MICROGRID KNOWLEDGE GUIDE

Power Quality

How to identify the hidden issues that affect utility performance and customer satisfaction

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Thesis

The modern electric grid or, more properly, the modernizing electric grid is putting utilities at risk of losing control of their distribution networks.

As new technologies proliferate, they raise the potential for adverse effects on power quality, jeopardizing equipment and performance. Without visibility into power quality at the end of the grid, utilities are blind to issues that can affect performance, customer satisfaction and, ultimately, revenues.

The U.S. Department of Energy (DOE), in its 2020 Annual Energy Outlook, projected that the share of electricity generation from renewable sources will double from 19% in 2019 to 38% by 2050, edging out generation fueled by natural gas, which the federal agency projects will account for 36% of total generation.

Introduction

There was a time, not too long ago, when electric power was simple. It was supplied by the local utility through an exclusive franchise agreement between utilities and regulators. It was sold in kilowatt hours and paid for at regulated rates, and consumers had little or no say in choosing their service provider or the services they purchased.

Times have changed. Today, a growing number of utility customers, from households to manufacturers, have an array of options that did not exist in the past, from rooftop solar panels and sophisticated demand response programs to battery energy storage systems (BESS) and a variety of rate plans. The result is that utilities are increasingly faced with customers who have choices, who are well informed, and who are eager for change.

The shift is evident in the changing nature of the electric power grid. The U.S. Department of Energy (DOE), in its 2020 Annual Energy Outlook, projected that the share of electricity generation from renewable sources will double from 19% in 2019 to 38% by 2050, edging out generation fueled by natural gas, which the federal agency projects will account for 36% of total generation. Solar power will account for most of that renewable energy growth, according to the DOE's projections, going from 14% of total renewable generation in 2019 to 46% by 2050.

The growth of renewable energy sources, including distributed energy resources (DERs), along with more electric vehicles (EVs), the proliferation of battery energy storage systems, and advanced microgrids means that utility customers are no longer passive. In addition to seeking change, they are taking a more active role in managing their energy consumption.

The growing array of options is also changing a grid that was built around the idea of one-way energy flows, from central station to customer. Often, that is no longer the case. Utilities are now faced with customers who actively produce their own power and who are using the grid in new ways, whether it is to charge an EV or to store energy to offset their load (and demand charges).

In either case, utilities must still maintain grid stability and reliability as well as manage the grid for the benefit of all customers.

For utilities, the potentially destabilizing effects of new technologies such as DERs, EVs and BESS can cause a variety of problems, but it is difficult to diagnose and remedy a problem if little is known about it. That, unfortunately, is the situation in which many utilities find themselves today.

With little or no visibility into what is happening on the customer side of the transformer or substation, utilities have little knowledge of conditions that can affect their customers. Without data, utilities are forced to operate in the dark.

Gathering data about power quality at the customer end of the distribution system is the first step toward understanding and resolving these issues. Power quality data can be used for a variety of purposes, but two stand out for their importance and impact.

Power Quality Data Uses

1. Power quality data can explain or point to causes, or potential causes, of issues that previously were inexplicable. Knowledge of those issues and their causes can be used to improve relations with customers, helping to retain existing customers or even to recruit new customers.
2. Detailed knowledge of conditions on the grid can also supply the data that provides the rationale for capital programs aimed at improving network performance.

Significance

While the modern grid holds benefits for both utilities and customers, these benefits do come at a cost in terms of power quality.

Low inertia

Renewable energy resources that lack the rotating components of traditional turbines have low inertia. As a result, system controllers have less reaction time to balance disturbances in supply and demand, and frequency fluctuations on the system can be much higher. In Texas, where wind power contributes about 20% of the generation mix, the state's grid operator is seeking solutions to ensure there is sufficient inertia on its system.

Dirty power

Another innovation, modern energy efficient equipment, can also lead to problems, namely, "dirty power" that can result in flickering lights, equipment damage and tripped breakers. There is also the basic fact that the electric power network is becoming more complex with new, and often sudden, flow patterns. One example is the "duck curve" in California that occurs when solar power fades in the evening, creating a sudden need for fast-ramping power. There is also the prospect that electric vehicles will create new load patterns as EV owners plug in their vehicles to charge in the evening peak hours.

Sag and swell

Degradation of power quality can manifest in many ways. Among the major power quality issues are sag and swell, that is, a deviation above (swell) or below (sag) from nominal designated voltage. Voltage can swell when a large load is suddenly shut off. Voltage can sag because of a short circuit, an overload situation or when a large motor starts. Other causes of sag or swell can be a damaged voltage regulator or even the intermittent generation from solar power sources.

Spike in voltage

Another power quality issue is a transient, or spike, in voltage. Transients are similar to swells, but they are shorter in duration. Transients can damage equipment, particularly computers and related technology and control devices. Transients can be the result of a lightning strike or of the cycling of heavy-load motors.

Harmonic distortion

A third category of power quality issues is harmonic distortion. Sometimes known as "dirty power," harmonics are distortions in the sine wave form of a power source. A common cause of harmonic distortion is interference from nonlinear loads that convert alternating current to direct current, such as computer equipment and devices.

