taking 1 hour data variations)

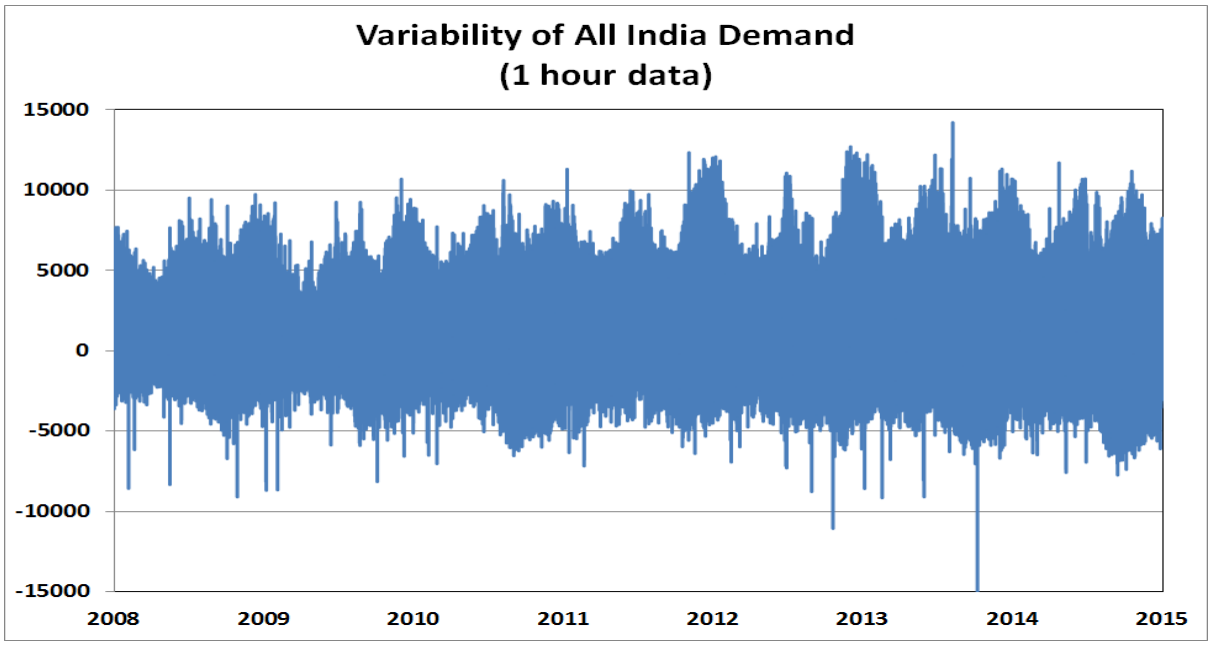
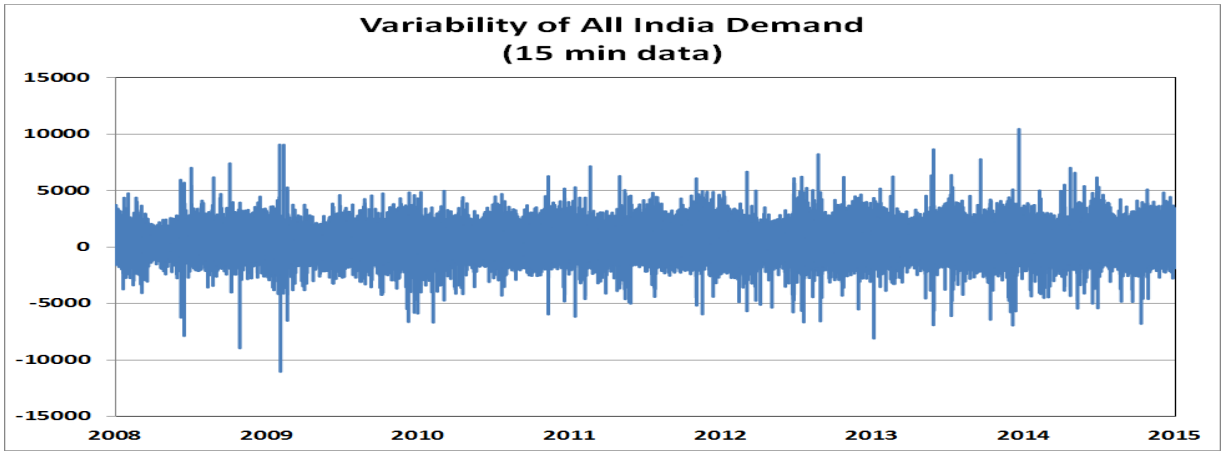


Figure 4: MW Variability of All India Demand (taking 15 minute data variations)



12.3 CIGRE Technical Brochure 450 [12], section 3.5.2 provides methodology adopted world-wide for estimation of reserves. Variability may be worked out either on hourly basis, 5-minute basis or 15-minutes

Standard deviation (σ) of variability could then be worked out. Reserves adding to 2σ to 4σ would cover 95 to 99.99% of all such variations. (1σ would cover 68.7%). Hourly basis would give tertiary reserve requirement. 5 minute/15 minute basis indicates secondary reserve. Computations on net load basis and comparison with above would give additional requirement of reserves on account of Renewable Energy (RE)

12.4 As discussed above, Power Reserves are necessary to take care of these variations in demand met. The variability and the statistical index of 3σ suggests a tertiary reserve of at least 7000 MW and secondary reserves of the order of 2500 MW. This is considering the load met data only and would go up marginally with increasing penetration of RE generation. For primary reserves, it is necessary to define the 'event' and the quasi steady state frequency by which the entire reserves should be harnessed. In the Indian context, there are several large power stations with generation capacity of the order of 3000-4000 MW at Sasan, CGPL Mundra, APL Mundra, Vindhyachal, Talcher, Rihand. Outage of 4000 MW capacity is a credible contingency (which is unlikely to change with RE penetration also) and primary reserve of this quantum is required to be available and must come automatically by the quasi steady state frequency drops to 49.80 Hz. Hence, the total quantum of reserves (primary, secondary and tertiary) works out to 13,500 MW if first principles are followed rigorously.

