Abstract

How can stakeholders in the electric power industry enhance grid resilience, more rapidly decarbonize, and significantly improve the affordability of delivered electricity?

This white paper describes five artificial intelligence-powered solutions that deliver these benefits. AI can process vast amounts of data, perform predictive grid modeling and dynamic grid control, and facilitate autonomous grid management. With AI, utilities, independent power producers, and developers can efficiently route energy like data to where it is needed most, from any energy source. The paper illustrates how AI applied to grid management holds the key to a cleaner, more reliable and efficient grid.

The paper concludes with a vision of the future of energy: "Inter-energy." In this new world, Veritone’s AI technology powers an interconnected, on-demand, secure, green, and autonomous electrical grid.
ENERGY CHALLENGES

Electric Power Resilience to Wildfires and Extreme Weather

The electric power industry worldwide faces a significant challenge to enhance resilience to wildfires, extreme weather, and other threats. To help address this challenge, the industry applies solutions such as:

- Improved vegetation management
- Selective Transmission and distribution undergrounding
- Hardened central station power generation
- Modified operating procedures
- Early detection of wildfires
- Planned outages in high wildfire risk areas
- Expanded local weather data gathering and forecasting
- Training and drills
- Improved storm response practices
- Elevated substations

These resilience solutions can help address the near-term effects of global climate change [1,2].

Decarbonization

While industry leaders address the resilience challenge, many of them are simultaneously taking on a second challenge – decarbonization. Utilities and independent power producers typically do this by working towards emission of less carbon in power generation, through the deployment of distributed, renewable clean energy resources. At the same time, equipment providers deliver solutions that support these measures. The fundamental premise underlying this work, as well as the Paris Agreement within the United Nations Framework Convention on Climate Change (UNFCCC), is that reducing emissions of carbon (i.e., decarbonizing) will ultimately address the underlying causes of global climate change.

Affordability of Electricity

A third challenge that most all entities in the electric power industry also tackle is cost containment. As electricity rates rise across the US and internationally, electric utilities seek to find ways of minimizing the cost of electricity production. This applies to peak consumption periods, when incremental costs can skyrocket due to extremely hot or cold weather, or untimely, unplanned outages. However, cost reduction also applies to everyday “blue sky” operation. For example, in many areas, grid operators are forced to curtail or dump energy from clean renewable resources due to excess supply, which can increase production costs.

At the same time, independent power producers seek to deliver power to the grid at least cost to remain competitive. Further, equipment providers need to deliver cost-competitive solutions to support these efforts.
IS ARTIFICIAL INTELLIGENCE THE ANSWER?

This discussion of electric power resilience to wildfires and extreme weather, decarbonization, and electricity affordability begs the following question:

Can Artificial Intelligence help address these challenges?

The answer is a resounding “yes.” Artificial intelligence (AI) can:

• Enhance grid resilience to extreme weather and/or wildfires
• Make possible the mass deployment of clean energy to reduce carbon combustion and emissions
• Reduce the cost of everyday provision of electric power to electricity users

AI delivers benefits across multiple aspects of energy generation and management, including:

• Distributed Renewable Generation
• Distributed Electricity Storage
• Electric Vehicles
• Demand Response
• Microgrids

MANAGING THE GRID WITH AI

Distributed Renewable Generation

Distributed renewable generation, such as rooftop solar (photovoltaics, PV), has transformed the grid of today. It’s easy to understand why. Utility customers with hardened PV systems are more resilient because they can continue to generate power to meet a portion of the electric load for their home or business during lengthy power outages (assuming their PV system is undamaged and the sun shines). PV decarbonizes because it can displace combustion of fossil fuels. With the rise of the power purchase agreement business model for PV systems, residential electricity users can save up to 50 percent annually on their electric bill.

However, distributed renewable generation brings its own set of challenges due to its inherent intermittence. Variable, difficult-to-predict local cloud cover and wind speed causes distributed solar and wind capacity to fluctuate in real time. This complicates short-term dispatch and energy trading of these resources, and can cause grid congestion and require curtailment during periods of over-generation of these resources. The amount of data that needs to be processed in real-time to effectively address the intermittency of distributed renewables is overwhelming. No human being could do it. But AI is uniquely suited to this task. Properly designed and calibrated AI-based solutions can:

• Process this vast amount of data in real-time
• Generate continuously-updated and optimized predictive models of weather, electricity supply and demand, and pricing
• Control and synchronize grid and end-user devices and distributed resources in real-time
• Enable arbitrage through predictive energy purchase, sales, and dispatch in real-time, hour-ahead, and day-ahead power markets
For example, AI can lessen the impact of the intermittency of solar generation via intelligent solar smoothing solutions. Weather and demand forecasting combined with predictive device control can smooth the transition between local solar power generation, the grid or microgrid, and end-use energy devices. This can enhance grid and device response to fluctuations in solar generation.

