Evolve at the Pace of Change: Optimizing the Distribution Grid

White paper

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Introduction

The current pace of change within the electric grid is challenging. In the past, when electric utilities needed to evolve, they might have a decade or more to do so. Today, the operating environment is changing dramatically and rapidly — the landscape is likely to transform more in the next 10 years than in the previous 100. At the same time, due to the continually evolving energy mix, distribution operators are experiencing an ongoing increase in grid complexity coupled with rising uncertainty due to changing business and regulatory models.

Successfully meeting these new demands requires digital transformation. The world’s electric grids must become stronger and smarter, as well as more flexible and resilient. Utilities are increasingly turning to distribution optimization to address common challenges:

- Delivering more with less – network efficiencies and operational productivity
- Identifying and preventing issues — blending historical data and forecasting to drive predictability
- Providing the right amount of power at exactly the right time — balancing supply and demand

The forward-thinking utility recognizes distribution optimization as a critical enabler of next-generation distribution grids, which are maximally efficient, reliable, and, ultimately, sustainable. This paper explores the value for utilities in embracing digital transformation to accelerate, adapt, compete, and succeed.
The opportunity to optimize

Current industry drivers demand utilities deliver clean, reliable, and affordable energy. Yet the grid is becoming increasingly complex as more distributed generation (DG) and distributed energy resources (DERs), such as photovoltaics (PVs), smart inverters, energy storage, and electric vehicles (EVs), are deployed. Today’s utilities must integrate these new players as well as adapt to the associated multi-directional flow of electrons. Simultaneously, the volume of smart sensors and meters utilized on the grid is steadily increasing by multiple orders of magnitude. Meanwhile, distribution operators are encountering an increasing volume and speed of data generated by the grid that presents a significant challenge to consume, understand, and act upon.

To protect business and improve results, utilities must:
- Protect and increase current reliability levels
- Decrease outage response times
- Improve power quality
- Integrate DG and DERs
- Provide resiliency to natural disasters and other threats

The control room requires operationally relevant analyses and optimizations for both advisory or fully automated (closed-loop) modes. Utilities must also forecast weather impact on generation and load as well as understand net loads and automated restoration implications in outage scenarios.

Without digital transformation, and software delivering greater automation and control, utilities are missing opportunities to better connect, orchestrate, and optimize their distribution grids.

Delivering distribution optimization

Protecting and improving grid resiliency requires proven software solutions to control and connect the many new sources of generation, and load and orchestrate them with the rest of grid operations.

Distribution power analysis gives enhanced situational awareness for the distribution network, and provides not only visual information to the operators, but also the underlying data for many of the advisory and optimization features of an Advanced Distribution Management Solution (ADMS). This distribution power analysis can calculate the operating state of the entire distribution network, filling in gaps in telemetry data visibility without operator intervention, and make results available to view in both current and simulated network states.

GE offers several distribution optimization applications accelerating the utility’s journey to network-level optimization. From automated fault restoration (FLISR) to voltage management (IVVC), GE solutions are built on a solid foundation of a field-proven and trusted distribution power flow (DPF) engine.

ADMS Results in Production Today
- Up to 33% reduction in SAIDI
- Up to 30% reduction in SAIFI
- Up to 3% reduction in voltage for greater network efficiency
- Up to 20% increase in renewable exports onto the grid
Distribution Power Flow (DPF)

Many utilities are still blind to what is going on in areas of their networks, often with their customers being the first to know of a problem. Progress can be seen on this front with more smart sensors and SCADA devices at lower voltages. Yet significant sections of distribution networks still lack sufficient telemetry measurements to provide required operational awareness and control. By adding a Distribution Power Flow (DPF) application, distribution operators can locate and calculate complex voltages at all nodes across the distribution network as well as the power flow through all feeder segments in the distribution system. By filling in the gaps, DPF provides the foundation and confidence for distribution operators to automate more of their networks and accelerate the journey towards network level optimization.