Primary reserves (4000 MW) should come from all possible generating resources irrespective of ownership. Secondary reserves of the order of 2500-3500 MW could come from the regional ISGS whose tariff is regulated by CERC as suggested in the sections below. Tertiary reserves could come from the different state control areas which could be obligated to carry at least 50% of its largest sized generating unit as a tertiary reserve within its control area and 50% outside the control area through say its entitlement in Central Generating Stations.

12.5 Area Control Error (ACE) is calculated at the All India Level for all the regions for every 10 seconds, for all the regions considering schedules, actual drawls of the constituents, frequency and the statistical Frequency Response Characteristics (FRC) in MW/Hz of each region for a typical day. Area Control Error (ACE) is defined as $ACE = \Delta P_{tie} + k\Delta f$, expressed in MW. The details for a typical day of 6th May 2015 as per POSOCO are as under:

Region	**FRC in MW/Hz**	**Maximum Value of ACE (in MW) for a typical day 6th May 2015**
NR	1260	1281
WR	1700	704
SR	2250	746
ER	373	903
NER	86	392
Simultaneous sum (same time)	**5669**	**2053**

12.6 The above table also suggests that at least 2000 MW secondary control reserves are required.

12.7 With the current capacity and peak demand, above computations of reserve requirement may hold good but with the increase in the size of power system and growth in demand in future coupled with large integration of renewables sources of energy, spinning reserve requirement may vary to a great extent and a dynamic mechanism may have to be devised for the estimation of reserve requirement in future.

13. Whether to maintain spinning reserve at country level, regional level or separate for each control area

13.1 The IEGC defines each State as the control area and each of the regions as separate control areas. In the existing legislative frame work it may be difficult to do away with such demarcation of control areas. In case, reserves are to be maintained at the State level the reserve requirement would go up and since the maintaining reserves has cost implications for the power system, it may be desirable to maintain the spinning reserves at the regional levels depending upon the largest unit size in the regional grid. From operational expediency point of view also it may be desirable to carry the spinning reserves at regional level.

13.2 The other question is which of the stations should carry these spinning reserves. Whether the reserve should be carried on one or more generating stations amongst central generating stations, UMPPs, IPP stations and State generating stations or it should be limited to the generating stations regulated by CERC.

13.3 Whereas it may be desirable to have participation of all generating stations whether regulated by CERC or the SERCs, it may be difficult to put this in operation due to various technical and commercial issues.13.4 On the other hand carrying these reserves only of ISGS regulated by CERC, the population for carrying these reserves also gets limited in each region. From among the aggregate capacity of about 130,000MW (excluding RE) which is in service during high demand periods, the capacity of CERC regulated ISGS may be only about 50000MW. In this also there will be Nuclear, RoR hydro etc. This leaves just about 40000MW ISGS capacity for the proposed spinning reserve services after excluding such capacity of hydro and nuclear plants. Most of the ISGS targetted may not be among the highest variable cost units in the system and keeping spare capacity in these units will have a cost implication for the system. **However, to start with it is felt that the spinning reserves may be**

carried on the ISGS regulated by CERC and for the present, UMPP and other competitive bid projects may be kept out of this. In the longer term, however, the highest marginal cost/price generating units committed in service will have to be selected for achieving economy.

13.4 To start with following spinning reserves may be kept at regional level based on the maximum unit size in the region:

- 1000 MW in Southern region,
- 800 MW in Western region ,
- 800 MW in Northern region ,
- 660 MW in Eastern region and
- 363.30 MW in north-eastern region)

14. Pre-requisites for estimation of dynamic spinning reserve mechanism

14.1 Requirement of Automatic Generation Control (AGC): So long as the entire synchronous system is treated as one control area, there is no requirement of Inter-Area Exchange Control and hence no need for AGC. Delivery and withdrawal of Spinning Reserve can be achieved in such cases by LDC operator initiated commands to the chosen machines to change output as desired. However, the whole system as one control area does not satisfy the control needs of the system. It will be necessary to control the inter-area exchange of power across constrained flow gates and control areas will have to be suitably designed to make such control useful. Maintaining secondary spinning reserves at the regional levels would require that units have to be wired under AGC (Automatic Generation Control) and both sides communication between control room and generators has to be provided. AGC (Automatic Generation Control) software is needed to implement and handle the calculations, as this is an automatic process.

Currently, none of the Regional Load Despatch Centres' Energy Management System (EMS) has provisions for Automatic Generation Control (AGC) for achieving balancing at the regional level. The same would need to be implemented at RLDCs' level.

Implementation of AGC is necessary along with reliable telemetry and communication. The AGC may be planned to be operationalised in the power system from 1.4.2017.

14.2 **Mandatory Forecasting of load and renewable energy:** Net load is defined as **(Load- Power from RE sources).** It is therefore, essential that load forecasting is done at each discom level, at each SLDC/State level and each RLDC/Regional level and finally at NLDC/country level. IEGC provides for demand estimation by discoms and SLDC.

14.3 Similarly, it is also essential to forecast the generation from renewable sources of energy. The recently published framework on forecasting of RE sources mandates for regional entity solar and wind generating stations to undertake forecasting. CERC through Forum of Regulators has strongly emphasised States to operationalise a similar framework for the intra-state RE generators. This will ensure that SLDCs as well as RLDCs have visibility into net load that must be met through conventional generators and spinning reserves.

15. Framework and Mechanism of identification and utilising of spinning reserves

15.1 Presently there is no defined or specified frame work or a mechanism in existence for operationalizing spinning reserves. The design and application of such a mechanism for such large multi-utility power pools such as our grid will be quite complex and involved. **One view is that the required expertise is not available indigenously and it may be desirable to engage a consultant for the same.**

15.2 Nevertheless, a framework needs to be evolved which provides clear guidelines for determination of quantum of spinning reserve, identifying the generating units, decide the compensation for the generators, energy accounting and its requisite commercial settlement by the nodal agency.

15.3 The respective RLDCs and the NLDC should be the nodal agencies for the respective region and the country as a whole.

