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Electricity Grid Management in India- An Overview

by Vivek Pandey

Introduction

'Transmission' and 'Grid Management' are essential functions for smooth evacuation of power from generating stations to the consumers. Transmission function primarily consists of construction and maintenance of the transmission infrastructure while the job of the grid operator is to give operating instructions to the engineers in the field and ensure moment-to-moment power balance in the interconnected power system. Grid management involves taking care of the over all reliability, security, economy and efficiency of the power system.

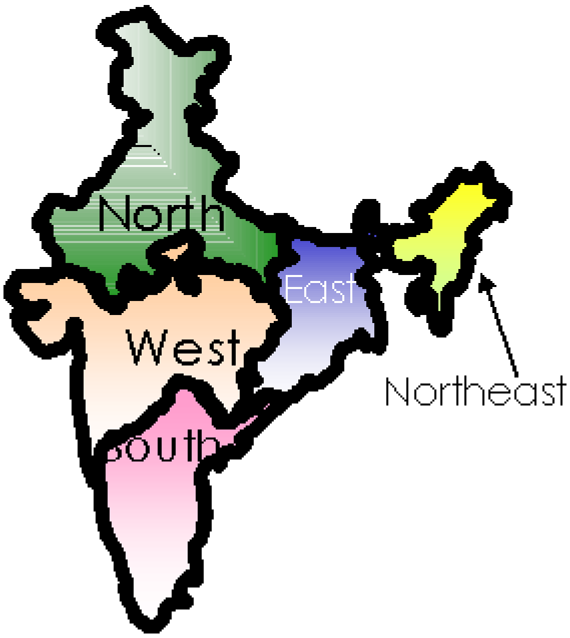


Fig-1: Five Regional grids in India

Grid Management in India is carried out on a regional basis. The country is geographically divided in five regions namely, Northern, Eastern, Western North Eastern and Southern. All the states and union territories in India fall in either of these regions. The first four out these five regional grids are operating in a synchronous mode, which implies that the power across these regions can flow seamlessly as per the relative load generation balance. The Southern Region is interconnected with the rest of India grid through asynchronous links. This implies that quantum and direction of power flow between Southern Grid and rest of India grid can be manually controlled.

Load Despatch Centres

Each of the five regions has a Regional Load Despatch Centre (**RLDC**), which is the apex body, as per the Electricity Act 2003 (EA 2003), to ensure integrated operation of the power system in the concerned region. The RLDCs for North, East, West, South and Northeast regions are located at Delhi, Kolkatta, Mumbai, Bangalore and Shillong respectively.

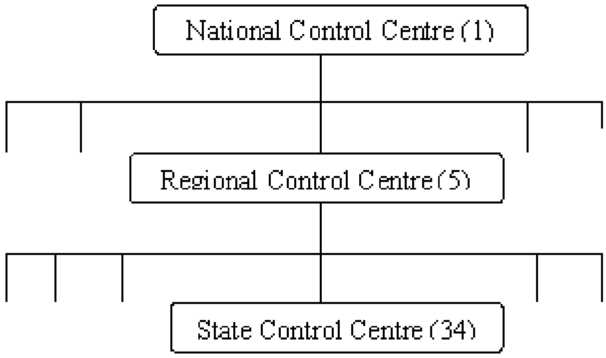


Fig-2: Load Despatch Centres

The RLDCs coordinate amongst themselves both offline as well as online for maintaining the security and stability of the integrated pan-India grid. In line with the federal structure of governance in the country, every state has a State Load Despatch Centre (**SLDC**), which is the apex body to ensure integrated operation of the power system in the state.

