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Availability Based Tariff and Deviation Settlement Mechanism for region wise All India Demand: A case study

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ABSTRACT:This paper presents overview of effect of 5th April 2020 lights off event. Prime minister of India Shri Narendra Modiji appealed all the people of India to light lamps and switch off lighting load for 9 min. Though it was planned event and no major grid collapse incident was happened, there was deviation of schedule and actual demand. Also, deviation of frequency was observed 47. 91 HZ to 50.20 Hz. Effect of lights off on Availability based tariff is studied in this paper and Unscheduled Interchange is calculated for frequency deviation during that time. Total deviation settlement charges for all India demand are calculated for each minute after total domestic load of India is off. Also, relation between frequency variation and UI is shown (during 9 min event) using latest data of UI charges taken from SRLDC website.

KEYWORDS: Scheduled demand; Availability based tariff; Unscheduled Interchange

I.INTRODUCTION

The Prime Minister of India, Shri Narendra Modiji appealed to all the people of India to switch off lights and light lamps/ candles on 5th April 2020 at 9:00 pm for 9 minutes. The total reduction in all India demand recorded during the event was 31089 MW. Grid Frequency during the event remained in the range of 50.26 Hz to 49.70 Hz with maximum and minimum frequency of 50.259 Hz and 49.707 Hz recorded at 9:08 pm and 08:49 pm respectively as per POSOCO report. According to POSCO the event was nicely managed without any major fault or collapse of lines. [1] The precautionary guidelines for COVID-19 regarding use of social distancing and mask was ensured at all locations. The permissible range of frequency band is 49.5 to 50.5 Hz as per CERC, union government regulates grid frequency through national and regional lad dispatch centres, state regulates intra state grids through State Load Dispatch Centre[1]. Generating stations and distribution companies are required to follow scheduled dispatch and drawl to ensure discipline of grid. There are penalties for 1) Deviating from limits of scheduled Dispatch and Drawl.
2) Deviation of frequency. [8] As power demand was planned well in advance and power grid cooperation already planned the reduction demand no major event of tripping or grid collapsed happened.
Grid safety, efficiency and reliability was not disturbed. Capacitors at distribution level were kept off to maintain voltage level. Also, other than lighting load rest all load was ON. Lights of all essential services including hospitals and police station as well as street light was not switched off during that time. Renewable energy sources and coal-based generators as well as gas-based power stations were already scheduled in a manner to manage the demand. Around 12 GW reduction of demand was predicted but actual demand reduction was 31 GW on the day of lights off event. Since the event was already planned there was enough time to manage [4]

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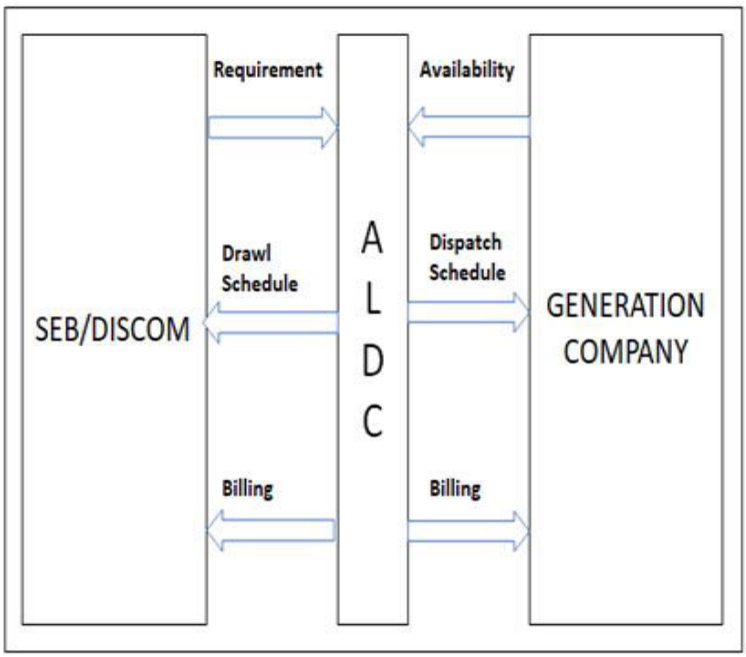

Fig 1: Role of Load Dispatch center

Table 1: All India demand and scheduled generation [4]