**Distributed Electricity Storage**

A second solution is distributed electricity storage (DES), or battery storage. Although not yet economical in many areas, the number of DES implementations is growing. DES can further enhance PV’s resilience value by storing energy for a few hours, facilitating use of the solar power gathered when needed. DES decarbonizes by further extending the practical use of fossil-fuel-displacing PV and easing the limitations of PV’s intermittent nature. Now economical in high peak load areas (e.g., arid climates), battery storage can help residential and commercial end-users reduce electricity costs.

AI can help optimally operate, control, and dispatch distributed electricity storage in concert with other grid and microgrid resources. Also, AI solutions can optimize the control of individual battery energy systems. Using real-time load and market data, an AI-based intelligent controller can optimize battery performance, maintain battery health, extend battery life, and optimize battery/inverter system operation. An additional benefit to the main grid (and the battery owner) is maximized ancillary services revenue where ancillary services markets exist, including VAR control, frequency control, and others.

**Electric Vehicles**

Electric vehicles (EVs) aid resilience by providing a home or business a mobile rechargeable electricity storage device (i.e., provides “vehicle-to-building” [V2B] resilience) that replaces or augments DES. During an extended power outage, in some situations, homeowners and business owners may be able to drive their EVs to undisrupted areas, recharge them, and return to their home or business to power their critical loads for a period of time, increasing resilience. An individual EV can provide enough energy to power an average home for two days [3,4].

Electric transportation decarbonizes by displacing gasoline and diesel-fuel-consuming vehicles, assuming that the electricity generated to power them uses non-carbon emitting resources. EVs can build load for electric utilities, enabling reduced curtailment of renewable resources.

As they proliferate, EVs provide a growing and largely untapped pooled resource that can provide vehicle-to-grid (V2G) services, such as voltage regulation, demand response, and more, potentially as part of a virtual power plant. In the future, this pooled resource may also facilitate energy arbitrage via vehicle-to-market (V2M) services. However, V2B, V2G, and V2M management and control present complex challenges. Due to their dual role for transportation and local distributed storage purposes, EV batteries require specialized algorithms for dispatch, control, and arbitrage, as well as incorporation of user choice in real-time. Because EVs may remain stationary, they become an intermittent storage resource themselves.
AI-based solutions are particularly well suited to this complex environment by constantly forecasting load, intermittency of generation, grid needs, real-time electricity prices, opportunities for electricity sales, and EV availability (magnitude and location) based on analysis of customer vehicle-use patterns. AI can perform these functions for each specific geographical area, thereby accounting for local variability of all of these parameters. This analysis can identify optimal time “windows” for EV charging and discharging to balance these factors – maximizing customer economic benefit while meeting load and grid needs.

**Demand Response**

Demand response aids resilience by reducing stress on the grid (or microgrid) during extreme events; it can reduce peak demand, which often occurs during extreme events. It can decarbonize via “automated emission reduction” (AER), according to nonprofit WattTime. AER enables online end-use appliances and devices to reduce emissions using real-time grid or microgrid data on plant emissions and online control of these devices. In everyday operation, demand response smooths electricity consumption peaks, potentially reducing costs [5].

AI can optimize demand response by synchronizing and intelligently controlling residential and commercial Behind-the-Meter DER (including generation and storage), as well as smart sensors. AI solutions do this by continuously gathering and synthesizing large amounts of electricity price, supply, and load data to facilitate timely decisions on optimal allocation of these resources.

**Microgrids**

Microgrids integrate the previous four solutions, incorporating distributed renewable generation, DES, EVs, and demand response. Microgrids can operate independent of the main grid (i.e., in “islanding mode”) during extreme events. They decarbonize via their incorporation of clean energy. Moreover, owner/operators of many of the over 2,000 microgrids operating in the US alone (primarily college campuses, industrial end-users, and military bases) realize cost benefits from their operation.

Microgrids are also a promising community-level solution, consolidating distributed, decarbonizing technologies into local grids. Community microgrids can extend resilience and decarbonization to the neighborhood level [6,7,8].

However, microgrids are only as good as their energy management and control systems. To maximize the resilience, decarbonization, and economic benefits of an autonomous grid system such as a microgrid, optimization of real-time operation is needed. Not surprisingly, AI is well suited to this application. It can provide active, real-time synchronization and control of microgrid resources, including PV, DES, EVs, and other DER.