15.4 **To start with a regulated framework in line with the Ancillary Services Regulations may be evolved.**

16. Identifying Generating Stations:

16.1 Once the requirement of reserve is determined at the regional level, it must be assigned to specific identified generating station or stations. For this purpose various technical and commercial considerations would play an important role. The nodal agency should be empowered to identify the ISGS irrespective of type and size of the generating station for providing spinning reserve services and it should be mandatory for such generating stations to provide spinning reserve services.

16.2 The factors such as type of plant, monsoon period or dry season, irrigation imperatives, pondage capacity at the relevant time etc needs to be duly considered in respect of hydro generating stations. Large Storage based hydro power stations have the ability to provide reserves subject to the condition that the reservoir is not overflowing and secondly the water release constraint, if any, is honoured.

16.3 Similarly, for the gas based stations availability of gas and the liquid fuel or alternate fuel, would be the main consideration. The take or pay obligation in case of gas may be relevant for the purpose of deciding compensation.

16.4 The energy charges of the respective generating station would also be the most relevant factor for taking a call on the generating stations to be identified. It may be desirable to identify generating stations in the order of highest energy charge to the lower energy charge subject to other technical considerations.

16.5 Keeping reserves on low cost units may not be desirable as the lowest cost machines un-dispatched to the extent of reserve margin would mean a certain cost to the system. Say for example this would mean 100MW capacity in the 2000MW Singrauli plant (and many other plants of low variable cost) to be left unutilised. This 100MW demand vacated by Singrauli will have to be served from the highest marginal cost machine in the system, say Jhajjar. Taking the variable cost of Singrauli as Rs1.25/kWh and the variable cost of Jhajjar to be Rs3.25/kWh, this 100MW capacity, withheld at Singrauli would amount to an incremental cost of Rs48 lacs per day to the system. Thus it may be desirable that the reserves are carried on higher cost units in the system so far as spinning reserves are concerned so that its impact on system

cost can be minimised. This would also require that such higher cost units are synchronized to the system which may not be the case always as some units in such high variable cost power stations may be under reserve shutdown. However, so far as primary reserves are concerned, such increase in system cost is imminent and cannot be avoided in the existing requirement of RGMO/FGMO compliance in IEGC which require all thermal units of 200 MW and above and hydro units of 10 MW above to provide primary response.

No generating unit would be earmarked exclusively as reserves. Rather the margins available on part loaded generating units would be the reserve actuated through different means. (primary, secondary or tertiary). For this purpose, certain stipulations might be required in IEGC such as no power station could be allowed to schedule more than Installed Capacity less normative auxiliary consumption. This would facilitate margins for primary response. Further, the scheduling limit as a percentage of Declared Capability (DC), might need to be done for the power station so that margins are available for secondary and tertiary control.

17. Quantum of reserve to be maintained on the identified plants

17.1 The nodal agency may have the option of carrying such reserves on one or more plants on technical and commercial considerations and may withhold a part of declared capacity on such plants from scheduling. It could be in terms of % of declared capacity or in MW term as deemed fit.

17.2 Further, the Central Commission has recently come out with Central Electricity Regulatory Commission **(Ancillary Services Operations)** Regulations, 2015 on 13th August 2015. This Regulation defines "Un-requisitioned Surplus" as follows:

> "un-requisitioned surplus" means the reserve capacity in a generating station that has not been requisitioned and is available for despatch, and is computed as the difference between the declared capacity of the generation station and its total schedule under long-term, medium-term and short-term transactions, as per the relevant regulations of the Commission.

17.3 It may be seen that the "Un-requisitioned Surplus" is in a way spinning reserve only.

18. Factors for triggering Reserves

18.1 The following factors may be considered by the Nodal Agency for triggering spinning reserves as specified in the Ancillary Services Regulations:

- Extreme weather forecasts and/or special day;
- Generating unit or transmission line outages;
- Trend of load met;
- Trends of frequency;
- Any abnormal event such as outage of hydro generating units due to silt,
- coal supply blockade etc.;
- Excessive loop flows leading to congestion; and
- Such other events.

18.2 Nodal agency shall direct the generating station which has been called in to provide spinning reserve services, to withdraw their services after the circumstances leading to triggering the service no longer exist.

18.3 The time-frame for withdrawal of service shall be determined as per the Detailed Procedure.

19. Scheduling and Compensation for the Spinning reserve services and commercial settlement

191 The Central Electricity Regulatory Commission (Ancillary Services Operations) Regulations, 2015 provide detailed frame work of scheduling and despatch, withdrawal, energy accounting and commercial settlement of Reserves Regulation Ancillary Services and also specify the role of each agency namely nodal agency and the RPCs.

19.2 The generating stations identified should be kept at the disposal of the system operator (NLDC/RLDC)), for changing its output within the pre-agreed band in its operating capacity.

19.3 The spinning reserves should be scheduled to the virtual pool on Day Ahead basis, along with other scheduling done on a Day Ahead basis.

Payments to such generating stations to the extent of reserves scheduled to the virtual pool should be made from the regional pool and corresponding adjustments of fixed cost liability of the original beneficiary should be made.

19.4 The CERC Ancillary Services Regulations provide for the following compensation for Regulation up services:

> "13.3. The RRAS Provider(s) shall be paid at their fixed and variable charges, with mark-up on fixed cost, as decided by the Commission through a separate order from time to time in case of Regulation Up services for the quantum of RRAS scheduled, from the Regional Deviation Pool Account Fund.
>
> Provided that, the fixed and variable charges allowed by the Commission and as applicable at the time of delivery of RRAS shall be used to calculate the payment for this service and no retrospective settlement of fixed or variable charges shall be undertaken even if the fixed or variable charges are revised at a later date. "

19.5 **Such framework for Regulation up services may be applied to the Spinning Reserve Services as well. The Central Electricity Regulatory Commission (Ancillary Services Operations) Regulations, 2015 may be amended to incorporate the necessary changes in this regard.**

19.6 Eventually a market determined framework would be desirable. This is considered essential with due regard to the need for efficiency and economy of the system. The transition framework suggested in this report (that is, the framework of utilising only the generating stations regulated by CERC for the purpose of spinning reserves) is limited in scope and does not necessarily bring in the optimum efficiency and economy in view of the fact that the population of generating stations covered is small and may not match with the reserves requirement in each control area. This has been recommended as a starting point as this can be implemented forthwith without much preparedness. In the long run, however, freedom and choice has to be provided to all sources of reserves, commitment charges have to be paid to enlist seriousness, of course with provision for consequent penalty for not meeting the commitment. Larger canvas of reserves sources, facilitated through competition is expected to bring in the desired level of economy in the procurement of reserves in the country.

