Economic Operation and Control of Power System

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Hello and good morning everyone. Welcome you all for the NPTEL online course on Economic Cooperation and Control of Power Systems. We will continue our discussion with respect to autonomous advanced distribution system management. So some understanding about ADMS is very much essential before we also conclude this topic today. The foundation of the ADMS at the core of the ADMS is ability to precisely define the network model and to process an unbalanced load flow algorithm. The network model the ADMS must be able to represent all aspects of the distribution network.

For example, variety of connector types, transformers, switches, fuses. So the model represents the as operated state of the network typically based on the as built state as mentioned or maintained by the geographic information system as we call it as GIS. So the dynamic data ADMS load flow algorithm requires data telemetry from the distribution network. Data is generally made available through SCADA systems telemetry where available through advanced metering infrastructure what we call it as EMI and outage management system.

So because any part of the control like SCADA certainly require data that is coming through telemetry and the control action is taken place with the help of SCADA. So the amount of data to be telemetered and stored is significant and changes frequently. So high performance data management is critical for quick and efficient analysis by the ADMS. This data provides a variety of information example voltage current and device status to enable the load flow algorithm to provide more reliable results. So you are getting data from PMUs and RTUs of SCADA then the smart meters so many data which are coming in in real time.

So you should segregate which data are very much important to take up appropriate decision and then once the data is being segregated so these data have been used so for further action. Then the unbalanced load flow algorithm the ADMS must have a very fast load flow algorithm that can solve unbalanced distribution networks based on every changing data telemetry from the field. As we have very familiarly known about this issue of distribution system which is unbalanced. So we need to solve this unbalanced

issue in the distribution network with the advanced features of ADMS. So this is what we are intend to do.

Then visualization of ADMS results with a complex network model significant quantities of data both telemetered and calculated wide variety of ADMS users like operators, dispatches, management, planning, engineers etc these are the wide varieties of ADMS users. Visualization of ADMS results are needed. An ADMS should be able to display network data in a geographic view, a schematic view and single line diagrams. What we have discussed in the previous class is that we can have a HDMI based vision of data bird's eye view on the entire system data can be obtained by using ADMS. So further the end user should be able to easily manage the level of information displayed in this views.

Individual utilities have developed different means to view their network information over time. The ADMS must be flexible through support flexible enough to support the format desired with the utility. So operations, planning and analysis. So in this part of understanding one of the primary uses of the ADMS is the real time analysis that enables optimization of the distribution network. The ADMS continuously runs real time analysis, identifies problems, suggest approaches to better balance the load, suggest switching to minimize the losses, identifies other potential and real problems and likely solutions.

See there is a data so real time analysis being done with the data and identify the problem, suggest suitable solutions so that you can have better load balancing or loss minimization, network reconfiguration by which you can have loss minimization, proper volt war optimizations and then identifies other potential and real problems that may be coming up in the real time operation. So the ADMS enables utilizes to reduce energy waste on the distribution networks through a more detailed understanding of losses through reconfiguration and network optimization. So convergence of technologies, distribution SCADA, the ADMS combines feature rich distribution management technology incorporated field proven distribution SCADA system. The smart grid era is showing us dramatic increase in the deployment of intelligent field devices yet legacy SCADA systems were not designed to scale to a high number of connected points. But utilities now have a luxury of deploying ADMS to integrate with their existing SCADA systems or replace them now or in the future with the least and greatest in distribution system SCADA technology.

Results in flexibility and strategic approach to bringing control room applications together into one secure single user interface solution. So there are SCADAs and latest intelligent field devices like PMUs have been placed. So utilities will have a luxury of taking an appropriate decision with ADMS in place because ADMS gives more

flexibility from the utility perspective to take an appropriate decision. So and then outage management system, the ADMS provides analytical support to ensure that outage causes are identified and resolved more quickly with the functionality of a traditional OMS such as call and event management, prediction analysis, incident and crew management. It provides a next generation level of functionality to improve network reliability.

