PREDICTIVE GRID MODELING AND CONTROL:

How Utilities Can Leverage AI to Dynamically Manage Complex Grids

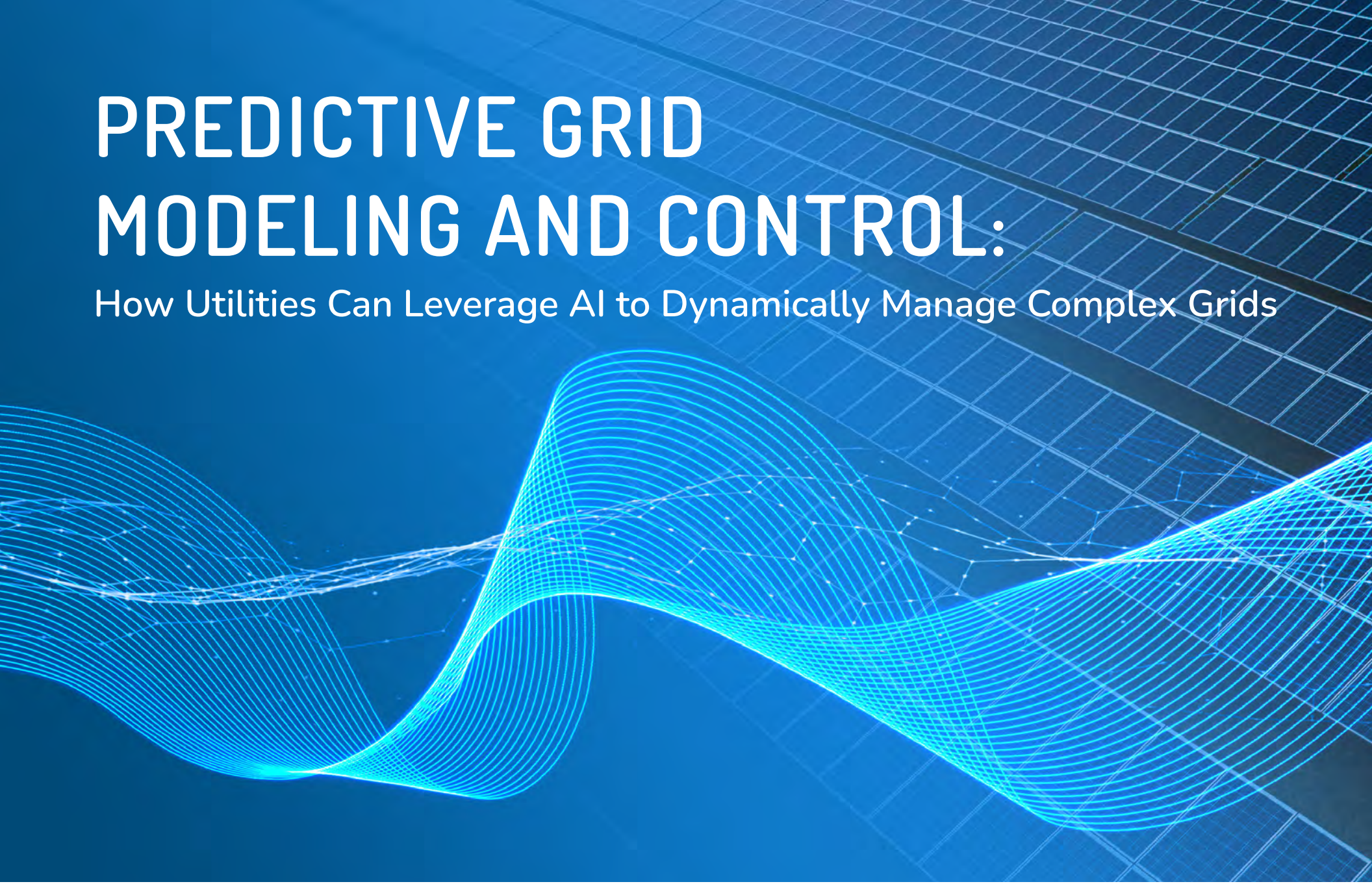

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TABLE OF CONTENTS

THE CHALLENGE: GRID COMPLEXITY

The long-term future of electric power systems will be highly distributed, decarbonized, dynamic and resilient. Distribution networks will rely more heavily on grid-connected and unpredictable renewable resources, energy storage and microgrids. Growth in electric vehicles (EVs) and building electrification will further multiply the variables affecting grid operations and asset management. With such exponential growth in power system complexity, utilities will find it increasingly challenging to maintain day-to-day reliability, as well as resilience to many types of grid disruptions.

