# INTERFACE ENERGY METERING SYSTEM - EXPERIENCE AND RECENT INITIATIVES IN INDIA

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***Abstract*—This paper shares the experience associated with the existing interface energy metering system in India. It also dwells upon the prevailing challenges in the administration of metering infrastructure, testing, time synchronization, diagnostics, metering errors, meter data collection, validation, processing and preparation of energy statements. It proposes the desirable features of the new generation of interstate metering system such as smaller data integration period, automated meter data reading system and advanced meter data management system. The paper highlights the need for implementation of the SAMAST framework and shares the recent initiatives at various levels for implementation.**

**Keywords—Energy metering, settlement**

## I.INTRODUCTION

The Availability Based Tariff and Unscheduled Interchange mechanism (ABT/UI) at the interstate level in India mandated by the Hon'ble Central Electricity Regulatory Commission vide its order in January 2000 brought a paradigm change in the inter-utility energy accounting [1]. The accumulation energy meters (mechanical) at the inter-utility interface points were replaced by 15-min interval meters (Special Energy Meters, digital). The Special Energy Meters has an internal clock and are capable of recording active/reactive energy, voltage and grid frequency accurately and in a tamper-proof manner in pre-defined time interval of 15-min (one time block). The meter data is downloaded every week with the help of a hand held unit through the optical port and transferred over email to the control centre in an encrypted format. The CEA Metering Regulations that were notified in 2006 [2] standardized the metering infrastructure in India.

Pursuant to the unbundling of state electricity boards and introduction of open access in transmission, the experiment at the interstate level was replicated in several States, though with varying degree of success. With the growing penetration of renewable energy, there is a thrust towards economy transactions, sharing of resources and improving the efficiency of operations. There is a growing interest in interval meters and smart meters for demand side management. The need for faster markets calls for increasing the granularity of metering.

## II.EXISTING METERING INFRASTRUCTURE

Section 6.4.2.21 of Indian Electricity Grid Code (IEGC) [3] mandates that the CTU shall install special energy meters (SEM) on all inter connections between the regional entities and other identified points for recording of actual net interchanges with the grid. All concerned entities (in whose premises the SEMs are installed) take weekly readings and transmit them to RLDC by Tuesday noon.

The number of SEMs installed at various interconnection points in Western Region is 1695 (as in June 2018) and number of entities (injecting/drawee) under the jurisdiction of Western Regional Load Despatch Centre is 52. Out of 52 entities, 41 entities are generating stations and rest 11 are Drawee entities. The approximate inter-utility SEM distribution in India is shown in Table 1.

**Table 1: Population of interstate energy meters in India**

| Total No. of SEMs installed in India (as on 01/11/18) | | | | | | |
|---|---|---|---|---|---|---|
| Type | WR | NR | NER | ER | SR | Total |
| Main | 798 | 789 | 154 | 390 | 470 | 2601 |
| Standby | 688 | 940 | 244 | 763 | 890 | 3525 |
| Check | 209 | 211 | 45 | 103 | 90 | 658 |
| Total | 1695 | 1940 | 443 | 1256 | 1450 | 6784 |

The encrypted meter data received at RLDC is decoded through the proprietary software

provided by meter vendors. Data validation and processing is through an in-house software. The inconsistent/erroneous main meters data is replaced with the standby/check meters data.

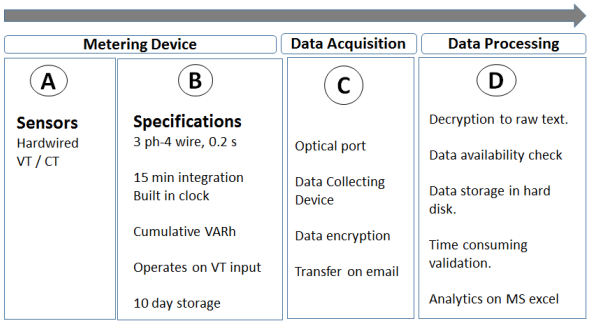


**Figure 1: Existing metering architecture**

The entire raw and processed data is uploaded on the RLDC website and forwarded to the secretariat of the Regional Power Committee (RPC) for preparation of various regulatory accounts like Deviation account (DSM), Regional Energy Account (REA), Regional Transmission Deviation Account (RTDA), Reactive Energy Charges Account (REC), and Congestion Charges Account (CCA) etc. Consequently the regulatory accounts are settled. The typical amount settled through various western regional regulatory accounts mentioned above is shown in Table 2.

