software has been installed at one location and each of the RLDCs access the software with their respective user credentials.

2.3.1 FILE UPLOAD

The file upload feature is used to upload .npc files into the MDP software application. The Start Date & End Date for which the .npc files is to be uploaded is customizable. The type of "Five min' or 'Fifteen min' depending upon the type of .npc files to be uploaded can be selected. A sample page is depicted in Fig. 4.

Figure 4: File Upload

2.3.2 DATA AVAILABILITY

Data availability feature is used to check availability of all data (i.e. data received / not received/ partially received) of the uploaded files into the MDP software. The Start Date & End Date for the period for which data availability is to be checked is customizable along with the list of locations. A sample page is depicted in Fig. 5.

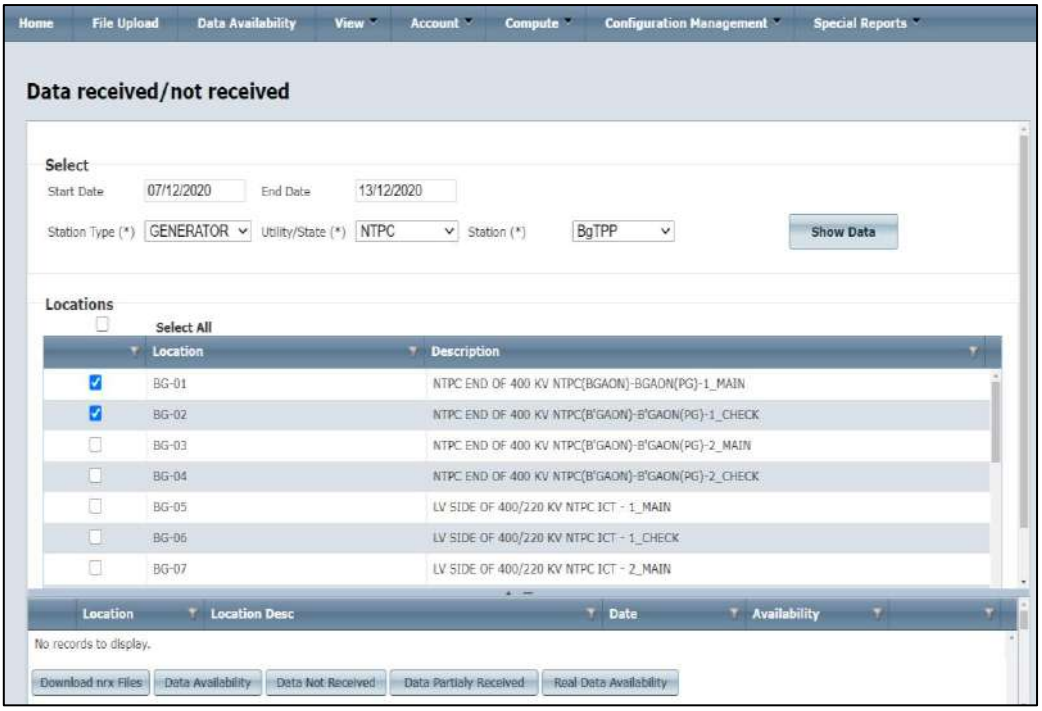

Figure 5: Data Availability

2.3.3 VIEWING DATA

The view data functionality is used to view & download (M)WH data (block-wise and daily) of the selected locations in a customized manner. A sample page is depicted in Fig. 6.

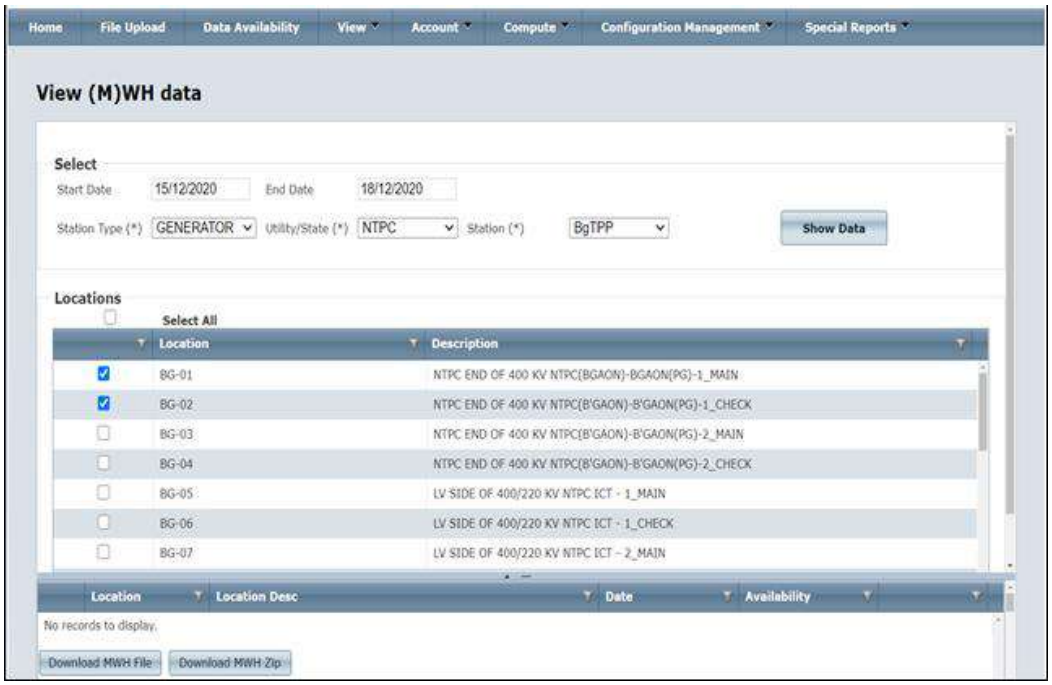

Figure 6: View Data

2.3.4 ACCOUNT OUTPUT DATA

The account output feature is used to compute active energy (MWh), reactive energy (MVARh) accounting of 5-min SEMs & 15-min SEMs along with Load Curve and Load Duration Curve. The Start Date & End Date for the period MWh output data is customizable. The five-minute output (for 5-minute block-wise data) or Fifteen-minute output (for 5-minute converted to 15-minute data) can be downloaded (Fig. 7).

The daily (Low & High Register) reactive data can be downloaded as per VAR Low & VAR High record feature of Reactive Energy Accounting. Load Curve feature is used to obtain a graphical representation of the power flow, frequency pertaining to all the locations for the selected time periods (Fig. 8). Load Duration Curve feature is used to view and download a graphical representation of the MW load flow vs time duration (in percentage) for which the load flow was below/ above a particular maximum or minimum load (Fig. 9).