The ADMS has a strong level of functionality around fault location, isolation, service restoration apart from what we have discussed which is optimal utilization of the network, network reconfiguration, loss minimization, reducing the unbalance in the load. With all these functionalities, the another important feature of ADMS as we have repeatedly discussed is the fault location, isolation and service restoration. So the FLISR functionality already present at most utilities is enhanced with the ADMS ability to locate faults based on telemetry and analysis, provide rank switching options to a dispatcher, example prioritization based on connected load and connected customers. Basically locate the fault, isolate the healthy part and ensure that the infected part of the system which is fault segment would be resolved as quickly as possible. So some ADMS standard tools that we can see from industries, so Siemens Spectrum Power Advanced Distribution Management System, GE ADMS, Schneider Electric EcoStructure ADMS, Survalent One ADMS, OSI spectra, Oracle Utilities Network Management System, ETAP ADMS, Auto Grid Flex, ACS PRISMA, PRISM ADMS.

So multiple top industry professionals they have developed this ADMS tool box which would be used in multiple distribution systems across the world. So ADMS network model, you can see here this is a distribution system model and then there is a GIS, geographic information system, wire size, arrangement, geo coordinates etc because this is very important as the network topology may keep changing. So snapshot of the entire distribution system is very much important. So and then the live data from SCADA. So this is the live data which is coming from SCADA, temporary changes like cuts, jumpers, manual switching.

So this is the changes if it is anything as such is seen in the distribution system and then geographic displays. The outcome is you can see here the geographic displays. And then online power flow, up to date topology which is used for outage management system, then online power flow will be helpful for taking actions such as volt work control, fault location installation, service restoration, optical optimal network reconfiguration, switch order management. So this is complete the ADMS network model. So there is a distribution system model, there is real time information flow through SCADA.

So if there is any change in the distribution system topology as such that can be also given as an input to distribution system model and the outputs are FLISR, fault location isolation, service restoration and volt for control, outage management, then optimal

network reconfiguration and overall monitoring and display for the utility as well as the customer. And then integrating IT and OT, information technology and operation technology very important aspect. IT is actually information and operation technology associated with machine. So there is a information data and there is also machine connected. So actually it is a marriage between IT and OT, it is very important.

Critical infrastructure, storage, computing, data processing these are the part of IT and there is OT which is machine aspect, equipment, industrial control, production, monitoring these are operation technology and IT OT convergence suggest sharing the data that each collects and distributes getting two terms that have worked independently for their resources and expertise. So there is a information at once and there is a component. So there is interfacing of IT and OT. So ADMS technology trends system consolidation, IT OT convergence, analytics and utility big data handling, energy efficiency and demand response and managing the renewable energy sources as well. So system consolidation replacing old equipment so that we can deploy management system on a common platform.

IT OT convergence as we have discussed just now, convergence and growing of IT OT with the utility so that operation monitoring and control of grid becomes faster and less challenging. And analytics and utility big data for installing of new sensors and for retrieving new information from the grid requires new technology to store, analyze and process the new data. Then managing the distributed energy resources for management of smaller modular energy generation like wind turbines, photovoltaics, need an advanced management system and new technologies. So issues in current distribution systems, reliability, power quality, efficiency, complexity and cost. So these are the typical issues in current distribution system.

One should have good reliability and as from the customer expectations and customer also expects good power quality, efficiency is very important from system operator perspective because so there is a generation and there is a distribution and there is a transmission. So basically in transmission and distribution generation all these process there will be losses taking place. So if you can reduce the loss, overall loss in the entire operation of a power system so we can save lot of energy and then complexity. So when you are controlling a system, we should not complicate so much that the control parameters are very difficult to get tuned. So complexity of control system, complexity of the entire system architecture should be as minimal as possible and nothing more than important that cost reduction.

So ultimately everybody looks forward to reduce their operation and maintenance cost. So in this regard also a distribution system is always interested to reduce the overall cost of the operation. So now I would like to discuss some real time ADMS studies in some various popular collaborative research projects and some industry oriented ADMS based

tool boxes which have been implemented in real systems. So the first one I would like to discuss is collaboration for ADMS in India and US.

This is a famous project U.I. assist. In 2009 the government of India, GOI and the United States through the Indo US science and technology forum launched the US India partnership to advance clean energy pace program. In 2017 the US India collaborative for smart distribution system in storage, U.I. assist was announced as a third collaborative project between department of science and technology and the GCEERDEC program. It is a 30 million dollar five year research project to leverage expertise in universities, national laboratories, research centers, electric utilities and technology providers in the two countries to collaboratively develop local solutions with global impacts related to advance green distribution systems including micro grids and to develop a future workforce that considers international perspectives. So this is a collaborative research project between India and US. So various themes have been defined like cyber security, storage aspects, distribution system operators, hardware validation, simulation, benchmarks, benchmark modeling. So there are multiple themes and field pilot deployment as well.

