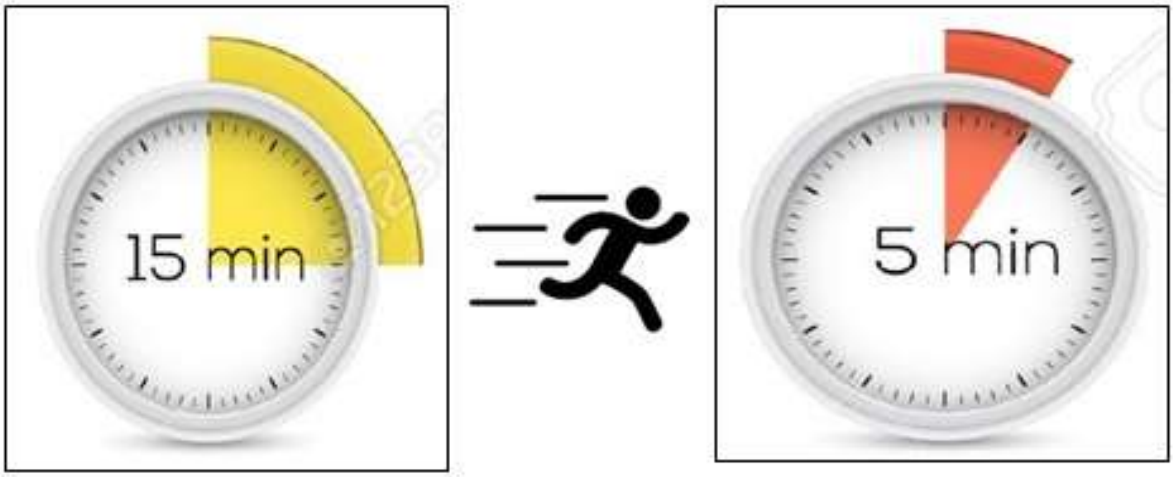
Sub-Group Report on Introduction of Five Minute Scheduling, Metering, Accounting and Settlement in Indian Electricity Market



February, 2018

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Executive Summary

Good decisions depend on good measurement. What gets measured gets monitored and what is monitored gets delivered. Therefore, measurement systems have to be modernized so as to adapt to the fast changing energy landscape.

In the 11th meeting, while deliberating the subject of shorter scheduling and settlement intervals, FOR Technical Committee members appreciated the need to move to 5-minute scheduling and settlement in view of the increasing RE penetration and constituted a sub-group comprising of CEA, CTU, RPCs, POSOCO and CERC Staff.

The sub-group deliberated on various pros and cons of moving to 5-Minute Scheduling, Metering, Accounting and Settlement alongwith associated activities. The implementation of ancillary services and AGC system has kick-started the transition to 'fast' markets. The sub-group also noted the developments in other sectors for fast processes such as banking sector, oil sector and aviation sector. The sub-group identified the imperatives for moving to fast markets viz. increasing renewable energy penetration, harnessing and incentivizing flexibility, ramp management, reduced requirement of reserves, more economy in system operation, implementation of primary, secondary (AGC) and tertiary reserves/frequency control, facilitating & enabling participation of new technologies and need for economic (price) signals at shorter intervals.

The sub-group studied the policy mandate and the regulatory provisions for moving towards 'fast' electricity markets in the present frameworks. The sub-group also carried out review of international case studies of Australia, USA etc. for the deeper analysis of challenges and solutions for transition to five-minute scheduling and settlement.

Two 5-Minute Meter Demonstration by meter vendors were held viz. on 13th September, 2017 at 400/220 kV Magarwada PGCIL S/s, Daman-Diu UT and on 10th October, 2017 at 765/400 kV Vadodara (Wagodia) PGCIL S/s, Gujarat. The meter testing was witnessed jointly by representatives of POSOCO (NLDC, WRLDC), POWERGRID, Gujarat SLDC and Meter Manufacturers. During the 5-minute meter demonstration, it was observed that additional parameters are available in the meters which were kept disabled as the requirement was not posed to the meter manufacturers. The need for software validation and new data exchange format, requirement of Automated Meter Reading (AMR) alongwith communication infrastructure, storage enhancement, standardized data and information protocols were noted as key learnings by the sub-group.

The sub-group also identified suitable amendments required in various Regulations including Grid Code and CEA Metering Regulations. The cost benefit assessment of the metering infrastructure requirements in terms of hardware & software upgradation needed for scheduling, metering, accounting and settlement by the NLDC, RLDCs, SLDCs and RPCs/NPC including for cross border transactions was also carried out.

The sub-group has evolved a detailed action plan for migration to the five-minute scheduling and settlement in a phase-wise manner. The sub-group has also suggested time-frames for the implementation of identified activities and set the target date for migration to 5-minute scheduling, metering accounting and settlement as **01st April, 2020**. The sub-group recommends extensive information dissemination requirements and capacity building measures required for all stakeholders.

The recommendations of the sub-group are summarized as follows:

- Move to "Fast" Markets
- Development of Forecasting as a Core Area in System Operation
- Implementation of Five minute Scheduling and Despatch
- Implementation of 5-minute bidding in OTC and Power Exchanges
- Five-minute Energy Accounting and Settlement System
- Administration and Treatment of the five-minute deviation price.
- Pan-India Pilot Project on 5-minute metering
- Change in data exchange file structures and other technical issues
- Regulatory Interventions
- Amendments in CEA Metering Standards
- Upgradation/Replacement of Metering Infrastructure
- Holding workshops, dissemination, stakeholder capacity building
- Implementation of SAMAST Recommendations

Action Plan

Required Action	Action By	Timeline
Pilot Projects implementation (Freezing technical specs for ISTS meters to enable pilot project implementation. After specs is in place, time for NIT, LOA, type test, delivery, installation etc.)	CTU / RPCs / POSOCO	June 2018
CERC Staff Paper on Regulatory Framework for 5-minute Scheduling, Metering & Settlement arrangements	CERC	June 2018
Changes in CEA standards & regulation	CEA	June 2018
Final Regulatory Framework	CERC	September 2018
Formulation of Technical specifications for new meters and configuration change at RPC/State level	CTU/RPCs/ POSOCO	July 2018
Software upgradation at RPC/NLDC/RLDCs/SLDCs	CTU/RPCs/ POSOCO	July 2018
Procurement process from tendering to commissioning led by CTU at inter-state level and STU at intra-state level	CTU/RPCs/ POSOCO	September 2018
Power Exchanges to migrate to 5-minute bidding framework	CERC / Power Exchange /POSOCO	April, 2019
Trial Run (Transition)	All	April 2019 – March 2020
Go Live	All	01st April, 2020

Acknowledgement

The sub-group would like to thank the Forum of Regulators, Technical Committee of the FOR and CERC for supporting & guiding the sub-group towards accomplishment of this assignment. The sub-group is also thankful to the RLDCs and NLDC for providing resources, logistics and support to the sub-group. The contribution of WRLDC, SLDC, Gujarat and CTU is appreciated in coordinating the meter demonstration & testing with the meter manufacturers.

The cooperation extended by the organizations viz. CEA, NPC, RPCs, TANTRANSCO, TANGEDCO, WBSEDCL, UGVCL, BRPL and POSOCO has enabled the sub-group to examine the various aspects and recommend the appropriate activities.

The contributions of Sh. S S Barpanda, Sh. S C Saxena and Sh. K V N Pawan Kumar from POSOCO with insightful suggestions and preparation of the report are sincerely acknowledged.

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Chapter 1 - Introduction

1.1 Context and Background

The Forum of Regulators (FOR) had constituted a "Technical Committee for Implementation of Framework on Renewables at State Level" (hereinafter referred to as FOR Technical Committee) to facilitate large scale grid integration of renewables. In the 11th Meeting of the FOR Technical Committee held at Chennai on 28th March 2017, deliberations were held on the agenda item *"Introduction of 5 Minute Time Block – Rationale, Preparedness and Costs (towards metering and related infrastructure) and Benefits, and Way Forward"*.

The 15-minute scheduling, metering, accounting and settlement system has been implemented in India in 2002-2003 with genesis in the landmark Central Electricity Regulatory Commission (CERC) order on Availability Based Tariff (ABT) mechanism in Petition No. 2/99 dated 04th January, 2000 *[1]*. Power Exchanges, which were implemented in 2008, began with an hourly market and migrated to sub- hourly (15-minute) market with bidding for every 15-minute time block.

Government of India (GoI) has set a Renewable Energy (RE) target of 175 GW capacity by 2022. The need for implementing a 5-minute scheduling and settlement at the Inter State level is being felt considering the variability of load and renewables especially considering increasing RE penetration in the coming years. Worldwide, it has been recognized that shorter despatch and settlement period such as 5-minute offered a lot of advantages, particularly in terms of reduction in the requirement of reserves, robust price discovery and bringing out the value of flexibility.

The regulatory framework for reserves has been formulated by CERC as also mandated by the National Electricity Policy, 2005. Currently, in India, Ancillary Services have been implemented at the inter-state level, as tertiary reserves at the ISTS level where actions at the power plant happen after 16-30 minutes as advised by National Load Despatch Centre (NLDC) in coordination with Regional Load Despatch Centres (RLDCs), POSOCO.

Recently, in January, 2018, secondary reserves through Automatic Generation Control (AGC) system have been operationalized, on pilot basis at NTPC Dadri Stage-II with control at NLDC, after CERC approval vide order no. 79/RC/2017 dtd. 06th December, 2017 *[2]*. It paves the way forward for secondary regulation services through AGC to be introduced pan-India. CERC also observed that a settlement system based on 5-minute time block is likely to bring in better granularity in grid management and ramp monitoring. The Commission, therefore, directed that 5-minute accounting should be implemented for improved record of AGC signal and the up/down response of the plant.

The FOR Technical Committee recommended the implementation of its report on **S**cheduling, **A**ccounting, **M**etering **A**nd **S**ettlement of **T**ransactions in electricity (SAMAST) at the intra-state level *[3]*. The states implementing SAMAST at the intra-state level are required to factor the 5-minute periodicity in the metering as well as software being procured for scheduling and settlement.

In the 11th meeting, while deliberating the subject of shorter scheduling and settlement intervals, FOR Technical Committee members appreciated the need to move to 5-minute scheduling and settlement in view of the increasing RE penetration. For working out the modus operandi regarding migration to 5-minute scheduling, metering, accounting and settlement, it was decided that a sub-group would be constituted comprising CEA, CTU, RPCs, POSOCO and CERC Staff which would examine these issues in further detail and submit its report to the FOR Technical Committee.

1.2 Constitution of the Sub-Group

The Sub-Group has been constituted by the FOR Technical Committee, vide communication dated 02nd May, 2017 *(Annexure – 1)*, to examine the various aspects of migrating from 15-minute to 5-minute scheduling, metering, accounting and settlement at the inter-state level to facilitate large scale integration of renewables, comprising of the following members:

(a) Shri S.K. Soonee, Advisor, POSOCO
(b) Representative of all RPCs and NPC
(c) Representative of CEA
(d) Representative of POSOCO
(e) Representative of CTU
(f) Representative from one RE rich state each in NR, WR and SR

1.3 Terms of Reference

The broad terms of reference for the Sub-Group are:-

a) Look at all pros and cons of moving to 5-Minute Scheduling, Metering, Accounting and Settlement
b) Identify all activities to move from 15-minute to 5-minute scheduling, metering, accounting and settlement
c) Identify changes required in various Regulations including Grid Code and suggest the required amendments
d) Suggest amendments required to the CEA Metering Regulations and assess the metering infrastructure required
e) Suggest any specific requirements in this context for cross border transactions
f) Infrastructure requirements in terms of hardware & software upgradation needed for scheduling, metering, accounting and settlement by the NLDC, RLDCs, SLDCs and RPCs/NPC

g) Detailed action plan for migration including phasing of activities if required
h) Time-frames for the implementation of identified activities and target date for migration to 5-minute scheduling, metering accounting and settlement
i) Information dissemination requirements to be identified
j) Capacity building measures required for all stakeholders
k) Any other suggestions related to above

1.4 Meetings

Three meetings of the Sub-Group were held as follows:

a) First Meeting – 03rd August, 2017 at NLDC, Delhi
b) Second Meeting – 28th August, 2017 at NLDC, Delhi
c) Third Meeting – 25th October, 2017 at NLDC, Delhi

Two 5-Minute Meter Capability Demonstration by meter vendors were held as follows:

a) M/s Secure Meters and M/s Elster-Honeywell on 13th September, 2017 at 400/220 kV Magarwada PGCIL S/s, Daman-Diu UT
b) M/s L&T on 10th October, 2017 at 765/400 kV Vadodara (Wagodia) PGCIL S/s, Gujarat

Chapter 2 - Imperatives for Fast Markets

2.1 Existing Practices in Indian Electricity Market

In pre – ABT era, there was practice of daily energy booking, joint meter reading based monthly accounting, overlay accounts and frequency measurement from SCADA. There were no inbuilt incentives for generators/utilities to respond for issues like frequency control, merit order operation, grid discipline, power trading, etc.

The introduction of ABT was recommended by GoI appointed ECC (Energy Conservation and Commercialisation) Inc. Consultant in its comprehensive report on Bulk Power Generation and Transmission Tariff in February-1994. It was also supported by NTF (National Task Force) & RTF (Regional Task Force) recommendations from 1995-98. In line with these recommendations, CERC introduced multi-part tariff through implementation of ABT Mechanism vide order in Petition No. 2/99 dtd. 04th January, 2000 at inter-State level.

The ABT mechanism comprising of 15-minute scheduling, despatch, metering, accounting and settlement along with deviation accounts at the inter-state level was implemented in different regions in a phased manner during 2002-2003. Under the ABT mechanism, a coordinated multi-lateral scheduling model has been adopted. Electricity Act, 2003 mandated open access in inter-state transmission which was introduced in May, 2004 and a beginning was made with bilateral transactions through 15-minute trading in power and settlement. Subsequently, in 2008, collective transactions through the Power Exchanges (PX) were also introduced with hourly bidding, clearing and settlement of trades. Subsequently w.e.f. 1st April 2012, the PX also moved to a 15-minute price discovery in the Day Ahead Market (DAM). This shift aligned the PX markets with scheduling, despatch & settlement practice in India.

Ancillary Services were launched in April, 2016 to address the need for 'fast' deployment of tertiary reserves *[4]*. The amendments in Indian Electricity Grid Code (IEGC) in April, 2017 mandated primary response (within few seconds) *[5]*. CERC has also laid down roadmap for Automatic Generation Control (AGC) (few seconds to few minutes) for enabling Secondary Reserves on a regional basis in October, 2015 *[6]*. Recently, in January, 2018, secondary reserves through Automatic Generation Control (AGC) system have been operationalized, on pilot basis at NTPC Dadri Stage-II with control at NLDC, after CERC approval vide order no. 79/RC/2017 dtd. 06th December, 2017 *[2]*. CERC also observed that an energy settlement system based on 5-minute time block is likely to bring in better granularity in grid management and ramp monitoring & management. CERC, therefore, directed that 5-minute accounting should be implemented for improved record of AGC signal and the up/down response of the plant.

2.2 Development of 'Fast' Processes in Other Sectors

2.2.1 Banking and Financial Services Sector

The Reserve Bank of India administers the National Electronic Funds Transfer (NEFT) system. Prior to July, 2017, NEFT settlement was done at hourly intervals from 8:00 am to 7:00 pm on all working days.

With effect from 10th July, 2017, additional settlements in the NEFT system at half-hour intervals have been introduced to enhance the efficiency of the system and add to customer convenience [7]. Therefore, there is introduction of 11 additional settlement batches during the day (at 8.30 am, 9.30 am, 10.30 am … 5.30 pm and 6.30 pm), taking the total number of half hourly settlement batches during the day to 23.

The half hourly settlements speed up the funds transfer process and provide faster credit to the destination accounts thereby ensuring better service for customers.

2.2.2 Oil & Gas Sector

India joined the league of USA, Europe and Australia where fuel prices are revised on a daily basis. The dynamic auto fuel pricing mechanism was successfully implemented, on pilot basis, in five select cities from May 1, 2017. Under the daily revision exercise, the moving average of product price for the preceding 15 days with a lag of two days is taken into consideration for deciding the retail price. Subsequently, the scheme was rolled out pan-India w.e.f. 16th June, 2017. This move ensures that the benefit of even the smallest of changes in international oil prices is passed down the line to the end users every day.

2.2.3 Aviation Transportation Sector

Director General of Civil Aviation (DGCA) vide circular dated 27th September, 2017 [8] directed that departure slots may be distributed evenly within an hour with not more than five departure slots in 10 minutes and total of 30 per hour. The Air Traffic controller (ATC) approval for push back and start up shall be valid for five minutes only. Aircraft not adhering to pushback clearance will go back in the sequence. Airlines not adhering to their time slots will lose their "historicity" during the preparation of schedule for the next season, which means a poor track record will spoil their chances of getting the sought after slots such as those available during peak hours.

The move would penalise airlines with poor on-time performance and will ensure that those with a better record do not suffer. It will help prevent a ripple effect on operations if a flight gets delayed. The travellers would gain from the reduced delays of the flights.

2.3 Imperatives for moving to 5-Minute Scheduling & Settlement

The various imperatives for moving to fast markets are discussed below:

2.3.1 Increasing Renewable Energy Penetration

RE technologies such as solar and wind increase the level of variability and uncertainty in power grid operations; characteristics that are inherent of electric power systems. GoI has set a target of 175 GW of RE by 2022. A recent Greening-the-Grid joint study *[9]* by Ministry of Power, GoI and USAID analyzed that peak system wide one-hour up-ramp increases 27% compared to a system with no new renewables, to almost 32 GW up from 25 GW (Figure 1). This ramp rate can be met if all generating stations exploit their inherent ramping capability. A significant change in load shape could affect the net load ramp rate. Five-minute scheduling and despatch has been demonstrated world-over to better handle faster ramping needs pushed up by grid integration of RE.

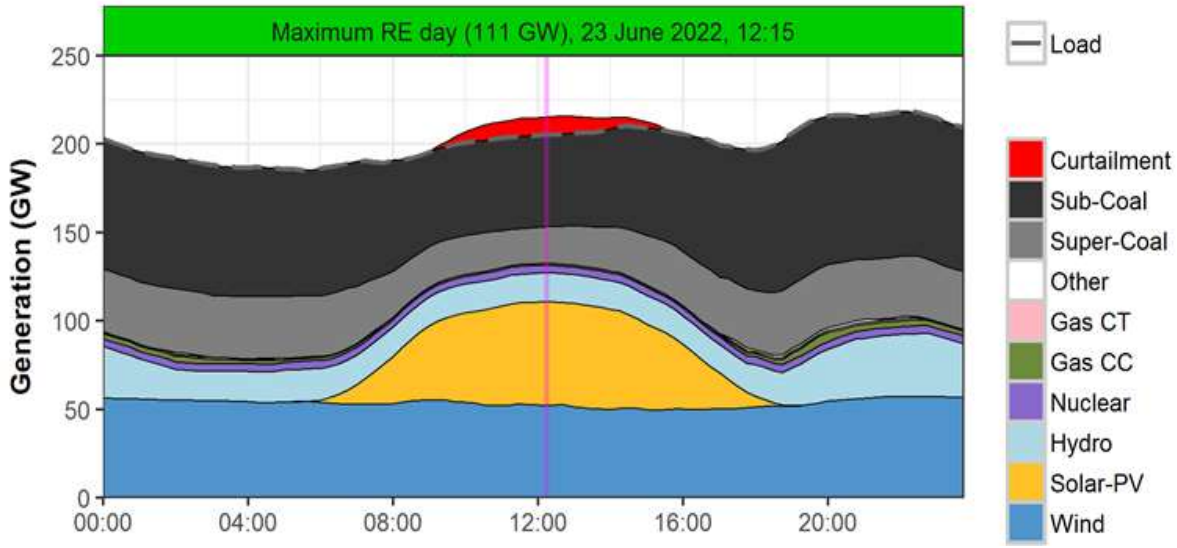


Figure 1: Sample Day in 2022 (Source: GtG Study Report)

Faster markets will allow access to manoeuvring capability of the conventional generation to respond to fluctuations in load and variable generation *[10]*. There may be a need for an additional 'fast' responding ancillary service for supplemental ramping or load following when the generation fleet providing energy can't respond fast enough. Better alignment with the timescale of variable RE resources, enables better utilization of wind and solar forecasts and therefore, lead to reduced wind and solar curtailment.

2.3.2 Harnessing and Incentivizing Flexibility

In India, power demand depends upon many factors including weather, season and time of the day. An analysis of the All India yearly demand shows that there is difference of the

order of 45 GW in maximum and minimum demand during winter months as against the about 25 GW during summer months.

The data analyzed by POSOCO in the "Electricity Demand Pattern Analysis" report *[11]* demonstrates that there is minimum demand of around 100-105 GW for about 95 % of the time in a year (Figure 2). There is need for peaking up/backing down for about 5 % time of the year.

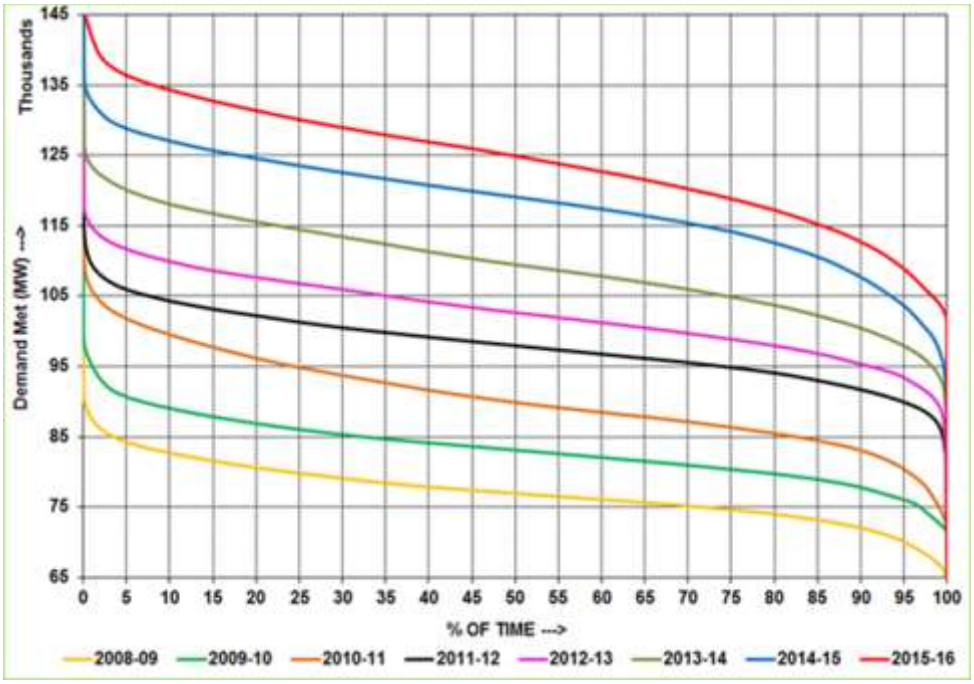


Figure 2: All India Demand Duration Curve (2008-2017)

With changing load profile, flexibility in the existing fleet of conventional generation has to be harnessed to facilitate integration of RE. As more renewable generating capacity is added, increasingly different net load shape takes place. The fast ramping/backing down & peaking support capability of the generators viz. hydro, gas etc. has to be valued and incentivized. The hydro and thermal flexing is already helping the Indian power system flexibility needs. However, with 175 GW of renewables, the flexibility needs of the Indian power system will grow manifold.

As per Figure 3 below, the hourly variations in hydro generation of the order of 8000 MW reduce to about 3500 MW in case of 15-minute despatch. Similarly, the hourly variations in the thermal generation of the order of 8000 MW reduce to 2500 MW in case of 15-minute despatch. Therefore, further reduction in the scheduling and despatch time-frame from 15-minute to 5-minute would result in reduced variation in generation leading to better efficiency.

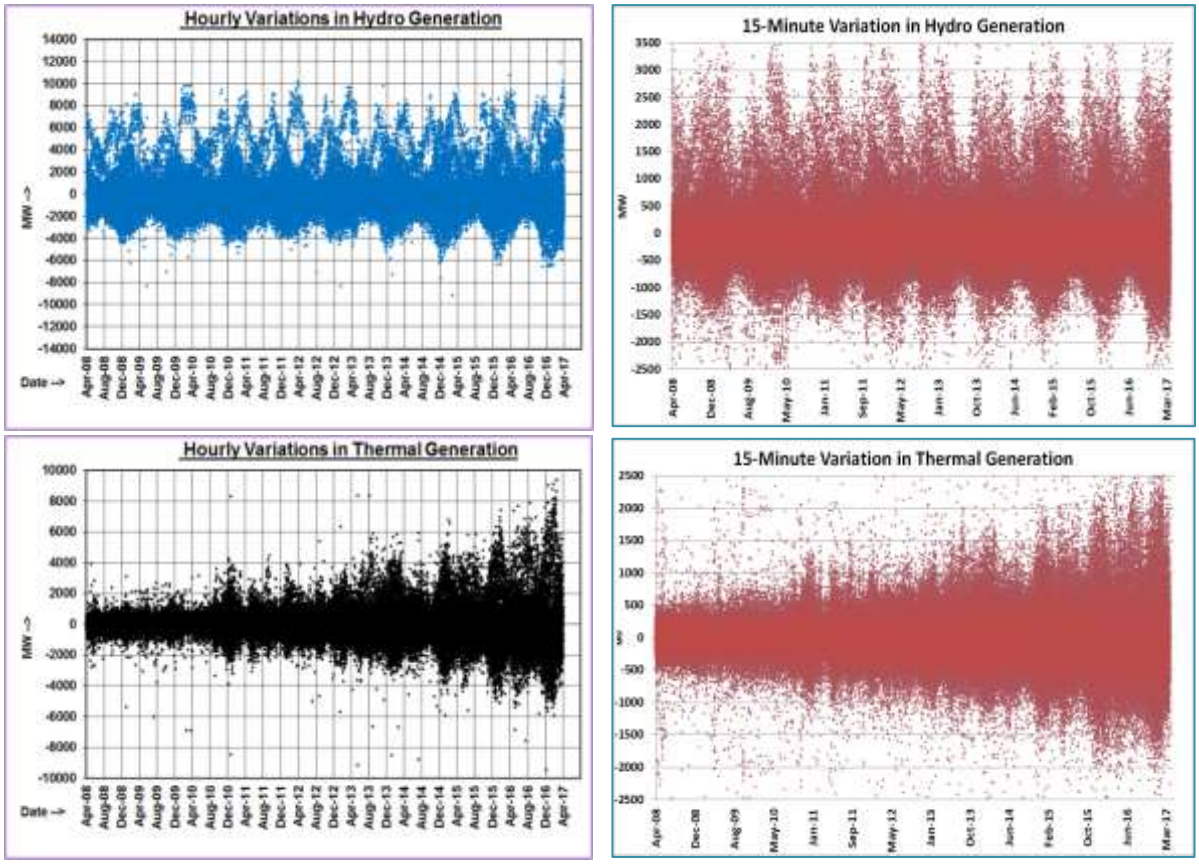


Figure 3: Comparison of Hydro and Thermal Generation (Hourly vs 15-Min)

The demand for and provision of flexibility materialises in short-term markets. Through market design refinements, flexibility needs can be fulfilled and efficient flexibility provision can be achieved *[12]*. The electric grid has always been somewhat flexible in order to meet variable electricity demand at every instant. But increasing variability and ramping requirements introduced by cleaner, more modern power system means system flexibility is poised to become more and more valuable.

Many different resources are already available to deliver grid flexibility on both the short-term operational timeframe and the long-term planning timeframe. Flexibility can come from physical assets, such as batteries and fast-ramping hydro, natural gas plants, but it can also come from improved operations, such as shorter dispatch intervals and improved forecasting tools *[13]*. Shortening dispatch schedules can allow the grid to respond more rapidly to changes in supply from variable renewables. Shortening dispatch intervals also creates value for flexible resources that are capable of responding in near-real-time by ramping up or down easily.

2.3.3 Ramp Management

The effects of variability in demand are compounded by the variability of wind and solar power generation, which increases the volatility of the power system. At present, in the Indian system, typical ramp up/down of 250-300 MW/min for about an hour

is observed during morning and evening peaks (Figure 4). However, when the granularity of the ramp is analyzed on minute to minute basis, it goes to as high as 600 MW/min for few minutes (Figure 5). Presently, much of the ramping requirement is taken care through scheduling of fast acting hydro generation.

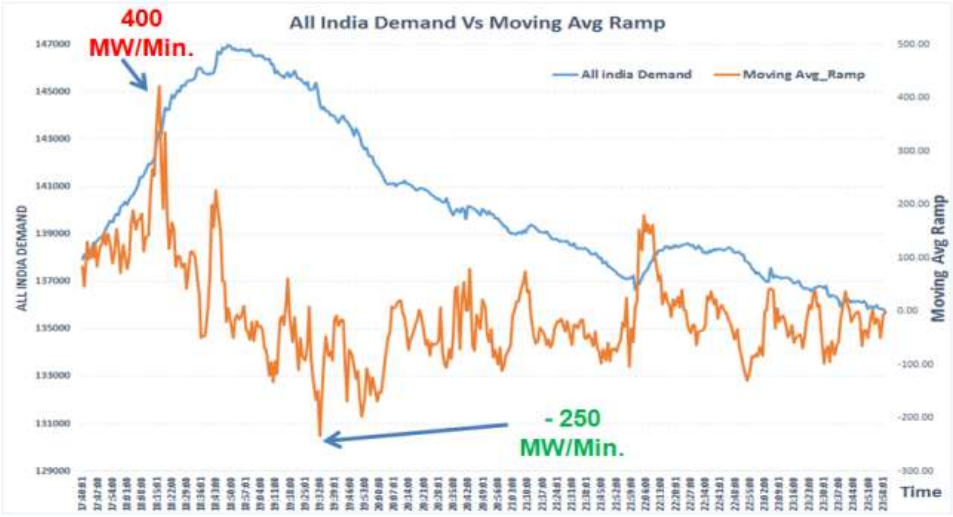


Figure 4: Ramping Requirement during Peak Hours

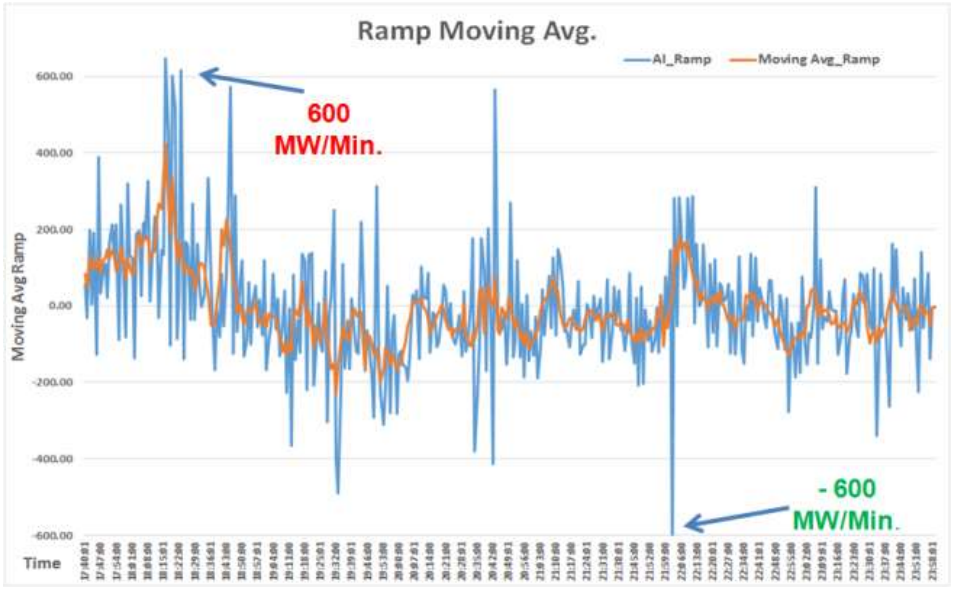


Figure 5: Ramping Requirement within a Ramp (Acceleration)

CEA National Electricity Plan (NEP, Dec-2016)-draft *[14]* analyzed the hourly data of three years and estimated the All India Load profile and Net load curve (Figure 6) for the year 2021-22 based on respective projected Peak Demand and Energy Requirement. It is observed that high ramping up and down requirements are there especially in the peak and off-peak times. The duck belly demand to peak demand ratio is 61% which will lead to partial loading and two shifting i.e. cycling of conventional power plants.

The ramping requirement for 2021-22 for 8760 hours (24X365) has been estimated (Figure 6). There is substantial amount of hours when ramping requirement is in the range of 350-450 MW/min. in a year. Therefore, NEP requires that fast ramping capabilities of conventional generators must be harnessed for grid integration of RE along with suitable market framework through fast ancillary services to incentivize the capability.

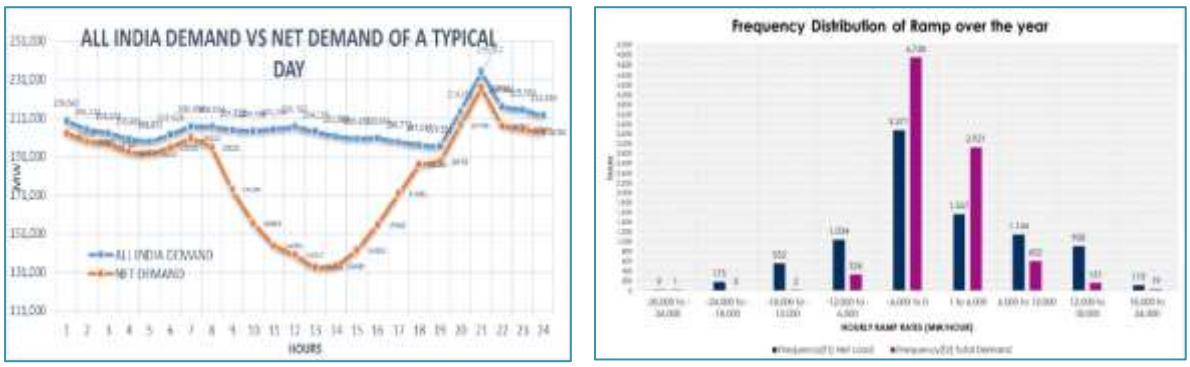


Figure 6: All India Load Curve, Net Load Curve and Ramp Distribution in 2022 (Source: NEP, CEA)

As per Figure 7, it is observed that the ramp management through 5-minute schedule is easier than with 15-minute schedule. In case of 15-minute despatch, there is always possibility of over-scheduling or under-scheduling resulting in large deviations from schedule.

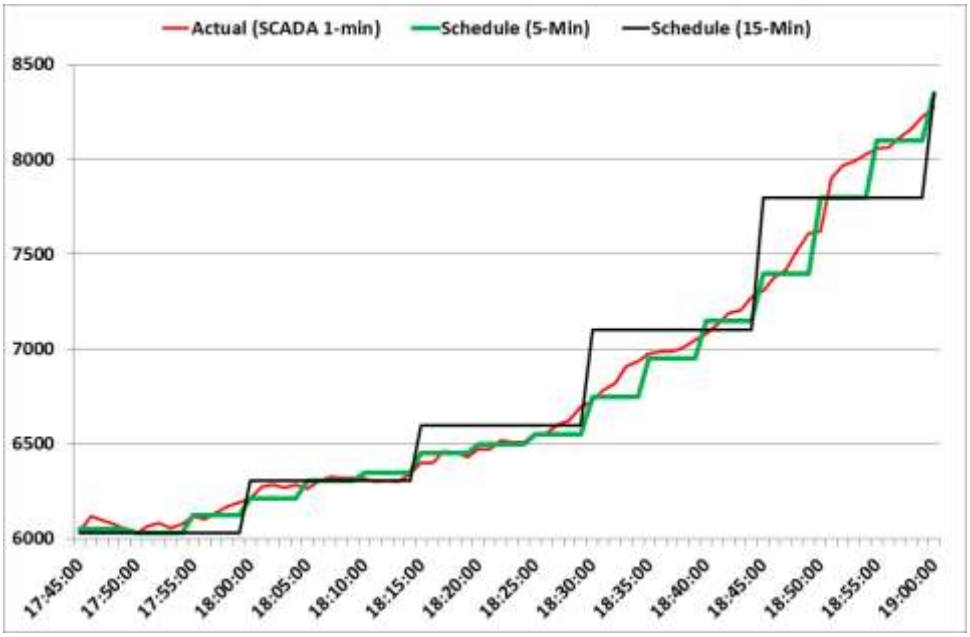


Figure 7: Ramp Management through 5-Minute and 15-Minute Scheduling

Therefore, faster markets will facilitate introduction of flexible ramping products to help improve the short-term operational flexibility of the electric grid. The benchmarking of ramp rate of generating units is also required.

2.3.4 Improved Forecasting, Scheduling and Despatch

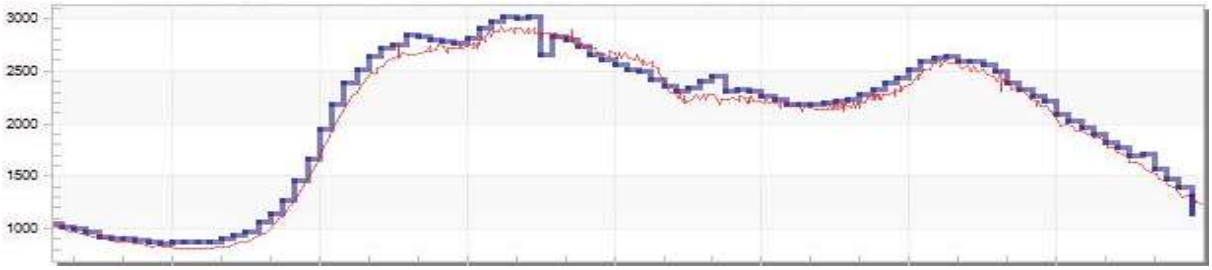
It is understood that the difference between the forecasted and actual values has a bearing on the confidence level of the system operators relying on forecasts for maintaining system security and reliability, especially with increasing level of variable renewable generation. The state utilities can take advantage of relationships between forecast error and forecast horizons, and between the magnitude of output variability and the length of the despatch period [15]. Improved forecasting leads to better scheduling and despatch of the system resources. Further, this migration of value upstream from system operation necessitates improvements in both forecast skill and effective forecast communication.