To manage constant change and rising complexity, utilities must significantly improve their ability to see accurately into the very near future of the power grid. They will also need better tools for executing proactive, automatic, highly targeted grid control. Utilities must be able to quickly and accurately model everything that is happening on, and likely to impact, grid operations and asset management — both across the entire grid and at a fine level of local detail.

THE SOLUTION: ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) excels at solving this type of problem. By adding a layer of AI to existing distribution management system technology, utilities can vastly enhance their ability to manage complexity and adapt to change. This will enable utilities to become better prepared for extreme temperatures, severe weather events. It also can help utilities cope with sudden surges or drops in energy supply and demand that are becoming more common as more distributed clean energy resources are connected to the grid, in front of and behind the meter.

AI can prevent more outages and help accelerate outage recovery. Also, because AI is self-learning, grid predictions and control will improve with experience. As AI learns a utility's grid, it can suggest new strategies, efficiencies and opportunities for utility professionals to consider and implement.

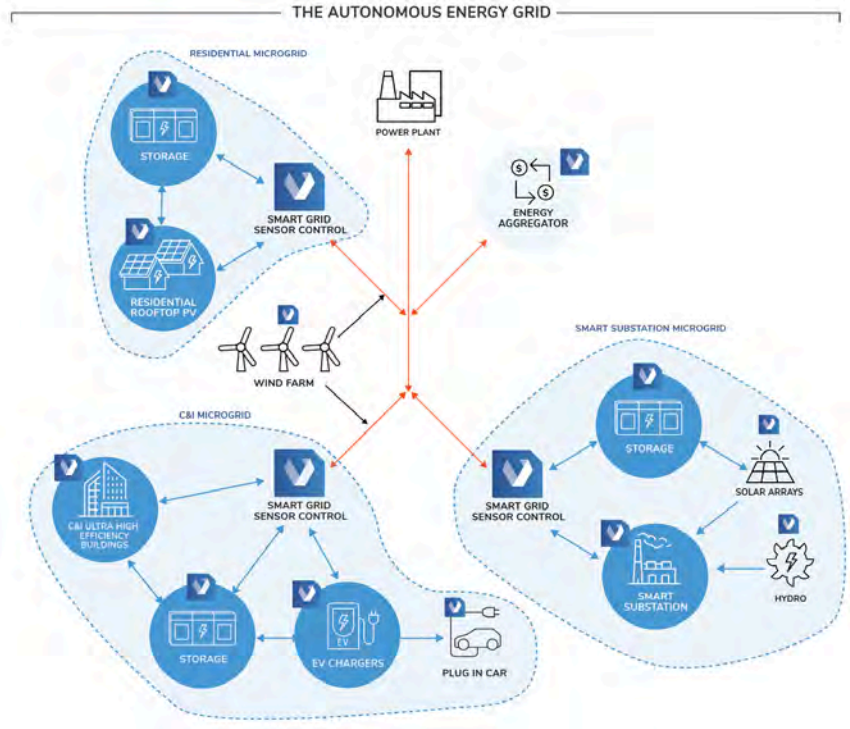
AN AI LAYER FOR ADMS

AI can help utilities keep a step ahead of ongoing system changes. This directly supports power system stability, efficiency and resilience — especially when AI can automatically execute at least some grid control actions in real time, within parameters determined by the utility.

Currently, even the most advanced distribution management systems (ADMS) exercise grid control that is primarily reactive; based on a complex set of if/then rules, and requiring at least some human intervention. “ADMS relies on good modeling capabilities, but overall most utilities still struggle to build an accurate, up-to-date model of their distribution network,” said Dr. Murali Baggu, laboratory program manager for the National Renewable Energy Laboratory (NREL). “Loads, supply and external conditions change moment by moment. There’s a huge opportunity to provide better grid intelligence and control based on data from sources on and outside the power grid.”

Baggu oversees ADMS research at NREL — including a new test bed where utilities, vendors and researchers can evaluate existing and emerging grid management applications in a realistic laboratory environment to support a confidence in new grid control technologies before deployment. The test bed can evaluate centralized and distributed grid functions, and an AI layer for ADMS would be considered a distributed functionality.