**Table 2: Typical amount settled weekly in regulatory pool account in Western region**

| S.No | Account | Period | Rs in crores |
|---|---|---|---|
| 1 | Deviation Settlement | Weekly | 80 |
| 2 | Reserves Regulation Ancillary Services | Weekly | 6 |
| 3 | Regional Transmission Deviation | Monthly | 4 |
| 4 | Reactive Energy Charge | Weekly | 2 |
| 5 | Congestion Charge | As and when imposed | 2 |
| | Total | | 94 |

The meter data is also used for computation of average regional ISTS losses. The loss arrived from meters data of last week (W-1 week) is used as scheduled loss for next week (W+1 week).

## III.PREVAILING CHALLENGES IN METERING

The meters data is used for commercial settlement of interstate power and scheduling purpose. It is important to ensure the accuracy, availability and redundancy of metering system. The challenges observed in the existing metering infrastructure are listed below [4]:

- Meters are hard coded without any provision for software upgradation
- Most of the old SEMs are AMR non-compliant
- Non-availability of facility for automatic time synchronization with GPS leads to drift in meter clock. Limited time correction is possible through DCD at site (1 minute/week).
- Limited data storage capacity (10 days)
- Challenges in exception management
- Challenges in data collection.
- Challenges in downloading the data using DCD due to battery failures, display failures, data extraction errors, cable problems etc.
- Extraction of processed meter data for desired elements is tedious and time taking. Limitations are faced during validation, processing of meters data and preparation of energy statements
- Limitations in the existing meter data processing software for handling large number of meters at one time.
- Compatibility issues in downloading and processing of meter data from meters of different make due to proprietary software
- Data Collecting Device is three times costlier than the meter
- Onsite testing of meters is a costly affair
- Challenge in Reactive Energy validation due to availability of only day wise total cumulative reactive energy (high voltage /low voltage) values.

## IV.EMERGING SCENARIO

Capacity of Renewable Energy Sources (RES) in the grid is growing at a fast rate. Efforts are being made to enable the RES to participate in the electricity market. Competition in generation is being encouraged through open access in transmission and distribution. Transmission system is being strengthened to facilitate intrastate/interstate/transnational transactions and achieve economy in the market competition. New products are being introduced in the electricity market for enhancing flexibility and ensuring energy balance in the grid. Experts recommend higher granularity of scheduling, despatch and settlement period for economic deployment of

reserves and ancillary / flexibility services to complement grid reliability [5, 6, 7, 8, 9].

## V.SAMAST FRAMEWORK

The emerging scenario and the challenges in settlement of transactions in the electricity market were deliberated in detail in the report on scheduling, accounting, metering and settlement of transactions in electricity (SAMAST) published by the Forum of Regulators in July 2016 [8]. It states that – "*The financial settlement of all energy transactions whether from conventional or renewable; whether intra state or interstate or transnational; would ultimately require scheduling and book keeping besides a tamper-proof, robust, scalable and dispute free energy metering, accounting and settlement system…The integrity, probity and timeliness of the energy accounting and settlement system are indispensable for the viability, financial stability and sustainability of the sector.*"

The report recommends that "*the electricity energy accounting procedure should comply with the accounting principles of 'economic entity', 'accrual', 'going concern', and double entry. The energy statements should have all the attributes of 'understandability', 'relevance', 'reliability', and comparability as enumerated in the standards for financial accounting*"

The report highlighted the following requirements for establishing a robust infrastructure for interface energy metering in India:

- Harmonization of the technical specifications for interface energy meters
- Ensuring adequacy and redundancy of metering
- Automated time synchronization of meter clock
- Maintenance, testing and calibration
- Automated data collection and bad data detection
- Redundant communication system meter data transfer
- Robust and scalable IT infrastructure for data processing and preparation of energy statements
- Updating of metering standards

The Forum of Regulators endorsed the SAMAST – framework and suggested that the utilities could avail financial grant from the Power System Development Fund (PSDF) for implementation.

