ADVANCED DISTRIBUTION MANAGEMENT SYSTEM (ADMS)

The Cornerstone of Grid Modernization

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Secure and Sustainable Grid Integration

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Our electric distribution infrastructure is aging, and it is impractical to replace and upgrade on a large scale. Furthermore, it is being pushed to address new needs beyond the original design. For these reasons and others, modernizing the grid is challenging and complex, requiring new approaches to utility business models, regulation policies, infrastructure assessments, updated system design criteria, and funding strategies. In addition, recent technological advancements such as low-cost communications, computing technology, and the Internet of Things (IoT) are driving an industry trend towards creating enterprise-wide programs on grid modernization that are intended to focus on new and innovative approaches.

These technologies, when appropriately implemented, provide equipment and controls that communicate and work together to deliver electricity in a more reliable, efficient, and resilient manner. When left unaddressed, the aging infrastructure results in declining power quality and increases in frequency and duration of outages. However, grid modernization can reverse this decline in performance and significantly improve reliability, reduce storm impacts, and improve resiliency. Additional utility benefits include improved security, improved capital utilization, the ability to support a higher penetration of renewables, and lower operational costs. Consumers also benefit as they can better manage their energy consumption and costs because they have easier access to their data and can control behind-the-meter devices. They can also connect their Distributed Energy Resources (DER), such as solar panels, electric vehicles, battery storage, etc., to the utility's distribution system.

Grid Modernization technologies include two-way communication technologies, sophisticated control systems, cost-effective automated field devices, and improved and lower-cost computer processing. These advanced technologies include sensors that allow operators to assess grid stability and Advanced Metering Infrastructure (AMI) that provide immediate access to load information, give consumers better information, and automatically report outages. Intelligent Electronic Devices (IEDs) such as relays that sense and recover from faults in the substation automatically, automated feeder switches that reroute power around problems, and other "grid-edge" technologies that provide "real-time" and "near-real-time" insight into what is occurring on the grid. Making sense of the complexities of status changes, alarms, data values, and DER impacts from these various technologies must be managed in such a way as to provide Distribution System Operators (DSO) and their support staff with decision-support information that is clear, timely, actionable, and easily visualized. These factors, as well as grid optimization and self-healing functions, are why utilities are increasingly employing Advanced Distribution Management Systems (ADMS) as a cornerstone to their Grid Modernization strategy.

DISTRIBUTION SYSTEMS MUST CHANGE TO SUPPORT ADMS

Historically, the distribution portion of the electrical grid received little attention compared to transmission and generation systems unless the lights went out. For decades, distribution system operators utilized mostly manual, paper-driven business processes to manage the system. Recently, managing the distribution system has evolved to electronic computer and communication-based decision support and control systems, including the three key components of an ADMS: Supervisory Control and Data Acquisition (SCADA), Distribution Management Systems (DMS), and Outage Management Systems (OMS). These systems worked well with the legacy distribution systems, designed with a one-way power flow from the generator to the consumer, as depicted in Figure 1.
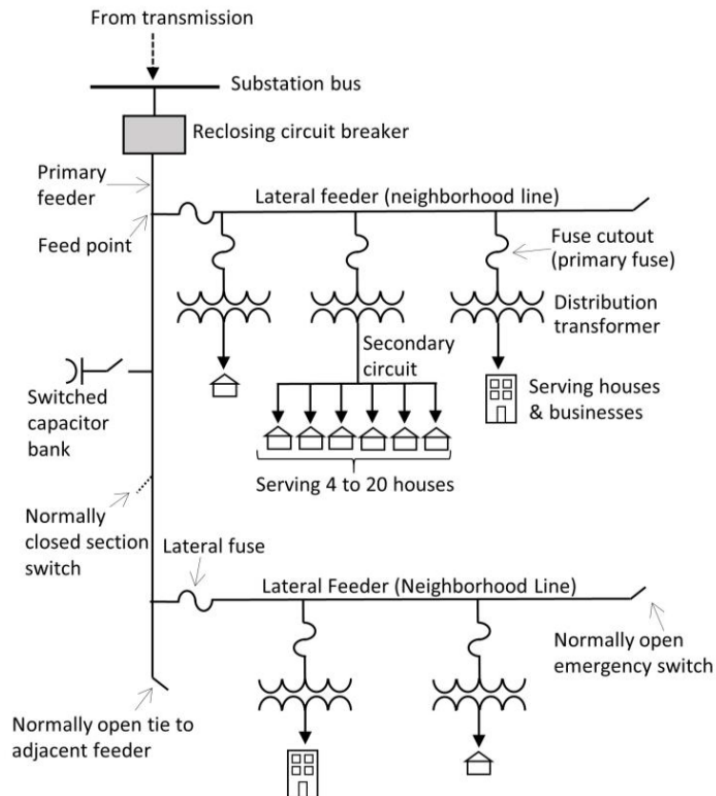
Figure 1 Traditional Distribution System Design [1]

Utilities are upgrading the capabilities of distribution systems with AMI, field sensors, automated equipment, and other grid modernization devices. The increasing penetration of residential and municipal solar generation, and distributed generation in general, impose challenges on the existing distribution infrastructure and the system operator. Bi-directional flow patterns will require changes to protection and control strategies, enhanced distribution automation and microgrid capabilities, voltage and VAR management, and overall modernization of the distribution grid infrastructure, including two-way communication and control.

