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CIGRE US National Committee
2013 Grid of the Future Symposium

Understanding the Value of Uninterrupted Service

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SUMMARY

This paper outlines the need for improved information about the costs of interruptions and longer duration outages. Information that is specific to locations, regions, types of customers, season, conditions, etc. can be extremely beneficial in helping to prioritize investments to improve performance and develop regulations that guide this investment. Background on understanding the costs of outages to customers is provided from a variety of sources and the need for improved information is documented. Different approaches for developing the improved cost information is described with advantages and disadvantages of each approach. Applications that can take advantage of the improved information are also described briefly.

KEYWORDS

Reliability, Resiliency, Customer Costs, Value of Service, Interruptions, Outages, Power Quality

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Background

Electricity supports essential services, including water, telecommunications, and transportation; the operations of businesses and industry; the lighting, heating, and cooling that enable modern living; and new digital applications that provide consumers tremendous value. Yet, the value that customers place on uninterrupted service is seldom quantified by utilities or regulators. Asking customers about the value that they attach to reducing service interruptions can have important implications for both utilities and regulators. A lack of alignment between how customers value uninterrupted electric service and regulatory incentives to minimize utility costs can have significant economic impacts by shifting outage costs onto customers. Understanding the costs outages impose on customers can help provide the basis for and prioritize investments needed to replace aging infrastructure, enhance the resilience of the power grid, and reduce the risk of service disruptions from cyber-security events. In some cases, quantifying the value of uninterrupted service also could provide a basis for changing service classifications or pursuing new business opportunities.

The Value of Uninterrupted Service

The value of uninterrupted service can vary significantly both within and between customer classes. There also can be important differences by region, season, timing and duration of outages. The range of differences in outage costs for different customers is illustrated in part by a widely cited Department of Energy report. Consolidating outage cost estimates from nine utilities, the study finds that the cost of an eight hour outage on a summer afternoon, in 2008 dollars, to be $10.70 for an average residential customer, $4,768 for an average small commercial and industrial customer, and $93,890 for an average large commercial and industrial customer. However, within the large commercial and industrial class, the study finds that the cost of such an eight hour outage might range from $41,250 for an average agricultural customer, to $147,219 or average customers in finance, real estate and insurance, and up to $214,644 for an average customer in construction. Individual customer impacts could be higher. These results they illustrate that different customers will be impacted differently when their service is interrupted.

Although the Department of Energy (DOE) report provides a useful starting point, additional studies of how customers value reliable electric service would be very beneficialare needed. The DOE analysis was based on datasets from surveys conducted for nine utilities over the period from 1989 to 2005. Only two of the utility datasets include any surveys conducted after the year 2000. Reliance on digital control systems, telecommunications, and devices that require reliable electric service has increased significantly in the intervening years. Moreover, none of the underlying data is from utilities in Northeastern, Mid-Atlantic, or Mountain West states.

New surveys may well find that the value customers place on uninterrupted service has increased. Business and industry have become increasingly dependent on information, communications, and digital control technology. The U.S. population has become more urban and dependent on electricity to support critical infrastructure. Moreover, major outages have increased significantly and are occurring at a rate more than double their historical frequency. Outages, such as super storm Sandy, have increased the salience of outage costs to customers and potentially their willingness to pay for a more resilient power system.
The risk of additional disruptive events may be increasing, making it more important to understand their impacts on customers.

- Increasingly frequent severe weather events would be consistent with current climate modelling. The impacts of climate change on the electric grid could be very significant. The damage caused by Sandy has led to expanded consideration of how the power system in New York and elsewhere can adapt to severe storms, rising sea levels, major heat waves, droughts, and other potential climate change impacts.

- Electric utilities are now on the front line defending against disruptive cyber-security events. As President Obama's 2013 Executive Order on Improving Cyber Security states, "The cyber threat to critical infrastructure continues to grow and represents one of the most serious national security challenges we must confront." Utilities also must consider the possibility of physical or combined physical and cyber threats. The National Academy of Sciences concluded that, "Economic costs from a carefully designed terrorist attack on the U.S. power delivery system could be as high as hundreds of billions of dollars."

