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

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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

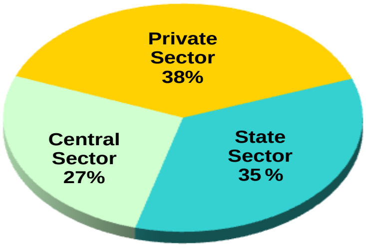
9.1 India has an Installed Capacity of 2, 72,503 MW as on 31.5.2015. The Fuel wise and sector wise break up is as follows:

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)

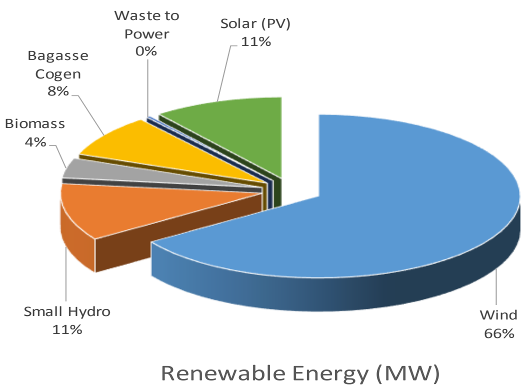
Total generation in 2014-15 : 1048.402* BU

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

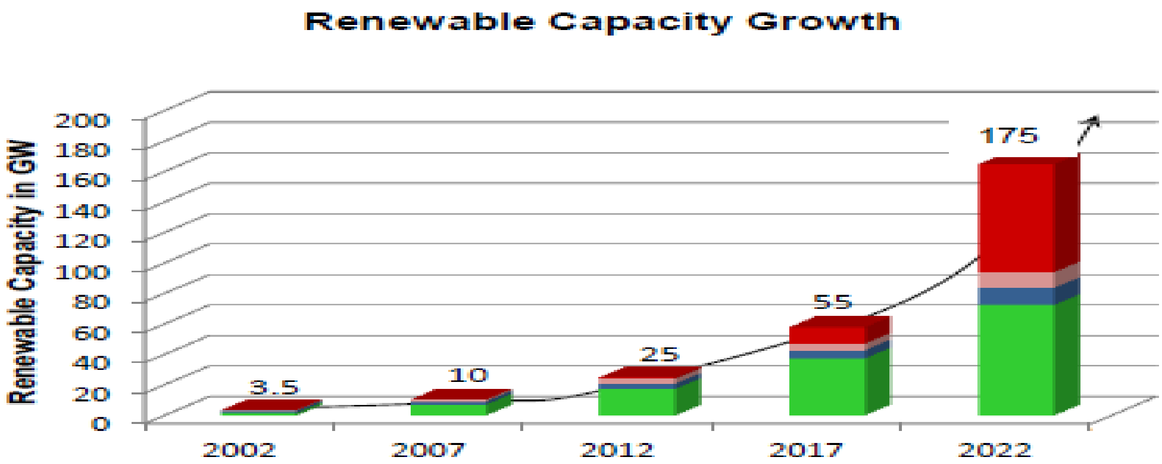


Source: Ministry of New and Renewable Energy

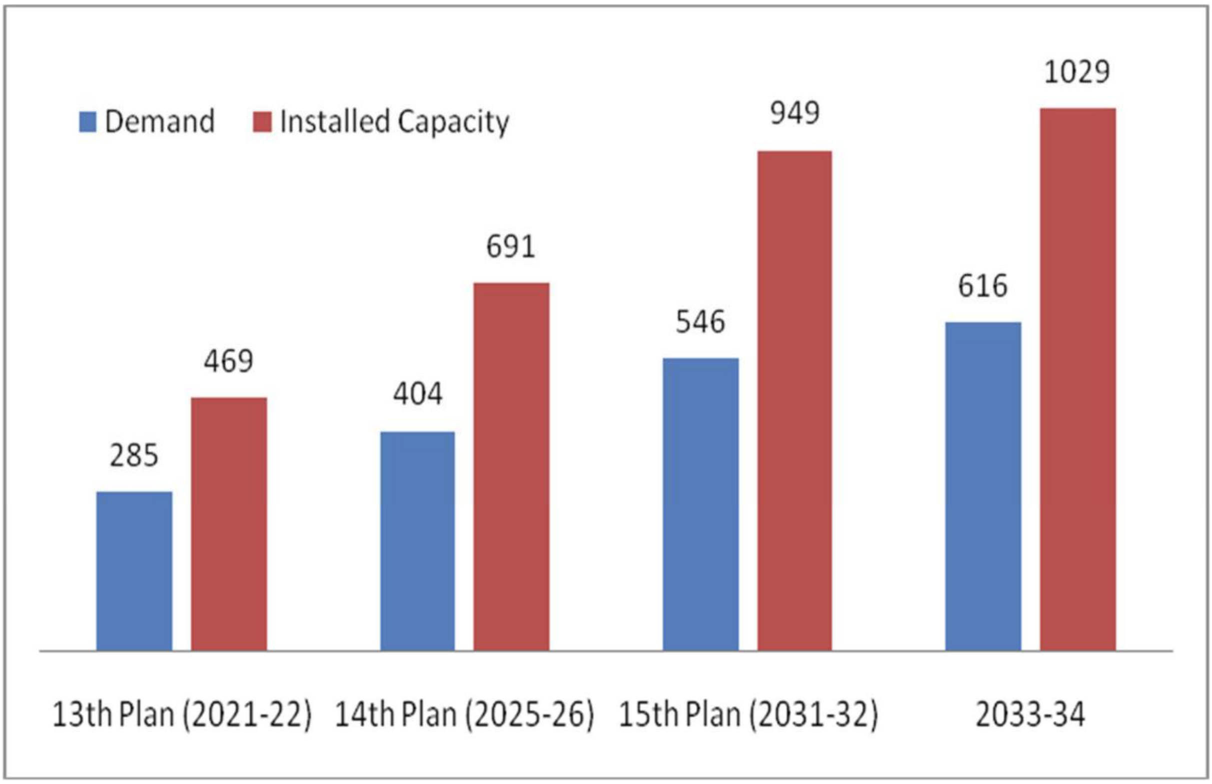
9.3 The Government has rolled out a scheme for development of Solar Parks and Ultra Mega Solar Power Projects on 12th December 2014 which envisages setting up at least 25 Solar Parks and Ultra Mega Solar Power Projects targeting over 20,000 MW of solar power installed capacity within a span of 5 years 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