The DPF solution is integrated into the un-ganged switch modeling capability of the core platform, which means accurate three-phase results can be calculated and displayed. Suitable for radial or meshed networks, including networks with multiple embedded generation resources connected, the DPF engine is optimized for speed and benchmarked for accuracy against IEEE reference models.

DPF analysis also provides the next level of information utilities need. Users can run “what if?” studies based on past or predicted scenarios. Comparing several different options, users can save state and study results to compare one network configuration with another (forecasting different switching positions, different running loads, etc.). Instead of relying on reactive manual calculations, the DPF enables proactive, automated calculations to be run in the background on a constant basis. The resulting data can then be fed into other applications to further optimize network performance.

GE customers have over half a million real-time DPF executions in production worldwide, per day.

One of GE’s customers, a North American IOU, currently has 850 distribution substations continuously solving real-time DPF with SCADA inputs on a periodic basis and upon switching events. This customer and others around the world have been very impressed with how close the estimated solutions of the DPF match up with the SCADA measurements, with one in Australia whose operators call the results of DPF “pseudo-telemetry.”
Fault Location, Isolation and Service Restoration (FLISR)

Reducing outage pain is always a utility’s goal. Faults on the distribution network can trip out circuit breakers and result in all customers on a feeder losing power. FLISR software takes an overarching view of the network to restore power when outages occur and works to minimize consumer disruption.

FLISR uses telemetry data from circuit breakers and fault detectors to locate the issue, recommend remediation, or automatically send a sequence of switching actions to isolate the fault and restore power to the rest of the network.

The solution attempts full downstream restoration from a single donor circuit. If no single donor has the spare capacity required, the solution can be configured to use other techniques to fully restore the outage as follows:

• Outage Splitting: Seeks to split the downstream outage and fully restore the outage from multiple donors. Where more than one donor or split option is available, FLISR works out the best switching option based on optimized load spreading following switching.

• Load Transfer: If an immediate neighbor circuit doesn’t have enough spare capacity, FLISR can identify second tier (adjacent+1) circuits suitable for offloading to allow full restoration.

FLISR delivers distribution optimization by:

• Restoring customers quicker and ensuring that network sections with the highest number of customers, especially if they include sensitive or priority customers, are among the first to be restored.

• Preventing damage to assets by taking into account the load on a faulted circuit and the spare capacity of neighboring circuits before deciding the best solution.

• Improving quality of supply and potentially improving power quality indices (e.g., SAIDI) to reduce the likelihood of regulatory penalties.

• Lowering system maintenance needs as FLISR can be applied on a circuit-by-circuit basis considering the current network topology and status of equipment.

• Enhancing field crew effectiveness by automating the creation and relay of switching instructions via seamless integration with Mobile Switching.

In addition, FLISR also checks for devices with control inhibits, recent switching, live line work, and other network conditions which would affect safe execution of automation programs.

The distribution optimization delivered via GE’s FLISR technology allows utilities to transition their electrical system management from the standard “break-and-fix” theory to a more effective and efficient “predict-and-prevent” model.
Integrated Volt-Var Control (IVVC)

Utilities strive towards reduction in peak demand as reducing system voltage delivers significant energy savings. IVVC uses available telemetry, including flows and voltages, to accurately target voltage reduction to decrease load in periods of high demand or reduce energy consumption and losses around the clock. This real-time application determines desirable capacitor switching and transformer tap control actions in order to optimize the network and can reduce network losses by up to 3% through effective network optimization.

Two primary modes of operation — Voltage Control and VAR Control — can be operated together or independently:

- Voltage Control temporarily reduces the total system load below defined levels during peak load periods by reducing substation voltage levels.
- VAR Control maintains the power factor at bulk supply points above minimum defined levels by switching capacitors on and off.

Using advanced algorithms to reduce voltage while maintaining equipment lowest limits, IVVC optimizes distribution networks. Economic benefits are also achieved by meeting several objective functions such as relieving violations, shaving peak loads, and reducing power losses through voltage reduction.

IVVC also supports smart inverters as a means of managing voltage and reactive power control via these growing device types as rooftop solar proliferates. This has the potential to provides a more flexible and potentially less expensive option than controlling via traditional devices such as tap changers, voltage controllers, capacitor banks and shunts. IVVC models the dynamic nature of smart inverters as an input to the power analysis suite which enables IVVC to make use of this information.