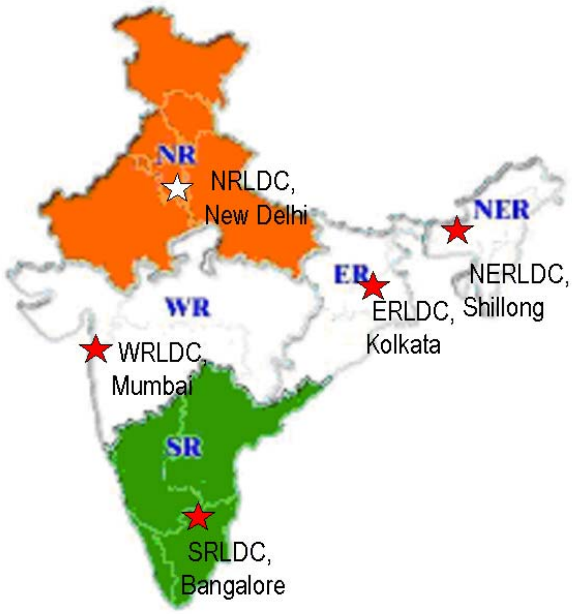


Fig-3: Regional Load Despatch Centres

The RLDCs in India are presently owned, managed and operated by the Central Transmission Utility (**CTU**), POWERGRID while the SLDCs in the state are owned operated and managed by the respective State Transmission Utility (**STU**) or the State Electricity Board (**SEB**) as the case may be. The EA 2003 has a provision for a National Load Despatch Centre (**NLDC**) for optimum scheduling and despatch of electricity across various regions and also coordinating cross border energy exchanges in real time. Ministry of Power has notified the functions of NLDC that is under construction. Presently, POWERGRID is operating a National Power System Desk (**NPSD**) in New Delhi for information exchange and facilitating inter-regional transactions. The cross border exchanges are coordinated by the RLDC of the region wherein the international interconnection is situated.

Role of Load Despatch Centres

As per the Electricity Act 2003, the Regional Load Despatch Centre monitor grid operations, exercise supervision and control over the inter-state transmission system, are responsible for optimum scheduling and despatch of electricity within the region, in accordance with the contracts entered into with the licensees or the generating companies operating in the region and keep accounts of quantity of electricity transmitted through the regional grid. RLDC is responsible for carrying out real time operations of grid control and despatch of electricity within the region through secure and economic operation of the regional grid in accordance with the Grid Standards and Grid Code. The functions of SLDC elaborated in EA 2003 are similar to that of the RLDC except the area of jurisdiction, which in case of SLDC is the state.

Grid management functions

Functions of grid management can be segregated into ex-ante, real-time and post-facto functions. The ex-ante functions are more in the nature of planning for the day of operation. It involves estimating the future scenarios, evaluating options and making elaborate plans to meet the anticipated as well as unforeseen events.

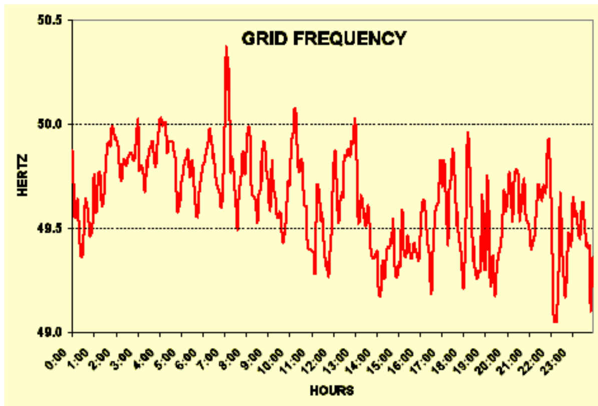


Fig-4: Typical frequency variation in a day

The real time functions primarily comprise of balancing the dynamically varying supply and demand of electrical energy in the interconnected system.