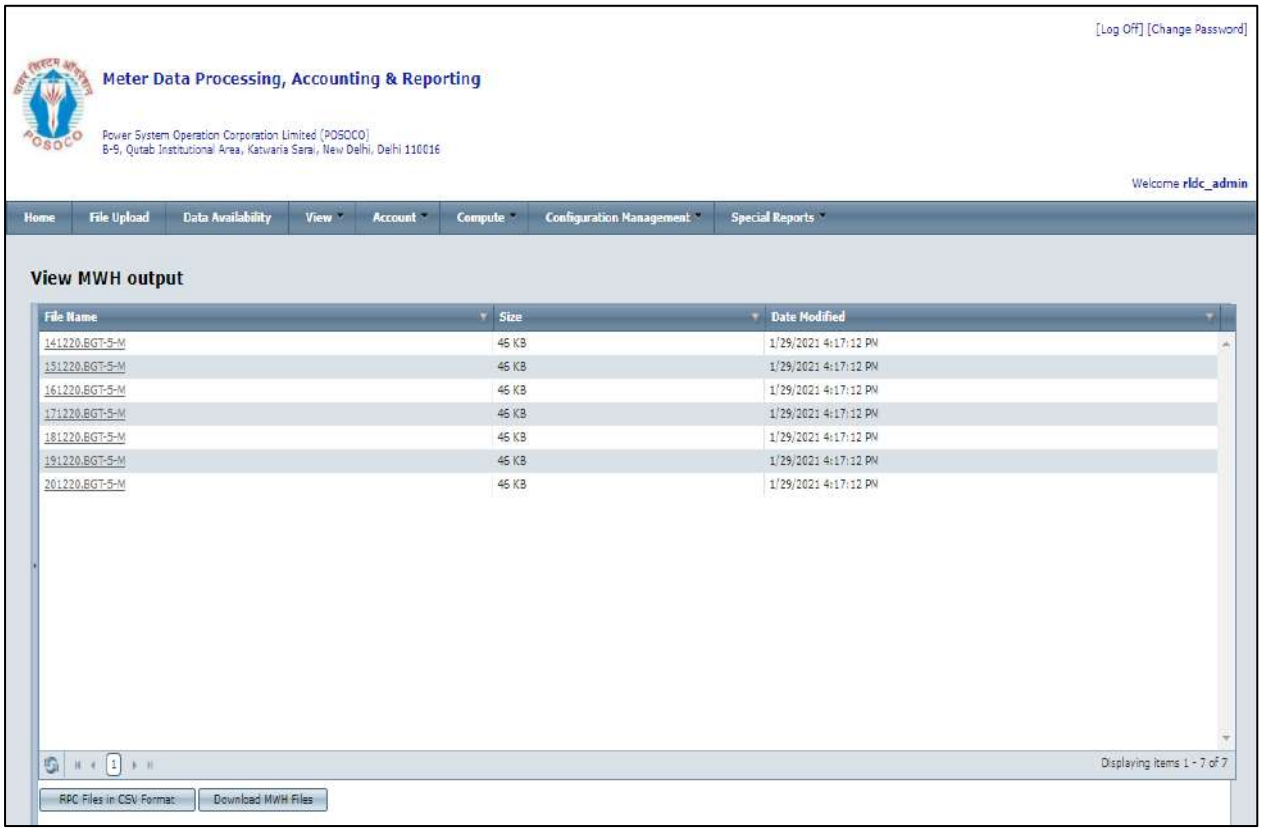

Figure 7: Account Output

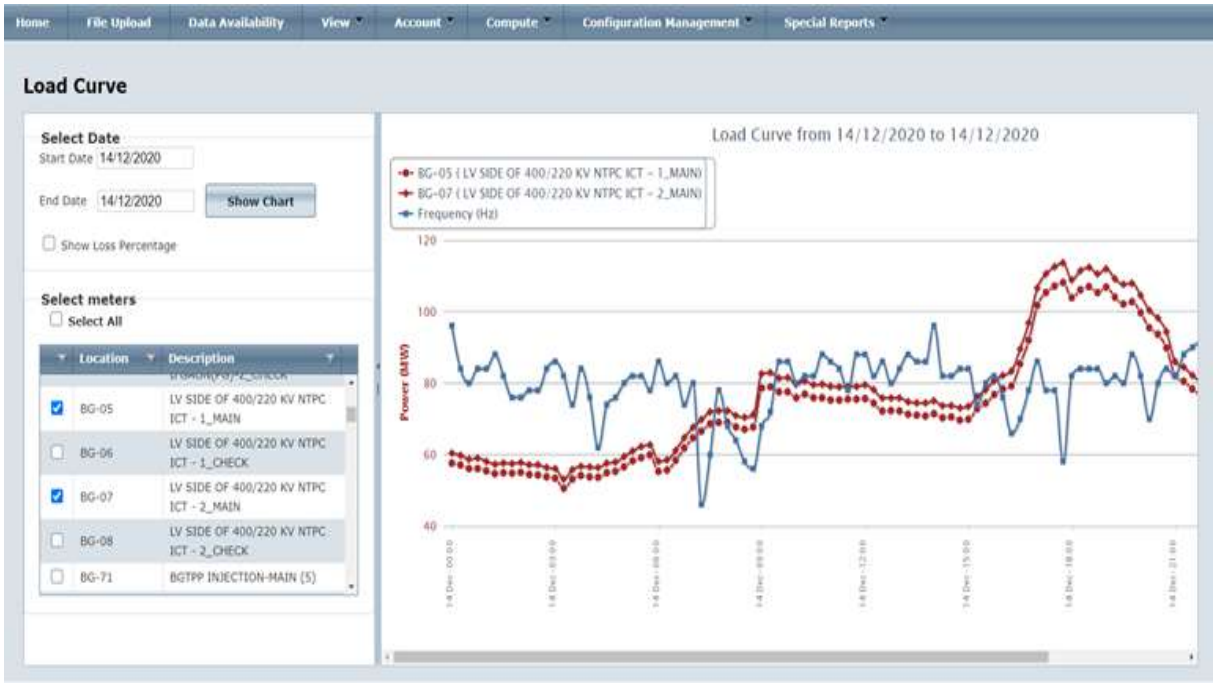

Figure 8: Load Curve

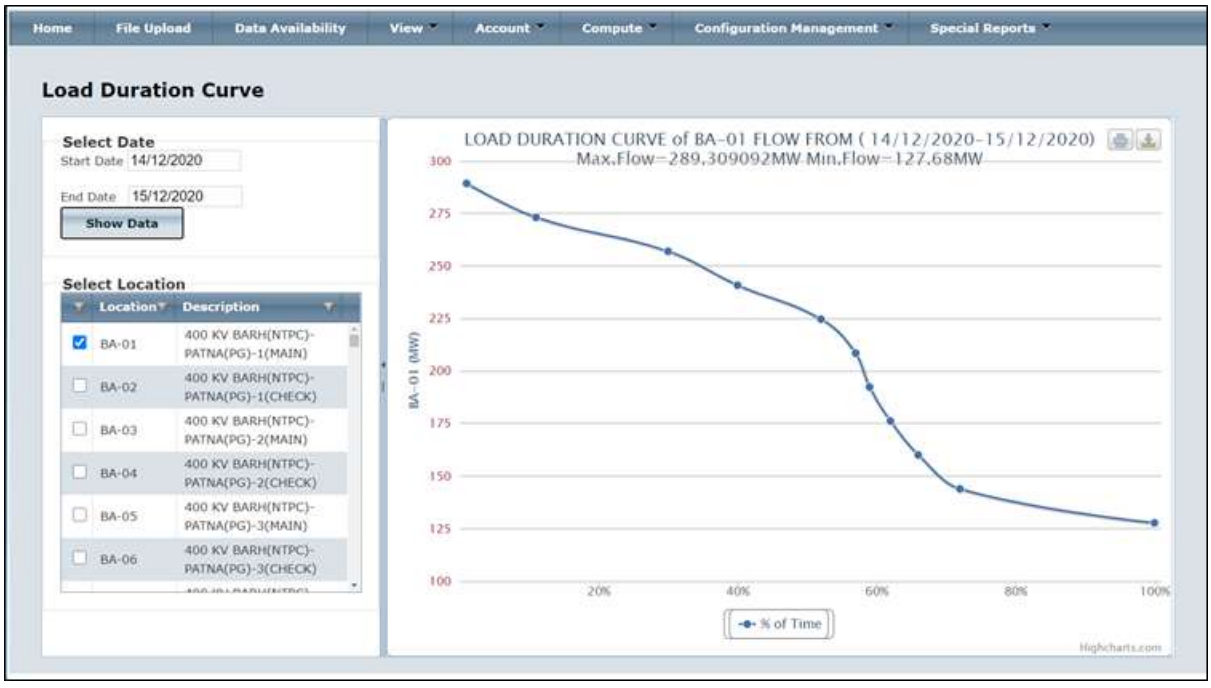

Figure 9: Load Duration Curve

2.3.5 PAIR CHECK

Pair Check is used to validate the correctness of 5-minute IEM & 15-minute SEM data. The Start Date & End Date for the period whose pair check data validation is to be done is also customizable. The Pair Check curve functionality

is used to validate the correctness of 5-min & 15-min SEM data in graphical interface for ease of user (depicted in Fig. 10)

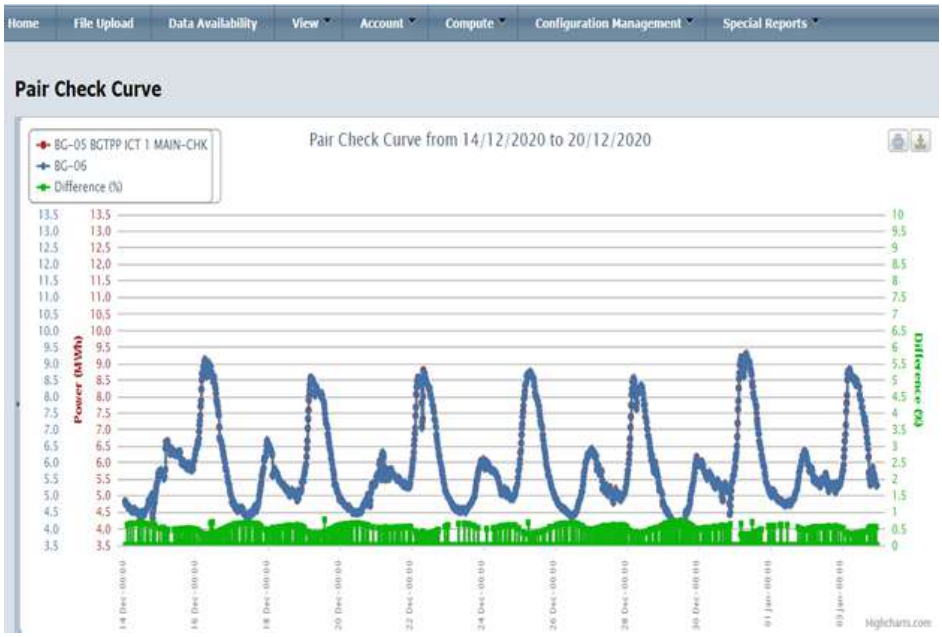

Figure 10: Pair Check Visualization

2.3.6 REACTIVE POWER VS VOLTAGE

MVAR vs. Voltage curve is used to monitor reactive performance with respect to voltage curve of 5-min block wise IEM data in graphical interface. A sample page is depicted in Fig. 11.

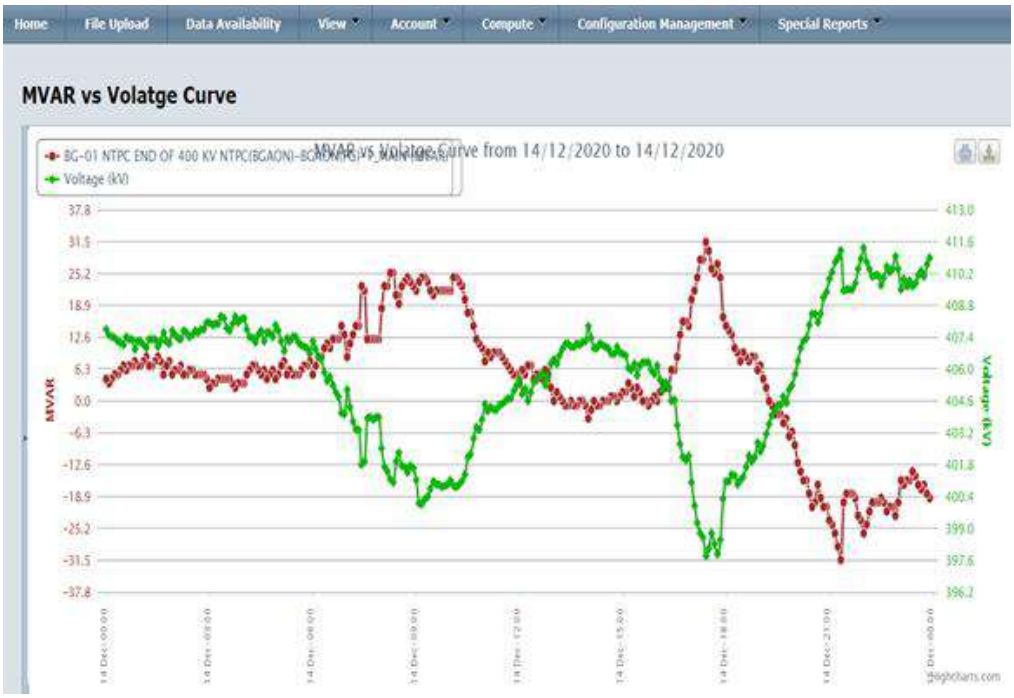

Figure 11: Reactive Power vs Voltage

2.3.7 CONFIGURATION MANAGEMENT

In the configuration management, Location/ Meter functionality is used to create, enter, update, delete or modify details pertaining to Real Meters or Virtual (Fict) Meters, new beneficiaries & generators into the system database, as per requirement from time to time. There is Find & Replace functionality in case the data pertaining to a meter is missing due to any reason.

The output MWh configuration is used to configure the formulae for obtaining the desired active MWH output of an entity. Pair Check configuration is used to configure the pairs (Main & Check of 5-min or 15-min SEM; 5 min converted to 15-min SEM) for validation. Master Frequency Configuration is used to configure the master frequency for 5-min IEM and 15-min SEM.

2.4 REGION-WISE SUMMARY

The region-wise summary of 05-minute meter pilot project is tabulated in Table 2 as follows:

Table 2: Region-wise Summary of 05-minute meter pilot project

S. No.	Plant	Type	Number of Meters	Contract Awarded	Date of Installation
1.	NTPC Mauda-II (WR)	Thermal (Coal)	22	M/s Secure	15 July 2020
2.	NTPC Bongaigaon (NER)	Thermal (Coal)	8	M/s Secure	08 October 2020
3.	NTPC Dadri (NR)	Thermal (Coal, Gas), Renewable (Solar)	23	M/s L&T	15 August 2020
4.	NTPC Simhadri-II (SR)	Thermal (Coal)	12	M/s L&T	06 November 2020
5.	NTPC Barh-II (ER)	Thermal (Coal)	16	M/s L&T	16 December 2020
6.	NHPC Teesta-V (ER)	Hydro	4	M/s Secure	13 November 2020
7.	NHPC Loktak (NER)	Hydro	8	M/s L&T	05 November 2020
8.	THDC Tehri (NR)	Hydro	4	M/s L&T	19 August 2020
Total			**97**		

2.4 POST IMPLEMENTATION CHALLENGES

2.4.1 ONLINE DEMO OF IEM AND SOFTWARE

Normally, the demo of IEM and software supplied by the vendor used to be at the RLDCs and sites. The vendor representative was supposed to visit the RLDCs

and sites. However, due to pandemic situation in 2020, the software installation was done through remote access provided by respective RLDCs and sites to the vendor. The demo of IEMs and software applications usage was given by the vendors through online/virtual mode.

2.4.2 HARMONIZATION OF OUTPUT FILE OF MULTIPLE VENDORS

The meter data downloaded by the power plant sites are sent to RLDCs for further processing. The data is encrypted in a binary file to prevent tampering of data. After receiving the binary file/meter data, RLDCs convert the data into readable text file called "*.NPC" format. This conversion is done with the help of respective vendor proprietary software. The converted "*.NPC" files of multiple vendors have to be in standard format which can be uploaded in common MDP software developed for 5-minute IEM.

There were structural changes in "*.NPC" file format in 05-minute IEMs compared to 15-minute IEM. Though this aspect was covered in technical specification, however, there was requirement of harmonization of "*.NPC" file format generated by both the vendors. After detailed discussions between the stakeholders and vendors, a common format "*.NPC" file format was finalized. The sample NPC "*.NPC" file format is given at **Annexure-3**.

2.4.3 TIME TAKEN FOR DATA DOWNLOAD

The sites/power stations informed that the time taken for meter data download from new 05-minute IEM to Hand Held Unit (HHU)/DCD is around 20 minutes. The time taken for further transmission of the data from HHU/DCD to Computer is also around 20 minutes. The total time taken for data download per IEM is around 40 minutes. Therefore, as the number of meters installed is more at a particular site, the time taken for meter data download is proportionately increased which leads to considerable time consumed by the associated manpower. The observations sent by different power stations is enclosed at **Annexure-4.**

The new IEMs in the pilot project are capable of recording additional parameters like voltage, reactive energy etc. as per the requirement of technical specification. These IEMs are new generation IEMs which are also Device Language Message Specification (DLMS) compliant and hence, have additional registries to handle more instantaneous parameters & individual harmonic parameters. Further, these IEMs are capable of storing and exporting data up to 15 days unlike 10 days of current 15-minute IEMs. Since the parameters are handled on 05-minute basis, the total size of export meter data

file has increased much higher than the current meter data file in 15-minute IEM which handle lesser number of parameters.

These additionalities have resulted in elongated time consumed in meter data downloading through Data Collection Device (DCD). However, this issue is likely to get resolved once data collection is done through Automated Meter Reading (AMR) system as envisaged finally.

The new generation IEMs are also having field configurability. The number of parameters can be configured in the 05-minute IEMs through authenticated password protected mechanism. During reconfiguration process, all the stored data available would be wiped out. It was noted that if additional data from meter is removed/reconfigured, then, data downloading time may reduce. It was also noted that configuration of the IEM at site may take some time and during that time, other end IEM data may be used for accounting purpose.

Since the "*.NPC" file format generated by new 05-minute meters in pilot project is having a greater number of parameters than required for accounting and analysis purpose, therefore, additional parameters may be removed. It has to be ensured that if any configuration change is done at site, the revised "*.NPC" file format should remain same to avoid hamper of accounting and analysis part. Further changes would also be required in the MDP software to read the revised "*.NPC" file format.

2.4.4 TIME DRIFT

In order to avoid time drift in meters, there was is need to synchronize the new 05-minute IEMs time with GPS which was outside the scope of pilot project. Drifting of time in meter clock is a phenomenon which occurs over a period of time which is required to be addressed either through manual correction or through GPS synchronisation.

