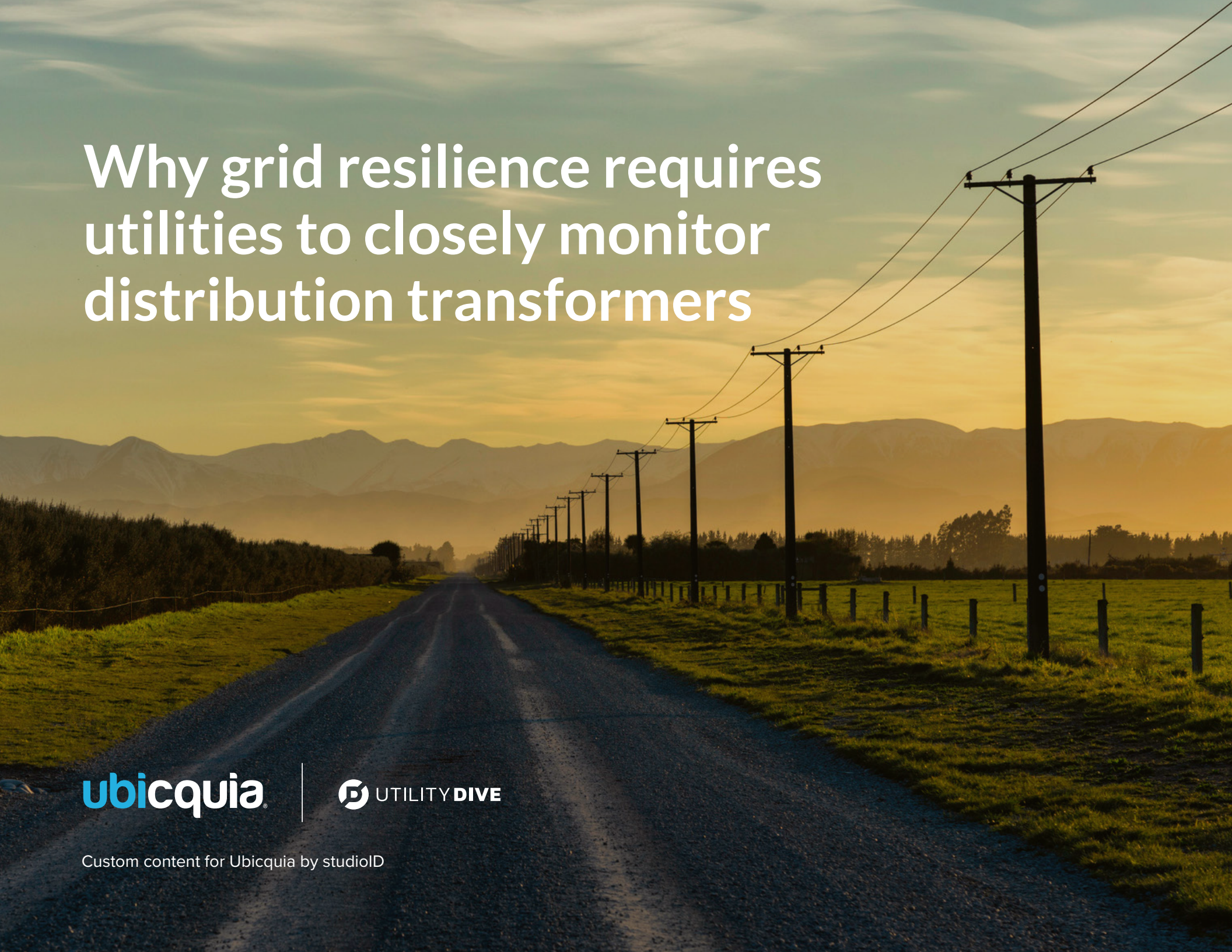
Why grid resilience requires utilities to closely monitor distribution transformers



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When Kevin Cornish first began his career in the utility industry in the mid-1980s, the collective attitude toward distribution transformers was pretty blasé. Cornish worked in a variety of positions in utility engineering and operations groups, and the hands-off attitude he observed made sense.

"They weren't monitored, and we did not have robust information to identify loading. The view was that going out and surveying all the transformers and identifying ones that might have problems wasn't worth the cost because we didn't have that many fail," said Cornish, now vice president, smart infrastructure, for Utilligent, a California-based consulting company that helps utilities deploy advanced enabling technologies. "Running them to failure was perceived as the best economic approach to managing normal distribution transformers."