## VI.INITIATIVES IN WESTERN REGION

Considering aging of energy meters, the uneconomical cost of on-site testing of meters, prevailing challenges in meter data collection and the recommended SAMAST framework, the 33rd Western Regional Power Committee decided to get all the SEMs replaced with AMR compliant meters (15-min meters with 5-min features) in Western region. WRLDC was assigned the responsibility of preparing specifications.

Based on the inputs from the leading meter manufacturers in India and in consultation with the RLDCs/NLDC, the model technical specifications of Interface Energy Meters (IEM) provided in the SAMAST report were improved upon. The implementation of AMR and meter data processing system at WRLDC was also included in the scope of work. A comprehensive specification was deliberated in the WRPC forums and finally approved on 8th July 2017 in the 34th TCC/WRPC meeting [10].

## VII.DEMO OF 5-MIN METERS

An initiative was also taken to study the feasibility of re-configuring the new generation of SEMs for data integration at 5-min interval. Accordingly a demo was conducted at 400/220kV Magarwada substation in UT Daman and Diu on 13th Sep 2017 and at 765/400/220kV Vadodara substation in Gujarat on 10th Oct 2017. Three meter vendors participated in demonstration. The objectives of the demonstration were as under:

- To test the feasibility of re-configuration of integration time in existing SEM
- To assess the adequacy of reconfigured SEM (5-min) memory for shorter integration period
- To check if the output from the reconfigured SEM (5-min) is in standard format or not
- To validate data from the reconfigured SEM (5-min) by comparing it with existing SEM (15-min)

The methodology adopted for demo was as under:

- The reconfigured SEM (5-min) was installed in series with the existing SEM (15-min) on a selected feeders

- Time synchronization of the SEM (5-min) was done with the SEM (15-min)
- Initially, demo meters were configured for data accumulation at 15-minute interval and were kept in service for two hours.
- 15-minute interval data from demo meters was extracted after two hours and subsequently, the demo meter was reconfigured at site for data accumulation at 5-minute interval.
- The demo meters were kept in service for more than ten days to check the adequacy of meter memory for 5-minute interval

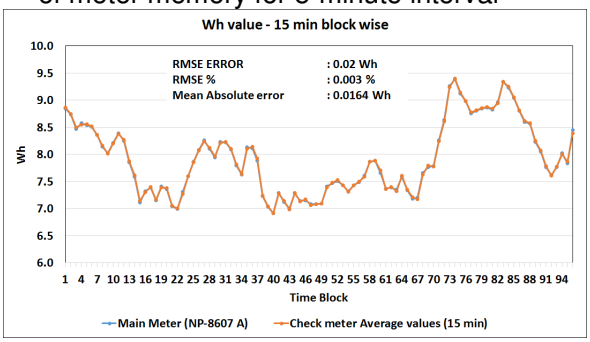


**Figure 2: Active Energy Comparison of Existing 15-minute meter and new demo meter**

The active energy (Wh value) recorded for three consecutive time blocks of 5-minute were aggregated to arrive at the active energy for 15-minute interval. Frequency value of three consecutive time blocks of 5-minute were averaged to arrive at 15 minute average frequency. The comparison of 15-minute interval active energy and frequency data recorded by existing 15-min meter and demo 5-min meter is shown in Fig. 2 and Fig. 3 respectively.