Listening to customers and developing customer outage cost estimates for specific utilities, regions, customer segments, and event scenarios will be important to developing efficient and pragmatic investment strategies, understanding the context within which to assess cyber-security risks, and the development of utility regulatory and business models based on delivering value to customers.

Methods of Estimating the Value of Uninterrupted Service

Determining the value of uninterrupted electric requires estimating the cost of electric service outages for relevant customer segments. Historically, a variety of approaches have been used to estimate customer outage costs, each with its own set of pros and cons, including:

- Proxy methods: This approach uses an observable behavior to estimate the value of outage avoidance. For example, where a customer has purchased back-up generator, the cost of future avoided outages may be expected to equal or exceed the marginal cost of the backup power supply. The purchase of a backup generator would be evidence of "revealed preference" toward avoiding outages. However, proxy methods are available in only limited circumstances, offer little insight about consumer preferences among alternative approaches, and suggest only an upper or lower bound on outage costs.

- Consumer surplus: These methods estimate the value of uninterrupted service based upon observations of price elasticity. They are based on an assumption that consumer responses to longer term changes in prices provides useful information on the value lost by a short term interruption electricity service. These methods have the advantage that they are based on actual observed behavior; however they have the drawback of relying on an assumed correspondence between long- and short-term value estimates. The limited information provided by this approach has severely restricted its use in practice.

- Reliability demand models: These models explicitly include the quality of service in a demand model, however, because U.S. electric reliability levels have been uniformly high, these models have not been applied in the U.S. Their use has been limited to studies for developing countries.

- Meta-analysis based on prior surveys: In 2009, DOE's Lawrence Berkeley National Laboratory published the report, mentioned above, which included an updated meta-analysis of outage costs based on prior surveys and a model for estimating such costs. The analysis was based on datasets from twenty-eight surveys conducted by nine utilities from 1989 to 2005. While an important advance in the analysis of outage costs, a model based on surveys conducted up to 24 years ago may reflect too many geographic and temporal differences to provide an adequate basis for current investment and policy decisions.

- Survey-based methods: Survey-based methods have become the most widely used approach and are generally preferred over other measurement protocols because they can be used to obtain outage costs for a wide variety of reliability conditions not observable using other techniques. Survey methodologies can be used to examine a wide range of possible conditions under which outages might occur by asking about outages occurring in different seasons, at different times of day, with varying interruption durations, with and without advance notice. In a typical survey, each customer respondent is presented with 3-8 scenarios and asked the costs they would incur for the specific conditions described in each scenario. Using this approach, it is possible to develop results that can be applied to a wide range of utility planning and regulatory policy questions. Properly structured surveys can provide robust content validity in that the customer is in the best position to assess the impacts based upon their experience and requirements. An additional advantage of survey-based methods is that the use of "stratified" sampling can ensures that responses meet the desired precision criteria and are representative of the customer populations of interest and not just those customers who may have experienced a particular outage. Commercial and industrial customers typically are surveyed about the value of lost production, other outage related costs, and outage related savings, after taking into account their ability to make up for any lost production. This is known as the "direct worth approach". For residential customers, the vast majority of outage impacts are not directly observable economic costs. As a result, surveys usually inquire regarding residential customers' "willingness to pay" to avoid outages with specific characteristics and / or the amount of compensation they would require to be subject to a scenario involving an interruption of service (i.e., their "willingness to accept").

With modern statistical methods, some of which were not in widespread use when earlier studies were conducted, and additional data on customers, which are increasingly available from different sources, utilities may be able to identify those segments within each customer class that place the greatest value on service reliability. Traditional customer classifications may not be the only or most important drivers for differences in the value of uninterrupted service for different customers. By linking survey data on outage costs with other demographic and / or psychographic information, it may be possible to identify the customer characteristics most associated with differences in the value of service reliability. Such associations could be used to segment customers in a manner that identifies high value reliability upgrades or targets specific reliability related programs and services to customers who can and would pay for additional services. By segmenting customers appropriately, the utility may be able to provide services that are less costly, provide higher reliability, and avoid environmental impacts that otherwise would be associated with individual customers deploying dispersed generating units to ensure the availability of a back-up source of power.