20. Long Term Framework and Future Road Map

20.1 To start with the framework suggested is based on the administered pricing principles and is limited to generating stations whose tariff is determined by CERC and is in due consideration of preparedness of electricity market in India. This framework may continue till 31.3.2017.

20.2 Going forward this could be extended to all generating stations and a market based frame work may be put in place from 1st April 2017.

20.3 The new frame work may have following features:

- The system operator shall undertake load forecasting (from the SLDC to NLDC level based on the inputs from distribution/supply companies) and shall also forecast reserves requirement in each region.
- Based on the forecasting/estimation of the reserves requirement the system operator shall estimate the commitment charges likely to be paid to generators providing reserves. The estimated liability towards such commitment charges could be included as part of the system operator's annual revenue requirement/fees and charges.
- The system operator can requisition reserves from all generating stations on the assurance of payment of commitment charges. The generators could be paid commitment charges irrespective of whether they have been dispatched or not .
- Price discovery could be through power exchanges.
- Energy charge shall be paid on actual generation.
- In such a scenario, the commitment charges shall be socialized through the ARR of the system operators and the variable charge can be allocated to causers of the deviation.

A detailed study is required to be carried out before the market mechanism as suggested above is put in place. It is suggested that the NLDC be directed to commission study through a consultant in the context and submit a proposal to the Commission for approval.

Chapter – V

Recommendations

21. Conclusions

21.1 Spinning Reserves required to be maintained of requisite quantum depending upon the grid conditions. Operation at constant frequency target of 50.0 Hz with constant area interchange would be the philosophy adopted.

21.2 Definition of Spinning Reserve in IEGC to be modified with following:

> "The spinning reserve means **"the capacity which can be activated on decision of the system operator and which is provided by devices which are synchronized to the network and able to effect the change in active power.**"

21.3 The spinning Reserve may be maintained, to start with at the regional level.

21.4 The respective RLDC shall be the Nodal agency at the regional level and NLDC at the country level.

21.5 Each region should maintain secondary reserve corresponding to the largest unit size in the region and Tertiary reserves should be maintained in a de-centralized fashion by each state control area for at least 50% of the largest generating unit available in the state control area. This would mean secondary reserves of 1000 MW in Southern region; 800 MW in Western regions; 800 MW in Northern region; 660 MW in Eastern region and 363MW in north-eastern region. (total approx. 3600 MW on an All India basis). Primary reserves of 4000 MW would be maintained on an All India basis considering 4000 MW generation outage as a credible contingency. The same would be provided by generating units in line with the IEGC provisions.

21.6 The reserve requirement may be estimated by the nodal agency on day ahead basis along with day ahead scheduling of all available generating stations.

21.7 Implementation of AGC is necessary along with reliable telemetry and communication. **The AGC may be planned to be operationalised in the power system from 1.4.2017.**

21.8 It is essential that load forecasting is done at each discom level, at each SLDC/State level and each RLDC/Regional level and finally at NLDC/country level.

21.9 It is also essential to forecast the generation from renewable sources of energy by the generators, by the discoms, by the SLDcs and by the RLDCs.

21.10. **To start with a regulated framework in line with the Ancillary Services Regulations may be evolved for identification and utilising of spinning reserves and implemented with effect from 1.4.2016. This framework may continue till 31.3.2017.**

21.11 The reserve at the regional level, shall be assigned to specific identified generating station or stations duly considering the various technical and commercial considerations including energy charges of the generating stations. The nodal agency should be empowered to identify the ISGS irrespective of type and size of the generating station for providing spinning reserve services and it should be mandatory for such generating stations to provide spinning reserve services.

21.12 The nodal agency may have the option of carrying such reserves on one or more plants on technical and commercial considerations and may withhold a part of declared capacity on such plants from scheduling. It could be in terms of % of declared capacity or in MW term as deemed fit.

21.13 A framework as specified in the Central Electricity Regulatory Commission (Ancillary Services Operations) Regulations, 2015 may be followed for the Spinning Reserve Services as well. The Central Electricity Regulatory Commission (Ancillary Services Operations) Regulations, 2015 may be amended to incorporate the necessary changes in this regard.

21.14 Going forward, a market based frame work may be put in place from 1st April 2017 for achieving greater economy and efficiency in the system A detailed study is required to be carried out before the market mechanism on spinning reserves is put in place. It is suggested that the NLDC be directed to commission study through a consultant in the context and submit a proposal to the Commission for approval.

Summary of Recommendations

A. Spinning Reserves may be maintained of requisite quantum depending upon the grid conditions.
B. The philosophy of operation at constant frequency target of 50.0 Hz with constant area interchange may be adopted.
C. The Spinning Reserve may be maintained, to start with at the regional level.
D. Each region should maintain secondary reserve corresponding to the largest unit size in the region and Tertiary reserves should be maintained in a de-centralized fashion by each state control area for at least 50% of the largest generating unit available in the state control area. This would mean secondary reserves of 1000 MW in Southern region; 800 MW in Western regions; 800 MW in Northern region; 660 MW in Eastern region and 363MW in north-eastern region. (Total approx. 3600 MW on an All India basis). Primary reserves of 4000 MW would be maintained on an All India basis considering 4000 MW generation outage as a credible contingency. The same would be provided by generating units in line with the IEGC provisions.
E. Implementation of AGC is necessary along with reliable telemetry and communication. The AGC may be planned to be operationalized in the power system from 01st April, 2017.
F. The reserve requirement may be estimated by the nodal agency on day-ahead basis along with day ahead scheduling of all available generating stations.It is essential that load forecasting is done at each discom level, at each SLDC/State level and each RLDC/Regional level and finally at NLDC/country level. It is also essential to forecast the generation from renewable sources of energy by the generators, by the discoms, by the SLDcs and by the RLDCs.

G. To start with a regulated framework in line with the Ancillary Services Regulations may be evolved for identification and utilising of spinning reserves and implemented with effect from 1.4.2016. This framework may continue till 31.3.2017.

