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THE DISTRIBUTION GRID CAN BE THE HERO OF THE ENERGY TRANSITION —

with the Right Planning and Investment

Introduction

Federal and state government agencies, Wall Street and corporate America are all urging U.S. utilities toward rapid change. Utilities today are tasked with building an electric grid to withstand increasingly extreme weather, decarbonizing the grid, transitioning transportation and buildings from fossil fuels to electricity, and enabling a wave of customer-owned distributed energy resources (DERs), such as rooftop solar PV systems.

Much of the private and government funding to pursue those goals is channeled to new generation and transmission projects. Meanwhile, investment in the distribution grid comes up short, even though it must support the wave of electric vehicles (EVs), heat pumps and DERs that will connect to the grid's edge. Without an improved distribution grid, electrification and decentralization cannot be fully realized and decarbonization will be much more difficult.

As the leader in grid transformation, S&C Electric Company focuses on the role the distribution grid must play to enable the energy transition. This white paper from S&C includes how utilities can prepare their distribution grids effectively and efficiently by exploring:

- What the distribution grid is today and what it needs to become.
- Challenges the distribution grid must overcome to enable the energy transition.
- An affordable, effective pathway to achieve a digital, decarbonized, decentralized distribution grid.

The Distribution Grid Needs Attention to Be Ready for the Future

Today's distribution grid is designed to do one thing: act as a conduit between traditional, centralized power generation to energy-consuming homes and businesses.

As the energy transition unfolds, the distribution grid must be ready to deliver a decarbonized, decentralized, electrified future. Specifically, the grid must:

- Play its part in delivering reliable electricity from power plants to end users, who will be increasing their consumption of electrical power.
- Expand to provide a resilient infrastructure base to support a wave of electrification (new demand) and generating capacity (new supply).
- Serve as a multidirectional distribution "host" for DERs, located behind the meter and owned by customers as well as those located in front of the meter and owned by utilities.
- Enable flexibility and automation to enhance demand management.

Unless it's modernized to provide those capabilities, the distribution grid will limit the adoption of DERs, be unable to provide a resilient supply of electricity as consumers buy more EVs and electric heating solutions and will delay efforts to reduce greenhouse gas emissions.

3 Challenges the Distribution Grid Must Overcome to Enable the Energy Transition

As they chart paths to modernize the grid for the decentralized, decarbonized, electrified future, utilities are looking for help to overcome three primary challenges.

1. Digitizing a grid composed of aging infrastructure

About 70% of U.S. distribution grid infrastructure is more than 50 years old. Most of the U.S. distribution grid was built out in the 1960s and 1970s during the age of suburban expansion in America when expectations were entirely different and demand was limited to refrigerators, TVs and some air conditioning.

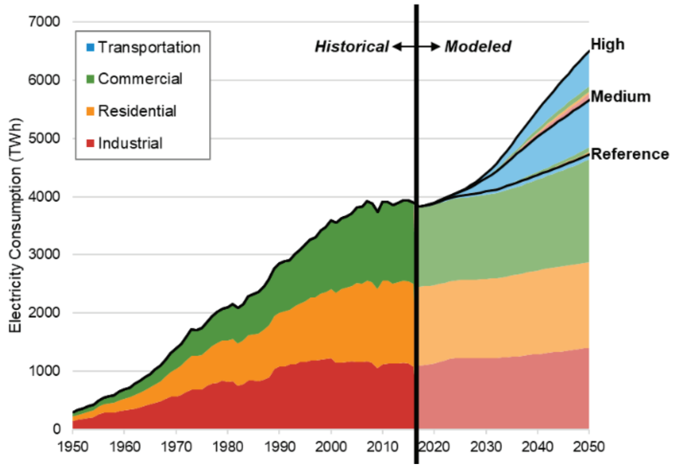
As grid assets have aged, they've suffered wear and tear, resulting in increased outages. They also come from a predigital age, and utilities desperately need to digitize the distribution grid to collect data and enable automation needed for the energy transition.