Applications of the Value of Uninterrupted Service

The value of uninterrupted service to different customer segments can play a key role in utility planning. It can help establish a basis for and prioritize the replacement of aging infrastructure. Much of our electric infrastructure was built more than 40 years ago and is in urgent need of replacement and modernization. In a typical utility, as many as three-quarters of the wooden poles and half of the transformers may be approaching or beyond the end of their expected service lives. The American Society of Civil Engineers (ASCE) estimated in 2011 that maintaining the U.S. electric infrastructure will require $673 billion in new investment by 2020. To put these investment requirements in context, as of December 31, 2012, the total market capitalization of U.S. shareholder-owned electric companies was $463.9 billion. Failing to close the investment gap would have economic consequences. The ASCE forecast that if the power industry fails to make needed investments:

> "As costs to households and businesses associated with service interruptions rise, GDP will fall by a total of $496 billion by 2020. The U.S. economy will end up with an average of 529,000 fewer jobs than it would otherwise have by 2020. In addition, personal income in the U.S. will fall by a total of $656 billion from expected levels by 2020."

Reductions in outage costs can play a significant role in justifying investments in grid modernization. For example:

- The monitoring and control capabilities of Fault Detection, Isolation, and Restoration as well as Advanced Feeder Restoration systems may be justified on the basis of utilities acquiring an ability to isolate outages while maintaining service to surrounding customers. Initial results from the implementation of such self-healing systems on 1,250 distribution feeders at four utilities, funded through Department of Energy investment grants, identified a reduction in the average frequency of customer outages of 11% to 49% and reductions in the average duration of customer outages of up to 56%.

- Outage restoration is being accelerated at some utilities by the combination of improved outage management systems and advanced metering. Advanced metering infrastructure provides utilities real-time visibility regarding when customers are affected by an outage and when their service is restored. Historically, utilities had to wait for customers to report an outage. By bringing data on outages and service restoration into an advanced outage management system, the distribution utility can efficiently deploy its personnel to restore service, provide customers better estimates of when service will be restored, and cut days off of the time required to restore service after a major storm.

- Understanding outage costs can help make the case for such investments and can also provide valuable information to help prioritizing these investments.

In 2005, EPRI developed the concept of a "Service Quality Index" that could be applied to individual utility circuits or portions of circuits. The concept is an index that would be based on the economic costs of power quality and reliability characteristics to all of the customers on the circuit. The concept is illustrated in Figure 1. The index is dependent on two categories of information that must be available:

1. Characterization of the performance of the power supply system in terms of interruptions, voltage sags and possibly other power quality characteristics if they can have important economic consequences. This characterization is location specific in order to be a basis for comparison of different circuits and possible prioritization of investments.

2. Characterization of the costs associated with these conditions (outages, momentary interruptions, voltage sags).

The ability to characterize circuit performance in combination with the associated costs of the performance can be extremely valuable in prioritizing investments to improve performance. Of course, many factors will go into these decisions but documenting the economic justification from a customer perspective should be a critical part of the decision.

