Power System Operation in India –Few Challenges

Prithwish Mukhopadhyay, Rajkumar Anumasula, Chandan Kumar, Vishnu A.V.
WRLDC, Mumbai

Abstract

India is in a fast pace growing economic phase and the very backbone to achieve the same is the electricity. The growth in electricity sector is very phenomenal with large addition in generation capacity in conjugation with transmission and distribution network. At present, the Indian Grid is among the largest synchronized grid in the world. It constitutes of five regional grid that are synchronously connected with each other. The total installed capacity of the grid is 250 GW as on date and is growing with fast pace. Along with that, a large number of extra high voltage lines (765 kV and 400 kV) are also coming which has resulted in a complex meshed network. With the so much of complexity, the major challenge is its safe and reliable operation in real time. The fast growth has resulted in a very rapid change in system operation from the operator point of view. This has to be handled with the enhanced market mechanism combined with changing regulation in a reliable, efficient and economic manner.

These changes have resulted in paradigm shift in the system operation from earlier days. The system operator has adopted these changes with the introduction of new technologies and tools. These new technologies include an efficient SCADA system for complete overview and monitoring of the system at state, regional and national level. The SCADA system gives data to system operator in seconds for steady state operation. As power system is a dynamic system that changes in millisecond so there was a need of system, which should provide system operator with sub second level data. This led to adoption of the Wide area measurement system (WAMS) by the system operators, which provide the sub-second data to look into the finer aspect of the power system, and associated phenomenon. The ultimate objective of these tools is to provide system operator with sufficient information to operate grid in safe and reliable manner with optimal utilization of available resources.

At present a large number of distributed generation in form renewable energy like solar, wind, biomass is being added to the grid. These generations being intermittent in nature may result in threat to grid and to handle that better tools in form of automatic demand management system (ADMS), renewable energy management center (RMC), efficient load forecasting tools are being adopted. In future, the renewable has to play an important part to meet the electricity need of the country and system operator are now moving towards another major shift for better operation and control of the electrical grid.

Keywords: Indian grid, Wide Area measurement System, Supervisory control and data acquisition

Introduction

The Indian electricity grid is one of the largest synchronised power grids in the world with installed capacity of 250 GW [1] comprising five regional grids namely Northern, Eastern, North Eastern, Western and Southern grids. The grid is operating synchronously as N-E-W-S grid on a single frequency. It consist of basic three functional blocks which are Generation, Transmission and Distribution. As the electrical grid is the largest man made machine by the human being, all these functional block should run at the same frequency in synergy with each other. Here come the role of the grid management which is the link between all the three systems to maintain them in equilibrium at all the time.

Grid Management in India is carried out on a regional basis. The Regional load despatch centre (RLDC) take care of the operation of the regional grid in close coordination with their constituent's State load despatch centre (SLDC). The coordination among the five RLDCs and inter regional and transnational exchange (with Nepal, Bhutan, Bangladesh) is being monitored by the National load despatch centre (NLDC). So, the Indian Power grid is operated by hierarchy of control centres with the National Load Dispatch Centre (NLDC) at the top of the hierarchy and five regional load dispatch centres (RLDCs) ,thirty three state load dispatch centres(SLDCs) in the middle and number of sub-load dispatch centres at the bottom of hierarchy [2]. It's very challenging job for operators to operate such a large grid having large size generators of 800 MW units, ultra mega power plants of 4000 MW capacity, several 765 kV transmission lines across long distance corridors, upcoming 800 kV Multiterminal HVDC and 1200 kV AC transmission systems. Also due to lack of automatic control, challenges in operation get further aggravated. All these challenges has to be taken into account during the real time operation of the grid. Next section discusses the various challenges in details.

Challenges in the Grid Operation

Indian Power system is full of diversity just like our Indian Culture. The generations are concentrated in coal rich, hydro rich areas while the loads centers and consumers are elsewhere. This brings the utmost challenge that is efficient transmission of generated power from the generation rich areas to the load centers in reliable and economic way. The diversity in Indian power sector is shown in the figure 1 which best explains the power scenario in the nation. The grid operators have to handle such situation of power scenario for better utilisation of resources in the nation. There are lots many challenges that are being faced by the system operator on day to basis, which can be summarized as following:

1. Lack of automatic control in the grid i.e. Primary and Secondary response.
2. Rapid change in the network with fast pace development in Indian power sector.