H. The reserve at the regional level, shall be assigned to specific identified generating station or stations duly considering the various technical and commercial considerations including energy charges of the generating stations.

I. The nodal agency should be empowered to identify the ISGS irrespective of type and size of the generating station for providing spinning reserve services and it should be mandatory for such generating stations to provide spinning reserve services.

J. The nodal agency may have the option of carrying such reserves on one or more plants on technical and commercial considerations and may withhold a part of declared capacity on such plants from scheduling. It could be in terms of % of declared capacity or in MW term as deemed fit.

K. A framework as specified in the Central Electricity Regulatory Commission (Ancillary Services Operations) Regulations, 2015 may be followed for the Spinning Reserve Services as well. The Central Electricity Regulatory Commission (Ancillary Services Operations) Regulations, 2015 may be amended to incorporate the necessary changes in this regard.

L. A market based frame work may be put in place from 1st April 2017 for achieving greater economy and efficiency in the system A detailed study is required to be carried out before the market mechanism on spinning reserves is put in place. It is suggested that the NLDC be directed to commission study through a consultant in the context and submit a proposal to the Commission for approval.

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"Framework for Smooth Real-time Data Transfer between the Wind/Solar Pooling and State Load Despatch center

Introduction

There are more efforts all over the India for development of renewable energy generation like wind/solar as against energy generation from conventional fossil fuels as renewable energy provides clean, safe, and environmentally-friendly power. For this purpose, many large-scale wind/solar power farms (WPFs) are already in the operation phase, and others are currently under construction or in the design phase. To harness full advantages from these clean energy resources, it is required to integrate them with the main grid and operate them with their full potentials.

Wind/solar generator are generally installed in large quantities concentrated at some remote location in the form of farm. These are located far from load centers due to need of large area and required wind speed. To evacuate generation from these farms, first generation from a group of some turbines/solar panels is pooled to a low voltage level sub-station installed by the developers then fed to the grid through grid connected sub-station generally owned by STU/CTU. To successfully utilize and integrate the generation from wind/solar farms, smooth and reliable real-time data flow to grid control center is a fundamental requirement and also mandated by various regulations. Various data requirement from wind power farm is attached at annexure-I.

This document lay down a framework for end to end data and voice communication from wind and solar power farms.

Existing Provisions:

The availability of real-time data and voice communication from any power generation plant including renewable energy generating plant is very much essential in the control room controlling the grid. In this regard various provision exists in the regulation of CERC mandating all users for providing data and voice connectivity to grid control room. These provisions are mentioned below:-

As per para 4.6.2 of IEGC 2010 approved by the Hon'ble commission, the associated communication system to facilitate data flow up to appropriate data collection point on CTU's system shall also be established by the concerned user or STU as specified by CTU in the connection agreement.

Quote

4.6.2 Data and Communication Facilities

Reliable and efficient speech and data communication systems shall be provided to facilitate necessary communication and data exchange, and supervision /control of the grid by the RLDC, under normal and abnormal conditions. All Users, STUs and CTU shall provide Systems to telemeter power system parameter such as flow, voltage and status of switches/ transformer taps etc. in line with interface requirements and other guideline made available by RLDC. The associated communication system to facilitate data flow up to appropriate data collection point on CTU's system shall also be established by the concerned User or STU as specified by CTU in the Connection Agreement. All Users/STUs in coordination with CTU shall provide the required facilities at their respective ends as specified in the Connection Agreement.

Unquote

The detailed Procedures of Central Transmission Utility under regulation 27(1) of the CERC (Grant of Connectivity, Long-Term Access and medium-term open Access in inter-state Transmission and related matters) Regulations 2009 has been approved by the Hon'ble commission vide its order No. L-1/(3)/2009-CERC dated 31st December 2009. As per para 1.1 (c) of the Draft Connection agreement FORMAT-CON-6 (Draft Connection agreement) of this approved procedure " The applicant or inter-state transmission licensee shall provide necessary facilities for voice and data communication for transfer of real time operational data such as voltage, frequency, real and reactive power flow, energy, status of circuit breaker & isolator positions , transformer taps and other parameters from their station to Data collection Point (DCP) of CTU as per IEGC. CTU shall provide access to applicant's data transfer through communication Network in case spare channels are available on mutually agreed terms. The location of DCP of CTU shall be the nearest station connected electrically where wideband communication capacity of POWERGRID is available. Additional communication system from the DCP to the concerned RLDC shall be the responsibility of CTU; however its cost shall be borne by the applicant. The responsibility of data transfer shall be that of the applicant."

As per para 5 (3) of CEA (Technical Standards for connectivity to the Grid) Regulations, 2007

Quote:

The requestor and user shall provide necessary facilities for voice and data communication and transfer of operational data, such as voltage, frequency, line flows, and status of breaker and isolator position and other parameters as prescribed by Appropriate Load Despatch centre

Unquote

As per para 5.2(u) of IEGC 2010 approved by the Hon'ble commission

Quote:

Special requirements for Solar/ wind generators: System operator (SLDC/ RLDC) shall make all efforts to evacuate the available solar and wind power and treat as a must-run station. However, System operator may instruct the solar /wind generator to back down generation on consideration of grid security or safety of any equipment or personnel is endangered and Solar/ wind generator shall comply with the same. For this, Data Acquisition System facility shall be provided for transfer of information to concerned SLDC and RLDC

Unquote

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Subsequent to the recommendations of, Pradhan Committee formed to examine issues relating to manpower, certification and incentives for the personnel employed on System Operation at various levels and also for ring-fencing the Load Despatch Centres to ensure their functional autonomy, Government of India, Ministry of Power vide order dated 13th October 2008, constituted a Task force under the Chairmanship of Shri. Satnam Singh, CMD, Power Finance Corporation of India Ltd. to look into the financial aspects for augmentation and up gradation of State Load Despatch Centres and issues related to emoluments (compensation structure, incentives etc.) for the personnel engaged in System Operation and give its recommendations.