Time	All India Demand met	Hydro Gen (MW)	Gas (MW)	Thermal (MW)	Total Scheduled Gen
20:55	113251	22848	7336	74037	MW
20:56	111778	21921	7385	73811	104221
20:57	110333	20817	7291	73600	103117
20:58	108073	18965	7241	73311	101708
20:59	105632	17618	7060	72740	99517
21:00	101667	14890	6865	72170	97418
21:01	97471	12222	6526	71060	93925
21:02	94034	10480	6259	70331	89808
21:03	91068	9357	5974	69756	87070
21:04	89644	9091	5867	69179	85087
21:05	88731	8955	5730	68811	84137
21:06	87880	8743	5613	68325	83496
21:07	87206	8569	5508	68119	82681
21:08	86557	8293	5423	67942	82196
21:09	85901	8019	5372	67952	81658
Time	All India Demand met	Hydro Gen (MW)	Gas (MW)	Thermal (MW)	81343

this demand reduction, the demand reduction was managed by reducing hydroelectric power 17.5 GW, thermal 6.9 GW gas 1.9 GW and wind 2 GW. When demand started to rise after event these resources were gradually scaled up to meet the increase in demand. Grid stability issue happens when frequency is not within the specified limit. On 5th April 9:00 pm to 9:09 pm the frequency was between 49.7 to 50.26 HZ.[4] Pumped storage hydro units were in pumping mode till 9:09 pm.

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||Volume 9, Issue 7, July 2020||

Also, arrangement was done for withdrawing the generator if frequency goes below 49.7 Hz. State and intra state level wind generating stations were automatically disconnected if frequency goes more than 50.2 Hz. POSCO has asked all the generating station to synchronize their clock to the Indian standard time, also highest dip in demand and ramp in demand was predicted[4]. The 5th April 2020 event management of demand variation was done without any market price signal. As frequency was within limit there is no extra deviation settlement charges implemented on state utilities. This event has proved Indian power system robustness and reliability.
PowerGrid Corporation has asked its regional centres to advise all station in charge and Regional Transmission Asset Management Centre, operation staff to be on high alert with required staff. Extreme watch needs to be maintained and immediate connection with National Transmission Asset Management Centre may be made in case of any abnormality/assistance required.

All bus/line reactors were in service or available for taking into service as per advice of RLDCs and NLDC[2]. Station in charge and senior level executives should be available at their respective station control rooms. Central Power Coordination Centre to require care of any contingency and also for smooth coordination with respective RLDCs[2].
The power reduction in load and recovery were handled through coal, gas, hydro, nuclear and green energy sources travel by the Centre, States and therefore the private sector. Also, India's national grid is connected with Bangladesh, Nepal and Bhutan. The lights in hospitals and every one other essential service like public utilities, municipal services, offices, police stations, manufacturing facilities, was remain on. The power reduction in load and recovery are going to be handled through coal, gas, hydro, nuclear and green energy sources travel by the Centre, States and therefore the private sector. Also, India's national grid is connected with Bangladesh, Nepal and Bhutan.[2]
Two things happened,
1) the demand had reduced to 25% and 2) generation was reduced slowly to adjust the demand.[3]
DISCOMs in India are dependent on govt policies and schemes to upgrade and expand their assets. Operationally they suffered as demand and billing from commercial and industrial consumers reduced drastically [3]. Also, they were not allowed to take actions against defaulters as directed by state govt. [3] Following are the key points discussed by P.K. Patnaik, IEEMA 2020
1) Automation towards digital and smart grid to manage the correct pre-defined supply and demand response to maintain system stability
2) Auto governor control mode to the generator for quick response to the allotted band of system parameter.
3) Strong pre scheduling plans for power generator mix with penalty control mechanism for the deviation beyond allowable limit.

