Availability Based Tariff: A Reliable and Economical Experience of Western Grid

Mrs. Surekha R. Deshmukh, *IEEE Member*, Mrs. G.A.Vaidya , *IEEE Member*, Dr. Sanjay Kulkarni

I. INTRODUCTION

The Availability Based Tariff mechanism (founded in 1980), was presented by power grid as 'a solution for technical and commercial problems in regional grid operation in India' in1991, along with the development of special energy meters for implementation of ABT [4] In1993, the mechanism was examined and endorsed by world bank. In1994, ABT was accepted by govt. India, but its implementation got delayed due to mis-apprehensions and inconclusive discussion. The Govt. of India has referred it to Central Electricity Regulatory Commission (CERC) in 1999. Due to stiff opposition from some parties notification has been deferred (2000 Jan). In Dec.2000, revised notification is issued by CERC. But implementation is held up due to stays obtained in high court by some State Electricity boards. But ultimately Western Region Electricity Board has taken initiative in implementing ABT on full strength on 01-07-2002, followed by Northern Region on 01-12-2002. Southern Region started it on 01-01-2003, on 01-04-2003 Eastern Region joined the group, finally on 01-11-2003. North-Eastern Region stepped in.

Balancing of generation and load demand is an important task as excess generation results in unnecessary high frequency and shortage of generation results in low frequency, hence poor quality of power supply. To have reliable and quality supply a suitable tariff mechanism needs to be in place, so as to send commercial signals to the generators and beneficiaries. The Availability Based Tariff (ABT) is a scheme of tariff for central generators as well as tariff for deviations in SEB drawals. In the final regulations for terms and conditions for Electricity Tariff declared by Central Electricity Regulatory Commission (CERC), ABT was adopted and successfully implemented across the whole country at the regional and inter-state level [5]. As ABT incentives grid discipline and reliability of supply through frequency linked pricing mechanism, CERC has decided that ABT would be continued during the new tariff period.

Mrs. Surekha R. Deshmukh is with Pune Vidyarthi Griha's College of Engg. and Technology, working as a lecturer in Electrical Engg. Dept.,Pune,Maharashtra.
Mobile –9890179398, Fax No. 020-24226858
Email: - d_surekha@hotmail.com
Mrs. G.A Vaidya is with Pune Vidyarthi Griha's College of Engg. and Technology, working as a head of department in Electrical Engg. Dept.,Pune,Maharashtra.
Mobile –9422506249, Fax No. 020-24226858
Email:- geetvaidya@yahoo.com
Dr. Sanjay S Kulkarni is an Executive Engineer ,working with State Load Dispatch Center,Maharashtra State Electricity Board, Kalwa,Navi-Mumbai-400708
Email:- drsanjayskul@rediffmail.com

II. NEED FOR ABT

In the pre-ABT tariff mechanism prevailing in almost all the regions total ex-bus generation of all multi-shared projects form a pool of power. The beneficiaries draw from this pool and pay for actual energy drawals at a pool rate, which is, weighted average rate of all the ISGS stations within the region. The generating stations receive total cost of their generation from this pool. This way each beneficiary pays to each station in proportion to its drawal. The entitlements of beneficiaries in different power projects have no sanctity. The pre ABT tariff mechanism inadequacies observed were, the absence of merit-order operation, scheduling and commercial aspects de-linked, Non-utilization of Utility's surplus power (within region), inability to dispatch generation according to grid requirement.

It is well known that the low frequency situation results when the total generation available in the grid is less than the consumer load connected at that time. This was to be controlled by enhancing the generation and/or curtailing the consumer load. High frequency used to be result of insufficient backing down of generation when the total consumer loads come down during off-peak hours. The earlier tariff mechanisms did not provide any incentive for either backing down the generation during off-peak hours or for reducing the consumer load or enhancing the generation during peak-load hours. In fact, there was a financial advantage in generating at a high level even when the consumer demand has come down. In other words, the ABT tariff mechanism encouraged grid discipline.

