



Interface Energy Metering- Experience and Expectations

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Workshop on “Technical and Testing Challenges for Smart Meters”



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National Smart Grid Mission
Ministry of Power
Government of India

National Smart Grid Mission

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Interstate Energy Settlement-Background

- Availability Based Tariff and Unscheduled Interchange mechanism (ABT/UI)
 - mandated by the Hon'ble CERC vide its order in January 2000
 - frequency linked deviation settlement for every 15-min time block
- Required New Generation of Energy Meters with internal clock and battery
 - 3-ph, 4-wire
 - Active
 - Reactive energy
 - Grid frequency accurately at every 15-min and in a tamper-proof manner
- Special Energy Meters (SEM) as well as the associated hardware/software for data downloading, validation and processing were custom-developed
 - Rolled out in the five regional grids in phases between 2002-2003
- The CEA Metering Regulations paved way for standardization of the metering infrastructure in India

Special Energy Meters- features

- Application Specific Microprocessor based solid state Energy meter
- Records Active Energy for every 15-min time block in Wh. (+ve sign for Wh export and a –ve sign when there is a net Wh import)
- Two reactive energy registers, one for the period when average RMS voltage is above 103% and for the period when the voltage is below 97%
- Working voltage of 63.5 V (Ph to N)
- Accuracy class of 0.2S
- Two types: 110 V,1 A and 110 V, 5 A
- Operates from power drawn on secondary side of PT
- Instrument Transformers of 0.5S accuracy class
- Stores data for a period of ten days, FIFO
- Operating Voltage range +20% to -30% of Rated Voltage
- Operating Current range 0.2% to 200% of Rated Current
- Limited Time drift correction- 1min/Week
- Frequency Step size-0.02 & 0.01 HZ
 - 0.01HZ Step size meter on 400KV Mahan line at Korba STPS- DSM Accounting



Inter-utility Metering in Western Region

Control Areas in WR-57

Entity Name	No.
Injecting Entities	46
Drawee Entities	11

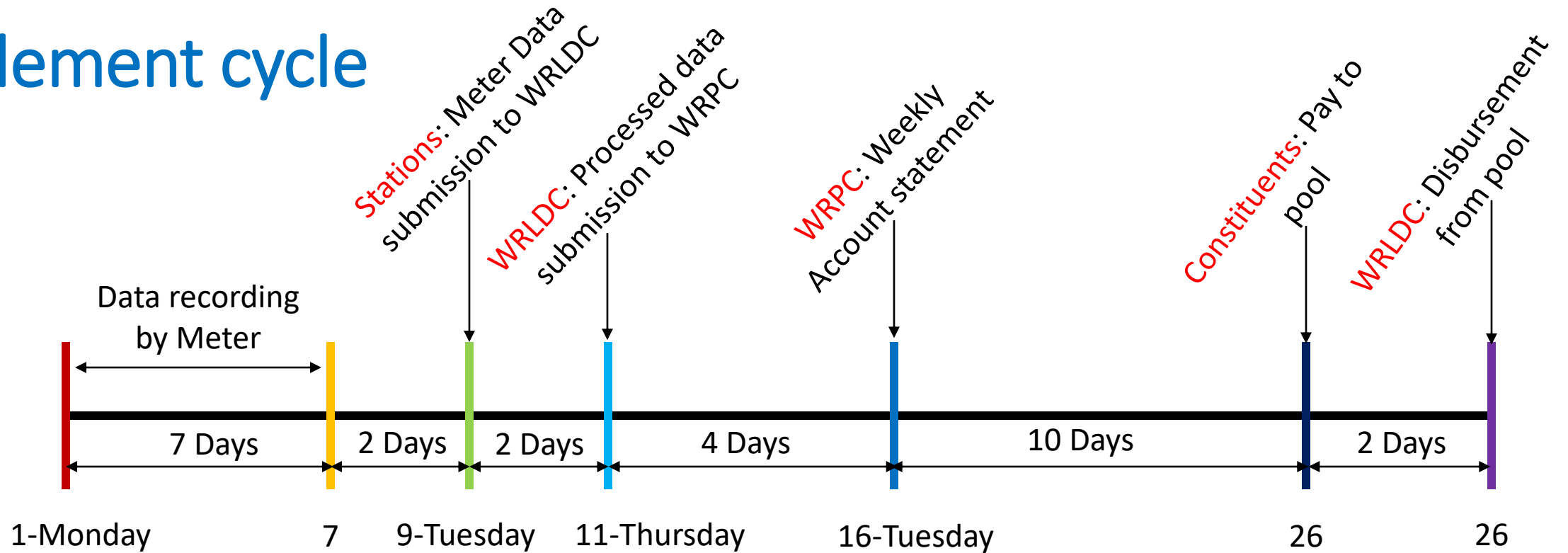
Main Meters	Standby Meters	Check Meters
648	634	188

SEM Make	No.
Secure	648
L&T	580
Honeywell Elster	242
Total	1470

Station Type	No. of Meters
Transmission Station	856
Generating Station	614

S.No	Number of locations with	Locations
1	0-5 meters	59
2	5-10 meters	44
3	10-15 meters	23
4	16-20 meters	19
5	> 20 meters	16
Total number of locations		161

Settlement cycle

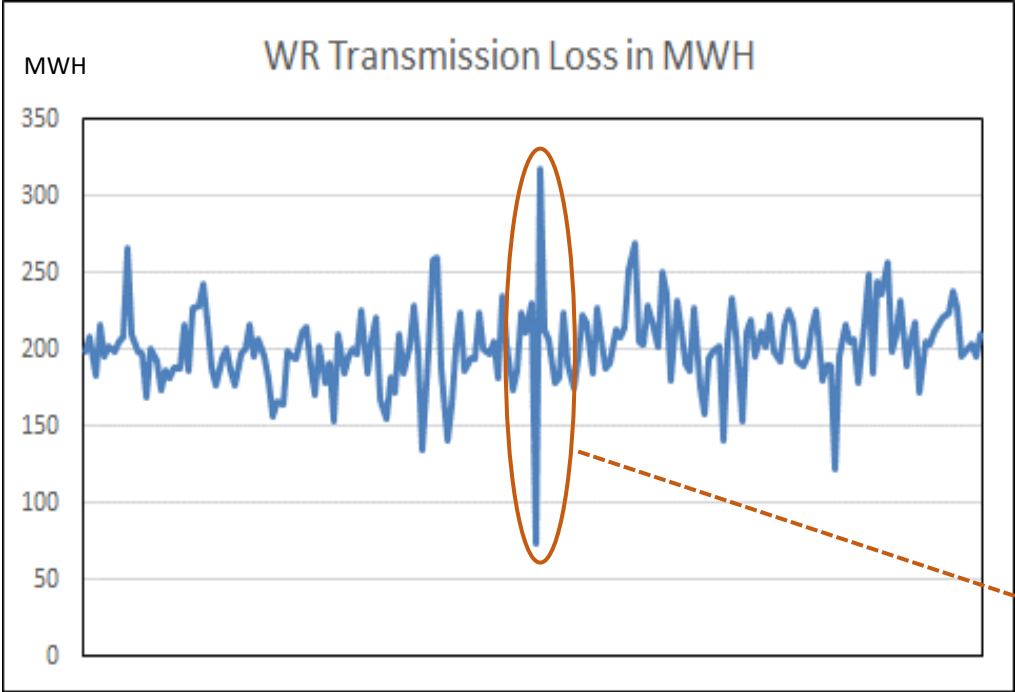
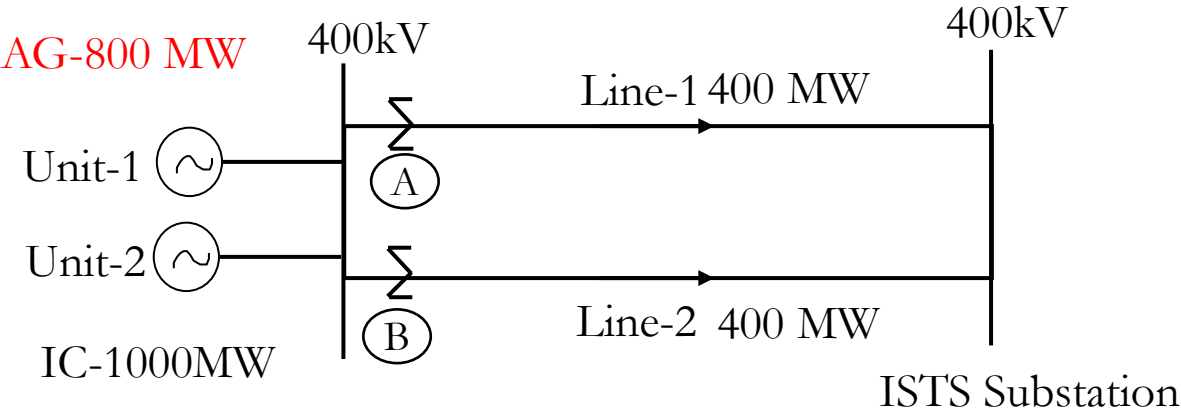