With these changes, it is becoming evident the legacy distribution system cannot adequately support the requirements of distribution grid modernization, resulting in an ADMS becoming an essential tool and cornerstone for grid management. As a result, ADMS is no longer an optional, nice-to-have system; it has become a must-have operational system.

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[1] Pacific Northwest National Laboratory
Electricity Distribution System Baseline Report
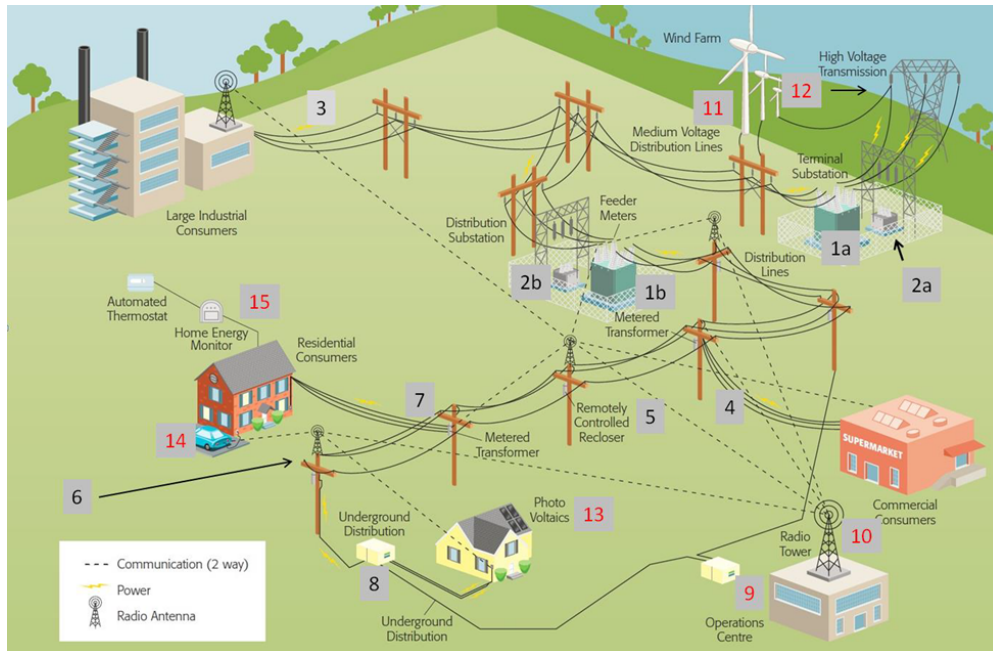Prepared for the U.S. Department of Energy
July 2016, Page 24

Figure 2 The Distribution System Re-Imagined[2]

The legacy system is transformed into the modernized distribution grid by adding grid modernization infrastructure and the proliferation of DER, as depicted in Figure 2. The modernized distribution grid employs the following characteristics:

- Power flows on the distribution system are bi-directional.
- Two-Way Communications are enabled. In this example, communication is done via Radio for illustration purposes as many communication options are available.
- Distribution Operations Center (9) and distribution system supervisory control and data acquisition system (D-SCADA) coupled to a central communications system and integrated into an ADMS—in this illustration, using radio signals (10). This enables two-way information flows among customers, customer meters, and control infrastructure on the grid, including automated equipment including switches, reclosers, voltage regulators, tap changing transformers, and capacitor banks
- Distributed renewable generation, such as distributed wind systems (which tend to use smaller turbines) and photovoltaic (PV) arrays, are connected to the distribution grid (11).
- DERs like rooftop PV connect to the distribution system through the same lines serving their host customer (13), as do electric vehicles (14).
- Home area networks (HAN) that control end-user devices such as air conditioning, water heaters, thermostats, etc. can be controlled via the communication system(s) to regulate end uses to provide demand response or reduce the cost of power by shifting the use schedule (15). Note the same capabilities also apply to commercial and industrial customers.