III. WHAT IS ABT

As the name signifies, the major part of payment for the stations' output in this tariff scheme is based on station's availability, rather than on MWh/ MVAh

output or peak MW/MVA as in conventional two-part tariff applicable presently.

Payments under ABT basically comprise of three parts –capacity charge, energy charge and charges for deviation [2]. The *capacity charge* for a time block is paid for the declared MW output capability of the station for that particular time block (for target availability of 80% in the year). The capacity charge is meant to cover the total fixed cost for the generating station i.e. interest on loan, return on equity, loan repayment provision or depreciation/ amortization, fixed O&M cost, insurance, taxes, interest on working capital etc.

The *energy charge* is meant to cover the variable cost of the station that is the fuel cost component, which goes up with amount of energy generated. They are payable on schedules and not actual drawals.

The third part, which is of much importance is – *charges for deviations***.** These charges are payable for deviations of injections of Central plants and deviations in the drawals of S.E.Bs from their respective schedules.And the deviations are linked to average frequency in particular time block. Schedules for S.E.Bs shall be prepared on the basis of their requisitions from the declared capabilities of Central plants. The charges for deviations i.e. Unscheduled Interchange (UI) rates are maximum at 49Hz and below and is zero at 50.5Hz and above, with constant slope between two extremes as shown in Fig.1 which reveals the relation between frequency and present Unscheduled Interchange rate in (Rs/MWh) . The maximum rate will get revised from 1st October 2004 with two-slop curve [5] .

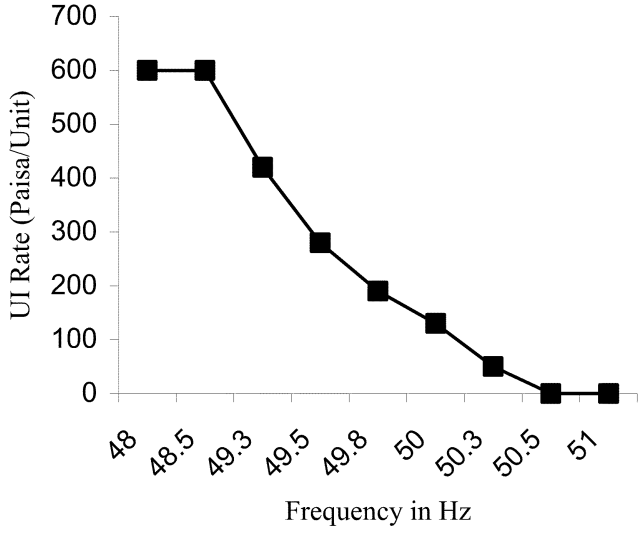

Fig.1:- Graph of frequency variation and UI charge
This graph is linearized for simplicity.

IV. Procedure Of Implementation Of ABT

ABT gives incentives for enhancing the output capability of the power plants, which would enable more consumer load to be met during peak load hours. Secondly, backing down during off-peak hours would not result in a financial loss to the generating station, therefore the present incentive for not backing down and raising the system frequency would get neutralized. Thirdly, the shares of beneficiaries in the Central generating stations would be given a meaning, which has not been there so far. The beneficiaries would have well defined entitlements, and they would be able to draw power up to this at normal rates of the respective power plants. In case of over-drawls, they would have to pay at a high rate during peak load hours, which should discourage them from overdrawing and pulling down the frequency. This payment would go to the beneficiaries who received less energy than scheduled.

In general, the pool price would rise to a ceiling level in following cases.

- When all the generators are in operation and load shedding is required (peak load hours) .
- The frequency dips to lowest allowable limit i.e. 49.0Hz,,or would fall to zero when all generation has already been backed down to the lowest technically allowable level (off-peak hours) .
- When frequency touches the highest allowable limits i.e. 50.5Hz.

A very important change brought out by this mechanism is linking of schedules and system operation.

V. Salient Features Of Unscheduled Interchange (U.I.)

Following are the important features of Unscheduled Interchange [4]-[5].

