The Indian Medicine

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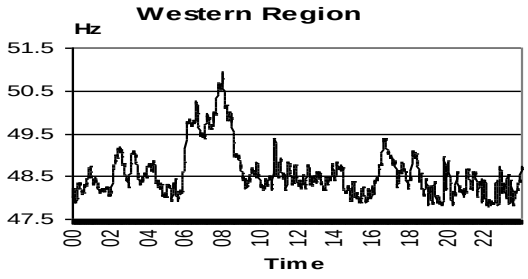
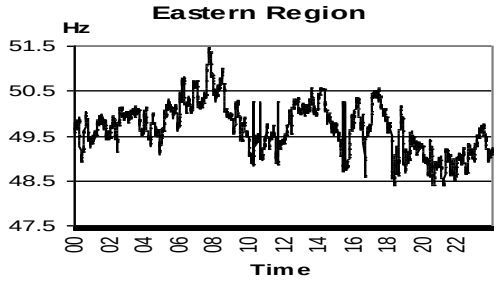
For over two decades, the operation of power systems in India had been plagued with serious problems. A glaring symptom was the wide fluctuation of grid frequency – from below 48.0 Hz to above 52.0 Hz, on a daily basis. Frequency plots of the four regional grids for typical days (which represent the situation prevailing till the year 2002) are presented in figures 1 to 4. Because the grids still continued to operate (with a major problem only once in a while), the seriousness of the situation was really not being appreciated generally, and such conditions were being allowed to continue.

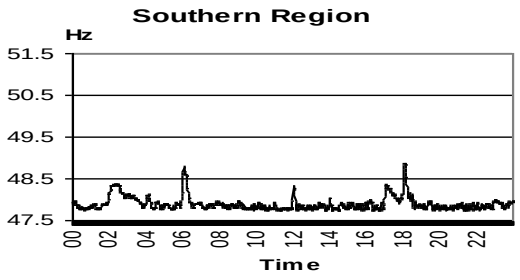
Abnormally low frequency during peak-load hours was caused by inadequacy of generating capacity and attempts to meet consumer demand in excess of available generation. High frequency during off-peak hours was a result of the generating stations not being backed down adequately when consumer demand came down.

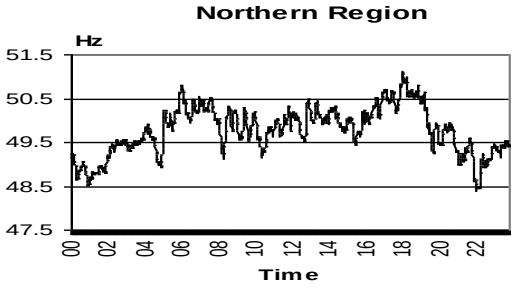
Utilities blamed each other for the prevailing anarchy but little was actually being done to tackle the root cause: the then prevailing faulty tariff structure for bulk power supply. Power from Central Government–owned generating stations was being supplied to the State Government-owned vertically integrated utilities as per simplistic, single-part, constant (Rupees per kWh) tariffs, which disregarded drawal pattern, deviation from schedules, system conditions (surplus/deficit), etc. On one hand, the State utilities were not being discouraged from overdrawing, even when generation was inadequate (during peak-load hours). On the other hand, both the Central generating companies and State utilities were being encouraged to go on generating, even when the consumer load had come down (during off-peak hours).





Figures 1 & 2 : Frequency Profiles of Western and Eastern regional grids in 2002 prior to ABT





Figures 3 & 4 : Frequency Profiles of Southern and Northern regional grids in 2002 prior to ABT.

Although each State (India has a federal structure like the USA) had a specified share in the above referred Central Government–owned generating stations (which supply about 30% of the total power), the payments by the States to the Central generating companies were based on net energy drawn in a month, disregarding the states' shares and any upward or downward deviation from schedules. A State could nullify its overdrawal during peak-load hours by under-drawal during off-peak hours. This led to another problem: the more efficient, low variable cost pit-head plants of Central companies were being required to back down during off-peak hours, before the State utilities' load centre plants (with a higher variable cost) were backed down, against the basic principles of economy dispatch.