The recommendations of the Task Force regarding ownership of the assets are as under:

- Ownership of new RTUs should rest with the entities in whose premises these RTUs would be located. Regarding ownership of existing as well as work-in-progress RTUs in central sector stations and state sector stations, these could rest with the CTU and STUs/SEBs respectively as per the prevailing arrangement. However in due course of time, modalities for their transfer to actual entities can be planned by mutual consent.

- The responsibility of owning and providing the communication system from substation to the nearest control centre as well as between control centres should continue to be that of CTU or STUs/SEBs. However, in case of any special requirements, the LDCs can assess, plan and take on lease such communication system from other telecom service providers also.

- The computer system along with software and peripherals located in the control center building of NLDC/RLDCs and SLDC/Sub-LDCs should be transferred to respective entities managing these LDCs.

- The recovery of tariff in respect of the assets to be retained or created in future by CTU/STUs/SEBs, as per the methodology suggested

above, could be appropriately charged as per norms prevailing from time-to-time.

Each user i.e. renewable energy generating plant owner/developer, power generating plants using fossil fuels etc. is required to enter into a grid connectivity agreement for transferring its power through the centricity grid. In the agreement each user agreed for proving data and voice to grid control center.

Terms and conditions of tariff issued by CERC also mentions that each transmission license, generator etc. is required to establish communication system from its facility to control center. As per its provision, the licensee can not commercialize its element without establishing data and voice communication facility.

Regulation Clarity Required:

The regulatory provision and standards as explained in above para are applicable for new substations/Power plants. It may be mentioned that the above regulatory provision considers implementation of communication on piecemeal basis which is neither economical nor technically conducive from interoperability point of view. Further the communication system has to be fully reliable and secure from cyber security point of view which is not being considered during the implementation due to fragmented way of implementation. Further the following issues still remains uncovered: -

(a) When expansion takes place, existing substation may not meet the requirement of connectivity with grid control room due to increase in the hops of the substations. The requirement of existing substations is not covered by the regulatory provision.

(b) The responsibility for providing communication link up to DCP (data collection point) is with the agency establishing Power Plant such as IPPs, UMPPs, and ISGS. All these agencies approach CTU for taking up this minor work on their behalf which is to be implemented on the substations/transmission lines not owned by them. They also do not have expertise in the field of communication system. This leads to several operational problems for minor amount of work.

(c) In few cases, the agencies are also planning lease line circuits up to LDC which has not been found convenient as LDCs have limited space, managing several lease lines/communication equipment would be difficult. Further, it is also not possible to monitor the leased lines and some times, the reliability of leased lines for SCADA system is doubtful.

(d) Further the above regulatory provision does not identify the responsibility for providing connectivity between RLDC and SLDCs.

Though all provisions mentioned above do mandate the user for providing data and voice connectivity to the grid control room, but they are not clear as how these facilities will be established, is each user has to establish dedicated facility, how these facility will be shared between many users, who will own and maintain the communication hop by hop etc.

In view of issues brought out above it is considered essential that an Institutional arrangement be mandated for planning, implementation and maintenance of dedicated high band width communication network connecting all the existing and new renewals energy power plants under central sector, IPPs, merchant coming under the control area of grid control centers.

Framework:

Communication of data from wind power/solar power farms to grid control central takes place in many hops as shown in figure-1 and mentioned below:-

[1] From wind turbine CMS (Central Management Station) of power farms.
[2] From CMS to Low-voltage substation.
[3] From Low-voltage substation to CTU/STU owned grid sub-station.
[4] From Grid sub-station to grid control center.

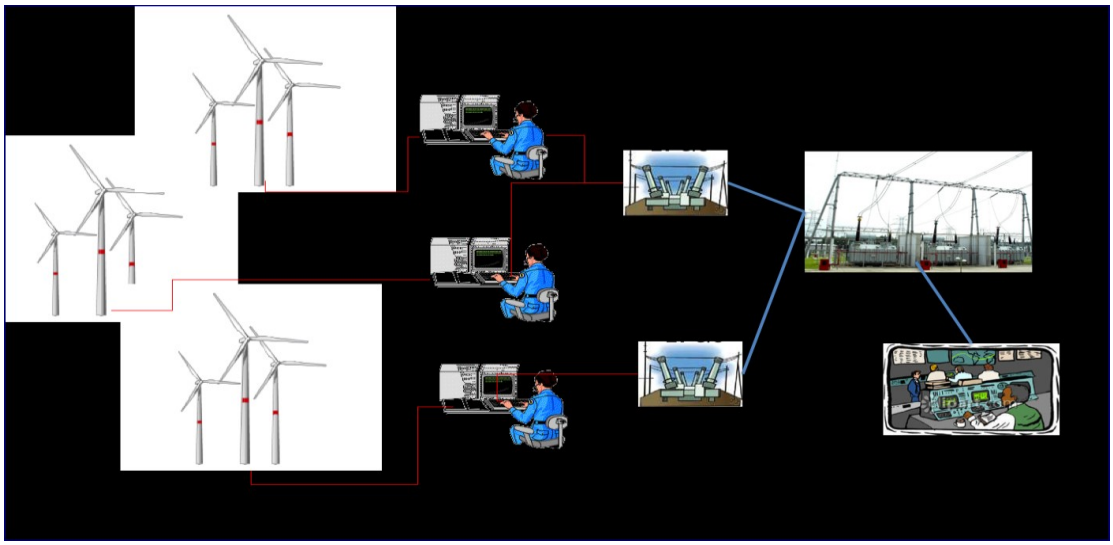

Figure 1 - Communication from Wind Turbine to Grid Control Room

In view of above, framework for communication infrastructure needed between wind/solar power farms and grid control room can be divided in three parts:-

- Communication within Wind/Solar Power Farms.
- Communication from Wind/Solar Power Farms to grid station
- Communication from grid station to grid control room

Communication within WPF

Communication from wind/solar generation to CMS and from CMS to low voltage sub-station generally takes place in IEC 61400-25 protocol, a standard based on IEC-61850 standard. Generator data falls into three different categories: analogue measurements (AM), status information (SI), and protection and control information (PCI). The AM and SI represent different sensors and measurement devices periodically transmit the sensing data to the CMS at different time intervals. Furthermore, the wind turbines enable the CMS to connect, manage, and control the wind turbine remotely. Based on turbine manufacturer, sometimes proprietary protocol is used instead of IEC 61400-25 protocol.