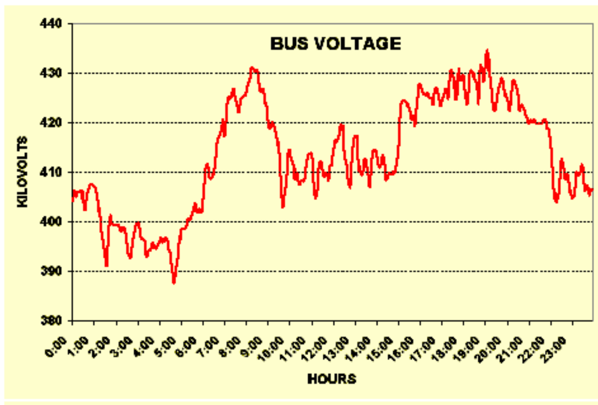


Fig-5: Bus voltage variations in a day

Vital grid parameters such as frequency, node voltages, transmission line loading, transformer loading, electrical (angular) separation between generation pocket and load centre etc. are monitored round the clock and suitable instructions are passed on to the SLDCs or generating stations in case the values of the above parameters are seen to be outside the permissible bands. The operating band has been specified in the Indian Electricity Grid Code (**IEGC**), approved by Central Electricity Regulatory Commission (**CERC**).

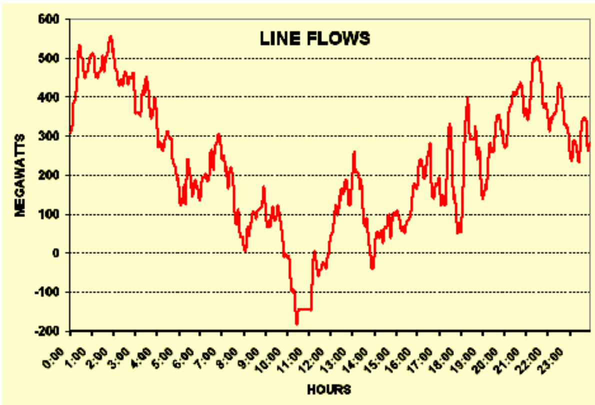


Fig-6: Line power flows

All this requires extensive coordination with the operating personnel positioned at switching stations, generator control rooms and other load dispatch centres. Critical decisions have to be taken at the spur of the moment. Post facto functions involve grid performance reporting, post mortem of events, settlement of accounts, documentation of experience and interaction with stakeholders.

Operating aids for grid management

In order to enhance the power system visibility and improve the quality of supervision in real time power grid operation in the country, the grid control rooms at the regional and state level have been equipped with a state-of-the-art communication and data acquisition system.

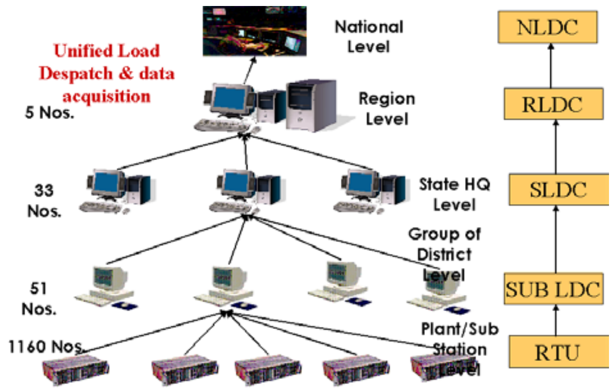


Fig-7: Data acquisition system

Under the system the vital system variables are measured by transducers installed at all the important locations. The recorded data is transmitted through communication channels and ultimately displayed in the operator consoles in the load despatch centres.

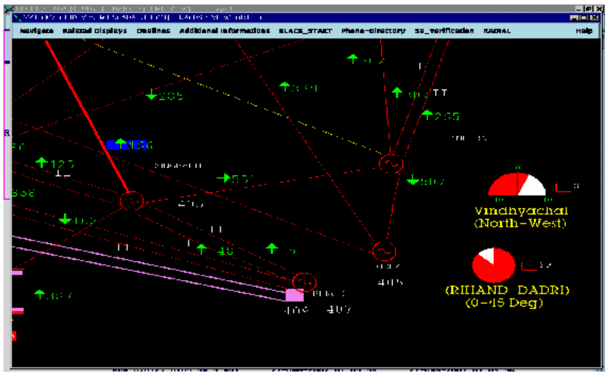


Fig-8: Typical real-time display

The grid operator supervises the power system through this system. It acts like the sensory organs of the grid operators and helps them to diagnose the states of system and also take corrective measures. It also ensures transparency in grid operation and facilitates amicable resolution of day-to-day problems associated with this complex task of grid operation. The real time data is archived continuously and is later retrieved for analysis of events occurring in the grid.