Short despatch intervals allow more frequent re-dispatch of the whole systems, enabling deviations to be dealt with by adjustment of every market participant in the system as appropriate. Long scheduling and despatch intervals mean that deviations in load and variable generation from the central set point for the interval for be significantly larger, requiring larger regulation services.

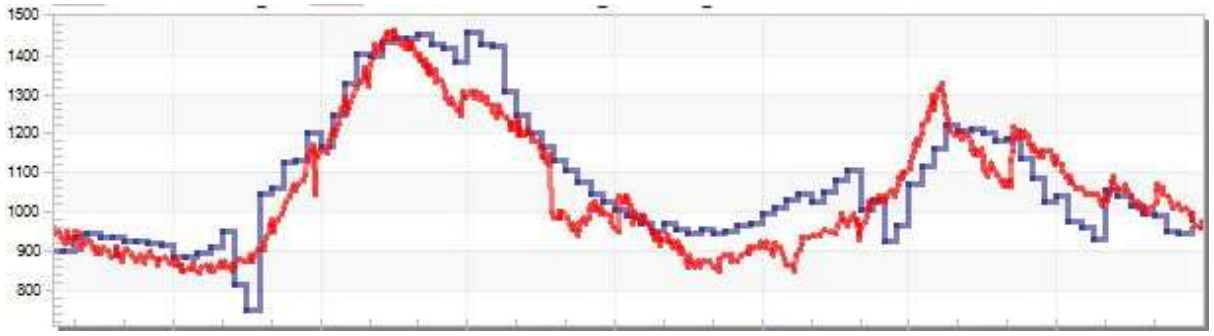
The timing of solar and wind variability occurs more in the sub-hourly to multiple-hour timeframe, not in the minute-to-minute timeframe for which regulation service (more expensive) is intended. The accuracy of RE forecasts is significantly higher the closer they get to dispatch. Consequently, the ancillary service requirements will also be lower. Enabling more dynamic despatch capabilities takes advantage of the implicit nature of renewable energy and weather, just as other scheduling practices, such as start-up costs and minimum run times, are used to reflect the implicit characteristics of thermal generators and fuel sources [15].

It is observed that the constituent states can closely match their schedules with actual drawal from the grid through better portfolio management. It results in lesser stress on the grid. Hence, faster despatch interval leads to improved forecasting and scheduling in system operation with/without renewable generation.

Delhi

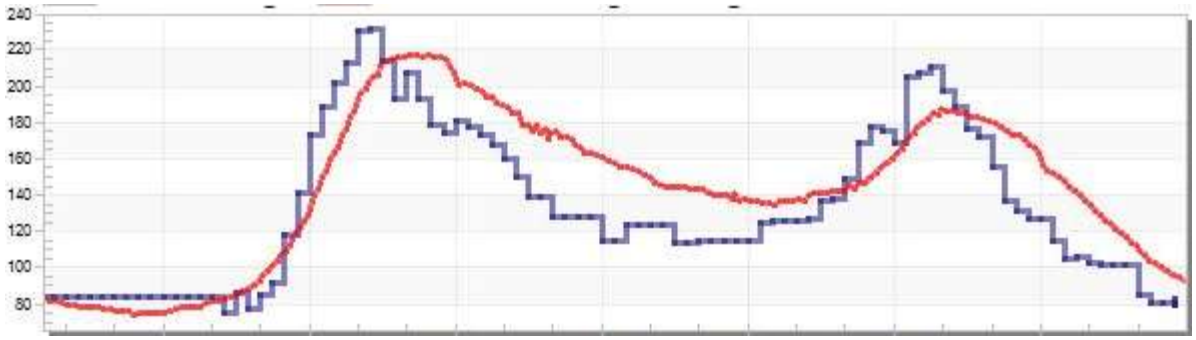


Uttarakhand

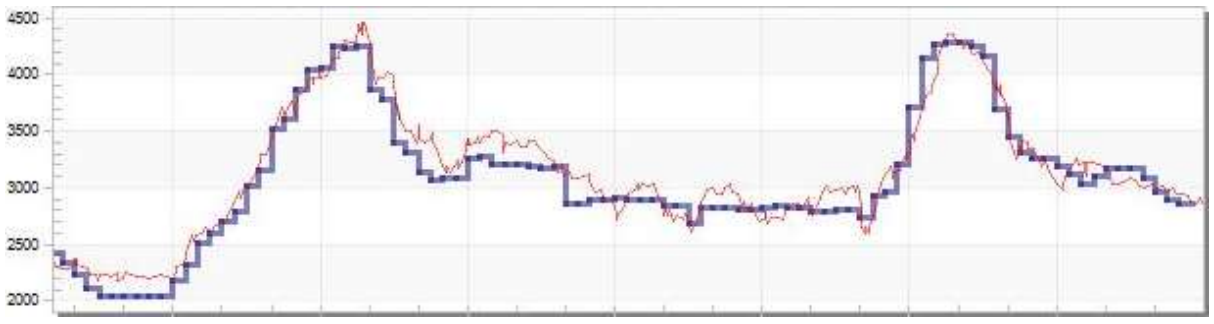


Uttar Pradesh

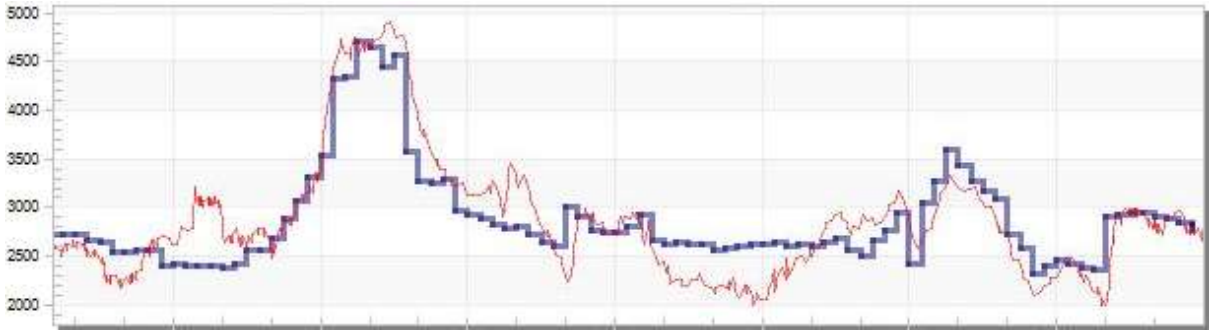
Chandigarh



Haryana



Rajasthan



2.3.5 Reduced Requirement of Reserves

The operating reserve requirements are dynamic and change based on system conditions. Therefore, operating reserve requirements majorly depend on the operating despatch interval frequency. It has been observed that faster markets improve access to generation that may be available to alter its output, whereas slower markets restrict units on economic dispatch so that they cannot respond to demand changes within the dispatch period *[16]*.

As observed from Figure 8 below, analysing the data from 2008-2017, the hourly variations of the order of 14000 MW reduce to 5000 MW in case of 15 minute despatch.

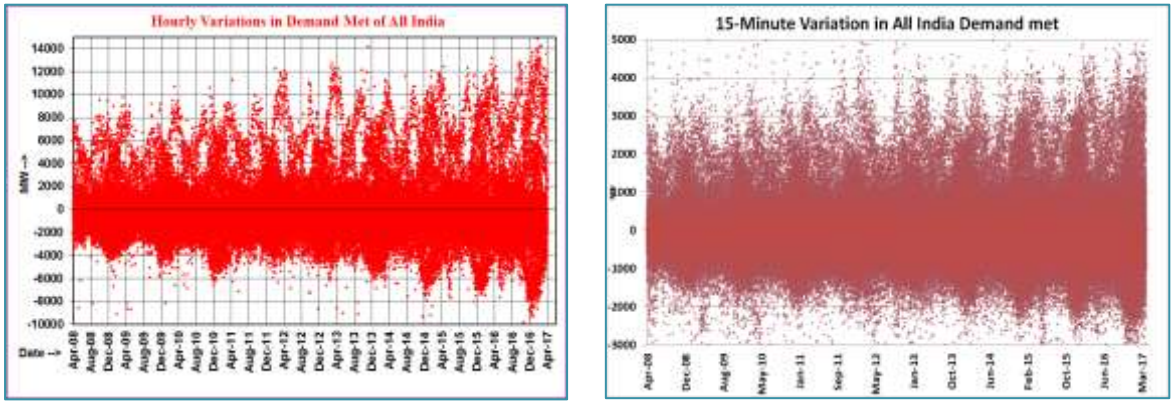


Figure 8: Comparison of Variation of All India Demand (15-minute vs Hourly)

As observed from Figure 9 below, in 2016-17, the hourly demand variations of the order of 12000 MW reduce to 4000 MW in case of 15 minute and further to 2000 MW in case of 5-minute scheduling and despatch.

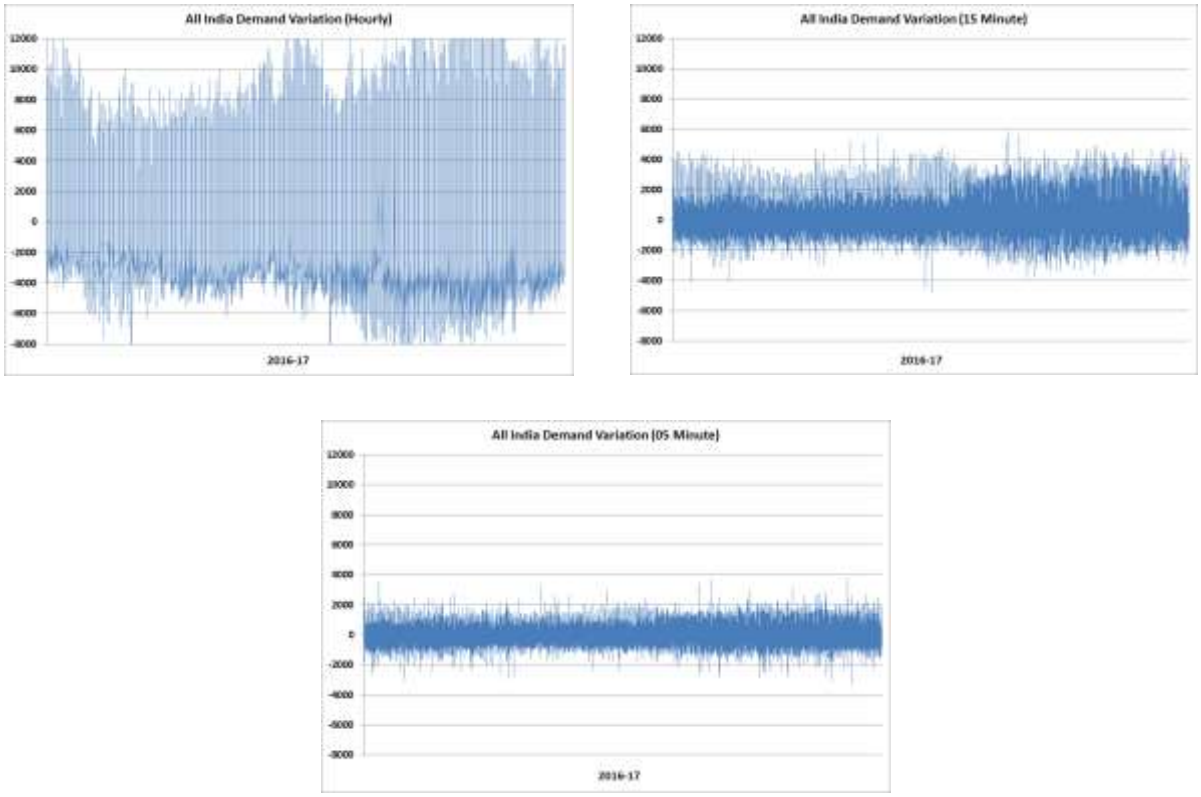


Figure 9: Reduced Reserve Requirement

It is observed from literature available that the standard deviation (σ) of the 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 analysis of the 2016-17 data indicates that in case of hourly despatch, the reserve requirement is of the order of 11,000 MW which reduces to 3300 MW in case of 15-minute and further reduces to 1400 MW in 5-minute scheduling and despatch. Therefore, 5-minute scheduling and settlement will further reduce the variations and therefore, the requirement of reserves is reduced.

Generally, moving from 15-minute to 5-minte would help in maintaining better load generation balance and consequentially, better frequency control, which also requires sufficient primary and secondary controls (i.e. Governor response, and AGC). The 5-minute despatch interval provides an opportunity to better balance the system in the 'scheduling' time frame itself and subsequently, the automatic controls (primary and secondary frequency controls) would play an important role in the real time. . CERC has already directed for roadmap for reserves in its order in Petition No. 11/SM/2015 dated 13.10.2015. There is a need for compliance monitoring of the primary control through FGMO, as also directed by CERC vide order dated 31-July-2017 under Petition 84/MP/2015.

Recently, in January, 2018, secondary reserves through Automatic Generation Control (AGC) system have been operationalized, on pilot basis at NTPC Dadri Stage-II with control at NLDC, after CERC approval vide order no. 79/RC/2017 dtd. 06th December, 2017.

CERC also observed that an energy settlement system based on 5-minute time block is likely to bring in better granularity in grid management as well as ramp monitoring & management. CERC also directed that 5-minute accounting should be implemented for improved record of AGC signal and the up/down response of the plant. The implementation of 5-minute scheduling and settlement is vital for control and compliance monitoring of the pan-India AGC implementation.

2.3.6 Implementation of Primary, Secondary (AGC) and Tertiary Reserves/Control

The introduction of Ancillary Services in Indian power system has seen a marked improvement in the frequency profile. The average frequency remains very close to 50.00 Hz in a day. The Frequency Variation Index (FVI) has improved to around 0.03-0.05 with the frequency remaining within the IEGC Frequency Band for 75-80% of the time and more (Figure 10).

It is observed that while the frequency is remaining within the IEGC specified frequency band close to 50.00 Hz, there are frequency excursions occurring outside the allowed frequency band at the hour boundaries. The frequency excursions are short and sharp in nature and managing these frequency excursions require fast responding resources, such as hydro, which can be pulsated for a short duration and ramped up/down quickly in succession.

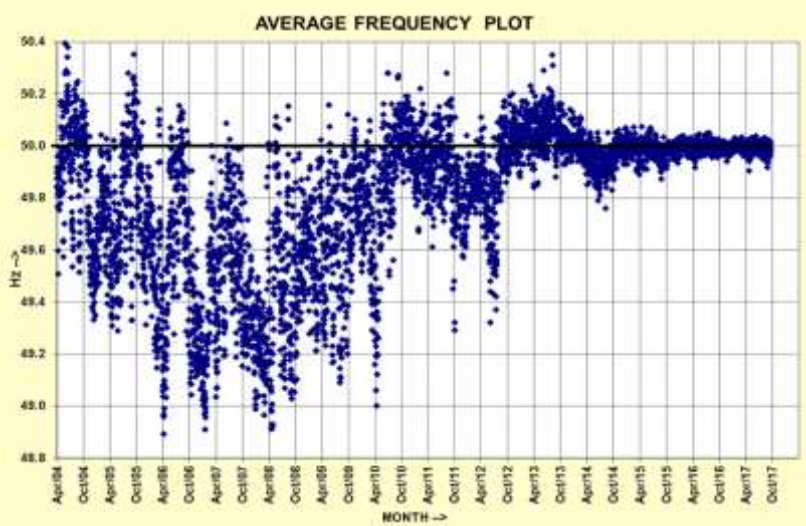
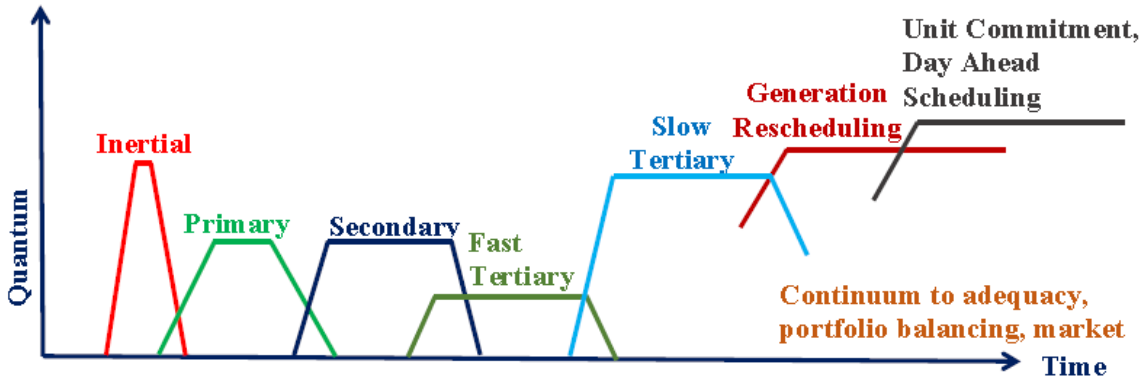


Figure 10: Frequency Profile over the Years

Different frequency control mechanisms, namely, primary frequency control, secondary frequency control and tertiary frequency control act in different time frames as shown in the Figure 11. Presently, in India, primary frequency control is mandated and needs to be enforced. A pilot for implementation of secondary frequency control has been implemented. The present Ancillary services implementation falls in the category of tertiary frequency control at the inter-state level where actions at the power plant happen 16-30 minutes after the same is advised by NLDC.

In order to further reduce the frequency fluctuations and achieve a more stable frequency profile, implementation of primary response and secondary response as per the CERC Roadmap for Reserves is essential.



Response → Attribute ↓	Inertial	Primary	Secondary	Fast Tertiary	Slow Tertiary	Generation Rescheduling/ Market	Unit Commitment
Time	First few secs	Few sec - 5 min	30 s – 15 min	5 - 30 min	> 15 – 60 min	> 60 min	Hours/ day-ahead
Quantum	~ 10000 MW/Hz	~ 4000 MW	~ 4000 MW	~ 1000 MW	~ 8000-9000 MW	Load Generation Balance	Load Generation Balance
Local / LDC	Local	Local	NLDC / RLDC	NLDC	NLDC / SLDC	RLDC / SLDC	RLDC / SLDC
Manual / Automatic	Automatic	Automatic	Automatic	Manual	Manual	Manual	Manual
Centralized / Decentralized	Decentralized	Decentralized	Centralized	Centralized	Centralized/ Decentralized	Decentralized	Decentralized
Code / Order	IEGC / CEA Standard	IEGC / CEA Standard	Roadmap on Reserves	Ancillary Regulations	Ancillary Regulations	IEGC	IEGC
Paid / Mandated	Mandated	Mandated	Paid	Paid	Paid	Paid	Paid
Regulated / Market	Regulated	Regulated	Regulated	Regulated	Regulated / Market	Regulated / Market	Regulated / Market
Implementation	Existing	Partly Existing	Pilot	Yet to start	Existing	Existing	Existing

Figure 11: System Balancing in India – A schematic

Recently, in January, 2018, secondary reserves through Automatic Generation Control (AGC) system have been operationalized, on pilot basis at NTPC Dadri Stage-II with control at NLDC, after CERC approval vide order no. 79/RC/2017 dtd. 06th December, 2017 *[2]*. CERC also observed that an energy settlement system based on 5-minute time block is likely to bring in better granularity in grid management and ramp monitoring. The Commission, therefore, directed that 5-minute accounting should be implemented for improved record of AGC signal and the up/down response of the plant. Mileage based settlement has been mandated for AGC payment on a 5-minute interval as per CERC order.

In the NEM (Australia), Frequency Control Ancillary Service (FCAS) is sourced from markets operating in parallel to the wholesale energy market, with the energy and FCAS markets being optimised simultaneously so that total costs are minimised *[17]*. Contingency FCAS is divided into raise and lower services at three different speeds of response and sustain time: fast (6 seconds), slow (60 seconds) and delayed (5 mins). In response to a contingency event, each type of contingency FCAS works together to recover the power system frequency within the applicable frequency bands and time frames defined in the frequency operating standard, as displayed in Figure 12.

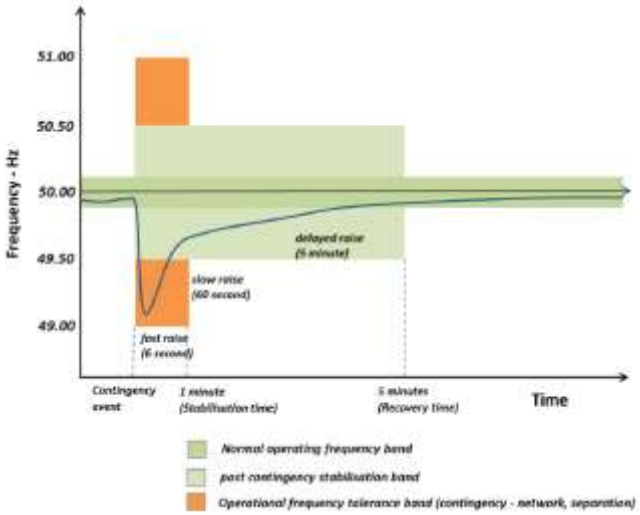


Figure 12: Frequency Deviation and FCAS Response (source: AEMC Issues Paper [14])

Australian Energy Markets Commission (AEMC) has released an issues paper *[17]* to review the structure of FCAS markets, to consider:

- any drivers for changes to the current arrangements, how to most appropriately incorporate FFR (fast frequency response) services, or alternatively enhancing incentives for FFR services within the current six second contingency service
- any longer-term options to facilitate co-optimisation between FCAS and inertia provision.

Similarly, in USA, some systems with higher penetration rates are introducing new Ancillary Services *[18]* as follows:

- MISO introduced a 5-minute ramping ancillary service
- CAISO introduced a 5-minute flexible ramping product.
- ERCOT proposed a redesign of its AS market to enable new technologies to help meet an anticipated growing need for frequency response in case inertia fell

Therefore, there is need to integrate faster frequency control services offered by new technologies into the current regulatory and market arrangements.

2.3.7 Facilitating & Enabling Participation of New Technologies

Product duration (how long a product has to be delivered) can have relatively restrictive consequences for market participation, especially in balancing markets. The longer a product has to be contracted (capacity) or delivered (energy), the more this restricts the potential number of flexibility providers. Longer contracting requirements are restrictive for RES and DSR (or small-scale storage) need shorter duration for commitment *[19]*. The three technology trends bringing disruption to the electricity industry – electrification, decentralization and digitization – will affect grid and behind-the-meter economics

differently depending on their trajectory of adoption. Therefore, 5-minute scheduling and settlement will encourage such providers to participate in the Indian electricity market.

Arrangements should be designed to take into account the full range of potential market and network solutions. They should not be targeted at a particular technology, or be designed with a particular set of technologies in mind. Technologies are changing rapidly and, to the extent possible, a change in technology should not require a change in arrangements *[19]*. The design of the market should enable the market to choose the least cost technology for supply or the technology that is most valued by consumers. Technology neutrality is therefore important in that it enables an efficient mix of generation and consumption market responses in the short term and an optimum mix of supply side and demand side investment in the longer term. This minimises the costs of supply over time.

There is already some level of investment in fast response technology – such as aggregating distributed battery storage, next generation gas peaking plants and faster start demand response. Five minute settlement will enable efficient investment to be directed towards generation and demand side technologies that represent the optimal path to balance supply and demand over time *[19]*. The capital costs of new technologies – such as utility-scale battery storage – have been decreasing and investors' expectation of wholesale market revenues are increasingly becoming a key decisive factor in their uptake. In this context, it is important that the market design features such as settlement processes do not inadvertently create artificial barriers for efficient new generation and demand response technologies to enter the market.

2.3.8 Need for Economic (Price) Signals at Shorter Intervals

A market where the price signals provide incentives to respond to supply and demand changes over the shortest timeframe practicable, will provide more efficient wholesale market outcomes. To promote efficient outcomes in the electricity market, spot prices should generally reflect the marginal cost of supply and value of consuming electricity. When supply and or demand conditions change frequently, a shorter scheduling and settlement interval is likely to lead to prices that more accurately reflect the value of supplying or consuming electricity at different times. With hourly bidding, the conventional generators could place sell bids and the buyers could place buy bids for each hour of the next day of delivery. After introduction of sub-hourly bidding in the power exchanges in India, the granularity of 15-minute bids gave greater flexibility to the generators on supply side to utilize their ramping and start-stop capabilities.

The distribution utilities also adapted the sub-hourly bidding to manage their procurement portfolio on the demand side. The Sub-Hourly bidding in the Power Exchanges has helped in reduction of steep ramps, elimination of sharp discreet changes, reduction in frequency fluctuations, facilitation of better load management and integration of renewables. The 15

minute versus hourly schedules, volumes and prices for a sample day in Sub-hourly and Hourly time blocks in the Power Exchange(s) are illustrated in Figure – 13, 14 and 15 resp.

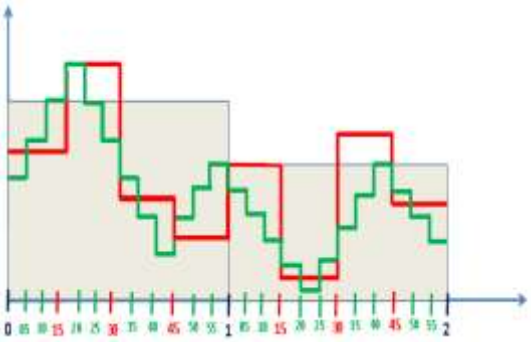


Figure 13 : 5 Minute, 15 Minute and Hourly Schedules

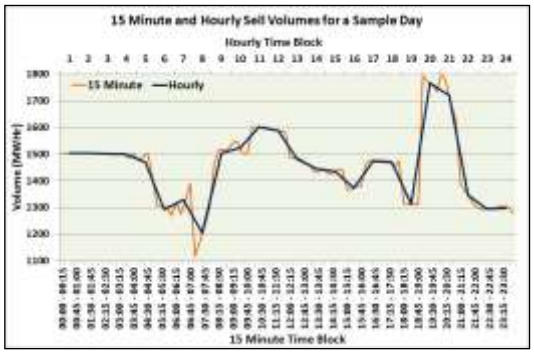


Figure 14 : 15 Minute and Hourly Volumes

Figure 15: 15 Minute and Hourly Prices in PX

At present, four time–blocks of 15-minutes (total 60 minutes) is provided for re-scheduling of resources. With the advent of new technologies and fast responding resources i.e. Storage, Demand Response, Electric Vehicles, there is need for faster despatch to incentivise the participation of distributed resources, aggregators and neighbouring markets best able to contribute to system needs. Scheduling rules that restrict generators to hourly movements artificially hobble the conventional generation fleet, resulting in lost opportunities for those generators and increased costs for all *[10]*.

The suite of day-ahead, intraday, real-time (balancing) and ancillary services markets are where prices optimise the system in the short run, and reveal the value of electricity (and thus investments in the long run).

Chapter 3 - Policy and Regulatory Mandate

3.1 CERC Consultations and Orders (2010, 2017)

CERC deliberated the adoption of shorter bidding and despatch intervals for bringing in more efficiency in the Indian electricity market. In this direction, CERC floated a Consultation Paper on Modifications in Power Market Design: Evening Market, 15 minute Bidding time block and Ancillary market on Power Exchange dated 13th August, 2010 *[20]*. The relevant extracts are quoted as below:

"…B. Change of bidding time block from 1 hour to 15 minutes on Power Exchange

2. Rationale for 15 minutes bidding time blocks

1. One of the major benefits will be attracting wind generators and solar generators to power exchanges. Wind generator and solar generators which are untamable resources and dependent on wind velocity and sunlight availability respectively for carry a higher risk in bidding and committing supply for time blocks of 1 hour.

Further, these generators are small in size and loss of opportunity for even a single time block of 15 block has a high impact on the generators in terms of UI liability. Smaller bidding time blocks will increase their comfort to bid and will attract them to the day ahead market. This is also relevant especially in the context that there is a greater push towards renewable at all policy making levels.

2. Hourly bids results in the high ramp rates at the hour boundary (kink), particularly at the start and the end of the morning and evening peak hours. In real time load ramp is seasonal and linked to sunrise/sunset etc which is a gradual process. Implementation of 15 minute bidding interval in the Power Exchange(s) would increase the operational flexibility, accommodate the ramp rate and reduce the UI.

3. This will increase the operational flexibility of the system operator and the utilities. As the utilities move closer to the day of operation, the uncertainty in forecasted demand is reduced and maximum flexibility is needed in the day–ahead procurement to balance their portfolio. This inflexibility manifests as imbalances in real time operation thereby posing a threat to grid security. This will get address with 15 minute bidding time block.

4. It is well know that value of electricity is dependent on the time when it is consumed. At a granular level it means that the value does not necessarily remain the same for each 15-minute time block and hence 'hourly bids' do not truly reflect the perceived value. Allowing 15-minute bidding to participants will help them manifest their value for electricity with time more precisely and would thus result in better price discovery.

5. The 15 minute bidding could also help in handling transmission congestion issue. If the corridor is available for a period shorter than the hour the corridor can then be used which is not possible presently…."

Recently, in December, 2017, CERC approved the commissioning of the Automatic Generation Control (AGC) Pilot Project between NLDC and NTPC Dadri Stage-II vide order no. 79/RC/2017 dtd. 06th December, 2017 *[2]*. The relevant extracts are quoted as below:

"…The Commission finds that 5-minute accounting is possible for this project, and directs that the same should be implemented for improved record of AGC signal and the up/down response of the plant. This data will also be utilized for payment purposes for the mark-up. Settlement of energy charges and deviation charges shall continue to be on the basis of 15-minute time block…"

3.2 NITI Ayog Report - India's Renewable Electricity Roadmap 2030 (2015)

NITI Ayog in its Report on India's Renewable Electricity Roadmap 2030 *[21]* recommended that for RE Grid Integration and More Efficient Grid Operation, 5-minute Scheduling and Dispatch may be adopted. The relevant extracts are quoted as below:

"…Interventions to reduce overall system costs [Section 3.23(ii)]

"Scheduling and Dispatch: Through both practice and theory, it has become evident that grids that are operated in a manner where scheduling and dispatch are implemented over short time durations (e.g., as low as five minutes) have significantly lower overall costs to consumers as the need for ancillary resources decreases.

Currently, in India, scheduling occurs on a day-ahead basis while dispatch occurs on a 15-minute basis. System operations technologies and protocols need to be updated to enable five-minute scheduling and dispatch of all resources connected to the grid and automated incorporation of RE forecasts. It should be noted that accuracy of RE forecasts is significantly higher the closer they get to dispatch. Consequently, the ancillary service requirements will also be lower…"

3.3 Ministry of Power Technical Committee Report (2016)

A high level Technical Committee was constituted by GoI in April, 2015 for various issues relating to large scale integration of renewable generation. Out of several actions recommended for grid integration of renewables, one was for more frequent market clearing as well as new products such as real time markets. The relevant extracts from the report of the Technical Committee *[22]* are quoted as below:

"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.…"

3.4 Forum of Regulators (FOR) - SAMAST Report (2016)

The FOR Technical Committee recommended the implementation of its report on SAMAST *[3]* at the intra-state level. The states implementing SAMAST at the intra-state level are required to factor the 5-minute periodicity in the metering as well as software being procured for scheduling and settlement. The relevant extracts are quoted as below:

"5.6……The States who are about to implement the intrastate accounting and settlement system could leapfrog and go for scheduling and settlement at 5-min interval. The scheduling software and the energy meters specifications could in line with the above. All the other States and the Regional Pools shall also endeavor to have systems and logistics for 5-min scheduling and settlement system…."

"Appendix – 6: …….One static type composite meter shall be installed for each EHV circuit, as a self-contained device for measurement of active energy (MWh) transmittals in each successive 5 minute block and certain other functions, as described in the following paragraphs……"

3.5 FOR Model Deviation settlement Regulations (2017)

FOR had brought out model DSM regulations at state level for adoption by respective SERCs in March, 2017 *[23]*. The relevant provisions are quoted as below:

"…u. 'Time-Block' means a time block of 15 minutes, for which specified electrical parameters and quantities are recorded by special energy meter, with first time block starting at 00.00 hrs;
Provided that time block shall be revised to 5 minutes from the date to be notified by Central Commission and [State] Commission…"

4. Principles for Operationalising Deviation Settlement Mechanism:

"…(A) Scheduling Period:….. Provided that from the date to be notified by Commission, the scheduling period shall be revised to 288 time blocks, each of 5-minute duration starting from 00:00 hours (IST) ending with 24:00 hours (IST). Accordingly, the Interface Metering, Energy Accounting and Deviation Settlement should be capable to undertake transactions with 5-minute duration. All future resource planning, IT and communication system requirement and infrastructure development shall be undertaken to cater to this requirement.

Andhra Pradesh, Uttarakhand, Chhattisgarh have notified the final DSM regulations. Madhya Pradesh, Karnataka, Gujarat, Rajasthan, Tamil Nadu, Odisha have DSM regulations at draft stage.

3.6 NITI Aayog - Draft National Energy Policy (2017)

In the draft National Energy Policy (2017), NITI Aayog recommended measures required to ensure that the large envisaged Renewable Energy capacity integrates well with the electricity system *[24]*. One of the measures is to upgrade the Scheduling and Dispatch protocols in grid operation to enable five-minute arrangements. The relevant extracts are quoted as below:

"…Scheduling and Dispatch: Scheduling and dispatch will be upgraded from the current 15-minute basis. System operations technologies and protocols will be updated to enable five-minute scheduling and dispatch of all resources connected to the grid and automated incorporation of Renewable Energy forecasts. This will lower consumer costs and also lower ancillary service requirements…"

3.7 CERC (Communication System for Inter-State Transmission of Electricity) Regulations (2017)

The 'Meter' has been defined *[25]* as follows:

"…o) "Meter" means a device suitable for measuring, indicating and recording consumption of electricity or any other quantity related with electrical system and shall include, wherever applicable, other equipments such as Current Transformers (CT), Voltage Transformer (VT) or Capacitor Voltage Transformer (CVT) with necessary wiring and accessories…."

The respective RLDC has been designated as the nodal agency for ensuring integration of communication system at regional level including Automatic Meter Reading (AMR) for ISGS, ISTS and SLDCs; and respective SLDC for State Generating Stations, distribution companies, Intra-State entities, intra-State transmission system, etc.

NLDC has been made responsible for preparation and issuance guidelines with the approval of the CERC on the "Interfacing Requirements" in respect of terminal equipment, RTUs, SCADA, PMUs, Automatic Generation Control (AGC), **Automatic Meter Reading (AMR), Advanced Metering Infrastructure (AMI),** etc. and for data communication from the User's point to the respective control centre(s) based on technical standards issued by CEA within 60 days of issuance of technical standards.

3.8 16th Meeting of FOR Technical Committee (2017)

The 16th meeting of Technical Committee on Implementation of Framework for Renewables at the State level was held under the chairmanship of Shri A. S Bakshi, Member, CERC on 24th November 2017. The committee members reiterated the need for firming up of technical standards by CEA and making it mandatory to purchase only the meters with 5 minute recording capability in future.

Chapter 4 - International Experience

4.1 Resolution of Market Design

International Energy Agency (IEA) report on `*Re-powering Markets Market design and regulation during the transition to low-carbon power systems*' *[26]* presents the analysis that existing markets were designed to address the most salient issues at the time of their introduction. In the United States, the primary objective of regional transmission organisations (RTOs), such as PJM, CAISO, and NYISO etc. was to ensure the co-ordination of small balancing areas that were poorly interconnected. In Europe, the primary objective of market design was to enable cross border trading of electricity between large national balancing areas. The IEA report further elaborates that certain markets have opted for a simple design with "low resolution", i.e. they capture few of the underlying physical properties of the system, which they leave to system operators to handle. Others adopted a market design with "high resolution", to factor the physical reality of power systems into the process of price formation on the market itself. The resolution refers to the geographical resolution (nodal pricing vs. large bidding zones), as well as the temporal resolution (five-minute real-time prices are the highest resolution found in existing markets).

The notion of resolution also includes the quality of market information in the intraday time frame. High-resolution market design has been implemented in about one-half of US states. As illustrated in Table 1, this approach provides a still-simplified but much more detailed representation of electricity systems. This market design is more demanding and complex for market participants.

Table 1: Comparison of Characteristics of International Electricity Markets (Source: IEA)

	High resolution	Low resolution	Intermediate (high temporal resolution with low geographic resolution)
Example of market	PJM	Germany	Australian National Electricity Market
Power market platform	System operator	Power exchange	Power exchange
Bidding information	Unit/plant, complex bids	Portfolio, aggregated bid	Unit/plant
Geographic resolution	Nodal	Single national price	Zonal
Primary market	Real-time	Day-ahead	Real-time
Real-time balancing prices	Single marginal price	Asymmetric prices	Single marginal price
Dispatch internal	5 minutes	15 minutes or longer	5 minutes
Operating reserves	Co-optimised with energy	Separate markets	Separate markets

Low-resolution market design can be found in Europe. Electricity prices provide a rough economic representation of actual system conditions. The main advantage of a low-resolution system lies in its simplicity, which was sufficient in the 1990s to open up the electricity system to competition and facilitate cross-border trade of electricity on the day-ahead timeframe.

4.2 Australia

In Australia, "Scheduling and Despatch" has been decoupled with "Settlement" from 1998. The scheduling and despatch is at 5-minute interval and settlement at 30 minute interval using average of 5-minute prices in that interval. In recent development, in late 2016, AEMC initiated stakeholder consultations to align both "scheduling & despatch" and "settlement" to five minute interval.
On 19 May 2016, the Australian Energy Market Commission (AEMC) published a notice advising of its commencement of the rule making process and consultation in respect of the rule change request. AEMC observed that aligning dispatch and settlement at five minutes will have the following significant enduring benefits relative to the current arrangements:

- improved price signals for more efficient generation and use of electricity
- improved price signals for more efficient investment in capacity and demand response technologies to balance supply and demand
- improved bidding incentives.

Aligning financial incentives with physical operation will more accurately reward those who can deliver supply or demand side responses when they are needed by the power system. In contrast, 30 minute settlement provides an incentive to respond to expected 30 minute prices, rather than the five minute dispatch price. This leads to generator and demand responses occurring up to 25 minutes after they are required by the power system.

There is increased evidence of the price distortion occurring across the NEM today, with the trend most pronounced in Queensland and South Australia. It is expected that in the absence of any change this distortion will get worse in the future.

Aligning dispatch and settlement will also provide an improved price signal for innovation and investment. Over time, this will promote a more efficient mix of generation assets and demand side technologies, leading to lower supply costs. Consumers will benefit as reduced wholesale electricity costs flow through to lower retail prices.

