Best Practices in Outage Management:

Delivering Additional Value Through Integrated Damage Assessment

A GTM Research White Paper

CONTENTS

1 INTRODUCTION

In the wake of recent extreme weather events, the goal of improving reliability and minimizing outage duration at the distribution level has become paramount for utility executives. Driven by changing regulations, including the adoption of performance-based incentives and penalties, increasing customer service-level expectations, and evolving business models, utilities are searching for tools that will allow them to better plan for, identify, assess and restore outages in the most resource- and cost-effective manner possible.

To date, the outage management lifecycle has been primarily a back-office process, driven through the outage management system with limited integration of the information collected by field crews. The majority of post-storm damage assessment still occurs largely through manual processes, with no common standards in place for collecting and integrating data, which contributes to inefficient restoration processes, as well as lengthy post-event reporting procedures. For the majority of utilities that have already deployed software systems, including an outage management system and a mobile workforce management system, unlocking additional outage management benefits requires tools which can facilitate the rapid assessment and integration of information collected in the field with back-office systems, as well as the generation of additional work orders from a mobile platform. Furthermore, these tools must be as accessible and familiar to field crews during extreme weather events as they are during normal daily operations. Recognizing these unmet needs, GE has extended and automated the outage management process beyond the back office to the field, allowing utilities as well as their customers to achieve a myriad of previously unrealized benefits.

2 DRIVERS AND INCENTIVES FOR IMPROVING OUTAGE MANAGEMENT

The core of the utility business model is providing reliable power within an expected range of service voltages and power quality. Furthermore, as the traditional role of utilities continues to be challenged by increasing adoption of disruptive technologies such as distributed generation, it has become especially critical that when power is lost, utilities are able to provide an accurate estimate of the time it will take to restore service to customers. Now more than ever, numerous stakeholders including regulators, government officials, and customers demand a higher level of service quality and a greater degree of communication when the power does go out. In addition, tightening operating budgets are forcing utilities to achieve better results with fewer resources.

Reliability and Resiliency

Reliability

"Reliability" refers to the ability of distribution infrastructure to deliver power within a range of pre-established service conditions. Reliability improvements tend to be implemented proactively; examples of commonly implemented initiatives include vegetation management and basic infrastructure hardening such as burying above-ground distribution lines. In addition, extreme weather events are typically exempted from the calculation of commonly used reliability indices such as the System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI).

Resiliency

While reliability and resiliency are interrelated, "resiliency" is defined as the ability of the distribution grid to withstand and recover from damages incurred during storms and other anomalous events. Recent examples of extreme weather events including Hurricane Sandy, which left parts of the eastern United States without power for several weeks, as well as ice storms in the Midwest and cyclones in parts of Australia, have exposed many of the vulnerabilities of electric distribution infrastructure.

According to the World Meteorological Organization, extreme weather events are increasing in both intensity and frequency. Outside of equipment failures, weather events including windstorms and rainstorms are the single largest contributors to service interruptions. In certain geographies, including most of North America, this is compounded by the susceptibility of the primarily overhead distribution infrastructure.

In addition, government agencies in the United States and overseas have already identified the need to address the anticipated impacts of climate change which are expected to affect resiliency. For example, President Obama's June 2013 Climate Action Plan contains measures aimed at "boosting the resilience of buildings and infrastructure" and "supporting communities as they prepare for climate impacts." [1]

As extreme weather events increase in frequency, they will present difficult but surmountable challenges for utilities. Preparing for these weather anomalies will require basic infrastructure hardening, as well as improved outage response and planning processes, which include better damage assessment practices that more effectively make use of utility resources.

Financial Drivers

Sustained outages can cause utilities to incur a variety of additional costs. From an operating expense perspective, outages result in additional truck rolls and, in the case of the majority of unplanned outages, overtime pay for line workers, which can be as much as two to three times the rate of typical daily compensation. In addition, regulators in geographies such as North America and Australia have placed increasing pressure on utilities to reduce operating expenses.

[1] http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf

Regulatory Drivers

Many utilities earn a regulated rate of return determined by governing bodies such as state public utility commissions, based primarily on expected energy sales and operating expenses through a process known as cost-of-service ratemaking. Rates and allowed returns are typically set to multi-year periods through "rate cases," with little to no immediate recourse for subpar performance until the next rate-case cycle. In addition, regulating agencies typically exempt a predefined number of weather events from the calculation of annual reliability indices.