Various states of grid operation

The interconnected network under current technology creates strong interactions across locations. Behaviour of various power system elements synchronised with the grid influence the system parameters giving rise to a dynamically varying system states. These states are normal, alert, emergency, extreme and restorative.

The operator actions are perpetually guided by the objective of maintaining the system directed in normal state for most of the time. Nevertheless the system may slip from a normal to alert, emergency or extreme state in less than a second due to a small or large perturbation in the system. Contingencies disturb the grid parameters and call for immediate operator intervention. Normally it takes a few minutes to restore the system back to normal state but during major disturbances it may take several hours or several days to restore normalcy. It is therefore essential that all precautions be taken to prevent the system from degenerating to an extreme state. This requires suitable and timely interventions in the power system in short term as well as in medium and long-term.

Regional Electricity market

The regional electricity market in India that operates over the Inter State Transmission System (**ISTS**), is governed by the frequency linked operation and commercial settlement mechanism known as the Availability Based Tariff (**ABT**) and Unscheduled Interchange (**UI**) mechanism. The ABT mechanism has replaced the command and control system employed earlier with a contractual approach. The utilities have full freedom and choice to enter into long-term and short-term bilateral contracts. These contracts are incorporated in the daily interchange schedules issued by the RLDCs.

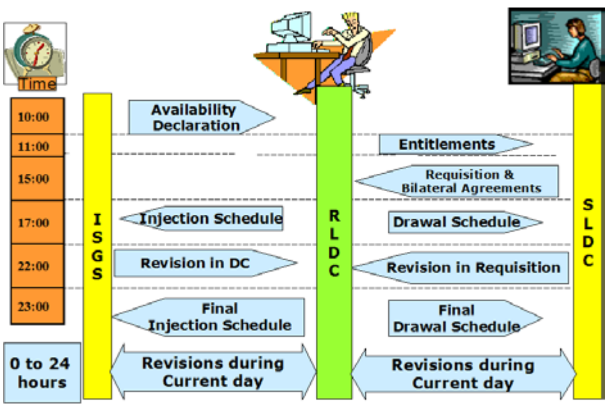


Fig-9: Day-ahead resource scheduling process

The interchange schedules whether despatch, drawal or inter-regional are treated as commitment to deliver or withdraw a certain quantum of power at a designated time from the grid. The utilities also have the option of reviewing and revising the scheduled interchanges in real time to suit the demand/supply position in real time. The revised schedules get implemented within six time blocks after registering the request with the RLDCs.

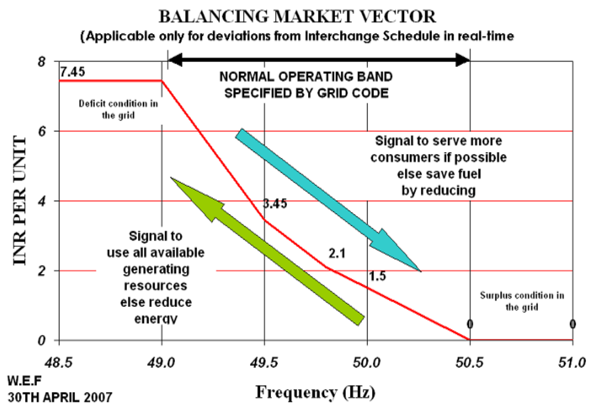


Fig-10: UI price vector

Further, the generating station operators and state grid operators have been empowered to respond to the real time pricing signals generated from the frequency dependent UI price vector.