The AEMC has made the final rule on 28th November, 2017 *[19]*. Five minute settlement will commence on Thursday, 1 July 2021, noting that the transitional provisions of the final rule will commence on 19 December 2017.

From 1 July 2021, the following processes will occur on a 5 minute basis:

- Bidding and offering into the National Electricity Market
- Settlement
- Intervention pricing
- Calculation of trading amounts
- Calculation of the cumulative price threshold

Therefore implementing five minute settlement will require:

- reviewing and where necessary updating existing contract terms and conditions
- upgrading metering to provide five minute granularity data (where required)
- upgrading IT systems to store and process five minute granularity data

The Australian Energy Market Operator (AEMO) will govern and oversee the implementation of five minute settlement.

4.3 USA

There are seven regional transmission organizations (RTOs) and independent system operators (ISOs) that manage parts of the electric grid in the United States. In ISOs like CAISO, NYISO and SPP, there is five minute despatch and settlement. There are also ISOs like ISO-NE, MISO and PJM where there is five minute despatch but hourly average settlement interval (Table 2). The United States Federal Energy Regulatory Commission (FERC) in September 2016 ruled that all system operators under its jurisdiction must settle energy in their real-time markets at the same interval that those markets are dispatched (i.e. five minute settlement). The extracts from the FERC Final Rule on "Settlement Intervals and Shortage Pricing in Markets Operated by Regional Transmission Organizations and Independent System Operators", 16th June 2016 [27] is quoted as below:

"…….We require that each regional transmission organization and independent system operator align settlement and dispatch intervals by: settling energy transactions in its real-time markets at the same time interval it dispatches energy; settling operating reserves transactions in its real-time markets at the same time interval it prices operating reserves; and settling intertie transactions in the same time interval it schedules intertie transactions….."

Table 2: Comparison of Despatch Interval and Settlement Interval across USA ISOs

RTO / ISO	Despatch Interval	Settlement Interval
CAISO	5-minute	5-minute
ISO - NE	5-minute	Hourly average
MISO	5-minute	Hourly average
NYISO	5-minute	5-minute
PJM	5-minute	Hourly average
SPP	5-minute	5-minute

Spot electricity markets in the US are built around the two-settlement concept, which refers to the day-ahead and the real-time market settlements. The day-ahead market can be considered "a forward market subject to all the physical and reliability power system constraints that are known at the time to affect the next-day (real-time) dispatch" (Helman et al., 2008), so it has a similar role to the one in European PXs although–while remaining a financial market–it represents the physical reality with a much higher level of detail [28].

A study was carried out in the Western Interconnection (USA) by NREL [16], as part of Western Wind and Solar Integration Study, to evaluate the regional energy imbalance service (EIS) implication on operating reserves under several alternative scenarios of the market footprint and participation. The impacts of faster dispatch, shorter gate closure and larger balancing areas (Figure – 16) have been studied which indicates that large, agile systems can more cost-effectively integrate high quantities of variable wind and solar. Also, faster interchange with faster gate closure has a similar impact as faster despatch in the power system operation.

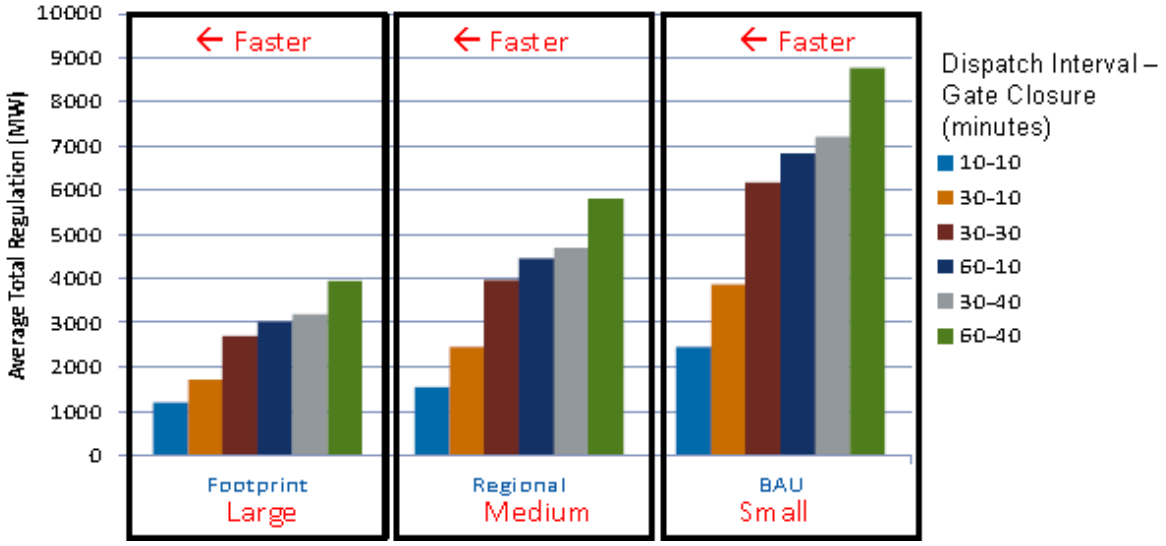


Figure 16: Average Total Regulation 6 Despatch/Gate Closure Schedules

Day-ahead markets in the US are cleared via a so-called Security Constrained Unit Commitment and Economic Dispatch (SCUC/SCED) optimization model considering the physical constraints of generators (e.g. minimum and maximum output, ramp constraint) and the transmission system (congestion and losses), the multipart offers submitted by generators (including, among others; offers for the start-up cost, no-load cost and variable cost) and the demand bids [28]. In CAISO, the real-time market system dispatches power plants every 15 and 5 minutes, although under certain grid conditions the ISO can dispatch for a single 1-minute interval.

The real-time market resembles the day-ahead market in the characteristics of the SCED model employed, but the real-time market is not run in a single process, instead, it consists of various runs throughout the day. Each SCED run produces dispatch instructions only a few minutes before each period (typically, five minute periods). Real-time market prices capture the marginal cost of generation dispatch when the final system conditions are known, and are used to settle the difference between day-ahead and real-time schedules.

Last-minute dispatch instructions can only make relatively small schedule changes, so the ISO has additional tools to make more significant modifications (essentially, to commit

additional units) longer in advance. Intraday commitment processes are slightly different for each ISO as summarized in Table 3. The table includes the denomination of the procedure, with which frequency and look-ahead horizon it is executed, and whether it produces binding commitment or dispatch instructions, and financially binding prices.

Table 3: USA ISOs Intraday Timeline Summary (Source: MIT Energy Initiative)

Table i. ISO's intraday timeline summary[4]

ISO	Procedure	Frequency	Look-ahead	Commitment	Dispatc	Prices[5]
CAISO	Residual unit commitment (RUC)	Daily	24-168 h	Long start units		Availability[6]
	Short-term unit commitment (STUC)	1 h	4 h	Medium/short		
	Real-time unit commitment and FMM	15 min	60-105 min	Fast start units	✓	✓
	Real-time economic dispatch	5 min	Up to 60 min		✓	✓
ISO-NE	Resource Adequacy Analysis (RAA)	Daily	Oper. day	Non-fast start		
	Additional RAAs	As needed	Oper. day	✓		
	Unit dispatch software	5 min	60 min		✓	Ex-post
MISO	Reliability Assessment Commitment	Daily	Oper. day	✓		
	Intraday RAC	As needed	Oper. day	✓		
	Look-ahead commitment (LAC)	15 min	3 h	✓		
	Real-time SCED	5 min	N/A		✓	Ex-post
NYISO	Supplemental resource evaluation	As needed	Oper. day	✓		
	Real-time commitment (RTC)	15 min	150 min	✓		
	Real-time dispatch (RTD)	5 min	60 min		✓	✓
PJM	Reliability Assessment Commitment	Daily	Oper. day	✓		
	Combustion Turbine Optimizer (CTO)	As needed	Oper. day	✓		
	Ancillary Service Optimizer (ASO)	1 h	60 min	✓		
	Intermediate-term SCED	15 min	60-120 min	✓		
	Real-time SCED	5 min	15 min		✓	✓
ERCOT	Day-ahead Reliability Unit	Daily	Oper. day	✓		
	Hourly RUC	1 h	Oper. day	✓		
	SCED	5 min	N/A		✓	✓

4.4 Europe

In major European electricity markets like UK product duration requirements for the Day-Ahead Market (DAM) and the Intra-Day Market (IDM) are typically set at 1 hour, with the exception of the Austrian DAM and the Austrian, German, and Swiss IDMs that facilitate trading of 15 minute products as well. They have been popular because they are not mandatory, are relatively inexpensive to implement and allow trade in electricity over large geographical areas. The drawback of this low-resolution approach is that the markets cannot manage network congestion, which then has to be dealt with separately. System operators take re-dispatching actions within price zones before gate closure, and this interacts with market prices. Consequently, low-resolution market design is likely to lead to increasing inefficiencies as more renewables are introduced into electricity systems and increase congestion.

Chapter 5 - Deliberations and Stakeholder Consultations

5.1 First Meeting - 03rd August, 2017

The Gist of Discussions in the first meeting of the Sub-Group is placed at *Annexure – 2*.

The main imperatives for moving to 'Fast Markets' were recognized as follows:

- Learning from implementation of Ancillary Services
- Re-scheduling of Resources
- Increasing RE penetration
- Ramping requirements
- Recognizing flexibility as a requirement
- Implementation of Primary, Secondary (AGC) and Tertiary Reserves/Control
- Reserves: Despatch, Accounting & Settlement

There were deliberations on Forecasting, Scheduling & Despatch, Transition in Electricity Market : Power Exchanges – 5 minute price discovery, Transition in DSM Mechanism, Commercial interface metering, Settlement system –Energy Accounting, Financial settlement, Changes in various CERC/SERC Regulations, Changes in CEA Metering Standards, Holding workshops, dissemination, stakeholder capacity building and Implementation of SAMAST Recommendations.

It was decided that generators and meter vendors views/suggestions are to be taken in next series of meetings. All RPCs may discuss the 5-minute scheduling and settlement as an agenda item. It was also decided to co-opt representative from CEA and CERC.

5.2 Second Meeting – 28th August, 2017

The Gist of Discussions in the second meeting of the Sub-Group is placed at *Annexure – 3*.

Some of the features required in 5 minute metering infrastructure were highlighted as follows:

- Record frequency data at 0.01 Hz resolution
- Net VARh and voltage to be recorded for each time block.
- Auxiliary Supply - SEM may normally be capable of operating with power drawn from the VT secondary circuits.
- Provision to operate on control power supply to the SEM from 110V DC / 220V DC.
- Built-in calendar and clock
- Secured software based solution for meter time correction & synchronization with GPS
- DLMS compliant for SEM communication protocol – Indian COSEM standard
- Data security ensured as per IEC-62056-51 standard

- Automated Meter Reading (AMR)
- Uniform protocol for communication for meters of different vendors.
- Optical coupling cable should be compatible with all types of meters.
- Replacement of defective meters within a stipulated time frame

Three meter manufacturers viz. M/s Secure Meters, M/s Elster-Honeywell and M/s L&T were invited by the sub-group for discussions on the proposed features in the 5-Minute capable interface meters

There were deliberations on capability of existing Special Energy Meters (SEM) (15 min, ABT meters) to migrate to 5-minute metering through minimal changes, Parallel transition to 5 minute arrangements in addition to existing 15 minute, Live Testing & Demonstration of 5-Minute capability in exisiting meters, Meter time correction and synchronization with GPS, Security Considerations and need for re-calibration for Transition to 5 Minute Arrangements, International Experience, Impact on Storage capability on transition to 5 minute arrangements, Interoperability and common communication protocol, Change in NPC coded file structure, CTU Activities for transition to 5 minute arrangements and Suggestions by NPC-CEA.

It was decided that stakeholder views/suggestions are to be taken in next meeting. All RPCs may discuss the 5-minute scheduling and settlement in a more focused manner. It was also decided that meter manufacturers may be invited to demonstrate the implementation of 5 minute arrangements in existing models/version of meters within two weeks. CTU to coordinate for meter testing and live demonstration with meter vendors at Vadodara testing facility. Gujarat-SLDC requested to provide support in this demonstration. Meter vendors to verify and confirm the feasibility and compatibility of migration to 5 minute arrangements in the existing metering infrastructure Meter vendors to give information on international experience. It was also decided to recommend the constitution of a separate expert group to discuss changes in the NPC coded file format.

5.3 Third Meeting – 25th October, 2017

The Gist of Discussions in the third meeting of the Sub-Group is placed at *Annexure – 4*.

The meter testing was witnessed jointly by representatives of POSOCO (NLDC, WRLDC), POWERGRID, Gujarat SLDC and Meter Manufacturers (M/s Secure Meters & M/s Elster-Honeywell) at 400/220 kV Magarwada PGCIL S/s, Daman-Diu UT and 765/400 kV Vadodara (Wagodia) PGCIL S/s, Gujarat (M/s L&T) on 13th September, 2017 and 10th October, 2017 respectively.

During the 5-minute meter demonstration, it was observed that additional parameters are available in the meters which were kept disabled as the requirement was not posed to the

meter manufacturers. File transfer formats (presently, ".npc" files) need to be reviewed when migrating from 15-minute to 5-minute metering.

The need for software validation and meter data exchange format, requirement of Automated Meter Reading (AMR) alongwith communication infrastructure, storage enhancement, standardized data and information protocols were noted as key learnings by the sub-group. It was also mentioned that reconfiguration of the meters should be with adequate safeguards and ensure that the meters are tamper-proof.

It was deliberated that CTU may identify the region-wise interface meters which are needed to be replaced and those that can be reconfigured (along with upgrade of storage) for the transition to 5-minute scheduling and settlement. CTU was requested to facilitate collection of the required data on type, vintage and location of existing meters so that assessment of the implementation timeline and financial implication for transition to the 5-minute framework could be estimated. It was also recognized that cross border interconnections will also need to be upgraded for the transition.

The sub-group also recognized the need for review of the exisitng technical specifications for interface meters for implementation of 5-minute metering. This may taken up by an expert group so as to ensure a smooth transition.

It was proposed that, ***on a pilot basis, 5-minute capable meters may be installed at say, 4-5 locations in each Region to gain practical experience*** in 5-minute metering, interfacing requirements / file interchange formats and develop data analytics/tools for 5-minute metering, data validation, reporting, etc. It was recognized that pilot project would help in formulation/refinements of Technical specifications and Software Requirement Specifications (SRS) for Metering Software at RLDCs and Accounting Software at RPCs for 5-minute metering. The locations suggested for pilot project are Generating stations – Conventional / RE, Substations – 765 kV / 400 kV and Inter-Regional inter-change points. CTU representative, was requested to facilitate the pilot project with installation of 5-minute meters.

Tamil Nadu representative highlighted that replacement of meters for industrial consumers is being undertaken. Around 8500 meters comprising 90 % of the industrial consumers have already been replaced. However, DLMS compliance is not possible in those meters. Further, Tamil Nadu representative observed that that there would be difference in the measurement based on 5-minute metering/settlement at inter-state periphery and the 15-minute metering/settlement at intra-state level.

Both Gujarat and Delhi discom representatives agreed that the transition to 5-minute scheduling and settlement is possible and can be done. West Bengal representative said that WBSEDCL pays for the deviation including by the OA consumer embedded for PX/OTC

transactions. The representative expressed difficulties regarding implementation of 5-minute scheduling & metering.

It was decided that NPC to follow up the status of amendment of Metering standards with CEA and also place the required amendments as agenda item in the next NPC meeting.CTU to facilitate collection of the region-wise data on type, vintage and location of existing meters along with proposed procurement process.
It was recognized and emphasized that there is need for capacity building for better forecasting and scheduling - SLDCs to coordinate with RLDCs/NLDC. Interactive sessions (e.g. Hackathons) may be organized at different RPCs for generation of ideas and solutions. Simulation analysis / comparative study of 5-minute & 15-mintute deviations to be done by POSOCO. There is need for intra-state imbalance handling and settlement framework in all states.

5.4 Stakeholder consultations

5.4.1 NRPC

The discussions on *"Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement"* took place in the 33rd Meeting of NRPC Commercial Sub-Committee held on 28th July, 2017. The relevant extracts from the Minutes of Meeting are as follows:

"…2.1. ….Executive Engineer (Commercial), NRPC, made detailed Presentation on "Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement". He briefed about chronological changes in Scheduling, Despatch, Metering & Settlement mechanisms. He explained about the benefits and challenges of the 5 minute scheduling, metering, accounting and settlement. He also briefed about the international practices being followed in current scenario. He mentioned that as per decision taken in the 11th Meeting of "Technical Committee for Implementation of Framework on Renewables at the State Level" held at Chennai on 28th March 2017, a Sub-Group had been constituted to examine the various aspects of migrating from 15-minute to 5-minute scheduling, metering, accounting and settlement at the inter-state level to facilitate large scale integration of renewable….

….The Commercial Sub-Committee advised all NR states to implement the recommendations of SAMAST report at the earliest…."

Further, the five minute scheduling and settlement was deliberated in the138th meeting of the NRPC Operation Co-ordination Sub-Committee held on 22nd & 23rd August, 2017. The relevant extracts from the Minutes of Meeting are as follows:

"…On the issue of provision of the prospective plan of 5 minute scheduling in the AMR, Power Grid was asked to take up the matter with the manufactures so that adequate provision for the same can be made in the new AMR being installed…."

The status was updated in the139th meeting of the NRPC Operation Co-ordination Sub-Committee held on 18th & 19th September, 2017. The relevant extracts from the Minutes of Meeting are as follows:

"…On the issue of provision of the prospective plan of 5 minute scheduling in the AMR, Power Grid representative expressed their inability to get modifications made for 5 minute scheduling. They further stated that once the regulation is notified they will take the further necessary action…."

5.4.2 WRPC

A large number of SEM's installed in Western Region are more than 5 / 10 years old and are due for testing / replacement. This issue was also discussed in the 73rd and 74th CCM (Commercial Coordination Meeting). During the 33rd TCC/WRPC meeting on 31st January – 01st February, 2017, it was decided to replace the entire fleet of existing SEMs (15-min recording) with Interface Energy Meters (5-min interval) and implement the Automated Meter Reading and Meter Data Processing System. The relevant extracts from the Minutes of Meeting are as follows:

"…After discussion, WRPC agreed for replacement for all SEMs with AMR, with communication and server at WRLDC and PGCIL may implement the same and recover the cost under ARR (Regional tariff mode). WRPC also agreed for the communication of data from CTU AMRs to WRLDC server and to State Server. Further, WRLDC server can exchange data of both CTU and state AMRs with states. Accordingly WRPC directed to proceed with the proposal, with 5 minute energy integration, and also bring to the notice of CEA for upgradation of technical standards. WRLDC was requested to prepare the draft specifications accordingly…."

It was highlighted that in 33rd WRPC meeting held on 01.02.2017, it was decided to replace all the existing interface SEMs (Special Energy Meters) installed in Western Region with SEMs capable of recording and storing of 5 mins as well as 15 mins block data of Frequency, Wh & VArh (Low & high) along with suitability for transmitting the data to remote locations using appropriate communication medium (AMR). In this regard, in April, 2017, a communication has also been sent to CEA vide letter dated 27th April, 2017 *(Copy at Annexure – 5)* regarding amendments in clause (I)(b)(i), (ii), (iii} & (iv) of Part II Standards for interface meters of the CEA (Installation and Operation of Meters) Regulations, 2006 to accommodate the above mentioned provisions.

Discussions in 75th CCM

"…WRLDC representative gave a brief presentation stating in brief the specifications for Interface Energy Meters (IEM), Automated Meter Reading (AMR) system and Meter Data Processing system (MDP). SE (C), WRPC requested members of the committee to give their comments/feedback within 10 days so that the same may be incorporated in the technical specifications of Interface Energy Meters (IEM) and put up before the 34th TCC/WRPC for further necessary guidance…."

The *"Technical Specification for Interface Energy Meters, Automated Meter Reading System and Meter Data Processing for Inter State System in Western Region"*, attached at *Annexure – 6*, was approved in the 34th TCC/WRPC meeting held on 27-28 July 2017 in Mumbai. The relevant extracts from the Minutes of Meeting are as follows:

"…TCC Discussion:

CE, SLDC, Gujarat made a presentation containing concerns on specification. After presentation, WRLDC confirmed that GETCO's concerns have been incorporated in the specifications. TCC approved the specifications and PGCIL to take up the execution/implementation.

WRPC Discussion: TCC, Chairman appraised TCC discussion to the forum.

WRPC agreed with the TCC decision…."

5.4.3 ERPC

The discussions on "Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement" took place in the 35th ERPC Commercial Sub Committee Meeting held on 02nd August, 2017. The relevant extracts from the Minutes of Meeting are as follows:

"…GM, ERLDC informed that introduction of 5 minutes scheduling and dispatch were being actively discussed by the policy makers and may become a reality in near future. In such a scenario, current SEM's need to be either retrofitted or replaced by 5 minute meters. Powergrid may discuss with the vendors of existing meters for options available…."

Further, the matter was discussed in the 137th OCC Meeting held on 21st September, 2017 at ERPC, Kolkata. The relevant extracts from the Minutes of Meeting are as follows:

"…In order to accommodate intermittency and variability of around 175 GW Renewable energy, requirement of fast ramping of conventional generator is absolute necessity. In order to facilitate fast ramping of conventional generator, it is felt that ongoing 15 min scheduling, metering accounting and settlement methodology need to be shifted at 5 min interval level in near future.

Keeping in view of Implementation of 5- Minute Scheduling, Metering, Accounting & Settlement, Technical specifications for "Interface Energy Meters (5-min compatibility) for Western region was approved by 34th TCC/WRPC on 27.07.17/28.07.17.

At present approximately 600 new meters are yet to be delivered by vendor M/s Genus for Eastern Region and inspection of those meters is not yet done. It is felt that the new meters should have the provision of giving data in parallel, in 5 min new coded format as well as old meters (present) coded format i.e in 15 min.

Deliberation in the meeting

Powergrid added that M/s TCS and Genus will give the cost estimation for implementation of 5 min schedule. The cost is to be borne by the constituents…."

5.4.4 NERPC

The discussions on "Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement" took place in the 33rd Commercial Committee Meeting held at Assam on 25th August 2017. The relevant extracts from the Minutes of Meeting are as follows:

"…8.5 SAMAST implementation in NER:

DGM (MO), NERLDC gave a presentation on SAMAST, copy attached at Annexure-II. Regarding SAMAST implementation in NER, all the States were requested to initiate action to prepare DPR and submit for funding from PSDF. It was intimated that action has been initiated in case of Assam and one meeting of SAMAST Group-NER has taken place at AEGCL Office, Guwahati where sequence of activities have been decided. It has also been agreed to go for procurement of 5 minute meters in case of SAMAST in Assam (copy of minutes attached at Annexure-8.5 (A)).The letter of Member Secretary, NERPC notifying formation of SAMAST Group of NER is attached at Annexure-8.5 (B). The States other than Assam and Meghalaya were requested to nominate members in SAMAST group…."

The relevant extracts from the Minutes of Meeting on SAMAST Implementation in Assam held on 24th August, 2017 are as follows:

"…it was agreed that procurement of Meters would be as per decision taken by FOR sub group on metering at 5-minute interval.

The action plan was decided as below:

1. Identification of Intra State Entities

2. Demarcation of Interface boundary for each Intra State Entity

3. Assessment of Meters - Main, Check and Standby (AEGCL-APDCL interface, AEGCL-APGCL interface, Open Access customers, IPPs, AEGCL transmission elements).

4. Assessment of Automatic Meter Reading requirement

5. Assessment of IT infrastructure (Hardware and Software) – Scheduling software, Meter data processing software, Accounting Software and Open Access software.

6. Preparation of Bill of Quantities

7. Preparation of Detailed Project Report

8. Submission of application for funding from PSDF

Assam SLDC representative intimated that they have already started work on sl. Nos. 1, 2, 3 above and these would be completed shortly. He further stated that there would be a need to have meeting with Meter manufacturer(s) for 5 minute metering and also with vendors for AMR scheme implementation.

It was agreed that a meeting would be convened at SLDC, Kahelipara on 30.08.2017 involving SAMAST group and manufacturer / vendor to have discussion regarding 5 minute metering, AMR etc. Vendors like TCS, M/S Secure Meters would be invited in the meeting.

By that date SLDC would freeze the complete details regarding points 1, 2 and 3.

Target date for completion of DPR would be by 30th. Sept'17…."

Further discussions were held in 136th NERPC OCC meeting held on 13th September, 2017. The relevant extracts from the Minutes of Meeting are as follows:

"…Regarding SAMAST, it was decided that a uniform DPR would be prepared by NERPC Secretariat (through Core Group Members of NERPC, NERLDC, POWERGRID, Assam & Meghalaya) and this would act as a model to the remaining States of NER and only the quantities have to be intimated by the States. The Combined DPRs of 2-3 NER States would be sent by NERPC to NPC, CEA and NLDC so that the work scheme can be completed on time. The OCC requested NERPC to get it endorse during the 18th TCC/NERPC Meetings.

Members agreed…."

Chapter 6 - Meter Capability Demonstration and Testing

Two 5-Minute Meter Demonstration by meter vendors were held as follows:

a) M/s Secure Meters and M/s Elster-Honeywell on 13th September, 2017 at 400/220 kV Magarwada PGCIL S/s, Daman-Diu UT (Minutes & Analysis of results placed at *Annexure – 4*)

b) M/s L&T on 10th October, 2017 at 765/400 kV Vadodara (Wagodia) PGCIL S/s, Gujarat (Minutes & Analysis of results placed at *Annexure – 4*)

The meter testing was witnessed jointly by representatives of POSOCO (NLDC, WRLDC), POWERGRID, Gujarat SLDC and Meter Manufacturers. Further, another meter manufacturer viz. M/s Genus Meters, in a written communication to Tamil Nadu, expressed that it is possible to program integration period from 15 minute to 5 minute for ABT meter application after revision of standards, upgradation of storage etc. (*Annexure – 5*). The Meter Demonstration & Testing Results are tabulated in Table 4 as follows:

Table 4: Comparison of Meter Vendors Demonstration & Testing Results

Title	Elster	Secure	L & T
Reconfiguration of existing 15-min meter to 5-min	Possible in Existing meters, Simple, on-site	Not possible in existing meters, possible in new models only, on-site	Not possible in existing meters, new models only, off-site
Reconfiguration Time	Fast	Fast	At factory
Retention of old data	Old data erased	Block wise data erased cumulative data retained	No retention
Conversion software for NPC File	The software for conversion to .npc file is available	Software for converting to NPC format needs upgrade	The software for conversion to .npc file is not available
Wh recording	Acceptable	Acceptable	Acceptable
VARh recording	Variations observed due to integration time difference		Data not available
Storage	Could not be ascertained		Storage upgraded in factory

During the 5-minute meter demonstration, it was observed that additional parameters are available in the meters which were kept disabled as the requirement was not posed to the meter manufacturers. File transfer formats (presently, ".npc" files) need to be reviewed when migrating from 15-minute to 5-minute metering. It may be taken into consideration that on pan India basis these ".npc" files are being read by different utilities /regional entities for preparation of their own DSM accounts, so any large change in format may require all the utilities to revisit their S/W.

New software is required for conversion of 5-min data into 15-min data during the transition phase. The need for software validation and new .npc format, requirement of Automated Meter Reading (AMR) alongwith communication infrastructure, storage enhancement, standardized data and information protocols were noted as key learnings by the sub-group.

Chapter 7 - Regulatory Provisions to Handle Transition

7.1 Suggested Amendments in CERC Regulations

The sub-group studied and analyzed the various CERC regulations which need amendments for transitioning to five minute arrangements. The suggested amendments are tabulated as below:

S.No.	Aspect	Present Clause	Proposed Clause
CERC (Terms and Conditions of Tariff) Regulations, 2014.			
1	Deviation charges	"34 (2)… Actual net deviation of every Generating Stations and Beneficiaries shall be metered on its periphery through special energy meters (SEMs) installed by the Central Transmission Utility (CTU), and computed in MWh for each 15-minute time block by the concerned Regional Load Despatch Centre…"	"34 (2)… Actual net deviation of every Generating Stations and Beneficiaries shall be metered on its periphery through special energy meters (SEMs) installed by the Central Transmission Utility (CTU), and computed in MWh for each ~~15-minute~~ 5-minute time block by the concerned Regional Load Despatch Centre…"
CERC (Open Access in inter-State Transmission) Regulations, 2008			
1	No Objection or Prior Standing Clearance	"(2A) ….the applicant shall declare that he agrees to ensure that aggregate quantum in each time block of 15 minutes for all the bid(s)….	"(2A) ….the applicant shall declare that he agrees to ensure that aggregate quantum in each time block of ~~15~~ 5 minutes for all the bid(s)….
2	Definitions	(r) "time block" means 15 minutes time period specified in the Grid Code for the purposes of scheduling and despatch;	(r) "time block" means ~~15~~ 5 minutes time period specified in the Grid Code for the purposes of scheduling and despatch;
CERC (Measures to relieve congestion in real time operation) Regulations, 2009 - Detailed Procedure			
3	Notice for application of Congestion charge	5.6 If violation of TTC limits persists for 2 time-blocks not counting the time-block in which warning notice was issued by RLDC and no affirmative action is taken by the defaulting agency, NLDC/ RLDC(s) shall issue a notice for	5.6 If violation of TTC limits persists for ~~2~~ 6 time-blocks not counting the time-block in which warning notice was issued by RLDC and no affirmative action is taken by the defaulting agency, NLDC/ RLDC(s) shall issue a notice for application of congestion charge.

		application of congestion charge.	
4	Application of Congestion charge	6.4. Congestion charge shall be applicable only after two time blocks from the time of issuing the notice, not counting the time block in which notice is issued.	6.4. Congestion charge shall be applicable only after ~~two~~ six time blocks from the time of issuing the notice, not counting the time block in which notice is issued.
5	Withdrawal of Congestion charge	6.5. Congestion charge shall be withdrawn after the power flow on the affected transmission link/ corridor has come down to the ATC and remains at this level for one time block.	6.5. Congestion charge shall be withdrawn after the power flow on the affected transmission link/ corridor has come down to the ATC and remains at this level for ~~one~~ three time blocks.
6	Format VI	96 Time - blocks	288 time-blocks
CERC (Indian Electricity Grid Code) Regulations, 2010			
7	Revision of Schedule by Wind and Solar Generators	6.5 (23) (iii)….The schedule by wind and solar generators …..Such revisions shall be effective from 4th time block, the first being the time-block in which notice was given…."	6.5 (23) (iii)...The schedule by wind and solar generators …..Such revisions shall be effective from ~~4th~~ 09th time block, the first being the time-block in which notice was given….."
8		There may be one revision for each time slot of one and half hours starting from 00:00 hours of a particular day subject to maximum of 16 revisions during the day.	There may be one revision for each time slot ~~of one and half hours~~ 45 minutes starting from 00:00 hours of a particular day subject to maximum of ~~16~~ 32 revisions during the day.
9	Forecasting	Regulation 4 of the Annexure-I Day ahead forecast: Wind and solar energy generation forecast with an interval of 15 minutes for the next 24 hours for the aggregate generation capacity of 50 MW and above. ….	Regulation 4 of the Annexure-I Day ahead forecast: Wind and solar energy generation forecast with an interval of ~~15~~ 5 minutes for the next 24 hours for the aggregate generation capacity of 50 MW and above. ….

10	Reversal of sign of Deviation	Regulation 6.4.6 Every regional entity shall ensure reversal of sign of deviation from schedule at least once after every twelve time blocks.	Regulation 6.4.6 Every regional entity shall ensure reversal of sign of deviation from schedule at least once after every ~~twelve~~ thirty(30) time blocks.
11	Revision of DC/Schedule	Regulation 6.5.18 ...Revised schedules/declared capability in such cases shall become effective from the 4th time block, counting the time block in which the request for revision has been received in the RLDC to be the first one.	Regulation 6.5.18 ...Revised schedules/declared capability in such cases shall become effective from the ~~4th~~ 09th time block, counting the time block in which the request for revision has been received in the RLDC to be the first one.
12	Revision of DC/Schedule in case of Forced Outage	Regulation 6.5.19…in case of forced outage of a unit of a generating station...The revised schedules shall become effective from the 4th time block, counting the time block in which the forced outage is declared to be the first one.	Regulation 6.5.19…in case of forced outage of a unit of a generating station...The revised schedules shall become effective from the ~~4th~~ 09th time block, counting the time block in which the forced outage is declared to be the first one.
13	Definition of Time Block	aaaa) "Time Block" means block of 15 minutes each for which Special Energy Meters record values of specified electrical parameters with first time block starting at 00.00 Hrs;	aaaa) "Time Block" means block of ~~15~~ 05 minutes each for which Special Energy Meters record values of specified electrical parameters with first time block starting at 00.00 Hrs;
14	Demand Estimation	5.3(e) Demand Estimation for Operational Purposes - ...facilitate on-line estimation of demand for daily operational use for each 15 minutes block....	5.3(e) Demand Estimation for Operational Purposes - ...facilitate on-line estimation of demand for daily operational use for each ~~15~~ 05 minutes block....
15	Revision of Schedule in case of transmission constraint	6.5.16 Scheduling and Despatch procedure for long-term access, Medium – term and short-term open access - .... In the event of bottleneck in	6.5.16 Scheduling and Despatch procedure for long-term access, Medium – term and short-term open access - .... In the event of bottleneck in evacuation of power ..... the RLDC shall revise the

		evacuation of power ..... the RLDC shall revise the schedules which shall become effective from the 4th time block, counting the time block in which the bottleneck in evacuation of power has taken place to be the first one. Also, during the first, second and third time blocks of such an event, the scheduled generation of the ISGS shall be deemed to have been revised to be equal to actual generation, and the scheduled drawals of the beneficiaries shall be deemed to have been revised accordingly.	schedules which shall become effective from the ~~4th~~ 09th time block, counting the time block in which the bottleneck in evacuation of power has taken place to be the first one. Also, ~~during~~ from the first, ~~second and third~~ to 08th time blocks of such an event, the scheduled generation of the ISGS shall be deemed to have been revised to be equal to actual generation, and the scheduled drawals of the beneficiaries shall be deemed to have been revised accordingly.
16	Computation of actual net injection/drawal	6.4.22 The RLDC shall be responsible for computation of actual net injection / drawal of concerned regional entities, 15 minute-wise, based on the above meter readings.	6.4.22 The RLDC shall be responsible for computation of actual net injection / drawal of concerned regional entities, ~~15 minute-wise~~ 5 minute-wise, based on the above meter readings.
17	Calculation of Deviation	While the 15-minute wise, deviations from schedule would be accounted for as Unscheduled Interchange (UI), the net energy deviation for the whole day, if any, shall be additionally accounted for as shown in the illustration.	While the ~~15-minute wise~~ 5-minute wise, deviations from schedule would be accounted for as Unscheduled Interchange (UI), the net energy deviation for the whole day, if any, shall be additionally accounted for as shown in the illustration.
18	Revision of Schedule in case of forced outage of a unit for a Short Term	" 6.5.19...The revised schedules shall become effective from the 4th time block, counting the time block in which the forced outage is declared to be the first one…"	" 6.5.19...The revised schedules shall become effective from the ~~4th~~ 09th time block, counting the time block in which the forced outage is declared to be the first one….'

	bilateral transaction		
19	Revision of the schedules by RLDCs in the interest of better system operation	"6.5.20...the revised schedules shall become effective from the 4th time block, counting the time block in which the revised schedule is issued by the RLDC to be the first one.	"6.5.20...the revised schedules shall become effective from the ~~4th~~ 09th time block, counting the time block in which the revised schedule is issued by the RLDC to be the first one.
20	Forecasting by RE generators	Regulation 4 of the Annexure-I of the Principal Regulations…"...(i) Day ahead forecast: Wind and solar energy generation forecast with an interval of 15 minutes for the next 24 hours…."	Regulation 4 of the Annexure-I of the Principal Regulations…"...(i) Day ahead forecast: Wind and solar energy generation forecast with an interval of ~~15~~ 05 minutes for the next 24 hours…."
21	Revision of Schedule by Wind and Solar Generators	"...6.5 (23) (iii) The schedule by wind and solar generators... revisions shall be effective from 4th time block, the first being the time-block in which notice was given…."	"...6.5 (23) (iii) The schedule by wind and solar generators... revisions shall be effective from ~~4th~~ 09th time block, the first being the time-block in which notice was given…."
22		"...6.5 (23) (iii)...There may be one revision for each time slot of one and half hours starting from 00:00 hours of a particular day subject to maximum of 16 revisions during the day…."	"...6.5 (23) (iii)...There may be one revision for each time slot of one ~~and half~~ hours starting from 00:00 hours of a particular day subject to maximum of ~~16~~ 24 revisions during the day…."
23		Regulation 4 of the Annexure-I….Such revisions shall be effective from 4th time-block, the first being the time-block in which notice was given.	Regulation 4 of the Annexure-I….Such revisions shall be effective from ~~4th~~ 09th time-block, the first being the time-block in which notice was given.
24		Regulation 4 of the Annexure-I…There may be one revision for each time slot of one and half hours starting from 00:00 hours of a particular day	Regulation 4 of the Annexure-I…There may be one revision for each time slot of one ~~and half~~ hours starting from 00:00 hours of a particular day subject to maximum of ~~16~~ 24 revisions during the day."

		subject to maximum of 16 revisions during the day."	
25	Rounding -off	Annexure-I clause 2: "… All 15-minute energy figures (net scheduled, actually metered and UI) shall be rounded off to the nearest 0.01 MWh…."	Annexure-I clause 2: "… All ~~15-minute~~ 5-minute energy figures (net scheduled, actually metered and UI) shall be rounded off to the nearest 0.01 MWh…."
CERC (Deviation Settlement Mechanism) Regulations, 2014			
26	Definition of time-block	"….2. (q) 'time-block'means a time block of 15 minutes, for which specified electrical parameters and quantities are recorded by special energy meter, with first time block starting at 00.00 hrs;…"	"….2. (q) 'time-block'means a time block of ~~15~~ 05 minutes, for which specified electrical parameters and quantities are recorded by special energy meter, with first time block starting at 00.00 hrs;…"
27	Reversal of sign of Deviation	"...7(10) In the event of sustained deviation from schedule in one direction (positive or negative) by any regional entity, such regional entity (buyer or seller) shall have to make sign of their deviation from schedule changed, at least once, after every 12 time blocks...."	"...7(10) In the event of sustained deviation from schedule in one direction (positive or negative) by any regional entity, such regional entity (buyer or seller) shall have to make sign of their deviation from schedule changed, at least once, after every ~~12~~ thirty (30) time blocks...."
28	Calculation of Forecast error for RE	"...2(1)(a) " (aa) „Absolute Error" shall mean the absolute value of the error in the actual generation of wind or solar generators which are regional entities with reference to the scheduled generation and the 'Available Capacity' (AvC), as calculated using the following formula for each 15 minute time block...":	"...2(1)(a) " (aa) „Absolute Error" shall mean the absolute value of the error in the actual generation of wind or solar generators which are regional entities with reference to the scheduled generation and the 'Available Capacity' (AvC), as calculated using the following formula for each ~~15~~ 05 minute time block...":
29	Error calculation for deviation charges	"…5(1) Table - 1...Deviation Charges in case of under injection…..Absolute	"…5(1) Table - 1...Deviation Charges in case of under injection…..Absolute Error in the ~~15~~ 05 -minute time block…"

		Error in the 15-minute time block…"	
30		"…5(1) Table - 2...Deviation Charges in case of over injection…..Absolute Error in the 15-minute time block…"	"…5(1) Table - 2...Deviation Charges in case of over injection…..Absolute Error in the ~~15~~ 05-minute time block…"
CERC (Ancillary Services Operations) Regulations, 2015			
31	Definition of time-block	t. "time-block" means a time block of 15 minutes each for which special energy meters record values of specified electrical parameters with first time block starting at 00.00 hrs;	t. "time-block" means a time block of ~~15~~ 05 minutes each for which special energy meters record values of specified electrical parameters with first time block starting at 00.00 hrs;
CERC (Sharing of Inter State Transmission Charges and Losses) Regulations, 2010			
CERC (Communication System for inter-State transmission of electricity) Regulations, 2017			
CERC (Grant of Connectivity, Long-term Access and Medium-term Open Access in inter-State Transmission and related matters) Regulations, 2009			
CERC (Procedure, Terms and Conditions for grant of trading licence and other related matters) Regulations, 2009			
CERC (Power Market) Regulations, 2010			
CERC (Terms and Conditions for recognition and issuance of Renewable Energy Certificate for Renewable Energy Generation) Regulations, 2010			
CERC (Regulation of Power Supply) Regulations, 2010			
No Amendment Required			

7.2 Amendments in CEA Metering Standards

The desired features, which need to be incorporated appropriately in the CEA Metering Standards, in the 5-Minute capable interface meters as deliberated by the sub-group are as follows (but not limited to):

- Non-volatile memory, Automatic storage
- Net Wh transmittal during each successive 5 min block (up to 2 decimal)
- Cumulative Wh transmittal at each midnight, in eight digits (one decimal)
- Net VARh transmittal during each successive 5 min block (up to 2 decimal)
- Cumulative VARh transmittal at each midnight in eight digits (one decimal)
- High VARh when Voltage above 103 % of Vref
- Low VARh when Voltage is below 97% of Vref
- Average frequency (5 min) in Hertz (up to 2 decimal, truncation)

- Date and time blocks of failure of VT supply on any phase
  - as a star (*)/ (Z) mark.
- Voltage (V) (up to 2 decimal, truncation)
- Meters shall store data in memory for 15 days
- Provision to operate from DC auxiliary supply
- Availability of ports for data extraction: Optical port, RS-485, Ethernet and USB port
- Facility for time synchronization with GPS signal (Local/Remote) and from PC using software

The sub-group is of the opinion that a robust metering system could be established only when all the following aspects are suitably addressed:

- Interface Energy Meters
- Automated Meter Reading System
- Communication Infrastructure
- Application software at Central Location
- Metering System Administration
- Recovery of CAPEX and O & M charges

Chapter 8 - Action Plan

8.1 Forecasting

15-minute and hourly forecasts are being done by the load despatch centres across India. It is recognized that forecasting has a vital role in secure and reliable grid operation. Both load and RE forecasting have to be done so that portfolio of the states is balanced at all times and reliance on deviations, as a balancing resource, is minimized. There is need for 360 degree holistic approach for forecasting. Additional resources are required to develop forecasting as a faculty, which is still in nascent stage, in India. State level capacity building is essential which would allow pool of talent in each state to grow and achieve self-reliance especially in the area of forecasting, especially, at 5-minute interval.