1) Variation between actual generation and actual drawal and scheduled generation or scheduled drawal shall be accounted for through Unscheduled Interchange (UI) charges. UI for a generating station shall be equal to its actual generation minus its scheduled generation. UI for the beneficiary shall be equal to its total actual drawl minus its total scheduled drawal. UI can be worked out for each 10-15 minutes time block. The charges for all UI transactions shall be based on average frequency of the time block and the following rates will be applied with effect from 1/4/2004.

TABLE I
DETAILS OF U.I.RATES WITH RESPECT TO FREQUENCY

Average Frequency of Time Block in Hz	UI Rate (Paisa / kWh)
50.5 Hz & above	0.0
Below 50.5 Hz & up to 50.48 Hz	8.0
Below 49.04 Hz & upto 49.02 Hz	592.0
Below 49.02 Hz	600.0
Between 50.5 Hz & 49.02 Hz	Linear in 0.02 Hz step

(Each 0.02 Hz step is equivalent to 8 paisa per kWh within the above range)

2) For any generation up to 105% of declared capacity in any time block of 15 minutes and averaging upto 101% of the average declared capacity over a day, the generator shall be entitled to UI charges for such excess generation above the scheduled generation (SG).

3) U.I. Rates are related to the average frequency for corresponding 15-min time block. The previous U.I. Rate is 0.0 paise/unit, at & above 50.5 Hz and 420 paise/unit at 49 Hz and below. Now the maximum rate at present is 600 paisa/unit.This is to effectively curb the tendency to generate beyond the *Schedule* at high frequency. Payment for over-generation at High frequency will be at a lower rate. The Generator will be paid at a higher rate when it *over-generates* at frequency *below* 50.00 Hz. U.I. Rate for any operating frequency between 49 to 50.5 Hz can be computed by following discrete function in steps of 0.02 Hz.

UI Rate at freq. f = ((50.5 – f) x5.6)/0.02);paise/unit; where 49<=f<=50.5

VI. Block Wise Unscheduled Interchange And UI Rates

To understand the concept of 15-minute time block, consideration of total effect of overdrawal –under drawal on UI charges and rate with respect to frequency, the details of 8th March 2004 with old UI rates are presented (Table II). This includes the date, time block of total 24 hour with a step of 15 minute, frequency, scheduled drawal, actual drawal, overdraw, underdraw, UI charges and UI rate. All energy figures are in Mus,UI charges figure are in Rs.Lacs,UI rate is in Rs./kWh.

TABLE II

DETAILS OF UI CHARGES AND UI RATE FOR DATE: - 8TH MARCH 2004

Time	Freq	Drawal SC	Drawal AC	OD UD	UI Charge	UI Rate
00.15	50.02	0.4999	0.5275	-0.03761	0.5055	1.34
00.30	49.88	0.5000	0.5482	-0.04821	0.8369	1.73
00.45	49.96	0.4999	0.5196	-0.02000	0.3025	1.51
01.00	50.00	0.4995	0.5212	-0.02173	0.3043	1.40
01.15	50.08	0.4997	0.5013	-0.00161	0.0190	1.17
01.30	50.14	0.4996	0.4821	0.01747	-0.1761	1.00
01.45	50.08	0.4997	0.4946	0.00208	-0.0597	1.17
02.00	50.10	0.4995	0.4938	0.00572	-0.0640	1.12
02.15	50.14	0.499	0.491	0.00784	-0.0790	1.00
02.30	50.20	0.4994	0.4997	-0.00026	0.0021	0.83

As presented in table 1,the *15 minute Block wise* detailing is done for complete day i.e. 24 hours Thus, at the end of day the information gained is as follows: -

Time	Freq	Drawal SC	Drawal AC	OD UD	UI Charge	UI Rate
Total	----	48.666	55.6400	-6.9734	140.5095	----

Besides benefits of implementing ABT as listed, the grid as a whole got many other associated benefits such as voltages improvement, increase in transmission capacity, restoration of automatic under-frequency load shedding, improved grid security, improved power plants' performance, reduction in tripping and long-term damage, resolution of commercial and operational disputes

VII. Experience With Unscheduled Interchange (UI)

1) Low Frequency Over Drawl:

This is a serious situation as U.I. Rates are very high, and constituent is at default. Actions to be taken are increase own generation to maximum possible extent, carry out Load Shedding, increase Central Sector schedule to full entitlement, try to take support from another system (purchase)

3) High Frequency Under Drawl:

Now, U.I. Rates are low and constituent is loosing. Actions to be taken are withdraw Load Shedding if any, reduce own generation to possible extent, try for bilateral sale of power, reduce Central Sector schedule to keep UI minimum.Following control action is taken by M.S.E.B.