However, more recently, public scrutiny of utility performance by the media and elected officials has led to the increased utilization of performance-based ratemaking by regulators, which employs performance metrics that in many cases tie financial returns to reliability indices such as the Customer Average Interruption Duration Index (CAIDI) and the System Average Interruption Frequency Index (SAIFI). In addition, utility performance has prompted many regulators to consider limiting extreme weather exemptions, as this undervalues improved outage management protocols at a time when they are most critical. A recent example of performance-based ratemaking implemented by the Illinois regulator is presented below.

Figure 1: Performance-Based Ratemaking Under the Illinois Electricity Infrastructure Modernization Act

Metric	Performance Target	Penalty
SAIFI	20% Reduction over a 10-year period	5-basis-point deduction from return on equity
CAIDI	15% Reduction over a 10-year period	

Source: Illinois Commerce Commission

Similarly, regulators are increasingly benchmarking utility performance against peers, and the financial repercussions of poor performance are non-trivial. Even for utilities that have not been subject to comparable performance standards, poor outage responses can have a significant impact on the returns allowed by regulators under more traditional cost-of-service ratemaking.

3 SHORTCOMINGS OF THE HISTORICAL APPROACH TO OUTAGE MANAGEMENT

Comprehensive outage management policies require the rapid identification, assessment, and prioritization of work orders, as well as post-event analysis, which can be used to better prepare for future events. In addition, a comprehensive outage management solution requires the integration of key software systems, which typically incorporate the outage management system (OMS), mobile workforce management system (MWFMS), geographic information system (GIS), and distribution management system (DMS).

Despite the fact that most utilities today have some variation of either a commercial off-the-shelf or a homegrown outage management system, these systems are rarely integrated with other key software systems involved in outage management processes, including MWFMS and mobile asset management software. Siloed operation of these tools can lead to inefficient work order creation and resource utilization, resulting in longer restoration times with manually calculated estimated times of restoration (ETR), ultimately causing utilities to incur additional operating expenses (in addition to potential penalties for subpar performance). Further, lack of situational awareness can jeopardize the safety of work crews.

During weather events in the past, the processes of pinpointing outages and dispatching the correct resources and personnel have been hampered by utilities' inability to consolidate pertinent information into a single, mobile view. For example, many mobile workforce management systems may contain outage information, but without relevent asset data. Conversely, mobile mapping solutions typically contain asset information, but without relevant outage order information. In addition, as inspections occur, field crews require the ability to electronically create new work orders, escalate the priority of existing work orders that may have been overlooked, and confirm that work has been completed. These issues are further complicated by mutual aid efforts during extreme weather events, in which other utilities are called upon to supplement restoration efforts. Visiting utilities rarely employ the same damage assessment tools and protocols, making it all the more important that the host utility's damage assessment tools can be easily understood and used by mutual aid crews. Standardizing the data collection process through mobile software can help address many of the challenges created by inter-utility coordination.

It is critical to remember that the data and models which enable the effective operation of these systems must be continually refreshed. Network models, asset data and geospatial information must be able to be updated as quickly and easily from the field as they can be from the back office. However, it is also important that standardized data collection can still occur even when a communications link to the back office may not be available.

4 BENEFITS OF IMPROVED OUTAGE MANAGEMENT

Improving outage management and damage assessment processes to address the aforementioned limitations provides many quantifiable and more intangible benefits for both customers and utilities. While financial and operational benefits are key outcomes of improved outage management processes, equipping line crews with an information-rich set of tools also increases situational awareness, ensuring that work crews are able to complete assigned tasks in a safer, more efficient manner. By integrating many of the traditionally disparate steps of outage management and service restoration and extending functionality to the field, GE has empowered utilities with the tools to achieve numerous benefits, which will be detailed in the following sections.

Utility Benefits

From a utility perspective, the single largest monetary benefit resulting from improved outage management processes can be a reduction in operating expenses, which includes fewer truck rolls, reduced wear and tear on fleet vehicles, and fewer overtime hours for field crews. Recent analysis by the U.K.'s Department of Energy and Climate Change found that a 5% reduction in the operational costs associated with fixing faults would yield approximately $130 million in benefits over a twenty-year period. In addition, incorporating the "last-gasp" functionality of smart meters into outage restoration processes is expected to lead to an almost twofold increase in cost benefits, resulting in a combined savings of $236 million. These financial benefits are even more pronounced in other geographies such as North America and Australia, given the higher-than-average annual customer outage minutes experienced in these parts of the world. However, realizing these benefits requires extending outage management processes beyond the back office by empowering line crews through enhanced and integrated mobile capabilities. An example of the benefits that can be achieved through greater mobile functionality is presented in the following figure.