8.2 Scheduling & Despatch

The response of the conventional generators to ramping requirements is taken care in the day-ahead scheduling process. The five minute scheduling and despatch would further discretize the load curve and ramping requirements and hence, cause economy and efficiency to meet the demand. The sub-group recognizes that reserves and 5-minute scheduling & settlement are all interwoven processes. the sub-group recommends migration to 5-minute scheduling and despatch at inter-state level. Subsequenctly, states implementing SAMAST can also move to 5-minute scheduling and settlement.

8.3 Power Exchanges – 5 minute price discovery

In the beginning in 2008, the hourly results for power exchange transactions were obtained by intrapolating the hourly trades at 15 minute time interval. There was mismatch in the bidding interval and scheduling interval. In order to harmonize the scheduling and bidding intervals, capacity building measures were undertaken for increased awareness amongst the utilities to move towards more complex 15 minute bidding format. Post implementation in April, 2012, the state utilities have been bidding on a 15-minute basis in the Power Exchange platform. The granular pricing by utilities helps them manifest their value for electricity with time more precisely, which results in better price discovery. Similarly, the implementation of 5-minute bidding format in OTC/PX markets will lead to more efficient price discovery. PX have to gear up and migrate to 5-minute scheduling and settlement.

8.4 Administration and Treatment of DSM

In the present Deviation Settlement Mechanism, the step size of frequency has been decreased from 0.02 Hz to 0.01 Hz which provides greater granularity for the tightening frequency band and DSM price. In the present 15 minute regime, the over-drawal/under-drawal is averaged out in the 15 minute period. Therefore, there is need for reducing the interval to 5-minute so as to encourage portfolio management. In order to maintain

frequency at 50 Hz, along with other parallel measures of frequency control, reserves and ancillary services, the 5-minute DSM prices would be a vital indicator for imbalance handling caused especially by renewable generation.

8.5 Metering and Settlement

The committee recognizes that 5-minute metering should be in parallel with 15 minute metering for a transition period. A changeover date (say 01st April, 2020) may be decided by the appropriate commission which would be applicable to all the meters. The provisions for 5-minute may be made mandatory for future procurement of meters.
The sub-group is of the view that "Scheduling and Despatch" has to be aligned with "Settlement" process in 5-minute timeframe too. The new meters may give data, in parallel, in 5 min new coded format as well as in old meters (present) coded format. To begin with, accounts for both 15-minutes and 5-mintues accounting may be kept in parallel so that the transition from 15 minute to 5 minute accounting is seamless and dispute–free.

8.6 Regulatory Amendments

The sub-group noted that five minute scheduling and settlement arrangements entail regulatory interventions at both inter-state and intra-state level. It was noted that at the inter-state level, the CERC Regulations shall be studied and specific recommendations related to amendments in regulatory provisions will be made by the sub-group.

8.7 Gate closure provisions

With coordinated multilateral scheduling process and continuous revisions, overlapping of the RRAS instruction and the schedule modifications being carried out by the concerned RLDC is taking place. For example, re-scheduling of un-despatched surplus on the request of one of the beneficiary, tripping of power system elements, natural variations etc. The available URS is thus changing continuously also and simultaneous ancillary dispatch has added another dimension of complexity to the process as there could be overlapping changes by the NLDC (for ancillary) and the RLDCs (schedules).

Therefore, there is need for introduction of gate closure concept in the scheduling process so that system operator has the clarity of the quantum of reserve and resources at hand at any given point of time. Better optimization of the scheduled despatches and the real time ancillary despatch needs to be formulated.

In physical terms, the concept of gate closure would facilitate better system balancing through a thin layer of centralized despatch over decentralized scheduling by the constituents. The following is proposed in respect of implementation of gate closure:

(a) The maximum number of revisions in schedule will be restricted to 96 (presently, it goes beyond 100 revisions sometimes). In order to implement this, RLDCs shall implement

'batch processing' of schedule revisions where each batch of schedule revision runs once every 5-minutes.

(b) "Gate Closure", meaning no further revision in schedules (either by beneficiary or the generator) shall be accepted one hour prior (on an hourly basis) to start of despatch for three five-minute blocks (15 minutes). This would be on a rolling basis. The final schedules would be worked out 60 minutes prior to the time of despatch.

(c) After gate closure, firm information would be available with the NLDC/RLDCs regarding the quantum of reserves available and ancillary despatch can then be undertaken in a more economical way with more certainty.

(d) Despatch under ancillary will be incorporated in the schedules in the next upcoming batch of schedule revision. Only ancillary schedules can be issued during the gate closure window.

8.8 CEA Metering Standards Amendments

There is requirement of amendments in the CEA Metering Standards which is followed by the pan-India utilities for procurement of metering infrastructure. In 33rd WRPC meeting held on 01.02.2017, it was decided to replace all the existing interface SEMs (Special Energy Meters) installed in Western Region with SEMs capable of recording and storing of 5 mins as well as 15 mins block data of Frequency, Wh & VArh (Low & high) along with suitability for transmitting the data to remote locations using appropriate communication medium (AMR).

In this regard, in April, 2017, a communication has also been sent to CEA regarding amendments in clause (I)(b)(i), (ii), (iii} & (iv) of Part II Standards for interface meters of the CEA (Installation and Operation of Meters) Regulations, 2006 to accommodate the above mentioned provisions (*Annexure – 6*). The RPCs have discussed this item in their agenda. The WRPC Approved Technical Specifications for Interface Energy Meters and Automated Meter Reading System for Western Region (Summary at *Annexure - 7*) may be referred for faster development of region-specific technical specifications by all RPCs/NPC.

8.9 Upgradation/Replacement of Meters

It was deliberated that CTU may identify the region-wise interface meters which are needed to be replaced and those that can be reconfigured (along with upgrade of storage) for the transition to 5-minute scheduling and settlement. CTU may make an assessment of the implementation timeline and financial implication for transition to the 5-minute framework after collection of the data on type, vintage and location of existing meters. Earlier implementation in the regions ready for the transition is always welcome. It was also recognized that cross border interconnections will also need to be upgraded for the transition.

8.10 Cost Recovery

Two methodoligies for cost recovery of metering infrastructure are in vogue in different regions. One is the one-time reimbursement of the expenditure and the other is through regulated tariff route. The sub-group recognizes that there is a need to harmonize through an appropriate regulatory framework by CERC keeping in view the lifecycle maintenance, testing, calibration and replacement of meters.

In the given circumstances, the sub-group recommends that necessary provisions to facilitate the recovery of meter costs are also required to be incorporated in the regulations keeping in view that meter has to be maintained, periodically checked and if needed replaced also.

8.11 Software upgrade at the RPC/RLDC/SLDC

The sub-group recognizes that a system of Automated Meter Data Reading (AMR)/Meter Data Processing (MDP) software along with the associated hardware for meter data collection, validation and processing at RLDC has to be there before forwarding the meter data to the respective RPC Secretariat for regional energy accounting. The hardware and software at respective RPCs/RLDCs/SLDCs has to be upgraded along with ensuring reliable communication infrastructure between the metering infratructure and RLDC for seamless transfer of meter data from substation to RLDCs.

8.12 Implementation of SAMAST Recommendations

In view of SAMAST implementation, the states who are about to implement the intrastate accounting and settlement system could leapfrog and go for scheduling and settlement at 5-min interval. The scheduling software and the energy meters specifications could in line with the above. All the other States and the Regional Pools shall also endeavor to have systems and logistics for 5-min scheduling and settlement system.

8.13 Stakeholder Capacity Building

There is need for capacity building and sensitization regarding hardware and software upgrade at the RPCs/RLDCs/SLDCs in the areas of scheduling, meter data processing, accounting and settlement. CTU/STU has to interact with all the stakeholders including vendors regrading meter development, testing, production, installation and commissioning.

8.14 Centre for Power Sector Information Technology Services

The CRIS is an autonomous organization under the Ministry of Railways. It develops and manages the Information Technology applications of the Indian Railways. Their current portfolio of projects covers the gamut of Indian Railways functions, such as passenger ticketing, freight operations, train dispatching and control, crew management, e-

procurement, management of Railways' fixed and moving assets, and production of rolling stock. Their Human Resource strength include a pool of competent IT professionals, whose skillsets include system architecture, system analysis and design, and program development, complemented by an experienced group of serving and former Railway personnel with domain knowledge and system implementation skills. They have a collaborative model of working to ensure the delivery of cost-effective, sustainable information systems. CRIS has been successful in using cutting-edge technologies in practical ways to ensure workable IT solutions for the Railways in many areas.
[Source: http://cris.org.in/CRIS/About_us/About_us]

It may be inferred from the above that there is an urgent need for a 'Centre for Power Sector Information Services' similar to CRIS that caters to the customized requirements of the Load Despatch Centres. The Centre for Power Sector Information Services could collaborate with other IT service providers to provide the IT solutions to the utilities in power sector. The in-house IT team at a Load Despatch Centre could perform the role of project management, system/database/network administration, and help-desk support and data centre operations with necessary support from software vendors. The maintenance of IT hardware could be outsourced. LDCs also need to take up vendor development programmes to encourage and attract IT solution providers in Load Dispatching.

Chapter 9 - Metering Infrastructure and Cost Estimates

9.1 Regional Entities

There are more than 200 regional entities on pan-India basis connected to the inter-state grid (Refer Table – 5). The scheduling, metering, accounting and settlement of these regional entities need to be done at the regional level by respective RLDCs/RPCs. Thus, in 15-minute framework, matrix of 96x210x50 (assuming average 50 revisions) i.e. roughly one million numbers daily are involved in the scheduling & despatch processes at RLDCs/NLDC. Apart from above, in bilateral transactions, traders and intrastate entities are also involved which further complicate the matters.

Table 5: Pan-India Regional Entities

Region	Regional Entities		
	Generator	Drawee	Total
North	44	12	56
East	43	10	53
West	21	7	28
South	22	8	30
North-East	10	8	18
All India	**158**	**55**	**213**
Bhutan	**4**	**1**	**5**
Bangladesh	**-**	**1**	**1**
Nepal	**-**	**1**	**1**
Myanmar	**-**	**1**	**1**
Total	**162**	**59**	**221**
Future	**~ 250**	**~ 100**	**~350**

When migration to 5-minute framework takes place, the scheduling & despatch matrix bloats to three million numbers daily at RLDCs/NLDC which further complicates the

processes at RLDCs/NLDC. There is need for robust metering infrastructure at both inter-state and intra-state level for full-fledged pan-India implementation of 5-minute scheduling & settlement.

9.2 Present Metering Infrastructure at Inter-state Level

The number of Interface Energy Meters in the regions is depicted in Figure 17.

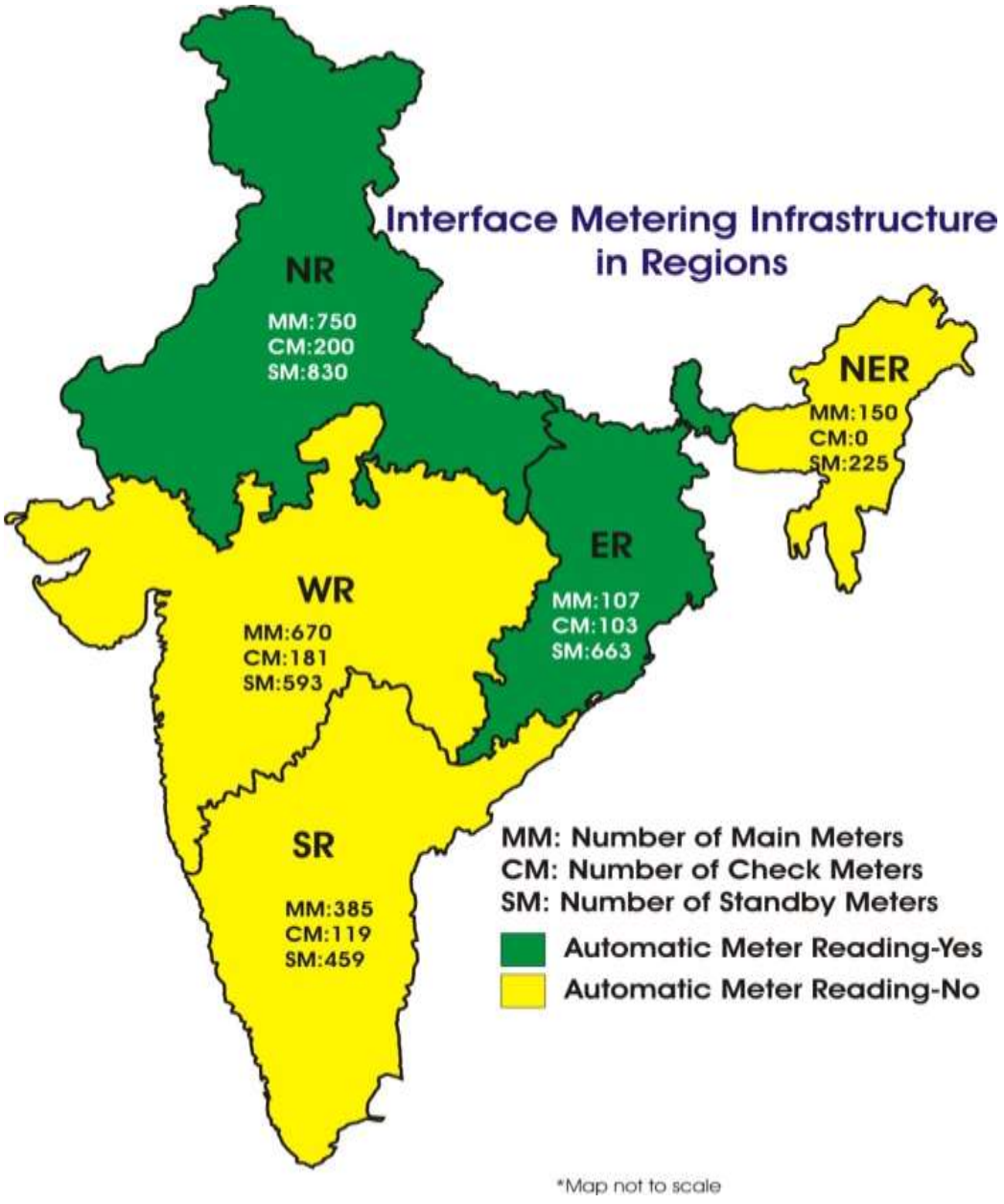


Figure 17: Interface Metering Infrastructure in Regions (Source: FOR SAMAST Report)

There are more than 5000 interface meters at more than 800 locations across India. The largest numbers of meters have been installed in Northern region followed by Western region and Southern Region (Table – 6).

Table 6: All India Metering Locations and Numbers

Region	Metering Locations	Number of Meters
North	274	1666
East	146	828
West	164	1490
South	157	887
North-East	75	375
All India	**816**	**5246**
Bhutan	**3**	**18**
Bangladesh	**2**	**8**
Nepal	**4**	**8**
Myanmar	**1**	**2**
Total	**826**	**5282**
Future	**~ 1000**	**~ 10,000**

9.3 Cost Benefit Analysis

The sub-group analyzed and estimated the cost implication for replacement of interface meters at inter-state level (Table -7) The total tentative cost of replacement of present ABT meters with ABT Energy Meters (0.2S class) with 5 minutes integration is around **₹ 30 Crore**.

Table 7: Estimated Costs for 5-Minute Integration

S.No.	Item	Estimated cost
1.	Tentative Cost of replacement of all Pan-India Interface Energy Meters	₹ 20 Crore
2.	Additional costs for hardware/software upgradation (@ 50 %)	₹ 10 Crore
3.	**Total**	**₹ 30 Crore**

The PoC Yearly Transmission Charges (YTC) at inter-state level are in the range of **₹ 32,000 Crore**. Therefore, the cost of replacement of present ABT meters with ABT Energy Meters (0.2S class) with 5 minutes integration is around **0.009 % of YTC**.

The sub-group has recognized that given the size of the Indian electricity market and the investment required, it would only take very minor efficiency increases in operating and investment decisions from the improved price signal to outweigh the implementation costs. This is particularly the case given that the benefits from the improved price signal resulting from five minute scheduling and settlement will be enduring, while the costs are largely one-off. For example, if optimized wholesale price signals resulted in as little as **₹ 100 Paisa/MWh** reduction in average wholesale costs, this would represent just under **₹ 110 Crore per year** saving in energy costs that will be passed onto consumers. Thus, the payback period of the investment is very low (less than one year).

Chapter 10 - Handling Transition and Timelines

The sub-group has recognized that the metering upgrades to accommodate a move to five minute scheduling and settlement are quite daunting in nature and require phase-wise approach in the implementation process. Moving to a standard of five minute resolution data will require information system and process changes for most market participants. The workflows for Energy Metering, Accounting and Settlement System in the Indian electricity market are illustrated in Figure 18 and 19 respectively.

It shows that the IT systems of RPCs, NLDC/RLDCs, generators, discoms and other entities would be most affected by a move to five minute scheduling and settlement. The changes mostly relate to system upgrades to handle five minute resolution metering data and to manage five minute bidding into the wholesale market. For example, changes would be needed to MDP systems for collecting, cleaning and storing metering data, and retailer systems for wholesale market settlement and potentially for billing of customers.

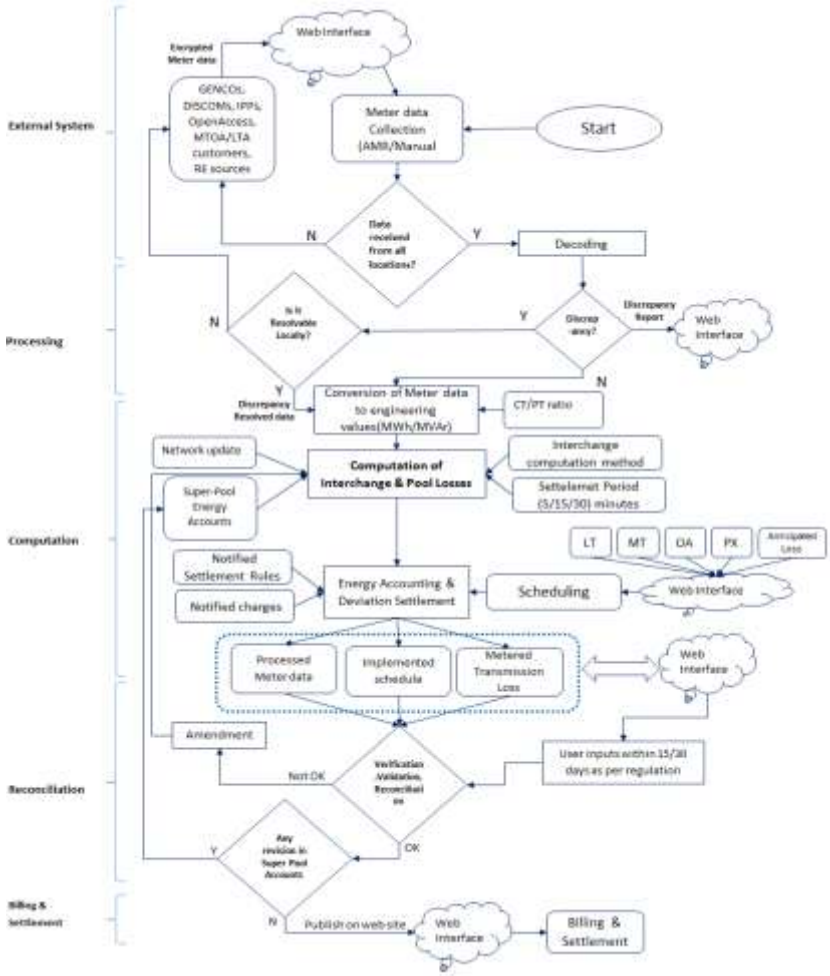


Figure 18: Workflow for Energy Metering, Accounting and Settlement System (Source: FOR SAMAST Report)

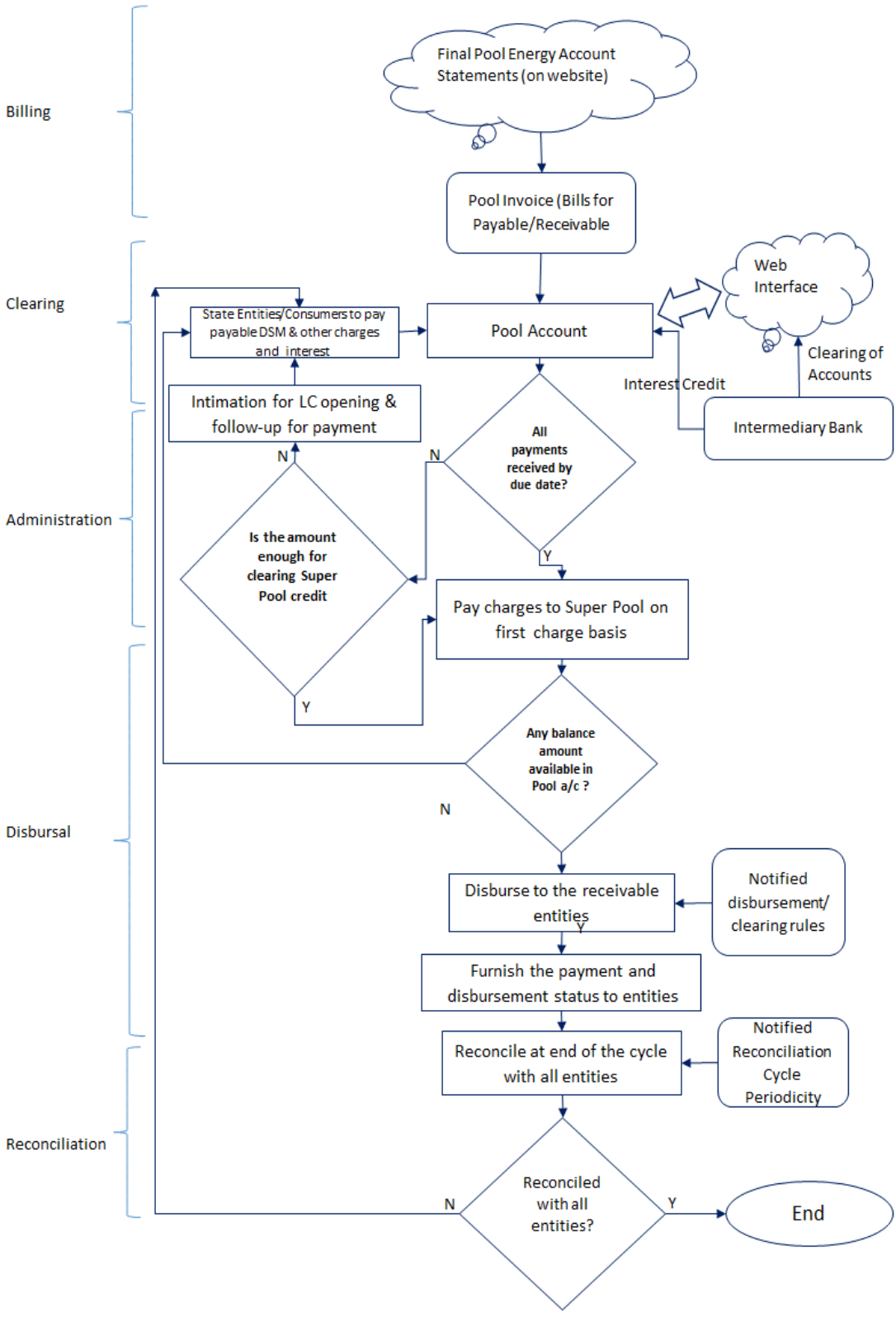


Figure 19: Workflow for Regulatory Pool Account Billing and Clearing (Source: FOR SAMAST Report)

10.1 Functional Blocks and IT applications required

All the activities in Market Operation are highly data intensive and rigorous. The energy account statements prepared by SLDCs/RLDCs/NLDC/RPC are required by utilities for billing and settlement of their transactions. Thus the Deployment of Information Technology tools are desirable for automation of the above activities. Software applications are particularly required for the following functions:

a. User Registration
b. Open Access processing
c. Energy Scheduling
d. Energy Metering Design and Maintenance
e. Energy Meter Data Management- Collection, Validation, Processing
f. Energy Accounting
g. Active Energy Deviation Accounting
h. Reactive Energy Accounting
i. Transmission Usage Accounting
j. Billing and Settlement
k. Clearing and Pool Account Administration
l. Supervision and Compliance Monitoring
m. Information Dissemination
n. Data Archiving and Retrieval
o. Fees and Charge Billing and Collection
p. Reconciliation
q. Reporting
r. Big Data Analysis

Market Operation function can no longer succeed with fragmented and standalone IT systems. Each process has multiple inputs and interface with internal as well as external systems. Thus standardization, scalability and flexibility are essential. The typical workflow for the above activities is illustrated in the flow charts that follow. These processes need to be automated to enable fast processing of data and minimizing the settlement period. Several activities such as scheduling and open access processing require web-based interface for facilitating simultaneous and continuous coordination with multiple Users / stakeholders. Such activities require web-based interface for convenience of internal as well as external stakeholders. The software applications need to be continuously aligned with the evolving regulations and evolving requirement of the stakeholders and Users of the applications.

10.2 Typical Hardware requirement

The typical hardware requirements for a Data Center in a LDC are as under:

a. Main Web Servers for hosting LDC web portal
b. Main Database Servers for hosting the LDC data
c. Application Servers for hosting the LDC applications

d. Representational State transfer (REST) or Simple Object Access Protocol API servers to provide the data to the application's view and model servers and web servers
e. Caching Servers configured with large amount of memory (typically >64 GB) to provide fast access to the frequently used data (e.g. current day schedules, active STOA transactions etc.) to offload the main database servers.
f. Load Balancer to distribute network load evenly on application and database servers.
g. Backup Appliances on site as well as at the Disaster Recovery Site
h. Network Management Servers to monitor and control the networking infrastructure and internet service providers (ISPs) leased lines.
i. Security Devices such as Routers, Network Firewalls, IDS/IPS, Gateway antivirus.
j. Unified Threat management (UTM) devices to provide all the network security functions (i.e. firewall, IDS/IPS, antivirus etc.) on one device

10.3 Phase-wise Activities for Transition to 5-Minute Scheduling & Settlement

The phase-wise activities have been identified by the sub-group for the transition to the 5-minute scheduling and settlement as follows:

Phase – I: Pilot Project

On a pilot basis, 5-minute capable meters may be installed at say, 4-5 locations in each Region to gain practical experience in 5-minute metering, interfacing requirements / file interchange formats and develop data analytics/tools for 5-minute metering, data validation, reporting, etc. The pilot project would help in formulation/refinements of Technical specifications and Software Requirement Specifications (SRS) for Metering Software at RLDCs and Accounting Software at RPCs for 5-minute metering. We can go for 5-minute schduling early with 15 minute settlement.

The suggested locations are at Generating stations – Conventional / RE, Substations – 765 kV / 400 kV and Inter-Regional inter-change points. The pilot project for installation of 5-minute capable metes may be undertaken at different locations with different vendors. These meters should be capable of data downloads in both 5-minute and 15-minute formats so as to facilitate handling of transition during the final implementation of 5-minute metering. CTU would facilitate the pilot project with installation of 5-minute meters by June, 2018. CTU will coordinate with the stakeholders for freezing technical specifications for ISTS meters to enable pilot project implementation. After specifications are is in place, NIT, LOA, type test, delivery, installation, CTU would facilitate the commissioning of the pilot project. CTU may approach CERC for suitable tariff recovery modus operandi.

Phase – II: Regulatory Framework

CERC would circulate a Staff Paper on Regulatory Framework for 5-minute Scheduling and Settlement arrangements by June, 2018. The regulatory framework would cover the

amendments required in the scheduling, despatch, metering, accounting and settlement processes at the inter-state level. After stakeholder consultation and three months experience of pilot project, the final regulatory framework may be notified by September, 2018.

Phase – III: Amendment in CEA Metering Standards

There is requirement of amendments in the Metering Standards by CEA which is followed by the pan-India utilities for procurement of metering infrastructure by June, 2018. The WRPC Approved Technical Specifications for Interface Energy Meters and Automated Meter Reading System for Western Region may be referred for faster development of region-specific technical specifications by all RPCs/NPC.

Phase – IV: Formulation of Technical specifications

The formulation of technical specifications for new meters and configuration change at RPC/State level has to be undertaken by CTU in coordination with RPCs and POSOCO. The activity may be completed by July, 2018 so that the procurement process may be initiated for pan-India roll-out of 5-minute scheduling and settlement. An expert group may be seprately constituted to finalize the Technical Specifications once the amended CEA metering standards are notified.

Phase – V: Upgradation of Hardware and Software

There is need for hardware and software upgradation at RPC/NLDC/RLDCs/SLDCs for implementation of 5-Minute scheduling and settlement. There are actions to be initiated to formulate Software Requirement Specification (SRS) documentation alongwith associated system of Automated Meter Data Reading (AMR)/Meter Data Processing (MDP) software and hardware for meter data collection, There is need to deliver an end to end solution for energy metering at the interstate level in the all the regions.

Phase – VI: Procurement process

The procurement process from tendering to commissioning shall be led by CTU at inter-state level and STU at intra-state level so that by April, 2019, all the upgradation / replacement of the existing fleet of Special Energy Meters (15 min, ABT meters) in the Inter State Transmission System (ISTS) in all the regions is done with Interface Energy Meters (5 min, Interface meters).

Phase – VII: Trial Run

The trial run from April 2019 – March 2020 will enable the stakeholders to gain practical experience in 5-minute metering, interfacing requirements / file interchange formats, resolve

the teething troubles, test the data analytics/tools for 5-minute metering, data validation, reporting with adequate capacity building of the personnel at RPC/NLDc/RLDC/SLDC.

The sub-group also recommends that the design concepts of forward and backward compatibility may be adopted by the meter manufacturers. It will make the new metering infrastructure compatible with both previous and future versions of itself. This typically means that it can seamlessly use the same data and equipment. It is recognized that state utiltiies will be hesitant to buy a product that makes their work obsolete or requires cumbersome migration. It is common to establish a roadmap whereby support for old versions of data formats and equipment are eventually dropped from the product.This usually means that it tries to accept future data formats or includes dormant physical features that may be useful to the future. The future is often unknown and forward compatibility is associated with flexible designs that won't fail when things change.

The final framework shall be implemented w.e.f ***01st April, 2020.***

Chapter 11 - Recommendations and Way Forward

The sub-group, after detailed deliberations and analysis, recommends as follows:

11.1 Move to "Fast" Markets

The sub-group recommends moving to "fast" markets which would better value flexibility by incentivizing those generators or consumers (or other future market participants like storage owners, aggregators etc.) that can adjust their production or consumption quickly in response to changing market conditions. In effect, this reform would extend the role of the energy market for managing real-time variation in supply-demand conditions.

11.2 Development of Forecasting as a Core Area in System Operation

It is recognized that forecasting has a vital role in secure and reliable grid operation. The sub-group recognized that achieving FGMO and AGC become essential for moving to lesser time interval. Also, better load and RE forecasting tools within stipulated accuracy ranges are necessary to achieve optimal system operation. The sub-group recognized the need for a multi-pronged approach with actions in all possible areas so as to improve the overall system operation.

The sub-group recommends that both load and renewable energy forecasting have to be done so that portfolio of the states is balanced at all times and reliance on deviations, as a balancing resource, is minimized. Additional resources are required to develop forecasting as a faculty, which is still in nascent stage, in India. State level capacity building is essential which would allow pool of talent in each state to grow and achieve self-reliance.

11.3 Implementation of Five minute Scheduling and Despatch

The sub-group recommends that five minute scheduling and despatch would further discretize the load curve and ramping requirements and hence, cause economy and efficiency in the resource utilization to meet the demand. Therefore, the sub-group recommends that five minute scheduling and despatch may be implemented at inter-state level, to begin with and thereafter, after gaining experience, at intra-state level. The benchmarking of ramp rate of generating units is also required.

11.4 Implementation of 5-minute bidding in OTC/PX

It is recognized that the granular pricing by utilities helps them manifest their value for electricity with time more precisely, which results in better price discovery. Therefore, the sub-group recommends the implementation of 5-minute bidding in

OTC/PX markets. The necessary capacity building measures have to be undertaken for increased awareness amongst the utilities to move towards more complex 5 minute bidding format.

11.5 Five-minute Energy Accounting and Settlement System

The sub-group recommends that "Scheduling and Despatch" has to be aligned with "Settlement" process in 5-minute timeframe too. The new meters may give data, in parallel, in 5 min new coded format as well as in old meters (present) coded format. Further, accounts for both 15-minutes and 5-mintues accounting may be kept in parallel till a specified cut-off date.

11.6 Administration and Treatment of the Five-minute Deviation Price

In the present Deviation Settlement Mechanism, the step size of frequency is 0.01 Hz which provides greater granularity for the tightening frequency band and DSM price. In the present 15 minute regime, the over-drawal/under-drawal is averaged out in the 15 minute period. Therefore, the sub-group recommends that there is need for reducing the deviation settlement interval. This would facilitate administration and treatment of the five-minute deviation price.

11.7 Pan-India Pilot Project on 5-minute metering

The sub-group recommends that, on a pilot basis, 5-minute capable meters may be installed at say, 4-5 locations in each Region to gain practical experience in 5-minute metering, interfacing requirements / file interchange formats and develop data analytics/tools for 5-minute metering, data validation, reporting, etc. The Technical Specifications approved in the WRPC may be used as reference. There has to be MDP in place as well to process/compute the data of new 5-minute meters of pilot project.

It is also recognized that the experience in WR and the pilot projects in other States/Regions would help in formulation/refinements of Technical specifications and Software Requirement Specifications (SRS) for Metering Software at RLDCs and Accounting Software at RPCs for 5-minute metering. CTU may facilitate the pilot project with installation of 5-minute meters. Besides SRS for MDM, SRS for Meter conversion software (ie VINPLUS, SmartGrid, PEARL etc) and SRS for software loaded in the DDC/MRI also need to be standardised. Similarly SRS for AMR also may be thought of.