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[2] Pacific Northwest National Laboratory
Electricity Distribution System Baseline Report
Prepared for the U.S. Department of Energy
July 2016, Page 43

Additionally, the modernized distribution grid will distinguish itself from the legacy distribution system by its ability to interact with grid components responsible for maintaining power quality, reliability, and continuity of service through the use of advanced engineering applications and analytics.

ADMS FUNCTIONS

The key components of a fully integrated ADMS generally fall within the following categories:

- Monitor
- Analysis
- Operation
- Optimization
- Planning (near & long term)
- Training

Vendors tend to categorize ADMS functions based on the strengths of their offerings. For example, Gartner, recognized as a respected and independent industry source, has organized ADMS functions into the following groupings and their respective functions:[3]

MONITOR AND OPERATE

The monitor and operate objective is to provide a shared network model and common user experience for roles involved in monitoring, controlling, and optimizing the distribution grid. The function has been sub-divided into four categories with components for each indicated below:

User Experience
- Geospatial & Schematic Network Displays
- Automatic feeder and station display generation
- Major event mode
- Operator training simulator
- Role-based workspaces
- Collaboration support (shared field displays, streaming video)
- Visualization support (surface table displays, virtual reality)

"As operated" Network Model
- Model manager
- Topological tracing/coloring for single-phase and three-phase networks
- Switch plan visualization
- Temporary network elements
- Safety tagging and interlock checks
- Tagging lockout

Interfaces to External Systems
- Geographic information system (GIS) model import and incremental model build
- Interactive voice response interface
- Customer information system (CIS)/customer portal interface
- Mobile workforce management (MWM) interface
  o SCADA system interface (if SCADA is not included as a native capability)
- Meter data management (MDM) system interface
  o Demand-response management system (DRMS) interface
  o DER management system (DERMS) interface
  o Weather/lightning system interface
  o Digital relay/fault indicator interface

Distribution SCADA
- Alarm processing
- Substation/distribution automation system interface
- Inter-control center interface
- Communication front-end processor

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[3]Gartner, Inc.
Magic Quadrant for Advanced Distribution Management Systems
Published: 10 April 2017 ID: G00303431

TRACK AND RESTORE (OUTAGE MANAGEMENT)

The objective of Track and Restore is to proactively and safely guide distribution operators during severe storms and when they are conducting outage-related restoration activities. Components include:

- Trouble call processing
- Meter notification processing
- Outage analysis
- Outage event summary
- Auto-generated switch plans
- Resource needs prediction

- Crew management
- Switch order management
- Reliability performance indexes
- Storm modeling and impact analysis
- Storm replay analysis

ANALYZE AND OPTIMIZE (NETWORK MANAGEMENT)

The objective of analysis and optimization is to enable distribution operators to manage network loading at peak times and to optimize the network for improved asset utilization and overall network efficiency and reliability. Components include:

- Distribution power flow
- Fault location, isolation, and service restoration (FLISR)
- Conservation through voltage reduction (CVR)
- Volt/volt-ampere reactive (VAR) optimization
- Distribution state estimation (DSE)
- Protective relay coordination
- Predictive feeder load flow/peak planning
- Price-sensitive load modeling
- Load allocation

- Near-term load forecasting
- Optimal network reconfiguration
- Peak demand reduction
- DER aggregation, forecasting, and optimization
- Scheduling for microgrid and distributed generation operation
- Modeling and interfaces for electric vehicle (EV) to grid interaction
- Modeling and management of energy storage services
- Long-term planning functions
- Short-term planning functions

This listing of components reflects requirements that have been identified industry-wide. Many of these components have been included in some vendor product roadmaps and may not be currently offered by all vendors. As ADM's implementations are costly and complex, it is unlikely that a utility would implement a full suite of these components in a single project. In addition, ADMS implementations involve significant integration with other utility systems, and developing the required network model to support ADMS is challenging.

IMPORTANCE OF NETWORK MODEL & DATA

To provide a complete decision-support system for monitoring and controlling the electrical grid, an advanced ADMS must encompass or integrate systems and equipment within the utility infrastructure and at the customer premises. An ADMS must also be able to effectively control appropriate field devices. These complex tasks require the integration of GIS, SCADA, DMS, and OMS.

Additionally, ADMS requires data sources that are not found in either of these models. For example, today's network must deal with many different data sources—not just from SCADA-controlled devices and OMS but also advanced metering infrastructures (AMI), intelligent sensors, weather feeds, demand response, and many more. Other examples include:

- Detailed equipment data typically not stored in a GIS, such as short circuit impedances,
- Engineering values for resistance and reactance, susceptance, transformer impedances, etc.
- SCADA monitoring and control points associated with the correct devices in ADMS
- Substation internals, typically in a one-line diagram or schematic format.
- To-be-constructed/energized conductors or devices, which are typically imported from GIS and often managed by a graphic work design application. This data can be used within ADMS for planning and analysis. Tracking the system changes in the ADMS as the equipment is energized in the field is critical for ADMS operations.