Electricity trading

Open Access (OA) in ISTS has been implemented in all the regions since 6th May 2004 in line with the open access regulations issued by CERC. The regulations aim at promoting non-discriminatory usage of the transmission system by customers after payment of appropriate charges. Access can be granted under two categories: long -term and short-term. Long-term access is granted for usage of 25 years or more while the short-term access is for a maximum for three months at a stretch. As per the existing regulations the long-term users pay higher charges and have a higher priority over short-term users. The grid operator declares the anticipated power transfer capability available in the transmission system during the forthcoming three months. Within the short-term category reservations on the transmission corridor may be made under any of the categories: advance, first-come-first-served, day-ahead and same day.

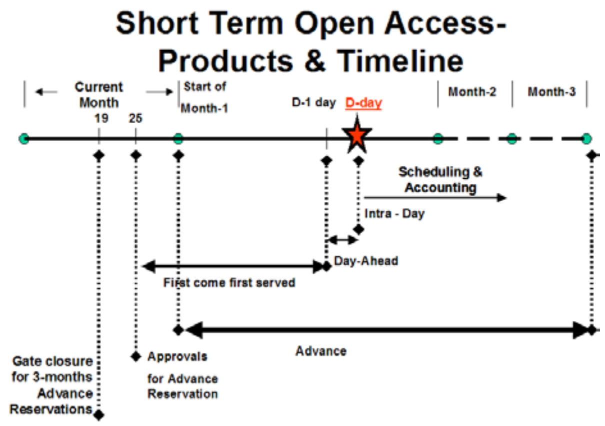


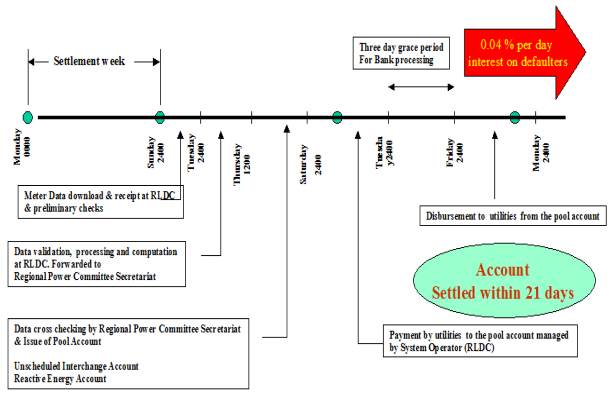
Fig-11: Short-term Open Access

Open access in transmission effectively introduces competition in wholesale electricity market. Although, the overall inter state trade volume is currently only 3.0 % to 5 % of the country's total energy consumption, it has had a multiplier effect on the entire power sector by promoting competition, efficiency and economy. The RLDCs and SLDCs are playing a key role in facilitating and scheduling these transactions without compromising on the security and reliability of the grid.

The regional transmission system and the interregional links are being utilized to transport surplus hydro generation in northeastern region and pithead generation in the eastern region to the energy deficit load centres in the northern, western and southern regions. The inter-regional exchanges have increased manifold after introduction of open access. Almost all utilities in the grid have taken advantage of the open access provisions and transactions have taken place in all possible directions in the country say from Northeast to North (e.g. Tripura to Haryana), North to South (e.g. Punjab to Andhra Pradesh), South to North (e.g. Kerala to Punjab), West to North (e.g. Gujarat to Uttar Pradesh), North to West (e.g. Punjab to Maharashtra) and East to all other corners of the country. The electricity trade in the country is expected to grow further after the commissioning of new generating stations and establishment of the proposed organized platform for trading in the form of Power Exchange (**PX**). The grid operator would continue to provide the interface between the physical system and the electricity market.

Settlement system

For purpose of scheduling and settlement the entire day in divided into 96 time blocks of 15 minute each. At the end of the day all before the fact revisions in schedules get incorporated as 'Implemented Schedules' and they serve as a datum for the payment of capacity charge, energy charge and generation incentive to the generating stations governed by the ABT regime. The actual energy interchanges for every 15-minute time block, are recorded with the help of Special Energy Meters (SEM) installed at all inter utility exchange points in the region. These readings are used for working out the actual injection of Inter State Generating Stations (ISGS) and off-takes of each state utility from the grid. The actual values are then compared with the scheduled values to obtain the deviations from schedules. Real time deviations in a particular time block are priced at the corresponding Unscheduled Interchange rate (UI rate), and settled through a pool account being maintained by RLDC.



