# When you modernize your grid, optimize it too

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The U.S. is about due for another infrastructure report card from the American Society of Civil Engineers. The grade the U.S. power sector earned in 2009, 2013 and 2017 was below average, but utilities are working hard to raise it.

Utilities now spend about $100 billion annually in grid upgrades. That's not surprising when you consider that 44% of respondents to a Black & Veatch 2019 survey named aging infrastructure their chief worry and according to the National Conference of State Legislatures, an estimated 60% of U.S. distribution lines have surpassed their 50-year life expectancy.

Given the enormity of grid modernization required, utilities should be thinking about more than merely swapping out old equipment for new. They also should be looking to optimize their grids with every update and upgrade.

So, what is grid optimization? You won't find an industry standard to define it, but an optimized distribution system will at least these help utilities achieve these goals: minimize technical losses, extend distribution asset life, improve power quality and supply, keep operating expenses down, increase reliability, and improve power quality.

**Minimize technical losses**

Technical line losses from causes such as energy dissipated in conductors, equipment on transmission, sub-transmission and distribution lines, and magnetic losses in transformers in U.S. electricity transmission and distribution (T&D) networks could average some 5% annually between 2014 and 2018, according to the U.S. Energy Information Administration. In an optimized system, line losses decrease.

Here's an example of how that might work in relation to phase imbalance. Ideally, customers along a distribution circuit are balanced between the A, B and C phases of conductor on the circuit.  When building out the circuit, utility engineers assume people in the same neighborhood will have similar consumption patterns, but over time that may change. For example, homes on the circuit add electric vehicle charging to their load. Or maybe one neighbor gets a pool, and another installs a power-hungry air conditioner. Eventually, circuits often suffer phase imbalance.

A study conduced in 2014 found that increasing phase imbalance from zero to 15% raised technical line losses from approximately 80kW to approximately 100kW in a test-case distribution system. That corresponds to a 25% increase. “The same study reveals that kW losses of a distribution line increases exponentially with the percentage of the phase imbalance. For instance, 37.5% phase imbalance increases the line losses from ~80kW to ~150kW which corresponds to about 87.5%increase,” noted a report produced by the Department of Energy’s Oak Ridge National Lab.

**Extend distribution asset life**

Not only are line losses wasteful of energy itself, as explained above, they also are associated with the generation of heat, which impacts asset life. Specifically, this is about Ohmic loss, which refers to the Joule heating that results from resistance in power lines. You may be familiar with this as I2R loss, meaning loss equals current squared times the resistance on the line. With I2R loss, the more heat that’s generated, the more the life of utility equipment deteriorates. When utilities instrument their circuits to regularly track loading versus ampacity ratings, they can not only reduce losses from phase imbalances but also take steps to avoid premature asset failure.

**Improve power quality and supply**

There are two jobs an electric utility cannot shirk: Delivering enough power to meet demand and delivering it with sufficient quality to not damage customers’ equipment.

Power quality will be increasingly difficult for utilities to maintain with the proliferation of distributed energy resources. Variable generation can create rapid and localized voltage swings, while inverters on solar installations can create harmonics on the system. Harmonics are signals that are out of sync with the fundamental frequency of the network. Inverters use pulse width modulation switching to convert a solar array’s direct current to alternating current. These devices switch at such high speeds, they continuously generate harmonics which can be damaging to both utility and customer equipment.

**Keep operating expenses down**

It is also less expensive to prevent an outage through predictive maintenance that it is to rush crews out for restoration once people start calling the utility because the power is out. Pre-emptive maintenance eliminates fault-location guess work and restoration time, plus it cuts down on overtime for crews who need to be called during off-hours to fix an emergency outage.

A good example relates to substation monitoring. Electric utilities often don’t monitor their substations, simply because retrofitting them with Supervisory Control and Data Acquisition (SCADA)-based monitoring solutions is costly and takes years to plan and build. But without monitoring, electric utilities are flying blind – not knowing what is happening at there substations until an outage or other problem occurs.

This is one area where grid monitoring comprised of smart grid sensors and Predictive Grid® analytics can help provide SCADA-equivalent visibility to network operators, as well as greater flexibility and value during emergency situations. During a heat wave in the summer of 2015, for example, a major fire at one of DTE Energy's substations resulted in the loss of power to more than 10,000 customers of the Michigan-based utility.

As described in this case study, DTE collected data using smart grid sensors that were deployed at substations to monitor the system's loads and portable distributed energy resources in near real-time. The load data allowed DTE engineers to quickly identify issues and perform switching to safely.

**Improve reliability**

Utilities that have already implemented advanced metering infrastructure often have power quality data – voltage and current – at the very edge of the grid through advanced meters. That's helpful, but it's not enough. To truly optimize your system, you need in-line voltage and current values along the feeder as well.

Engineering models of circuits are critical to the planning and management of distribution networks. While models are initially created with sophisticated modeling tools and significant engineering effort, circuits and their loads can evolve significantly over time, especially the more DERs are added to the system. To keep circuits operating optimally, situational awareness is needed, and engineering models need to be kept up to date. However, gathering data to update and maintain these models can be a labor-intensive and time-consuming task using traditional tools and it is very difficult to keep up with changes.

At a recent conference, a utility executive issued this challenge to the other managers and engineers in the room, the people who made up his audience. "Raise your hand if you think you've got really accurate data models of all your circuits," he asked. No hands went up. The utility executive at the podium didn't raise his hand either.

The point was that everybody realized that utility data models of circuits are often lacking in terms of having sufficient, timely and accurate data. Smart grid sensors solve the problem because they can easily and inexpensively be placed at multiple points on a circuit and they'll monitor conditions continuously.

**Improve power quality**

Reactive power – the VARs on your system – represents wasted capacity on the network. With today's smart grid sensors, you can get load, voltage and now VAR profiles throughout circuits. Then, with analytic modeling, you can identify circuits that warrant power-factor correction as well as how many kVARs might be needed for a given section of line.

In addition, other devices can help utilities regulate reactive power. Consolidated Edison, for example, ran a one-year test that reduced reactive power requirements at 33 substations in Queens by about 9.9% through advanced load tap changers. This increased power factor by 1% for the year and slashed 4,500-megawatt hours of system energy losses, saving the utility about $340,000 in annual energy costs.

In another case, utility engineers realized that the backup line to a hospital wasn't capable of carrying full load and had to be reconductored at an initial estimated cost of $4 million. Hoping to avoid that expense, an engineer re-analyzed the backup circuit and realized that installing three capacitor banks in certain locations would reduce losses enough on the backup feeder to pick up the additional loading requirements to support the hospital. The revised upgrade was less than only $50k.

What does this tell us? There are a number of ways to get good visibility and optimize the performance of your system – whether using smart grid sensors or devices such as load tap changers and capacitor banks. Many problems can be simply solved by optimizing your circuit so that capital can be diverted to do other grid modernization projects in the utility.

Ben Franklin once said, "An investment in knowledge pays the best interest." When you're moving forward with grid modernization, adding smart grid sensors are a great early move. With them, you can more effectively build a modern grid that's optimized for today and tomorrow's challenges.