2.4.5 REVERSE POLARITY

In some of the pilot project locations/sites, the new 05-minute IEM was installed in reverse polarity as compared to the 15-minute IEM. The details of those IEM have been identified and steps have been taken to correct the polarity of those IEMs. Till the polarity of those IEM is corrected, the meter data is handled at RLDC level by reversing the polarity of data for deviation computation, data validity and comparing the data with the 15-minute IEM.

CHAPTER 3: DATA AND ANALYSIS

The chapter details the data and analysis carried out for 05-minute and 15-minute data in the pilot project

3.1 DATA COLLECTION

In compliance to IEGC, all concerned entities are sending the data to their respective RLDC by Tuesday noon. The new IEM data are also sent by the concerned generating station along with 15-minute IEM data. The data collected by Generating station from IEM is through DCD. The DCD provided by M/s Secure and M/s L&T is shown in Fig. 12 and 13 resp. Both the manufacturers provided SANDS make DCD and same model number

Figure 12: DCD for M/s SECURE IEM

Figure 13: DCD for M/s L&T IEM

3.2. DATA CONVERSION

The encrypted data is sent through email by the concern entities. Once data is received at RLDCs the new IEM data downloaded is processed through the propriety software provided by the IEM manufacture. The snapshot of software provided by M/s L&T and M/s SECURE is depicted in Fig. 14 and 15 resp.

Figure 14:L&T Software

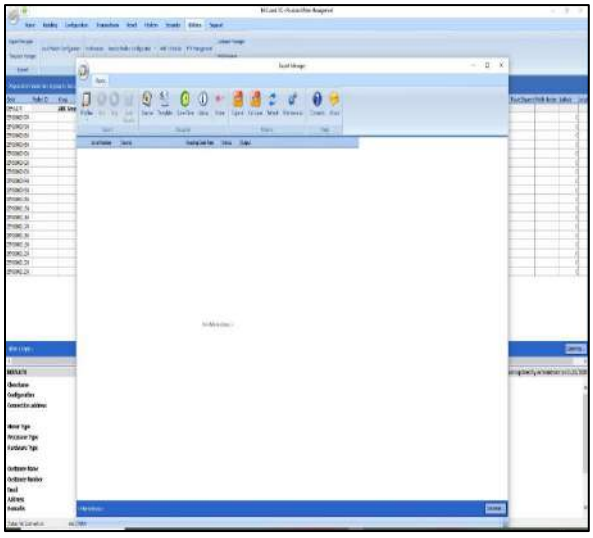

Figure 15: SECURE software

The converted readable data is generated with extension".npc". The snapshot of the data is shown in Fig. 16.

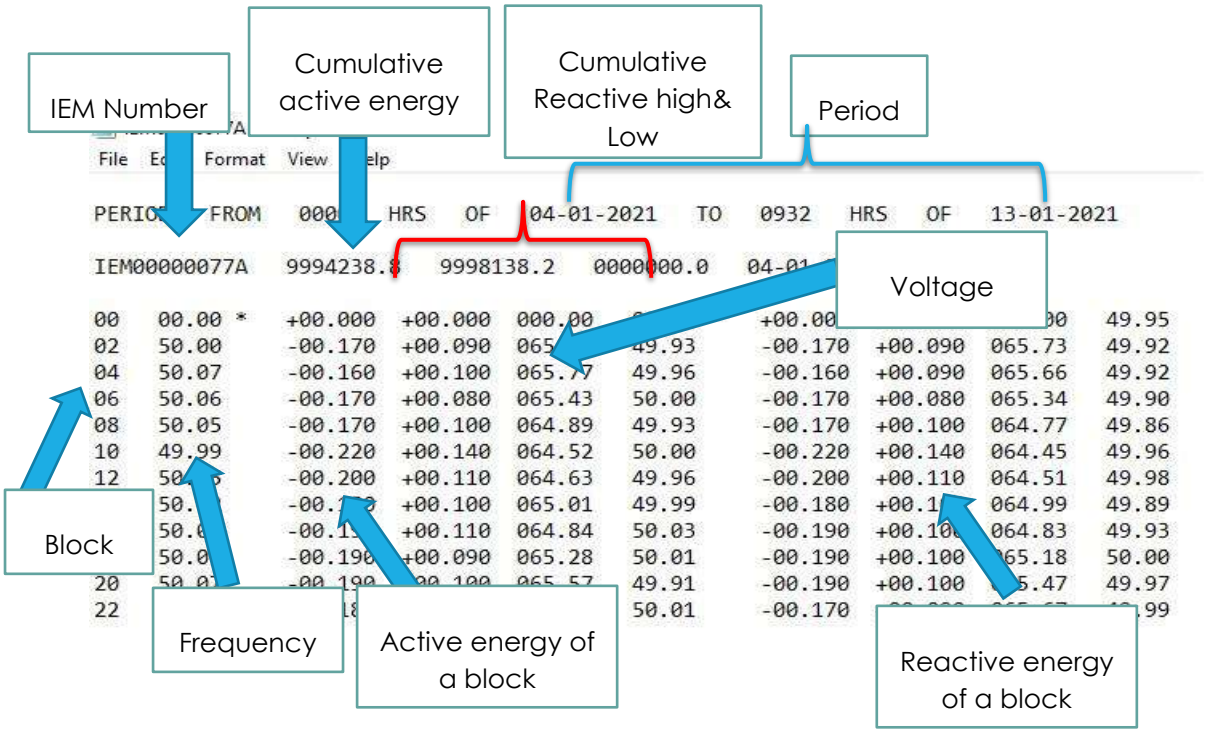

Figure 16: Snapshot of "*.NPC" file

In the current 15-minute SEM, frequency code (FC) is reflected and the same is converted to frequency (in Hz) through the formula (FC/100) + 49.5 Hz. The new 05-minute IEM directly provides the frequency data. It also provides additional data like live reactive energy exchanged and voltage in a time-block. In the new 05-minute IEM, total number of time-blocks in a day is 288.

3.3. DATA AVAILABILITY

A new Meter Data Processing (MDP) software has been developed to process the new 05-minute IEM data for the pilot project. The ".npc" file is uploaded for a particular station in MDP software. After uploading the data, the data availability is checked through data availability tab. The detail of generating station and the elements details is selected for which data availability is required to be checked. The snapshot of the window which shows details of data availability is depicted in figure 18.

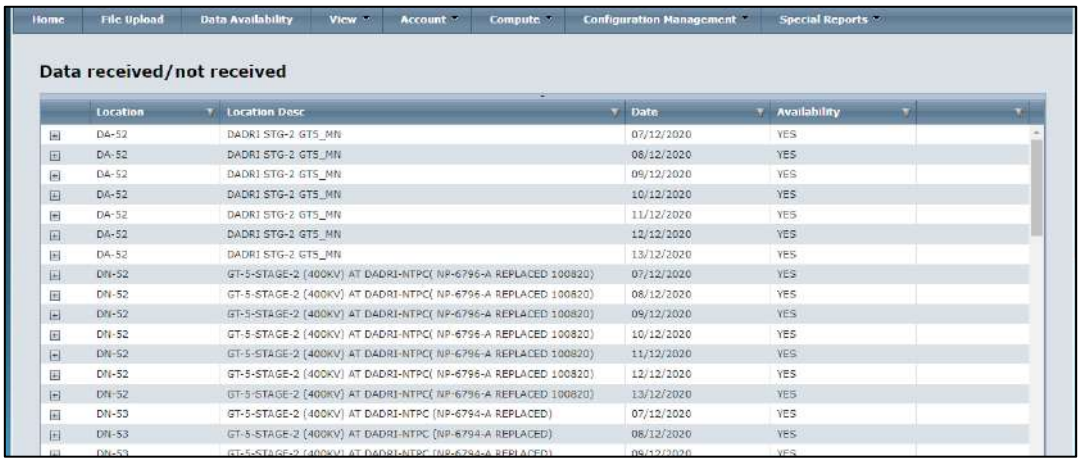

Figure 17: Data availability

3.4 DATA VALIDATION

Meter data is validated using pair check technique which is a comparison between recordings of main & check or main & stand-by meters. As per CEA "Installation and Operation of Meters" Regulation, 2006 and subsequent amendments thereof, the maximum allowable difference between a main and check meter is 0.5% in a month.

Since the new IEM is installed in parallel with the existing Main and check meter so the pair check was carried out between:

- Main (15minute) IEM- Check (15-minute) IEM
- Main (15minute) IEM- Main (05-minute) IEM
- Check (15minute) IEM- Check (05-minute) IEM
- Main (15minute) IEM- Check (05-minute) IEM
- Main (05minute) IEM- Check (15-minute) IEM

The pair check result for a sample day 14th December, 2020 for Teesta-V (ER), and Bongaigaon (NER) station is given in Table-3.

Table 3: Sample Pair Check

End-1	End -1 Name	End-2	End -2 Name	End-1 MWH	End-2 MWH	Difference	% Difference
BG-01	NTPC END OF 400 KV NTPC(BGAON)-BGAON(PG)-1_MAIN	BG-02	NTPC END OF 400 KV NTPC(B'GAON)-B'GAON(PG)-1_CHECK	-1,243.9	-1,243.7	0.2	0.01
BG-01	NTPC END OF 400 KV NTPC(BGAON)-BGAON(PG)-1_MAIN	NT-01	NTPC END OF 400 KV NTPC(BGAON)-BGAON(PG)-1_MAIN	-1,243.9	1,243.6	0.3	0.02
BG-02	NTPC END OF 400 KV NTPC(B'GAON)-B'GAON(PG)-1_CHECK	NT-02	NTPC END OF 400 KV NTPC(B'GAON)-B'GAON(PG)-1_CHECK	-1,243.7	1,242.5	1.2	0.09
BG-03	NTPC END OF 400 KV NTPC(B'GAON)-B'GAON(PG)-2_MAIN	BG-04	NTPC END OF 400 KV NTPC(B'GAON)-B'GAON(PG)-2_CHECK	-1,248.8	-1,249.0	-0.2	0.02
BG-03	NTPC END OF 400 KV NTPC(B'GAON)-B'GAON(PG)-2_MAIN	NT-03	NTPC END OF 400 KV NTPC(B'GAON)-B'GAON(PG)-2_MAIN	-1,248.8	1,248.1	0.7	0.06
BG-04 (05Min)	NTPC END OF 400 KV NTPC(B'GAON)-B'GAON(PG)-2_CHECK	NT-04(15Min)	NTPC END OF 400 KV NTPC(BGAON)-BGAON(PG)-2_CHECK	-1,249.0	1,248.3	0.7	0.06
BG-05(05Min)	LV SIDE OF 400/220 KV NTPC ICT - 1_MAIN	BG-06(15Min)	LV SIDE OF 400/220 KV NTPC ICT - 1_CHECK	1,747.8	1,746.8	0.9	0.05
BG-05(05Min)	LV SIDE OF 400/220 KV NTPC ICT - 1_MAIN	NT-06(15Min)	LV SIDE OF 400/220 KV NTPC ICT - 1_CHECK	1,747.8	-1,745.6	2.2	0.13
BG-06(05Min)	LV SIDE OF 400/220 KV NTPC ICT - 1_CHECK	NT-06(15Min)	LV SIDE OF 400/220 KV NTPC ICT - 1_CHECK	1,746.8	-1,745.6	1.3	0.07
BG-07(05Min)	LV SIDE OF 400/220 KV NTPC ICT - 2_MAIN	BG-08(15Min)	LV SIDE OF 400/220 KV NTPC ICT - 2_CHECK	1,834.1	1,834.0	0.2	0.01
BG-07(05Min)	LV SIDE OF 400/220 KV NTPC ICT - 2_MAIN	NT-07(15Min)	LV SIDE OF 400/220 KV NTPC ICT - 2_MAIN	1,834.1	-1,835.6	-1.4	0.08
BG-08(05Min)	LV SIDE OF 400/220 KV NTPC ICT - 2_CHECK	NT-08(15Min)	LV SIDE OF 400/220 KV NTPC ICT - 2_CHECK	1,834.0	-1,834.8	-0.8	0.04
TS-05(15Min)	400 KV TEESTA-RANGPO-1 (MAIN)	TS-07(15Min)	400 KV TEESTA-RANGPO-1 (CHECK)	1,866.1	1,866.6	-0.5	0.03
TS-05(15Min)	400 KV TEESTA-RANGPO-1 (MAIN)	TT-03(05Min)	400 KV TEESTA-RANGPO-1 (MAIN)	1,866.1	-1,865.9	0.2	0.01
TS-05(15Min)	400 KV TEESTA-RANGPO-1 (MAIN)	TT-04(05Min)	400 KV TEESTA-RANGPO-1 (CHECK)	1,866.1	-1,866.4	-0.3	0.02
TS-06(15Min)	400 KV TEESTA-RANGPO-2 (MAIN)	TS-08(15Min)	400 KV TEESTA-RANGPO-2 (CHECK)	1,797.1	1,796.4	0.7	0.04
TS-06(15Min)	400 KV TEESTA-RANGPO-2 (MAIN)	TT-05(05Min)	400 KV TEESTA-RANGPO-2 (MAIN)	1,797.1	-1,795.9	1.2	0.07
TS-06(15Min)	400 KV TEESTA-RANGPO-2 (MAIN)	TT-06(05Min)	400 KV TEESTA-RANGPO-2 (CHECK)	1,797.1	-1,795.9	1.2	0.07
TS-07(15Min)	400 KV TEESTA-RANGPO-1 (CHECK)	TT-03(05Min)	400 KV TEESTA-RANGPO-1 (MAIN)	1,866.6	-1,865.9	0.7	0.04
TS-07(15Min)	400 KV TEESTA-RANGPO-1 (CHECK)	TT-04(05Min)	400 KV TEESTA-RANGPO-1 (CHECK)	1,866.6	-1,866.4	0.2	0.01
TS-08(15Min)	400 KV TEESTA-RANGPO-2 (CHECK)	TT-05(05Min)	400 KV TEESTA-RANGPO-2 (MAIN)	1,796.4	-1,795.9	0.6	0.03
TS-08(15Min)	400 KV TEESTA-RANGPO-2 (CHECK)	TT-06(05Min)	400 KV TEESTA-RANGPO-2 (CHECK)	1,796.4	-1,795.9	0.6	0.03
TT-03(05Min)	400 KV TEESTA-RANGPO-1 (MAIN)	TS-05(15Min)	400 KV TEESTA-RANGPO-1 (MAIN)	-1,865.9	1,866.1	-0.2	0.01

From the Table-3, it can be inferred that the difference is less than 0.5% and are as per regulation. There is provision of graphical pair check curve in MDP software. Pair check between 400KV Wardha Line 1 at Mouda (Main) 05-minute meter (MD-21) and 15-minute meter (MD-501) for week 21st December to 27th December carried out. The pair check sample curve is shown in Fig 18.