It was in the above back drop that Indian engineers developed and introduced a new and unconventional concept – tariff linked to frequency. In this scheme, overdrawals are costly when the grid is short on generation (reflected by frequency being below 50.0 Hz), and are cheap when the grid has surplus generating capacity (reflected by frequency being above 50.0 Hz). Similarly, any oversupply (generation beyond given schedule) is paid for at a high rate when frequency is below 50.0 Hz and at a low rate when frequency is above 50.0 Hz. Underdrawal and undersupply also get the same treatment. The scheduled power is however paid for at specified/agreed rates, and its price does not get affected by frequency.

This new concept has been implemented in India at the inter-State level, starting from mid-2002, through the three-part tariff for Central generating stations, the so-called Availability Based Tariff (ABT). It is based on the recommendations of M/s. ECC of USA after a structured, World Bank/ADB – sponsored study in 1993-94. The three parts of ABT are (i) Capacity charge, for payment of fixed cost, linked to plant availability and shared by the States in proportion to their percentage allocation in the Central station, (ii) Energy charge, for payment of the variable cost, basically the fuel cost for supply of scheduled energy, and (iii) Unscheduled Interchange (UI) to account for deviations from schedule. The third part (UI) has frequency linked pricing, as per figure-5.

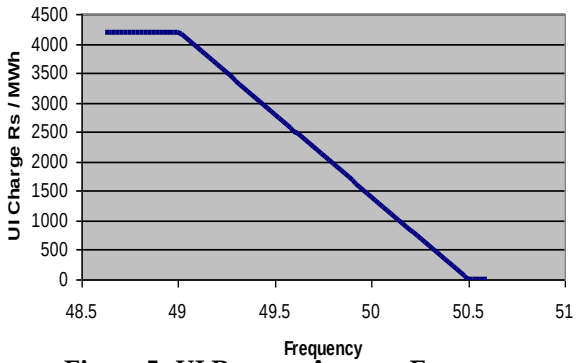


Figure 5: UI Rate vs. Average Frequency

The results of ABT introduction (along with certain other measures) have been most dramatic. Typical frequency plots of late 2003 are shown in figures 6, 7 and 8. The frequency of the regional grids now remains in the range of 49.0 – 50.5 Hz for most of the time. Many other benefits have also come about, and these are listed in the Annexure. It would be seen that many birds have been killed with one stone. But we have also deviated, consciously, from many of the established practices. The main features of our approach are:

i) The grid frequency would be allowed to float, with no attempt to keep it close to, or try to bring it back to, the rated value of 50.0 Hz.

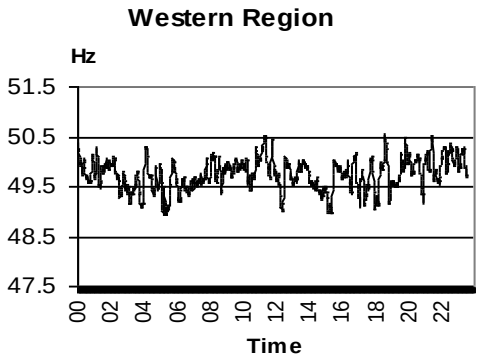
ii) There would be no attempt to achieve an average frequency of 50.00 Hz (for time error correction), as we have not had any frequency clocks in the country for over two decades (due to erratic frequency, as well as the advent of quartz clocks).

iii) Our national grid code, approved by the Central Electricity Regulatory Commission, does not mandate a tight frequency control, but only requires all concerned to "make all possible efforts to ensure that the grid frequency always remains within the 49.0 – 50.5 Hz band". We know from our past experience that from most angles, there are no disadvantages of letting the frequency vary in this range.