A Planned Load Shedding is implemented in a rotational manner to meet estimated constant shortfall in Demand and Supply as follows in rural and urban area.

Rural Area- *5 Hours block* (6-11, 11-16, 16-21 hrs) 2005 MW

Urban Area-*3 Hours block* (8:30-11:30, 11:30-14:30, 14:30-17:30 Hrs) 900 MW ,with emergency Load Shedding 400/800 MW ,if required.

To arrest fall in frequency below 49 Hz, group of EHV feeders is opened in steps, day wise as per required load relief (400/800 MW). Western Region Electricity Board has an automatic under frequency load relief plan. For the frequency of 48.2 Hz, with 0.3-second delay, 340MW-load relief is done. Same way for frequency of 48.0 Hz, 0.3-second delay, load relief of 340 MW is done and for freq. 47.9 Hz, instant 450MW load is shed.

VIII. Benefits Offered By ABT

ABT has proved its practical applicability by offering many benefits [2]

1) ABT has been highly successful in limiting the high frequency periods. The low frequency operation had increased due to large increase in demand largely on account of failure of monsoon and planned unit outages during this time of the year. The bandwidth of frequency has come to a large extent between 49 to 50Hz., ensuring/making it possible for the governor to be operated in the free mode. Fig.2 shows the variation of frequency for 26th and 27th April 2004.

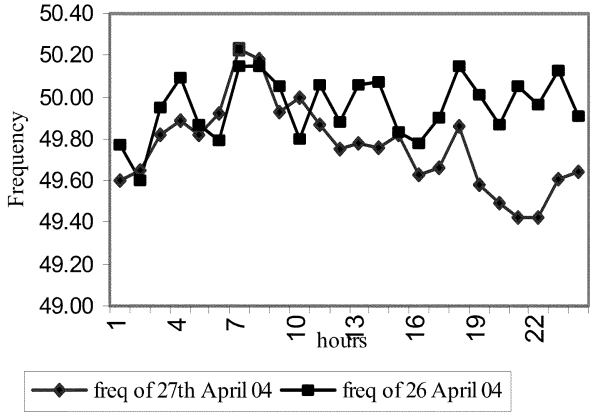

Fig.2.Frequency Variation for 26th and 27th April 2004

2) Better Grid Discipline:

ABT offered Better Grid Discipline by controlling the grid parameters by virtue of its mechanism. Constituents on their own are controlling their MW/MVAR drawal to maintain grid parameters in safe range. It has also led to better operational performance and improved grid discipline.

3) Planning of Load Generation balance:

With ABT it has become possible to be more realistic in planning their Load Generation Balance. It has resulted in realistic requisitions from all the constituents for scheduling of ISGS generation. Frequency linked dispatch coupled with merit order is leading towards flattening of load curve.Fig.3 is a load curve for 27th March 2004 and 27th April 2004

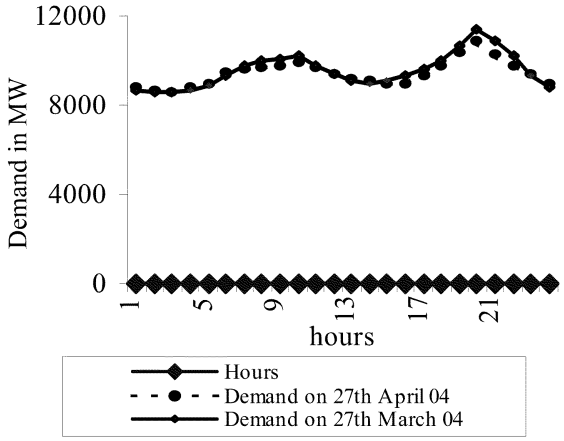

Fig.3. Load curve for 27th March 2004 and 27th April 2004

4) Strategic overdrawals / under drawls:

The ABT mechanism allows for *Strategic* over-drawals / under drawls within the frequency band of 49 to 50.5 Hz with the deviations priced at frequency linked UI prices. A state can get advantage if it overdrawing from the grid at high frequency. Fig.4 reveals the detail of frequency variation and actual drawl against the scheduled one.