Power factor

A fourth power quality issue is power factor, which is the ratio of real power to apparent power. A poor power factor, a ratio or value of less than one, can result in an inefficient power delivery system and, in some cases, extra charges for an electric customer.

Adverse effects

Degradations of power quality can create many adverse effects, including equipment failure, data errors, corrupted software and overheating of electric systems. Any of these problems can result in lost productivity and customer dissatisfaction. A **study sponsored by the Electric Power Research Institute** found that power quality disturbances cost the U.S. economy $6.7 billion per year.

Implications

With unprecedented changes occurring at the customer end of the distribution grid, there is the potential for an increase in power quality issues. These issues can have a direct impact on utility performance and on utility customers.

At the customer end of the electric grid, a customer can experience automatic resets of equipment, data errors, memory losses and even equipment failure. And the importance of high-quality electric power for utility customers is growing as the economy becomes more dependent on digital circuitry, which is increasingly sensitive to changes in power supply. For some equipment, a sag or swell in voltage can be as damaging as an outage.

Imagine a customer with a pumping station that is experiencing frequent breaker trips. Concerned about a loss of productivity and the possibility of damaged equipment:

1. The customer checks his equipment and finds no problem.
2. The customer then contacts the utility power provider.
3. The utility runs a check and reports back that there is no problem on its distribution network at its substation.
4. The assumption at that point is that the problem is on the other side. Each party sees the fault on the other side of the meter.

In reality, 80% of power quality issues originate on the customer side of the meter, but neither party can prove it. It is an impasse without a solution. Most utilities would be eager to solve the problem if they have the capability, but without data, they are blind to the cause of the problem.

Solutions

The first step in resolving problems, whether they are with customer issues or with utility performance, is having detailed and specific knowledge about the problems. The best way to do that is to collect data about power quality.

With visibility into what is going on at the end of its distribution lines, a utility can understand the true capacities of its circuits. This presents the opportunity to optimize line capacity without requiring an expensive rebuild.

In situations such as the pumping station example, the benefits of good data become apparent. Sustained voltage sags and swells can cause equipment, particularly sensitive equipment, to trip offline. Without proper monitoring, however, the cause of the trip would remain unknown.

On the customer side, data on power quality can pinpoint the problem and provide unambiguous analysis that can narrow the search for root causes, whether it is faulty wiring or a malfunctioning control system.

With shared data and analysis, the utility and the customer have a common platform from which to craft a mutually agreed upon recovery and mitigation plan. And the ability to identify a problem and its solution, in turn, leads to a quicker resolution of the problem.

Power quality data not only provides a potential solution to customer complaints, but it also offers a methodology for addressing customer issues. Going forward, a utility's ability to monitor power quality at the customer end of the grid on a consistent basis demonstrates a utility's commitment to customer service and a transparent approach to problem resolution. Both of these factors can help retain and, in some cases, recruit customers.

On the utility side of the meter, the ability to monitor and analyze power quality data leads to improved visibility into the distribution network. With visibility into what is going on at the end of its distribution lines, a utility can understand the true capacities of its circuits. This presents the opportunity to optimize line capacity without requiring an expensive rebuild. Optimizing existing equipment can improve performance as well as save resources and build trust with regulators.

On the other side of that equation, data on power quality can provide evidence of issues that need to be addressed. Armed with data and analysis, a utility can present regulators with sufficient evidence to warrant capital expenditures for improvements that will increase reliability and resilience as well as power quality.

Implementing a Solution

Any solution to power quality issues begins with knowledge, and data provides that knowledge. With visibility, power quality issues can change from problems into opportunities.

For a utility, the first step would be an investment in a power quality analyzer. The PQube 3e from Powerside is one such option. It monitors a full spectrum of power quality metrics, such as harmonics, including supra-harmonics (2-150 kHz), as well as accepting analog inputs.

With options for either screen choice or preprogrammed installation options, the PQube 3e makes deployment easy. In addition, it requires no software, only a network connection, which speeds installation and makes for seamless integration, with support for several widely used data exchange protocols (SNMP, DNP 3.0, Modbus, email, BACnet).

PQube 3's report capabilities are also fully customizable and support the Information Technology Industry Council (ITIC) curve functions and the Institute of Electrical and Electronics Engineers (IEEE) 519 protocols.

The PQube 3e also provides a robust platform for reports with the capability to automatically push event waveform reports to email without additional software, enabling fast analysis and corrective action planning. PQube 3e's report capabilities are also fully customizable and support the Information Technology Industry Council (ITIC) curve functions and the Institute of Electrical and Electronics Engineers (IEEE) 519 protocols.

The PQube 3e also is cost competitive against other brands of power analyzers. A single PQube 3e is capable of monitoring up to four circuits, providing up to one-eighth the cost per monitored circuit compared with competitors. For instance, one substation connected to 12 meters would require three PQube 3es but would require one of a competitor's power monitoring devices for each meter.

The combination of ease of installation, a wide range of protocol support, sophisticated report capabilities and high value makes PQube 3e an essential tool for any utility interested in improving grid performance while enhancing customer satisfaction and retention.

