

Significance of Unscheduled Interchange Mechanism in the Indian Electricity Supply Industry

S.K. Soonee, S.R. Narasimhan and V. Pandey

Abstract-- The Unscheduled Mechanism (UI) enforced in the interstate sale-purchase of power has succeeded in transforming the fabric of the Indian power system operation in a manner unparalleled. Nonetheless, categorizing the scheme as a disciplinary and penal mechanism would be like missing bull's eye wide off the mark. UI rate is much more than what meets the eye. The paper argues that the mechanism is primarily a real-time balancing mechanism and an instrument to achieve economy and efficiency at the macro level.

Index Terms-- Availability Based Tariff (ABT), Area Control Error, Capacity Adequacy, Merit Order, Power Exchange, Real time Balancing, Unscheduled Interchange.

I. INTRODUCTION

The two fundamental characteristics of power delivered to a customer are frequency and voltage. The short run supply-demand balance is indicated by frequency. Frequency is a 'public good' having large external effects. Stable operation of the interconnected power system, requires that frequency be maintained within a certain tolerance as defined by the standards adopted in a country.

II. REAL-TIME BALANCING

Power systems all over the world have to make provisions for achieving a balance between real time demand and supply. Power markets generally have control areas that are prohibited from deviating from scheduled interchange. Concept of Area Control Error (ACE) used to measure these instantaneous deviations takes into account of both frequency and net excess flow out of a control area. Control areas are required to keep their ACE near zero for maintaining a constant frequency in the interconnection. This model for load frequency control used in developed countries may be a good practice but given the techno-economic and socio-

political realities prevailing in India, it is currently incompatible with Indian power system.

III. PRE-ABT SCENARIO

Power system of a country is a manifestation of its society. The indiscipline, lawlessness and absence of accountability prevailing in the Indian society were visible even in power system operation. Till recently regional power system operation was more frightening than an Alfred Hitchcock horror movie. Scholars could be excused for getting a shock of their lives by a mere glance at the daily frequency and voltage profile of any region. System operation was an endless 'jihad' to prevent the system from collapsing.

The central public sector generation incentives were linked to the actual production and not on availability. Generators would continue to pump in as much energy into the system as they could irrespective of the system frequency and still be rewarded for the wastage of scarce resources! The load serving utilities/SEBs would compare the variable cost of their own generators to the composite cost (sunk cost + energy charge) of the external generator causing a skewed dispatch. Ironically, the Regional Grid operators had a harrowing time trying to get generation backed down to protect the turbines of the very generators causing that situation. On the other end of the spectrum, the state utilities could overdraw from the grid with impunity even during deficit and still escape Scot-free by returning equivalent energy to the system during surplus conditions. No wonder there was chaos and despair all around.

IV. THE IMPACT OF UI MECHANISM

The UI mechanism was brought in to perform under such trying circumstances. Although the complexities and contradictions in the system still prevail but there is not an iota of doubt that the scheme has delivered results. The UI mechanism rode on the chariot of floating frequency and the used 'the disease' itself for curing the chronic illness of the power system operation. It is the bedrock on which the foundation of competitive electricity market has been built in India and is flourishing.

The contribution of UI mechanism Indian power sector has been aptly summarised by **Mark Lively** in his paper titled, '**Creating An Automatic Market for Unscheduled**

Sushil Kumar Soonee is with Power Grid Corporation of India Ltd and heading Northern Regional Load Dispatch Center (NRLDC), New Delhi as Executive Director, (telephone: 91-11-26852843, e-mail: sksoonee@gmail.com)

S. Ramesh Narasimhan is with Power Grid Corporation of India Ltd. as Chief Manager (Technical Services) at NRLDC, New Delhi (telephone: 91-11-26854585, e-mail: srnarasimhan@gmail.com)

Vivek Pandey is with Power Grid Corporation of India Ltd as Senior Engineer (Technical Services) at NRLDC, New Delhi (telephone: 91-11-26854585, email: vpandey76@yahoo.co.in)

Electricity Flows Pricing. He says, “*Unscheduled flows of electricity can contribute more to the reliability of the network than could the establishment of mandatory reliability standards and the fines that would be associated with violating such standards. Pricing unscheduled flows of electricity improves reliability indices without resulting to the draconian policy of mandatory reliability standards and fines for non-compliance. India has led the way in showing an improvement in reliability indices when it began pricing Unscheduled Interchange. Pricing unscheduled flows of electricity can also improve bulk power competition.*”

UI mechanism has assumed cult-like status in the Indian power sector. It not surprising that the mechanism has split the Diaspora into ‘believers’ and ‘non-believers’. Everyone has interpreted the mechanism in his/her own way and in the process certain misconceptions and misunderstandings have also cropped up. A large section understands UI mechanism to be merely a penal and disciplinary mechanism to deter utilities from deviating from schedule. This view requires reconsideration.

V. FLOATING FREQUENCY REGIME

Post ABT the power system in India is operated as loose power pools where the state utilities /generators have the liberty to deviate from their interchange schedules as long as the frequency remains within the IEGC specified band of 49.0 to 50.5 Hz. However several experts have expressed reservations on the floating frequency regime adopted in our country. They argue that frequency deviation/fluctuation is problematic for non-digital clocks and rotating machines especially steam turbines.