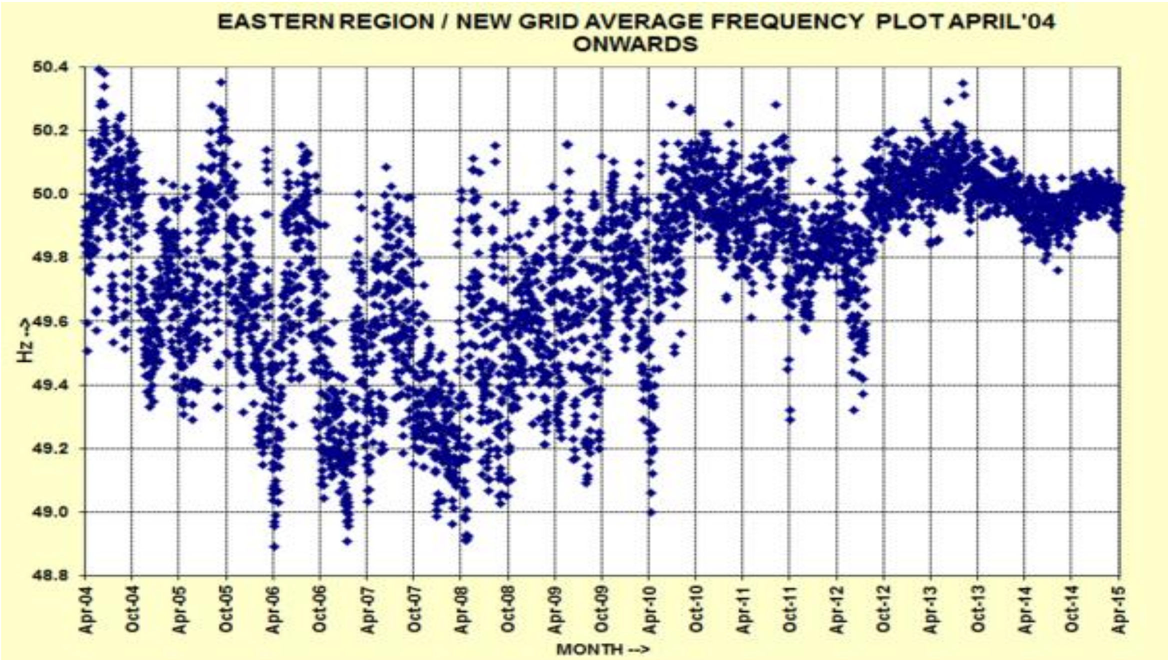
2	Capacity Addition (MW)		14228.00	26251.03	23466.97	19684.95	24608.40
3	Generation (BU)	771.55	811.143	876.89	912.056	967.15	1048.403
	% Increase		5.13	8.11	4.01	6.04	8.40
4	Energy Requirement (MU)	8,30,594	8,61,591	9,37,199	9,95,557	10,02,257	10,68,943
	% Increase		3.73	8.78	6.23	0.67	6.65
5	Energy 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

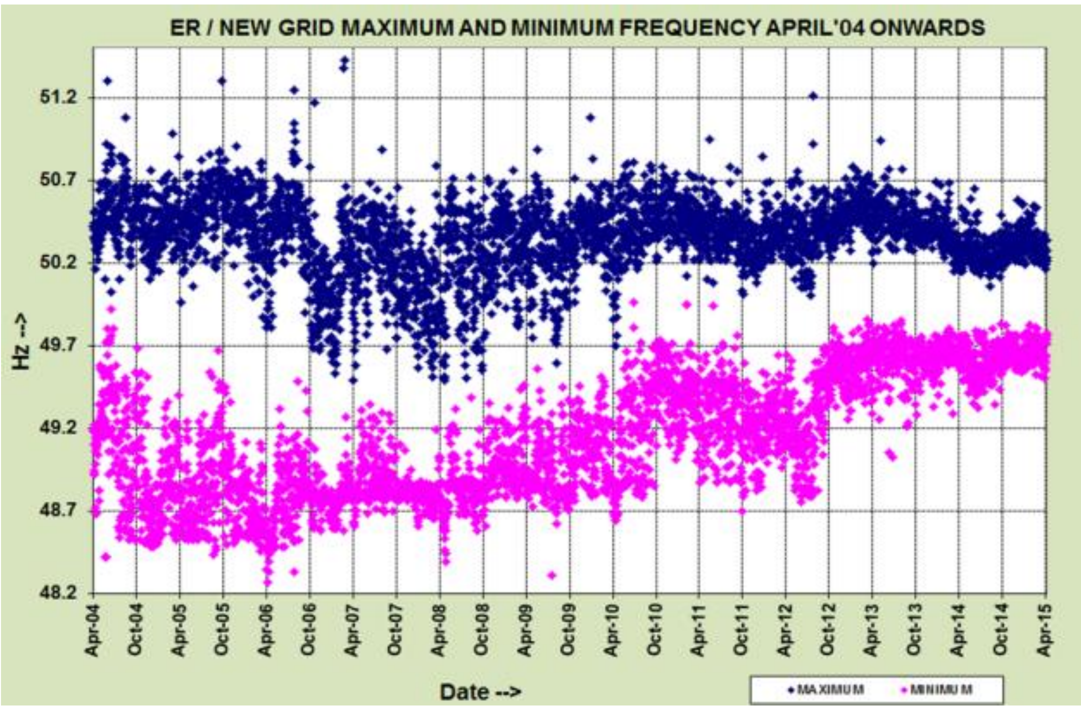
9.11 It may be seen that all India PLF for the thermal plants has gone down from 77.5% in 2009-10 to 64.46% in 2014-15; a drop of about 13%. The increase in demand has not been commensurate with the capacity addition. A capacity of only 100-110 GW of thermal capacity out of total capacity of coal and 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.