The SEMs also record the reactive energy interchanges at inter utility points. These are settled as per the prevailing reactive energy prices. The regional reactive energy accounts are also managed by the RLDCs.

Challenges in grid management

Large interconnected grids are essential for reliability of power supply and for economic exploitation of spatially distributed energy resources and consumption centres in the country. The manifold growth in the network size has increased the complexity of grid management.

The physical nature of the power flows on transmission lines, rapidly changing demand patterns, dramatic changes in the system parameters, unexpected events in the grid and calamities (natural or man made) make grid management extremely challenging. This requires tremendous presence of mind and multidimensional skills. A system operator has to quickly switch roles as a planner, a strategist, an administrator, a consultant, an economist and a soldier, which makes his job highly demanding.

The unbundling process in the power sector also has contributed significantly to the growing complexity in grid management. Competition has heightened the market pressure, forcing system to be operated closer to its physical limits. The number of utilities especially in the state level has also increased leading to increased difficulty in coordination during offline as well as in real time. The conflict of interests, unclear responsibilities, inconsistency of objectives, inadequacy of resources and legacy issues among these utilities often impair the collective performance of grid management.

All the above coupled with rapidly diminishing species of "power system engineers" and the general lack of appreciation of this vital function is making grid management a tough job.

Contribution of Grid Operators

Operating conditions require close monitoring and control on very short time duration. Advanced technologies are indispensable for successful operation of the grid during the various operating states but the contribution of the engineers at the operating desk is equally noteworthy. Very few people outside the grid control centres are aware of the sweat and toil that goes behind keeping the grid secure and healthy. In fact the grid operator carries the credibility of the entire electricity supply industry in the country on his shoulders. Against the few occurrences of large grid disturbances such as the one that occurred in Northern Region on 2nd Jan 2001, there are innumerable cases when the alertness and alacrity of the grid operators have been vital in rescuing the grid from 'near death' situations. The operators have successfully tackled the most unusual scenarios in real time grid operation occurring at the most unexpected and demanding hours of the day. It is unfortunate that the heroes of such "near miss" situations go unsung and unnoticed.

Neutrality of grid operator

Generation and transmission at the inter state level has already been unbundled in 1991 after the formation of POWERGRID. Unbundling of generation, transmission and distribution in states has been achieved to a large extent. As per the EA 2003 the STUs are also expected to disengage themselves from the trading function shortly. Both the RLDCs and SLDCs have been prohibited from engaging in the business of trading in electricity. Further the RLDC have been barred from engaging in generation of electricity.

The Central Electricity Regulatory Commission and State regulatory Commissions regulate the fees and charges of RLDCs and SLDCs respectively. The RLDC charges are shared by the constituent states of that region in ratio of their weighted average allocations in the Central Sector power stations. The fees and charges are independent of the volume of power flow on the network, which ensures the neutrality in grid management. The grid management/operation is so designed that grid operator merely provides a secure and reliable platform for energy exchanges between various players in the grid without becoming a party to those transactions.

Conclusions

Modern economies are dependent on reliable and secure electricity services. Electricity makes an essential contribution to economic performance, international competitiveness and community prosperity. The society's dependence on electricity shall intensify as the world moves ahead in the twenty-first century. The pressure to operate system in 'higher risk mode' is bound to increase with increasing network complexity, growing electricity markets and increasing intensity of surprises from Mother Nature. All these challenges have to be dealt with collectively and with sincerity of purpose. Grid management therefore deserves the recognition and attention of all the stakeholders. They must all come together to nurture this institution for the benefit of our own present and for posterity. The investment required for this might appear to be a high in absolute monetary terms especially when it has to be shared by the direct beneficiaries or the state utilities. But it would be peanuts when compared with the opportunity cost of unserved electrical energy due to a blackout that could have been averted by the intervention of the system operators.

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Disclaimer
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