II.ABT and UI

Availability based tariff is three-part tariff having three components.
1) Fixed charges
2) Variable charges
3) UI charges/deviation settlement mechanism charges.
As the name signifies the tariff is based on availability of supply. If actual generation is less than the scheduled generation, for the deviation there are UI charges applicable which are frequency linked charges [6]. To improve the efficiency in the operation of the power system some major changes into the structure of electric power utilities have been introduced by means of deregulating the industry and opening it up to private competition [7]
e.g. Scheduled generation is 100 MW and actual generation is 90 MW, for 10 MW Unscheduled Interchange charges or Deviation settlement mechanism charges are to be paid by state utility to central utility as per the frequency reading that time. Table 1 represents All India demand met and scheduled generation Hydro, Gas and Thermal for the time duration 20:55 pm to 21:09 pm.
Once we have Actual and schedule generation, we need deviation which is difference of scheduled and actual generation, we also need frequency for each reading of demand mentioned in table 2 for particular time period to calculate UI. Following tables represents deviation settlement charges calculation where latest UI rates are taken from SRLDC website.

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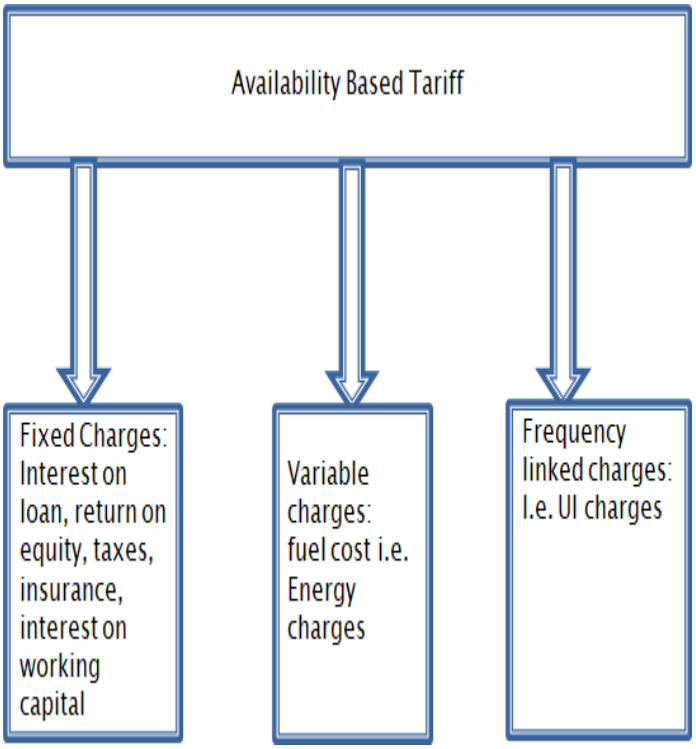

Table 2: Deviation settlement mechanism Calculation

Time	Deviation	Frequency	Charges for deviation	Total charges
Hours	MW	Hz	Paise /KWhr	INR (crores)
20:55	-9030	49.93	217	1.96
20:56	-8661	49.95	210.5	1.82
20:57	-8625	49.96	186	1.60
20:58	-8556	49.91	232.5	1.99
20:59	-8214	50.05	124	1.02
21:00	-7742	50.03	139.5	1.08
21:01	-7663	50.21	0	0.00
21:02	-6964	50.19	15.15	0.11
21:03	-5981	50.21	0	0.00
21:04	-5507	50.22	0	0.00
21:05	-5235	50.22	0	0.00
21:06	-5199	50.23	0	0.00
21:07	-5010	50.24	0	0.00
21:08	-4899	50.24	0	0.00
21:09	-4558	50.26	0	0.00
Total				9.58

UI=Total penalty per day for given deviation [8]

$$=\sum_{i=1}^{96}\sum_{k=1}^{N}(UI)_i^k$$

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||Volume 9, Issue 7, July 2020||

k=no of buses 1 to N, i=iteration count, total 96 blocks in a day
UI charge INR = UI rate per KWh× KW load on feeder× time in hour
Here we need UI calculation only for the duration of lights off event 20:55 pm to 21:09 pm.
Fig 3 and fig 4 represents graphical representation of UI mechanism.