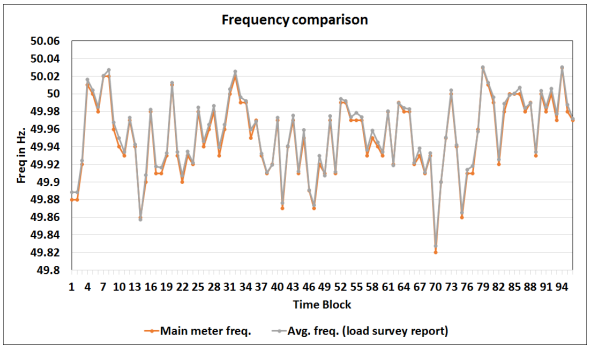


**Figure 3: Comparison of frequency recorded by 15-minute meter and demo 5-min meter**

The key learnings from the 5-minute meter demonstration were as under:

- Reconfiguration of the meters for a shorter integration time is possible in certain make of meters
- The recording of active energy and frequency at 5-min interval is satisfactory.
- The recording of reactive energy at every time block is possible if the feature is enabled
- The reconfiguration is not possible in the older version of SEMs. The old meters are AMR non-compliant
- The software for reading the meter data needs to be developed.
- There is a need for enhancement of the meter storage, strengthening the communication infrastructure, standardization of data and information protocols
- There should be adequate safeguards to ensure that the meters are tamper-proof.

## VIII. ENVISAGED INTERSTATE METERING SYSTEM

The architecture for the future interstate metering system in Western Region was developed based on learning from the existing challenges in metering and the best practices in Automated Meter Reading / Advanced Metering Infrastructure. Key features are illustrated in figure-4 and 5. Brief description is as under:

### A. Advanced Interface Energy Meters

The desirable features for new generation of interface energy meters are given below.

- Capable of recording frequency, active energy, reactive energy, voltage for every time block.
- Compliant to IS-15959 and IS-14697
- Shall be equipped with communication ports for communication with external device like modem, Data Collection Unit etc.
- Operate with power drawn from substation auxiliary DC power supply to reduce the VT burden with a provision to operate from VT secondary circuit as a back-up.
- Low voltage logging in meter memory with “*”(5% to 70% of Vref) and “Z” (less than 5 % of Vref)
- User configurable integration period (5 min/ 10 min / 15min etc.)

- Automatic meter clock synchronization from master GPS stationed at Central Data Collection Centre.
- Interoperable meters.
- Active energy, Reactive Energy storage up to 4 decimals in the memory.
- Shall be able to report their healthiness status to the central system.

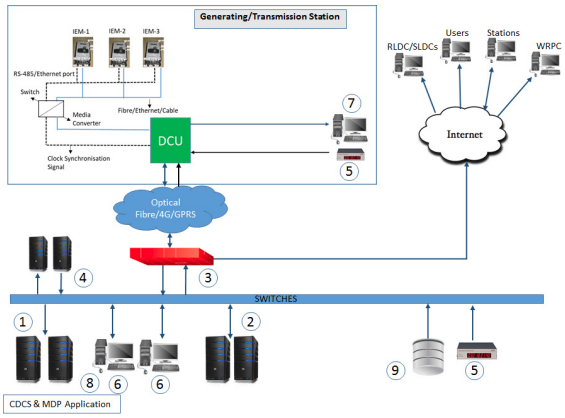


**Figure 4: New System Architecture**

| Sr.No. | Description |
|---|---|
| 1 | Application Server - Main & Standby |
| 2 | Database Server |
| 3 | Firewall |
| 4 | Web Servers |
| 5 | GPS clock |
| 6 | Client PCs |
| 7 | Local PC at site |
| 8 | Network Management System |
| 9 | Storage |

## B. Automated Meter Reading (AMR)

The desirable technical features for AMR system to automate the task of data collection from each meter/location are given below.

- Preferable communication system for data transfer from energy meter to Data Concentrator Unit (DCU) shall be optical fibre.
- Communication system from DCU to Central Data Collection System (CDCS) shall be Optic Fibre /4G/3G
- Provision for data transfer from station to RLDC at user defined schedule/on demand.
- AMR system shall be capable to transfer GPS signal to meter for automatic time synchronization
- AMR system shall be capable of configuration changes in meters from remote end through authorized approach
- AMR system shall have self-monitoring functions to monitor the operating conditions and the performance of the system and reporting of abnormalities.