Considering IEC 61400-25, the standard does not provide any specific communication network requirement for WPFs. However, critical communication characteristics such as security and QoS should be considered in order to design a communication network for WPFs. The network security must ensure the wind farm data and its protection against attacks. The QoS is one of the important parameters to evaluate the WPF communication network. It defines the network characteristics such as bandwidth, latency, packet loss, etc.

Two different communication technologies, i.e., wired and wireless, could be used for local communication of a wind turbine data and also for the connection between the wind turbines and the CMS. Figure-2 shows different communication options for WPF.

Technology	Standard/protocol	Data rate	Coverage range
Fiber optics	PON	155 Mbps–2.5 Gbps	Up to 60 km
	WDM	40 Gbps	Up to 100 km
	SONET/SDH	10 Gbps	Up to 100 km
ZigBee	ZigBee	250 kbps	Up to 100 m
	ZigBee Pro	250 kbps	Up to 1600 m
WLAN	802.11x	2–600 Mbps	Up to 100 m
WiMAX	802.16	75 Mbps	Up to 50 km
Cellular	GSM	Up to 14.4 kbps	1–10 km
	GPRS	Up to 170 kbps	
	3G	384 kbps–2 Mbps	

Figure 2 - Different Communication Options

Since, this data and voice communication is dedicated and used only by the developer/owner of the power farms, the responsibility establishing communication infrastructure within WPF should be solely lies with the developer/owner of the WPF. Developer may choose any or combination of above communication technologies for establishing the communication infrastructure within WPF.

Communication from WPF to Grid Sub-station

Power farms developer/owner is required to provide data and voice connectivity to grid control center as per IEGC and hence responsibilities of communication path should lie with them only as a user of the grid. This is also mandated as per connection agreement. Following options are available:-

[1] Leased line from a telecomm service provider.
[2] Fiber optic (OPGW/ADSS) on transmission line
[3] GPRS (General Packet Radio Service).

General packet radio service (GPRS) is a packet oriented mobile data service on the 2G and 3G cellular communication system's global system for mobile communications (GSM). GPRS is a best-effort service, implying variable throughput and latency that depend on the number of other users sharing the service concurrently. Quality of service (QoS) is not guaranteed during the connection. GPRS provides data rates of 56–114 kbit/second. Since, GPRS is shared service without QoS, data delivery is not guaranteed and data transfer time may be even in minutes. In view of this, GPRS is not suitable for real-time data transfer.

Selection between leased line and OPGW/ADSS is depending on availability of Telecomm Service provider in that area and service level agreement offered by him. However, reliability and security of data being exchanged should be ensured by the user while making choice.

Communication from Grid Sub-station to Grid Control Room

Communication infrastructure between grid sub-station to control room is a shared communication since grid sub-station transfers data from other WPF whose power is being pooled to that substation. OPGW is the best option for establishment of communication infrastructure form grid station to grid control room. A taskforce is has been constituted by CERC for regulation on communication system in power sector which will also look into communication from renewable energy generation. This regulation will take care communication requirements of renewable generation from solar/wind power pooling point to LDCs.

Annexure-I

Systems Requiring Communication

1. **SCADA SYSTEM**:

The SCADA system installed at the RLDCs and SLDCs which is an indispensable tool for grid operation. The RLDCs/SLDCs acquire the data of substations & power plants directly under its control area. In addition to this the RLDCs exchange the data of its interest with NLDC and SLDCs of its region. The geographical area of a region is very large and is spread over hundreds/thousands of Kilometres. The power transmission lines available with power utilities are most reliable communication media. Most of the substations and power plants which reports to RLDCs/SLDCs are several line sections (Hops) away from the LDCs, the data of these substations and power plant gets accumulated as it moves towards the control centre thus requiring high bandwidth. Further the reliable communication system requires at least two separate physical paths.

The data volume which is exchanged between control centers (Between RLDC & NLDC and RLDC & SLDC) is very high and the route length is also very long. As elaborated subsequently this requirement cannot be met by any means other than Fiber Optic based communication system.

2. **SYSTEM PROTECTION SCHEMES (SPS):**

SPS system is implemented for shedding of the matching load or backing down of the generation to avoid cascade tripping in case of tripping of major tie line like HVDC. The matching load has to be proportionally distributed across the utilities. Implementation of SPS requires communication over large distances involving multiple hops and multiple locations; all this necessitates wide band communication system for effective implementation of SPS. SPS can be planned and implemented anywhere in the network, if reliable wide band communication system is available. Implementation of SPS in Northern and Southern Regions has been possible due to availability of wide band communication links between the points of interest.

Due to implementation of UMPPs, establishment of large hydro power plants in Bhutan, upcoming HVDC interconnections between India & Bangladesh, India & Sri Lanka and high capacity AC and DC power transmission links the implementation of several SPS involving several regions may become essential in order to effectively manage the grid.

3. WIDE AREA MEASUREMENT SYSTEM (WAMS)

WAMS (Wide Area Measurement System) based technology is being implemented as a part of the Smart Grid implementation. WAMS requires installation of Phasor Measurement Units (PMUs) at the substations and power plants. The process for installation of PMUs has been done on pilot basis with the commissioning of sixty PMUs and 7 PDCs. Full implementation of WAMS technology is being taken up by Power Grid Corporation of India under URTDSM Scheme (Unified Real Time Dynamic State Measurement Scheme) would involves installation of hundreds of PMUs in each region. PMUs require reliable communication network with very high band width and with least latency. Fiber Optic based communication network is the only suitable communication media for implementation of WAMS technology. It may be mentioned that PMUs are the basic building blocks for implementation of Smart Grid.

4. LINE PROTECTIONS:

For shorter lines current differential protection along with distance protection is preferred as this ensures two line protections on two different principles which are considered a better protection philosophy. The available current differential protection relays exchange the current signals (the data such as magnitude of voltage & current, displacement angle etc.) between the two ends of a line on dedicated fibres. Further, the lines are being frequently LILO, many times resulting into smaller lines. The availability of fibres would make it possible to implement current differential protection on the lines.