Typical amount settled through WR-Pool Accounts	
Account	Rs in crores
Deviation Settlement	100
Reserves Regulation Ancillary Services	6
Regional Transmission Deviation	4
Reactive Energy Charge	2
Congestion Charge	1.5

Case Studies

- Case Study-1: Time Drift
- Case Study-2: Under recording
- Case Study-3: Voltage reference
- Case Study-4: Data extraction and transfer

Case Study-1: Time drift



03/11/2017

Line-2 tripped at 05:30 hrs and restored at 06:00 hrs

Assumption:

Time Drift in Meter-A =0

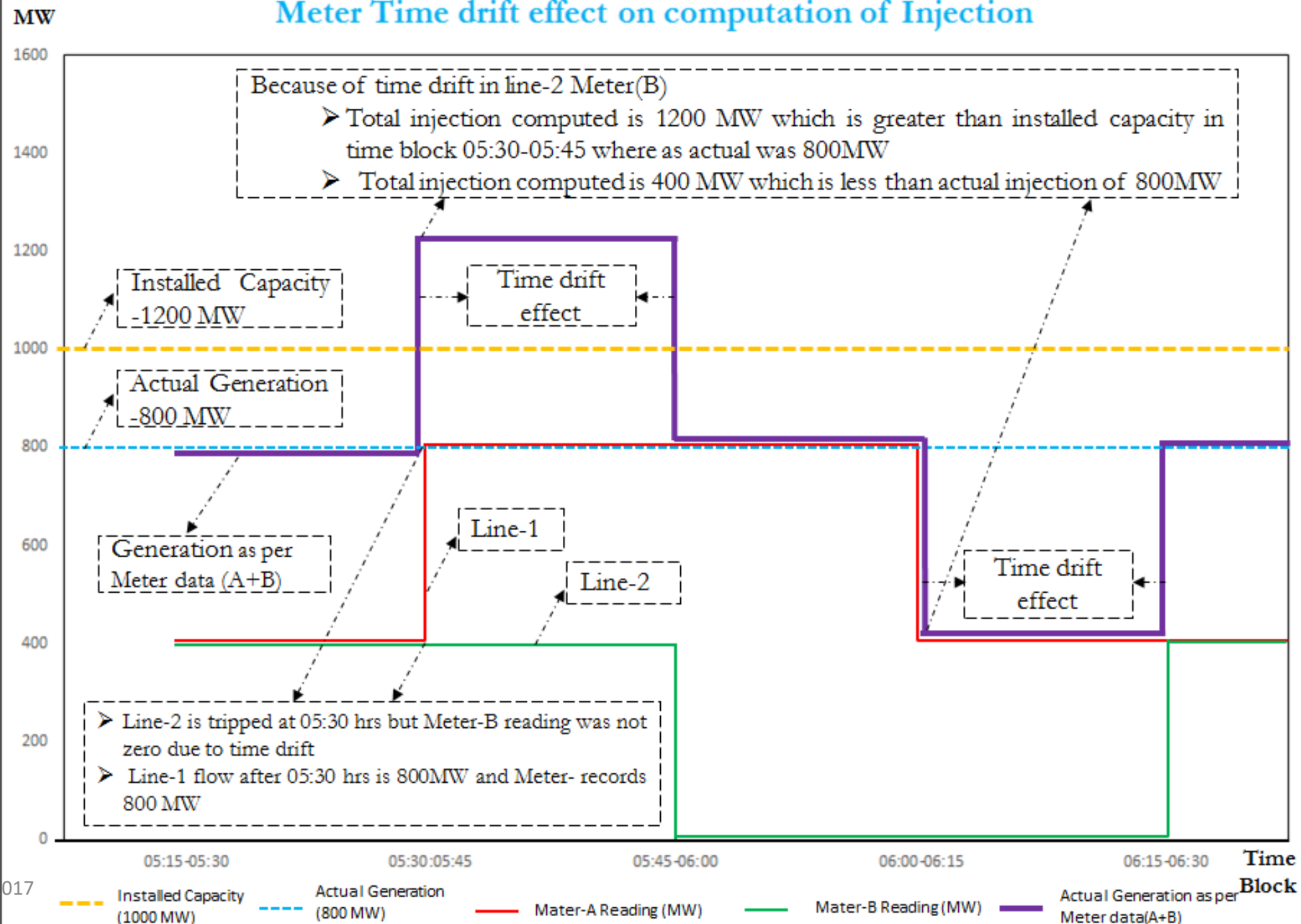
Time Drift in Meter-B =15min

Time Blk	Line-1 (Meter-A) MWh	Line-2 (Meter-B) MWh	Metered Injection (A+B) MWh
05:15-05:30	100	100	200
05:30:05:45	200	100	300
05:45-06:00	200	0	200
06:00-06:15	100	0	100
06:15-06:30	100	100	200

Due to Time drift in Meter B, Total injection is 1200MW (300*4) which is higher than installed capacity

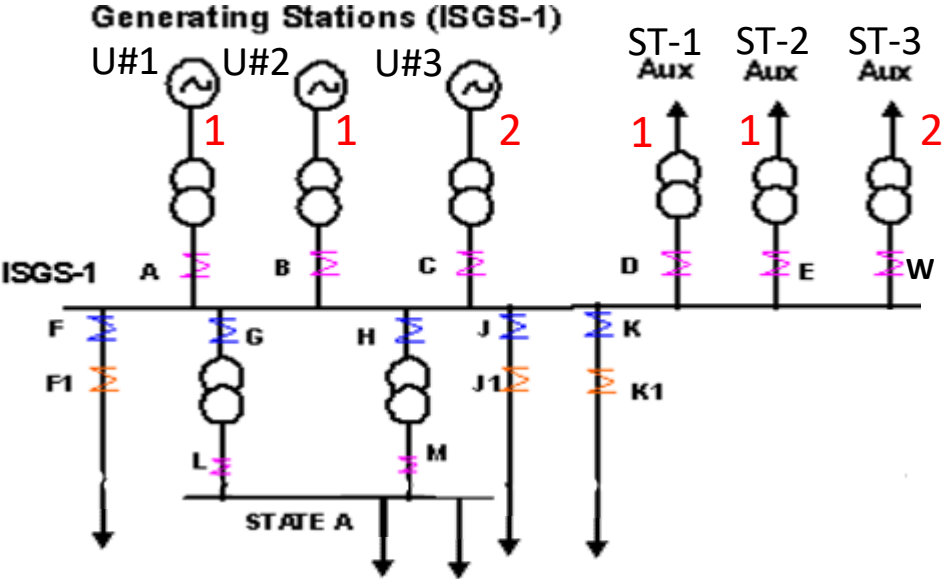
Sudden spikes in transmission loss is due to tripping/restoration of Generators/transmission lines/ICTs whose meters have large time drift