Figure 2: Benefits of Mobile Switching

Source: Western Power Corporation (Australia)

From an environmental perspective, a reduced number of truck rolls also equates to a small but measurable reduction in carbon emissions. In addition, reductions in unserved energy can also provide financial benefits due to the fact that when consumption ceases, the meter essentially stops spinning. From an operational perspective, updates made in the field during restoration processes can also serve as a means of validating the network connectivity model.

Over a longer time horizon, improving outage management processes can lead to more efficient resource planning, including improved asset maintenance schedules and protocols. In addition, utilities can capture many less tangible benefits such as improved worker safety and improved public perception. While these benefits may not directly contribute to the bottom line, they nevertheless are valuable outcomes in an era of heightened transparency and accountability.

Customer Benefits

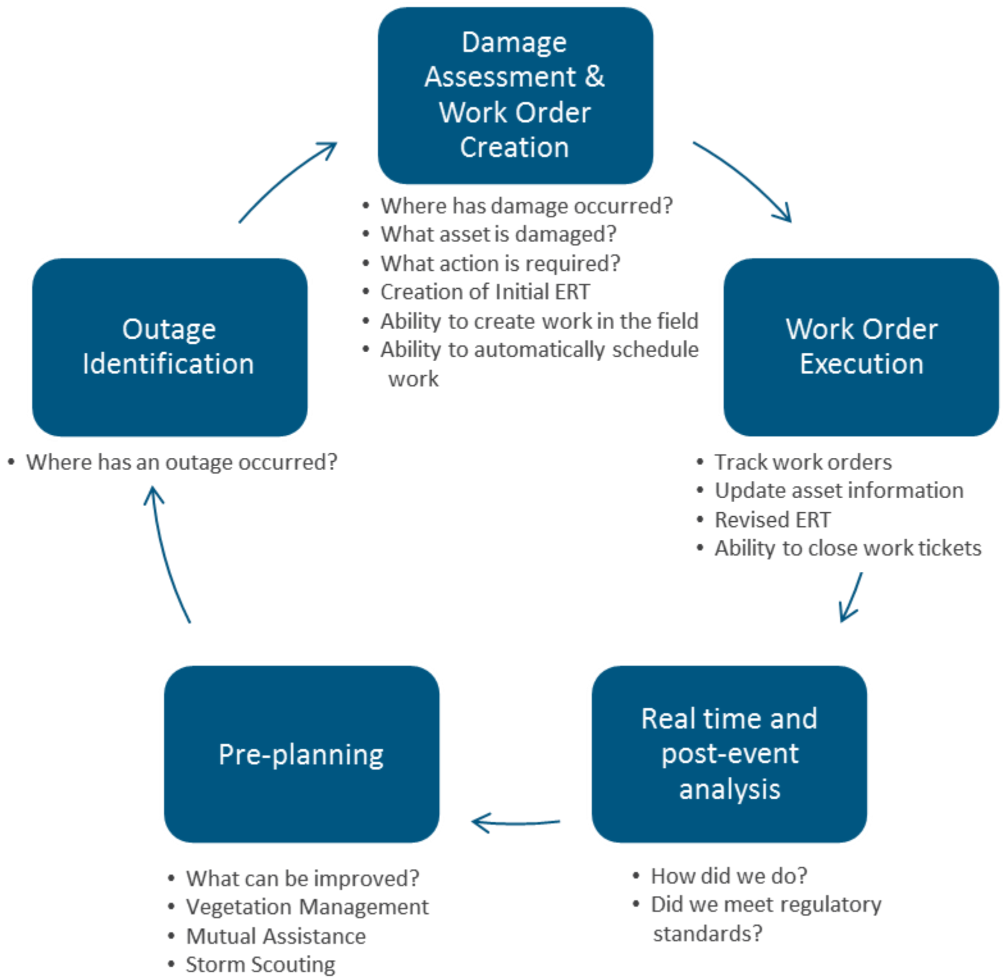
The world economy has become increasingly dependent upon digital technologies, which require a reliable supply of electricity. In turn, productivity losses from both momentary and sustained power outages can be costly. Lawrence Berkeley National Laboratory estimates that in the United States, the cost of power interruptions exceeds more than $80 billion annually.[2] In addition, the costs of losses are shared disproportionately between residential, commercial and industrial customers, with the largest economic burden falling on the latter of the three groups. Similarly, the Electric Power Research Institute (EPRI) estimates that among all business sectors, the U.S. economy loses between $104 billion and $164 billion per year, with businesses that are dependent upon data storage, retrieval and processing losing $6.7 billion annually.[3] Outside of the quantifiable economic benefits of fewer customer-minutes lost, more immediate service restoration can bring peace of mind through premise-level ETRs.