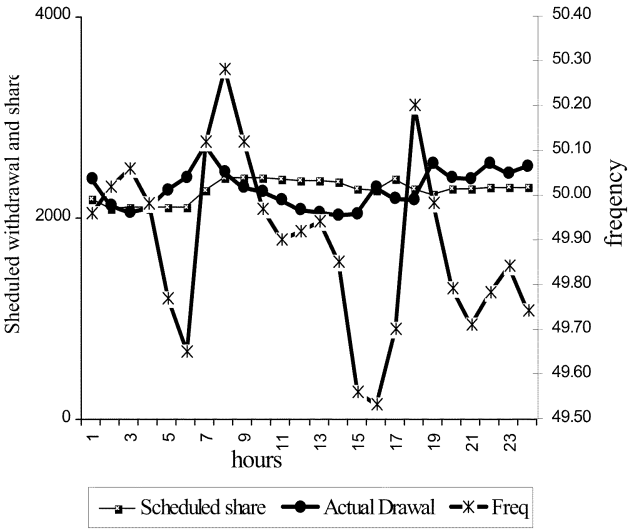

Fig.4 Details of frequency based with-drawal of power on 12th June 2004

Prior to ABT, in bilateral transactions for intra-regional exchanges, the states can overdraw as much as they can and whenever they can as the commercial mechanism prior to ABT was based on drawals and all drawals are priced at pool price (weighted average cost). Through ABT, merit order generation to gain commercial advantage is followed. There is a clear shift from earlier commercial mechanism, which was based on actual drawls. The intra-regional exchanges are in-built in schedule, which has helped them to derive advantages in UI thus helping in improving the grid discipline.

5) Utilization of other Resources:

Tata Power Company (TPC) had unutilized capacity of 100-300MW in the off-peak hours which was utilized by MSEB which otherwise was not being exploited by MSEB

6) Improved bilateral exchanges:

Prior to ABT, bilateral transactions for intra-regional exchanges were unheard of, as there was no sanctity for schedule and the states can overdraw as much as they can and whenever they can. The commercial mechanism prior to ABT was based on drawals and all drawals are priced at pool price (weighted average cost). There was no sanctity to entitlements or schedules. Constituents are now looking for bilateral exchanges rather than overdraw power as latter entails financial disincentives. It has resulted in more bilateral exchanges among the States.

7) Utilization of Hydel Resources:

Constituents are now being aware of frequency based UI prices and the incremental cost of their power system based on frequency. They have started utilizing scarce Hydel resources only when the cost of power is high. Slowly, constituents are adopting frequency based dispatch guidelines. Once all the stations (including those of NTPC) follow frequency linked dispatch guidelines, the operating cost will reduce further.

8) Merit Order Scheduling by SEBs **:**

ABT has acted as a catalyst in prompting all the constituents to follow merit order generation to gain commercial advantage. It has prompted all the constituents to back down their costlier generation.

9) Intra-regional trading:

ABT has incorporated sanctity in intra-regional transfer. There is a clear shift from earlier commercial mechanism, which was based on actual drawls. The intra-regional exchanges are in-built in schedule, which has helped them to derive advantages in UI thus helping in improving the grid discipline.

10) Generation-load balance and displacement of requisitioned power is facilitated due to ABT. Refer Fig.5.