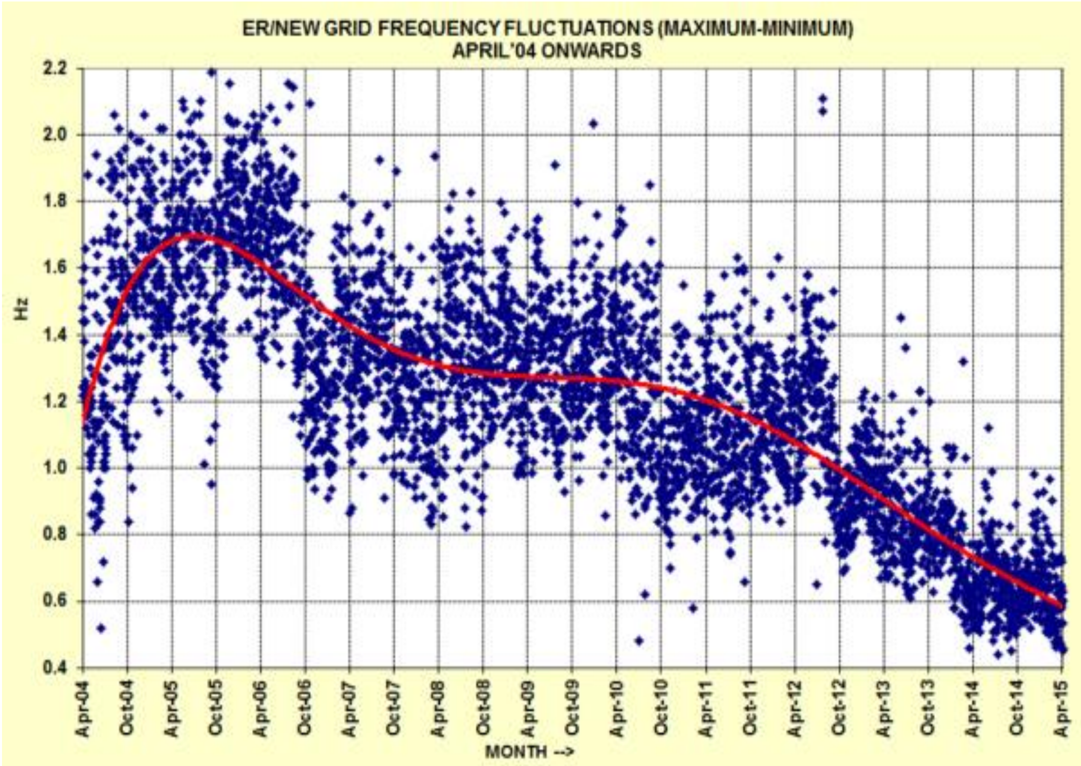
In this back drop, there appears to be no problem in creation of spinning reserves now. As such, spinning reserves of requisite quantum are required to be maintained.