While utilities have invested in digitization, many of their old distribution assets are analog and manual. To solve the problem, utilities need automated devices that collect and deliver data so they can harness the power of that data to make smart decisions on energy management, flexible loads and investment planning.

2. Serving increased and multidirectional loads

Electrification will likely lead energy demand to grow to new system peaks, and EVs will drive rapid swings in demand as temperatures rise and fall and with the rhythms of the daily commute. Decentralization, particularly in the form of distributed solar systems, means sources of energy supply will come from every direction. For locations with high solar penetration, grids will need to handle rapid shifts in energy supply as the sun rises and falls or clouds pass by.

Modeling medium and high electrification scenarios, the National Renewable Energy Laboratory estimates that U.S. electricity demand will grow from about 4,000 TWh in 2020 to between 5,500 and 7,500 TWh by 2050. For distribution grid infrastructure to handle that increase, data is needed from sensing devices that monitor switchgear, feeders, reclosers and other equipment to effectively troubleshoot problems and invest efficiently.



Source: NREL

Today, utilities simply curtail DERs when a fault occurs or grid stress is high. When DERs are disconnected during stress events, the results are unhappy customers missing out on financial opportunities, less clean energy production and more greenhouse gases. As DERs proliferate, these curtailments will only get more frequent unless the distribution grid is ready for them.

3. Overcoming a perfect storm of EVs, DERs and extreme weather

As mentioned, growing DER and EV adoption will cause distribution grid performance to suffer until the necessary modernization investments are made. But there's a third variable in a perfect storm facing the grid: Increasingly extreme weather is battering distribution grids from coast to coast.

When more than 20 storms caused more than $1 billion in damage in 2020 in the United States, it seemed like an extreme outlier. But after 2021 and 2022 also delivered 20-plus storms causing more than $1 billion in damage, utilities were forced to view more extreme, expensive storms as the new normal, especially considering those costs only reflect grid rebuilds and not the lost economic activity that could have been retained. On average, Americans spent eight hours without power in both 2020 and 2021 — more than double the rates seen in any year from 2013 to 2015. Major blackout events increased by more than 60% from 2015 to 2020. Currently, "bad days" in the form of extreme events like storms aren't counted in published utility KPIs. Thus they don't reflect the complete story of system resilience — whether it is being achieved or support is needed for system resilience investment. That blind spot will manifest in worsening customer satisfaction metrics.

Utility customers today have entirely higher expectations than those in the '60s. So, with the triple threat to reliability posed by DERs, EVs and storms, utilities must focus on how many customers retained power during a disruptive event and how quickly service was restored to those who did not. Adding automated technology to the distribution grid can limit outages and improve restoration times.

What's the Price Tag on Overcoming the Distribution Grid's Challenges?

To overcome the three challenges and build the distribution grid of the future in the United States, significant investment will be required. The American Action Forum, in a recent report, estimated that preparing the U.S. grid for the coming wave of distributed solar PV adoption and EVs will cost nearly $1 trillion by 2035.

That means utilities may need to spend upwards of $61 billion per year through 2035 to prepare their distribution grids for solar PV and EVs. In reality, utilities have been spending closer to $30 billion per year in recent years.

However, reports predicting daunting totals for distribution grid investments often assume expensive infrastructure upgrades. Fortunately, there are often more efficient pathways — technologies that are more economical and can, in essence, retrofit existing distribution grid infrastructure to serve the energy transition.

A typical primary distribution upgrade costs $150,000 to $6 million and upgrading a substation costs between $1 million and $9 million, according to ACEEE. But with careful distribution grid planning and research into new technology options, utilities can chart a quicker and more cost-effective path for grid modernization that allows them to defer larger investments by extending the life and increasing the flexibility of existing infrastructure.

How to Achieve a Distribution Grid Built for Digitization, Decentralization and Decarbonization

Much like the composition of the distribution grid itself, a strong vision for the future grid starts with the customer at their meter and the grid's edge and flows through every step to the substation.