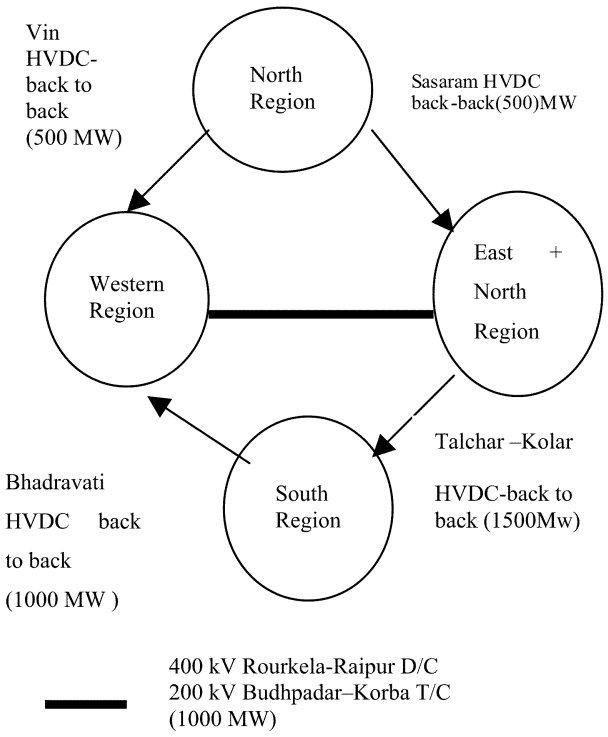

Fig.5. Power Exchange

IX. CONCLUSION

The experience of one-year ABT regime is encouraging. UI is accepted as a necessary feature of pooled operation. ABT flexible mechanism permits UI to the extent that frequency is maintained in acceptable range of 49 to 50.5 Hz. UI is a result of increase in demand as compared to generation availability and limitations on power purchase/load cut. ABT has acted as a catalyst in prompting all the constituents to follow merit order generation to gain commercial advantage.

It has prompted all the constituents to back down their costlier generation during high frequency regime and overdraw from the grid. However, as frequency comes down and UI price goes up, constituents maximize their generation / increase load shedding such that their drawal is less than schedule to gain UI advantage.

ABT gives boost up for infra-structural development for the power trading .At this stage of development and

in cost-plus regulated economy, ABT provides right signals for investment as well as protects consumer interest. Further, State Electricity Boards may take full advantage of ABT by devising Time-of-Use pricing and demand side management in their grids at retail level. India has several thousands of MW of captive generation in industrial plants, but the same are not being integrated with the grid because of present requency fluctuations and due to absence of proper commercial mechanism. Non-utility generation (NUG) is the next area for which ABT mechanism provides a solution.

The investment costs for new arrangements for changeover to ABT are insignificant. In ABT mechanism, no major changes are required to be brought out either at utility-level or RLDC-level except change of procedures and of course, bringing in grid discipline.

REFERENCES

1.Conference on "power system reforms in India", Jaipur, India, October29-31-1993, Energy sector management assistance programme.

2.Dr.Sanjay S Kulkarni, " Expereince of MSEB System operation and control with one year regime of ABT in Western Region",Proceeding of seminar on "One Year of ABT in Western Region ",18th Aug. 2003,Mumbai.organized by WRLDC ,Power Grid Corp. p.p 3.1-3.8.

3."MSEB Sites: - www.msebindia.com"

4. Site: - www.pgcl.org

5. Site www.cercind.com

Mrs. Surekha R Deshmukh has completed M.E. In Power Systems from Pune Vidyarthi Griha's College of Engg and Technology,Pune University, in 2002.She is a member of IEEE,IE(I),life member of ISTE. Currently she is working as a lecturer in Pune Vidyarthi Griha's College of Engg and Technology,Pune .

Mrs. G.A.Vaidya has done M.E. in Power Systems from Govt College of Engg.,Pune,in 1991.She is a member of IEEE,IE(I),life member of ISTE. Currently she is working as a Head of Electrical Engg. Dept ,Pune Vidyarthi Griha's College of Engg & Tech.,Pune.

Dr. Sanjay S Kulkarni has done M.E. in power systems, PhD in Electrical Engineering. Currently he is working as an Executive Engineer at State Load Dispatch Center, M.S.E.B.