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)

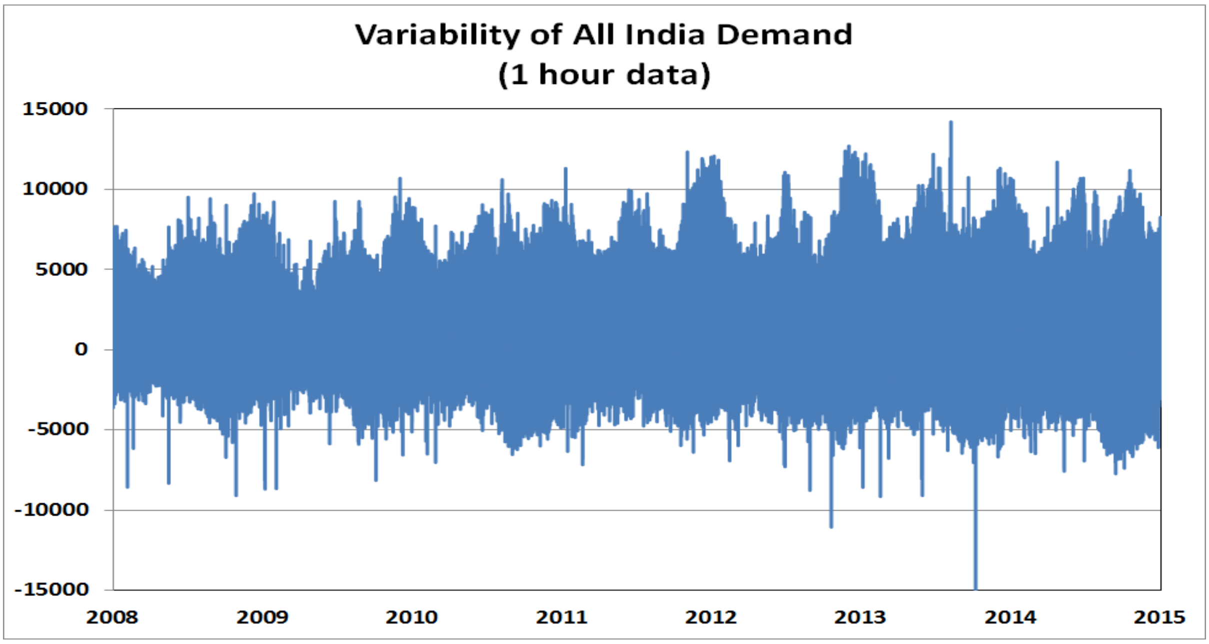
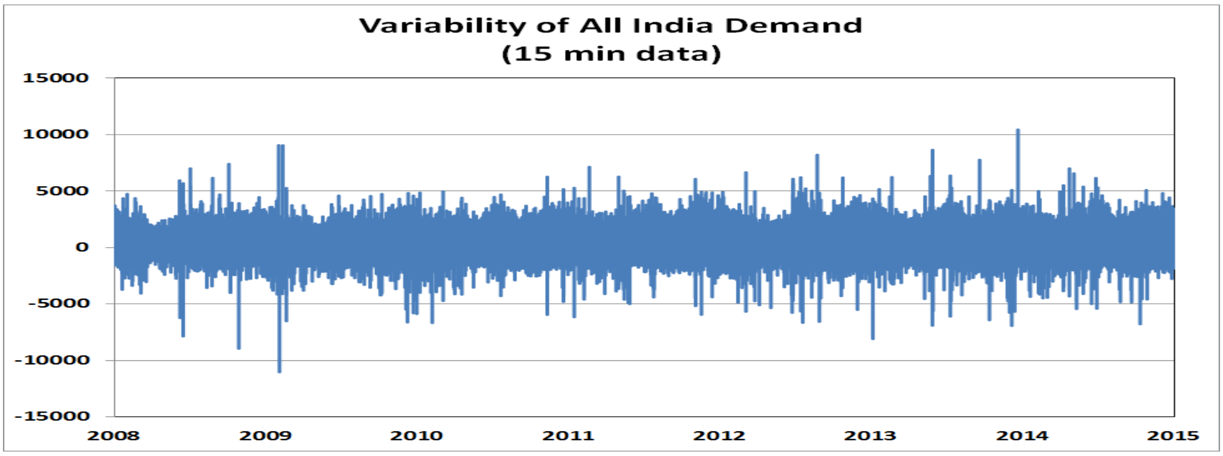


Figure 4: MW Variability of All India Demand (taking 15 minute data variations)



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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