IVVC in Production Today

One of GE’s customers, a North American IOU, implemented IVVC in 2015. Throughout that year IVVC delivered a MWh reduction of approximately 130,000, saving the utility more than $7M.
Moving further forward with grid modeling

Ultimately, increased grid digitization presents several opportunities operators can leverage via an ADMS. The network-level optimization the ADMS enables is also foundational to the grid modeling that can move utility modernization even further forward.

Having the ability to forecast generation and loads as well as enable predictive and prescriptive operations, will provide utilities with a competitive advantage while protecting and improving their reliability. No wonder more and more utilities today are implementing digital solutions to unlock the power of the data stored across the network. Yet, at the same time, having multiple individual and distinct digitized network models can hinder utilities in achieving the full potential of distribution optimization.

Unsynchronized network models across multiple systems mean more costs — data entry, maintenance to fix bad data, waiting for timely data — as well as negative impacts on operational performance, and often a lag in deploying new technologies. As utilities extend automation throughout their network, integration with an accurate and up-to-date network model is essential.

The ever-increasing level of DERs on the grid further increases the demand for an accurate network model. The power flowing through distribution transformers has dramatically changed, making it all the more important to work with a model that understands what, where, and how DERs are connected to the distribution network for safe, reliable operations.

With an ADMS as the foundation for distribution optimization, either in advisory or closed-loop mode (automation), utilities can model the network at all voltage levels and understand the impact of any connected DERs. This type of single, shared and up-to-date network modeling of all the utility’s real-world assets, including an accurate representation of current state and connectivity, is critical.

Imagine, for example, a FLISR scenario in which the faulted circuit is densely populated with rooftop PV. Without a shared and accurate network model, including DERs, the FLISR algorithm lacks an accurate understanding of the net load without the solar generation and what the actual load is that donor circuits will need to pick up (as the tripped PV inverters are no longer providing generation). This can generate significant challenges for the utility, at best resulting in a sub-optimal result or, in a worst-case scenario, an even larger potential problem down the line.

A single network model allows the ADMS to reduce data synchronization issues and can increase outage management efficiency, improve workflow, and provide an integrated view of the distribution grid from which to plan, design, build, commission, operate, monitor, maintain, and refurbish. Network-level transparency offers utilities the confidence needed to move to closed-loop control, which can ultimately lead to an autonomous grid.

Grid Modeling in Production Today

In March 2018, GE upgraded distribution grid management technology for the north and northwest parts of Dehli, India. The system, operated by Tata Power Delhi Distribution Ltd., includes mapping of low-voltage circuits in the field to keep tabs on the state of the full distribution network.

Integrating data through a geographic mapping system and installing modeling software was promptly advantageous. When one of the most destructive storms in two decades struck in April, control workers using monitors displaying a complete power distribution map were able to dispatch crews via smartphone to the scenes of damage when low voltage indicators alerted them to power outage. Tata was able to restore power in 3 to 4 hours, compared to 6 to 10 hours needed before the ADMS upgrade.
Why GE?

Electric grid digital transformation offers the opportunity for distribution operators to optimize their operations as well as their network. GE is here to support utilities on their journey. Our advanced power apps are:

- Field-proven and scalable
- Quickly and easily deployed
- Delivered via a DER-aware ADMS
- Currently in production at scale across numerous utilities in the US and worldwide.

We understand adaptive algorithms are critical to solving the challenges of today’s complex distribution grid — from automation to voltage control. Our Distribution Optimization solutions draw on deep industry know-how and experience gained from having the largest operational base of ADMS customers running network analysis applications on production systems.

Electric grids around the world must transform to stay abreast of new technology deployment trends, environmental concerns, weather patterns, regulatory requirements, and changing consumer needs. Continue to thrive by embracing the grid modernization and speeding advances in distributed energy with the expertise of GE and the power of digitized distribution optimization solutions.

Contact Us

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