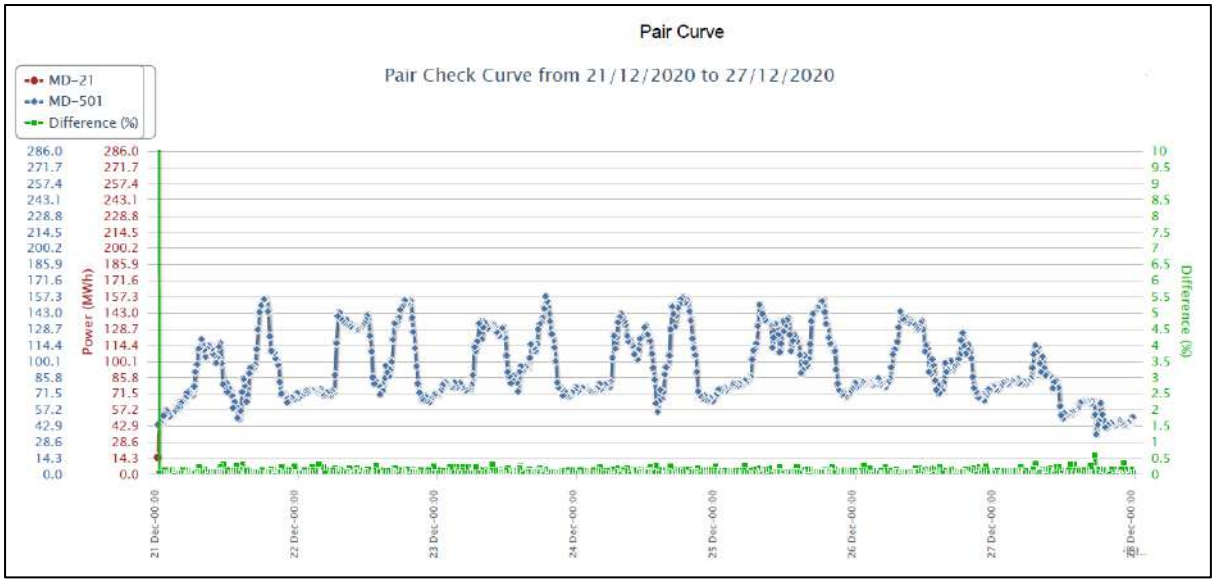

Figure 18: Sample Pair check Curve

The 05-minute energy was converted in 15-minute time block basis by adding the three 05-minute block and then compared with the 15-minute time block energy data for the main IEM. Except one or two blocks, in most of the block the difference in less than stipulated limits.

3.5 TIME DRIFT CHECK

Each interface energy meter has a built-in calendar and clock, which is required by regulation to have an accuracy of 30 seconds per month or better. The internal clock of the meter gets affected due to variable weather conditions encountered by the meter at site. The clock may drift creating mismatch with GPS time. The internal clock of meter is not automatically synchronised to the GPS time. Hence, the meter clock may drift creating mismatch between GPS clock and Meter clock. The time drift can be positive or negative. Positive means the IEM time is advance to GPS and negative time drift means IEM time is retarded compare to GPS time.

This mismatch can be corrected manually through DCD in steps of 1 minute per week. If the SEM clock is left to match GPS time, then, time-drift would accumulate. Time drift can be only checked & corrected at the site where the meter clock is accessible and difficult to verify and corrected remotely from control centre/RLDC. NTPC Barh reported time drift in new IEM (Table-4). Maximum time drift of 02 minute is reported in 400 kV Barh-Kahalgaon-2 Main IEM & 400 kV Barh-Patna-2 Main IEM.

Table 4: Reporting of Time-drift

Station Name	Meter No	Meter Location	Meter Type Main(M)/Check(C)	Meter No.	Time drift wrt to GPS time (mm:ss)
BARH	IEM00000061A	400 KV BARH(NTPC)-KAHALGAON(NTPC)-1(MAIN)	M	IEM00000059A	01:17
BARH	IEM00000059A	400 KV BARH(NTPC)-KAHALGAON(NTPC)-1(CHECK)	C	IEM00000061A	01:02
BARH	IEM00000050A	400 KV BARH(NTPC)-KAHALGAON(NTPC)-2(MAIN)	M	IEM00000052A	02:00
BARH	IEM00000052A	400 KV BARH(NTPC)-KAHALGAON(NTPC)-2(CHECK)	C	IEM00000050A	00:35
BARH	IEM00000058A	400 KV BARH(NTPC)-PATNA(PG)-1(MAIN)	M	IEM00000058A	01:30
BARH	IEM00000060A	400 KV BARH(NTPC)-PATNA(PG)-1(CHECK)	C	IEM00000060A	01:12
BARH	IEM00000064A	400 KV BARH(NTPC)-PATNA(PG)-2(MAIN)	M	IEM00000064A	02:00
BARH	IEM00000062A	400 KV BARH(NTPC)-PATNA(PG)-2(CHECK)	C	IEM00000062A	00:40
BARH	IEM00000063A	400 KV BARH(NTPC)-PATNA(PG)-3(MAIN)	M	IEM00000063A	01:04
BARH	IEM00000065A	400 KV BARH(NTPC)-PATNA(PG)-3(CHECK)	C	IEM00000065A	00:30
BARH	IEM00000053A	400 KV BARH(NTPC)-PATNA(PG)-4(MAIN)	M	IEM00000053A	01:00
BARH	IEM00000051A	400 KV BARH(NTPC)-PATNA(PG)-4(CHECK)	C	IEM00000051A	01:20
BARH	IEM00000055A	400 KV BARH(NTPC)- GORAKHPUR(NR) LINE-1(MAIN	M	IEM00000055A	01:00
BARH	IEM00000057A	400 KV BARH(NTPC)- GORAKHPUR(NR) LINE-1(CHEC	C	IEM00000057A	01:01
BARH	IEM00000056A	400 KV BARH(NTPC)- MOTIHARI LINE-2(MAIN)	M	IEM00000056A	00:30
BARH	IEM00000054A	400 KV BARH(NTPC)- MOTIHARI LINE-2(CHECK)	C	IEM00000054A	00:35

Large time drift can also be observed during pair check data of the above said line. Time drift phenomena is visualised as depicted in Fig. 19.

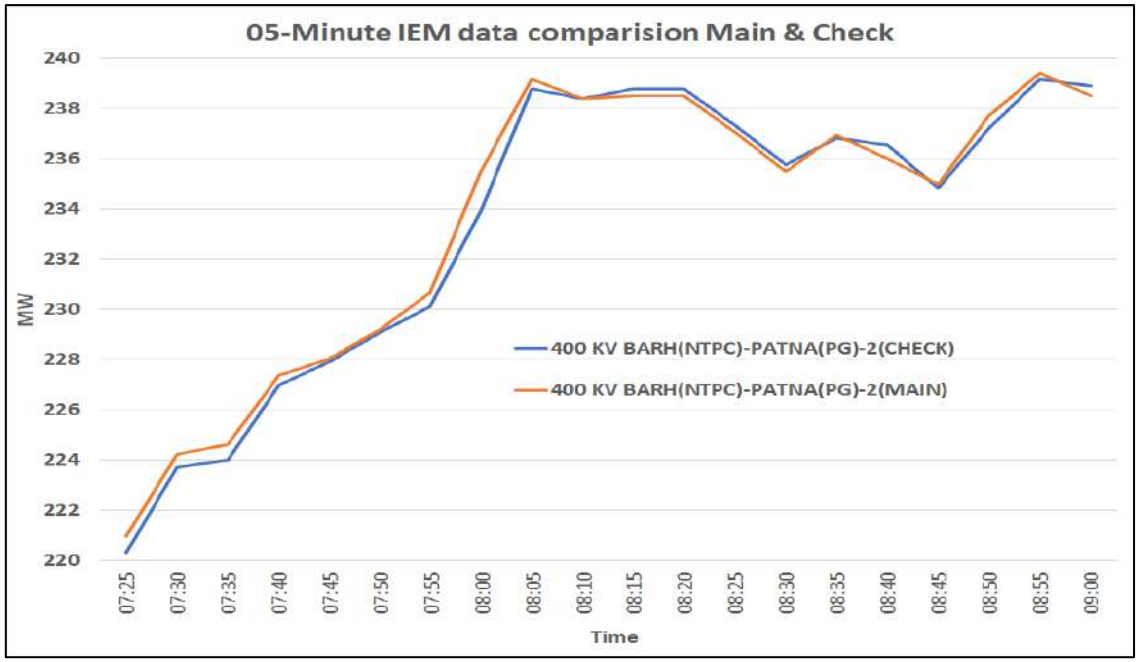

Figure 19: Pair Check Curve

An example of time drift in the sample data of 400 kV Teesta-Rangpo-1 in Eastern region for 30 November, 2020 is depicted in Fig. 20. The energy data recorded by new IEM on 05-minute time block basis was converted in 15-minute time block with addition of the block data and compared with the existing 15-minute SEM used for accounting and settlement purpose.

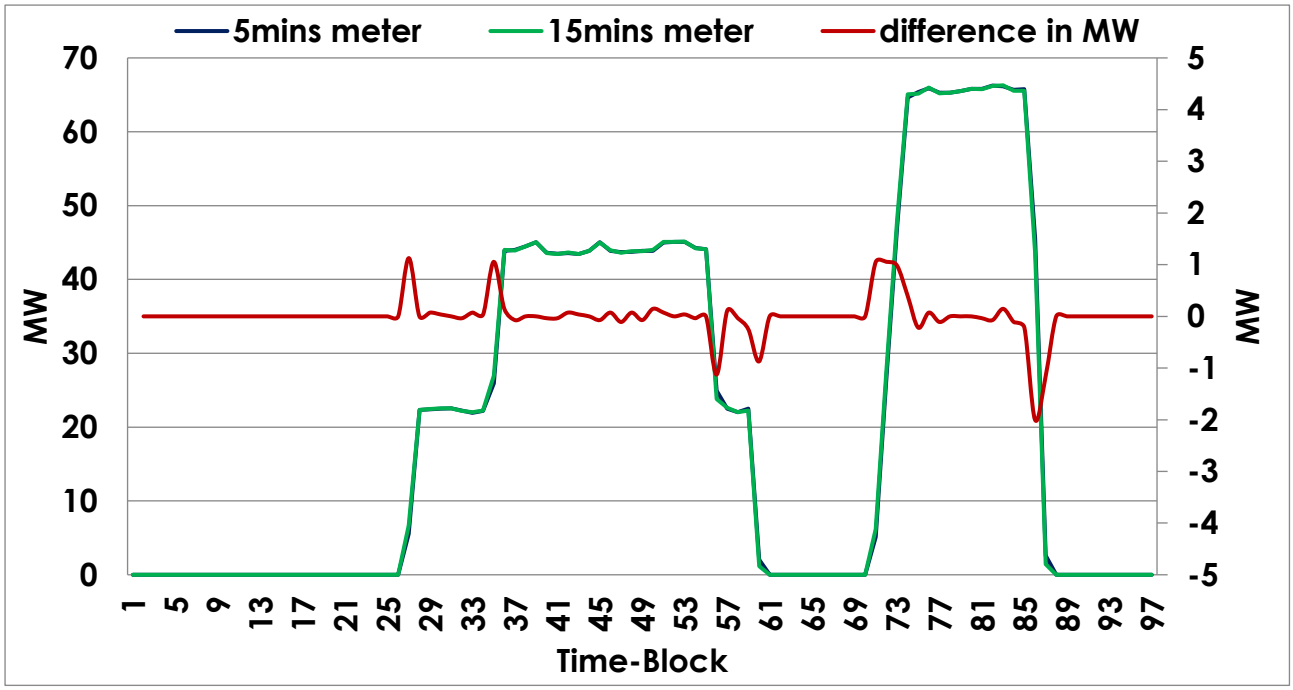

Figure 20: Sample Time Drift

Normally, the data of both the 05-minute IEM and 15-minute SEM would be the same. The spikes in the Fig. 15 can be attributed to time drift in the meters. The issue of time drift also leads to discrepancy with the SCADA data. SCADA data is used by system operator to manage the drawal from grid. The calculation of deviation from schedule is done with IEM data. In order avoid any such discrepancy, there is a need to synchronise the IEM either through AMR, GPS, NaVIC, Network Time Protocol (NTP) servers etc.