Meter Time drift effect on computation of Injection



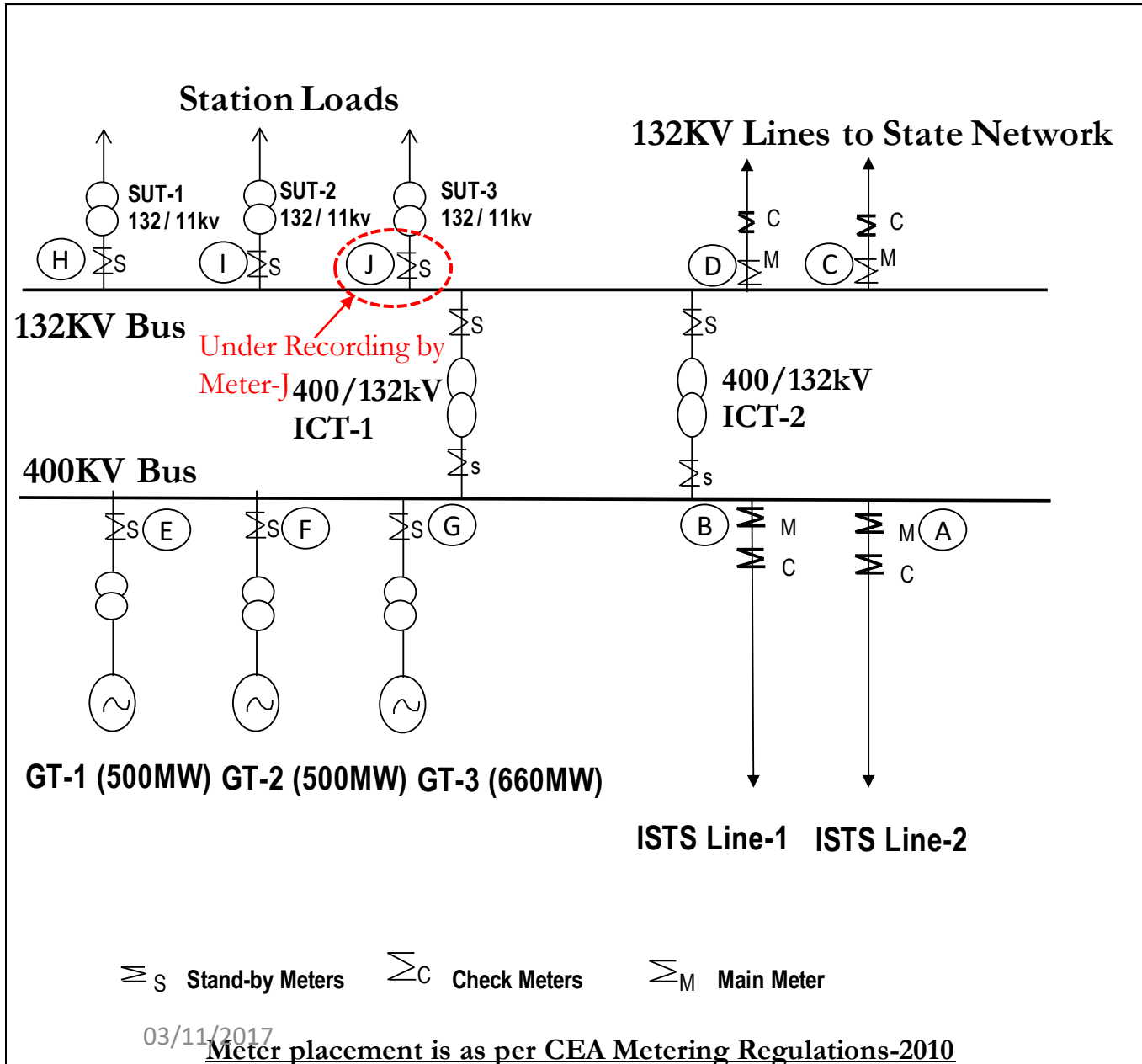
Case study-2: Under-recording of Meters

- **Generating Station with one Stage:** Total injection is computed from main meters in outgoings lines
- **Generating Station with multiple stages:** Stage-wise ex-bus injection is computed by apportioning Total injection in proportion to reading of respective meters on HV side of Generator Transformer & Station Transformer



Net Injection at outgoing feeders	$U1 = F+G+H+J+K$
Stage-1 Generation (GT+ST total)	$U2 = A+B+D+E$
Stage-2 Generation (GT+ST total)	$U3 = C+W$
Stage-1 + Stage-2 Generation	$U4 = A+B+D+E+C+W$
Stage-1 ex-bus injection	$U5 = (U1*U2)/U4$
Stage-2 ex-bus injection	$U6 = (U1*U3)/U4$

Cont.

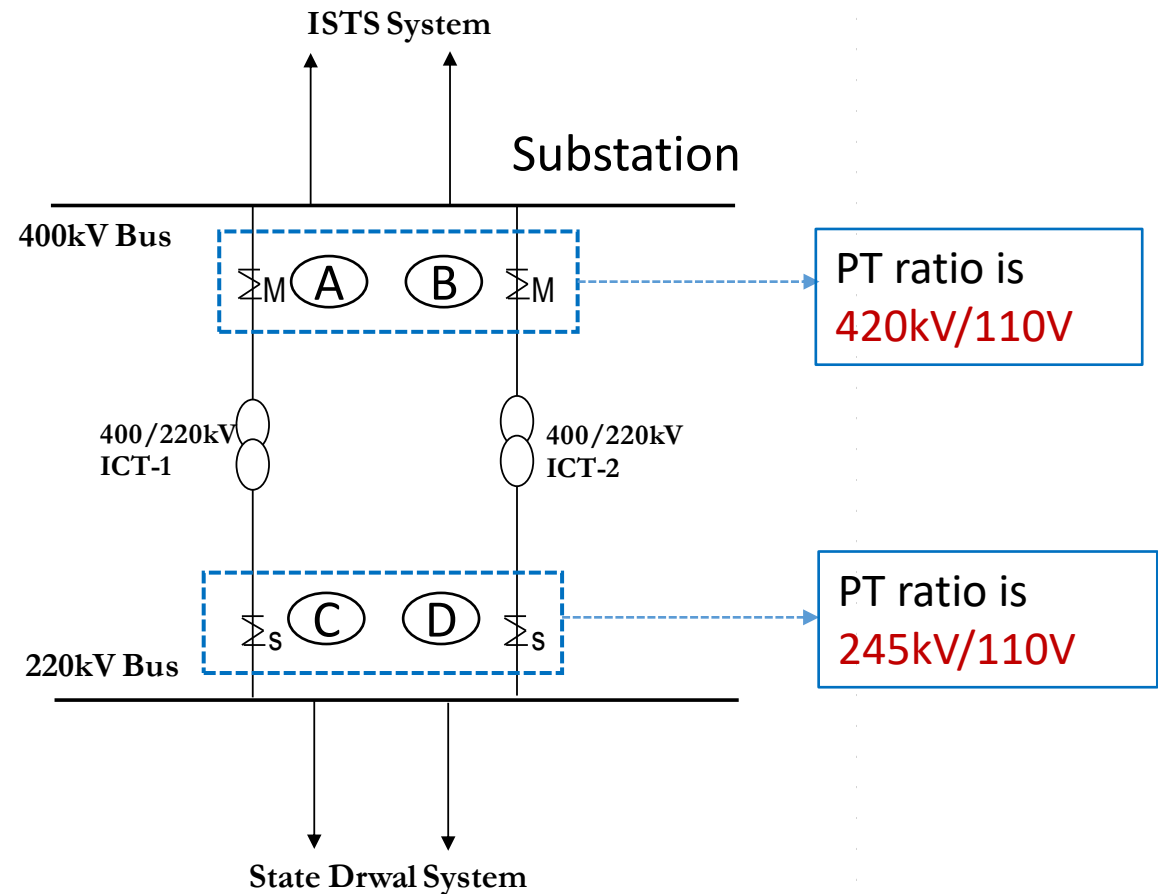


- Meter-J: Under recorded
- One of the Voltage input phases was open
- No standby meter for GT & ST side meters
- Apportionment of ex-bus generation w.r.to Stage-1 and 2 GT & ST Meter readings was erroneous
- Auxiliary Power Consumption of Stage-1 (Firm Generators) was increased and Stage-2 (Infirmer Generators) was decreased
- Applied M.F of 1.5 on ST-3 Meter reading during revision

Net Injection at outgoing feeders	$K = A+B+C+D$
Stage-1 Generation (GT+ST total)	$L = E+F+H+I$
Stage-2 Generation (GT+ST total)	$M = G+J$
Stage-1 + Stage-2 Generation	$N = E+F+G+H+I+J$
Stage-1 ex-bus injection	$O = (K*L)/N$
Stage-2 ex-bus injection	$P = (K*M)/N$

Case study:3 Voltage Reference Issue for Reactive Drawl Computation

- State-A drawl from substation= A+B



Voltage Level (kV)	PT Ratio	Lower Threshold (kV)	Upper Threshold (kV)
400	400kV/110V	388	412
400	420kV/110V	407.4	432.6

- IEGC: Reactive energy charges are applicable for Voltages “<97%” and “>103%”
- For 400kV/110V PT →Secondary rated voltage-63.5 V
- Logic in meter
 - Meter measures reactive interchange if voltage is “< 97% of 63.5” & “>103% of 63.5”
- Logic is incorrect for PTs other than standard ratios
- For 420kV/110V PT → 63.5 corresponds to 420kV
- Substation is GIS-
 - Spares are not available
 - Challenge in PT replacement
- Issue was addressed on site by changing reference voltage
- No hardware changes were done

Modified Logic

- For 420kV/110V PT
 - 420kV→63.5V (Secondary phase voltage)
 - 400kV→60.5V (Secondary phase voltage)
- For 245kV/110V PT
 - 245kV→63.5V (Secondary phase voltage)
 - 220kV→57.0V (Secondary phase voltage)

Case study-4: Data Extraction and Transfer Issues

Data Collection Device(DCD):

- Data extraction from Meter through DCD- Costs 3 times more than a meter.
- No spare DCD's at Stations.
- Limited time synchronisation capability
- Data extraction-Manual
- Data loss due to late data downloading
- Issues-Battery drain/Cable problem/Post problem etc.

Data Transfer to WRLDC:

- Data transfer- Email
- Manual downloading of data at WRLDC
- Station wise check- Data availability- Communication to stations for non receipt of data
- Time consuming.

Limitations in existing Metering Infrastructure in WR

- Hard coded meters with no provision for S/W upgradation
- No standard protocol in meters like DLMS
- No AMR System for Data Transmission
- Manual intervention for Data decoding for each meter data
- Frequency storage in Codes-Memory constraints
- Data extraction through DCD – DCD is costlier than Meter
- Frequency resolution-0.02Hz except 5 meters of 0.01 HZ in WR.
 - Frequency and time drift validation-Accurate if we go for 0.01 Hz
- Reactive energy measurement under HV and LV for standard PT ratios only
- Difficult to validate under recording of meters during low power flow cases
- Limited time synchronization facility (1 min/Week)-No provision for automatic time synchronization.