Most distribution grids still use old technology at every segment, so utilities build for the future by surveying the old technologies and assessing where a newer and better technology could be deployed. The following segment-by-segment strategies offer options to modernize a distribution grid for digitization, decentralization and decarbonization, building on broad distribution grid strategies to make the grid smarter.

Feeder strategies

Oftentimes, the first reaction in distribution grid planning offices to handle the increased load forecast in the coming wave of electrification is: "We need to add another line." However, new feeders are expensive. Segmentation could be a more affordable strategy. Reclosers were invented in the 1930s to shut off power at substations and feeders when trouble occurs and to reenergize the line to "blast" any contacts off the line. Only so many can be added in a series, limiting further segmentation. Reclosers also have limited use on underground feeders. Repeat and high-impact reclosing multiplies the fault current on cables.

Better technology is available that enables utilities to pursue multiple strategies. PulseClosing® Technology® uses a small pulse of current to detect the presence of a fault and isolate it automatically without the harmful fault-multiplier effect caused by reclosers, resulting in better reliability and improved power quality. Fault testing using this technology is low-stress by nature, an important attribute to help aging infrastructure continue to perform and protect underground lines.

By leveraging PulseClosing® Technology®, many devices can be added to feeders to segment them further than utilities have ever segmented them before, thereby minimizing outages. When a fault occurs, the devices help reduce the number of customers who experience an outage.

The devices also let utilities tie two existing feeders together for redundancy. Rather than building an expensive new feeder to limit the scope of disruptions, this configuration allows devices to reroute power from an alternate source — with or without communications.

Lateral strategies

The vast majority of customer electric meters in the United States are tied to laterals, and fuses have been an integral component on the millions of neighborhood lateral lines for as long as electric utilities have existed. The venerable fuse does its job, stopping the flow of electricity any time a temporary or permanent danger occurs. However, bringing power back online after a fuse blows requires manual work. That simply shouldn't be the case every time there is a fault, which is temporary 70-80% of the time.

Devices using self-resetting interrupter technology can replace fuses on lateral lines. When a fault occurs, these technologies briefly interrupt power, then check to see if the fault has disappeared, automatically bringing the line back on with no outage for customers in the case of a temporary fault. This saves utilities from performing high-cost manual work to restore power. These newer fault-testing technologies also reduce the number of outages for customers, thereby boosting customer reliability.

Transformer strategies

Utilities have been moving their laterals underground for decades. Today, utilities are discovering that these aging assets are wearing down, resulting in increased outages, and the underground location of the lines makes the problem very hard to fix using traditional means. If issues arise, technology exists that can be installed within existing transformers that prevent outages for customers served by underground laterals. Underground distribution restoration systems eliminate lengthy underground residential outages with an automated restoration solution. These devices automatically reroute power to keep customers online.

Additionally, lightning arresters on overhead distribution transformers help protect the system from the damaging effects of lightning, but device failures do happen. Utilities can add technology that detects those failures and clears the problem at the transformer, thereby avoiding the need for upstream protection devices to operate and cause power disruptions.

Conclusion

Utilities know the energy transition is coming and that the distribution grid needs significant enhancements to be ready. However, a disconnect has existed between what utilities know must be done and their investments to make it happen. With state and federal clean energy and EV goals backed by major government funding from the Infrastructure Investment and Jobs Act and Inflation Reduction Act, now is the right time to invest in the grid.

With careful distribution grid planning and efforts to research new technology options, utilities are working to chart a path to prepare their distribution grids quickly, before electrification, decentralization and severe weather cause reliability, resilience and customer satisfaction to suffer. This path is quicker and more cost-effective because it allows utilities to defer larger investments by extending the life and increasing the flexibility of existing infrastructure.

With more than 100 years of electrical grid expertise, S&C Electric Company helps utilities develop strategies to overcome the energy transition challenges facing their grids. S&C offers technology solutions that work with a utility's existing distribution grid infrastructure to automate the grid, extend the useful life of equipment, and improve reliability -- reducing customer outages and decreasing the length of outages.

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