3.6 DISCRETIZATION OF RAMP

Another aspect associated with ramping, which is to be appreciated, arises due to the scheduling, metering, and settlement philosophy. While the load curve, generation, and ramping are all continuous curves, they have to be discretized into 15-minute average MW blocks for the purpose of scheduling and settlement. The average MW drawn or injected by any entity during any 15-minute time block should be equal to their schedule in the corresponding time block.

The interface meters record the energy exchanged for each time block from which the average MW is derived. The relationship between the ramping in the actual generation, which is a continuous line versus the ramping in average MW schedule, which is a staircase, introduces complications in assessment of available ramping reserves in the scheduling timeframe.

The ramp rate that can be scheduled, therefore, instead of straightforward 1%, becomes a function of the schedule in previous time blocks. Further, any change in the direction of ramping between consecutive time blocks creates an additional constraint while scheduling. Modelling this dependence mathematically and incorporating it into scheduling and optimization logic adds another layer of complexity and is usually a trade-off from practical considerations.

While the scheduling is based on 15-minute average MW values, the power plant operator needs to convert it suitably to the generating unit load set points as well as the ramp rate. The discretization of ramp has been depicted in the Tehri (Hydro)(Fig. 21 & 22) and Mauda (Thermal) power plants)(Fig. 23 & 24) in the 05-minute format.