In many ways, the same attitude about not needing to monitor distribution transformers still prevails. Yet much has changed in the intervening years to elevate the critical importance of real-time monitoring of distribution system transformers. Perhaps the biggest change comes from the fact that the United States, along with other countries, is depending on increased electrification to achieve ambitious decarbonization goals.

Indeed, states, cities, corporations and entire countries are embracing some version of the so-called “electrify everything” movement, which builds on the utility industry’s decarbonization success. For example, analysis by the Electric Power Research Institute (EPRI) found that the utility industry reduced carbon emissions 33% between 2005 and 2020.

The move to electrify everything from transportation to heating and cooling to a wide range of industrial operations has the potential to elevate society’s dependence on electricity. EPRI estimates that electricity’s share of end-use energy could rise from around 20% today to 33% in 2030 and reach 60% by 2050. As society increasingly relies on decarbonized electricity, the need for a resilient and reliable grid also escalates.

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Challenges to resilience rise along with dependence on electricity

But here's the challenge: As society increasingly depends on a resilient grid, the tools necessary to maintain grid reliability are not yet in place. In particular, utilities have little visibility into the health and condition of distribution grid assets, notably transformers. This is problematic for a wide variety of reasons. One is simply because America's grid is so old. The most recent infrastructure report card from the American Society of Civil Engineers gave the power system a C- grade, in large part because so many assets are 50-plus years old.

Age isn't the only reason utilities need to increasingly monitor distribution transformers. Extreme weather related to climate change is also on a dramatic upswing. According to the National Oceanic and Atmospheric Administration, 2021 had a record 20 weather and climate disasters whose overall losses exceeded $1 billion — including rampant wildfires across the Western U.S. and the polar vortex cold snap that overwhelmed the power grid in Texas.

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>
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> *vice president of sales for Ubicquia*

Increasingly frequent extreme weather is affecting grid outages. A recent Associated Press analysis of utility data submitted to the U.S. Department of Energy found that the number of outages related to severe weather more than doubled since the early 2000s — from about 50 each year to over 100 annually over the past five years. On average, U.S. customers experienced about eight hours of power outages in 2020.

At the same time, the distribution grid is adding unprecedented volume through distributed energy resources, including electric vehicles and rooftop solar. These assets can affect grid resilience through two-way power flows that introduce harmonic distortion and by overloading transformers when multiple EVs are charging at once.

“The grid was not designed for two-way power flows. So now you place these new energy resources at the grid edge, and they back feed into transformers, creating abrupt changes in the customer loads, and voltage and current anomalies that can damage the distribution transformers,” said Charlie Nobles, vice president of sales for Ubicquia, a technology company that works with utilities and cities to monitor infrastructure. “Factoring in the increasing stress on distribution transformers with the increased demand for electricity, demand for transformers is at an all-time high. But supply chain issues are making it hard to get new transformers.”

Why smart meters aren't enough

Taken together, these and other issues highlight the need to monitor distribution transformers for their actual utilization and stress. But it's important to remember that some of the advancements in grid modernization that have taken place over the past few years do not provide the kind of visibility into transformer health that is needed to maintain grid resilience.

The massive deployment of smart meters is one example. According to the U.S. Energy Information Administration, about 103 million smart meters had been installed across America by the end of 2020 — a number that has undoubtedly increased significantly in subsequent years. Smart meters are an important tool and provide critical insights about when and how customers use electricity. But predictive analytics extrapolated from smart meter data can only go so far. It's difficult to truly understand transformer health status before equipment failure.

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"You'll hear people talking about using meter data, which is intended primarily for billing, to predict the circuit loads and asset health further up the feeder towards the substation. But that's impossible to do with any accuracy," Nobles said. "You can't even get beyond the next transformer upstream from the meter before you lose all visibility. Meters alone can't provide the data you need to feed into these predictive analytics."

Another significant limitation of smart meter data is the time lag that occurs between the collection and communication of potentially actionable information. For instance, while many understand correctly that smart meter data is collected in 15-minute increments, fewer people know about how long it takes to actually transmit that information. In most cases, smart meter data is transmitted every four hours and is broken into 15-minute increments. The grid changes a lot from minute to minute, let alone over the course of four hours.