Table- 3: Region wise load reduction on 5th April 2020[4]

Region	Rural load	Urban load	Reduction Rural load	Reduction of urban load	Reduction consumer	Reduction Grid
	MW	MW	MW	MW	MW	MW
Northern	2115	1321	1692	1057	2749	3054
Wesner	1783	1902	1427	1522	2948	3286
Southern	2193	467	1754	373	2128	3407
Eastern	2059	452	1647	361	2009	2168
North eastern	418	169	335	135	470	537
Total	8568	4311	6855	3449	10303	12452

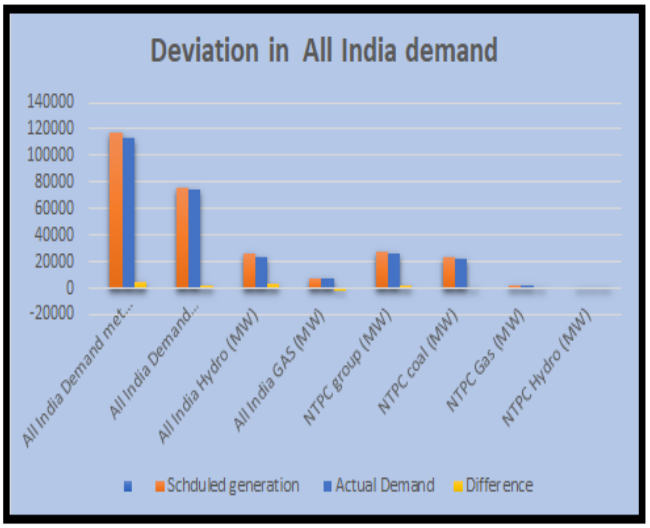

Fig 3: Deviation in demand [4]

Table 3 represents region wise demand reduction for rural and Urban consumers. Total reduction of demand appeared at consumer level was 10303 MW as per plan on 5th April 2020, and at grid level the predicted reduction of demand was 12452 MW. Actual reduction was found 31 MW as people switched off load other than lighting load as well.

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||Volume 9, Issue 7, July 2020||

III.RESULTS AND DISCUSSIONS

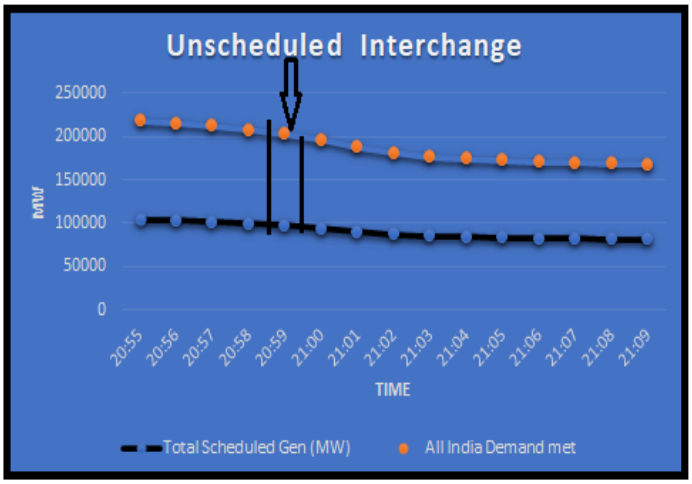

Fig 4: Unscheduled Interchange [4]

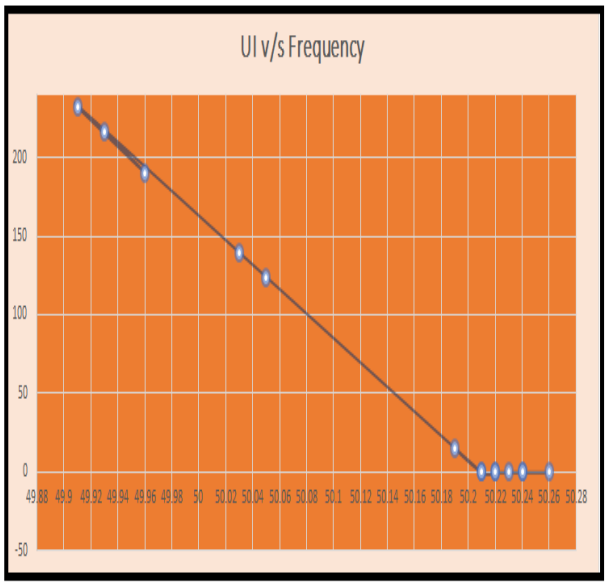

Fig 5: UI v/s Frequency

Fig 5 represents UI v/s Frequency graph for 9 min event on 5th April.
Here we can see inverse relationship between UI charges and frequency at particular time. As frequency increases UI decreases, once it becomes 50.2 Hz there are no deviation settlement charges applicable. In table 2 at 20:03 pm to 21:09 pm no charges applied. Fig 6 represents graphical representation of reduction in demand region wise, consumer level and grid level [4].Current ABT billing system is kWh based. Implementation of kVAh billing system in ABT metering in future will consider power factor of consumer load. kVAh billing will be advantageous to utility as consumer will improve consumption efficiency by improving power factor.