3. Extreme weather condition in the India affecting the transmission and distribution lines significantly like Kashmir where snowfall result in frequent tripping of lines.
4. Large uncertainty in generation, transmission and distribution system development in the nation.
5. Increase in addition of distributed generation like wind, solar, small hydro in the grid.
6. Fuel shortage in generation plant resulting in sub-optimal utilization of the generating units.
7. Variation in demand state wise as well as region wise.
8. Emergency like sudden reduction in Hydro due to silt, multiple line tripping on smog, events of unforeseen load crash etc.

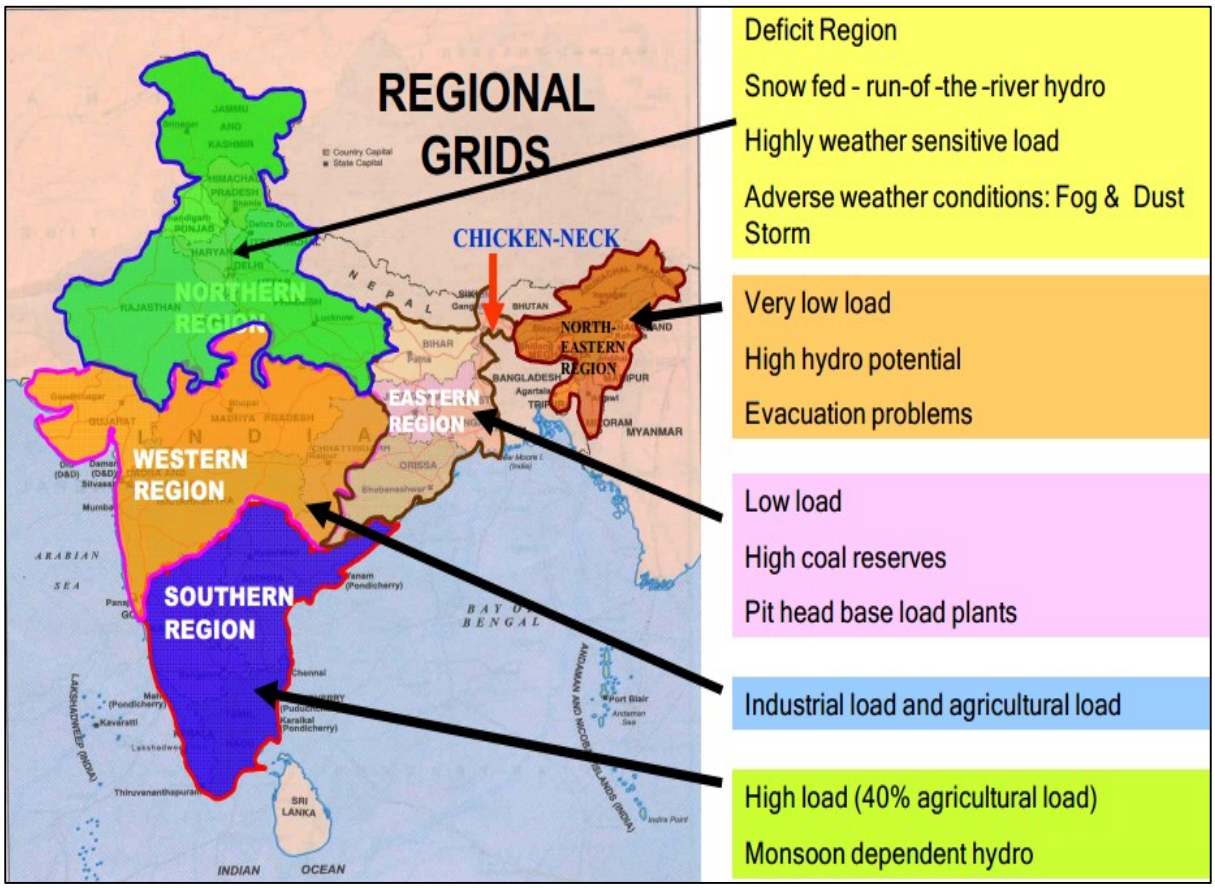

Figure 1: Characteristic of region in terms of generators and demands.

A system operator has to quickly switch roles as a planner, a strategist, an administrator, a consultant, an economist and a soldier in the present scenario of manifold development in the grid size and the challenges described[3].

Therefore, it was observed that there is wide uncertainty in real time operation, which can be reduced with the help of efficient monitoring of the power system. Grid operators have been equipped with the Supervisory control and data acquisition system (SCADA). The next section describes how the SCADA helps in real time operation of power system and in achieving the grid operation in efficient, reliable and economic way.