Emerging scenario

- RES integration
 - Ensure harmony of sharp rise/fall in RES generation with sharp reduction/rise in conventional energy sources
 - Ramping challenges
- Regulatory changes
 - Tightening of frequency band – Change from 0.02 to 0.01 Hz
 - DSM vector being reviewed
 - New market products being introduced under ancillary and flexibility services
- Reduction of settlement time period from 15-min to 5-min being deliberated
- Sub-group has been formed under Forum of Regulators feasibility of 5-minutes settlement

Demo of off-the-shelf Interface meters

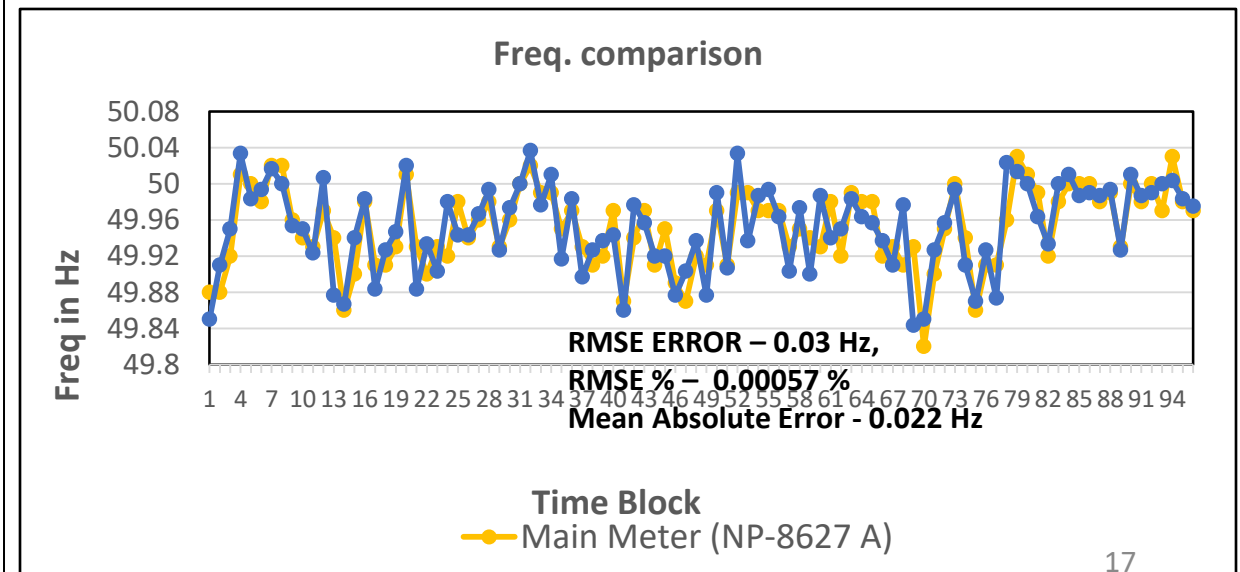
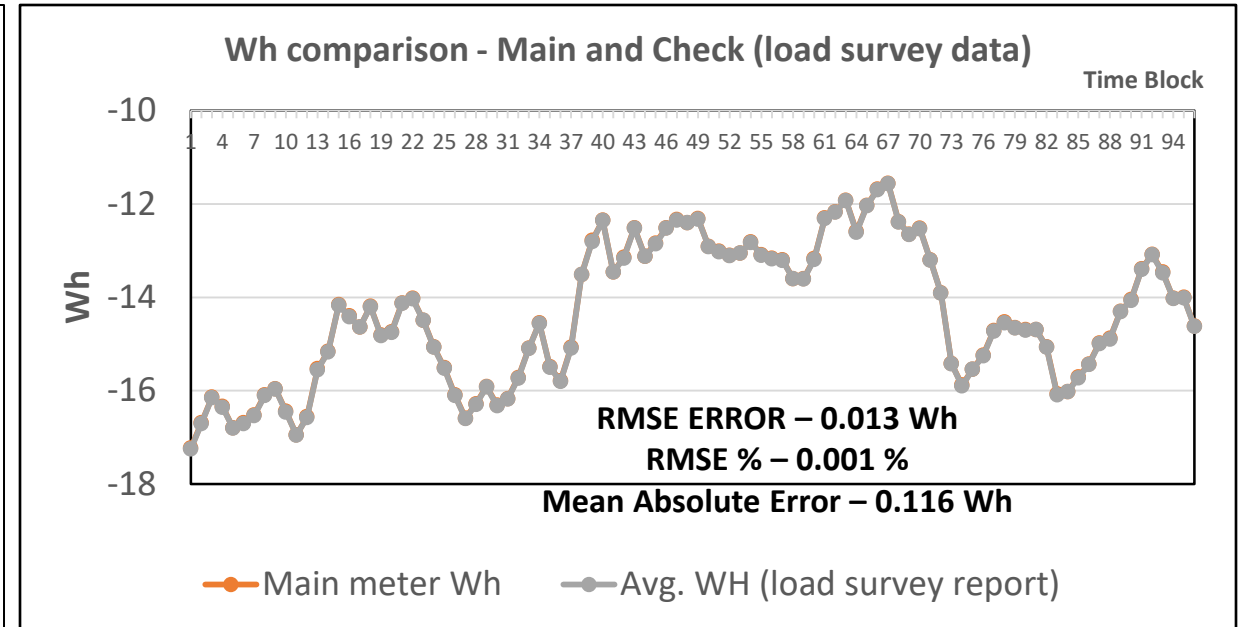
Objectives:

- Feasibility of Re-configuration of integration time in existing meter at site
- Adequacy of meter memory for shorter integration period
- Adequacy of Security features
- Output from the meter is standard format or not
- Additional features available in meters other than the features of SEMs

Observations with Elster Meter (13-Sep-17, Magarwada)

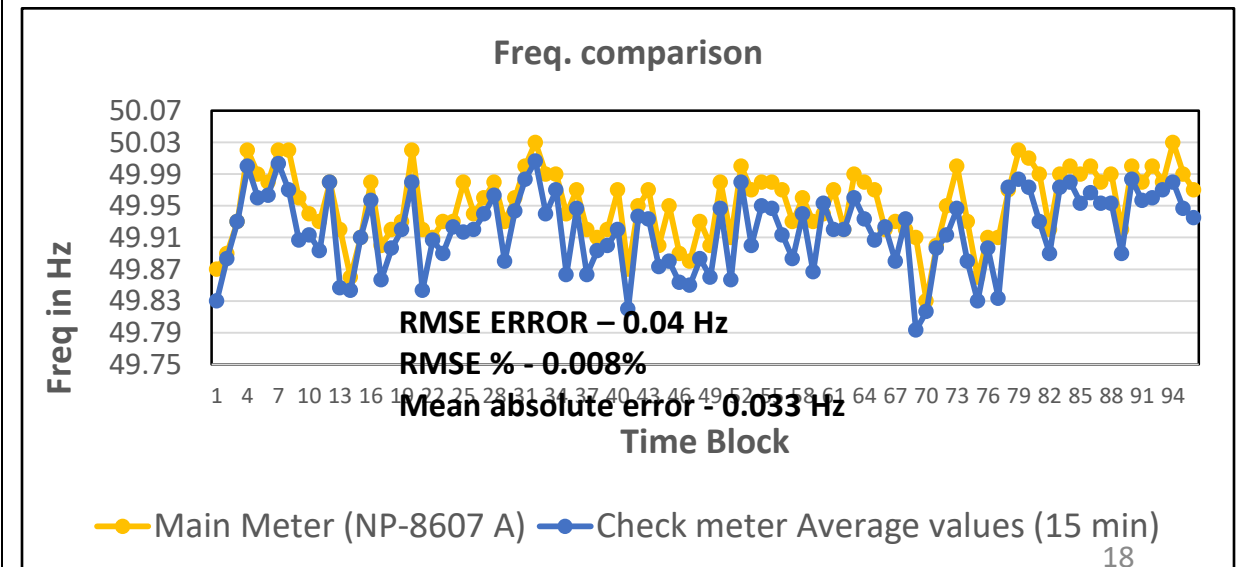
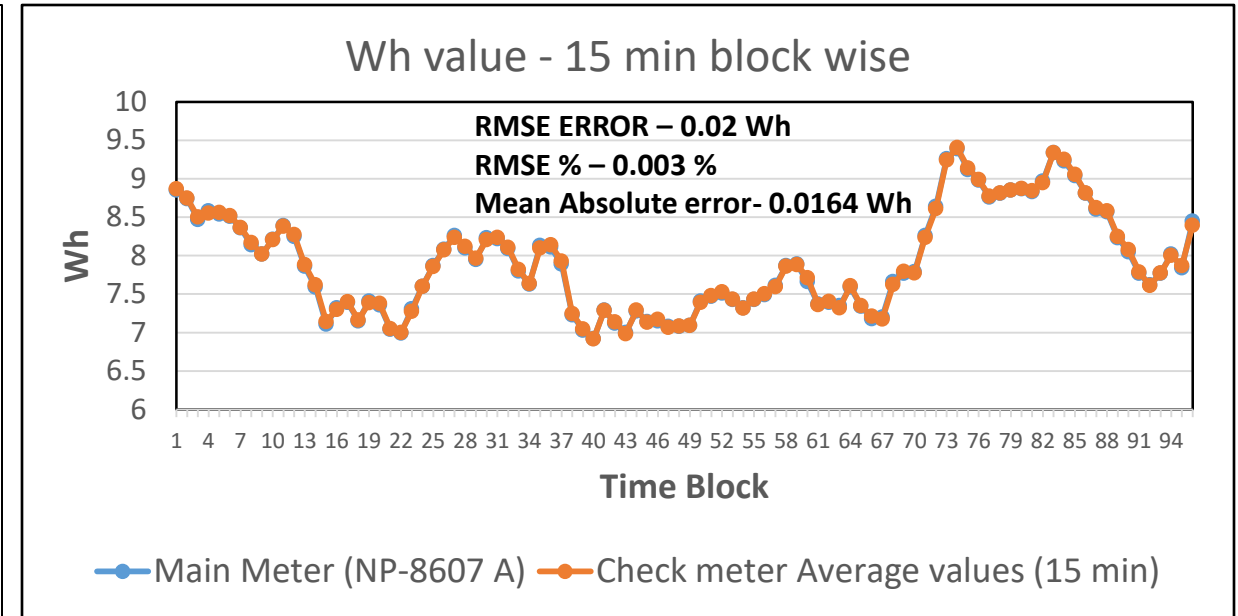
- Meter configured for 15-min and connected to system for 2 hours and reconfigured to 5-minutes
- Reconfiguration of existing meters to lower integration period is possible at site
- Comparison:
 - Load survey data- Active energy, Reactive energy, Voltage & Frequency-Matched
 - Output file (Standard format)- Mismatch observed
- Memory- Sufficient for data storage for lower integration period