11.8 Change in data exchange file structures and other technical issues

The sub-group recognizes that proposed 5 minute arrangements would require a change in NPC coded file structure which is essential for meter data exchange. During the 5-minute meter demonstration, it was observed that additional parameters are available in the meters which were kept disabled as the requirement was not posed to the meter manufacturers. This is the high time when we should shift to standard format and protocol to enable AMR and AMI in future. There is need for software validation, requirement of Automated Meter Reading (AMR) alongwith communication infrastructure, storage enhancement, standardized data and information protocols. The reconfiguration of the meters should be with adequate safeguards and ensure that the meters are tamper-proof. The sub-group recommends that a separate expert group under aegis of FOR Technical Committee may discuss on the NPC coded file format and other technical issues in detail.

11.9 Regulatory Interventions

The sub-group noted that five minute scheduling and settlement arrangements entail regulatory interventions at both inter-state and intra-state level. The various CERC Regulations have been studied and specific recommendations related to amendments in regulatory provisions have been made by the sub-group. The sub-group also recommends that suitable provisions in the regulatory framework at intra-state level may be replicated to facilitate 5-minute scheduling and settlement.

11.10 Amendments in CEA Metering Standards

The sub-group recommends that there is requirement of amendments in the CEA Metering Standards which is followed by the pan-India utilities for procurement of metering infrastructure. CEA already initiated review of CEA (Installation and Operation of Meters) Regulations, 2006 in August, 2016. The process may be expedited so that final amendments incorporate 5-minute provisions.

11.11 Upgradation/Replacement of Metering Infrastructure

The AMR System and Meter Data Processing System are centralized requirement of RLDCs. The technical standards on communication infrastructure and its Cyber security requirements are yet to be formulated and issued by the CEA. It is also understood that the approved guidelines in respect of interfacing requirements of terminal equipment for communication, AMR etc. based on the technical standards are yet to be issued by CEA. In the given circumstances, the sub-group recommends that necessary provisions to facilitate the recovery of meter costs are also required

to be incorporated in the regulations keeping in view that meter has to be maintained, periodically checked and if needed replaced also.

11.12 Stakeholder Capacity Building

The sub-group recommends that there is need for capacity building and sensitization regarding hardware and software upgrade at the RPCs/RLDCs/SLDCs in the areas of scheduling, meter data processing, accounting and settlement. CTU/STU has to interact with all the stakeholders including vendors regrading meter development, testing, production, installation and commissioning.

11.13 Implementation of SAMAST Recommendations

The sub-group recommends that, in view of SAMAST implementation, the states that are about to implement the intrastate accounting and settlement system could leapfrog and go for scheduling and settlement at 5-min interval. The scheduling software and the energy meters specifications could in line with the above. All the other states and the regional pools shall also endeavour to have systems and logistics for 5-minute scheduling and settlement system.

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Wisemen Speak

- *अनियतकालाः प्रवृत्तयो विप्लवन्ते*
  Aniyatakaalaah pravrittayo viplavante

  Actions not done at the appropriate time do not yield the desired result
  - Kaavyameemaamsaa (Kaviraja Rajashekharah)

- *Move fast. Speed is one of your main advantages over large competitors*. - Sam Altman

- *Move fast with stable infrastructure.* - Mark Zuckerberg

- *Innovation is moving at a scarily fast pace.* - Bill Gates

- *The question is not whether we are able to change but whether we are changing fast enough.* - Angela Merkel

- *Test fast, fail fast, adjust fast.* - Tom Peters

- *Anyone can build a fast CPU. The trick is to build a fast system.* - Seymour Cray

Annexure - 1

FORUM OF REGULATORS (FOR)
Secretariat: C/o. CENTRAL ELECTRICITY REGULATORY COMMISSION (CERC)
3rd & 4th Floors, Chanderlok Building, 36, Janpath, New Delhi 110 001.
Telefax Nos.: 23753920

No. 1/1/2017/Reg.Aff. (Sub.Group-ISMAS)/CERC Dated: 2nd May, 2017

Sub: Constitution of Sub-Group for "Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement" under FOR Technical Committee for Implementation of Framework on Renewables at the State Level

Sir,

In the Eleventh Meeting of the "Technical Committee for Implementation of Framework on Renewables at the State Level" held at Chennai on 28th March 2017, it was decided to form a Sub-Group to examine the various aspects of migrating from 15-minute to 5-minure scheduling, metering, accounting and settlement at the inter-state level to facilitate large scale integration of renewables. Accordingly, the competitive authority has constituted the Sub-Group comprising the following members:-

(a) Shri S.K. Soonee, Advisor, POSOCO
(b) Representative of all RPCs and NPC
(c) Representative of CEA
(d) Representative of POSOCO
(e) Representative of CTU
(f) Representative from one RE rich state each in NR, WR and SR

2. The broad terms of reference (TOR) for the Sub-Group are:-

a) Look at all pros and cons of moving to 5-Minute Scheduling, Metering, Accounting and Settlement
b) Identify all activities to move from 15-minute to 5-minute scheduling, metering, accounting and settlement
c) Identify changes required in various Regulations including Grid Code and suggest the required amendments
d) Suggest amendments required to the CEA Metering Regulations and assess the metering infrastructure required
e) Suggest any specific requirements in this context for cross border transactions
f) Infrastructure requirements in terms of hardware & software upgradation needed for scheduling, metering, accounting and settlement by the NLDC, RLDCs, SLDCs and RPCs/NPC
g) Detailed action plan for migration including phasing of activities if required
h) Time-frames for the implementation of identified activities and target date for migration to 5-minute scheduling, metering accounting and settlement
i) Information dissemination requirements to be identified
j) Capacity building measures required for all stakeholders
k) Any other suggestions related to above

The Sub-Group may co-opt any external expert as it deems fit.

3. The Sub-Group shall submit its report to the Technical committee within a period of two months from the date of issue of this order.

4. The respective organizations that have representation in the Sub-Group are requested to send the nominations to the FOR Secretariat at the earliest.

21/5/17

(Sushanta Kumar Chatterjee)
Joint Chief (Regulatory Affairs)

To:

1. Member Secretary NRPC/WRPC/SRPC/ERPC/NERPC
2. Chief Engineer, NPC
3. Secretary, CEA
4. CEO POSOCO
5. COO, CTU
6. Representative of SLDC, Rajasthan
7. Representative of SLDC, Gujarat
8. Representative of SLDC, Karnataka

--- With a request to send their nominations to the FOR Secretariat at the earliest.

Copy to:

1. Sh. A.S. Bakshi, Member, CERC
2. Chairperson/Member, TNERC
3. Member, GERC
4. Member, RERC
5. Member, MERC
6. Member, APERC
7. Member, KERC
8. CEO, POSOCO
9. Sh. S.K. Soonee, Advisor, POSOCO

Annexure - 2

FOR Sub-Group for "Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement"
1st Meeting - Gist of Discussions

Meeting Details				
Date		03rd August, 2017	**Venue**	National Load Despatch Centre, POSOCO, Delhi
Day		Thursday		
Time	Open	11.00 AM		
	Close	01.30 PM		
Subject		**First Meeting of Sub-Group for "Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement" under FOR Technical Committee for Implementation of Framework on Renewables at the State Level**		

Deliberations

The list of members of the sub-group enclosed at Annex – 1.

A. CEO, POSOCO welcomed the participants to the meeting. It was highlighted that, in view of large scale integration of renewables, the electricity market design needs to be realigned with the future requirements.

B. Advisor, POSOCO mentioned that 3 F's i.e. 'Fast', 'Flexible' and 'Frequent' is the new mantra to be followed in the electricity ecosystem. Therefore, the sub-group has been entrusted with important task of review of scheduling & settlement process which is the engine of the electricity market.

C. A presentation was made by POSOCO regarding terms of reference, developments in the electricity sector, developments in other sectors and future challenges. A copy of the presentation is attached at Annex – 2. The main imperatives for moving to 'Fast Markets' were recognized as follows:
- Learning from implementation of Ancillary Services
- Re-scheduling of Resources
- Increasing RE penetration
- Ramping requirements
- Recognizing flexibility as a requirement
- Implementation of Primary, Secondary (AGC) and Tertiary Reserves/Control
- Reserves: Despatch, Accounting & Settlement

D. Sh. B B Mehta, CE, SLDC, Gujarat presented the views/suggestions on Implementation of 5- Minute Scheduling, Metering, Accounting and Settlement. A copy of the presentation is attached at Annex – 3. The main highlights were as follows:
- There is a need for better and accurate forecasting of load and RE generation.
- More number of agriculture groups may have to be implemented as they have, at present, ½ hour and hourly schedules.
- All Renewables may be telemetered (supported by regulation/grid code)
- The generators are required to ramp up/down as per instructions of RLDC/SLDC
- Adequate provisions need to be introduced to check gaming.
- Amendments in ABT meter specifications and information dissemination to end consumers.
- There may be programmable/configurable reactive power measurement limit on both side i.e. 97 % & 103 % to mitigate change of regulation in future.
- The old meters may be kept in series with new meters till all the interface meters are provided with new meters.
- The new meters may give data in 5 min new coded format as well as in old meters (present) coded format in view of intrastate DSM accounts publishing.
- Meter Data may be on common protocol, irrespective of vendor, for AMR implementation.
- Funding support from PSDF may be extended for the new metering infrastructure.

- There is need for software upgrade at the RLDCs/SLDCs.
- There is need for capacity building at RPC/RLDC/SLDC level for new arrangements.

E. Tamil Nadu representative informed the sub-group that installation of ABT compliant meters is under progress all over the state. These meters are 15-minute capable meters and 85 % of the wind generators, 100 % of solar generators and 66 % of other generators have been covered till date under intra-state metering system. It was pointed out that proposed 5-minute scheduling and settlement arrangements may result in a requirement for replacement of these newly installed meters. The issue was deliberated by the sub-group and it emerged that the issue can be handled using the same meters with a firmware reconfiguration. The sub-group requested Tamil Nadu representative to discuss the possibility of firmware reconfiguration with the meter vendor.

F. The following points were discussed and finalized during the meeting.

1. **Forecasting**
   It was agreed that forecasting has a vital role in secure and reliable grid operation. It was noted that both load and RE forecasting have to be done so that portfolio of the states is balanced at all times and reliance on deviations, as a balancing resource, is minimized. MS, NRPC mentioned that there are many parameters for forecasting which make it much more challenging. Advisor, POSOCO highlighted the need for 360° holistic approach for forecasting. It was agreed that additional resources are required to develop forecasting as a faculty, which is still in nascent stage, in India. Gujarat representative called for exploration of ULDC-like scheme for forecasting at national level. However, the sub-group felt that state level capacity building is essential which would allow pool of talent in each state to grow and achieve self-reliance.

2. **Scheduling & Despatch**
   It was agreed that response of the conventional generators to ramping requirements is already taken care in the day-ahead scheduling process. The five minute scheduling and despatch would further discretize the load curve and ramping requirements and hence, cause economy and efficiency in the resource utilization to meet the demand. CEA representative queried on the reduction in requirement of reserves with five-minute despatch and settlement process and also mentioned that the general response time of secondary control reserves varies from about one minute to 15 minutes. It was pointed out that secondary control reserves once deployed need to be replenished in due course by Tertiary Reserves; the time limits would depend on the system conditions. In the present scenario, the exhaustion of reserves is major issue being faced by the system. Hence, earmarking of the reserves become all the more essential. It was highlighted that reserves and 5-minute scheduling & settlement are all interwoven processes.

3. **Transition in Electricity Market : Power Exchanges – 5 minute price discovery**
   The transition from hourly to 15-minute bidding in Power Exchanges was discussed. POSOCO representative informed the sub-group that beginning in 2008, the hourly results for power exchange transactions were obtained by intrapolating the hourly trades at 15 minute time interval. Capacity building measures were undertaken for increased awareness amongst the utilities to move towards more complex 15 minute bidding format. Post implementation, the state utilities have been bidding on a 15-minute basis in the Power Exchange platform. The granular pricing by utilities helps them manifest their value for electricity with time more precisely, which results in better price discovery. It was agreed that implementation of 5-minute bidding in OTC/PX markets will lead to more efficient price discovery.

FOR Sub-Group for "Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement"
1st Meeting - Gist of Discussions

4. Transition in DSM Mechanism

In the present Deviation Settlement Mechanism, the step size of frequency has been decreased from 0.02 Hz to 0.01 Hz which provides greater granularity for the tightening frequency band and DSM price. In the present 15 minute regime, the over-drawal/under-drawal is averaged out in the 15 minute period. Therefore, there is need for reducing the interval to discourage deviations. In order to maintain frequency at 50 Hz, along with other parallel measures of frequency control, reserves and ancillary services, the 5-minute DSM prices would be a vital indicator for imbalance handling caused especially by renewable generation.

5. Commercial interface metering

The Gujarat representative highlighted that 5-minute metering should be in parallel with 15 minute metering. A changeover date may be decided which would be applicable to all the meters. CEA representative called for physical verification of the proposed 5-minute metering infrastructure. Advisor POSOCO mentioned that meters installed post 2010 can implement 5-minute arrangements. It was agreed that provisions for 5-minute may be made mandatory for future procurement of meters.

6. Settlement system –Energy Accounting, Financial settlement

The sub-group agreed that "Scheduling and Despatch" has to be aligned with "Settlement" process in 5-minute timeframe too. There was broad consensus that the new meters may give data, in parallel, in 5 min new coded format as well as in old meters (present) coded format. To begin with, accounts for both 15-minutes and 5-mintues accounting may be kept in parallel so that the transition from 15 minute to 5 minute accounting is seamless and dispute–free.

7. Changes in various CERC/SERC Regulations

The sub-group noted that five minute scheduling and settlement arrangements entail regulatory interventions at both inter-state and intra-state level. It was noted that at the inter-state level, the CERC Regulations shall be studied and specific recommendations related to amendments in regulatory provisions will be made by the sub-group.

The sub-group agreed that a representative from CERC may be co-opted in the sub-group so as to have regulatory insights for amendments required for proposed arrangements.

8. Changes in CEA Metering Standards

The sub-group noted that there is requirement of amendments in the CEA Metering Standards which is followed by the pan-India utilities for procurement of metering infrastructure. It was highlighted that in 33rd WRPC meeting held on 01.02.2017, it was decided to replace all the existing interface SEMs (Special Energy Meters) installed in Western Region with SEMs capable of recording and storing of 5 mins as well as 15 mins block data of Frequency, Wh & VArh (Low & high) along with suitability for transmitting the data to remote locations using appropriate communication medium (AMR). In this regard, in April, 2017, a communication has also been sent to CEA regarding amendments in clause (I)(b)(i), (ii), (iii} & (iv) of Part II Standards for interface meters of the CEA (Installation and Operation of Meters) Regulations, 2006 to accommodate the above mentioned provisions. The sub-group agreed that other RPCs may also discuss this item in their agenda and communicate to CEA.

The sub-group also recommended that a representative from CEA may also be co-opted in the sub-group for insights on metering standards.

9. Holding workshops, dissemination, stakeholder capacity building

The sub-group agreed that there is need for capacity building and sensitization regarding hardware and software upgrade at the RPCs/RLDCs/SLDCs in the areas of scheduling, meter data processing, accounting and settlement. It was noted that CTU/STU has to interact with all the stakeholders including vendors regrading meter development, testing, production, installation and commissioning.

10. Implementation of SAMAST Recommendations

In view of SAMAST implementation, the states who are about to implement the intrastate accounting and settlement system could leapfrog and go for scheduling and settlement at 5-min interval. The scheduling software and the energy meters specifications could in line with the above. All the other States and the Regional Pools shall also endeavor to have systems and logistics for 5-min scheduling and settlement system. It was agreed that an interim report regarding the metering requirements may be submitted to FOR Secretariat as soon as possible pending detailed study of software and other related issues which may take time.

Key Decisions Taken

- Generators and Meter vendors views/suggestions to be taken in next series of meetings
- All RPCs may discuss the 5-minute scheduling and settlement as an agenda item
- Co-opt representative from CEA and CERC
- Next meeting to be held on 24th August, 2017

Annex – 4: List of Attendees

Annex - 1

List of Members of the FOR Sub-Group on Five Minute Despatch & Settlement

S.No.	Name	Designation	Organization
1.	Sh. K V S Baba	CEO	POSOCO
2.	Sh. S K Soonee	Advisor	POSOCO
3.	Sh. Prafulla Varhade	Director (Elec. Engg.)	Maharashtra ERC
4.	Sh. Pardeep Jindal	Chief Engineer (NPC)	NPC
5.	Sh. D K Srivastava	Director	NPC
6.	Sh. M A K P Singh	Member Secretary	NRPC
7.	Sh. P K Mishra	Member Secretary	NERPC
8.	Sh. J.K. Rathod	Superintendent Engineer	WRPC
9.	Sh. Upendra Kumar	Superintendent Engineer	NRPC
10.	Sh. Deepak Gawali	Executive Engineer	WRPC
11.	Sh. Ratnesh Kumar	Executive Engineer	NRPC
12.	Sh. Anil Thomas	Executive Engineer	SRPC
13.	Sh. B B Mehta	Chief Engineer	Gujarat - SLDC
14.	Sh. P. Rajagunanidhi	Executive Engineer	TNEB-SLDC
15.	Sh. S. Gomathi	Executive Engineer	TNEB-SLDC
16.	Ms. T Nirmala Mary	Executive Engineer	TNEB-SLDC
17.	Sh. A Thangappan	Executive Engineer	TNEB-SLDC
18.	Sh. Dilip Rozekar	AGM (CTU-Planning)	CTU- PGCIL
19.	Sh. S S Barpanda	Addl. General Manager	POSOCO
20.	Sh. S C Saxena	Dy. General Manager	POSOCO
21.	Sh. K V N Pawan Kumar	Deputy Manager	POSOCO
22.			ERPC
23.			Rajasthan
Co-opted Members			
24.			CERC
25.			CEA

Annex - 2

FOR Sub-Group for *"Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement"*

First Meeting

POSOCO-NLDC, New Delhi
03 August 2017

Constitution of Sub-Group

- 11th Meeting of the "FOR Technical Committee for Implementation of Framework on Renewables at the State Level" - Chennai - 28th March 2017

- Members
  - Shri S.K. Soonee, Advisor, POSOCO
  - Representative of all RPCs and NPC
  - Representative of CEA
  - Representative of POSOCO
  - Representative of CTU
  - Representative from one RE rich state each in NR, WR and SR

Terms of Reference

- *Pros and cons: 5-Minute Scheduling, Metering, Accounting and Settlement*
- *Identification of Activities*
- *Policy & Regulatory Interventions*
- *Regulations and assess the metering infrastructure required*
- *Suggest any specific requirements in this context for cross border transactions*
- *Infrastructure requirements in terms of hardware & software upgradation needed for scheduling, metering, accounting and settlement by the LDCs and RPCs/NPC*
- *Detailed action plan for migration including phasing of activities if required*
- *Time-frames for the implementation of identified activities and target date for migration to 5-minute scheduling, metering accounting and settlement*
- *Information dissemination requirements to be identified*
- *Capacity building measures required for all stakeholders*
- *Any other suggestions related to above*

Dilemma…

- Is there a need to review the scheduling & settlement interval?

- Is 15 minute good enough or we need a 'faster' interval? How fast?

- Impact of Scheduling & Settlement interval on
  - System Balancing ?
  - Renewable Integration ?
  - Handling Variability & Intermittency ?

- International Practices in Scheduling & Settlement ?

Developments in Other Sectors…

Airlines

Banking

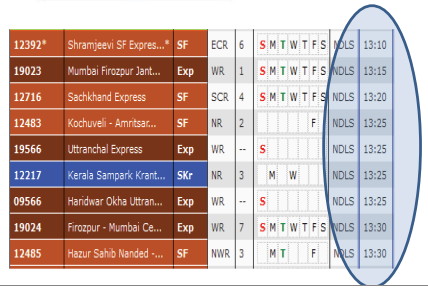
भारतीय रिज़र्व बैंक
RESERVE BANK OF INDIA
www.rbi.org.in

May 08, 2017

National Electronic Funds Transfer (NEFT) system – Settlement at half-hourly intervals

Petroleum

Railways



Stock Exchanges

Data Time-Interval	Annual Cost*
1 Minute	Rs. 13,20,000
2 Minutes	Rs. 7,50,000
5 minutes	Rs. 2,75,000
15 Minutes	Rs. 60,000

*NSE Annual Data Charges, Capital Market Segment

Looking Back to Look Forward

Pre – ABT era
- Daily energy booking
- Joint Meter Reading (JMR) based Monthly accounting
- Overlay accounts, frequency taken from SCADA

1994: GoI ECC Report

Inadequacies
- No incentives for utilities to respond for frequency control
- Absence of merit order operation, Grid indiscipline
- No signal for power trading
- Perpetual operational & commercial disputes
- Poor supply quality , Overall economy lost

1995-98: NTF and RTF

2000: CERC ABT Order

ABT Reforms
- 15-minute scheduling, despatch, metering (SEMs), accounting and settlement
- 15-minute deviation (UI) accounts

2002-03: ABT Implementation

Systemic Transformation
- Multi-Part Performance based Tariff
- Day Ahead Scheduling
- System of incentives and penalties

Bilateral transactions
- 15-minute trading in power and settlement

2004: Open Access

CERC ABT Order dated 04th Jan 2000

5.9.12 We have also considered the views of some of the beneficiaries to change the time block of 15 minutes. We are convinced that a short time block of 15 minutes can be expected to ensure alertness on the part of the dispatcher to take quick corrective action for maintaining desirable system parameters. If the interval is larger, there may be a tendency to defer the action with possibilities of steep frequency excursions thereby inviting damages to the system.

Looking Forward to Leap Ahead

Sub-hourly Bidding
- 15-minute clearing and settlement (energy)
- Aligning the Power Exchange markets with scheduling, despatch & settlement

2008: Power Exchanges

Collective transactions
- Hourly bidding
- Intrapolation to 15-minutes
- Hourly clearing and settlement of trades (energy)
- Deviation accounting at 15-minutes

2012: 15 Minute Bidding

RRAS
- Utilizing Un-despatched surplus
- Aligned with existing scheduling, despatch & settlement practice

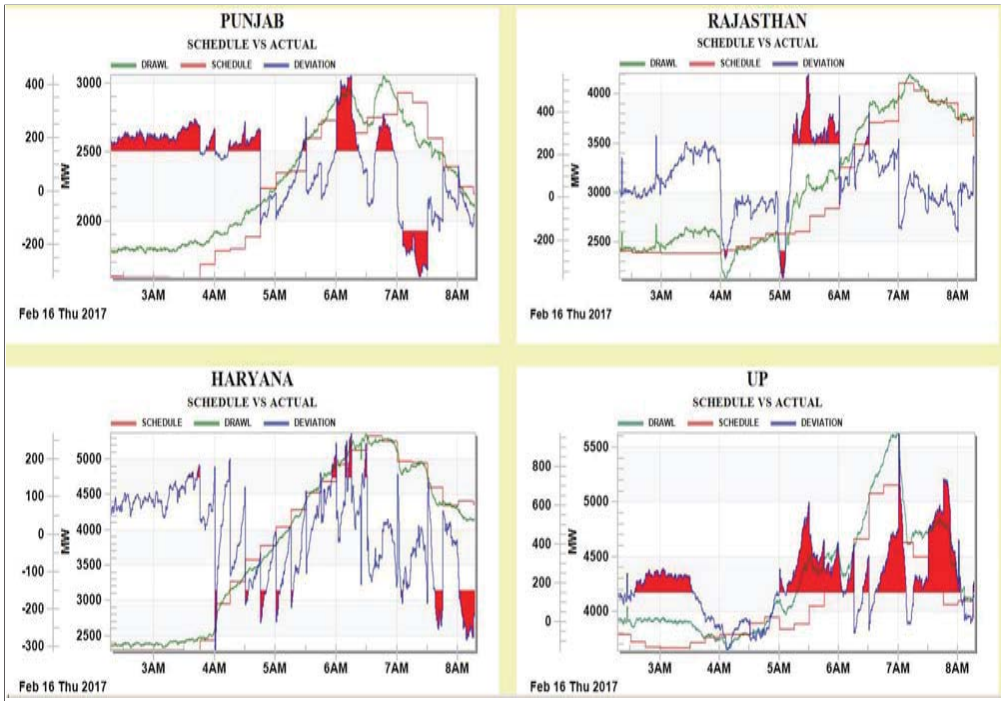
2016: Ancillary Services

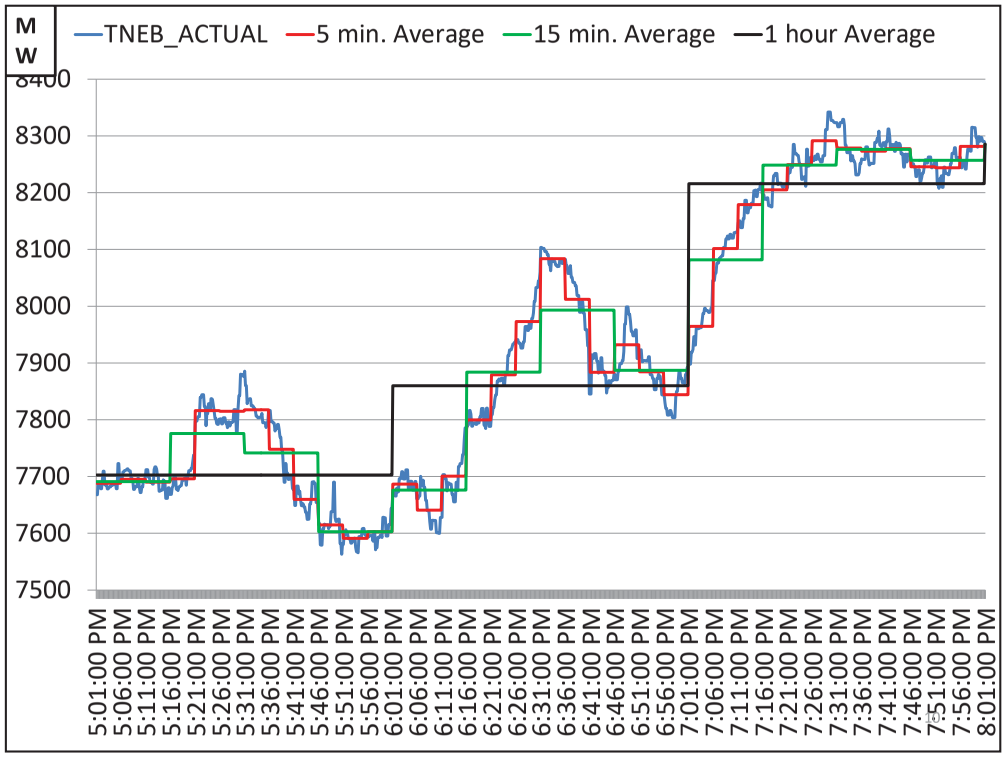
Petition with CERC in April, 2017
- Stakeholder consultations on implementation plan
- Secondary Control recommended as an Ancillary Service.

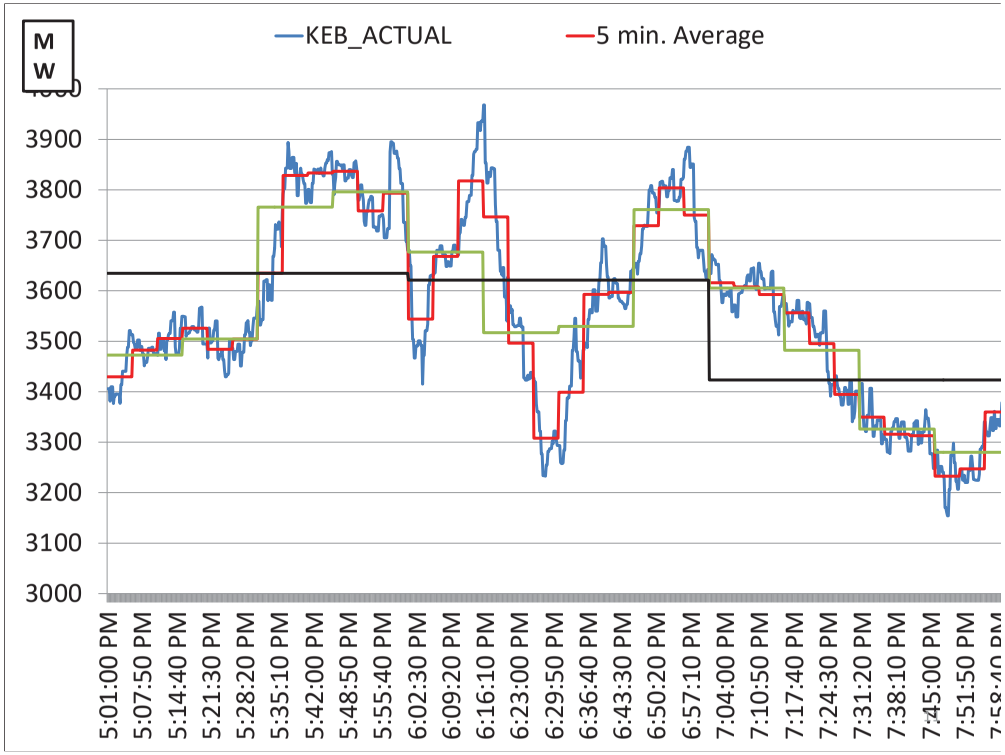
2017: AGC Pilot Project

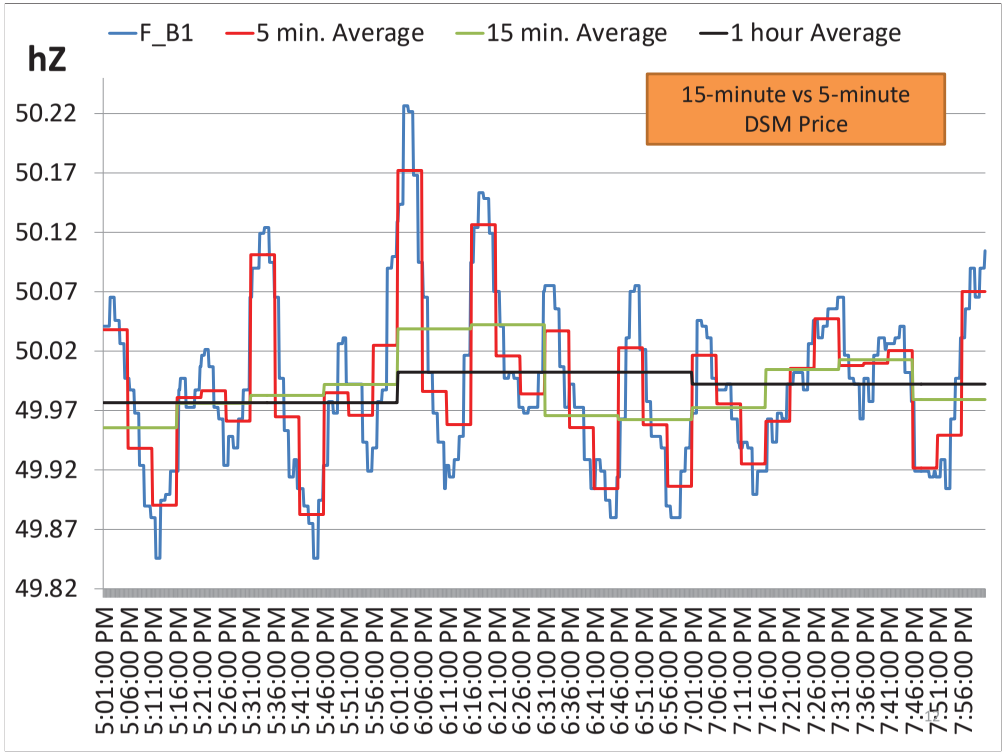
DERs, Electric Vehicles, Storage, Financial Products

Future


PUNJAB
SCHEDULE VS ACTUAL
DRAWL SCHEDULE DEVIATION
MW
Feb 16 Thu 2017
RAJASTHAN
SCHEDULE VS ACTUAL
DRAWL SCHEDULE DEVIATION
MW
Feb 16 Thu 2017
HARYANA
SCHEDULE VS ACTUAL
SCHEDULE DRAWL DEVIATION
MW
Feb 16 Thu 2017
UP
SCHEDULE VS ACTUAL
DRAWL SCHEDULE DEVIATION
MW
Feb 16 Thu 2017


MW
TNEB_ACTUAL
5 min. Average
15 min. Average
1 hour Average


MW
KEB_ACTUAL
5 min. Average


hZ
F_B1
5 min. Average
15 min. Average
1 hour Average
15-minute vs 5-minute DSM Price

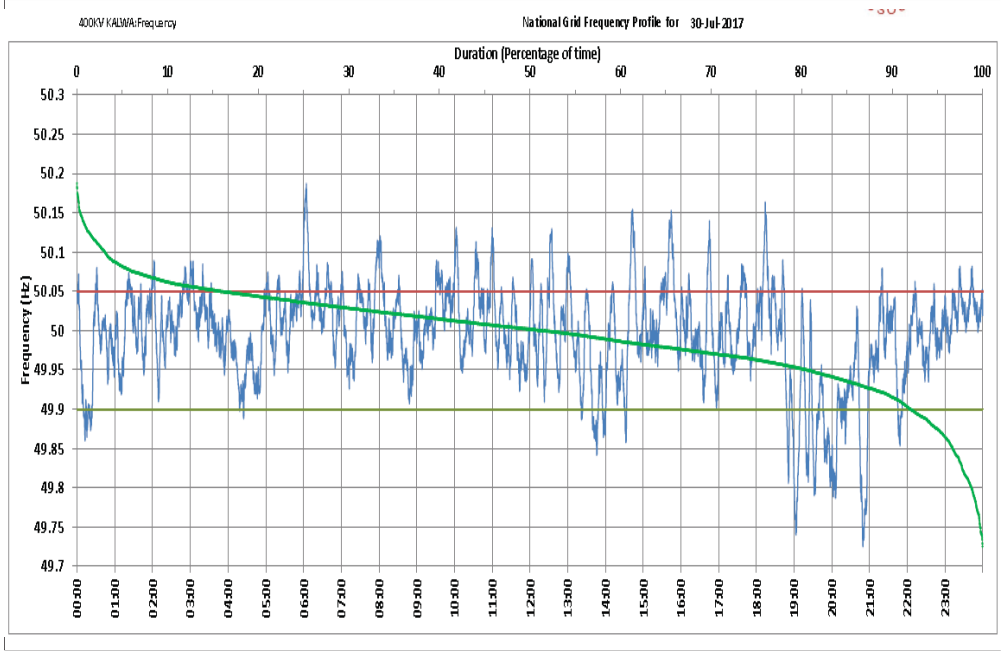
Imperatives for moving to 'Fast Markets'

- Learning from implementation of Ancillary Services
- Re-scheduling of resources
- Increasing RE penetration
- Ramping requirements
- Recognizing flexibility as a requirement
- Implementation of Primary, Secondary (AGC) and Tertiary Reserves/Control
- Reserves: Despatch, accounting & settlement

Learning from Ancillary Services

- Requirements under Ancillary Despatch are
  - Quick / Fast response & turnaround time
  - Despatch for short durations
  - Example: hour boundary changeover
- A costly resource, to be used in limited manner for system reliability
  - Increasing granularity would optimize cost of despatch
- Earliest possible implementation of RRAS despatch instruction is 16 minutes
  - Fast Tertiary control at best

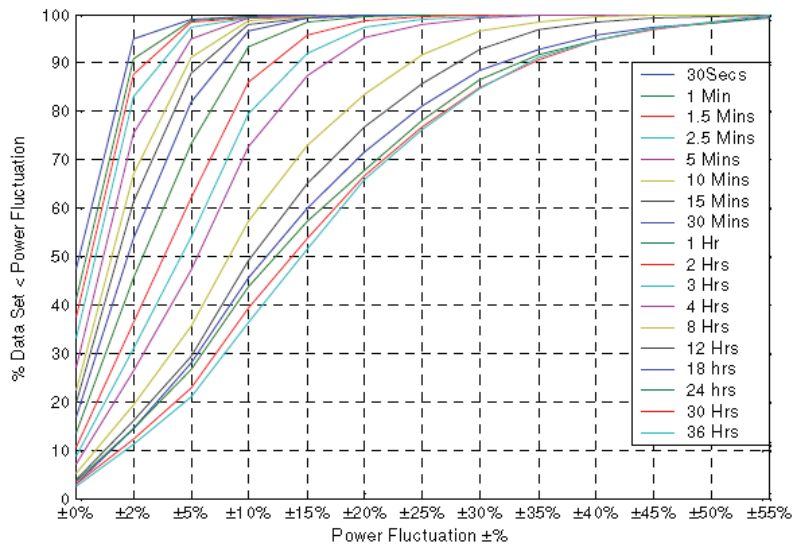
Frequency Fluctuations…Still Persist



Variability & Intermittency

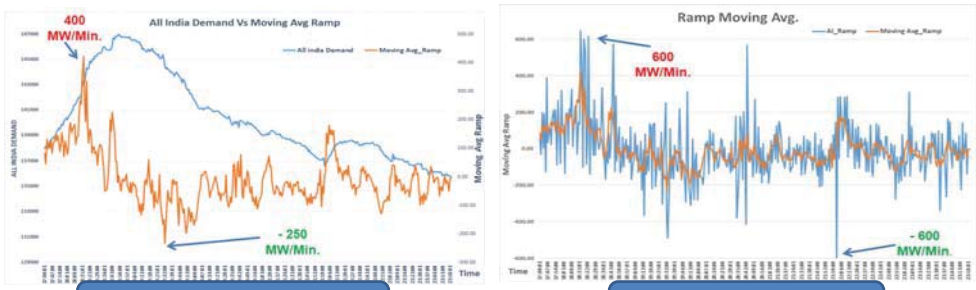
- Load varying every moment
- Renewables – Increased level of variability and uncertainty
- Faster markets allow manoeuvring capability of the conventional generation to respond
- Better alignment with the timescale of variability of RE resources.
  - 16 revisions allowed in CERC RE Framework
- Lowering of Overall System Operating Costs
  - Short dispatch intervals allow more frequent re-dispatch of the whole systems, enabling deviations to be dealt with by adjustment of every market participant in the system as appropriate.