So overall the objective, one of the key objective of this project is also develop ADMS toolbox such that whatever the objectives that we have defined is also functional. So this is a ongoing functional project at this point of time. So and then ADMS in India, Tata Power Delhi distribution limited. So Tata Power DDL, they look after Delhi distribution system. They distribute electricity north and northwest Delhi, serves a population of 7 million.

Peak load is 2106 megawatt, distributed area is 510 square kilometer. First utility in India to implement ADMS. ADMS is fully integrated with geographic information system to provide better reliability, safety and operation. So these are the key motives for implementing ADMS in Tata Power Delhi distribution limited. So features of Tata Power DDL and ADMS features are APRS, automated power restoration system, IVB is integrated volt power control.

So benefits of FFA, Tata Power Delhi distribution limited auto scheduling and dispatching of work orders of crews with event site, auto demand node generation based on integrated integration of FFA and GIS, offline mode for capturing site details even in areas without mobile network, real time augmented 3D view of underground high power cable network, crew feedback network condition, customer satisfaction measured real time. So basically it's a overall maintenance and operation being controlled and taken care by technology so which is featured in ADMS. So you can see here it's crew management, crew feedback, customer feedback so and then real time overall 3D view of underground high power cable network, demand node generation based on GIS informations and moreover the features including IVBC and APRS. And ADMS in India

by NPCL, this is ADMS transforms Noida power utility into a smart utility. Number of connection is 10,400 and then peak load 450 megawatt distributed area 335 square kilometer.

So Noida power company limited embarked on implementing the ETAP ADMS solution. So they have used this ETAP ADMS solution. ETAP ADMS has eased the NPCL distribution networks operation, improved outage response and saved revenue in the process. NPCL took the decision in 2015 to implement ETAP ADMS advanced distribution management system to improve its network reliability, performance and response to customers. This notable milestone for ADMS solution is enabling the transformation of NPCL's network into an intelligent, adaptive and sustainable grid that provides reliable and quality energy for their customers.

Overall project scope here is usage of IEC 61850 protocol. We have discussed about the significance of IEC 61850 which will help to improve the interoperability. It can combine the different devices manufactured by different manufacturers. So it's easy way of communication used across the industries especially for SCADA automation. So IEC 61850 oriented substation automation, integrated functionality of SCADA distribution management system and outage management system, open and scalable smart grid functionalities and distribution network applications, integrated functionality of SCADA, DMS and OMS as we have discussed here and integrated network modeling, planning and distribution analysis, intelligent monitoring control, automation and decision support system, intelligent model based solution with geospatial information system and integration electrical power system simulation capabilities.

So adoption of ADMS in COVID regime in NPCL, its remote monitoring and operation, integrated operation of control and dispatch center, logic based decision making, crew allocation, route identification, faster response via fault location service isolation, restoration, reduced human intervention, reduced footfall due to integration of system, consumer satisfaction, decision driven outage information with ERT. So these are the adoptions. So overall in summary the ADMS brings together distribution management system, SCADA and outage management system technologies along with the control room applications on one secure platform with a single user interface. At its core is the network model representing the as operated state and based on the as built state defined by the geographic information system. Load flow algorithm responds quickly to data source from throughout the network to analyze the balance unbalanced and dynamically changing network in real time.

State estimation validates viewed data and estimates non telemetered points to achieve a complete network representation. So demand can be managed through the reduction of technical losses by forecasting near term load and applying volt for control for peak shaving and by securely integrating and managing distributed energy resources including

energy storage to flatten the daily load curve. When a DMS has advanced functionality such as volt for optimization, fault management, near term load forecasting and distributed energy support and includes complete SCADA and outage management system technology in system platform with the same user interface then it is an ADMS. So there are multiple functionalities. It's up to a distribution system on to consider specific feature of ADMS.

So ADMS comes up with multiple portfolios. So as we have discussed Tata delhi distribution network, Tata power DDL, they have considered only FLISR and volt war optimization basically. So like that many based on their features and what sort of service they want to provide to the customers and the associated cost. So specific distribution system will have their individual ADMS and there are also multiple ADMS tool box provided by the industries. So one can look up to the most suitable ADMS tool box for their distribution system and hence improve the benefits of overall operation, improving the overall operation of the distribution system. So with this I will conclude the ADMS part of discussion. Thank you so much. We will come up with the next topic. Thank you.