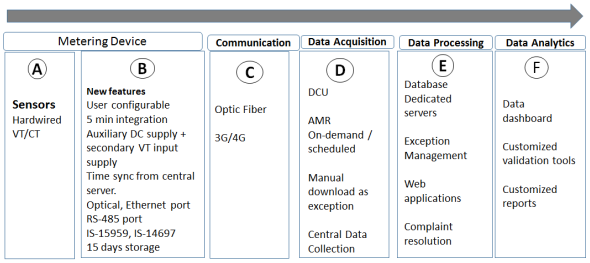


**Figure 5: Envisaged process flow**

## C. Meter Data Processing and Reporting

The MDPR system shall have strong database system having compatibility to exchange and share data / information with similar Database systems that may be used by other RLDC / NLDC with a view to meet requirements of Data Warehousing and Business Intelligence systems etc. The Client Interface shall be Browser/console based and report formats shall be in user defined multiple formats like PDF, MS Excel, CSV, Text etc. The MDPR system shall have the compatibility of automatic validation and replacement of erroneous data with pre-defined check/standby meters data with application of predefine loss percentage. MSPR shall also have following features.

- Provision for computation of regional/ICT (765/400kV, 400/220kV etc,)/line losses for user defined time period
- Graphical representation of data in user selection chart types (Bar/Pi/Area/Line etc.)
- Meter data analytics (Big data Analytics)
- Pre-defined data access to constituents via webpage
- Provision for addition/deletion of meters/entities
- User configurable formulae and reports

## IX.ROADMAP

The Technical committee of the Forum of Regulators constituted a sub-group in May 2017 to examine 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. The sub-group had representatives from CEA, CTU, RPCs, SLDCs, POSOCO and CERC staff. The sub-group also referred the WRPC approved specifications and interacted with meter manufacturers. It recommended transition to fast markets; implementation of 5-min scheduling despatch, metering, accounting and settlement; implementation of 5-min bidding in OTC and power exchange, pan-India pilot project for 5-min metering, amendment in the metering standards. It also suggested a roadmap for implementation across all regions. [9]

In May 2018, POSOCO submitted proposal to implement a pilot on fast response ancillary services through hydroelectric power stations along with 5-Minutes, scheduling, metering, accounting and settlement and requested for suitable directions from the Commission. Subsequently, CERC vide its suo motu order in petition No. 07/SM/2018 [11] mandated that all future procurements of Interface Energy Meters should ideally have recording at 5-min interval and frequency resolution of 0.01 Hz. They should be capable of recording vvoltage and reactive eenergy at every 5-min and should have feature of auto-time synchronization through GPS/NavIC. CERC also directed POSOCO to implement 5-minute metering covering hydro stations in NR, ER and NER as well as thermal stations with AGC installations in all five regions to gain experience which 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.

## X.ENVISAGED CHALLENGES

Available literature lists several challenges in AMR related projects [12-19]. The envisaged project is unique in several respects. It is the first project that conceives installation and operation of 5-min metering system with optic fibre based AMR at interstate level and remote time synchronization of meters. The success of the envisaged system depends on availability of reliable communication and interoperability among equipment from different manufacturers. The use of a common communication protocol is fundamental. Therefore compliance to IS- 15959 and IS-14697 is being insisted. Improving resolution of meter data from 15-min to 5-min would increase the volume of energy meter data by three times. Thus handling the increased data volume would also be crucial.

## XI.SUMMARY

This paper shares the experience and challenges associated with the existing metering system at interstate level. The paper also discusses the need for up-grading the metering system to facilitate integration of renewable energy sources at a large scale and for the development of niche markets for ancillary and flexibility services. This paper emphasise the need of a holistic solution in the metering system which caters to our end to end requirement. It shares the envisaged features of the interface energy metering system at the interstate level as evolved after extensive consultations with various stakeholders and the recent initiatives taken by the Forum of Regulators, Central Electricity Regulatory Commission and POSOCO for evolution of fast markets and robust energy scheduling, accounting, metering and settlement system in India.

## XII.ACKNOWLEDGEMENT

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