The IEC standards specify that the steam turbines have to perform satisfactorily within a tolerance of 49.0 to 50.5 Hz. This is precisely what the UI mechanism is trying to achieve in a simple and efficient manner. In the decentralized dispatch scenario, the UI mechanism provides the Automatic Generation Control (AGC) for the Indian electricity grids without employing a vast set of inputs, processing software and last mile connectivity to the generators. The whole design encourages the utilities to conserve when in surplus so as to provide for when in shortage and thus smoothening the frequency curve. Post ABT the operating frequency band has narrowed down considerably but still sharp fluctuations in frequency do persist. These fluctuations would get further smoothened out only after all the generators sincerely operate on free governor mode of operation as stipulated by IEGC. Switching in and switching out of hydro units, manual disconnection of large feeders to restrict over drawals and frequent interventions by the system operator results into wide variations in the interchange pattern of the utilities and grid frequency.

VI. UI AS REAL-TIME PRICING MECHANISM

The design of UI mechanism adopted in India is similar to the one proposed by **Arthur Berger & F.C Schweppe** in

their paper titled ‘**Real time pricing to assist in load frequency control**’ (IEEE Transactions on Power Systems, Vol.4, No. 3, August 1989). The paper says - “*The plants operate to maximize profits, and the loads operate to maximize a satisfaction index. The energy control centre has perfect information i.e. it knows the models used in the automatic control devices of the plants and the loads. Lastly, all computations take zero time.*” It further says, “*A key feature of this pricing scheme is that the independent power plants can themselves monitor the frequency deviations and thus no real time signal needs to be sent by the electric utility. This eliminates the problem of how the utility could compute and transmit the price faster than the time scale to be controlled.*”

The UI rate is a frequency-actuated signal available at any wall socket. Every utility reacts to this signal in real time and adjusts its generation/ demand and a new equilibrium is achieved. The UI curve by virtue of its design empowers every utility that has some means to regulate supply/demand to readjust its interchange with the grid and gain from the migration of frequency/UI rate from the earlier level. The decreasing marginal returns with every additional unit of deviation from the scheduled interchange acts as a counterweight, which forces the utility to seriously weigh the consequences of its actions. Thus the collective action by all the players in this non-cooperative zero sum game, restores the equilibrium to new value, which may or may not be the same as that before the perturbation. What results is a Nash equilibrium at which every player emerges a winner by having maximised his pay-off.

VII. UI FOR MERIT ORDER AND EFFICIENCY

Economists consider perfect competition as an instrument to realize productive and allocative efficiency. A market is considered perfect only when every competitor is small enough to have no discernible influence against the “invisible hand” of the market. This implies that every player in a perfectly competitive market is aware of the market condition and is a price taker.

The UI mechanism adopted in India tries to fulfill that design requirement in a rather unconventional manner. Every utility is aware of the UI vector ex ante and in real time (perfect information); the UI rate applies to all inter utility transactions at the regional level (homogeneity); there are no contracts to be signed, no access charges fees; no transmission charges; no losses applicable (no entry barriers); every utility big or small having some control over its generation or load is transformed into a formidable player in real time. All generators connected to the grid can contribute to the unscheduled flow of electricity, dramatically increasing the number of competitors that can serve any customer connected to the grid (atomicity).

The UI mechanism has established a real time balancing market that is workably competitive and provides a powerful force for efficiency and innovation. While the diligent and proactive players have derived rich dividends by being

proactive, a large number of players are yet to realize this aspect of UI mechanism. This also explains the unpopularity of UI mechanism in some quarters. **Steven Stoff in his book 'Power System Economics Designing Markets for Electricity'** says, *"Competition is least popular with competitors- every supplier wants to raise the market price, just as every buyer wants to lower it. Perfect competition frustrates both intentions."*

Likewise, **Larry Ruff** while talking about competition in his paper **'Competition in Electricity Markets'** says, *"Unfortunately, the features that make integrated real-time market/dispatch processes so successful – low transactions cost and market transparency and efficiency – are the very features that are provoking the counterrevolution. A transparent, efficient spot market allows producers and consumers to deal directly with each other with less need for middlemen and market makers, and helps new, small, niche players compete effectively with established, large, diversified players. Not everybody finds these features to their liking or advantage."*

VIII. TINKERING WITH THE UI VECTOR

The UI Rate at any frequency represents the marginal price of the costliest generator that is expected to be on bar at that frequency that forces players to optimise their exchanges with the grid in order to maximize their profits or minimize their costs. The generators behave as if they are selling their entire output to the pool at UI rate while the buyers behave as if they are purchasing their entire requirement from the pool.

The above feature of UI mechanism has brought in efficiency and merit order operation in the grid even in the absence of the centralised scheduling and dispatch mechanism. The UI rate therefore needs to be readjusted whenever the energy costs of generation in the country get revised. The ABT Order dated 04/01/2000 issued by Central Electricity Regulatory Commission recognised this aspect of UI vector and desired that the UI ceiling rate be linked to the energy charge of the diesel generation in the grid.

