

The Advanced Distribution Management System (ADMS)

Managing the distribution network in the Smart Grid era

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Introduction

Electric utilities are preparing for the multitude of challenges facing the industry — limited generation to supply increasing energy demand, growing regulatory and customer pressure for increased reliability and reduced carbon emissions, adoption of distributed renewable generation and energy storage, and the inevitability of both an aging workforce and aging infrastructure.

In a rather short period of time, these challenges have converged, and in doing so, have exposed the need for a comprehensive mission critical solution to monitor, analyze, and control the distribution network.

This paper will provide an overview of the Advanced Distribution Management System (ADMS), including its diverse portfolio of functionality and a host of benefits for the distribution network owner and the energy consumer.

The ADMS

For more than 40 years, utilities have used the strength and speed of computers to model electricity networks. For the most part, that focus has been on transmission networks, and there are many mature software products on the market that provide strong functionality for bulk power transmission networks.

Modeling distribution networks is a different, and in many ways, more complex problem.

Instead of the need to model static, meshed, and balanced transmission networks, today's ADMS technology must model meshed and radial, balanced and unbalanced distribution networks with rapidly-changing topologies and demand profiles. Instead of consistent and frequent telemetry from the transmission network, ADMS technology must be able to coordinate unsynchronized data for management of these network models. ADMS must also help prepare utilities for "islanding" portions of the distribution network — creating the potential for management of multiple and independent distribution networks.

What makes a DMS advanced?

When a DMS has advanced functionality — such as Volt/VAR Optimization (VVO), Fault management (FLISR), Near-term load forecasting, and Distributed energy support — and includes complete SCADA and OMS technology on the same platform with the same user interface, then it is an Advanced Distribution Management System (ADMS).

The ADMS must also deal with the evolving use of electricity, supporting variable, localized demand profiles created by changing consumption habits, and by new electricity-powered devices such as battery-powered vehicles and high-tech equipment. Further, the ADMS must deal with shifting consumption patterns and customer demand for higher levels of service for their devices. Not only must service levels improve, but also the service must be of high quality, including voltage levels that operate within regulatory norms.

The ADMS is the tool that enables the power system engineer and dispatcher to effectively and efficiently plan, operate, and facilitate work on the distribution network. It analyzes balanced and unbalanced and dynamically changing distribution networks in real-time, while providing study mode capability for both backward and forward review to identify options to improve network reliability while lowering electricity costs.

The ADMS is the critical tool for management of the distribution network, and enables the acquisition of many of the benefits utilities and consumers expect from their Smart Grid investments.

The foundation of the ADMS

At the core of the ADMS is the ability to precisely define the network model, and to process an unbalanced load flow algorithm based on that model with telemetered data taken from the network.

- **The network model**

The ADMS must be able to represent all aspects of the distribution network, including a variety of conductor types, transformers, switches (both manual and motorized), fuses, and other permanent and temporary devices used in distribution system operations. The model represents the as-operated state of the network typically based on the as-built state as maintained by a Geographic Information System (GIS).

- **The dynamic data**

To enable accuracy of the ADMS load flow algorithm, it requires data telemetered from the distribution network. That data is generally made available through supervisory control and data acquisition (SCADA) systems, telemetry, where available, through AMI, and via OMS.



The amount of data to be telemetered and stored is significant and changes frequently, suggesting that high performance data management is critical for quick and efficient analysis by the ADMS. This data provides a variety of information (e.g. voltage, current) and device status (e.g. open/closed) to enable the load flow algorithm to provide more reliable results.

- **The unbalanced load flow algorithm**

The ADMS must have a very fast load flow algorithm that can solve unbalanced distribution networks based on ever-changing data telemetered from the field including single phase operations such as on laterals, fuses, and underground network sections.

Visualization of ADMS results

With a complex network model, significant quantities of data (both telemetered and calculated) and the wide variety of ADMS users (operators, dispatchers, management, planning engineers, etc.), providing visualization of ADMS results is an important consideration. An ADMS should be able to display network data in a geographic view, a schematic view, and in single-line diagrams. Further, the end-user should be able to easily manage the level of information displayed in these views.

Individual utilities have developed different means to view their network information over time, and the ADMS must be flexible enough to support the format desired by the utility.

State estimation — ensuring the accuracy of ADMS results

Generically, state estimate can be defined as “a branch of probability and statistics concerned with deriving information about properties of random variables, stochastic processes, and systems based on observed samples.” In power networks, state estimation validates observable data and estimates all non-telemetered points in order to derive a complete network representation.

The quality of data collected from various points on the distribution network is typically imperfect. Problems in devices or in the telecommunications networks associated with those devices suggest that prior to conducting an advanced analysis, the data must be pre-processed to eliminate bad data points, estimate non-telemetered points, and resolve any issues with “time skew” for unsynchronized telemetry systems.



Distribution State Estimation is much more than simple Load Calibration. It is important to calculate the network state with the highest possible precision as it is the basis for all advanced functions and the benefits that can be derived from network optimization.

Operations planning and analysis

One of the primary uses for the ADMS is the real-time analysis that enables optimization of the distribution network. The ADMS continually runs real-time analysis, identifying problems and suggesting approaches to better balance load, suggest switching to minimize losses, and identify other potential and real problems, as well as likely solutions.