In fact, the reality is that utilities have great visibility at both the smart meter and the substation but very little insight into the vast territory in between, including transformers. That means that making decisions about transformer maintenance and health using meter data and predictive analytics requires a leap of faith. "We're extrapolating well beyond the actual data that we have ," Nobles said. "We have data at the substation, we have data at the meter, we have a relatively small number of switches and relays and devices with data. Then we have thousands and thousands of miles in between where nothing is monitored."

Transformer monitoring requires a robust network and the right sensor

Utilities understand the value of monitoring distribution transformers and the connection it has to grid resilience. They also grasp how continuous monitoring can save operations and maintenance (O&M) costs, bolster system average interruption duration index (SAIDI) scores and avoid unnecessary replacements of equipment that is functioning well. “There are a lot of old transformers out there, but that does not necessarily mean they’re in worse condition,” Cornish said. “Transformers can last a long time if they’re not overloaded for long periods and degrade the transformer internals.”

Direct monitoring of transformers allows utilities to shift toward condition-based maintenance that, in some cases, can extend the life of the asset and be capitalized rather than categorized as an O&M expense. Monitoring also empowers fast response when a transformer fails, which can limit the duration of an outage. Finally, monitoring provides utilities with data they need to make important planning and investment decisions. Given these and many other

benefits, the obvious question is, why aren't distribution transformers already monitored?

The main reason: The lack of a communications network to deliver real-time data to utilities about transformer health. Building a network specifically to monitor transformers would be extraordinarily expensive, particularly because so many transformers are in remote places.

But there is another alternative, one that is perhaps best understood by thinking about what happens when you try to use your cellphone in a location with little or no coverage. Even in those remote spots, the cellphone will still display the time and date because it can communicate with the cell tower, even if it's impossible to call or text someone. Existing LTE networks hold the key to effectively monitoring transformers in real time. "The LTE network is robust, it's secure, it's built out," Nobles said. "One of the biggest impediments to scaling monitoring of anything that is a disparate resource or asset out on the grid is the network needed to get real-time data. Public and private LTE provides that."

A robust, secure, low-cost network is critical for real-time transformer monitoring. But it also requires a sensor that measures the important parameters that will let a utility know when it's time to act to prevent or respond to an outage. Some monitoring solutions only track oil temperature and pressure in a transformer. Others only track the utilization of a transformer.

This is necessary but may not provide a full view of a transformer's current health or uncover signs that a failure could be coming. Ubicquia's UbiGrid DTM+ goes much further and also tracks kVA, voltage sags and swells, pole tilt and vibration, secondary current and voltage, and failed-transformer alerts. The UbiGrid DTM+ also provides information about the grid that isn't directly related to the transformer. The device delivers the benefits of a line sensor, with the ability to monitor grid faults, voltage and phase balancing.

This combination of a reliable and low-cost network with the capacity to measure and analyze the right metrics is new and unique. And in many ways, it's just the sort of advanced tool that utilities need to enhance reliability in a rapidly changing grid.

A solution built for a changing grid

Florida Power & Light (FPL) has been a pioneer in deploying technology to make its grid smarter, cleaner and more reliable. It's an approach that has achieved results. Since 2008, FPL has improved service reliability 32% and has now achieved 99.98% electric reliability. The company's smart grid investments have elevated its ability to detect, prevent and respond to outages and reduced its operating costs.

To achieve this high level of performance, FPL has worked with a variety of partners, including Ubicquia. In particular, Ubicquia teamed up with FPL to improve its monitoring of remote transformers and poles as a way to bolster its storm response and continue its move toward preventive, condition-based maintenance of its distribution system assets.