There have been proposals to change the UI rate to a penal charge but it may not bring the desired effect. **Peter Cramton and Robert Wilson** in **'A Review of ISO New England's Proposed Market Rules'** say, *"Reliance on penalties is highly inefficient and problematic in its workings and is unworkable on a sustained basis in a civilized and competitive market. The whole idea of relying on administered penalties is inefficient, subject to disputes and subject to continual pressure to seek modifications and exceptions. Non-compliance can also be justified by claiming an operating problem, etc."*

While speaking about real time balancing mechanism, **Sally Hunt** in her book, **'Competition and Choice in Electricity'**, argues that in a competitive market the deviations from scheduled interchanges and the actual flows on the day must be treated and settled as an energy transactions arranged at (infinitesimally) short notice. This

strengthens the argument that the real-time deviations have to be appropriately priced to be effective.

IX. CAPACITY ADEQUACY & UI MECHANISM

The UI mechanism has brought about varying degree of results in different regions. It has been observed that during peak demand situations, the absence of matching generation leads to the weakening of the counterbalancing forces that causes the frequency to hit rock bottom rather frequently. Only augmentation of capacity can resolve this situation. Investors could use the UI duration curve for different regions to arrive at nature and cost of generation that they are planning.

X. POWER EXCHANGE AND UI MECHANISM

There seems to be some substance in the argument put forth by the proponents of Power Exchange in the country that the absence of an organised day ahead-market is one of the reasons for the lack of investor confidence in the Indian market. Bilateral trading is being used for increasing the availability of power for a load serving utility especially after the enactment of the short term open access regulations but the exorbitant transaction costs and lack of transparency in price setting are a big deterrent. (Transaction costs are the costs of negotiating, executing and enforcing payment for each purchase.) The setting up of the Power Exchange could provide another option for power procurement. It could promote further competition on the supply side as well as on the demand side by bringing all sellers and buyers together on a common marketplace with standardized contracts, bid formats, and trading procedures. This would set up a transparent price discovery mechanism in day ahead exactly as UI mechanism is doing in real-time.

The setting up of a PX would in no way diminish the significance of the frequency-linked UI mechanism. It would in fact enhance its relevance as a real time pricing mechanism. The UI market would continue to compete with the long-term and short-term transactions as a means for trading electricity. The price for un-contracted flows underpins all other contract prices. Hence even if they handle only the deviations, they ultimately determine the viability of competitive generation.

XI. CONCLUSION

The UI mechanism has been a good course correction for the Indian power market and therefore we need to take further steps to reinforce the gains. It is time we started planning for the next step in this initiative. There are other difficult jigsaw pieces that have to be placed rightly before we can entirely solve the Indian power sector puzzle. We need to revisit and probably redesign the transmission pricing and hydro tariff to make it more scientific and effective. Intra state ABT and open access are essential for getting a stronger demand side response. With the interconnection of the Northern and Central grid in near future we would need to reconsider the reactive tariff to suit the new circumstances. Thus a lot more need to be accomplished to realize the vision of power to all by 2012.

XII. ACKNOWLEDGMENT

Authors owe an intellectual debt to the reference material, which would make an excellent compilation for further reading on the subject. Encouragement by POWERGRID management is gratefully acknowledged.

XIII. REFERENCES

- [1] Arthur Berger & Fred C. Schweppe, "Real time pricing to assist in load frequency control", IEEE Transactions on Power Systems, Vol.4, No. 3, August 1989
- [2] O.D.Butler and C.J.Swenson, "Effect of Reduced Voltage and/or Frequency Upon Steam Plant Auxiliaries", Symposium on Plant Capability at Low Frequencies and Load Relief, Feb 1955
- [3] Sally Hunt and Graham Shuttleworth, "Competition and Choice in Electricity" National Economic Research Associates; Published by John Wiley & Sons Inc, May 1996, ISBN: 0471957828
- [4] Sally Hunt, "Making Competition Work in Electricity" John Wiley & Sons, Inc
- [5] Steven Stoft, "Power System Economics Designing Markets for Electricity", IEEE Press, Wiley Interscience; John Wiley & Sons
- [6] A report on "Study of Bulk Power and transmission Tariffs and Transmission Regulations" by ECC in collaboration with NERA; Government of India and Asian Development Bank in cooperation with the World Bank, February 1994
- [7] Minutes of meetings of National Task Force on Availability Tariff, 1995-98
- [8] Bhanu Bhushan, "Proceeding towards Power Pools; Framework for Electricity Trading in India-A POWERGRID's Scheme", 1997
- [9] Bhanu Bhushan, "ABC of ABT_A Primer on Availability Tariff", 2005
- [10] Mark Lively, "Creating An Automatic Market For Unscheduled Electricity Flows Pricing", <http://www.livelyutility.com>
- [12] S.K.Soonee, "Realizing a Collective Vision through non-cooperation", Workshop on Electricity Market in India & Learning from Developed Markets, India Habitat Centre, New Delhi, March 2005