The ADMS enables utilities to reduce energy waste on their distribution networks through a more detailed understanding of losses — and through reconfiguration and network optimization — to minimize those losses.

Convergence of Technologies

Distribution SCADA

The ADMS combines feature-rich distribution management technology with the optional benefits of an incorporated, field-proven distribution SCADA system. The Smart Grid era is ushering in a dramatic increase in 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 the luxury of deploying ADMS to integrate with their existing SCADA systems or replace them, now or in the future, with the latest and greatest in distribution SCADA technology. Nothing beats the flexibility and strategic approach to bringing control room applications together into one secure, single user interface solution.

Outage Management (OMS)

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, and service restoration (FLISR)**. The FLISR functionality already present at most utilities is enhanced with the ADMS’s ability to locate faults (based on telemetry and analysis) and to provide ranked switching options to a dispatcher (e.g. prioritization based on



connected load, connected customers, etc.) based on the dynamic state of the network. The ADMS can go beyond the capability of traditional distribution automation by allowing it to operate on the as-switched network model in any arbitrary configuration.

The ADMS facilitates and automates the creation of switching orders, for planned and unplanned work that dispatchers or field operators can execute according to traditional procedures, or which can be executed automatically. This can all be accomplished while managing tagging functionality as needed, and ensuring that the state of the network is well represented at all times — including the incorporation of temporary elements that may be used to support outage restoration.

Demand Management

Demand management is a key capability that drives utilities to Smart Grid programs and to the implementation of ADMS software. Many options can be exercised to manage demand in the face of increasing energy usage, surging energy costs, and network instability. The ADMS understands that there are multiple approaches to demand response, and the software can direct the implementation of demand response options that are created by Smart Grid programs.

Examples of these options include:

1. Network Optimization

In order to reduce technical losses on the network, an accurate and efficient analysis of the location of higher concentration of losses is required. Loss optimization functionality can identify these areas and recommend (or automatically control) network devices and switches accordingly. Reduction of losses provides not only direct power and cost reduction, but implicitly means better voltage profile, balancing of loads, and better network utilization.

2. Peak Shaving

Near-term load forecasting is a great tool to identify the potential for a peak load event during the course of the day. Combining this forecast capability with **Volt/VAR Optimization** is a great way to continue to manage demand on the network without affecting any customers. Load tap changers, voltage regulators, and capacitors can be automatically or manually controlled to maintain



voltage profiles, within regulatory limits, in order to manage demand. This can be done only during peak events or as a normal mode of operation as desired.

3. Energy Storage

An ADMS can be implemented to model distributed energy resources including energy storage. Whether energy storage is owned by the utility or by the customer, monitoring, analysis, and ultimately control of energy storage can serve as an ideal approach to flattening the daily load curve. Utilities can operate distributed energy resources for both reliability and economic reasons to the benefit of all interested parties.

Distributed energy

The Smart Grid was initially intended to support the addition of environmentally-renewable energy resources to the distribution network, including wind, solar, biomass, and others. However, managing a distribution network with hundreds or thousands of potential energy sources requires an ADMS.

The ADMS can help maintain the balance needed to reliably operate a diverse supply environment in the face of dynamic changes in demand and in the topology of the distribution network.

As distributed generation becomes more prominent, distribution networks may tend to become small “islands” of energy that can operate while connected to the rest of the distribution network. They may also operate independently as a “micro-grid” in a disconnected manner. The ADMS can manage the network through these operating approaches, optimizing it for losses, reliability, or cost of operation, while maintaining a secure distribution network.

Dispatcher training simulator

In addition to the diverse real-time and off-line analytical functionality contained in the ADMS, it is also possible to replay a history of events against the network model. This can be used to train distribution system operators, validate system configuration, and plan for future activity. The ADMS can also support the storage of past forecasted models.



To be effective, the dispatcher training simulator must also have the ability to move through time (typical demand and supply changes), with events that can be programmed in advance. In this manner, the simulator enables training cases based on experience or in advance of anticipated events.

Summary

The ADMS is an indispensable tool of the Smart Grid era. Starting with the foundation of a fast, unbalanced load flow engine and the ability to validate data via state estimation, the ADMS provides complete functionality to help utilities optimize their distribution networks. The software also provides dispatchers, engineers, and others who operate and manage the network with easy network visualization.

The ADMS includes significant functionality to manage outages and perform FLISR operations. It also has the tools to support Volt/VAR Optimization, which enables Distribution System Demand Management (DSDM): a form of demand response that operates utility controlled devices with no impact to customers. The technology supports distributed energy, enabling the utility to grow and accommodate the renewable generation expected of the Smart Grid era, while optimizing the network for reliable service.

Lastly, the ADMS represents the evolution of control room technology by merging DMS, OMS, and SCADA technologies into one comprehensive network management solution. As part of a Smart Grid strategy, it can help utilities transition into next-generation energy providers.

The concept of the distribution power plant

Distribution power plants come from a utility's ability to dispatch power that exists in the form of distributed generation and demand management, instead of as a physical power plant.

Using a variety of demand management approaches and dispatching distributed energy resources (e.g. energy storage, renewable generation, etc.), a utility can create a profile of a distribution power plant, and start using it in its energy dispatch algorithms when balancing demand and supply.

This requires critical analytics and controls, such as those provided by the ADMS to create an environment where a utility can leverage the distribution network as a dispatchable resource.