"An AI layer can offer a substantial leap beyond traditional rules-based ADMS," explained Al Brown, chief technology officer of engineering for Veritone Energy Solutions. "AI can monitor and track all dynamic conditions on the grid, and model scenarios and evaluate risks in real time. AI interprets context as well as conditions, such as how load and DER [distributed energy resource] patterns on a grid tend to vary by time of day or season. That is how AI makes very good predictions. AI adapts and applies predictive control to prevent problems. Even the best ADMS can only react to problems that have already begun to emerge on a grid."



AI CAN MONITOR ALL DYNAMIC CONDITIONS ON THE GRID

AI FOR GRID RESILIENCE IN REAL TIME

Accurately predicting, modeling and adapting to conditions across the grid in near-real time is the foundation of effective grid resilience — especially as the impacts of climate change, new loads and power resources proliferate on and around power grids. Thus, augmenting existing distribution management tools with an AI layer can be an important investment in a top operational and business priority for utilities: grid resilience. Insights from AI can inform and target storm mobilization, vegetation management, spinning reserve use, energy storage charging and discharging, demand response programs, bulk power transfers, decisions about when microgrids should disconnect and reconnect to the utility grid and more.

Modern grid resilience depends on how well and how fast a utility can manage vast quantities of data, communicate in near-real time with devices at the grid edge, and execute actions that proactively address changing conditions. For instance, Veritone's AI grid-management tool constantly pumps highly granular weather data into its grid modeling. This allows the AI to see an extreme event coming, and strategize for backup power.

AI-CONTROLLED MICROGRIDS FOR RESILIENCE

"Our system can pretty accurately see a temperature spike coming at a particular time of day and then proactively max out battery storage capacity on the grid — either on its own or it can suggest this to utility staff, depending on the utility's risk tolerance," said Sean McEvoy, senior vice president at Veritone. "Then, when everyone comes home in the evening and switches on air conditioning, the utility can be ready — without needing to spin up diesel- or gas-fired peaker plants."

Microgrids are an increasingly common resilience feature of power systems. These may be created and operated by a utility (to maintain power to remote communities or critical facilities during a storm or disaster) or by local governments, large customers or other third parties to meet resilience and sustainability goals.

A microgrid can enter "island mode" (operating independently of the utility grid) to maintain local reliability and relieve grid stress, and then reconnect under favorable conditions. However, timing and managing these disconnections and reconnections is a delicate process; discrepancies in voltage levels and other factors can exacerbate grid problems. "AI can monitor and manage all the variables, so the microgrid and utility grid are both synched up to smoothly and gradually bring a microgrid off the main grid, and bring it back on," said McEvoy. "That reduces stress to the grid, as well as to microgrid assets. The last thing you want to do when recovering from an outage is to cause another outage."

AI RESOURCES FOR UTILITIES

The IT expertise and infrastructure needed to support robust AI is not a typical utility core competency. Fortunately, organizations with considerable experience in developing AI solutions and applying them to power systems can become key partners in grid resilience, and deliver this value to utilities via cloud-computing services.

For instance, in 2020 Argonne National Laboratory developed a neural network model that combines static and dynamic power system features in a single decision-making model, which vastly improved the accuracy of grid operational decisions. Historically, including both dynamic and static formulations in the same power grid model created problems that were essentially impossible to solve. Consequently, power system analysts either modeled static and dynamic grid features separately, or they used highly simplified models. The results of either approach largely fell short of the accuracy that utilities require. Argonne's new model can help utilities understand how to better control power systems with help from AI.

AI FOR PREDICTIVE DEVICE LEARNING AND CONTROL

Leading vendors are also innovating digital tools and partnering with utilities on grid resilience. For instance, Veritone's aiWARE Cooperative Distributed Interference (CDI) technology was designed to make complex, real-time decisions for grid forecasting, optimization and device control. This AI backbone can handle vast amounts of heterogeneous and distributed information, comprising millions of variables and hundreds of thousands of constraints — while constantly learning how grid conditions are changing, and aligning grid decisions with business priorities and operational requirements. Veritone models and learns device states for all energy resources at a plant or across grids, and synchronizes them to continuously balance supply and demand. In this way, Veritone learns from all of the energy organizations that use its technology, leveraging a broader and deeper understanding of best grid resilience practices across the industry.