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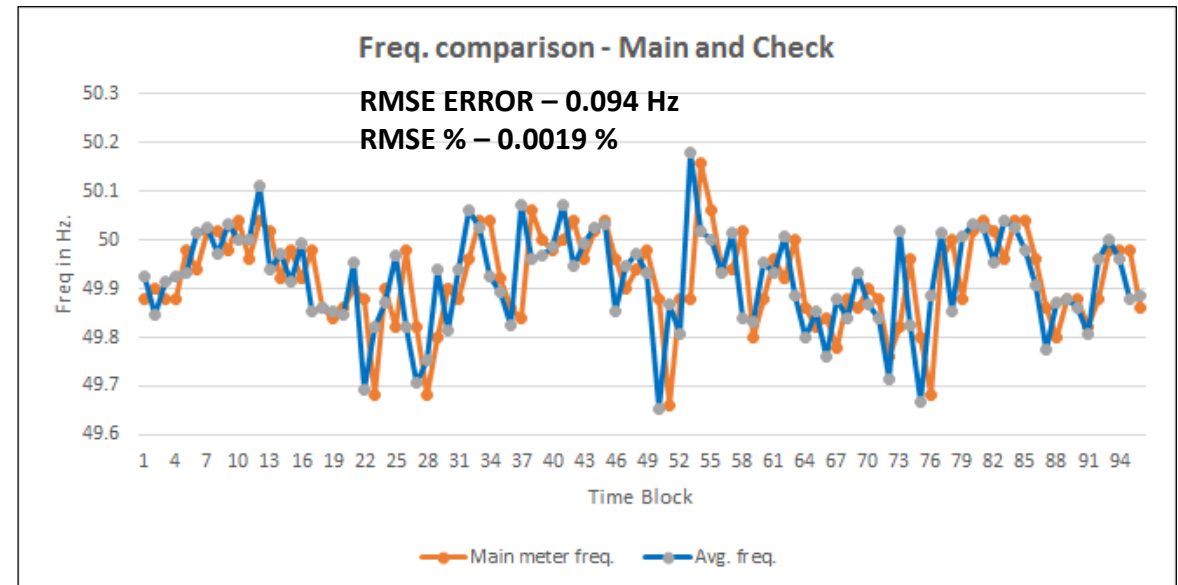
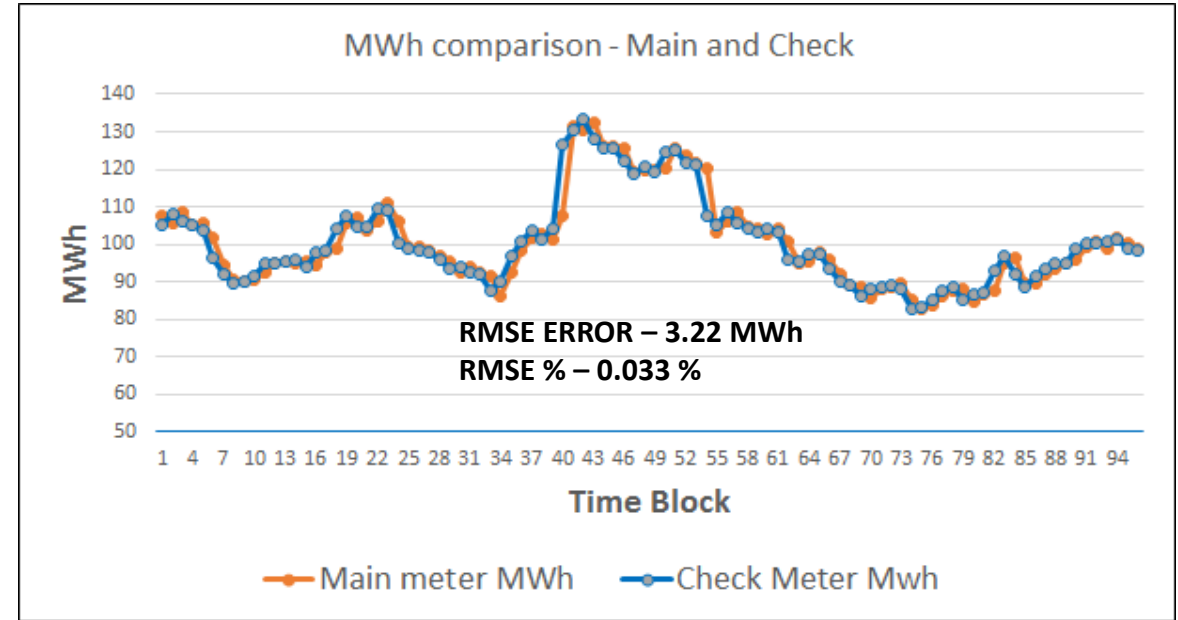
Observations with Secure Meter (13-Sep-17, Magarwada)

- Meter configured for 15-min and connected to system for 1 hour and reconfigured to 5-minutes
- Reconfiguration of Existing meters-Not possible
- Comparison:
 - Load survey data- Active energy, Reactive energy, Voltage & Frequency-Matched
 - Output file (Standard format)- Format issues & data mismatch observed



Observations with L&T Meter (10-Oct-17, Vadodara)

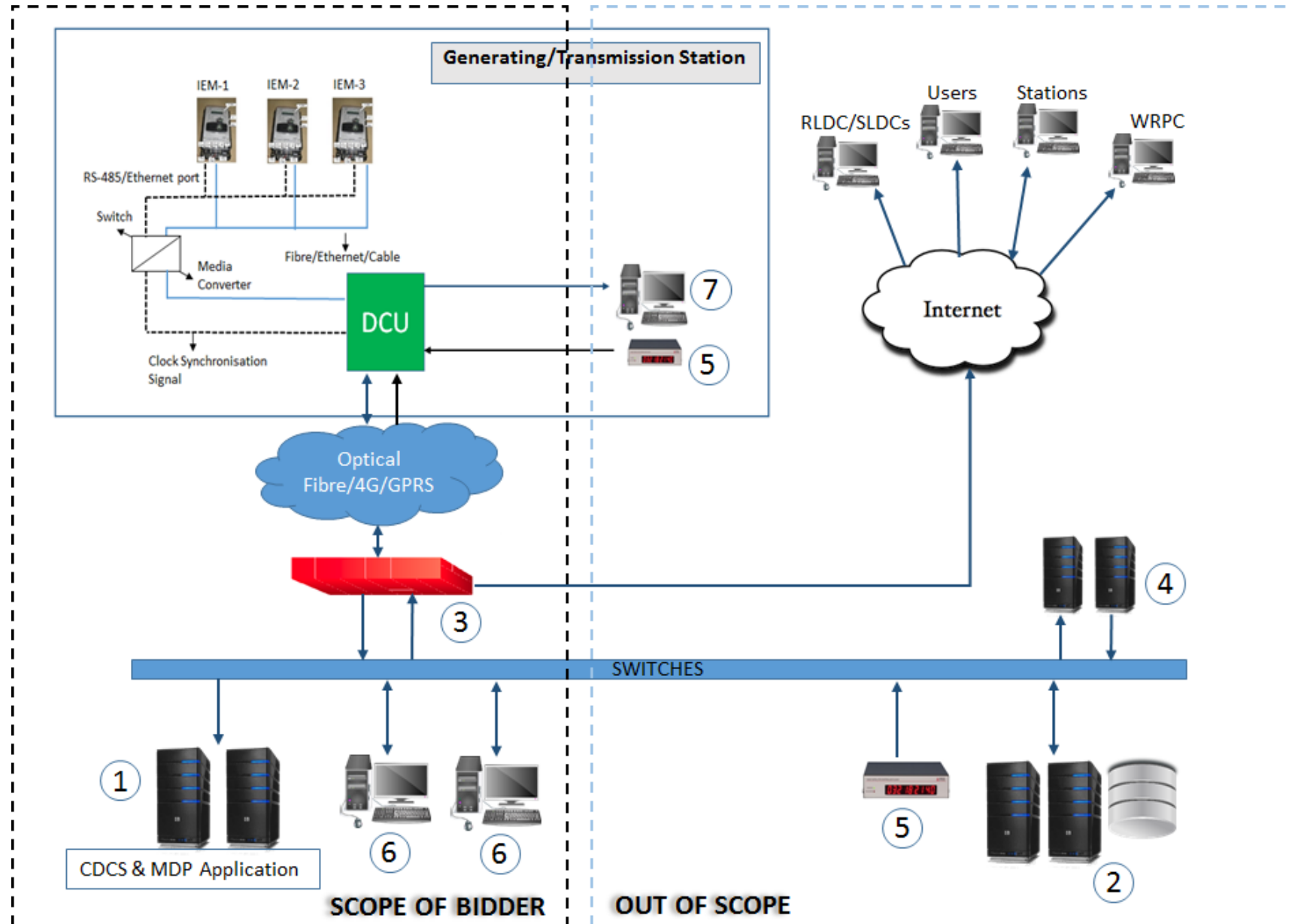
- Meter already configured for 5-min at factory.
- Reconfiguration could not be possible
- However it would be possible in new series of meters
- Meters are non-DLMS compliant
- Comparison:
 - Active energy & Frequency-Matched
 - Voltage & Reactive Energy-Yet to be made available