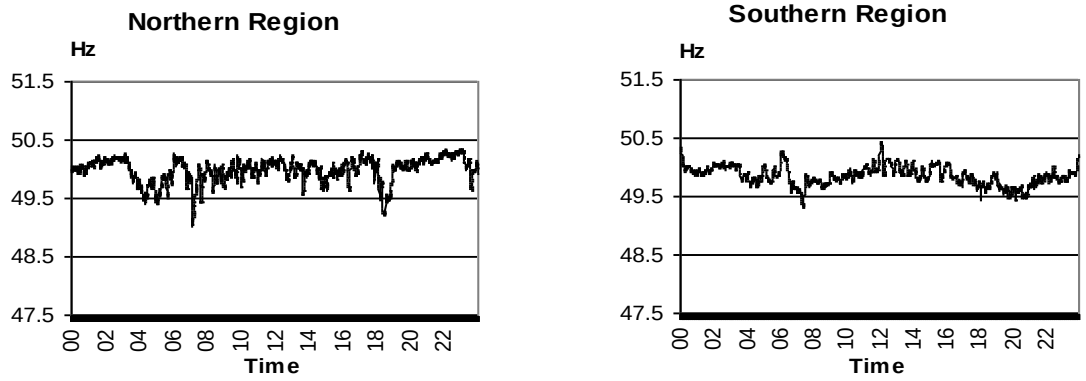
iv) There would be no requirement for the control areas to maintain their actual interchanges close to their net interchange schedules or to reduce the Area Control Error (ACE) to zero every ten minutes etc. The actual interchange can remain deviated from the net interchange schedule, because we are pricing the deviations. Also, deviations need not be returned in kind by adjustments in the future net interchange schedules.

v) There would be no "frequency-bias" or tie-line bias in our net interchange schedule. The required collective action for correction of frequency (only improvement of frequency in our case) would be induced through the pricing of UI, rather than through "frequency bias" in ACE.

vi) Control areas would be only notional, in the sense that it would not be mandatory for them to absorb their own load changes fully.



Figures 6 : Frequency Profile of Western Regional Grid (synchronously connected with Eastern and North-eastern regions) in late 2003.



Figures 7 & 8 : Frequency Profiles of Northern & Southern Regional Grids in late 2003.

The primary objectives of frequency – linked pricing of unscheduled interchange were: (i) to bring about merit-order operation of generating stations of diverse ownership, and (ii) improvement of grid frequency. But it has achieved much more, being a very versatile tool. It has established a true power market in India, overnight. One can trade with the pool, at the spot price known to all on-line, beside other modes of transaction. Also, trading through the UI mechanism does not require any agreement, trader, exchange or settlement system of any kind. UI rate is synonymous with the pool price of the original UK pool and the system buy/sell price for imbalances of UK's NETA. Besides, our new Electricity Act has provisions for "open access" and wheeling of captive generation. UI provides the ready mechanism for commercial handling of any mismatches/imbalances and thereby enables operationalisation of the above referred provision under the new Act.

We still have a long way to go. Most of the generating units in the country are still not on free-governor mode of operation, in the true sense. Fast frequency fluctuations, which can be seen on the enclosed frequency plots, are a direct result. Serious attempts are being made to implement the grid code provisions under which all generating units are mandated to be on a free-governor mode of operation.

This should stabilize the grid frequency (to provide consistent pricing and dispatch signals), and also allow a daily frequency pattern to emerge, mirroring the system load curve (to enable the generating stations to be scheduled in the most optimal manner).

Constraint-free transmission system is also a pre-requisite for trouble-free operation of the above scheme. Since India already has strong (mostly 400 kV) regional grids, really super-grids laid over the States' 220 kV/132 kV grids, we do not have too many transmission constraints. Regional grids can generally be taken as free-flowing systems, and uniform UI pricing can work. Transmission constraints on a few interfaces are however being noticed now (due to initiation of bilateral trading which was not foreseen earlier, and for which the transmission system was not planned). These constraints need to be overcome through additional transmission lines, for optimal utilization of available generating capacity. But in case any major constraints continue, a differential may have to be introduced in UI pricing (to have different UI prices on the two sides of a constraint).

Another item is introduction of Availability Tariff and UI mechanism within the intra-State systems, to enable the intra-State entities also to come on board.

Annexure

Benefits of Availability Based Tariff

- Improved frequency & Voltages.
- Economic Despatch.
- Autonomy to the utilities.
- Incentive for high plant availability, but no incentive to over generate during off-peak hours.
- Technically and Commercially right.
- Immediate solution for NUGs (IPPs and Captives).
- True Free market; No Regulator required.
- Pool price known **ON-LINE.**
- Total transparency.
- Elaborate arrangements for communication not required.
- Simple, practicable; meters already developed.
- Only, we do not aim at 50.0 ± 0.1 Hz.