5 IMPROVING THE OUTAGE MANAGEMENT LIFECYCLE

Improving outage management processes requires an integrated approach and the bidirectional flow of information between the back office and field. This includes the incorporation of additional sources of information such as smart meter, social media and breaker/switch status change data for improving the accuracy of outage detection, as well as a standardized, digital platform for capturing damage information and transferring that information to the back office. The ultimate impact of an integrated set of software systems and business processes is exponentially greater than that of each of its constituent parts. Through GE’s suite of PowerOn™ Solutions, Field Force Automation, MapFrame™ FieldSmart and Grid IQ™ Insight products, utilities have the option of implementing a complete, integrated solution for comprehensive outage management, or, alternatively, selecting the tools required to supplement and enhance the functionality of previously deployed systems.

[2] Hamachi, K.L. and Eto, J.H. “Understanding the Cost of Power Interruptions to U.S. Electricity Consumers.” 2004. Ernest Orlando Lawrence Berkeley National Laboratory.
[3] Lineweber, D. and McNulty, S. 2011. “The Cost of Power Disturbances to the Industrial & Digital Economy Companies.”

Figure 3: Outage Management Lifecycle



Outage Identification

The outage management system is the key enabler of identifying and predicting distribution-level outages. At the most basic level, outage identification typically occurs through a combination of supervisory control area and data acquisition (SCADA) devices and customer calls-ins, which are streamed into the outage management system and associated with geospatial information.

However, the increasing adoption of advanced metering infrastructure (AMI) and smart meters has allowed utilities to gain valuable insights into the last mile of the distribution grid – a portion of the grid where there historically has been limited telemetry. When power is lost, smart meters are capable of sending “last-gasp” messages to the outage management system in order to identify both sustained and momentary service disruptions. Similarly, after power is restored, meters downstream from the outage can be proactively “pinged” to verify that there are no nested outages and that service has been restored to all customers.

In addition, the near-ubiquitous adoption of smart phones and other mobile devices with internet connectivity provide additional data points against which to confirm suspected outages. For instance, a “tweet” sent from a phone with basic GPS functionality can allow distribution operators to quickly pinpoint and validate suspected outages by correlating this information with other sources of data. Similarly, broader enterprise analytics solutions allow utilities to create algorithms to analyze multiple sources of both structured and unstructured data.

Damage Assessment

As a recent EPRI publication notes, “Proper resiliency planning must provide for rapid damage assessment and crew deployment.”[4] However, many utilities still rely on a sub-optimized process and technology for conducting damage assessments. Collecting and integrating information in this dated fashion is both time- and resource-intensive. Furthermore, incorporating this critical information with back-office systems often occurs in an ad hoc manner, with no standard reporting or integrating procedures and no guarantee that the necessary changes will be implemented once restoration measures have been completed, creating a host of secondary problems such as a network model which may not reflect changes made in the field.

Work Order Creation

Creating and prioritizing work orders from the field to ensure that the appropriate resources are dispatched is arguably the most critical post-outage event. Best practices in outage management require field crews and damage assessors to be ready for deployment as soon as a storm or other extreme weather event passes in order to provide an initial estimate of restoration time, as well as subsequent updates as additional field work and assessments are completed.

For the majority of utilities which have already deployed an OMS, capturing the remaining marginal value through better outage management practices is largely dependent upon improving and integrating the processes involved in damage assessment and work order creation.

Furthermore, public officials and regulators are increasingly asking utilities to provide not only an accurate global ETR for their entire service territory, but also to provide ETRs for specific segments of the grid. Best practices in damage assessment, therefore, also require a link between outage order information and asset information. While the OMS serves as a sufficient initial predictor of damaged assets, it is critical that field crews are able to relate updated asset status and condition information observed in the field with outage orders generated by the OMS, in order to reconcile instances where

[4] EPRI. 2013. “Enhancing Distribution Resiliency: Opportunities for Applying Innovative Technologies.”

the OMS may have incorrectly identified the asset or condition that led to the outage. In addition to identifiying nested outages, relating asset information with outage orders allows for the establishment of localized ETRs for specific feeders and/or customers, helping to satisfy the growing number of outage management metrics required by regulators and public officials. Furthermore, localized ETRs can also aid in the identification of distribution segments with poor reliability which may not otherwise be captured in system-wide ETRs and post-event reliability index calculations.