Variability in Different Time Periods

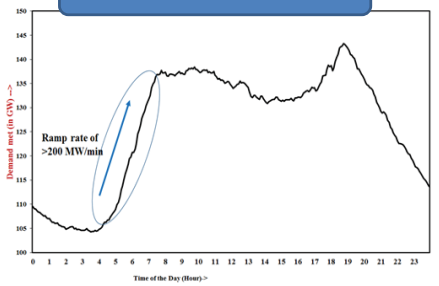


Source: CIGRE Technical Brochure 293 - **Electric Power System Planning with the Uncertainty of Wind Generation**

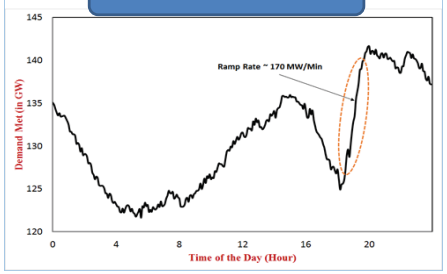
Ramping Requirements



Typical Winter Day (2016)



Typical Summer Day (2017)



Policy / Regulatory Mandate

- Report of the Expert Group on 175 GW by 2022, NITI Aayog (December, 2015)

Interventions to reduce overall system costs [Section 3.23(ii)]

".....Scheduling and Dispatch: Through both practice and theory, it has become evident that grids that are operated in a manner where scheduling and dispatch are implemented over short time durations (e.g., as low as five minutes) have significantly lower overall costs to consumers as the need for ancillary resources decreases....."

- CERC order in Petition No. SM/127/2011 (24 May 2011)

".....Thereafter matter was discussed in the Central Advisory Committee (CAC) meeting held on 29th September, 2010 with the agenda "How to make power markets more efficient". The CAC recommended for modification in the bidding time block from one hour to fifteen minutes....."

- SAMAST Report, Technical Committee of the Forum of Regulators, 2016

"5.6.....The States who are about to implement the intrastate accounting and settlement system could leapfrog and go for scheduling and settlement at 5-min interval. The scheduling software and the energy meters specifications could in line with the above. All the other States and the Regional Pools shall also endeavor to have systems and logistics for 5-min scheduling and settlement system...."

International Experience (1)

- Australia Energy Market Operator (AEMO)
  - "Scheduling and Despatch" decoupled with "Settlement" from 1998, prior to large scale RE integration
    - Scheduling and despatch at 5-minute interval
    - Settlement at 30 minute interval using average of 5-minute prices in that interval
  - 2016: Debate/Stake holder consultations being held to align "scheduling & despatch" interval and the "settlement" interval
- USA

RTO / ISO	Despatch Interval	Settlement Interval
CAISO	5-minute	5-minute
ISO - NE	5-minute	Hourly average
MISO	5-minute	Hourly average
NYISO	5-minute	5-minute
PJM	5-minute	Hourly average
SPP	5-minute	5-minute

FERC Final Rule on "Settlement Intervals and Shortage Pricing in Markets Operated by Regional Transmission Organizations and Independent System Operators", 16th June 2016

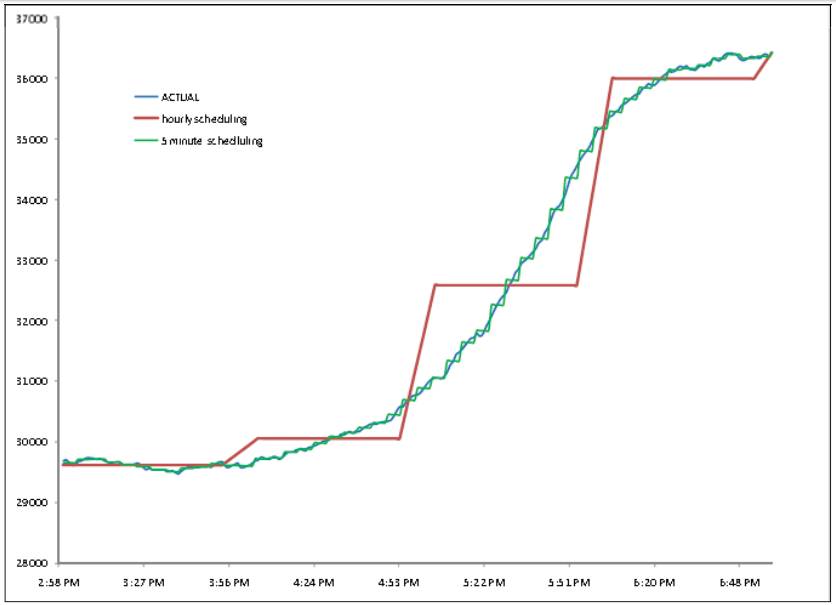
".....We require that each regional transmission organization and independent system operator align settlement and dispatch intervals by:

(1) settling energy transactions in its real-time markets at the same time interval it dispatches energy;

(2) settling operating reserves transactions in its real-time markets at the same time interval it prices operating reserves; and

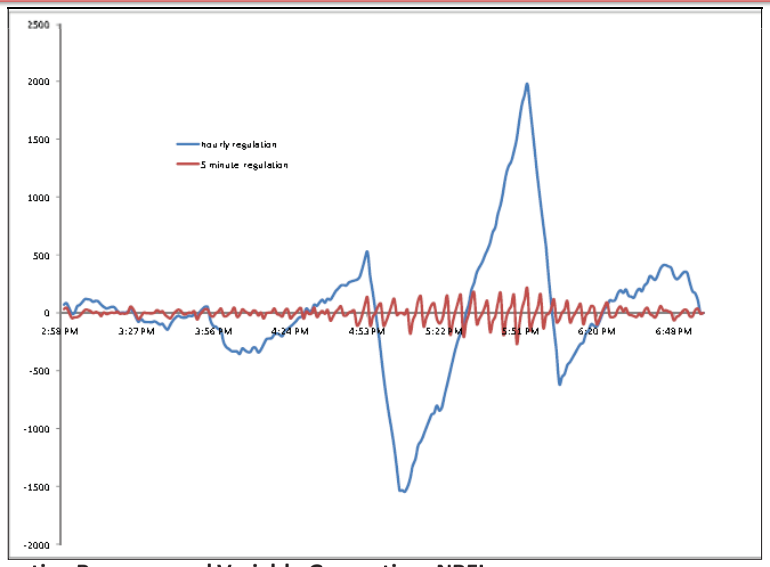
(3) settling intertie transactions in the same time interval it schedules intertie transactions....."

5-minute Scheduling vs. Hourly Scheduling



Source: Operating Reserves and Variable Generation, NREL
http://www.consultkirby.com/files/NREL-TP-5500-51978_Operating_Reserves_and_Variable_Generation.pdf

Regulating Reserve Needs for 5-minute scheduling vs. hourly scheduling



Source: Operating Reserves and Variable Generation, NREL
http://www.consultkirby.com/files/NREL-TP-5500-51978_Operating_Reserves_and_Variable_Generation.pdf

Discussion Points

- Forecasting
- Scheduling & Despatch
- Markets : 5-minute bilateral markets; Power Exchanges – 5 minute price discovery
- Deviation Settlement 5-minute prices in DSM
- Commercial interface metering
- Settlement system – energy accounting, financial settlement
- Changes in various CERC/SERC Regulations
- Gate closure provisions
- Changes in CEA Metering Standards
- Replacement of meters
- Software upgrade at the RLDCs/SLDCs – scheduling, meter data processing, accounting, settlement
- Software upgrade at the RPCs
- Holding workshops, dissemination, stakeholder capacity building

References

- AEMC, Five Minute Settlement, directions paper, 11 April 2017, Sydney http://www.aemc.gov.au/getattachment/fa4b80a5-e212-48a0-98dc-7478a370ab72/Directions-paper.aspx
- The Future of Wholesale Electricity Market Design, Brattle Group, http://www.brattle.com/system/publications/pdfs/000/005/359/original/The_Future_of_Wholesale_Electricity_Market_Design.pdf?1475081019
- Melbourne Energy Institute Submission to the AEMC Five Minute Settlement consultation paper, Jun'16 http://www.aemc.gov.au/getattachment/1d460acc-dbe2-45ea-bb4e-1903161d90f1/Melbourne-Energy-Institute.aspx
- IEA Report Re-powering Markets: Market design and regulation during transition to low-carbon power https://www.iea.org/publications/freepublications/publication/REPOWERINGMARKETS.PDF
- Grid Flexibility: Methods for Modernizing the Power Grid, Sonia Aggarwal and Robbie Orvis, March 2016 http://energyinnovation.org/wp-content/uploads/2016/05/Grid-Flexibility-report.pdf
- Big, Fast, and Flexible: Grid Operations for Efficient Renewable Integration, Michael Milligan, NREL https://cleanenergysolutions.org/sites/default/files/documents/big-fast-flexible-webinar-final-10oct2016.pdf
- CE Delft and Microeconomix (2016): Refining Short-Term Electricity Markets to Enhance Flexibility. Study on behalf of Agora Energiewende https://www.agora-energiewende.de/fileadmin/Projekte/2015/Penta_EOM/Agora_Penta_Refined_ST_Markets_and_Flexibility.pdf
- US DoE Solar Energy Technologies Program - The Role of Electricity Markets and Market Design in Integrating Solar Generation https://dx.doi.org/10.2172/1013270

Ball Started Rolling…
WRPC Communication to CEA

To,
Chief Engineer (DP & D),
Central Electricity Authority,
Sewa Bhavan,
R.K.Puram, New Delhi

Date: 27.04.2017

Sub: Proposed amendment in the CEA (Installation & Operation of Meters) Regulations 2006-reg.

Sir,

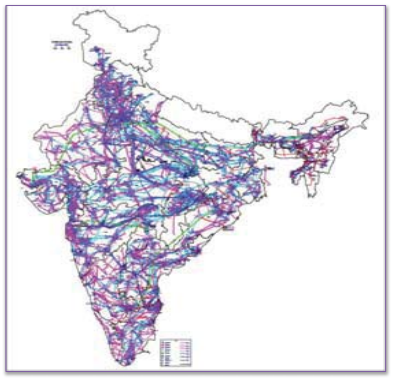
This is to inform that in the 33rd WRPC meeting held on 01.02.2017, it was decided to replace all the existing interface SEMs (Special Energy Meters) installed in Western Region, since most of the SEMs have crossed their useful life cycle(copy enclosed).

In anticipation of the Regulatory and technological changes, it was further decided to procure the SEMs capable of recording/storing of 5 mins as well as 15 mins block data of Frequency, Wh & VArh(low & high) along with suitability for transmitting the data to remote locations using appropriate communication medium (AMR). This will enable accommodation of any future regulatory requirement/change, such as change in "energy scheduling / recording block timings", in the SEMs being procured in WR.

It is therefore proposed to kindly amend clause (1) (b) (i), (ii), (iii) & (iv) of "Part II Standards for Interface meters" of the CEA (Installation and Operation of meters) Regulations 2006 notified on 17.03.2006, to accommodate the above provisions regarding integration/storage of data (i.e. interface meters capable of recording 5mins as well as 15mins block data of frequency, Wh & VArh (low & high)).

Yours faithfully,

Let's Ideate



Annex - 3

Implementation of 5- Minute Scheduling, Metering, Accounting and settlement

REFERENCE: BACK GROUND NOTES
First Meeting Of Sub-Group Under "FOR" Technical Committee

11.a Forecasting (Both Load and Renewables)

SUB GROUP	ISSUES	REMEDIES TO THE ISSUES
LOAD	Load Forecast accuracy varies from 3 % to 10 %	To mitigate accuracy of forecast additional resources shall be metered to minimise Deviation in 5 minute Block
	Ag group schedule are phased out Hourly/half hourly	1) More number of Ag Groups are to be made 2) Small MW quantum Grp to mitigate load deviation in 5 min.
RENEWABLES	All Renewables are not telemetered	All Renewables shall be telemetered (supported by regulation/grid code)

11.b Scheduling & Despatch

SUB GROUP	ISSUES	REMEDIES TO THE ISSUES
RLDC	Pick up/Back down are being advised by RLDC to holding company. Sometimes such frequent revisions to maintain deviation limit in 5 min block leads to wrong/un technical system operation	Revised instructions are sent through RLDC to holding company, hence technical effect of ,decision taken by RLDC, may take more than 5 minutes (over the block size proposed).
GENCO	GENCO required to ramp up/down as per instructions of RLDC/SLDC	1) Frequent up/down may also lead to frequent variation of threshold variable cost generated and it will damage the Machine, hence opinion of GENCO is mandatory. 2) effect of revision in schedule may be on 12/18th block with small Ramp

11.d Deviation settlement 5-minute prices in DSM

SUB GROUP	ISSUES	REMEDIES TO THE ISSUES
Gaming	Provisions for Gaming is for Over injection only	Provision shall be made for Under injection also in Regulation

11.e Commercial interface metering

SUB GROUP	ISSUES	REMEDIES TO THE ISSUES
ABT meter Specification	1) Daily Reactive Energy Measurement not Possible in existing ABT meter	1) .NPC file (Coded file) shall be record cumulitive Import/Export Reactive/Active Energy over & aove High-Low Voltage Reactive Energy Recording. 2) All data shall be having accuracy up to 2 decimal.
	2) Some of the meters are capable of recording 10 days of history	2) The interface-meter shall be capable to record 30 days of data & DCU shall be capable of recording 90 days of data.
	3) No provision for PT Fail Alert OR CT Unbalance	PT Failure Alert in form of Designated e-mail/Mobile SMS shall be made available. CT Unbalance more than 5 %, ALERT in form of e-mail/Mobile SMS shall be made available
	4) At present All ABT meters are self powered hence no access possible when PT supply is OFF	4) All ABT Meters are auxiliary powered, hence they shall be accessible all the time, including AMR communication (Live Zero measurement should be possible)
	5) Time drift permissible is +/- 2 min/year (IS 14697: 1999)	5) Time drift shall be made narrow to +/- 1 min/year
	6) ABT Meter Data out put is not competible to integrate to SCADA	6) ABT meter shall compatible for SCADA integration, which can be used for State Estimation.
General	Consumers are not having access of Metered energy of ABT meter Data	At consumer/Pool member end, meter raw data shall be accessible, up to last Block recorded energy. Local Display shall be made available for local End User of SEM meter Data.

11.f Settlement system - energy accounting, financial settlement

SUB GROUP	ISSUES	REMEDIES TO THE ISSUES
Energy accounting	Existing Meters are non compatible for 5 min time block recording	1) The Old meters are to be kept in series with New meters till all the interface meters are provided with new meters 2) new meters shall be able to give data in 5 min new coded format and as per old meters present coded format in view of intrastate DSM accounts publishing. 2) Further file extension should be self explanatory to discriminate that file is for 5 min / 15 min energy
	Reactive Energy Accounting is High/Low Volatage measurement i.e. outside 97% to 103%	There should be Programmable/configurable reactive power measurement limit on both side i.e. 97% & 103% to mitigate change of Regulation in future.

11.i Changes in CEA Metering Standards

SUB GROUP	ISSUES	REMEDIES TO THE ISSUES
Meter	Existing Meters are only give 15 min data	1) The Meter/Software should be capable to convert .MRI/.MRD/.DAT files in to .NPC file and there should be provision for selection of 5 Min conversion and 15 min conversion in to existing .NPC format.
	Meter Protocol are monopolised by Meter Vendors	Meter Data shall be on common protocol for AMR implementation

11.j Replacement of meters

SUB GROUP	ISSUES	REMEDIES TO THE ISSUES
CTU/STU	All meters are required to replace	PSDF fund support shall be extended for funding. Meters are required to replace in Phase manners considering Man-Material availability including Testing of meters in NABL lab. STU required to be involved.

11.K Software upgrade at the RLDCs/SLDCs

SUB GROUP	ISSUES	REMEDIES TO THE ISSUES
Scheduling	Software process only 15 min. Data	Software shall be upgraded to process 15 min data and 5 min data on selective basis for Interstate and Intrastate pool account separately
Meter Data Processing		
Accounting		
Settlement	At present Data are hendeled for 15 min average	Additional resources for H/W and Software required to handle 300% data in the same time. Also storage enhancement is required. Additional burden shall also be supported through PSDF fund

11.i Software upgrade at Control centres

SUB GROUP	ISSUES	REMEDIES TO THE ISSUES
RPCs/ RLDCs	Revisions in Software take more time , sometimes of the order of an hour	Software shall be capable to issue any revisions in less than 1 minute to adhere to sensitivity of issueing Revisions (higher resources and logic is required to apply)
SLDCs	Existing Intrastate ABT Software is not compatible to provide 05 min Data	1) Existing Software (M/S Infosys - EASS) Required to upgrade the Software. (Scheduling, MDM, Energy Accounting, settlement)

11.m Holding Workshops, dissemination, stakeholder capacity building

SUB GROUP	ISSUES	REMEDIES TO THE ISSUES
RPCs/ RLDCs/ SLDC	Holding Workshops, dissemination, stakeholder capacity building is required to be arranged	RPC/RLDC/SLDC officials shall be involved in various activity such as Meter's SAT/FAT. Various expert sub-Committee shall be formed for various Group activity & implementation thereof.

Annex - 4

List of Attendees

First Meeting of the FOR Sub-Group on Five Minute Despatch & Settlement on 03rd August, 2017 at NLDC, Delhi

S.No.	Name	Designation	Organization	E-mail Address	Contact No.	Signature
1.	U.K.VERMA	GM(J/C)	NLDC	ukverma@posoco.in	8902486220	
2.	P K MISHRA	MS, ~~NERPC~~	NERPC	ms-nerpc@gov.in	9436591068	
3.	PARDEEP JINDAL	CE (NPC)	CEA	jindl_pardeep@yahoo.co.in	9818768460	
4.	D. K. Srivastava	Dir, NPC	CEA	dhirajcea@gmail.com	9560763305	
5.	S. S. BARPANDA	AGM, NLDC	POSOCO	ssbarpanda@posoco.in	9717296928	
6.	DILIP ROZEKAR	AGM, NLDC	CTU	drozekar@powergrid india.com	9910378106	
7.	S R NARASIMHAN	AGM, NLDC, POSOCO	POSOCO	srnarasimhan@posoco.in	9971117022	
8.	SHYAM SUNDER GOYAL	Sr. Engr. CTU	CTU	shyam.goyal@powergridindia.com	9911708044	
9.	G. Chakraborty	DGM, NLDC, POSOCO	POSOCO	gchakraborty@posoco.in	9433041815	
10.	Kaushik Dey	MANAGER, NLDC, POSOCO	POSOCO	Kaushikdey@posoco.in	9999883622	
11.	T. NIRMALA MARY	EE/Open Access/ SLDC Tamil Nadu	TANTRANSCO	eeoa@tnebnet.org	9445857182	
12.	A THANGAPPAN	EE/REMC/SLDC/ Tamil Nadu	TANTRANSCO	eegremc@tnebnet.org	9442491143	
13.	SC SAXENA	DGM (MO)	NLDC, POSOCO	scsaxena@posoco.in	9910059972	
14.	KVN PAWAN KUMAR	Dy. Mgr. (NLDC)	NLDC, POSOCO	kvnpawankumar@posoco.in	9717924482	

S.No.	Name	Designation	Organization	E-mail Address	Contact No.	Signature
15.	RATNESH KR	Executive Engineer	NRPC	ratnesh.cea@gmail.com	9811101805	
16.	ANIL	EE	SRPC	anil.thomas@gov.in	9447106041	
17.	J. K. RATHOD	SE, WRPC	WRPC	jkrathod77@yahoo.com	9879110999	
18.	Upendra Kumar	SE NRPC	NRPC	upendra0309@gmail.com	9910180485	
19.	B B Mehta	CE	SLDC Guj	bbm@gebmail.com	9879200736	
20.	M.A.K.P SINGH	MEMBER SECY	NRPC	makpsingh@yahoo.co	9425066437	
21.	S.R.SOONEE	Advisor	POSOCO	srsoonee@posoco.in	9899091115	
22.	K.V.S.BABA	CEO	POSOCO	kvsbaba@posoco.in	8527607575	
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FOR Sub-Group for "Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement"
02nd Meeting - Gist of Discussions

Meeting Details				
Date		28th August, 2017	**Venue**	National Load Despatch Centre, POSOCO, Delhi
Day		Thursday		
Time	Open	11.00 AM		
	Close	01.30 PM		
Subject		**Second Meeting of Sub-Group for "Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement" under FOR Technical Committee for Implementation of Framework on Renewables at the State Level**		

Deliberations

A. CEO, POSOCO welcomed the participants to the meeting. In the first meeting, the need for interaction with different stakeholders responsible for implementation of 5-Minute Scheduling and Settlement was highlighted. In that direction, major meter manufacturers have been invited to apprise the sub-group regarding views/suggestions for the proposed migration to 5 minute scheduling, metering and accounting. Advisor, POSOCO mentioned that there is need for technical understanding on the philosophical and fundamental aspects of faster markets by all the stakeholders.

B. A presentation was made by POSOCO (Annex – I) regarding action points identified in the first meeting, required interventions and modifications in metering standards and relevant regulations. Some of the features which are required were highlighted as follows:

- **i.** Record frequency data at 0.01 Hz resolution
- **ii.** Net VARh and voltage to be recorded for each time block.
- **iii.** Auxiliary Supply - SEM may normally be capable of operating with power drawn from the VT secondary circuits.
- **iv.** Provision to operate on control power supply to the SEM from 110V DC / 220V DC.
- **v.** Built-in calendar and clock
- **vi.** Secured software based solution for meter time correction and synchronization with GPS
- **vii.** DLMS compliant for SEM communication protocol – Indian COSEM standard
- **viii.** Data security ensured as per IEC-62056-51 standard
- **ix.** Automated Meter Reading (AMR)
- **x.** Uniform protocol for communication for meters of different vendors.
- **xi.** Optical coupling cable should be compatible with all types of meters.
- **xii.** Replacement of defective meters within a stipulated time frame

C. Three meter manufacturers viz. M/s Secure Meters, M/s Elster-Honeywell and M/s L&T were invited by the sub-group for discussions on the proposed features in the 5-Minute capable interface meters (but not limited to):

- **i.** Non-volatile memory, Automatic storage
- **ii.** Net Wh transmittal during each successive 5 min block (up to 2 decimal)
- **iii.** Cumulative Wh transmittal at each midnight, in eight digits (one decimal)
- **iv.** Net VARh transmittal during each successive 5 min block (up to 2 decimal)
- **v.** Cumulative VARh transmittal at each midnight in eight digits (one decimal)
- **vi.** High VARh when Voltage above 103 % of Vref
- **vii.** Low VARh when Voltage is below 97% of Vref
- **viii.** Average frequency (5 min) in Hertz (up to 2 decimal, truncation) for each 5 minute time-block
- **ix.** Date and time blocks of failure of VT supply on any phase (as a star (*)/ (Z) mark)
- **x.** Voltage (V) (up to 2 decimal, truncation) for each 5 minute time-block
- **xi.** Meters shall store data in memory for 15 days

FOR Sub-Group for "Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement"
02nd Meeting - Gist of Discussions

D. CE, SLDC-Gujarat mentioned that there is need for consultations with generators and DISCOMs. It was highlighted that there is need for discussion on 5 minute scheduling and settlement as a separate agenda item in each of the RPC forums. Sh. Pardeep Jindal, CE, NPC-CEA proposed that discussion may also be taken up as a separate agenda item in the forthcoming NPC meeting at Indore in first week of September, 2017.

E. Tamil Nadu representative informed the sub-group that installation of ABT compliant meters is under progress in the state. These meters are 15-minute capable meters and 85 % of the wind generators, 100 % of solar generators and 66 % of other generators have been covered till date under new intra-state metering system. As requested by the sub-group in the first meeting, Tamil Nadu comunicated with meter vendors to discuss the possibility of firmware reconfiguration for transition to 5 minute arrangement. It was informed that only one meter vendor responded that it is possible to migrate to 5 – minute metering in the new generation meters.

F. The sub-group and meter manufacturers had detailed discussions on following aspects:

i. Capability of existing Special Energy Meters (SEM) (15 min, ABT meters) to migrate to 5-minute metering through minimal changes

M/s Secure Meters representative mentioned that the proposed features in the 5-Minute capable interface meters may be implementable in the future generation of meters. It was mentioned that there may be difficulties in implementation in the earlier generation of meters whch have features tightly linked to hardware to make them tamper-proof.

MS, WRPC queried regarding the need for replacement of entire existing fleet of meters when only change in memory is required with no change in number of ports and other inputs. He further added that change in the software/firmware embedded in the chip/electronics of the meters are easily configurable as the inputs to the meters are same and only fetching of data is being made faster. SLDC-Gujarat representative highlighted that the present meter infrastructure stores 96 readings per day upto 10 days which amounts to 960 readings. He emphasized that with 5 minute readings, the same meter can store the data but for lesser number of days say, 3 days. It was mentioned that only periodicity of meter recording accumulation is being made smaller. It was also recognized that the replacement of thousands of meters entails shutdown of transmisison infrastructure which would impact the power system operation in the country.

M/s Secure Meters representative mentioned that the change in the software program of meter can be done. However, change in firmware would require change in hardware. As there are different versions and models of meters installed across India, it was noted that M/s Secure Meters representative would verify and confirm the feasibiity and compatibility of migration in the existing metering infrastructure.

M/s Elster-Honeywell representative stated that there is no issue in new generation of meters. M/s Elster-Honeywell representative stated that 5 minute arrangements can be implemented within the existing parameters. However, implementation of additional parameters needs to be checked up with their technical teams. It was noted that M/s Elster-Honeywell representative would verify and confirm the feasibiity and compatibility of migration in the existing metering infrastructure.

SLDC-Gujarat representative highlighted that there is change only in buffer update time and 1/3 rd retention period. M/s L&T representative mentioned that the change in memory and logic would be discussed with their technical team and would give information to the sub-group.

Adviser, POSOCO highlighted that the vintage checkup of feasibility and compatibility may be done by technical experts from RPCs/RLDCs/Meter maufacturers in a separate forum.

ii. Parallel transition to 5 minute arrangements in addition to existing 15 minute

NLDC representative enquired about the possibility of parallel transition to 5 minute arrangements in addition to existing 15 minute.

M/s Secure Meters representative responded that configuration change can be handled within the existing framework. Data accumulation at 5 minute and accounting at 15 minute can be thought of in the transition phase.

M/s Elster-Honeywell representative agreed that proposed features can be incorporated in the next generation of meters. However, additional features and customized requirements have to be deliberated with their technical teams. M/s Elster-Honeywell representative stated that 5 minute arrangements can be implemented within the existing parameters through optical port on-site in a configuration change which may take upto maximum of ½ hour. .

M/s L&T representative mentioned that for the implementation of 5 minute arrangements, in case of firmware change also, the meters have to be taken off-site to factory because of the harware lock in the meter and caliberation of the meter.

iii. Live Testing & Demonstration of 5-Minute capability in exisiting meters

Member Secretary-NRPC proposed that meter manufacturers may demonstrate the implementation of 5 minute arrangements in exisiting models/version of meters. It was decided by the sub-group that the meter manufacturers may conduct the demonstration of 5 minute arrangements at one of the identified ISTS susbtations/meter vendor facilities. SLDC-Gujarat representative volunteered to coordinate for having the demonstration carried out at the testing facility of POWERGRID/meter vendors. CTU representative was requested to coordinate and confirm the demonstration.

iv. Meter time correction and synchronization with GPS

M/s Elster-Honeywell representative mentioned that software based solution for meter time correction and synchronization with GPS is not supported in existing generation of meters as 1 second pulse needs additional hardware. The time synchronization signal is being done through master station through communication protocol. It was noted that, at present, time drift of 1 minute is spread over 6 time blocks.

Adviser, POSOCO enquired about the design and experiential aspects for time drift issue during transition to 5 minute arrangements. He further called upon the meter manufacturers to dwell upon the metrology philosophy and domain expertise so as to incorporate best features keeping future requirements in mind with smooth and sustainable transition to 5 minute arrangements. NRLDC mentioned that there are regulatory requirements governing the time drift range. NLDC queried whether bulk time correction is possible in a single shot. M/s Secure Meters representative mentioned that there are bandwidth issues for synchronizing from central system.

Tamil Nadu representative also queried regarding time synchronization facility at meter end or AMR end. Adviser, POSOCO mentioned that time synchronization should be done only at meter end and not in a centralized manner. It was noted that there are latency issues in time synchronization from a central station in view of data security and communication. It was pointed that there are GPS and Antenna maintenance issues also at the individual meter level. SLDC-Gujarat representative also highlighted that GPS time synchronization facility should be at sub-station level or DCD end. CE, NPC-CEA mentioned that in the sub-stations, especially at generation sites where there are number of voltage levels, GPS at sub-station level would be optimal.

NLDC also queried on battery life of present meters. M/s Elster-Honeywell representative mentioned that it was in the order of 10 + years and upto 15 years.

v. Security Considerations and need for re-calibration for Transition to 5 Minute Arrangements

Member Secretary, NRPC enquired about the security of the meters for implementation of 5 minute arrangements. M/s Elster-Honeywell representative mentioned that there are 3 levels of security with passwords. Also, any configuration change is done by their company representative only. The load profile would be set to zero on transition to proposed arrangements.

Member Secretary, NRPC enquired about calibration of the meters after implementation of 5 minute arrangements. Member Secretary, WRPC mentioned that as existing fleet of meters are majorly electronic & static in nature with no transducers, the re-calibration may not be required.

Adviser, POSOCO highlighted that the focus of sub-group is on handling the transition from 15-minute to 5-minute and meter specificaitons in detail would be looked at by a separate set of experts. The main motive is to have granular scheduling and settlement so as to introduce various market products as well as facilitate renewable integration.

M/s Elster-Honeywell representative informed the sub-group that transition to static meters was done in late 90s especially on LT metering side. Now, the transition is being done from non-smart to smart metering.

Adviser, POSOCO cautioned that in order to have more flexibility & value addition in terms of data analysis, it is better to do the data process through software after extracting the data from the meter. Member Secretary, NRPC also highlighted the issue of PT supply failure and need for check meter arrangements.

vi. International Experience

On being queried about international experience, both M/s Secure Meters representative and M/s Elster-Honeywell representative mentioned that they will provide the relevant information for countries to which they have supplied meters.

vii. Impact on Storage capability on transition to 5 minute arrangements

Member Secretary, NRPC raised the issued of decreased storage capability and its impact on accounting & settlement cycle. M/s Elster-Honeywell representative mentioned that only after live demonstration and testing only, they will be able to gauge the exact amount of decrease in the memory storage capability of the exisitng meters when transition to 5 minute arragement takes place.

viii. Interoperability and common communication protocol

On being queried regarding interoperability issues by SLDC-Gujarat representative, both M/s Secure Meters representative and M/s Elster-Honeywell representative informed that all the new generation of meters are DLMS compliant with common communication protocol.

ix. Change in NPC coded file structure

M/s Elster-Honeywell representative mentioned that the proposed 5 minute arragements would require a change in NPC coded file structure. SLDC-Gujarat representative pointed out that NPC coded file is essential for meter data security. NRLDC proposed that a separate expert group may discuss on the NPC coded file format and other technical issues in detail.

x. CTU Activities for transition to 5 minute arrangements

The process and timelines for handling transition from 15-minute and 5-minute needs to be communicated by CTU to the sub-group in the next meeting. CTU representive informed that they would coordinate with metering testing facility at Vadodara and faciltate live demonstration of 5 minute arrangements by meter vendors within 2 weeks.

xi. Suggestions by NPC-CEA

CE, NPC-CEA had circulated the suggestions to the sub-group members. The sub-group recognized that achieving FGMO and AGC become essential for moving to lesser time interval. Also, better load and RE forecasting tools within stipulated accuracy ranges are necessary to achieve optimal system operation. The sub-group recognized the need for a multi-pronged approach with actions in all possible areas so as to improve the overall system operation. A copy of the inputs is attached at Annex – II.

CE, NPC-CEA also highlighted that other stakeholders views may also be taken so that holistic feedback of all stakeholders viewpoints may be incorporated.

The sub-group agreed that a draft interim report will be prepared by first week of October, 2017 for deliberation in the sub-group.

Key Decisions Taken

- Stakeholder views/suggestions to be taken in next meeting
- All RPCs may discuss the 5-minute scheduling and settlement in a more focused manner
- Meter manufacturers to demonstrate the implementation of 5 minute arrangements in existing models/version of meters within two weeks. CTU to coordinate for meter testing and live demonstration with meter vendors at Vadodara testing facility. Gujarat-SLDC requested to provide support in this demonstration.
- Meter vendors to verify and confirm the feasibility and compatibility of migration to 5 minute arrangements in the existing metering infrastructure
- Meter vendors to give information on international experience
- A separate expert group may be constituted to discuss changes in the NPC coded file format.
- A draft interim report will be prepared by first week of October, 2017
- Next meeting inviting the stakeholders to be held in the week starting 11th September, 2017.

Annex – III: List of Attendees

Annex - 1

FOR Sub-Group
for
"Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement"

Second Meeting

POSOCO-NLDC, New Delhi
28 August 2017

Outline

- Action Points - First Meeting of the Sub-Group
- Required Regulatory Interventions
- Interaction with Meter Manufacturers – Discussion Points
- NPC Inputs
- Next Step Forward - Action Points

Action Points - First Meeting of the Sub-Group

- Stakeholders views/suggestions to be taken in next series of meetings
  - Meter Manufacturers invited
- All RPCs may discuss the 5-minute scheduling and settlement as an agenda item
  - WRPC and NRPC already deliberated
  - Other RPCs may like to update
- Co-opt representative from CEA and CERC
  - Communications sent; Nominations awaited

Required Regulatory Interventions

- Change in clauses pertaining to Time-Block, Scheduling & Despatch, Metering, Accounting & Settlement
- CERC Regulations
  - Indian Electricity Grid Code
  - Deviation Settlement Mechanism
  - Open Access in inter-State Transmission
  - Ancillary Services Operations
- CEA Regulations (Installation and Operation Meters) Regulations 2006
  - Meter specifications
  - Changes in Standards referred in the Regulations

Modifications in Metering Regulations

- Record frequency data at 0.01 Hz resolution
- Net VARh and voltage to be recorded for each time block.
- Auxiliary Supply - SEM may normally be capable of operating with power drawn from the VT secondary circuits.
- Provision to operate on control power supply to the SEM from 110V DC / 220V DC.
- Built-in calendar and clock
- Secured software based solution for meter time correction and synchronization with GPS
- DLMS compliant for SEM communication protocol – Indian COSEM standard
- Data security ensured as per IEC-62056-51 standard
- Automated Meter Reading (AMR)
- Uniform protocol for communication for meters of different vendors.
- Optical coupling cable should be compatible with all types of meters.
- Replacement of defective meters within a stipulated time frame

Interaction with Meter Manufacturers – Discussion Points (1)

Features in the 5-Minute capable interface meters (but not limited to):

- Non-volatile memory, Automatic storage
- Net Wh transmittal during each successive 5 min block (up to 2 decimal)
- Cumulative Wh transmittal at each midnight, in eight digits (one decimal)
- Net VARh transmittal during each successive 5 min block (up to 2 decimal)
- Cumulative VARh transmittal at each midnight in eight digits (one decimal)
- High VARh when Voltage above 103 % of Vref
- Low VARh when Voltage is below 97% of Vref
- Average frequency (5 min) in Hertz (up to 2 decimal, truncation)
- Date and time blocks of failure of VT supply on any phase
  - as a star (*)/ (Z) mark.
- Voltage (V) (up to 2 decimal, truncation)
- Meters shall store data in memory for 15 days

Interaction with Meter Manufacturers – Discussion Points (2)

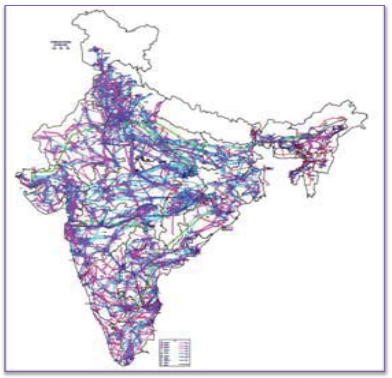
- Capability of existing Special Energy Meters (SEM) (15 min, ABT meters) regarding the ability to migrate to 5-minute metering through minimal changes
  - Whether there is any hardware/firmware/software upgrade solution
  - Which genre of meters are capable of this upgrade
  - SAMAST is in different stages of implementation
- Readiness in respect of availability of new 5-minute capable meters
- Interface with Metering software at the RLDCs
  - Is it possible to record at 5-minutes and convert to 15-minutes
  - Compatibility with existing software at the RLDCs/RPCs
- Any practical experience elsewhere / in other deployments
- Timelines
- Cost estimates

Presentation by Meter Manufacturers

Next Step Forward - Action Points

- CTU Activities
  - Handling Transition
  - Upgrades of existing metes
  - Procurement to implementation of new meters, Process, Timelines
- Suggested changes in the Regulations in track mode to be included
- Identify Changes in Software at RPCs/RLDCs/NLDC
- Draft Interim Report to be presented in the Third meeting of Sub-Group (say First week of October, 2017)

Let's Ideate



Reference

- CEA (Installation & Operation of Meters) Regulations 2006 available at
- http://www.cea.nic.in/meteringreg.html
- Functional Requirement of AMI – CEA report available at
- http://www.cea.nic.in/reports/others/god/dpd/ami_func_req.pdf
- CERC Regulations on IEGC, DSM, Congestion Alleviation, Ancillary Services, Sharing of Transmission Charges as available at http://www.cercind.gov.in/updated_consolidated_reg1.html
- Report on Scheduling, Accounting, Metering and Settlement of Transactions in Electricity "SAMAST", http://www.forumofregulators.gov.in/Data/WhatsNew/SAMAST.pdf

Thank You

Annex - 2

First Meeting of Sub Group for "Implementation of 5-minute scheduling, metering, accounting and settlement held on 3rd August, 2017 at NLDC, POSOCO.

Discussion on item no. 1 of TOR i.e. "Look at pros and cons of moving to 5-minute scheduling, metering, accounting and settlement".

1. The presentation made by POSOCO highlighted the benefits that are expected to be achieved by moving from 15-minute regime to 5-minute scheduling, accounting regime. It was informed that moving to 5-minute schedule regime would mainly provide benefit of (i) better frequency control and (ii) reduction in regulating reserves. It was also informed that some parts of USA grid/electricity market and Australia have 5-minute interval for scheduling.

2. In this regard, CE(NPC), CEA provided made following inputs:

   (i) Generally, moving from 15-minute to 5-minte should help in better frequency control, however, this would be a fictitious benefit in the absence of sufficient primary and secondary controls (i.e. Governor response, and AGC). And thus, achieving FGMO and AGC become essential for moving to lesser time interval.

   (ii) The USA and Australia grids, which have 5-minute scheduling interval, already have good primary reserves and a working AGC. And so is the case is in many of the European countries/grids (e.g. Spain, Germany, Denmark etc which even have significant percentage of RE generation). These European countries have well developed electricity market and still do not have 5-minute scheduling interval. But they do have good load and RE forecasts.