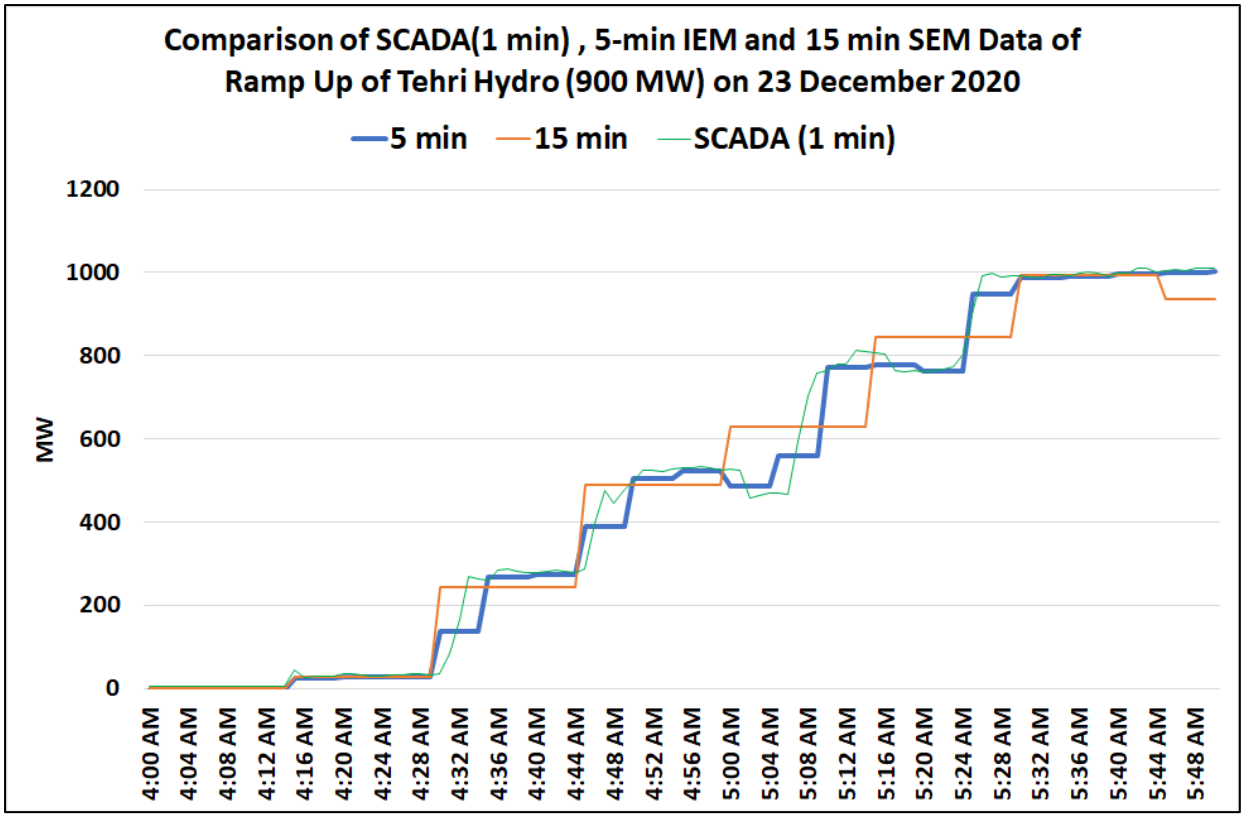

Figure 21: Tehri Hydro Ramping Up

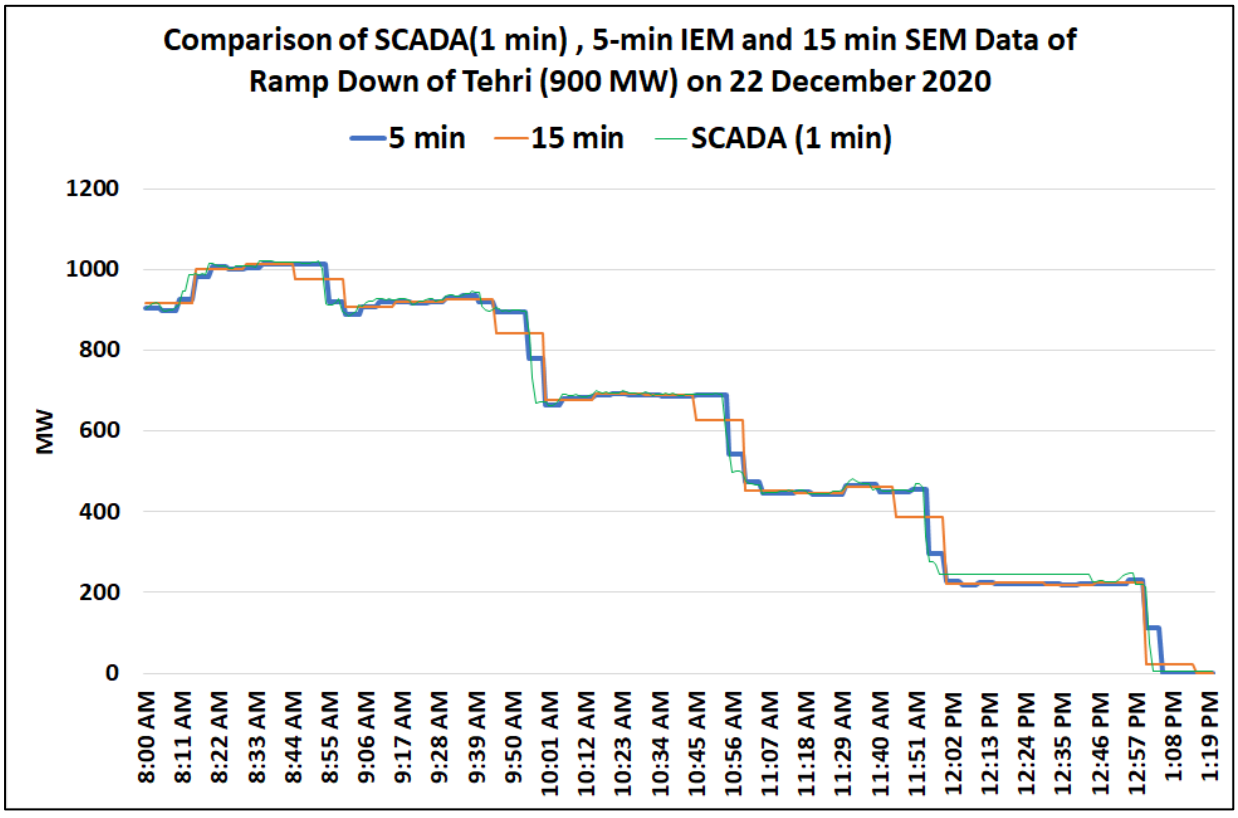

Figure 22: Tehri Hydro Ramping Down

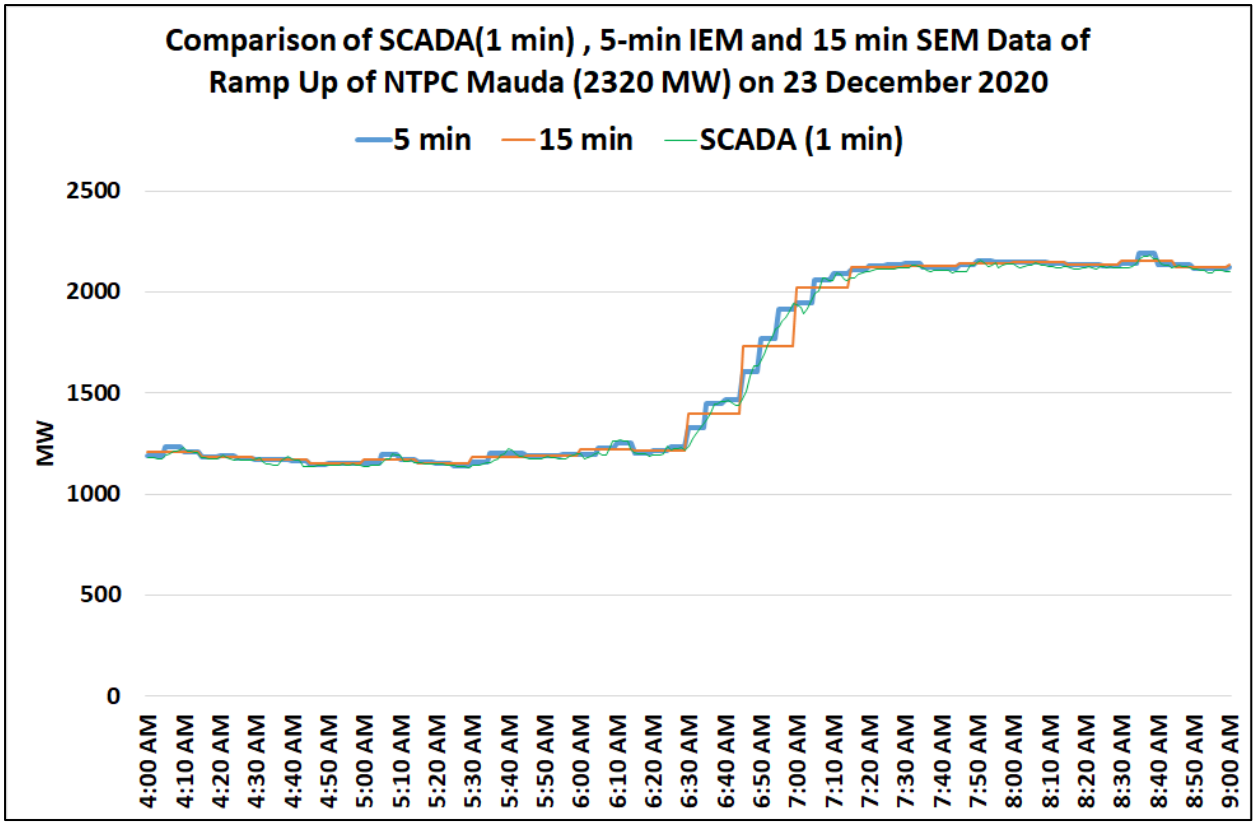

Figure 23: Mouda Thermal Ramping Up

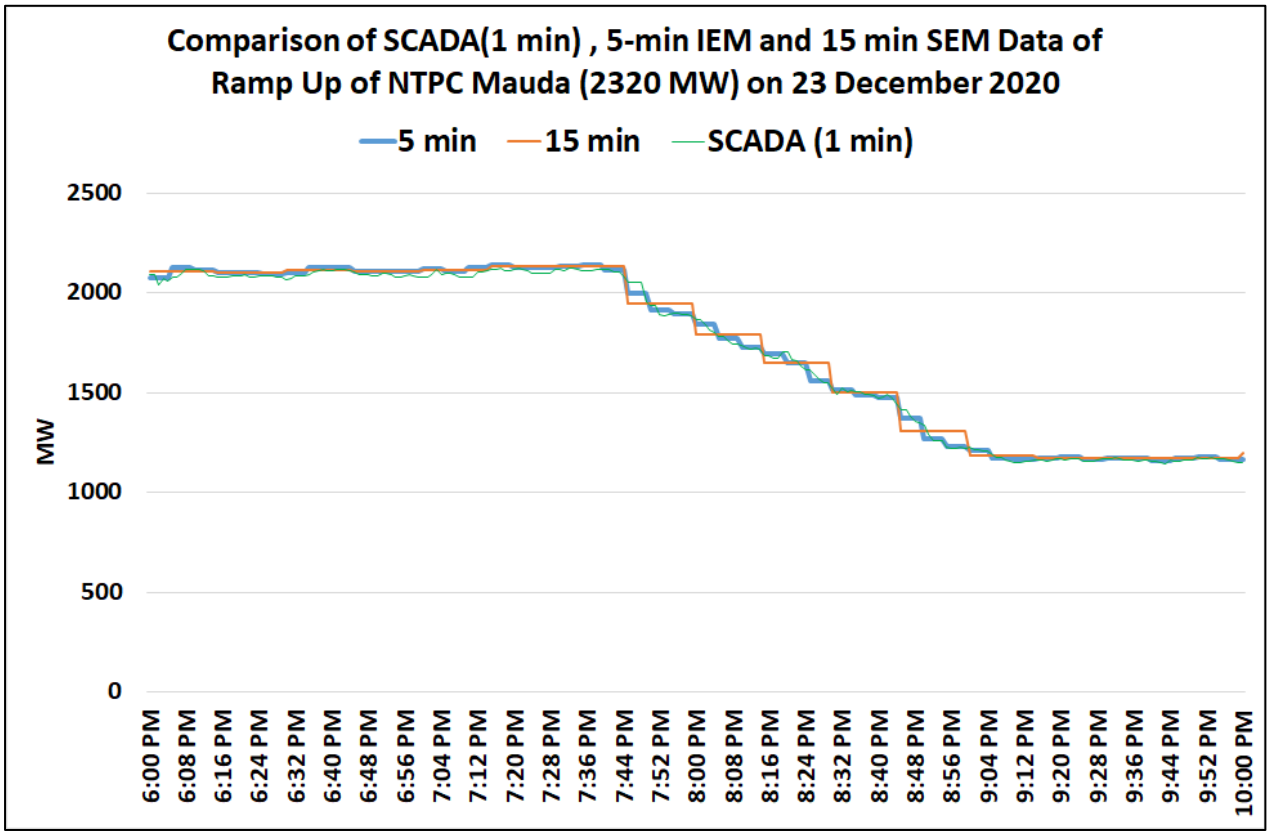

Figure 24: Mouda Thermal Ramping Down

3.7 REACTIVE ENERGY AND VOLTAGE

New IEMs are capable of recording the 05-minute reactive energy and the voltage. These parameters are outside the scope of current SEM used for accounting and settlement. CEA (Installation and Operation of Meters) Amendment Regulations, 2019 applicable from 23 December, 2019 also mandated to have this feature for all the meter going to be procured from the date of implementation of the said regulation. The relevant clause is reproduced as below:

"…*(vii) net VArh transmittal during each successive time block upto two decimal with plus sign for reactive power sent out from station busbars and minus sign for reactive power received into the busbars;*

(viii) average voltage upto 2 decimal truncation:.."

Reserve Regulation Ancillary Services (RRAS) was implemented from 18th April, 2016 for despatch of active power. The major hurdle for implementation of Voltage Control Ancillary Services is the measurement of the reactive power actually absorb/supplied to the grid as per the requirement. With the new IEM installation pan India, the implementation of Voltage Control Ancillary Services may be explored. The sample plots of reactive power flow vis-à-vis voltage as depicted in MDP software is depicted in Fig. 25.

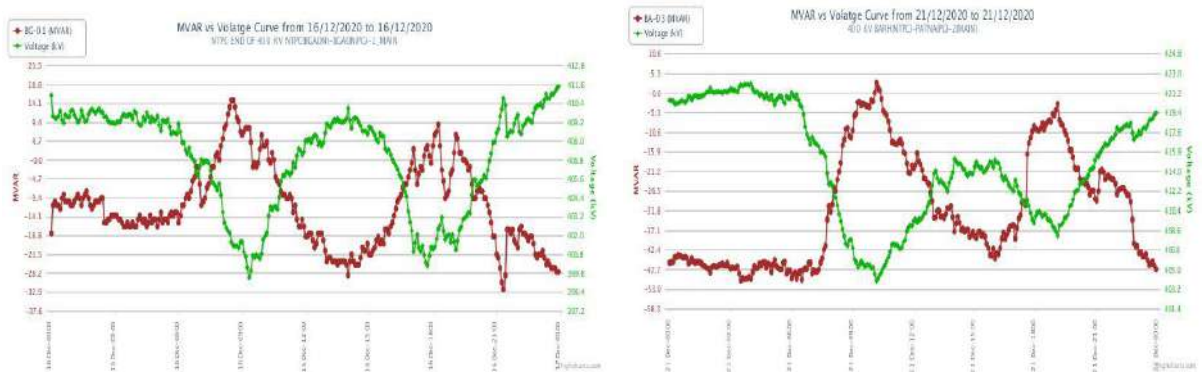

Figure 25: MVAR vs Voltage

The new 05-minute IEM reactive and voltage data is also compared with the SCADA data converted to average 5 minute for a sample day for Tehri Hydro power station which has four units of 250 MW each. The reactive data comparison is given in Fig. 26 and voltage comparison is give in Fig. 27.

It can be inferred that there is minor deviation in reactive power recorded by the SCADA and by new 05-minute IEM. This may be due to the difference in

sample data frequency used by SCADA system and the IEM. Further, it may also be due to time synchronisation related issues.

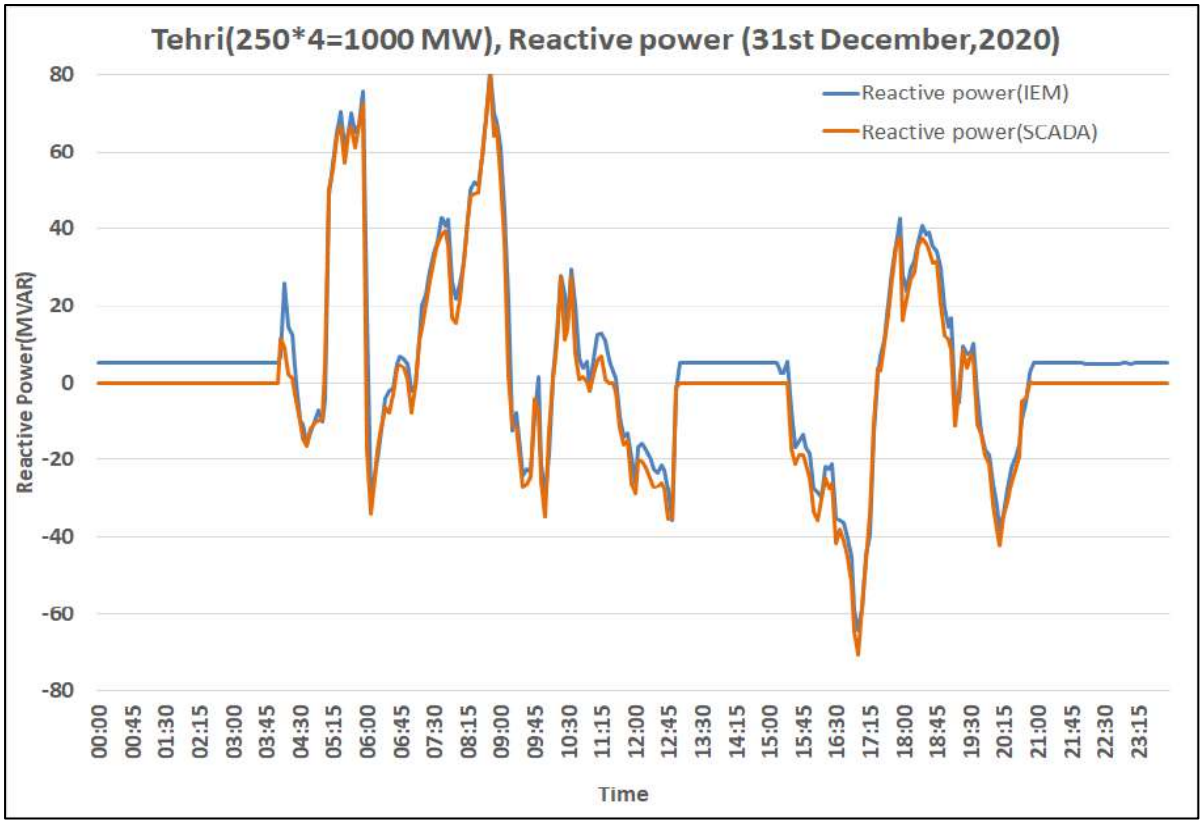

Figure 26: Tehri SCADA Vs IEM reactive power

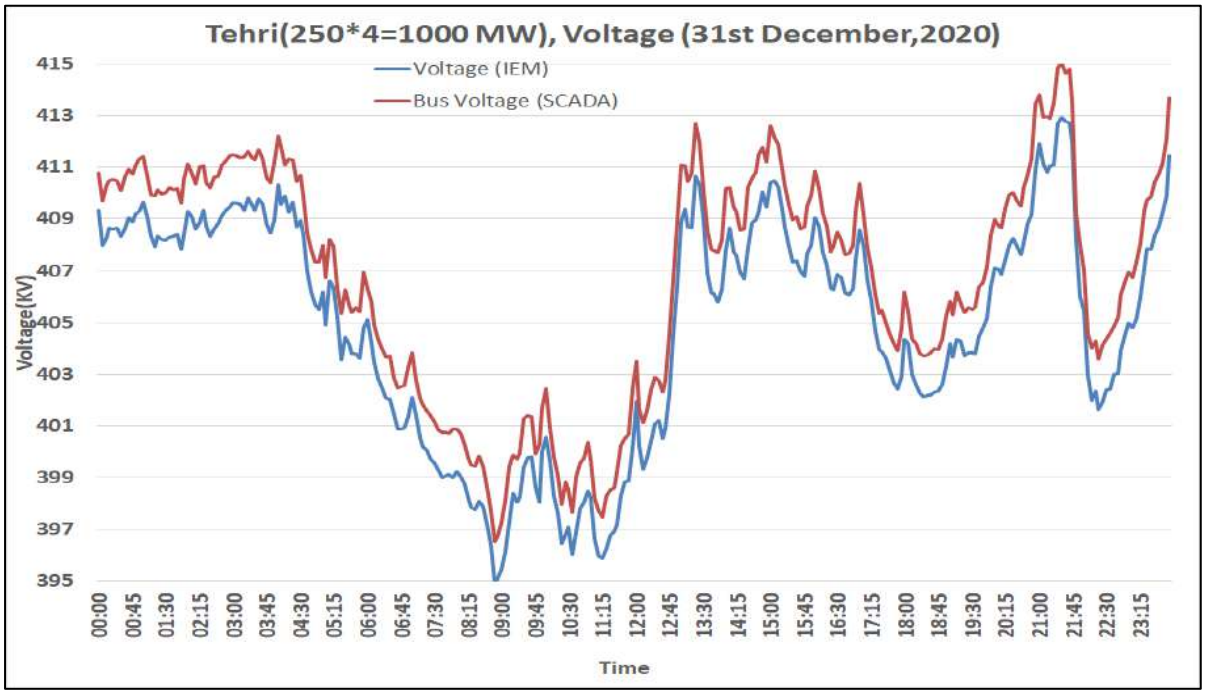

Figure 27: Tehri SCADA Vs IEM voltage

3.8 DATA ANALYSIS OF HYDRO STATION

Hydro stations are fast ramp capable power stations; however, they are also considered as energy limited resource. They are generally scheduled to meet the peak demand requirement. The fast ramp capability was demonstrated by hydro station during pilot project of Fast Response Ancillary Services (FRAS).

Some sample days data for Loktak Power station having three units of 35 MW each and installed capacity of 105 MW was analysed. The actual 05-minute energy and 15-minute block-wise energy has been worked out. The analysis of the time-block wise energy data for both 05-minute IEMs and 15-minute SEMs was carried out. The sample percentage difference is depicted in Fig. 28.