Supervisory Control and Data Acquisition (SCADA) System

The SCADA system at the operator console is the eye of the power system. It gives the situational awareness for real time operation to the system operator. It provides the visualization of electrical parameters to system operator and gives alarms to system operator when these parameters cross the operating limit band as specified IEGC and CEA Grid standard. Figure 2 shows the SCADA view of western region grid.

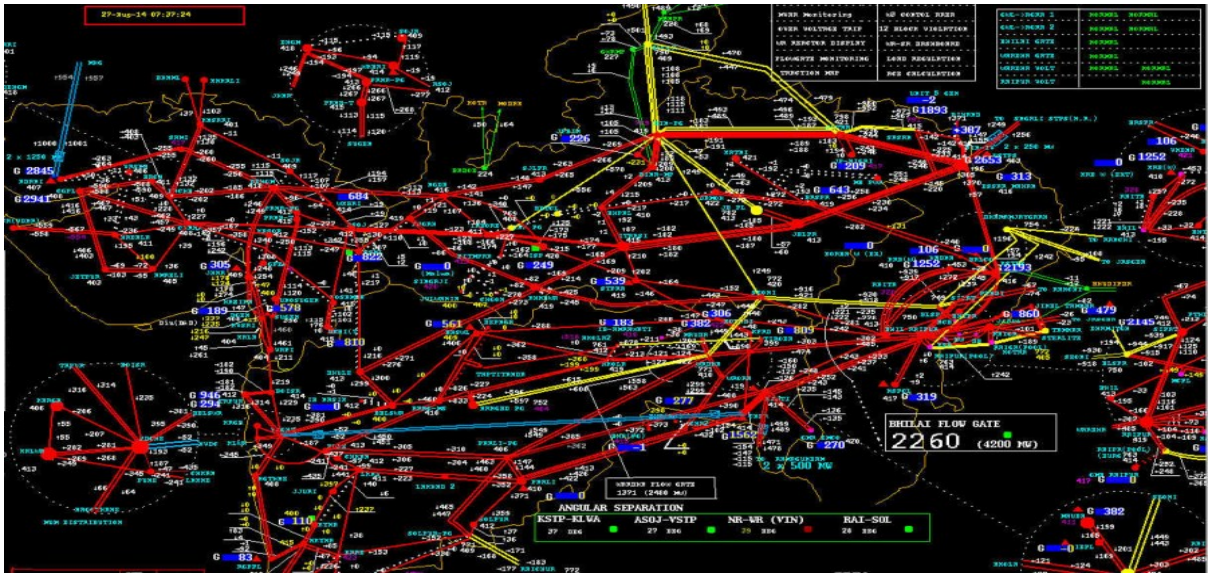

Figure 2: SCADA View of Western regional Grid

These parameters visualization helps in better utilization of the generation, transmission and distribution system in reliable and economic way. In addition, it helps operator in taking various actions after any event so that grid is always in safe mode of operation. Earlier SCADA were reporting at lower bandwidth, but with the increased communication infrastructure, the operators now get a better overview of the system with 4-15 seconds interval updates. The SCADA provides a steady state view of the Power system.

Being a very dynamic system running at 50 Hz, power system stability is better understood in fractions of seconds. There are various phenomenon in power system, which occur in fraction of seconds and have severe impact on the system. In such cases, operator has to rely on the automatic control in terms of generator control system, HVDC and FACTS devices control system and system protection scheme. These responses are not captured with the existing SCADA, as the resolution is data is less being updating in 4-15 seconds. These phenomenon data and analysis are desired during the future planning of the power system and tuning of the various controllers in the grid and their validation. To have such a dynamic view of the system, Synchrophasor Units were integrated in the Indian Grid in form of Pilot projects. These devices send the fast rate time synchronized data to RLDCs/NLDC and helps in visualization of the grid on micro scale [4, 5]. The collective technology of synchrophasor

devices is called as wide area measurement system (WAMS). Next section gives an overview of the WAMS system and its utilization.