In general, current ADMS technology has limited ability to learn from experience, which can make it slower to adapt to change. "A typical ADMS can do a reasonably good job of forecasting loads on a regular basis, but that's not the same thing," said Baggu. "There's a great need for true self-learning systems, as power systems become more complex and dynamic especially in the presence of DER. There's a huge pool of existing data, especially from smart metering infrastructure, that could be connected, analyzed and learned from. ADMS can implement guidance from smart systems that have learned how to handle new kinds of disruptions well."

AI CAN SYNCHRONIZE DERS

Vertione's AI backbone is complemented by robust, real-time communications with devices at the grid edge and also with devices behind the meter and third-party resources connected to utility grids. This communication can leverage an existing ADMS, and also reach beyond it.

"Grid-edge communication is the key to navigating grid disruptions, without needing to install lots of extra sensors or controls," Brown explained. "For instance, say a utility has a large battery system, and a large unexpected demand spike happens. By itself, the controller for the battery can only optimize the response from that battery, often directed by an ADMS. However, when AI is watching all resources across the entire grid, it can marshal other DERs in response, to ride out the spike. Experienced utility professionals might decide to take the same actions, but they cannot accomplish that automatically, in a few seconds or less."

Utility funding for digital tools such as AI can be challenging. Advanced digital tools, including AI solutions, have been widely deemed by regulators to be operational expenditures, which are granted rate recovery less frequently than traditional capital expenditures (equipment or facilities). Across the utility industry, this has hindered the deployment of advanced digital tools that are systemic rather than tied to a specific capital investment or project.

AI GRID SIMULATION OF BENEFITS

However, regulatory perspectives are shifting on digital tools for utilities. Climate change is driving policymakers to issue tougher mandates to reduce carbon emissions from power systems, and to encourage regulators to be more open-minded about approving utility investments that will increase resilience to the impacts of climate change. A flexible, scalable, self-learning resource like AI for grid intelligence and management can serve both of these goals — as long as utilities can prove to regulators that it would succeed in making utility operations greener as well as more resilient.

"Our system includes a simulator that can work with real data from a utility to create a model, suggest control recommendations, and calculate the difference that applying AI would make compared to the utility's existing technology," said McEvoy. "This gives the utility something to show to their executives and board, and also to include as supporting documentation in rate cases. When you can show how it would make a difference in real situations, that can help regulators understand why this is an investment in the future of the grid, to the benefit of ratepayers and the public at large."