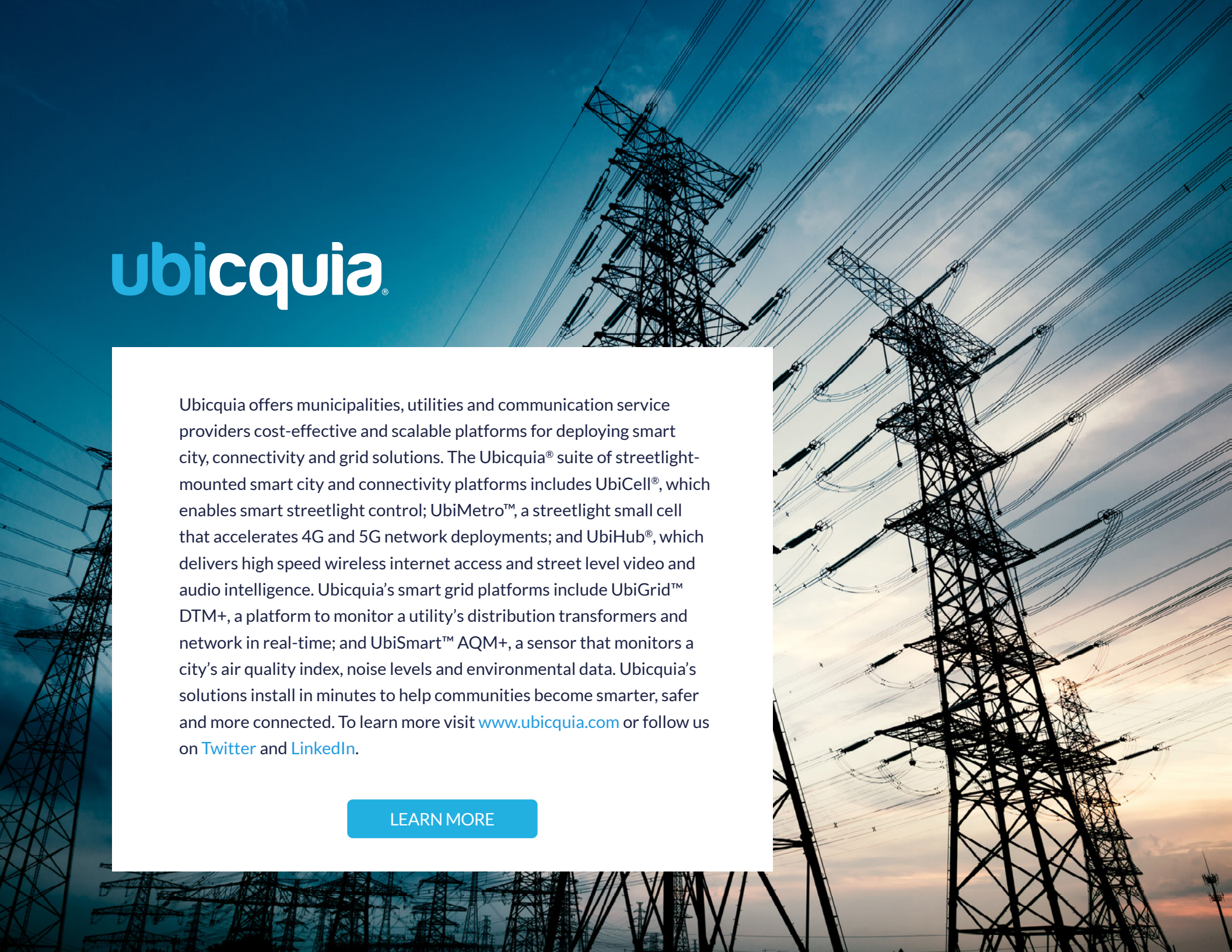
FPL wanted three things from any solution to monitor its 1.2 million distribution transformers. The utility required critical and holistic data about the health of its transformers; it demanded high-speed, secure and reliable communications to deliver that data; and it needed actionable insights to guide how FPL should respond when the data indicated a transformer failure or impending problem.

FPL collaborated with Ubicquia to develop the UbiGrid DTM+ and has since deployed it across its grid. The sensors are already delivering results. For one thing, because they leverage existing LTE networks, the sensors are easy to deploy. But they also help FPL enhance its storm response and make real progress toward condition-based maintenance. For example, real-time monitoring of transformer health reduces the number of times FPL has to send crews out to investigate whether there has been a failure.

The UbiGrid DTM+ can also help the utility identify transformers that may fail soon and replace them before they cause an outage. This is important both because it can improve FPL's SAIDI scores and because proactive transformer maintenance can qualify as capital rather than O&M expenses.

"When you run assets to failure and then replace them, that's all O&M costs," Nobles said. "But if you can take data about the asset and do things to extend the life of the asset, that can sometimes be capitalized. Everyone wants to migrate to condition-based maintenance. That's the end-game. But it requires transformer and circuit analytics based on real-time data sets."

That is exactly what utilities can get when they enable real-time monitoring of transformers via sophisticated sensors and reliable networks. It's the kind of solution a changing grid needs. "You have to have an industrial design that can cost-effectively measure those things that are important, that truly give you the health of the transformer. And you have to have a wireless network that brings that information back in real time," Nobles said. "The game has changed, and you need some tools to help you change effectively."



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