Meter Demonstration & Testing Results-Summary

Title	Elster	Secure	L&T
Reconfiguration of existing 15-minmeter 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 of new 15-min meters to 5-min	Possible	Possible	Possible
Conversion Software for decoding	Possible in existing S/W	Existing S/W needs upgradation	Existing S/W needs upgradation
Wh recording	Acceptable	Acceptable	Mismatch observed
Frequency recording in load survey file	Acceptable	Acceptable	Acceptable
Frequency data in npc file	Mismatch observed	Mismatch observed	Acceptable
Voltage recording	Acceptable	Acceptable	Data yet to be made available
VARh recording	Variations observed		Data yet to be made available
Storage	Could not be ascertained		Storage upgraded in factory

Envisaged architecture for SMART Interface Meters



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)

Desirable Features for SMART Interface Meters

1. Meter hardware/software related

- a. User configurable integration period : 5 min/ 10 min / 15min
- b. User configurable frequency step size : 0.02 Hz / 0.01 Hz / 0.005 Hz
- c. Flexibility for data transfer – Modem/ DCU/ DCD etc.
- d. Exception management for under recording of meters
- e. Capable for configuration changes from remote end
- f. Automatic Meter clock synchronisation with GPS clock – Station GPS/Remote GPS
- g. Auxiliary supply/PT supply to operate
- h. Memory storage capacity- minimum 15 days
- i. Vendor independent protocol for data exchange

2. AMR system related

- a. Communication system & supporting software
- b. Data collection at user defined schedule/ on demand
- c. Capable to detect abnormalities in data transfer
- d. Capable to transfer GPS signal to Meter for time synchronisation
- e. Capable of configuration changes in meters from remote end- Authorised user
- f. Data security aspects

Cont.

3. Meter Data Management

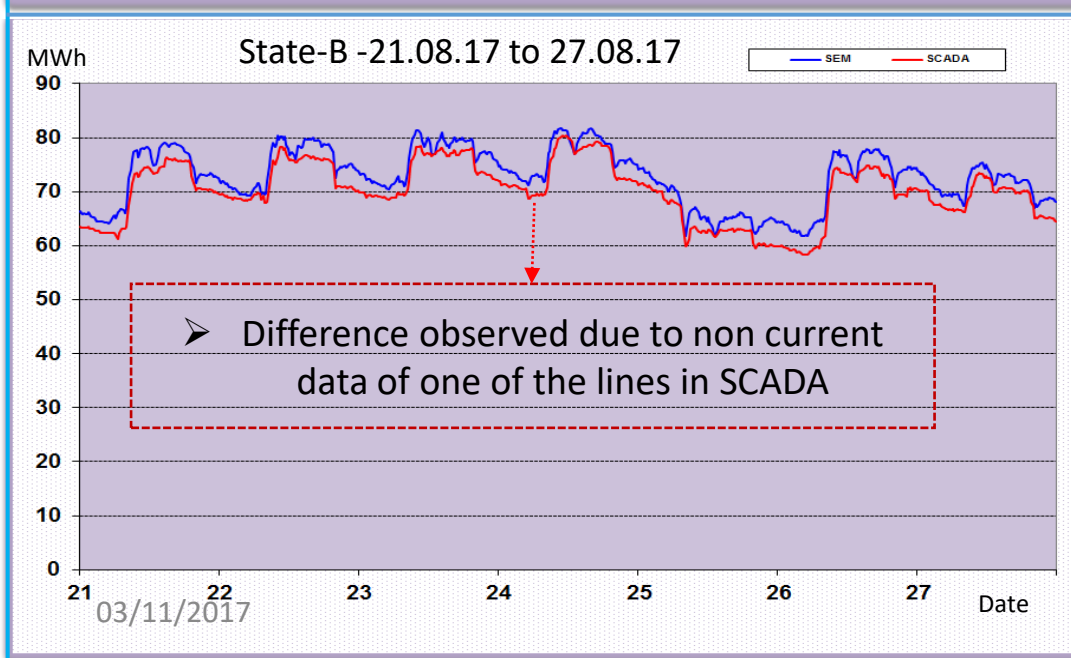
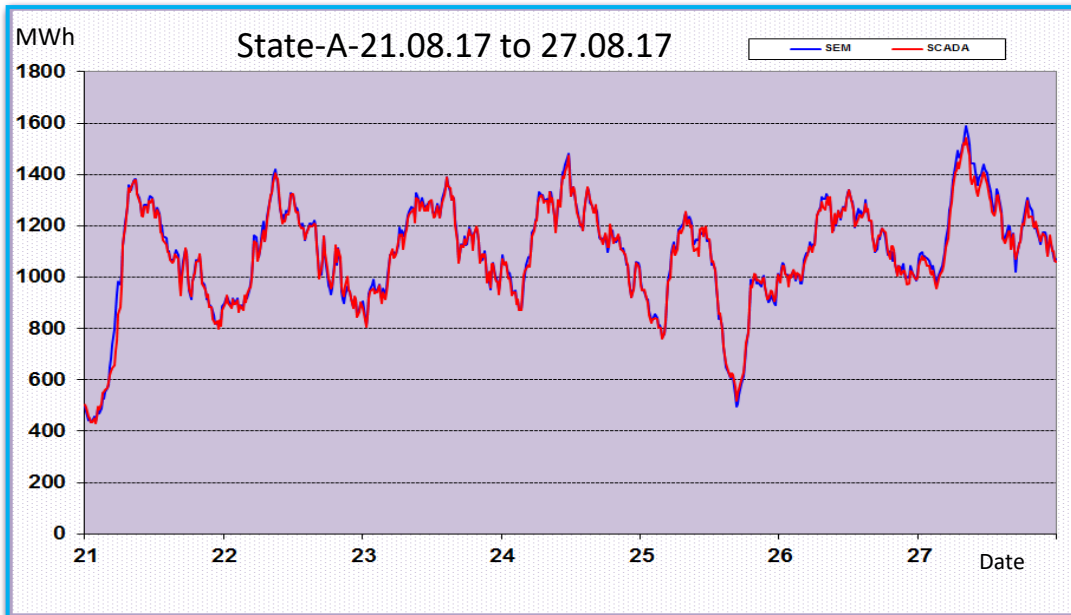
- a. Data extraction from AMR system
- b. Data Validation and replacement of erroneous data with check/standby meter with predefined loss %
- c. Addition/deletion of meters/entities-User configurable formulae and reports.
- d. Discrepancy report
- e. Transmission loss computation- User defined time period
 - a. Regional Loss
 - b. ICT loss-765/400kV, 400/220kV etc.
 - c. Line Loss- 765kv, 400kV, 220kV etc.
- f. Frequency comparison-User defined set of meters.
- g. Entity wise reports in the existing formats-WRPC submission.
- h. Reports preparation- User defined integration period – 5 min/10 min/15 min
- i. Graphical representation of data in user selection chart types- Bar/Pi/Area/Line etc.
- j. Meter Data Analytics (Big Data Analysis)
- k. Provision to change the methodology/concept to handle various regulatory changes in settlement system
- l. Predefined data access to constituents via webpage.