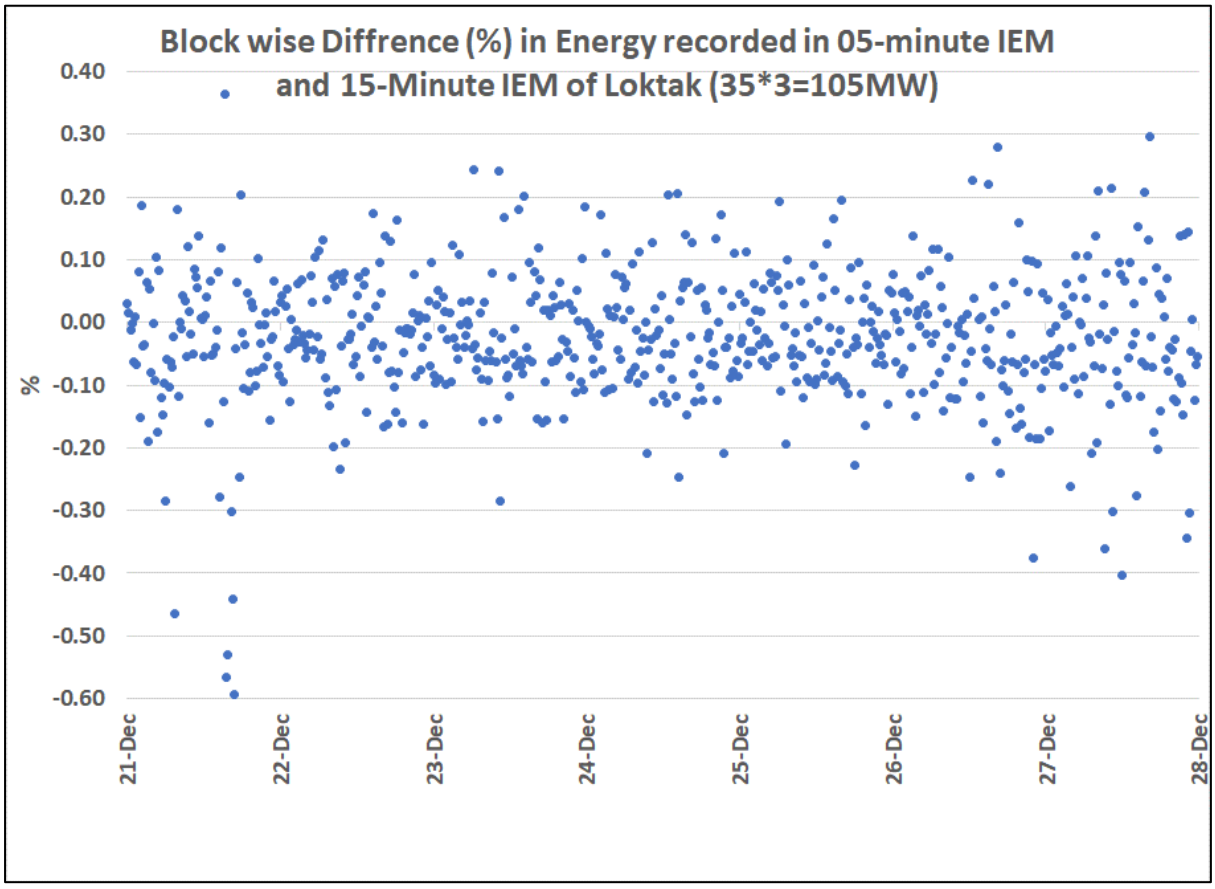

Figure 28: 05-min IEM &15-min SEM in hydro station

Further the 15-minute schedule was converted into 05-minute block and plotted along with the 05-minute actual IEM data. The graph is given in Fig. 29. It can be seen that most of the time the plant is maintaining the actual generation equal to scheduled generation.

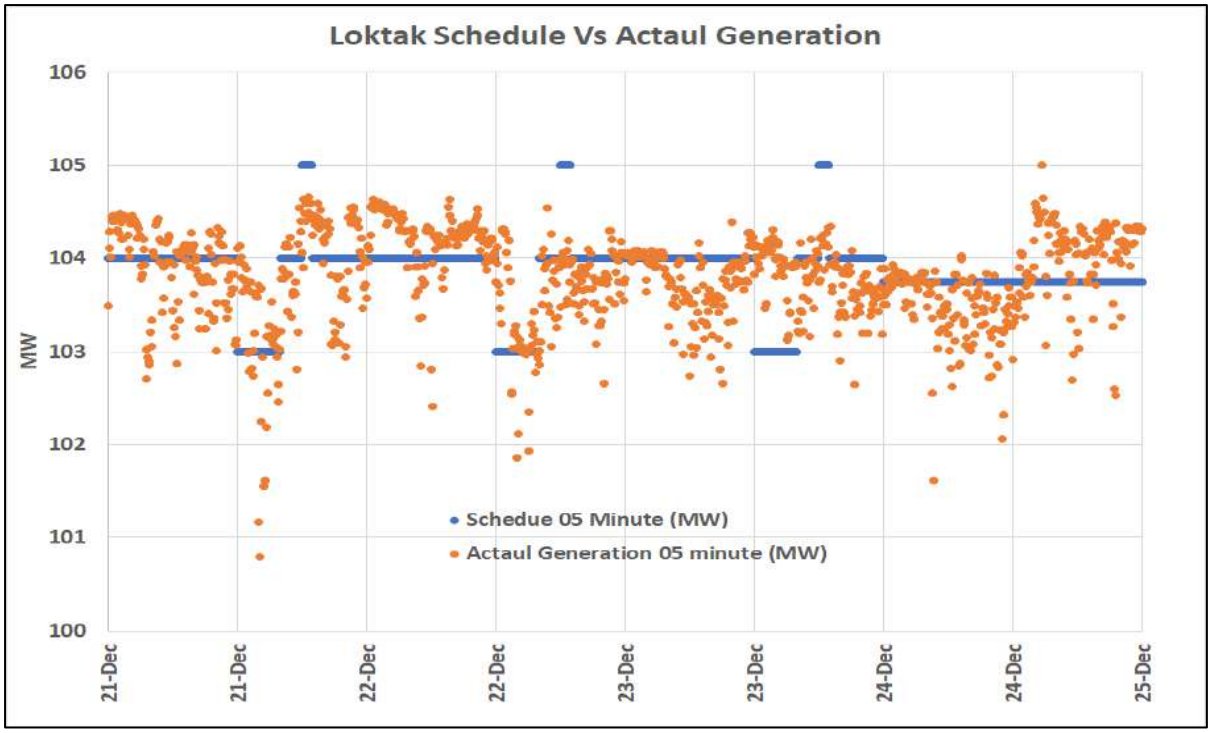

Figure 29: 05-min Schedule vs 05-min Actual (hydro)

Deviation Account was prepared for the Loktak power station for sample week starting from 21st December'20 to 27th Decemebr'20. While doing sample calculations, additional deviation charges due to sign change has been excluded for 15-minute deviation calculation, Korba frequency was considered and for 05-minute, the frequency was taken from the new 05-minute IEM of installed at Loktak. The net ex-bus injection was also calculated from the new 05-minute IEM. The details of the actual energy and deviation amount is given in Table 5.

Table 5: Comparison of Deviation Settlement Charges

Date	15 Minute IEM (MWh)	05 Minute IEM (MWh)	Deviation calculated as per 15 Minute IEM actual (Rs)	Deviation calculated as per 05 Minute IEM actual (Rs)
21-12-2020	2492.84	2491.51	-5178	-2690
22-12-2020	2494.03	2493.62	-4775	-5497
23-12-2020	2490.64	2490.23	-285	-129
24-12-2020	2490.31	2489.88	-7919	-6799
25-12-2020	2494.47	2494.10	-15231	-13899
26-12-2020	2000.26	2000.40	-3499	-5620
27-12-2020	1664.41	1663.81	31049	28814
Total Deviation	16126.95	16123.55	-5839	-5820

(-) Recivabale by Power Station from Pool/(+) Payable by power station to pool

The hydro stations have fast ramping capability. With necessary regulatory framework for scheduling and all necessary infrastructure like 05-minute IEM in place, only schedule needs to be converted on 05-minute time block basis for

05-minute schedule and settlement implementation. Further, Fast Response Ancillary Services (FRAS) for hydro stations can also be enabled. FRAS would help in integration of 175 GW of renewables by 2022 and 450 GW by 2030 in Indian grid.

3.9 MOCK EXERCISE OF 05-MINUTE SCHEDULING OF TEHRI HEP

As a mock exercise during the pilot project, 05-minute schedules were communicated to THDC, Tehri by NRLDC w.e.f 0000 hrs of 27th November, 2020 for experience on 05-minute scheduling, metering and settlement. A sample day data of the schedule and actual with granularity of 05-minute and 15-minute time block is depicted in Fig. 30 & 31 resp. Further, the data recorded through SCADA system is also depicted in Fig. 32.