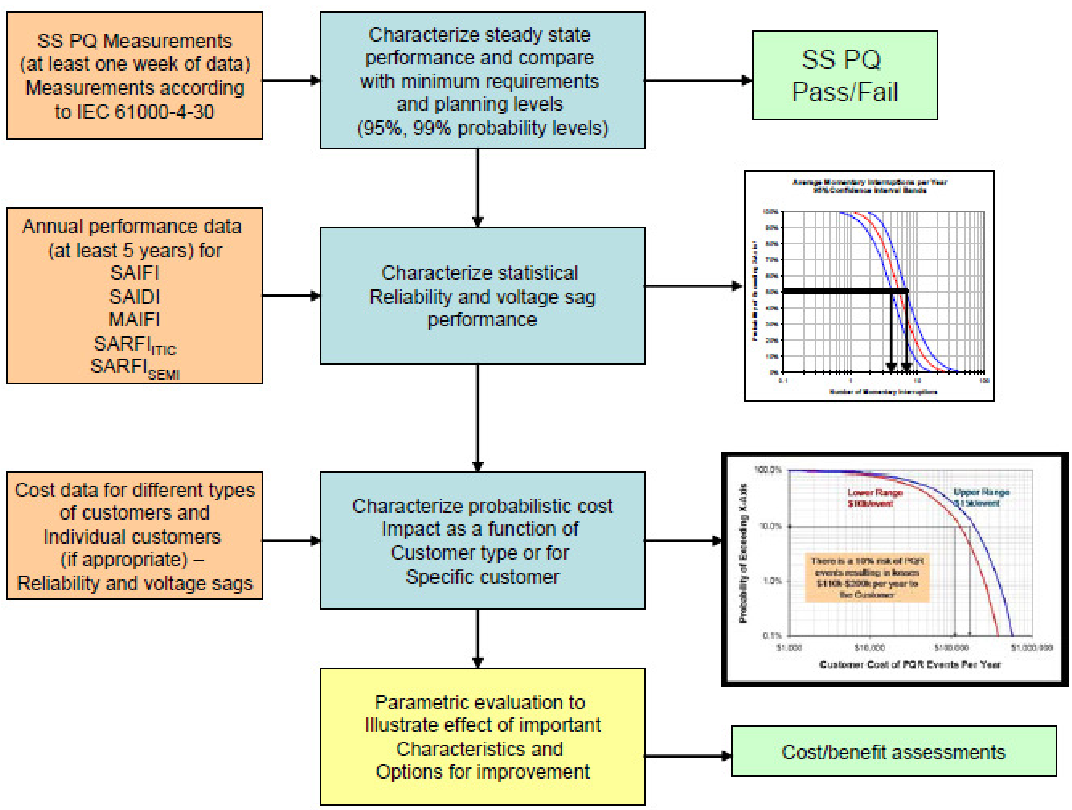

Figure 1 – Procedure for applying a "Service Quality Index" for evaluating economic impact of reliability and power quality.

An understanding of customer outage costs also can be a valuable input into outage management and scenario planning for service restoration. Additionally, it can help provide a context for evaluating what could be a reasonable level of investment to mitigate or avoid cyber security risks.

Regulatory Recognition of the Value of Uninterrupted Service

A number of jurisdictions are starting to consider new or enhanced performance based models to incent improvements service reliability. As of 2005, three states offered both incentives and penalties related to the quality of electric service and two additional states adjusted return on equity based on the quality of service provided. An additional eleven states had rules or practices imposing penalties for poor service quality. And, twenty-three other states set service targets or required utilities to report performance. Estimates of the value to customers of uninterrupted service are integrated into performance based regulatory incentives in parts of Europe and Australia. As U.S. utilities and regulators seek to define regulatory models that can both support needed investments and provide an appropriate balance of cost savings and performance incentives, rate plans that base incentives on the value to customers of improvements in service reliability may become increasingly common. Most of the existing incentives are structured around traditional reliability indices. These are usually designed to exclude major events such as storms that cause widespread outages for longer durations. It is becoming increasingly important to design economic assessment procedures and investment guidelines for these events. Understanding the cost differences between a 1 hour outage, a 1 day outage, and a 5 day outage will be critical information in developing these investment decisions.

Conclusion

Utilities can gain planning, operational, business and regulatory benefits from a better understanding of how their customers value uninterrupted service. As the industry seeks a closer engagement with customers, it will be essential to have current knowledge of the value that different segments of customers place on the services that utilities can provide. Modern survey and analytical techniques offer an opportunity to gain new insights into how different customers value uninterrupted electric service.

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