Utility will give discount of 0 % to 3.5% on total bill for improvement in power factor from 0.95 to 1. Consumers having low power factor has to pay more. Power factor penalties are 0% to 5 % of total bill for range of power factor 0.90 to 0.812. kVAh billing implementation on ABT metering will open up new ideas for future reserch. [9]

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Table 4 UI data as on 1st Jan 2019 [5]

	Average frequency of time block Hz		Charges for deviation
Sr No	Below	Not Below	Paise/kwh
1		50.20	0.00
2	50.20	50.18	15.50
3	50.18	50.16	31.00
4	50.16	50.14	46.50
5	50.14	50.12	62.00
6	50.12	50.10	77.50
7	50.10	50.08	93.00
8	50.08	50.06	108.50
9	50.06	50.04	124.00
10	50.04	50.02	139.50
11	50.02	50.00	155.00
12	50.00	49.98	170.50
13	49.98	49.96	186.00
14	49.96	49.94	201.50
15	49.94	49.92	217.00
16	49.92	49.90	232.50
17	49.90	49.88	248.00
18	49.88	49.86	263.50
19	49.86	49.84	279.00
20	49.84	49.82	294.50
21	49.82	49.80	310.00
22	49.80	49.78	325.50
23	49.78	49.76	341.00
24	49.76	49.74	356.50
25	49.74	49.72	372.00
26	49.72	49.70	387.50
27	49.70	49.68	403.00
28	49.68	49.66	450.00
29	49.66	49.64	497.00
30	49.64	49.62	544.00
31	49.62	49.60	591.00
32	49.60	49.58	638.00
33	49.58	49.56	685.00

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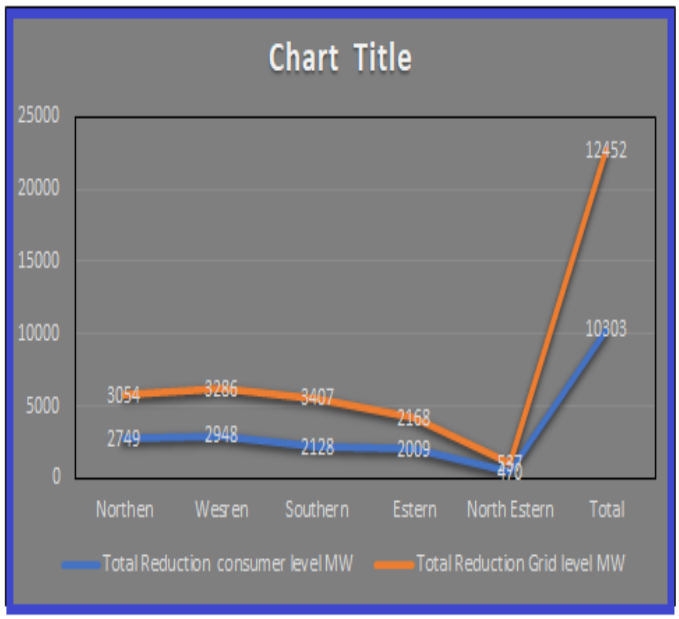

Fig 6: Region wise reduction in demand [4]

IV.CONCLUSION

The study describes overview of effect of 5th April 2020 lights off event. The event was studied considering region wise all India demand and scheduled generation details [4]. Frequency during the 9 min event was 49.91 Hz to 50.20 Hz. As it was not big swing of frequency, the supply and demand mismatch was handled by gradually decreasing hydro and gas generation. The event was well planned and no major fault incident was happened. Unscheduled interchange which is third component of Availability based tariff is calculated in this paper for 9 min event and also the relation between deviation settlement mechanism and frequency is shown graphically considering UI calculations for 9 min.Results show that though the event was planned and only lighting load was off, no major mismatch happened for scheduled and actual all India demand. Total UI changes payable for 20:55 pm to 21:09 pm on 5th April are 9.58 crores INR. for 9 min i.e. 21:00 pm to 21:09 pm it was 1.19 crores INR.

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