   (iii) So, to achieve the stated benefits of shorter scheduling interval, what we need is the following:

      (a) Sufficient Primary control through FGMO, as also directed by CERC vide order dated 31-July-2017 under Petition 84/MP/2015.

      (b) Implementation of AGC in Indian grid as early as possible. CERC has already directed for this in its order in Petition No. 11/SM/2015 dated 13.10.2015.

      (c) Each State/utility need to forecast its load (and ISTS withdrawal) with higher accuracy. We need to fix a desired value of percentage error (between scheduled and actual demand) that must be achieved, otherwise we would unnecessary be keeping large quantum of spinning reserves. And same is the case for wind and solar generation forecasts.

      (d) It is a recognized fact that forecasts are more accurate as we move closer to

the event, i.e. the accuracy of forecast is higher during day of operation (say 2-3 hours before the real time) as compared to day-ahead and even much better as compared to 2-3 days ahead when gates are closed for short-term-market. And therefore, unless we achieve a desired value of forecast errors, moving to 5-minute scheduling would be ineffective and unfruitful.

(e) Regarding Pros and Cons, we need to analyse/simulate at least past one year data to determine the benefits, in terms of savings and improvement in frequency, if there were 5-minute interval instead of 15-minute. Also, the cost of implementation of 5-minutes interval should also be assessed.

(f) This sub-group should also invite DISCOMs and Generators, who are key stake holder in this change, for the purpose of identifying activities, infrastructure, readiness etc.

3. The Grid Standards/Regulations need to at least specify – (i) permissible frequency deviation both in terms of percentage and duration, (ii) time-lines for deployment and release of Primary, Secondary and Tertiary controls. A few examples of rules of deployment of primary and secondary controls in some countries are given in Annexure. The rules of AGC time-lines and 5-minutes scheduling would need to be co-adjusted.

   It has been seen that presently, ancillary services are many a times used much in advance against stated 16 minutes and are being used for longer duration and for maintaining Load Generation balance at Regional level.

4. From above discussion, especially from the fact that forecast errors are lesser as we move closer to real-time market/operation, it emerges that the advantages of 5-minute would be seen only as markets move closer to real time. For example, the efficiency gains of implementing a 5-minute product in a day-ahead market are less significant than if the same product is implemented in an intraday market. In fact, the five-minute product could even be detrimental in the day-ahead market if it overly complicates bidding and clearing processes.

Other Inputs for discussion:

5. Re-scheduling of resources in shorter time frame would reduce the cost of operation for the DISCOMS provided they have ample flexibility to reschedule their portfolios. Short Term Markets are rigid with no opportunity for rescheduling collective transaction and also more than 48 Hours for Short term revision. Thus, presently, limited opportunity (Only under LTA & MTOA) to DISCOMs to take the advantage of 5- Minutes scheduling for re-scheduling. Under the existing regulation Short-term Market would be deprived with the advantage of 5- Minutes Scheduling.

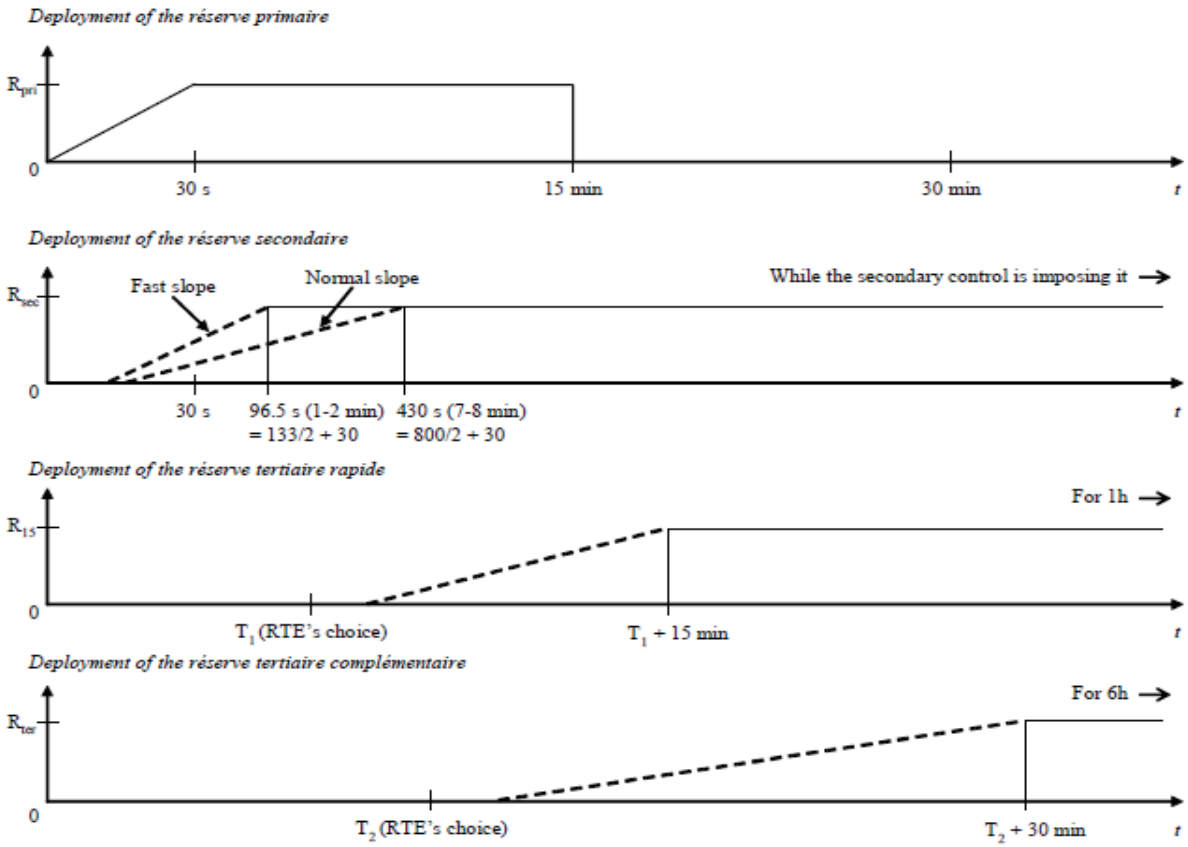
6. For effective Faster Market, from where DISCOMS is able to buy flexibility of Generator, it is necessary that such products are available and also there is enough liquidity of wiling flexible generator in the market.

   This can only be achieved with – (i) more flexible market products and less gate closure provisions, and (ii) Generators to cope up with lots of re-scheduling requests in very short duration of time.

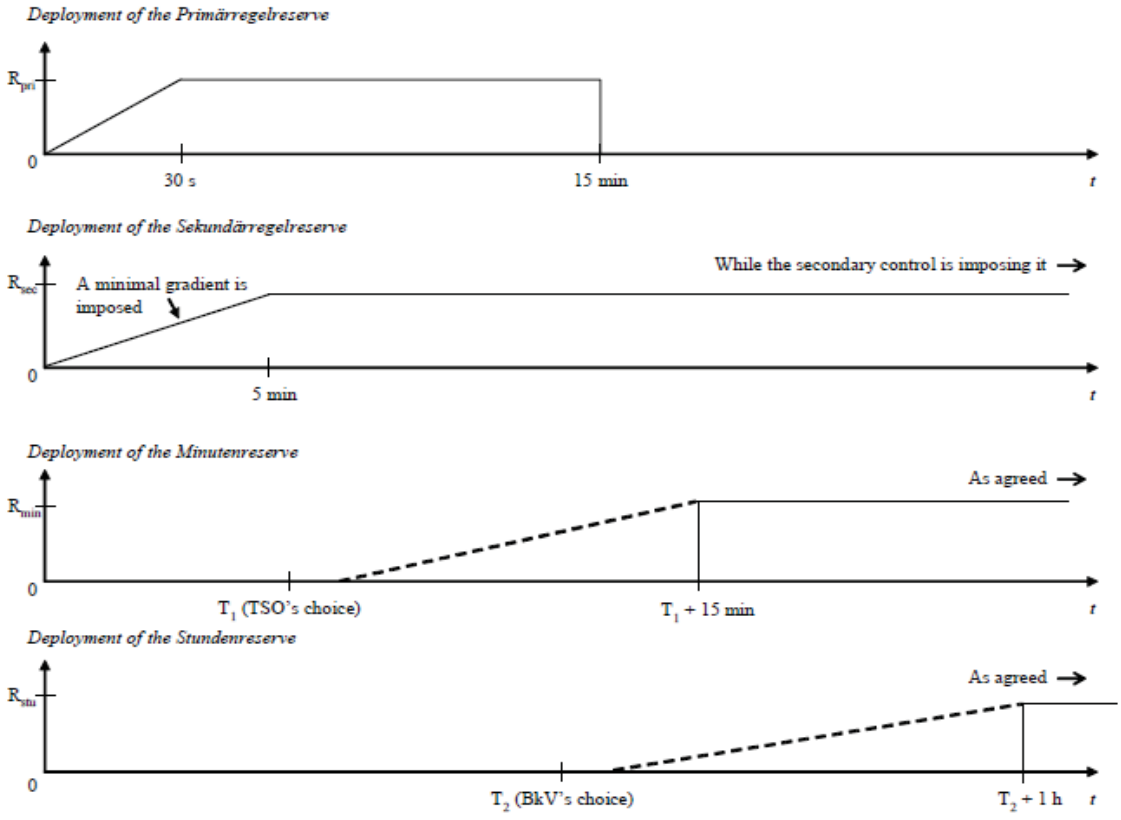
   It may be noted that for any anticipated uncertainty, as of today, only Short term market is available which is totally rigid for any uncertainty in power gird operation which could reduce the overall system operating cost and minimise deviation.

Annexure

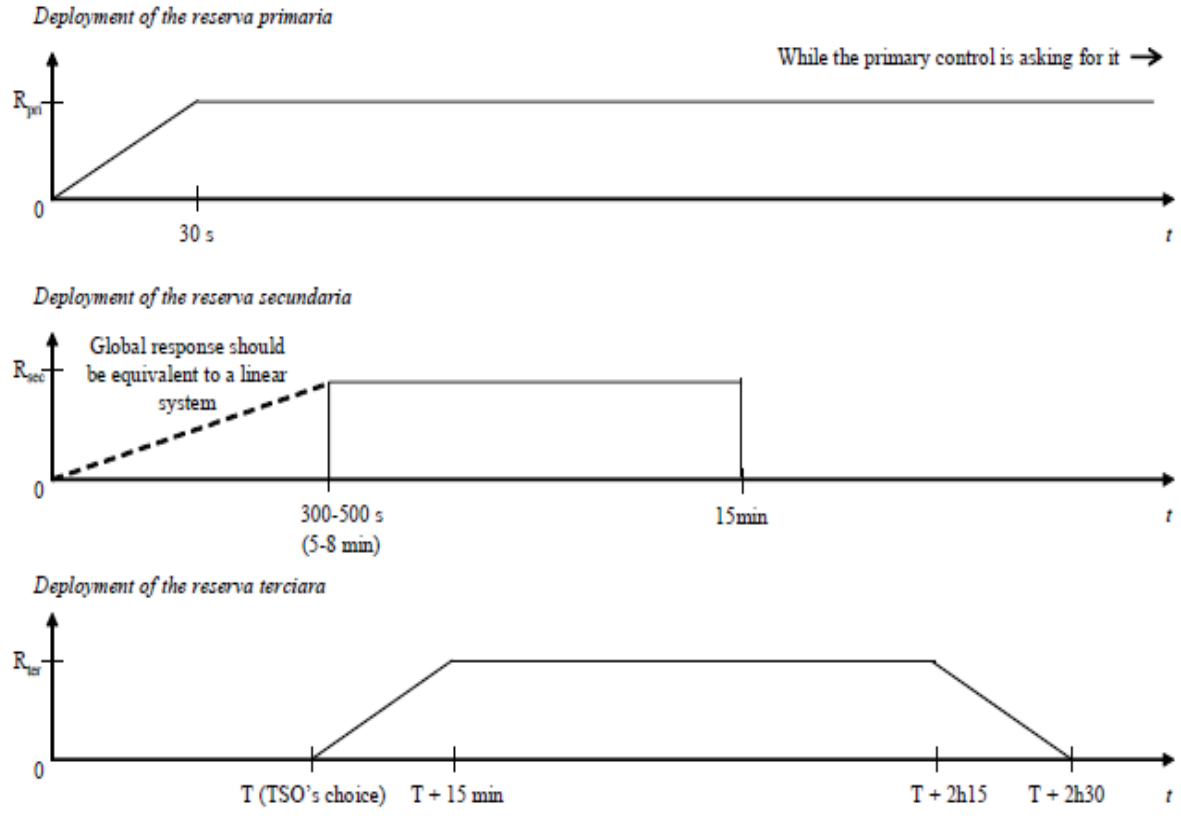
France:



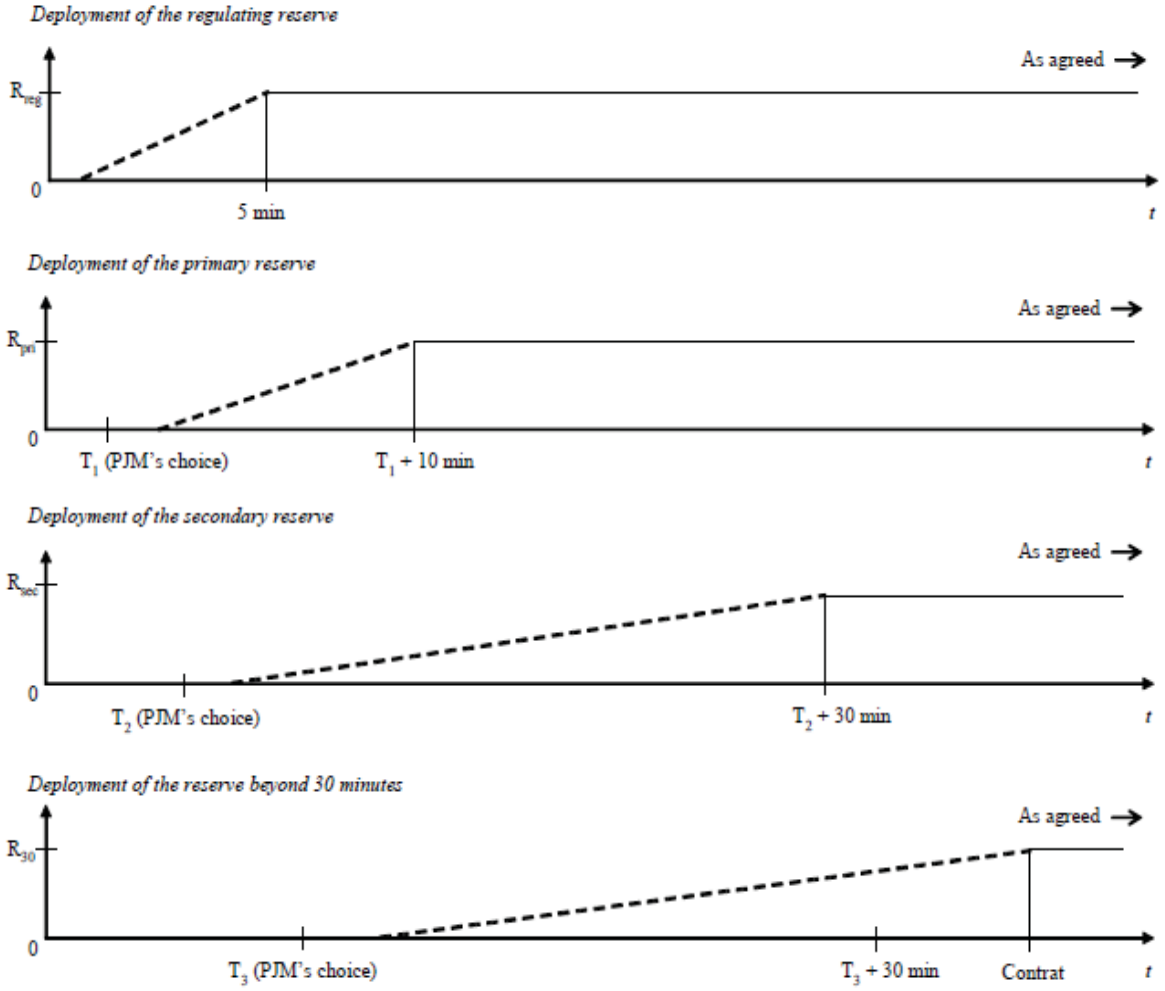
Germany:



Spain:



PJM:


Deployment of the regulating reserve
As agreed
R_{reg}
0
5 min
t
Deployment of the primary reserve
As agreed
R_{pri}
0
T_1 (PJM's choice)
T_1 + 10 min
t
Deployment of the secondary reserve
As agreed
R_{sec}
0
T_2 (PJM's choice)
T_2 + 30 min
t
Deployment of the reserve beyond 30 minutes
As agreed
R_{30}
0
T_3 (PJM's choice)
T_3 + 30 min
Contrat
t

Annex - 3

List of Attendees

Second Meeting of the FOR Sub-Group on Five Minute Despatch & Settlement on 28th August, 2017 at NLDC, Delhi

S.No.	Name	Designation	Organization	E-mail Address	Contact No.	Signature
1.	N. NALLARASAN	DGM,	Posoco,	Nallarasan@posoco.in	8527097022	
2.	A. THANGAPPAN	EE/SLDC/TN	SLDC/TAMILNADU	ee2remc@tnebnet.org	9445491143	
3.	MAKPSINGH	MS	NRPC	makpsingh@yahoo.com	9425066433	
4.	Upendra Kumar	Director	NRPC	upendra0309@gmail.com	9910180485	
5.	A. Balan	MS	WRPC	ms-wrpc@nic.in	9483540528	
6.	B B MEHTA	CE	SLDC GETCO	bbm@gebmail.com	9879200736	
7.	Amarjeet Singh	DGM- Sales	L&T, Delhi	amarjeetsingh.panesar@Lntebg.com	8750446444	
8.	S. K. SOONEE	Advisor	POSOCO	skssoonee@posoco.in	9899091115	
9.	PARDEEP JINDAL	CE (NPC)	CEA/NPC	jindal_pardeep@yahoo.co.in	9818768460	
10.	S.S. BARPANDA	GM	POSOCO	ssbarpanda@posoco.in	9717296928	
11.	PARAS JAIN	Manager	Secure	PARAS.JAIN@SECUREMETGAS.COM	8290348246	
12.	Vinod Katra	manager	Secure	vinod.katra@securemetgas.com	9871014465	
13.	Ajay Sharma	Sr. Manager	Elster - Honeywell	ajay.sharma2@honeywell.com	9871067171	
14.	Anil Bhide	Sr. manager	Elster - Honeywell	anil.bhide@~~elst~~honeywell.com	9820429211	
15.	D K Srivastava	Director, NPC, CEA	CEA	dhirajsrivastava@nic.in	9560763305	

S.No.	Name	Designation	Organization	E-mail Address	Contact No.	Signature
15.	S. R NARASIMHAN	GM, NLDC,	Posoco	srnarasimhan@posoco.in	9971117022	
16.	राजीव पोरवाल	उ प्र, NRLDC	Posoco	rk.porwal@posoco.in	9871581133	
17.	G Chakraborty	DGM, NLDC	POSOCO	gchakraborty@posoco.in	9433041815	
18.	Ratnesh Kumar	E (C)	NRPC	ratnesh.cea@gmail.com	9811101805	
19.	Shyam Sundar Goyal	Sr. Engr.	CTU, POWERGRID	shyam.goyal@powergridindia.com	9911708044	
20.	KVS Baba	CEO	Posoco	kvs.baba@posoco.in	85276 07578	
21.	SC SAXENA	DGM	NLDC, Posoco	sc.saxena@posoco.in	9910059972	
22.	KVN PAWAN KUMAR	Dy. Manager NLDC, Po	NLDC, POSOCO	kvnpawankumar@posoco.in	9717724488	
23.						
24.						
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FOR Sub-Group for "Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement"
03rd Meeting - Gist of Discussions

Meeting Details				
Date		25th October, 2017	**Venue**	National Load Despatch Centre, POSOCO, Delhi
Day		Wednesday		
Time	Open	11.00 AM		
	Close	01.30 PM		
Subject		**Third Meeting of Sub-Group for "Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement" under FOR Technical Committee for Implementation of Framework on Renewables at the State Level**		

Deliberations

1.0 CEO, POSOCO welcomed the participants to the meeting. In the second meeting, it was decided by the sub-group that testing & demonstration of 5-Minute capability in exisiting meters by meter manufacturers may be conducted at one of the identified ISTS susbtations. Further, the need for interaction with different stakeholders responsible for implementation of 5-Minute Scheduling and Settlement was also highlighted. Accordingly, testing & demonstration was conducted in coordination with three meter manufacturers. Also, representatives from Discoms, one from each of the five regions, were invited to pariticipate in the 3rd Meeting and give views/suggestions for the proposed migration to 5 minute scheduling, metering and accounting.

2.0 A presentation was made by POSOCO (Annex – I) giving the status update, deliberations in the previous meetings, meter demonstration process and results, identification of further activities, proposal for pilot project, action plan, time-lines and target date for migration including phasing of activities at inter-state level.

3.0 The deliberations in the past meetings were summarized as follows:

- Need to move to “fast” markets is recognized.
- 5-minute scheduling & settlement and earmarking of the reserves are interwoven processes.
- 5-minute bidding in OTC/PX markets would lead to more efficient price discovery.
- 5-minute DSM prices would be a vital indicator for imbalance handling caused especially by renewable generation.
- Provisions for 5-minute may be made mandatory for future procurement of meters.
- Requirement of amendments in the CEA Metering Standards
- 5-minute scheduling & settlement entail regulatory interventions
- Handling Transition
    - To begin with, 5-minute metering will be in parallel with 15 minute metering.
    - “Scheduling and Despatch” has to be aligned with “Settlement” process in 5-min too.
    - To begin with, accounts for both 5-minute and 15-minute accounting may be kept in parallel.
- Need for capacity building for 5-minute granular forecasting at state level
- SAMAST implementation would enable states to leapfrog

4.0 The sub-group and Discoms had detailed discussions on following aspects:

FOR Sub-Group for "Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement"
03rd Meeting - Gist of Discussions

4.1 Results and Analysis of Live Meter Demostration and Testing

The meter testing was witnessed jointly by representatives of POSOCO (NLDC, WRLDC), POWERGRID, Gujarat SLDC and Meter Manufacturers (M/s Secure Meters & M/s Elster-Honeywell) at 400/220 kV Magarwada PGCIL S/s, Daman-Diu UT and 765/400 kV Vadodara (Wagodia) PGCIL S/s, Gujarat (M/s L&T) on 13th September, 2017 and 10th October, 2017 respectively.

During the 5-minute meter demonstration, it was observed that additional parameters are available in the meters which were kept disabled as the requirement was not posed to the meter manufacturers. File transfer formats (presently, ".npc" files) need to be reviewed when migrating from 15-minute to 5-minute metering. The Meter Demonstration & Testing Results were summarized as follows:

Title	Elster	Secure	L & T
Reconfiguration of existing 15-min meter to 5-min	Possible in Existing meters, Simple, on-site	Not possible in existing meters, possible in new models only, on-site	Not possible in existing meters, new models only, off-site
Reconfiguration Time	Fast	Fast	At factory
Retention of old data	Old data erased	Block wise data erased cumulative data retained	Data yet to be made available
Conversion software for NPC File	The software for conversion to .npc file is available	Software for converting to NPC format needs upgrade	Software for converting to NPC format needs upgrade
Wh recording	Acceptable	Acceptable	Data N.A.
VARh recording	Variations observed due to integration time difference		Data yet to be made available
Storage	Could not be ascertained		Storage upgraded in factory

Further, another meter manufacturer viz. M/s Genus Meters, in a written communication to Tamil Nadu, expressed that it is possible to program integration period from 15 minute to 5 minute for ABT meter application after revision of standards, upgradation of storage etc.

The need for software validation and new .npc format, requirement of Automated Meter Reading (AMR) alongwith communication infrastructure, storage enhancement, standardized data and information protocols were noted as key learnings by the sub-group. It was also mentioned that reconfiguration of the meters should be with adequate safeguards and ensure that the meters are tamper-proof. Chief Engineer, NPC enquired on methodology for measurement of 15 minute vis-à-vis 5 minute integration period. He mentioned about the need for a comparitive study for the two intervals. The detailed summary of the meter testing / demonstration is enlosed at Annex-II.

4.2 Amendments in CEA Metering Standards/Regulations

POSOCO highlighted the need for change in CEA Metering Regulations. CEA initiated review of CEA (Installation and Operation of Meters) Regulations, 2006 in August, 2016. Further, in February, 2017, WRPC sent a communication to CEA regarding change in metering standards to facilitate 5-minute scheduling and settlement. The sub-group requested CE, NPC to follow up the matter with CEA and also place the required amendments as agenda item in the next NPC meeting.

FOR Sub-Group for "Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement"
03rd Meeting - Gist of Discussions

4.3 Amendments in CERC Regulatory Framework

It was noted that CERC Regulatory Framework viz. Indian Electricity Grid Code, Deviation Settlement Mechanism, Open Access in inter-State Transmission, Ancillary Services Operations etc. need amendment for facilitating 5-minute scheduling, metering, accounting and settlement. The Members suggested that the requisite amendments in the regulatory framework may be included in the Report of the Sub-Group. Further, there is need for replication of the same at intra-state level.

4.4 Identification of Interface Energy Meters and locations by CTU/STU

It was deliberated that CTU may identify the region-wise interface meters which are needed to be replaced and those that can be reconfigured (along with upgrade of storage) for the transition to 5-minute scheduling and settlement. CTU was requested to facilitate collection of the required data on type, vintage and location of existing meters so that assessment of the implementation timeline and financial implication for transition to the 5-minute framework could be estimated. It was also recognized that cross border interconnections will also need to be upgraded for the transition. The sub-group also recognized the need for review of the exisitng technical specifications for interface meters for implementation of 5-minute metering. This may taken up by an expert group so as to ensure a smooth transition.

4.5 Handling Transition to 5-Minute Scheduling, Metering and Accounting systems by RPC/RLDC/SLDC/STU in the transition period upto the cut-off date

The sub-group noted that significant metering software changes including hardware upgrade are required at RPCs, RLDCs and SLDCs. The data communication from sites to RLDCs/SLDCs is also critial from the viewpoint of Data Validation, Processing, Reporting, Archival and Website uploading.

4.6 Capacity Building of stakeholders

MS, NRPC stressed on the immediate need for capacity building for forecasting and scheduling so that experience may be gained and shared. He also highlighted need for parallel dummy software for 5 minute accounting and settlement to be operationalized at RPCs for proper understanding, smooth and dispute-free transition to 5-minute framework.

5.0 The sub-group noted that primary response should be given real thrust as also suggested by Chief Engineer, NPC.

6.0 It was proposed that, on a pilot basis, 5-minute capable meters may be installed at say, 4-5 locations in each Region to gain practical experience in 5-minute metering, interfacing requirements / file interchange formats and develop data analytics/tools for 5-minute metering, data validation, reporting, etc. It was recognized that pilot project would help in formulation/refinements of Technical specifications and Software Requirement Specifications (SRS) for Metering Software at RLDCs and Accounting Software at RPCs for 5-minute metering. The suggested locations were at Generating stations – Conventional / RE, Substations – 765 kV / 400 kV and Inter-Regional inter-change points. It was also noted that pilot project was undertaken when going for 0.02 to 0.01 Hz step change in interface meters few years back. The sub-group agreed that pilot project for installation of 5-minute capable metes may be undertaken at different locations with different vendors. It was opined that these meters should be capable of data downloads in both 5-minute and 15-minute formats so as to facilitate handling of transition during the final implementation of 5-minute metering. CTU representative, was requested to facilitate the pilot with installation of 5-minute meters.

FOR Sub-Group for "Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement"
03rd Meeting - Gist of Discussions

7.0 Tamil Nadu representative highlighted that replacement of meters for industrial consumers is being undertaken. Around 8500 meters comprising 90 % of the industrial consumers have already been replaced. However, DLMS compliance is not possible in those meters. Adviser, POSOCO and CEO, POSOCO stated that the transition, to begin with, is at inter-state level only. CEO, POSOCO also stressed that migration would be done in phased manner. DGM, POSOCO and CTU representative highlighted the need for DSM regulation to be modified by CERC.

8.0 Further, Tamil Nadu representative observed that that there would be difference in the measurement based on 5-minute metering/settlement at inter-state periphery and the 15-minute metering/settlement at intra-state level. POSOCO representative mentioned that it is a case of transition in settlement process which can be taken care of in due course of time. Adviser, POSOCO stated that CEA Regulations cover both interface meters and consumer meters.

9.0 West Bengal representative said that WBSEDCL pays for the deviation including by the OA consumer embedded for PX/OTC transactions. The representative expressed difficulties regarding implementation of 5-minute scheduling & metering. Regarding the difficulty faced by West Bengal, the Gujarat representative mentioned that frequent changover of source of supply by open access consumers is not allowed in Gujarat and once an OA consumer decides to go to the market, he has to procure for 24 hours at least. POSOCO representative highlighted that two positive experiences of transitions were enabled by cooperation from the states i.e. introduction of ABT and change of bidding format from hourly to 15 minute in Power Exchanges. The sub-group also noted that there is need for capacity building in the forecasting area for better load management.

10.0 Both Gujarat and Delhi discom representatives agreed that the transition to 5-minute scheduling and settlement is possible and can be done.

11.0 Suggested Action plan, time-lines and target date for migration including phasing of activities at inter-state level were agreed as follows:

Required Action	Action By	Timeline
Submission of Sub-Group Report	FOR Sub-Group	30 Nov 2017
Pilot Projects implementation	CTU / RPCs / POSOCO	March 2018
CERC Staff Paper on Regulatory Framework for 5-minute Scheduling, Metering & Settlement arrangements	CERC	March 2018
Changes in CEA standards & regulation	CEA	March 2018
Final Regulatory Framework	CERC	September 2018
Formulation of Technical specifications for new meters and configuration change at RPC/State level	CTU/RPCs/ POSOCO	July 2018
Procurement process from tendering to commissioning led by CTU at inter-state level and STU at intra-state level	CTU/RPCs/ POSOCO	September 2018
Trial Run (Transition)	All	April 2019 – March 2020
Go Live	All	**01st April, 2020**

FOR Sub-Group for "Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement"
03rd Meeting - Gist of Discussions

Key Decisions Taken
• All RPCs may discuss the 5-minute scheduling and settlement
• NPC to follow up the status of amendment of Metering standards with CEA and also place the required amendments as agenda item in the next NPC meeting.
• CTU to facilitate collection of the region-wise data on type, vintage and location of existing meters along with proposed procurement process.
• Need for capacity building for better forecasting and scheduling - SLDCs to coordinate with RLDCs/NLDC. Interactive sessions (e.g. Hackathons) may be organized at different RPCs for generation of ideas and solutions.
• Simulation analysis / comparative study of 5-minute & 15-mintute deviations to be done by POSOCO
• Need for intra-state imbalance handling and settlement framework in all states
• Final meeting to be held during the third week / last week of November, 2017

Annex – III: List of Attendees

Annexure - 1

FOR Sub-Group
for
"Implementation of 5-Minute Scheduling, Metering, Accounting and Settlement"

Third Meeting

POSOCO-NLDC, New Delhi
25 October 2017

Status Update

- **Two Meetings of the Sub-Group**
  - First Meeting – 03rd August, 2017 at NLDC, Delhi
  - Second Meeting – 28th August, 2017 at NLDC, Delhi
- **5-Minute Meter Demonstration and Testing**

  - **M/s Secure Meters and M/s Elster-Honeywell**
    - 13th September, 2017
    - 400/220 kV Magarwada PGCIL S/s, Daman-Diu UT
  - **M/s L&T**
    - 10th October, 2017
    - 765/400 kV Vadodara (Wagodia) PGCIL S/s, Gujarat
  - **M/s Genus Power Infrastructure Ltd**. – Tamil Nadu SLDC

Deliberations in Meetings so far (1)

- Need to move to "fast" markets
- 5-minute scheduling & settlement and earmarking of the reserves are interwoven processes.

- 5-minute bidding in OTC/PX markets will lead to more efficient price discovery.
- 5-minute DSM prices would be a vital indicator for imbalance handling caused especially by renewable generation.
- Provisions for 5-minute may be made mandatory for future procurement of meters.

Deliberations in Meetings so far (2)

- Requirement of amendments in the CEA Metering Standards
- 5-minute scheduling & settlement entail regulatory interventions
- Handling Transition

  - To begin with, 5-minute metering will be in parallel with 15 minute metering. A changeover date would be applicable
  - "Scheduling and Despatch" has to be aligned with "Settlement" process in 5-min too.
  - To begin with, accounts for both 5-minute and 15-minute accounting may be kept in parallel.
- Capacity building for 5-Minute granular forecasting at state level
- SAMAST implementation would enable states to leapfrog

Status of Key Decisions Taken

Decision	Action Taken
Stakeholder views/suggestions to be taken	Interaction with Meter vendors held. Interaction with Discoms in this meeting
All RPCs may discuss the 5-minute scheduling and settlement as an agenda item	NRPC, WRPC, ERPC and NERPC held discussions. SRPC deliberations awaited
Co-opt representative from GM Division, CEA and representative from CERC	Communication sent for nomination. CEA/CERC nomination awaited
Meter manufacturers to demonstrate the implementation of 5 minute arrangements in existing models/version of meters	M/s Secure Meters, M/s Elster-Honeywell and M/s L & T meter demonstration held. M/s Genus gave written communication to Tamil Nadu.

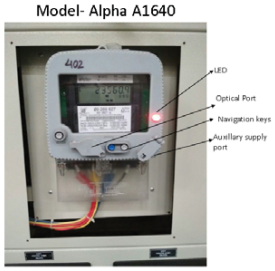
Meter Demonstration – M/s Secure

Main meter: NP-8607 A (Elster)
Model- Alpha M++

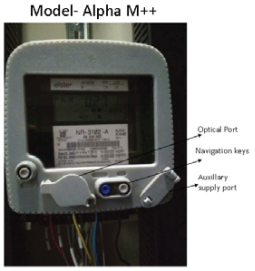
Check meter: Y0356046 (Secure)
Model- Apex 150

Meter Demonstration – M/s Elster Honeywell

Main meter: NP-8627 A
Model- Alpha A1640



Check meter: NR-3102 A
Model- Alpha M++



Meter Demonstration – M/s L & T

Main Meter – NP 2985A (Secure)
Model E2M021

Check Meter - H 170903 (L&T)
Model ER300P

Testing Process

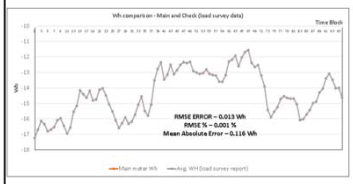
- Initially, the demo meter was configured for data accumulation at 15-minute interval.
- After recording the data at 15-minute interval, the data from main and demo (check) meters was downloaded directly into the laptop by vendor
- Subsequently, the demo (check) meter was re-configured to record data at 5-minute interval without any change in the main meter.
- Demo meters remained connected for recording data at 5-minute interval till at least 1200 hrs of 151h September 2017 so that one clear day (from 00 Hrs to 2400 hrs) data is recorded by the demo meters.

Methodology for Data Analysis

- Addition of "Wh" of three consecutive time blocks of 5 min
- Average of the "Frequency" of three consecutive time blocks of 5 min

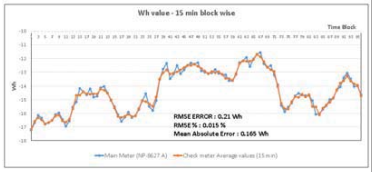
- Difference between the "Active Energy" cumulative register reading at 24 hrs and at 00 hrs
- Difference between the "Reactive energy (high)" cumulative register reading at 24 hrs and at 00 hrs
- Difference between the "Reactive energy (low)" cumulative register reading at 24 hrs and at 00 hrs

15 min block wise Wh comparison – Main and check (load survey data) Elster

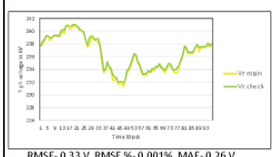


Elster Meter Results

15 min block wise Watt hour value comparison (Elster) (from NPC file)



Voltage Comparison (Elster)



RMSE- 0.33 V, RMSE %- 0.001%, MAE- 0.26 V

RMSE- 0.34 V, RMSE %- 0.001%, MAE- 0.27 V

RMSE- 0.43 V, RMSE %- 0.002%, MAE- 0.37 V

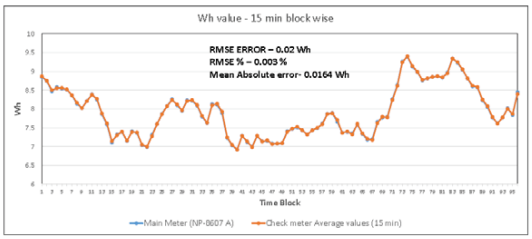
Main and check Meter data Comparison (ELSTER)

Cumulative Register Readings	Main meter	Check Meter	Diff.	Remarks
Net Wh recorded for 14.09.17	1379.6	1380.7	1.1	Diff. of 0.08 % (OK)
Net VARh (<97%) recorded for 14.09.17	0.0	0.0	0.0	
Net VARh (>103%) recorded for 14.09.17	64.4	67.2	2.8	Diff. of 4.34 %. This is due to the shrinking of the time block interval from 15 min to 5 min.

Additional Metering Parameters available in Elster (other than that in .npc file)

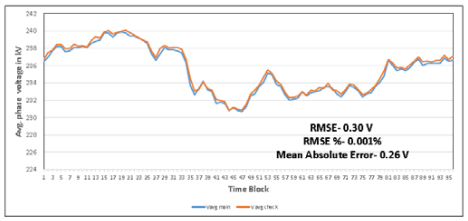
- Block wise Reactive Energy Data (VARh delivered and VARh received)
- Block wise Active Energy (Delivered and Received)
- Block wise voltage (R, Y and B) are available separately through reports provided by the *PEARL reporting software*.

15 min block wise Watt hour value comparison (Secure)



- *M cubed 100* software was used for generating reports from the *.cdf file.
- The .npc file generated from the M cubed software is erroneous as frequency code recorded is only 48,49 and 50 and no other value.
- Hence, data generated from .cdf file is used for the analysis.

Voltage comparison – Main & Check



Only Average Ph-N voltage is available in .cdf file.