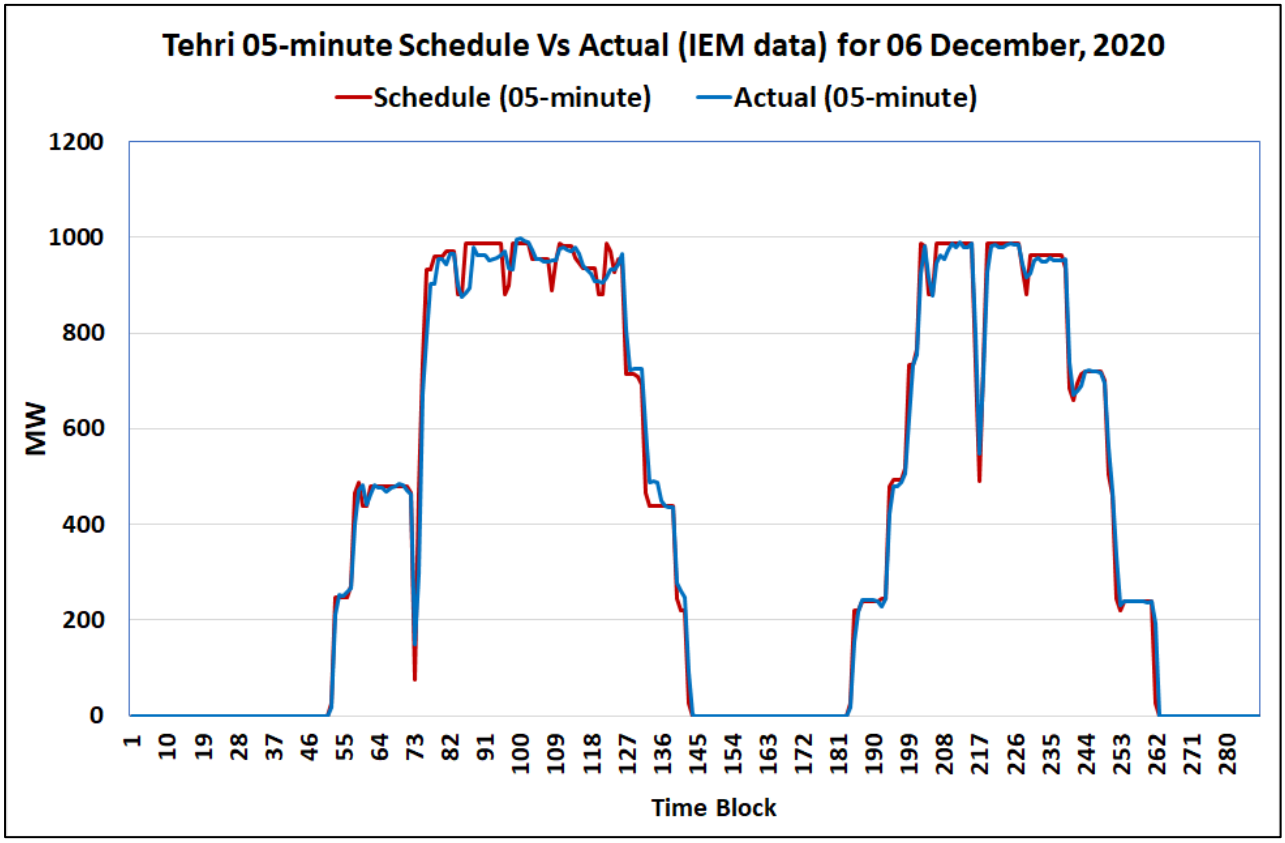

Figure 30: Tehri 05-minute Schedule vs Actual

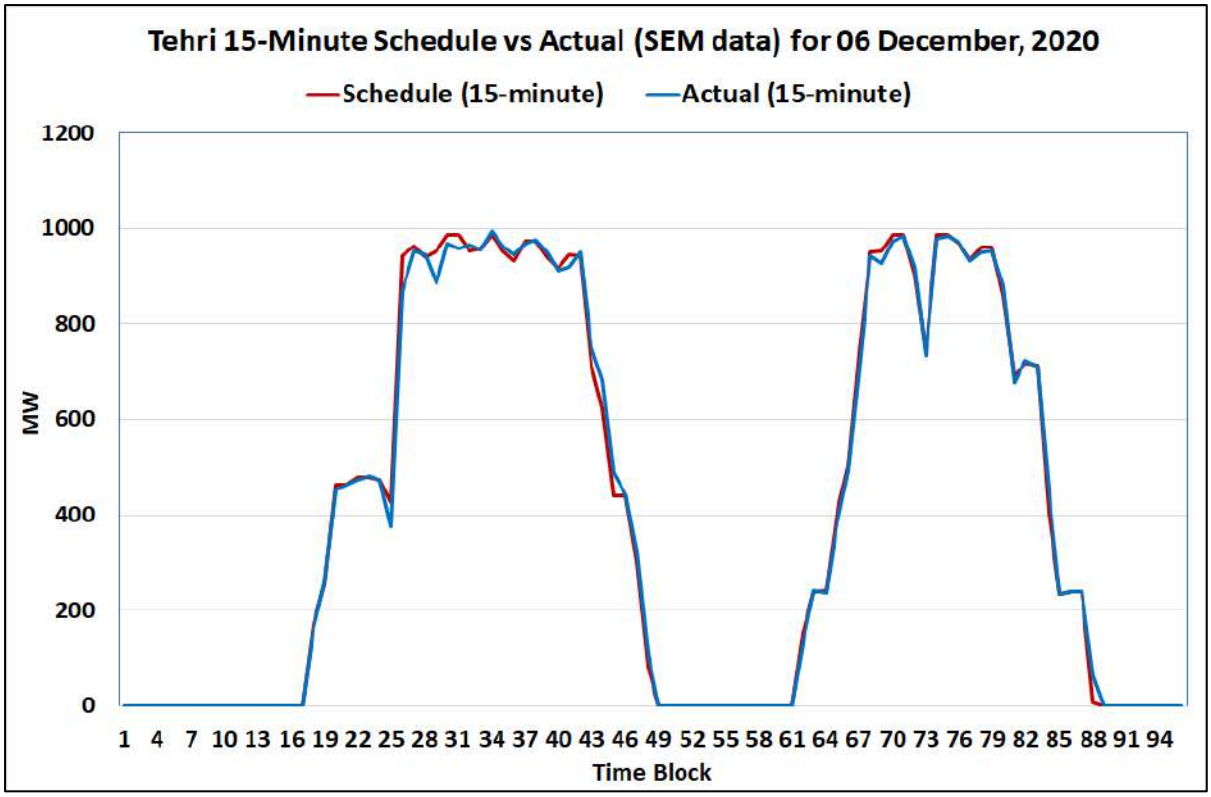

Figure 31: Tehri 15-minute Schedule vs Actual

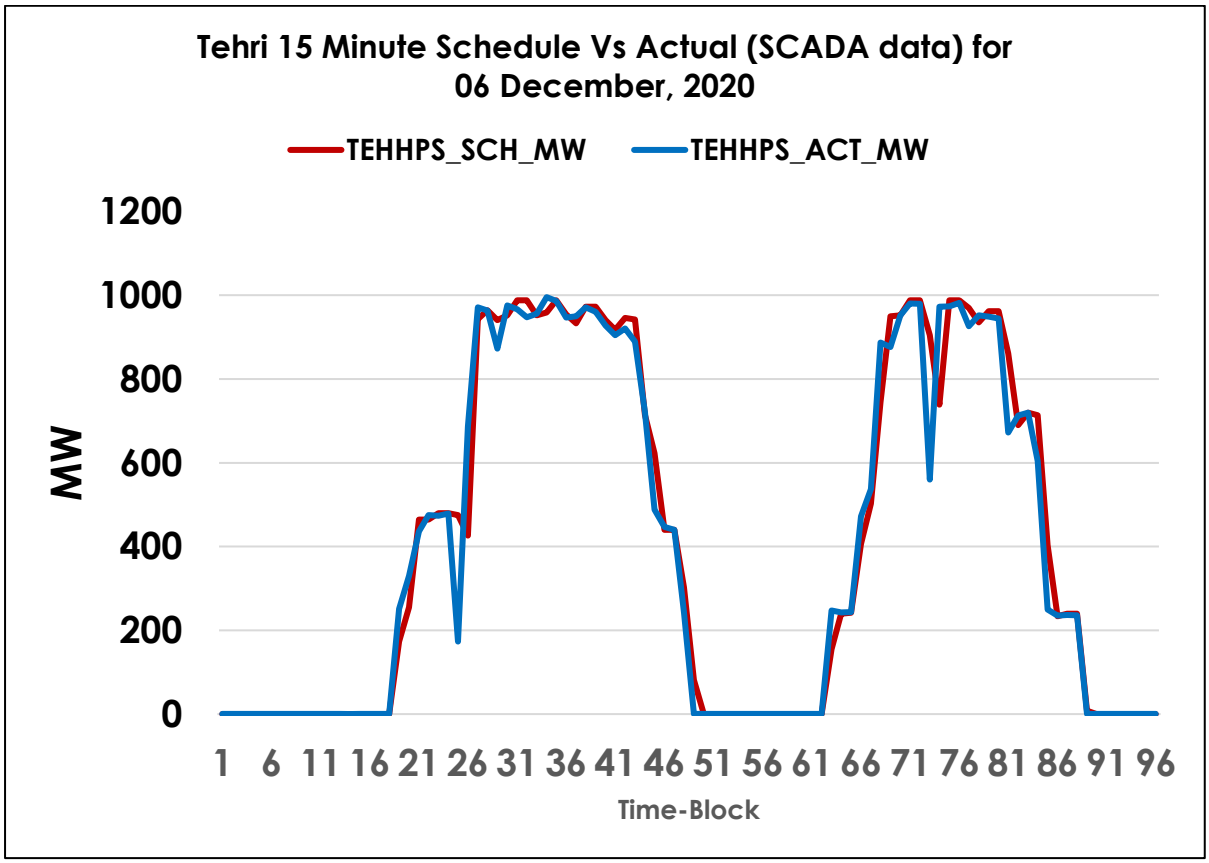

Figure 32: Tehri 15-minute schedule vs SCADA

During the course of implementation of 5-minute scheduling, THDC, Tehri highlighted certain operational constraints being observed. The summary of constraints which have been conveyed by THDC, Tehri are as follows:

- Forbidden zone of operation during transition
- High vibration during transition
- Ramp and ramp down issues
- Mechanical fatigue
- Hydraulic transients
- RGMO operation issue
- Load transition from peak load to 25 MW and vice versa causing stress in Governing system and Generator Thrust bearing

The sample accounts based on 5-minute and 15-minute settlement system for the week 30 November – 06 December, 2020 is depicted in Table-6.

Table 6: Sample 05-minute and 15-minute settlement

Date	15 minute				5 minute				Difference	
	Sch.	Act.	Dev. Charges	Cap Dev.	Sch.	Act.	Dev. Charges	Cap Dev.	Dev. Charges	Capped Dev.
	LU	LU	₹ Lakhs	₹ Lakhs	LU	LU	₹ Lakhs	₹ Lakhs	₹ Lakhs	₹ Lakhs
30-11	66.00	66.42	-0.50807	-0.43865	66.00	66.37	0.10964	0.42395	**0.61771**	**0.86260**
01-12	66.00	66.17	0.57265	0.21443	66.00	66.11	0.13366	1.38073	**-0.43899**	**1.16630**
02-12	77.55	78.25	-1.74104	-1.63361	77.55	78.17	-0.73274	0.14832	**1.0083**	**1.78193**
03-12	86.50	87.54	-5.38348	-3.04366	86.50	87.46	-2.76481	-1.12571	**2.61867**	**1.91795**
04-12	86.50	87.35	-2.89908	-2.18604	86.50	87.28	-0.56870	0.12889	**2.33038**	**2.31493**
05-12	86.50	87.24	-3.89301	-2.69044	86.50	87.16	-2.49625	-1.03802	**1.39676**	**1.65242**
06-12	99.50	99.25	-1.20070	-1.08316	99.50	99.16	-0.57618	0.26960	**0.62452**	**1.35276**

LU = 0.1 MU = 0.1 GWhr, 1 Lakh = 0.1 Million

3.10 DATA ANALYSIS OF GAS STATION

05-minute IEMs were installed in Dadri gas power station [GT (4x 130.19 MW), ST (2x 154.51 MW) =829.78] as part of pilot project. The station is scheduled under different gas fuel type (Regulated price gas/re-gasified liquefied natural gas (R-LNG)/Liquefied natural gas (LNG)/RLNG purchased through spot market). The schedule and actual of Dadri gas power station for sample week 14th December,2020 to 21st December, 2020 is depicted in Fig. 33.

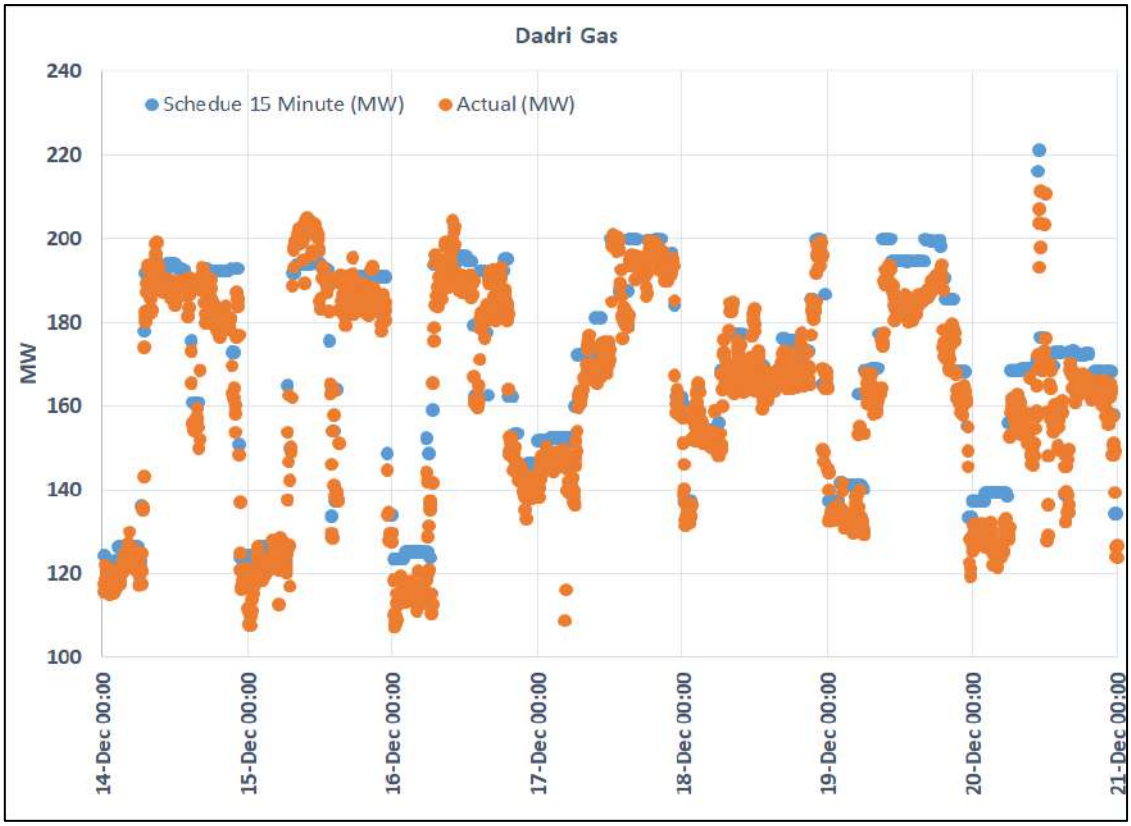

Figure 33: Dadri Gas Schedule & Actual generation

There is some deviation by the plant from the schedule. The DSM statement for the week for the Dadri Gas Power station given in Table 7.

Table 7: DSM Charges (+)Payable to Pool/(-) Receivable from Pool

DATE	Schedule (MWh)	Actual (MWh)	Deviation (MWh)	Deviation Amount (Rs)	Additional Deviation	Net Deviation Amount (Rs)
14-12-2020	4006	3819	-187	348202	918	349120
15-12-2020	4032	3904	-129	272868	7118	279986
16-12-2020	3956	3757	-199	473426	0	473426
17-12-2020	4266	4114	-152	363202	0	363202
18-12-2020	4038	3877	-162	309644	0	309644
19-12-2020	4171	3961	-210	443898	0	443898
20-12-2020	3868	3630	-237	424355	0	424355
Total	28336	27061	-1275	2635595	8036	2643631

The Ramp declared by Power station under RRAS is 50 MW/Block. The schedule ramp for sample period 14th December,2020 to 21st December,2020 is shown in Fig. 35. In most of the time-blocks, the schedule ramp is less than or equal to the declared ramp by the gas power station.