Envisaged challenges during transition Period

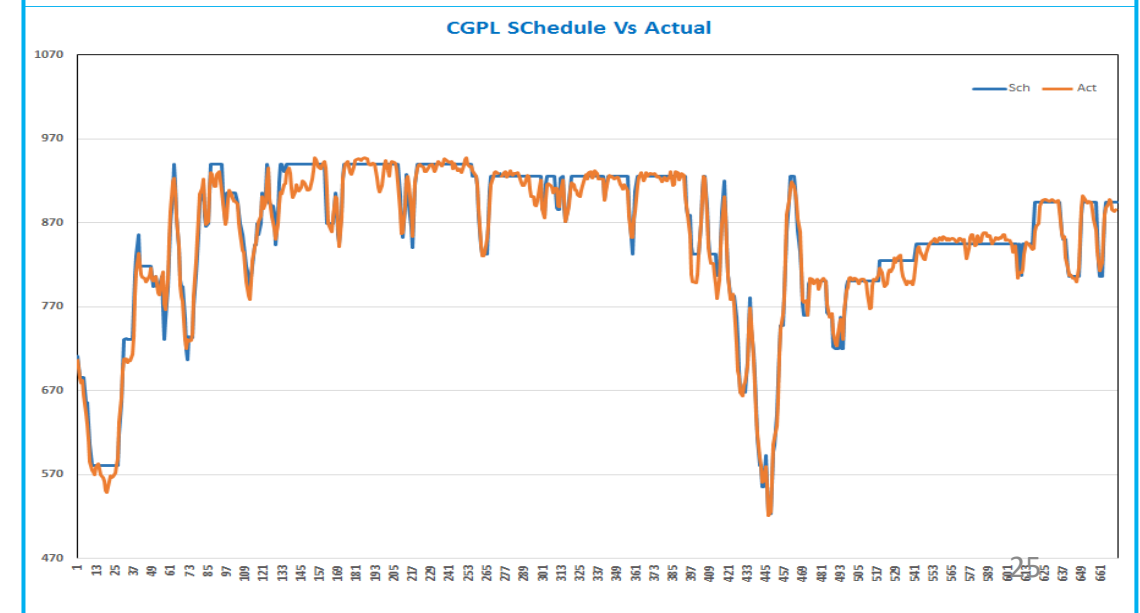
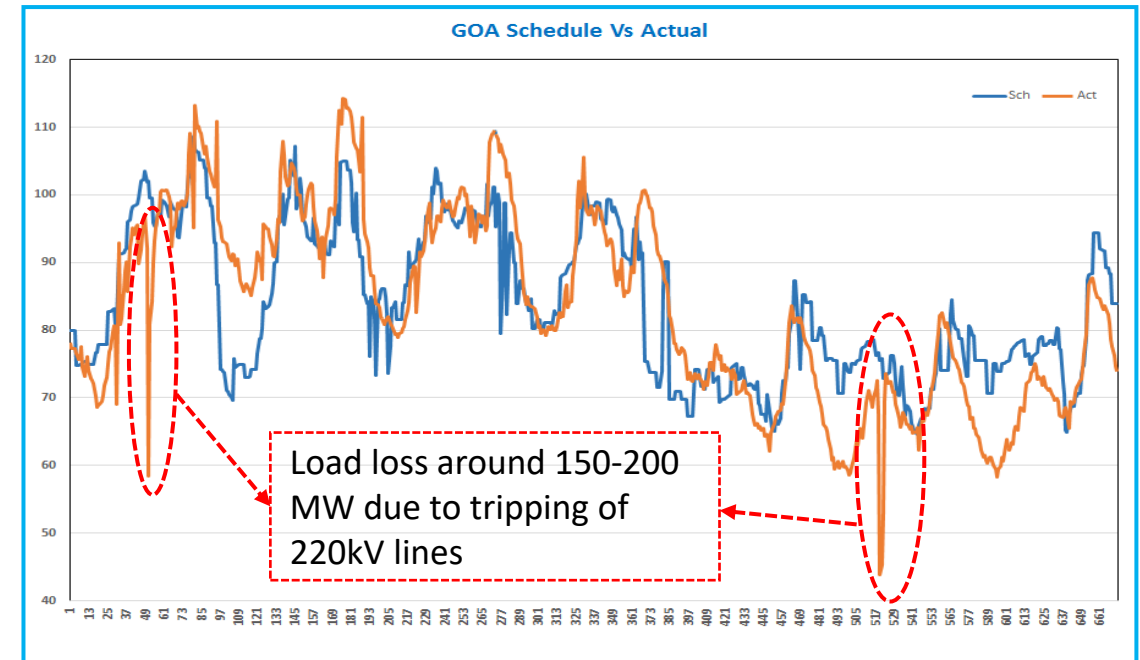
- Meter replacement- Shutdown may be required at few places
- Data loss- Ensure Check/Standby data availability
- Software compatibility – New meters output file format should be user configurable to meet the requirements of old Accounting S/W
- Meter ID format-To be addressed
- AMR system readiness prior to meter installation
- New Meter Data processing S/W at RLDC prior to meter installation to cater the requirements of WRPC
- Interface for data conversion from lower integration period to 15-min