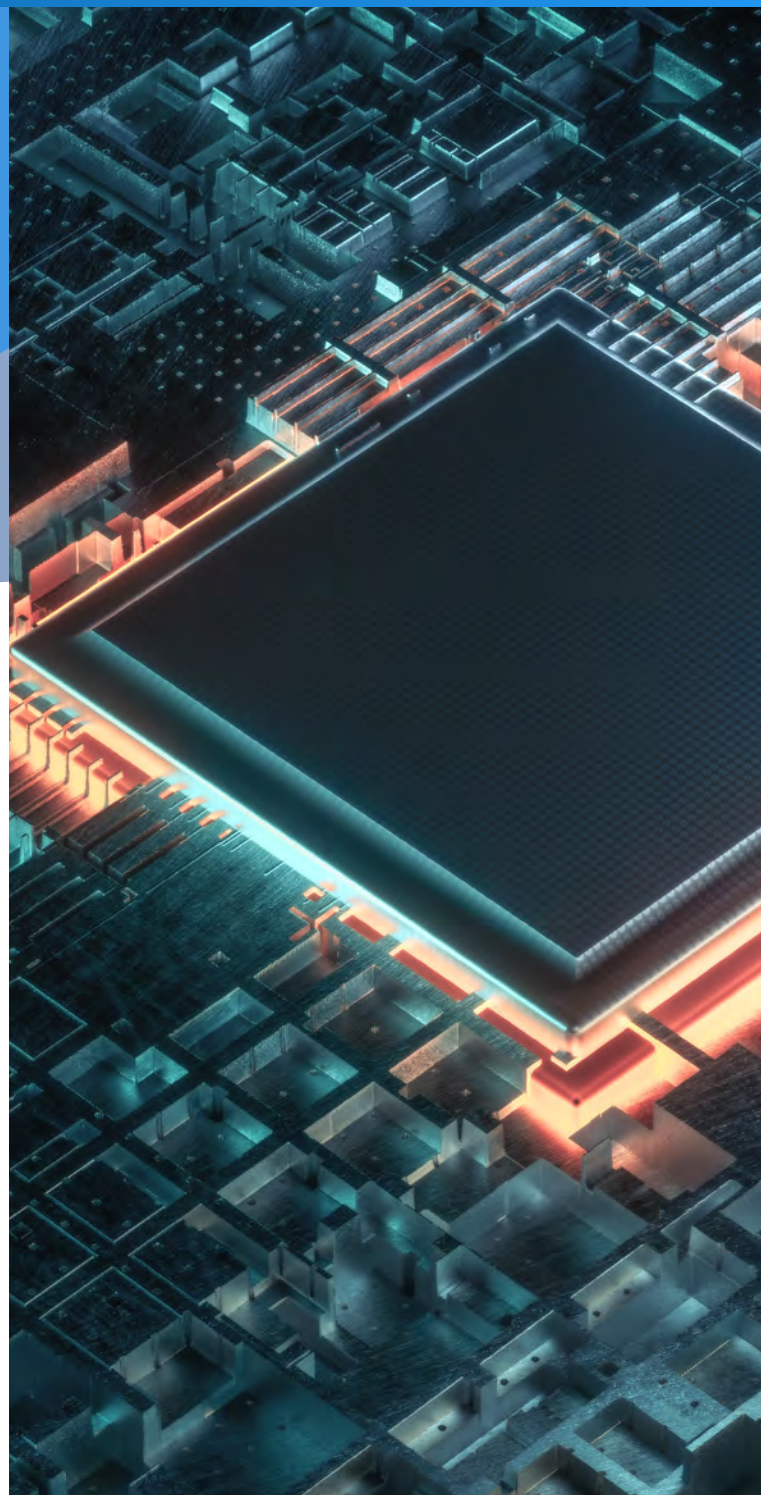
AI FOR DYNAMIC GRID MODELING

Ultimately, artificial intelligence can help utilities do more than navigate disruption and maintain reliability. It can also help utilities unlock new grid opportunities. “There is immense potential for AI to inform long-term planning for their power grid,” said Baggu. “Particularly with being strategic about how, where and when they add new DERs to the grid and how they design and manage demand response programs. Algorithms can surface the best opportunities based on real data that changes fast.”

For example, the EV share of the car market is likely to balloon in the next few years. This represents a big change for power grids and a potential new revenue stream for utilities. However, utilities and regulators will need large quantities of good data to make informed decisions about EV infrastructure and tariffs. The parameters for these models are still emerging.

Baggu envisions that power grids may eventually evolve from static model-based control (essentially, a picture of the network where key variables are mostly known) to dynamic modeling and control. Baggu describes this as, “taking data dynamically from the grid and using that data to inform changes to the model’s parameters.” He goes on to say, “We could handle modeling much more dynamically, and that would more accurately reflect the reality of the power system.”

AI CAN DELIVER NEW VALUE STREAMS TO UTILITIES



This approach to power-system planning might help the utility more easily embrace big change. For instance, many utilities have traditionally viewed microgrids primarily as a potential loss of load and revenue, rather than as a strategic resource or service that they could offer to customers. “More microgrids are coming, and it’s probably better for utilities to get out in front of this and manage that transition,” said Brown.

AI can help clarify the value that new resources, from microgrids to EVs and more, can bring to a utility. Right now, many utilities are struggling to evolve their business model. Insight from AI-augmented grid intelligence and control systems can show utilities what’s coming, contribute to grid resilience, and offer options that can lead to innovative strategies for both power systems and the utility business.

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ABOUT VERITONE

Veritone is accelerating the world's transition to more sustainable, reliable, and affordable energy. Our customers include utilities, independent power producers, and developers who use our software to optimize, synchronize, and intelligently control macro and micro grids. Veritone Energy Solutions use patented AI technology and the Veritone aiWARE operating system for AI to make clean energy more predictable, cost effective and resilient, accelerating the mission to end global dependence on fossil fuels. Veritone's patented, real-time dynamic modeling and predictive device control enables autonomous microgrid management, optimizing smart grid energy distribution by continuously knowing how much energy to deliver from which asset. This ground-breaking technology ensures consistent, cost-effective clean energy during normal operations and grid resilience in the face of the unexpected.

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