Integrating these systems and ubiquitous data sources requires a "real-time" network model. ADMS applications require the full functionality of the GIS connectivity model plus the operational aspects of a "real-time" network model. Most utilities rely on the GIS to create the network model. However, the GIS model is relatively static in comparison to the dynamic operational state of the network. Its intent is to represent the network "as constructed" for asset management and inventory accounting. The ADMS model is considered a dynamic operational model, often referred to "as operated" model, which has "real-time" and "quasi-real-time" aspects. This operational model represents the current state of the network. Change in connectivity and status is managed by device operations and by applying and removing cuts and jumpers to the network model. Another characteristic of the "as operated" model is that it must be electrically phase-based. This means the operational model requires the graphical GIS-based model to be built with the ability to carry out single- or multi-phase operations and not only display all present phases, as is typical of a geographical model.

The specifics of how the "as operated" model is created and maintained vary among vendors and utility requirements. As ADMS is the hub of data flowing between multiple systems and is the controlling intelligence of this mission-critical function, the importance of accuracy of the "as operated" network model and supporting data cannot be overstated.

Ramifications of bad data can include incorrect outage predictions and restoration responses, extended outages, equipment and system damage, and undesirable impacts on the crew and public safety. In addition, inaccuracies in the ADMS can propagate to the other integrated systems, multiplying the impact of poor data quality.

Dispatchers who see significant errors in the system are likely to lose confidence in the system and become an impediment to implementation. If they feel crew safety or operational integrity is compromised and untrustworthy, they will revert to what they trust (previous processes) and not the system.

The transformational changes in modernized distribution systems translate into the need for enhancements to the capabilities of the control systems and distribution network designs to extend well beyond what exists today. In addition, the operational benefits of implementing ADMS technology are needed to safely, and reliability operate distribution networks.

Distribution networks will become more complex over the next several years with emerging technologies, such as renewable distributed energy resources, EVs, microgrids, etc. The nature of distribution circuits will change in many places from simple radial feeders to feeders that will have generation sources feeding into the grid with bi-directional power flows. It will become increasingly crucial for the operator to have situational awareness of dynamic field conditions to ensure crew safety, enhance reliability, and improve the customer experience. ADMS addresses utility control room concerns of managing multiple systems simultaneously by providing the operator with a single fully integrated platform to perform daily activities and the benefits of enhanced decision support applications and analytics. Finally, making sure that the proper cyber protections are included in the planning and deployment of these systems is critical. Grid Modernization strategies will evolve based on the specific circumstances of each utility, but grid modernization technology roadmaps include an ADMS as the cornerstone of their implementation plans.

The decision process to proceed with ADMS technology is a complex one. A comprehensive roadmap and implementation plan that lays out the concepts, operational specifications, cyber requirements, systems integration, and functional requirements in conjunction with a robust business case is critical for any utility that sees an ADMS as part of its grid modernization strategy.

GridBright can help. Want to learn more about GridBright's ADMS and other Grid Modernization strategies, planning, and support offerings? We assist utilities in achieving business objectives through a unique blend of industry expertise, innovative focus, business strategy, thought leadership, and industry-recognized methodologies. For more information, contact us at www.GridBright.com

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DISCLAIMER

GridBright® does not claim that this report is entirely complete and may be missing data and other information about the project. GridBright advises readers to perform necessary due diligence before making decisions using this content.

ABOUT GRIDBRIGHT®

GridBright® securely and sustainably integrates utility grid systems helping the industry keep the lights on in the face of increased intensity of natural disasters, frequency of cyber-attacks, and penetration of renewable and distributed energy resources.

GridBright® is an employee-owned company with an entrepreneurial culture. It is headquartered near Silicon Valley and has clients and employees located nationally. Its deeply experienced management

team are industry leaders who have worked in utilities, consulting, and software companies. We are proud of our high employee retention and customer satisfaction record.

GridBright® is integrating the modern grid with services that include the interconnection of sustainable transmission and distribution level resources, systems strategy consulting, business case development, procurement process support, and system implementation and integration. Our capabilities span all domains of utility operations technologies and systems.

GridBright® has created GRIDEON®—a suite of SaaS applications for the secure exchange of grid data with funding support from the US Department of Energy (GRIDEON.com). GridBright's expanding offerings enable a secure, compliant, and efficient exchange of sensitive grid data across the entire grid ecosystem. Its BetterGrids Repository (BetterGrids.org) enables the exchange of publicly available grid data among researchers in 45 countries. To learn more, visit GridBright.com.