Meter Data Applications

1. SCADA vs SEM Comparison

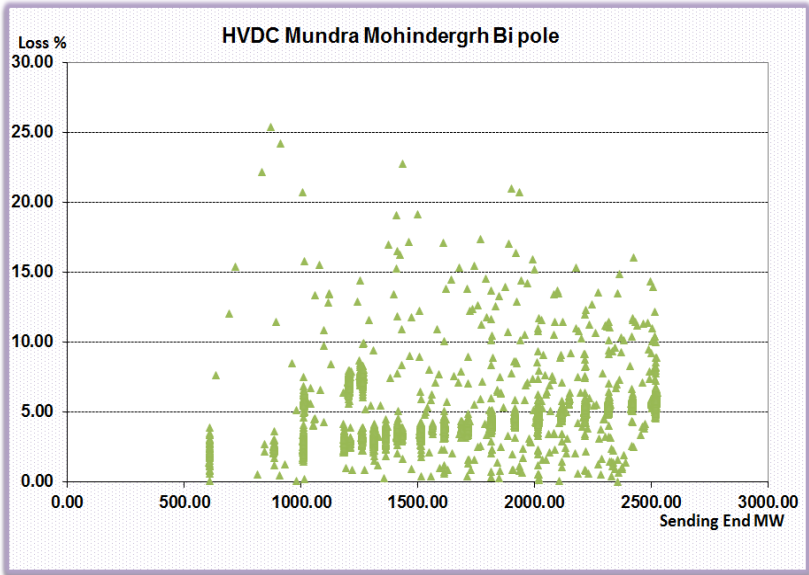
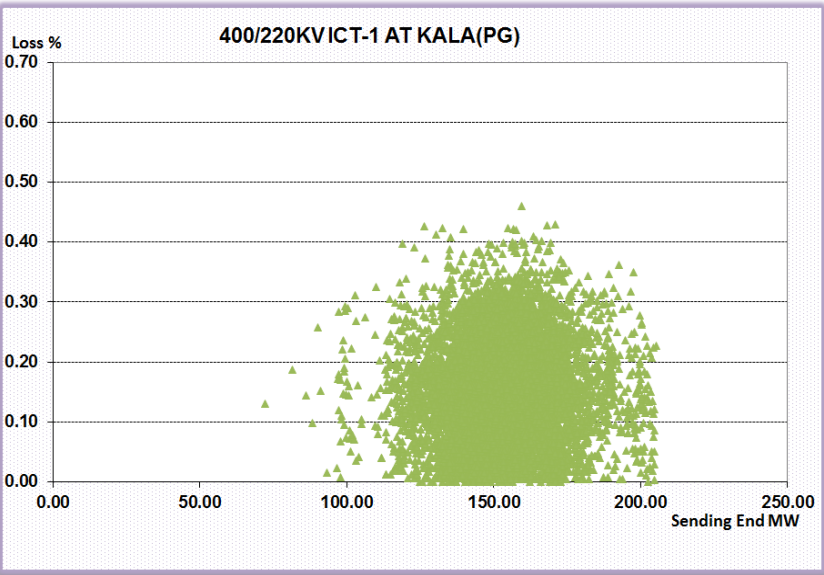
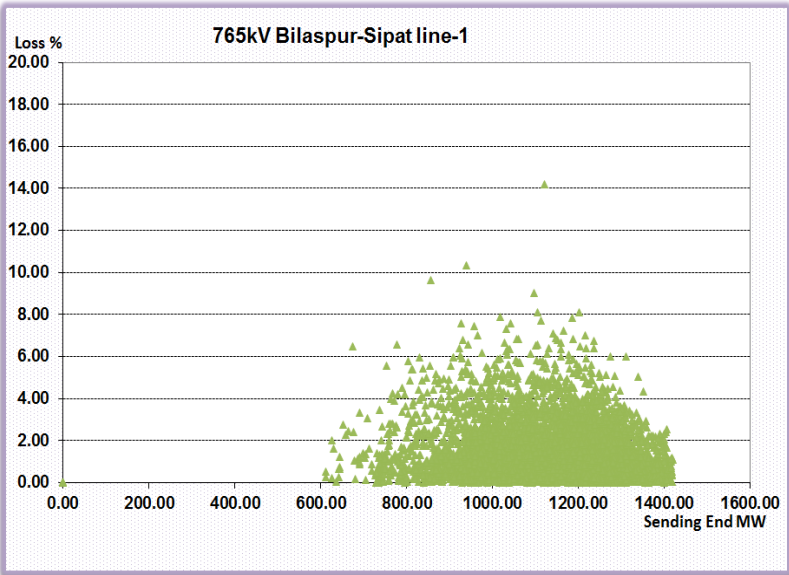
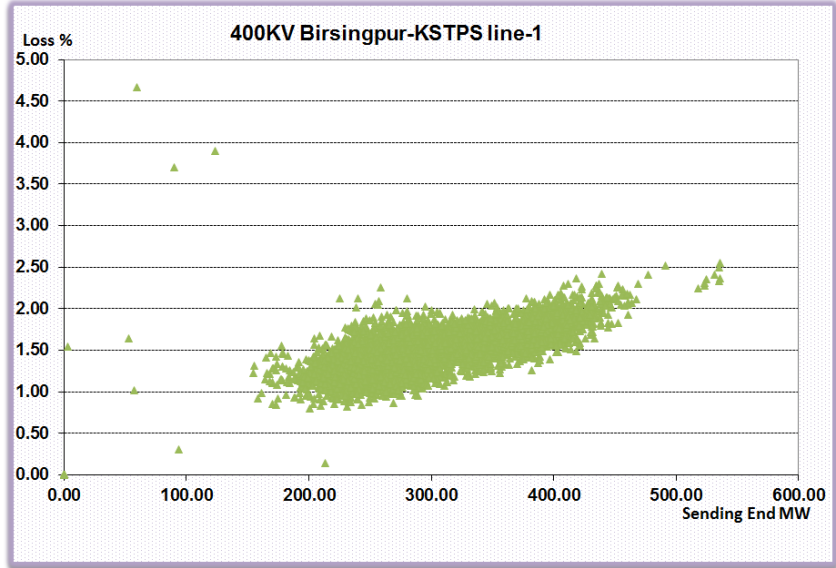
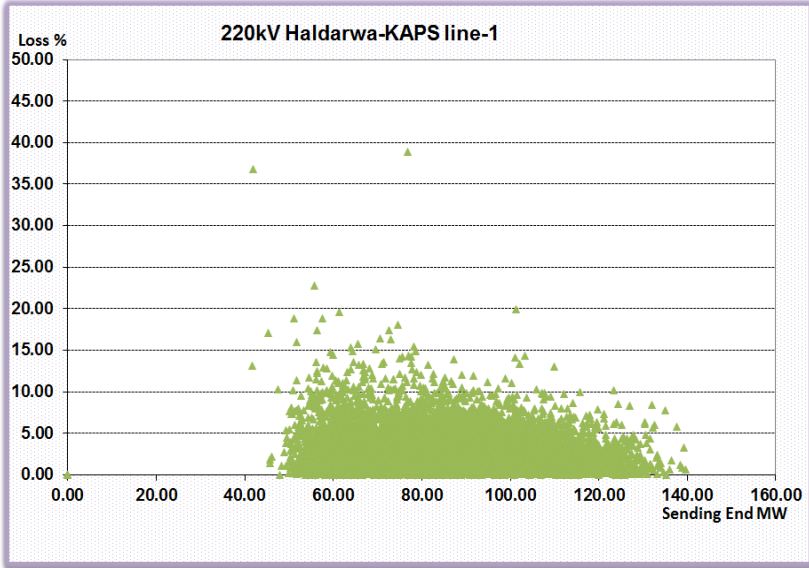
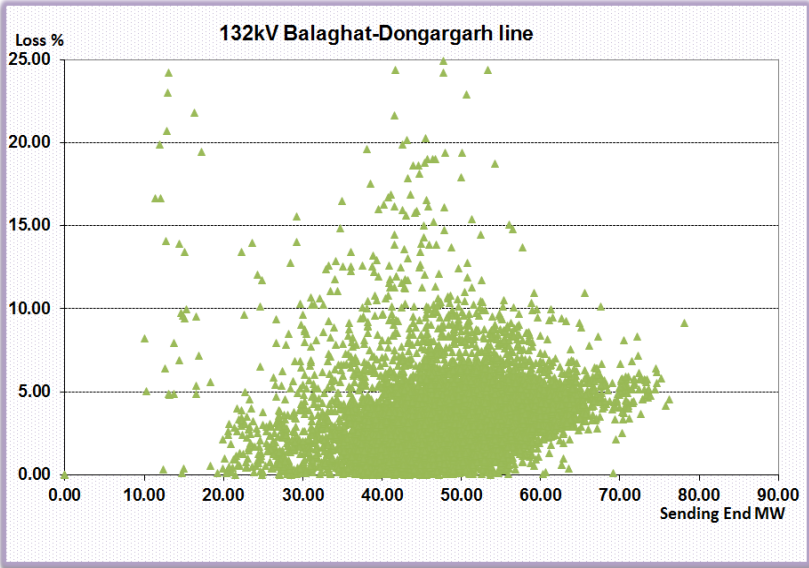


2. Schedule vs Actual Comparison

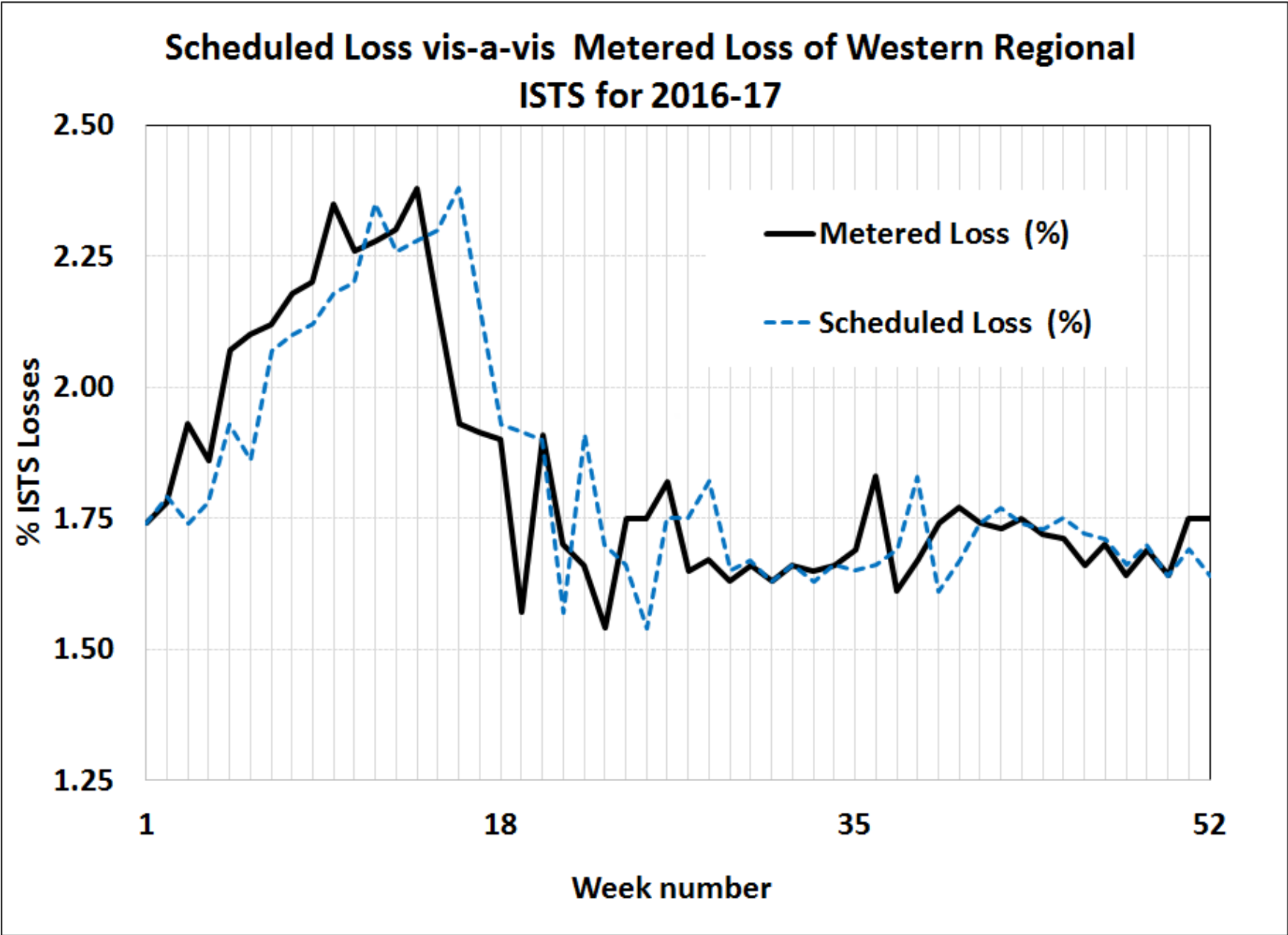


3. Transmission Loss Analysis

Loss in %



4. Scheduled Loss vis-a-vis Metered Loss of Western Regional ISTS for 2016-17



References

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- CERC Regulations on IEGC, DSM, Congestion Alleviation, Ancillary Services, Sharing of Transmission Charges, 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>
- Technical Specifications for Interface Energy Meters, Automated Meter Reading and Meter Data Processing, http://www.wrpc.nic.in/wrpc/34wrpc_minutes.pdf