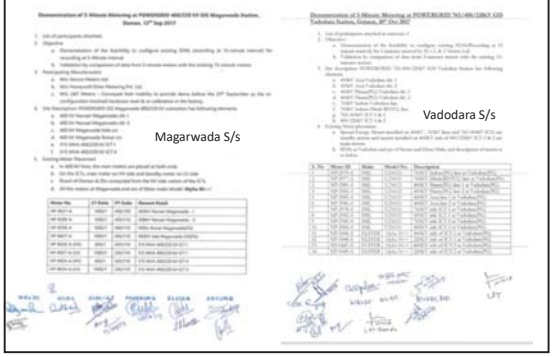
Main and check Meter data Comparison (SECURE)

Cumulative Register Readings	Main meter	Check Meter	Diff.	Remarks
Net Wh recorded for 14.09.17	760.7	761.2	-0.5	Error of 0.06 % (OK)
Net VARh (<97%) recorded for 14.09.17	0	0	0	
Net VARh (>103%) recorded for 14.09.17	12.0 (export)	12.925 (export)	-0.925	Error of 7.7 % . This is due to the shrinking of the time block interval from 15 min to 5 min.

Additional Metering Parameters available (Secure) in the .cdf file:

- Total active energy (all harmonics) import, export and net value
- Active Energy (fundamental harmonic) import, export and net value.
- Reactive Energy and power import (Active import) – kVArh & kVAr
- Reactive energy and power export (Active import) – VARh & kVAr
- Reactive Energy and power import (Active export) – VARh & kVAr
- Reactive Energy and power export (Active export) – VARh & kVAr
- Net reactive energy and power exchanged in a block – VARh & kVAr
- Net reactive energy (V>103%) and net reactive energy (V < 97 %) - VARh
- Average Voltage (V)
- Average Current (A)
- Total Active Power, Net active power (import and export)

Meter Testing Witnessed Jointly by Representatives of NLDC, WRLDC, POWERGRID, Gujarat SLDC and Meter Manufacturers



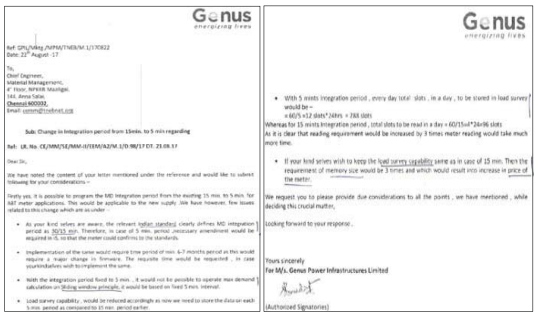
Magarwada S/s

Vadodara S/s

Meter Demonstration & Testing Results - Summary

Title	Elster	Secure	L & T
Reconfiguration of existing 15-min meter to 5-min	Possible in Existing meters, Simple, on-site	Not possible in existing meters, possible in new models only, on-site	Not possible in existing meters, new models only, off-site
Reconfiguration Time	Fast	Fast	At factory
Retention of old data	Old data erased	Block wise data erased cumulative data retained	Data yet to be made available
Conversion software for NPC File	The software for conversion to .npc file is available	Software for converting to NPC format needs upgrade	Software for converting to NPC format needs upgrade
Wh recording	Acceptable	Acceptable	Data N.A.
VARh recording	Variations observed due to integration time difference		Data yet to be made available
Storage	Could not be ascertained		Storage upgraded in factory

Inputs from M/s Genus Meters to Tamil Nadu



Genus energizing lives

Sub: Change in Integration period from 15min. to 5 min regarding

Genus energizing lives

Yours sincerely
For M/s. Genus Power Infrastructures Limited

(Authorized Signatories)

Revision of Standards, Upgradation of Storage

Key Learning – Meter Demonstration

- Need for software validation and new .npc format
- Automated Meter Reading (AMR) alongwith communication infrastructure required
- Storage enhancement needed
- Standardized data, information protocols

Modifications in Metering Standards

- Record frequency data at 0.01 Hz resolution
- Net VARh and voltage to be recorded for each time block.
- Auxiliary Supply - SEM may normally be capable of operating with power drawn from the VT secondary circuits.
- Provision to operate on control power supply to the SEM from 110V DC / 220V DC
- Built-in calendar and clock
- Secured software based solution for meter time correction and synchronization with GPS
- DLMS compliant for SEM communication protocol – Indian COSEM standard
- Data security ensured as per IEC-62056-51 standard
- Automated Meter Reading (AMR)
- Uniform protocol for communication for meters of different vendors.
- Optical coupling cable should be compatible with all types of meters.
- Replacement of defective meters within a stipulated time frame

Desired Features in the 5-Minute capable interface meters

- Non-volatile memory, Automatic storage
- Net Wh transmittal during each successive 5 min block (up to 2 decimal)
- Cumulative Wh transmittal at each midnight, in eight digits (one decimal)
- Net VARh transmittal during each successive 5 min block (up to 2 decimal)
- Cumulative VARh transmittal at each midnight in eight digits (one decimal)
- High VARh when Voltage above 103 % of Vref
- Low VARh when Voltage is below 97% of Vref
- Average frequency (5 min) in Hertz (up to 2 decimal, truncation)
- Date and time blocks of failure of VT supply on any phase
  - as a star (*)/ (Z) mark.
- Voltage (V) (up to 2 decimal, truncation)
- Meters shall store data in memory for 15 days

Identification of further Activities (1)

- Amendments in CEA metering standards/regulations
- Regulatory Framework by CERC for 5-minute scheduling, metering, accounting and settlement
  - Indian Electricity Grid Code
  - Deviation Settlement Mechanism
  - Open Access in inter-State Transmission
  - Ancillary Services Operations
- Identification of Interface Energy Meters and locations by CTU/STU
  - Number of meters to be replaced and number of meters to be upgraded
- Formulation of Technical specifications
  - for new meters and configuration change in the existing meters

Identification of further Activities (2)

- Procurement of meters
  - By CTU at inter-state level and STU at intra-state level
- Upgrade of metering infrastructure at the cross border interconnections
- Metering Software changes including any hardware upgrade required
  - At RLDCs, SLDCs
  - Data communication from sites to RLDCs
  - Data Validation, Processing, Reporting, Archival and Website uploading.
- Accounting software upgrade at the RPCs
  - Including any hardware upgrade needed
- Handling Transition to 5-Minute Scheduling, Metering and Accounting systems by RPC/RLDC/SLDC/STU in the transition period upto the cut-off date
- Capacity building of stakeholders

Proposal for Pilot Project

- Installation of 5-minute capable meters at 2 locations in each Region
- Objectives
  - Gain practical experience in 5-minute metering
  - Gain experience in interfacing requirements / file interchange formats
  - Develop Data Analytics / tools for 5-minute metering, data validation, reporting, etc.
- Advantages / Benefits
  - Helps in formulation/refinements of Technical specifications for 5-minute metering
  - Helps in writing the Software Requirement Specifications (SRS) for Metering Software at RLDCs and Accounting Software at RPCs
- Suggested Locations
  - Generating stations – Conventional / RE
  - Substations – 765 kV / 400 kV
  - Inter-Regional inter-change points

Suggested Action plan, time-lines and target date for migration including phasing of activities at inter-state level

Required Action	Action By	Timeline
Submission of Sub-Group Report	FOR Sub-Group	30 Nov'17
Pilot Projects	CTU / RPCs / POSOCO	March 2018
CERC Staff Paper on Regulatory Framework for New Scheduling, Metering and Settlement arrangements	CERC/POSOCO	
Final Regulatory Framework	CERC/POSOCO	
Amendments in CEA/CERC standards/regulations	CEA/POSOCO	
Formulation of Technical specifications for new meters and configuration change at RPC/State level	CTU/RPCs/ POSOCO	
Procurement process from tendering to commissioning led by CTU at inter-state level and STU at intra-state level	CTU/RPCs/ POSOCO	
Trial Run (Transition)	All	
Go Live	All	

Let's Ideate

Magarwada S/s

Vadodara S/s

Thank You !

Annexure - 2

Demonstration of 5-Minute Metering at POWERGRID 765/400/220kV GIS Vadodara Station, Gujarat, 10th Oct 2017

1. List of participants attached in annexure-1
2. Objective:
   a. Demonstration of the feasibility to configure existing SEMs(Recording at 15 minute interval) for 5-minutes interval by M/s L & T Meters Ltd.
   b. Validation by comparison of data from 5-minutes meters with the existing 15-minutes meters.
3. Site description: POWERGRID 765/400/220kV GIS Vadodara Station has following elements
   a. 400kV Asoj-Vadodara ckt. 1
   b. 400kV Asoj-Vadodara ckt. 2
   c. 400kV Pirana(PG)-Vadodara ckt. 1
   d. 400kV Pirana(PG)-Vadodara ckt. 2
   e. 765kV Indore-Vadodara line
   f. 765kV Indore-Dhule BDTCL line
   g. 765/400kV ICT-1 & 2
   h. 400/220kV ICT-1 & 2
4. Existing Meter placement
   a. Special Energy Meters installed on 400kV , 765kV lines and 765/400kV ICTs are standby meters and meters installed on 400KV side of 400/220kV ICT-1 & 2 are main meters.
   b. SEMs at Vadodara end are of Secure and Elster Make and description of meters is as below.

S. No	Meter ID	Make	Model No.	Description
1	NP-2979-A	SML	E2M021	765KV Indore(PG) line at Vadodara(PG)
2	NP-2977-A	SML	E2M021	765KV Dhule(BDTCL) line at Vadodara(PG)
3	NP-2981-A	SML	E2M021	400KV Pirana(PG) line-1 at Vadodara(PG)
4	NP-2983-A	SML	E2M021	400KV Pirana(PG) line-2 at Vadodara(PG)
5	NP-2985-A	SML	E2M021	400KV Asoj line-1 at Vadodara(PG)
6	NP-2986-A	SML	E2M021	400KV Asoj line-2 at Vadodara(PG)
7	NP-2978-A	SML	E2M021	765KV side ICT-1 at Vadodara(PG)
8	NP-2982-A	SML	E2M021	400KV side ICT-1 at Vadodara(PG)
9	NP-2980-A	SML	E2M021	765KV side ICT-2 at Vadodara(PG)
10	NP-2984-A	SML	E2M021	400KV side ICT-2 at Vadodara(PG)
11	NP-5446-A	ELSTER	Alpha M++	400KV side of ICT-1 at Vadodara(PG)
12	NP-5448-A	ELSTER	Alpha M++	220KV side of ICT-1 at Vadodara(PG)
13	NP-5447-A	ELSTER	Alpha M++	400KV side of ICT-2 at Vadodara(PG)
14	NP-5449-A	ELSTER	Alpha M++	220KV side of ICT-2 at Vadodara(PG)

10/10/17 10/10 SLDC Gujarat

Chitragadan 10/10/17 WRLDC NLDC

10/10/17 POWERGRID

10-10-17 L&T

10-10-17 L&T-Baroda

5. Methodology:
    a. Online installation of Demo (Check) Meters (without availing shutdown of the feeders) after obtaining operation code no 907 from WRLDC at 12:31 hrs.
        i. New meter (H170903) Model ER300P Provided by M/s L&T Meters was placed on 400KV Vadodara-Asoj Ckt-1(NP-2985-A).
        ii. Installation process of 5-minute demo meter took about one and half hour.
        iii. Time synchronisation of new L&T meter was done at 12:45 hrs after extending PT supply/Self power to Meter which last for 6 blocks(10seconds advancement per block of 5-minute).
        iv. New L&T meter brought for testing has limited time synchronisation facility (1 minute/ week). Time synchronisation (1 minute advanced) of the new demo meters was done with the 15-minutes meter. Still 20 seconds time drift retard in 5-minute L&T is observed which could not be time synchronised due to limited time synchronisation in L&T meters.
        v. CT supply to the meter installed on 400kV Asoj line-1was interrupted from 12:49 Hrs to 13:10 Hrs to install 5-minutes Demo meter.

6. M/s L&T informed that 5-minutes meters provided for testing has exactly same features that of existing 15-minutes L&T meter at ISTS level in WR. S/W has been upgraded for 5-minutes recording and memory also enhanced for recording of data for 10 days. 5-minutes demo meter is non DLMS complaint.
7. M/s L&T also informed that the new meter had configured for 5-minutes integration period only and reconfiguration for 15-minutes integration period could not be possible at site level. However they could provide the new 5-minutes energy meter with the features of 5-minutes and 15-minutes configurable integration period at site level.
8. It was decided that the demo meter shall remain connected for recording data at 5-minute interval till at least 24:00 hrs of 21/10/17 for comparison with 15-minutes main meter data.
9. After competition of recording of 5-minutes interval (on 21/10/17), M/s L&T Meters shall coordinate with 765kV Vadodara POWER GRID to download and furnish the data in raw (CSV/Excel/or any readable format) format and npc file format to WRLDC and SLDC Gujarat for further analysis, comparison and validation of the test data.
10. M/s L&T is requested to provide the list of models of ABT meters which are compatible to measure 5-minutes integration. Further M/s L&T is also requested to submit the following details for the ABT meters supplied in the last 5 years.
    a. Security features for making it tamper proof.
    b. The additional features that the meter is capable of recording other that the features included in specifications supplied by POWER GRID & GETCO.
    c. Possibility of alternative universal methods to download the data from meters other than DCD at site level.
    d. Possibility of decoding software development capable of giving output, from single encrypted input file, in the form of ".npc" for 15-minute and 5-minute on user selection.
    e. Possibility of reconfiguration of existing 15-minutes intergration to 5-minutes integration.

(PARAG PARMAR) 10/10/17 10/10/17 10/10/17

SLDC Gujarat WRLDC NLDC POWERGRID L&T

10/10

CH. JAGADEESH 10/10/17

L&T-Baroda

Demonstration of 5-Minute Metering at POWERGRID 765/400/220kV GIS Vadodara Station, Gujarat, 10th Oct 2017

S.No	Name	Organization	Email Id	Phone No.	Signature
1	PARAG PARMAR	SLDC-GETCO	parag.parmar@gmail.com	99252-12942	[illegible]
2	NITIN GOSWAMI	SLDC-GETCO	nhgsldc.getco@gebmail.com	9925208662	[illegible]
3	S.H. PATEL	SLDC. GETCO	sldcsecct.getco@gebmail.com	9925212401	[illegible]
4	N.A. Makwana	SLDC-GETCO	namsldc.getco@gebmail.com	9925212845	[illegible]
5	A.N. PATEL	SLDC GETCO	sldc [illegible] @gebmail.com	9409940194	[illegible]
6	C.C. DARJI	SLDC, GETCO	chefjdarji@gmail.com	9925212846	[illegible]
7	J.C. PRAJAPATI	SLDC, GETCO	jcp.10275@gmail.com	9925208090	Prajapati
8	Ch. Jagadeesh	WRLDC, Mumbai	jagadeesh537@gmail.c	9869469376	[illegible]
9	ANUPAM KUMAR	NLDC, New Delhi	anupamkumar@posoco.in	8527990878	अनुपम कुमार
10	S. PANDEY	POWERGRID, Vadodara	spanday@powergridindia.com	9429899292	[illegible] 10/10/17
11	Rajan Rana	L&T-Baroda	rajan.rana@LNTEBG.COM	8238232254	[illegible]
12	Rakesh Sing.	POWER GRID, VADODARA	rakesh.singh@powergridindia.com	9429896421	[illegible] 10/10/2017
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Demonstration of 5-Minute Metering at POWERGRID 400/220 kV GIS Magarwada Station, Daman, 13th Sep 2017

1. List of participants attached.
2. Objective:
    a. Demonstration of the feasibility to configure existing SEMs (recording at 15-minute interval) for recording at 5-Minute interval
    b. Validation by comparison of data from 5-minute meters with the existing 15-minute meters
3. Participating Manufacturers
    a. M/s Secure Meters Ltd.
    b. M/s Honeywell Elster Metering Pvt. Ltd.
    c. M/s L&T Meters – Conveyed their inability to provide demo before the 25th September as the re-configuration involved hardware reset & re-calibration in the factory.
4. Site Description: POWERGRID GIS Magarwada 400/220 kV substation has following elements:
    a. 400 kV Navsari Magarwada ckt. I
    b. 400 kV Navsari Magarwada ckt. II
    c. 400 kV Magarwada Kala s/c
    d. 400 kV Magarwada Boisar s/c
    e. 315 MVA 400/220 kV ICT I
    f. 315 MVA 400/220 kV ICT II
5. Existing Meter Placement
    a. In 400 kV lines, the main meters are placed at both ends
    b. On the ICTs, main meter on HV side and standby meter on LV side
    c. Drawl of Daman & Diu computed from the HV side meters of the ICTs
    d. All the meters at Magarwada end are of Elster make Model '**Alpha M++**'

Meter No.	CT Ratio	PT Ratio	Element Detail
NP-8627-A	1000/1	400/100	400KV Navsari Magarwada - I
NP-8589-A	1000/1	400/110	400KV Navsari Magarwada - II
NP-8598-A	1000/1	400/110	400kv Boisar Magarwada(PG)
NP-8607-A	1000/1	400/110	400KV Kala Magarwada GIS(PG)
NP-8626-A (HV)	600/1	420/110	315 MVA 400/220 kV ICT I
NP-8597-A (LV)	1000/1	245/110	315 MVA 400/220 kV ICT I
NP-8604-A (HV)	600/1	420/110	315 MVA 400/220 kV ICT II
NP-8624-A (LV)	1000/1	245/110	315 MVA 400/220 kV ICT II

WRLDC NLDC SLDC-GJ POWERGRID ELSTER SECURE

13/9/17

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6. Methodology:
    a. Online installation of Demo (Check) Meters (without availing shutdown of the feeders) after obtaining operation code no. 1285 from WRLDC
        i. New meter (No. NR-3102-A) Model **Alpha M++** provided by M/s Elster was placed on 400 kV Navsari Magarwada Ckt. I
        ii. New meter (No. Y0356046) Model **Apex 150** provided by M/s Secure Meters was placed on 400 kV Magarwada Kala S/C
        iii. The installation process of both the meters took about one and a half hour each.
        iv. Time synchronization of the new demo meters was done with the main meters.
    b. Elster Meter:
        i. CT supply to the main meter (No. 8627) was interrupted from 13:16 hrs to 13:34 hrs to install the Elster demo meter.
        ii. Initially, the Elster demo meter was configured for data accumulation at 15-minute interval from time block 1345-1400 to time block ending 1600 hrs.
        iii. After recording the data at 15-minute interval, the data from main and demo (check) meters was downloaded directly into the laptop by M/s Elster using *Pearl Reporting Software*.
        iv. Subsequently, the demo (check) Elster meter was re-configured to record data at 5-minute interval without any change in the main meter. The reconfiguration process for M/s Elster meter was completed within two minutes. Entire old data got erased when the meter was reconfigured.
    c. Secure Meter:
        i. CT supply to the main meter (No. 8607) was interrupted from 1630 hrs to 1645 hrs to install the Secure demo meter.
        ii. Initially, the Secure demo meter was configured for data accumulation at 15-minute interval from time block 1700-1715 to time block ending 1730 hrs.
        iii. After recording the data at 15-minute interval, the data from main and demo (check) meters was downloaded directly into the laptop by M/s Secure Meters using *M-Cubbed 100 Software*.
        iv. Subsequently, the demo (check) Secure meter was re-configured to record data at 5-minute interval without any change in the main meter. The reconfiguration process for M/s Secure meter was completed within one minutes. Block wise data got erased but the cumulative data was retained (M/s Secure Meters were requested to explain this further).

7. It was decided that the demo meters shall remain connected for recording data at 5-minute interval till at least 1200 hrs of 15th September 2017 so that one clear day (from 00 Hrs to 2400 hrs) data is recorded by the demo meters.

8. After completion of the recording of data at 5-minute interval, both M/s Elster and M/s Secure Meters shall download and furnish the data in raw (CSV/Excel/or any other readable format) format and NPC file format to WRLDC for detailed analysis, comparison and validation of the test data. Both meter manufacturers were also requested to provide a comparison of the 5-minute data of the demo meter with the 15-minute data of the main meter in consultation with WRLDC.

WRLDC NLDC SLDC-GJ POWERGRID ELSTER SECURE

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9. Both the meter manufacturers were requested to provide a list of models of ABT Meters they have supplied so far to POWERGRID and the current models available. They were also requested to give the following details for the ABT meters supplied in the last 5 years:
    a. Security features for making it tamper proof
    b. All kind of feature that the meter is capable of recording (other than those included in the POWERGRID meter specifications)
    c. Possibility of providing a universal DCD capable of data download may be mentioned

WRLDC NLDC SLDC-GJ POWERGRID ELSTER SECURE

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मगरवाडा उपकेन्द्र में दिनांक 13.09.2017 को 05 मिनट ऊर्जा मीटर के परख स्थापन के लिए आगंतुक कर्मचारियों की सूची एवं हस्ताक्षर

क्र.सं.	कर्मचारी का नाम	पदनाम	सम्बंधित संगठन	हस्ताक्षर
1	विवेक पाण्डेय	मुख्य प्रबंधक	प.ग्रि.भा.प्रे.के. पोसोको	
2	एच.एस.	Asst. GM	WRLDC, POSOCO	
3	आखिल गुप्ता	व.अभियंता	WRLDC, POSOCO	
4	पराग परमार	कार्यपालक इंजीनेर	SLDC-GETCO	9925212942
5	प्रतिक शि. मुन	Diploma Trainee	WRLDC, POSOCO	
6	जिग्ना. पटेल	Jr. Engg.	SLDC-GETCO	
7	जगदीश. एम	Mktg. Head-WR	Elster-Honeywell	
8	अयेश कांकरीया	Asst. Manger. Services	Elster-Honeywell	
9	हरेश पटेल	मु. प्रबंधक	पावरग्रिड	हरेश. 9869404497.
10	सुबोध कुमार	कनि० अभियंता	पावरग्रिड	सुबोध. 9425491077
11	एस० सी० सक्सेना	उप महा प्रबंधक	NLDC, POSOCO	समीर चन्द्र 9910019972
12	संदिप नागलवाडे	Exec. Sales & Mktg	Secure Meters	Sandeep
13	मुस्तफा लखोटिया	Exe Customer	Secure Meter	
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Annexure - 3

List of Attendees

Third Meeting of the FOR Sub-Group on Five Minute Despatch & Settlement on 25th October 2017 at NLDC, Delhi

S.No.	Name	Designation	Organization	E-mail Address	Contact No.	Signature
1.	C.MURALIDARAN	EE/MRT/N/ Coimbatore	TANGEDCO	eemrtcbe@tnebnet.org	09445851067	[signature]
2.	D.SENTHIL	Asst. Exe Engineer/	SLDC, TANTRANSCO	ee2remc@tnebnet.org	9445397069	[signature]
3.	T.Nirmala Mary	OPEN ACCESS EE/Open Access	SLDC TANTRANSCO	eeoa@tnebnet.org "	9445857182	[signature]
4.	DILIP ROZEKAR	AGM (CTU-Plg)	POWERGRID	drozekar@powergridindia.com	9910378106	[signature]
5.	PARDEEP JINDAL	CE (NPC)	CEA	jindal_pardeep@yahoo.co.in	9818768460	[signature]
6.	Preetam Banerjee	SE/WBSEDCL	WBSEDCL	preeban72@gmail.com	9432140765	[signature]
7.	S.S. BARPANDA	GM(MO), NLDC	POSOCO	ssbarpanda@posoco.in	9717296928	[signature]
8.	SHYAM SUNDER GOYAL	Sr. Engr (CTU-Plg)	POWERGRID	shyam.goyal@powergridindia.com	9911708044	[signature]
9.	M.A.K.P. SINGH	Member Secretary	NRPC	makpsingh@yahoo.com	9425066437	[signature]
10.	Upendra Kumar	S.E.	NRPC	upendra0309@gmail.com	9910180485	[signature]
11.	Kamlesh Jani	Deputy Engineer	UGVCL	janikamalesh1@yahoo.in, sldcugvcl@yahoo.co.in	9909940117	[signature]
12.	A.P. Shah	DE	SLDC, GETCO	sldcregen@gmail.com	9925212841	[signature]
13.	D.S. Chauhan	Executive Engineer	SLDC GETCO.	oasldc.getco@gmail.com, dschn3012@gmail.com	9925211044	[signature]
14.	A. K. GERA	Asst. V.P	BRPL	anand.gera@relianceada.com, anand.gera2011@gmail.com	9313898750	[signature]

S.No.	Name	Designation	Organization	E-mail Address	Contact No.	Signature
15.	SC SAXENA	DGM, NLDC	POSOCO	scsaxena@posoco.in	9910059972	
16.	K Anupam Kumar	Dy. Mgr., NLDC	POSOCO	kanupamkumar@posoco.in	9717724488	
17.	अनुपम कुमार	असिस्टेंट मैनेजर, NLDC	POSOCO	anupamkumar@posoco.in	8527990878	अनुपम कुमार
18.	R. M. Rangarajan.	SE.	SRPC	rm_rangarajan@yahoo.com	9449078899	R.M.
19.	G Chakraborty	DGM, NLDC	POSOCO	gchakraborty@posoco.in	9433041815	
20.				srpc.commercialdata@gmail.com		
21.						
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Annexure - 5

Genus
energizing lives

Ref: GPIL/Mktg./MPM/TNEB/M.1/170822
Date: 22th August -17

To,
Chief Engineer,
Material Management,
4" Floor, NPKRR Maaligai,
144, Anna Salai,
Chennai 600002.
Email: cemm@tnebnet.org

Sub: Change in Integration period from 15min. to 5 min regarding

Ref: LR. No. CE/MM/SE/MM-II/EEM/A2/M.1/D.98/17 DT. 21.08.17

Dear Sir,

We have noted the content of your letter mentioned under the reference and would like to submit following for your considerations –

Firstly yes, it is possible to program the MD Integration period from the existing 15 min. to 5 min. for ABT meter applications. This would be applicable to the new supply .We have however, few issues related to this change which are as under --

- As your kind selves are aware, the relevant Indian standard clearly defines MD integration period as 30/15 min. Therefore, in case of 5 min. period ,necessary amendment would be required in IS, so that the meter could confirms to the standards.
- Implementation of the same would require time period of min. 6-7 months period as this would require a major change in firmware. The requisite time would be requested , in case yourkindselves wish to implement the same.
- With the integration period fixed to 5 min. , it would not be possible to operate max demand calculation on Sliding window principle, it would be based on fixed 5 min. interval.
- Load survey capability , would be reduced accordingly as now we need to store the data on each 5 min. period as compared to 15 min. period earlier.

....contd.2

Genus
energizing lives

- With 5 mints integration period , every day total slots , in a day , to be stored in load survey would be –
  = 60/5 =12 slots*24hrs = 288 slots

Whereas for 15 mints Integration period , total slots to be read in a day = 60/15=4*24=96 slots
As it is clear that reading requirement would be increased by 3 times meter reading would take much more time.

- If your kind selves wish to keep the load survey capability same as in case of 15 min. Then the requirement of memory size would be 3 times and which would result into increase in price of the meter.

We request you to please provide due considerations to all the points , we have mentioned , while deciding this crucial matter,

Looking forward to your response .

Yours sincerely
For M/s. Genus Power Infrastructures Limited

(Authorized Signatories)

Annexure - 6

भारत सरकार
Government of India
केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority
पश्चिम क्षेत्रीय विद्युत समिति
Western Regional Power Committee
एफ -3, एमआयडीसी क्षेत्र, अंधेरी (पूर्व), मुंबई - 400 093
F-3, MIDC Area, Andheri (East), Mumbai - 400 093
दूरभाष Phone: 022- 28221681; 28250004; 28200195; फैक्स Fax : 022 – 28370193
Website : www.wrpc.gov.in
E-mail: comml-wrpc@nic.in

आई एस ओ : 9001-2008
ISO: 9001-2008

No.:WRPC/Comml-I/Corrs./2017/ 686 – 711 Date: 27.04.2017

To,
Chief Engineer (DP & D),
Central Electricity Authority,
Sewa Bhavan,
R.K.Puram, New Delhi

Sub: Proposed amendment in the CEA (Installation & Operation of Meters) Regulations 2006-reg.

Sir,

This is to inform that in the 33rd WRPC meeting held on 01.02.2017, it was decided to replace all the existing interface SEMs (Special Energy Meters) installed in Western Region, since most of the SEMs have crossed their useful life cycle(copy enclosed).

In anticipation of the Regulatory and technological changes, it was further decided to procure the SEMs capable of recording/storing of 5 mins as well as 15 mins block data of Frequency, Wh & VArh(low & high) along with suitability for transmitting the data to remote locations using appropriate communication medium (AMR). This will enable accommodation of any future regulatory requirement/change, such as change in "energy scheduling / recording block timings", in the SEMs being procured in WR.

It is therefore proposed to kindly amend clause (1) (b) (i), (ii), (iii) & (iv) of "Part II Standards for Interface meters" of the CEA (Installation and Operation of meters) Regulations 2006 notified on 17.03.2006, to accommodate the above provisions regarding integration/storage of data (i.e. interface meters capable of recording 5mins as well as 15mins block data of frequency, Wh & VArh (low & high)).

Yours faithfully,

(M.A.K.P. Singh)
Member Secretary

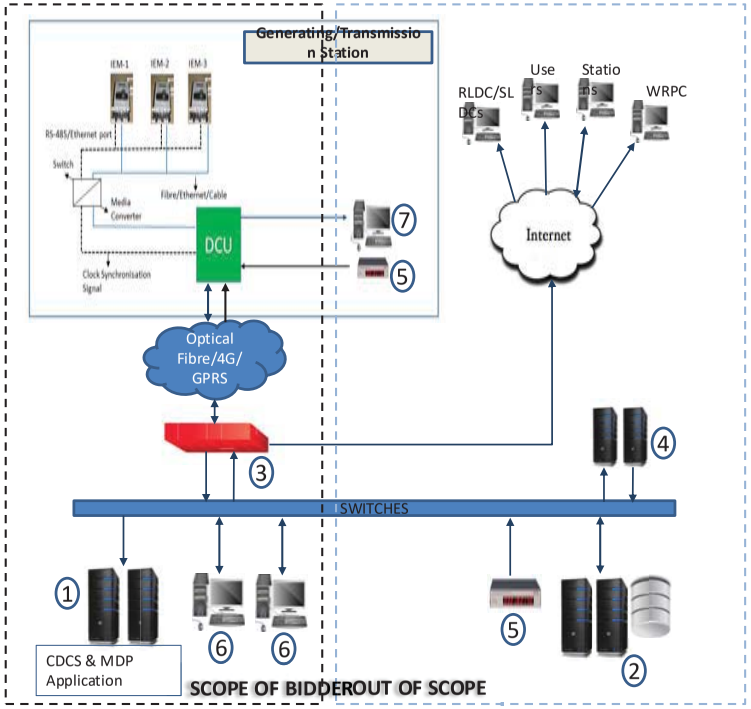
Copy to :
1. Chief Engineer (GM) Division, CEA, New Delhi.
2. General Manager, POSOCO, W.R.L.D.C., Andheri(East), Mumbai 400 093- for further needful

28/4

Approved
Technical Specifications for Interface Energy Meters
and
Automated Meter Reading System for Western Region

Project Scope

1. Replacement of all the existing Special Energy Meters.
   - 5 min
   - GPS synchronization
   - AMR compatible.
2. AMR system for data collection
   - Communication system & supporting software for data transfer from IEM to RLDC.
   - Meter data collection from stations to RLDC at user defined schedule/ on demand.
3. Hardware and Software system at RLDC for Meter Data Management
   - Data collection, Validation, Processing, Reporting, Archival and Website uploading.
   - Provision to send data from RLDC to Constituents on weekly basis.
4. Software for weekly energy account at RPC.



Sr.No.	Description
1	Application Server - Main & Standby
2	Oracle Database Server (Not in scope of bidder)
3	Firewall
4	Web Servers (not in scope of bidder)
5	GPS clock (not in scope of bidder)
6	Client PCs
7	Local PC at site (not in scope of bidder)

Bidder's responsibility

- Supply and Installation of end to end metering system.
  - IEMs, DCU, CDCS and Communication System, AMR and Data processing S/W etc.
- Maintenance of Metering System on call basis.
- Ensure healthiness of AMR including communication for timely collection of data at RLDC by 24 hrs of every Monday. In case of failure to deliver data there would be penalty for delay beyond due date.
- Meter testing after 5 years.
- Design document for end to end metering system.
- Training of Personnel (substation, SLDC, RLDC, RPC)
- Supplier should post a resident engineer to central site (RLDC) throughout the warranty and AMC period in order to diagnose and set right any problem in AMR system in minimum time.
- Supplier should post two skilled resident engineers to RLDC/RPC (One for maintenance of MDP & EA S/W at RLDC and other for DSM S/W at RPC) throughout the warranty and AMC period in order to diagnose and set right any problem in MDP, EA & DSM Accounting S/W in minimum time.

Scope : AMR

- Server System and Central Data Collection System (CDCS) at RLDC.
- Data Concentrator Unit (DCU) at each station.
- Connection of interface meters with DCU.
- Communication channels between each DCU and CDCS.
- All cabling, wiring, terminations and interconnections of the equipment.
- Database development, Displays and Reports.
- Software at Head End System (RLDC) to manage functionalities of
  - Scheduler and Data collection through DCU
  - Validation of data
  - Archival and Retrieval of data through Oracle database
  - Decoded text files in existing format
  - Standard database (RDMS) for storage of data at RLDC.
- Warranty for five years
- Support and Maintenance during 5 years of extended period after expiry of the warranty period.

Technical Specifications of IEM

- Each meter shall have unique code- **IEM-XXXXXXXX-A/B**
  - Series 1 for WR, 2 for NR, 3 for SR, 4 for ER, 5 for NER (1st digit)
  - Model A : Rated CT secondary 1 A;
  - Model B: Rated CT secondary 5 A
- All meters of the same model shall be totally identical in all respects except for their unique identification codes.
- Meters shall be suitable for communication with external device like modem, DCU, etc.
- Meters shall operate with power drawn from substation auxiliary power supply to reduce the VT burden. Provision to operate from VT secondary ckt as back up.
- The three line-to-neutral voltage shall be continuously monitored and in case any of these falls below defined threshold (70% of Vref), meter shall have suitable indication on LED/ LCD.
  - Low voltage logging in meter memory with "*"(5% to 70% of Vref) and "Z" (less than 5 % of Vref)

Standards to be complied with

- IS-15959:2011 Data Exchange for Electricity Meter Reading Tariff & Load Control – Companion Specification
- IS-14697:1999 Specifications for AC Static Transformer operated Watt Hour & VAR-Hour meters, class of 0.2S and 0.5S

Measurement Principle

Active Energy	Reactive Energy	Frequency	Voltage	Harmonics
• 3-Ph, 4 Wire Principle • 5 min Active Energy in block wise • Positive for Wh Export & negative for WH Import	• 3-Ph, 4 Wire Principle • 5 min Reactive Energy in block wise • Positive for WR Export & negative for WH Import	• Input is VT supply • Counts number of cycles in each block and divided by 300 • Stores in meters memory in HZ up to 2 decimal	• 3-Phase Average RMS voltage	• Only fundamental frequency components of WH, V and VARh shall be measured

Storage in IEM

- Non-volatile memory, Automatic storage
- Net Wh transmittal during each successive 5 min block (up to 2 decimal, rounding off)
- Cumulative Wh transmittal at each midnight, in eight digits including one decimal
- Net VARh transmittal during each successive 5 min block (up to 2 decimal, rounding off)
- Cumulative VARh transmittal at each midnight in eight digits including one decimal
  - High VARh when Voltage above 103 % of Vref
  - Low VARh when Voltage is below 97% of Vref
- Average frequency (5 min) in Hertz (up to 2 decimal, truncation)
- Date and time blocks of failure of VT supply on any phase, as a star (*)/ (Z) mark.
- Voltage (V) (up to 2 decimal, truncation)
- Meters shall store data in memory for 15 days

Metering Accuracy

Active Energy:	Reactive Energy:	Voltage and frequency:
0.2S, IS-14697	0.5S, IS-14697	0.5S or better

Clock:

- Accuracy of built-in calendar and clock is 10 sec/month or better.
- Automatic backup for continued operation of the meter's calendar-clock for at least 2 years.
- Intelligence to synchronize the time with GPS signal or through Central Data Collection System
- Limited time synchronization through meter communication port

Display

- Each meter shall have 12 character electronic display, for indication of following(one at a time), on demand.
  - Meter serial no. and model : IEM12345678A
  - Date (year month day) : 20170401 d
  - Time (hour min. sec.) : 195527 t
  - Cumulative Wh reading : 12345678.6 C
  - Average frequency of the previous block : 49.89 F
  - Net Wh transmittal during the previous block: - 28.75 E
  - Net VARh transmittal during the previous block: - 18.75 R
  - Average % voltage : 99.2 U
  - Reactive power (VAR) : 106.5 r
  - Voltage - high VARh register reading : 01234567.5 H
  - Voltage - low VARh register reading : 00123456.4 L
  - Auxiliary Supply failure indication
  - Low battery indication

Communication

- Optical port, RS-485 port and Ethernet port all together at a time and communicate independently.
- The Bidder may adopt best available technology as per site conditions
  - RF mesh/Optic Fiber/PLCC/4G/GPRS
- The bidder shall design a reliable, interference free & robust communication network keeping in view the site conditions
- The Bidder shall provide the necessary software which would enable a local PC/ HES to:
  - To download data from Optical/RS485 port
  - Polling feature to run data downloading S/W
  - To import data in a S/W for processing
  - To transmit collected binary data through appropriate communication link
  - To convert the binary files to test files
- Performance levels for collection of meter readings
  - All interval data from 99.99% of meters shall be reported to HES within 24 hours after the scheduled hour.
  - Day wise Compounding penalty for delay beyond 1200 hrs of Tuesday

Testing

- All equipment's before despatch from manufacturer's work, shall be duly tested.
- Routine and acceptance tests shall be carried out on the meters in line with IS 14697
- Any meter which fails to fully comply with requirements shall be liable to be rejected by the Owner
- Acceptance tests for IEMs
  - Downloading Meter Data from the Meter(s) to PC
  - Compatibility with PC Software
  - Functioning of advance and retard time commands
  - Per meter downloading time verification.

Warranty

- 60 months for the meter
- Warranty includes repair, replacement, part material replacement cost and one way transportation cost.
- Defective/Inoperative meters should be removed within one month of receipt of request

– Meter testing after 5 years and AMC support for 5 years after warranty