With the near-ubiquitous adoption of mobile computing, tools exist today which allow field crews to gain access to a plethora of data sources, including mobile mapping, asset information, network models and visualization in a single, intuitive, graphical interface. By consolidating these tools into a unified dashboard, damage can be assessed more rapidly. Similarly, standardized reporting procedures and the bidirectional flow of information enable more frequent assessment, as well as more accurate and frequent updates to ETR calculations. For the majority of utilities that have already deployed an OMS, capturing the remaining marginal value through better outage management practices is largely dependent upon improving and integrating the processes involved in damage assessment and work order creation. GE offers the tools to unlock this additional value through both a pre-integrated suite of product offerings and through a stand-alone damage assessment module.

Work Order Execution

Conditions change frequently in the field, and an accurate ETR is dependent upon the ability to track and close out work orders from the field. In addition, as tickets are closed out, it is critical that work crews are able to reflect any changes made to the connectivity model in the field, in order to ensure that the utility's geospatial model accurately represents real-world conditions.

Automating and extending work order execution to mobile devices has resulted in the realization of numerous additional business and safety benefits for utilities. For example, at Australian distributor Western Power Corporation, the implementation of GE's mobile platform has led to a 50% reduction in switching incidents. Similarly, in the U.K., implementation at Western Power Distribution has led to a 22% reduction in customer-minutes lost.

"Mobile switching has automated the communications between field crews and the control center [and has] reduced errors and bottlenecks caused by high call volumes, as communications now occur electronically. This results in more coordinated communication between field and control, reduced delays from the control center, faster restoration times, real-time data being received from the field, more accurate restoration times and improved reliability [and] data accuracy."- Western Power Corporation

In addition, GE's mobile platform allows for automatic network status updates as switching occurs, which improves the accuracy and frequency of the information sent to end-customers.

Planning and Post-Event Reporting

Planning is an implicit component of effective resource utilization, from both a financial and an operational perspective. Many outage management systems can be utilized to model what-if scenarios that allow utilities to determine what resources are needed and where they can be obtained in order to establish effective pre-planning protocols. In recent years, increasing data output has begun to provide the justification for implementing proactive and predictive maintenance routines, including targeted vegetation management, as well as more efficient asset maintenance schedules.

In addition, producing outage reports, whether for internal stakeholders or external stakeholders such as regulators or state/local authorities, has traditionally been a time-consuming process that has provided only limited visibility into the specific conditions that may have led to the outage. Standardizing the data collection process during the damage assessment phase of the outage lifecycle not only allows for faster restoration, but also facilitates minimal reworking of information for post-event accountability and outage reporting purposes.

While the capabilities of modern outage management systems have evolved significantly over the past several years and are now beginning to encompass many of the power flow modeling capabilities of distribution management systems, these software systems are only useful if the underlying data is accurate. This requires a constant bidirectional flow of information between field crews and distribution operators. Regardless of whether data collected in the field is brought back in real time or on a post-event basis, standardizing the incorporation of this dynamic information is critical for improving future performance.

6 CONCLUSION

Given the recent attention to utility performance in the aftermath of extreme weather events, the tasks of improving outage management processes and expediting service restoration have become top priorities for utility executives. Despite the fact that increasing volumes of data are enabling more automated processes of outage detection, delineation, and validation, utilities are still ultimately dependent upon line crews to physically inspect damaged assets and execute work orders so that power can be restored to end-customers. Based on this fact alone, field crews remain the most valuable assets that utilities have – providing increased visibility into the condition of devices in the field that may not be captured by traditional enterprise software. However, too often the valuable information collected by these crews is not leveraged to the maximum extent possible, largely due to the fact that the collection and assimilation of this data remains a manual process.

The absence of a standardized approach to damage assessment and data integration can result in increased restoration times, as well as a less comprehensive post-event understanding of the conditions which may have contributed to the outage. Similarly, ad hoc damage assessment protocols can make coordinating mutual aid efforts a complex task, leading to inefficient resource allocation and utilization. Addressing the aforementioned shortcomings of traditional outage management processes and leveraging the insights collected in the field, therefore, requires a set of integrated tools that can link these historically disparate processes, ultimately enabling utilities to realize exponentially greater benefits internally, as well as passing them on to their customers. Recognizing this need, GE has pioneered a set of best-in-class tools to close the loop around effective outage management through integrated damage assessment.

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