Appendix - I

Distribution System Operators (DSOs)

There is need for introduction of concept of Distribution System Operators (DSOs) in India to enable optimal integration and utilization of Distributed Energy Resources (DER), including distributed generation, electric vehicles, storage, and demand response. Distribution systems in India exhibit large scale penetration of behind-the-meter generation and small scale battery storage technologies, which are utilized in a largely uncoordinated and inefficient manner. These conditions warrant the study of evolution of utilities, or other independent agencies, to assume the role of a DSO, and perform a wider array of functions than they do presently in order to ensure more optimal utilization of DER.

With the introduction of distributed generation and information and communication technology, the DSO needs to adapt to the changing circumstances of the market place. Newer mechanisms such as micro-grids are coming into play which can almost be defined as smaller grids within the existing distribution grid. These grids have the ability to be somewhat self-sufficient in energy supply-demand under some circumstances. The advent of Automatic Metering Interface (AMI) and better sensing mechanisms in the field is allowing distribution utilities to control demand

The pro-active distribution system operator will have to manage new type of consumers (Prosumer, Aggregators, TSO) with different contracts and new consumer relationships. These new consumers will be in need of faster (real-time) and more transparent information in order to support the system and its system services.

Besides their traditional mission to operate, maintain and develop an efficient electricity distribution system, DSOs need to fulfil a new role: facilitate effective and well-functioning retail markets. Effective retail markets are markets which should give options to the customers allowing them to choose the best supplier and should allow suppliers to offer options and services best tailored to customer needs. In this new role as neutral market facilitators, DSOs are evolving towards information hubs to perform a reliable and swift change of supplier.

In this direction, Electricity (Amendment) Bill, 2014 seeks to segregate the distribution network business and the electricity supply business, and introduce multiple supply licensees in the market. The Bill introduces a supply licensee who will supply electricity to consumers. The distribution licensee will maintain the distribution network and enable the supply of electricity for the supply licensee. The SERCs will grant supply licenses. Consumers can choose to buy electricity from any of the supply licensees in a given area of supply.

There are multiple options for managing the new distribution system. One way is an integrated distribution planning process. A second way is that the utilities transform into a “Distribution System Platform” provider (DSP) which looks across all options to optimize the distributed system. A third way, the “independent distribution system operator” (IDSO or just DSO) would act as an independent market-maker for a diverse number of behind-the-meter participants to buy and sell energy services, and it would not own any physical assets

itself. The DSO would optimize DERs like energy efficiency, demand management, demand response, distributed generation, electric vehicle chargers, building management systems, and micro-grids.

The DSO would serve as a system optimizer on the local level, calling on least-cost resources to meet distribution system goals. Those least-cost resources could be provided directly by customers, but it's more likely they would be provided by third-party aggregators (e.g., traditional Energy Service Companies, new kinds of energy service businesses). Individual residential customers are unlikely to ever interact directly with the DSO.

In addition to a local system optimizer, the DSO would also act as an aggregator, bidding this optimized portfolio of resources into the traditional marketplace run by the Independent System Operator. Therefore, a DSO allows DERs to compete with traditional independent generators for ISO-level services and bilateral energy services contracts. Meanwhile, the distribution utilities would retain ownership of the assets related to distribution, including primary responsibility to maintain and upgrade the system subject to regulations and laws on performance.

There is need for detailed policy guidelines by Government of India regarding different functions that a DSO would be required to perform in order to ensure safe, reliable and resilient grid operation. Also, a model DSO regulatory framework may be designed by Forum of Regulators (FOR) for adoption at intra-state level with a minimum set of required functionalities and the associated data, communications and control system requirements.

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Appendix - II

Electric Vehicles

The inherent characteristic of renewables is that they are available at the time when the traditional usage level of electricity is not high e.g. off peak power demand hours. This can be gainfully utilized by the transportation sector through Electric Vehicles (EVs) and Plug-in Hybrid Electric Vehicles (PHEVs).

In this direction, Government of India launched the National Electric Mobility Mission Plan (NEMMP) - 2020 to achieve national fuel security by promoting hybrid and electric vehicles in the country. Government has launched the scheme namely Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME India) under NEMMP 2020 in the Union Budget for 2015-16 with an initial outlay of Rs. 75 Cr. The scheme will provide a major push for early adoption and market creation of both hybrid and electric technologies vehicles in the country. It is envisaged that early market creation through demand incentive, in-house technology development and domestic production will help industry reach a self-sufficient economies of scale in the long run by around 2020.

According to sample data analysis on Electric Vehicle in India, each electric car would lead to a load of 5-10 kW on the system. We can assume 8 kW which would be higher if the vehicle is on boost charge. Therefore, by 2020, taking into account about 10 Million EVs, there would be load, in terms of GWs, on the Indian grid.

Three key factors when considering the impact of EV on load profiles and load variations are charging moment, charging need and the charging location. The “vehicle-to-grid” (V2G) greatest near-term promise is for quick-response, high-value electric services. It is recognized that the electric power grid and light vehicle fleet are exceptionally complementary as systems for managing energy and power.

The power grid has essentially no storage (other than capacity in pumped storage), so generation and transmission must be continuously managed to match fluctuating customer load. This is now accomplished primarily by flexing conventional generation. By contrast, the light vehicle fleet inherently must have storage, since a vehicle’s prime mover and fuel must be mobile. Vehicles are designed to have large and frequent power fluctuations, since that is in the nature of roadway driving. The high capital cost of large generators motivates high use (large capacity factor). By contrast, personal vehicles are cheap per unit of power and are utilized only 4% of the time for transportation, making them potentially available the remaining 96% of time for a secondary function.

Compared with large generators, vehicles have low durability (about 1/50 of the design operating hours) and high cost per kWh of electric energy, suggesting that V2G power should be sold only to high-value, short-duration power markets. V2G most strongly competes for electricity when there is a capacity payment to be on line and available, with an added energy payment when power is actually dispatched. This is the case for integration of EVs and PHEVs into the ancillary service markets of spinning reserves and regulation. Suitable policy and regulatory measures are needed for the provision of demand- and supply-side incentives to help transform the market for vehicle electrification.

Ministry of Power
Government of India