Wide Area Measurement System

The dynamic state of the grid earlier were observed based on the offline study methodology or the small buffered data from the devices installed in the field like disturbance recorder. The system operator does not have access to these data in real time. In the absence of good situational awareness, there is a need for expert system to supplement conventional SCADA system as discussed in previous section to visualize dynamics of complex power grid at sub second level. The system operator has to be equipped with tools to comprehend situational awareness with better visualization, sub-second information to derive corrective actions while contingencies are propagating and automations including special protection schemes. The new technology based on time synchronized Phasor Measurement Units (PMU) with high sampling rate is making the above tasks possible. All the regional control centers had installed PMUs at selected locations and are reporting to Phasor Data Concentrators (PDC) at a reporting rate of 25 frames/second, which are being used for real time grid operation during power system faults, decision making for faster restoration of transmission link, oscillations etc. Along with that these are extensively used for post facto analysis and protection system operation validation and detecting underlying events. As of now, across India more than 60 PMUs are installed and it has provided a very good insight into the system at micro level. The same can be observed in figure 3 where conventional SCADA and Synchrophasor based information is compared.

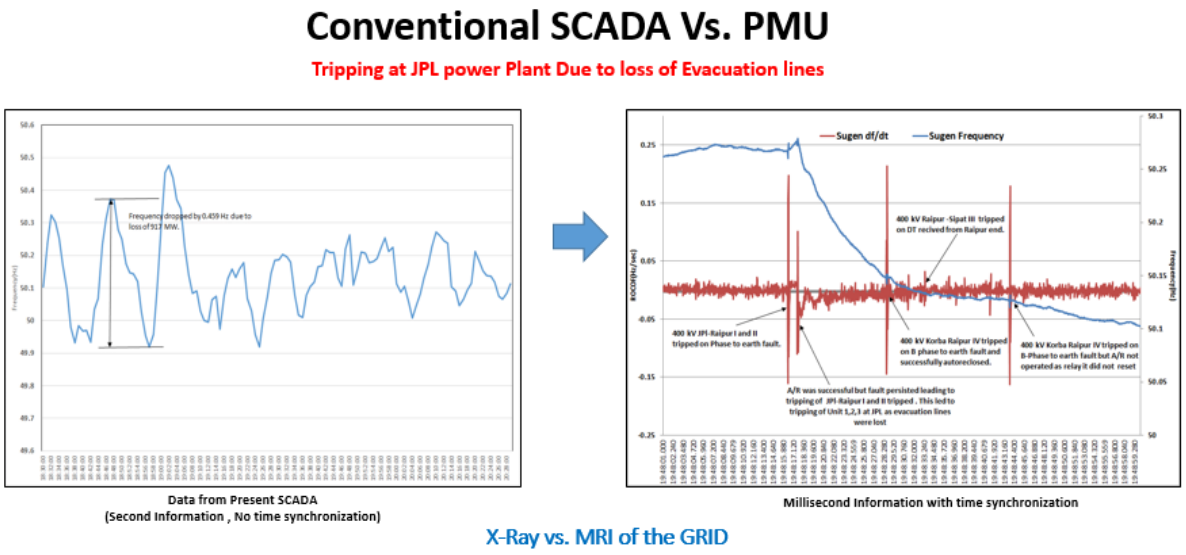

Figure 3: Conventional SCADA and PMUs

Indian grid operator will be supplemented with more than 1700 PMUs with the ongoing Unified real time dynamic state measurement (URTDSM) in coming years. The wide area system has provided the system response and based on that control system tuning is being

tested so that the real time operation becomes less challenging with automated actions. In view of the above, others tools are also being adopted which is discussed in next section.

Future Development in System operation

The integration of renewable energy is going with a very fast pace in Indian Grid. As the renewable has very high intermittency level depending on the weather condition, it has made the job of system operator very challenging in terms of best utilization of renewable power without endangering the system security. In view of this, the renewable energy management centers (RMC) are also being developed in India. In addition, better forecasting tools are being adopted at control centers and renewable plants in view of system reliability and efficient control. The demand response is also being developed in the system with automatic demand management system (ADMS) scheme at each state control center. This will help the operator in better control over the frequency of the system along with the line loading and help operator in taking remedial action when grid is in alert state.

Conclusion

Therefore, the paper summarizes the Indian grid and the Role of the system operator in the operation of the Indian grid. Also, the various challenges that is being faced by the system operator during every instant is also described. In addition, the various tools adopted by the system operator for efficient operation of the Indian grid are also discussed. The future tools, which will help in further control over the electrical grid, are also explained in detail.

Acknowledgement

The authors acknowledge with thanks the guidance and support given by managements of POSOCO as well as PGCIL and for permitting the publication of this paper. The authors are also thankful to WRLDC personnel for their support. The views expressed in this paper are of authors and not necessarily that of the organizations they represent.

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