Microgrids also provide an opportunity for beneficial energy arbitrage, which can increase the affordability of microgrids, reduce net electricity costs, and benefit both the microgrid and the main grid. Here again, AI is a crucial enabler. AI systems can optimally model, control, and dispatch individual devices and resources in ways that can optimize energy sharing and trading between individual connected microgrids, as well as between microgrids and the main grid. This can improve the stability, reliability, resilience, affordability, and energy efficiency of the entire electric power system.
AI APPLICATIONS

AI-controlled distributed renewable generation, distributed electricity storage, electric vehicles, demand response, and microgrids can provide:

• “Black sky” benefits (via enhanced extreme weather or wildfire resilience) and
• “Blue sky” benefits (via operational advantages and enhanced affordability) and
• “Future sky” benefits (via decarbonization that will benefit society in the future)

If equipment and service providers incorporate these solutions – enabled by appropriate AI technology – into their offerings for electric utility and independent power producer implementation, the entire industry ecosystem benefits.

Consider the following key areas where Veritone AI offers important benefits: islanded microgrids, virtual power plants, building smart sensors, and electric vehicles.

Grid Resilience: Islanded Microgrids

With Veritone Energy Solutions, communities, businesses, independent power providers, and government agencies such as the U.S. Department of Defense can utilize AI to enhance clean energy predictability and microgrid resilience during extreme weather or cyberattack events. These solutions can help to ensure that islanded microgrids continue to operate autonomously. Multiple microgrids can be synchronized and controlled, further enhancing autonomous operation if one microgrid fails.

Moreover, AI-based control of the microgrid can address other challenges, such as energy waste from curtailment or dumping of solar and wind power when consumer demand is low. AI-based controllers can efficiently route this excess clean energy to charge storage resources, pre-cool buildings, etc.

Virtual Power Plants (VPP): Solar and Storage

AI will do for energy what the internet did for personal computing: energy on demand, sourced from anywhere, and always accessible. A Veritone-powered Virtual Power Plant makes this vision a reality. In a VPP application, the energy from crowd-sourced decentralized resources (e.g., rooftop solar, distributed storage, and EV battery storage) can be aggregated across a community. In this arrangement, the AI-based controller sends energy dispatch instructions to individual customers, or transfers excess battery energy back to the main grid.

VPP participants can access and share energy from all of these resources, including wherever their EV is connected (e.g., home or work). This approach helps ensure reliable energy delivery at the lowest possible customer cost.

Buildings: Smart Sensors

Using smart sensors, Veritone Energy Solutions can capture and analyze data on key performance indicators, such as energy use and renewable utilization in commercial buildings and military bases. Using temperature sensors located inside and outside each building, the AI solutions can control heating, ventilating, and air conditioning devices to improve equipment efficiency and lower overall building energy consumption.
Electric Vehicles: Grid-Connected and Managed

Electric vehicle charging stations are emerging everywhere. Veritone Energy Solutions can optimize supply to these charging stations to satisfy peak demand, and re-route that supply back to the grid during off-peak hours. EV charging stations provide a two-way energy flow that only AI can effectively automation and optimize.

VERITONE ENERGY CAN HELP

Veritone harnesses the power of AI to predict, manage and control today's dynamic and decentralized electrical grids. Veritone Energy Solutions consist of AI software that predicts required energy generation, optimizes dispatch scheduling, and controls energy sources individually and collectively. With Veritone Energy Solutions, utilities and other power producers can optimize, synchronize, and intelligently control the energy grid, using predictive AI to make clean energy more predictable and efficient, cost-effective, safe, and resilient.

A city’s main grid can be divided into micro and nano grids, interconnected and synchronized with Veritone for optimal performance and resilience. Distributed AI agents ensure optimal economic dispatch of energy between multiple DERs (for example, batteries, solar inverters, and wind turbines) in a microgrid, allowing for autonomous, continuous operation in an emergency. Veritone’s overall system model knows the state of each asset under control within that system.

In a weather emergency or cyberattack, microgrids can be islanded and operated autonomously using Veritone. Grid resilience is assured as Veritone fuses together data from real-time weather and load forecasting, economics, NERC/FERC compliance rules, and real-time grid learning to deliver optimal grid management and predictive control within and between grids. With AI controlling the grid, everyone always has the power they need, and total blackouts can be prevented.

Veritone's patented Cooperative Distributed Inferencing (CDI) technology forms the backbone of Veritone Energy Solutions, delivering real-time dynamic modeling and control that ensures predictable energy distribution and resilience across the grid. CDI self-learns and adapts to ensure all energy devices in a microgrid, such as solar and battery power, deliver consistent, cost-effective energy at peak demand times and continue to operate autonomously if isolated from the main grid.

Use cases for Veritone Energy Solutions include:

Utility Companies
- VAR control
- Frequency control
- Optimal economic dispatch
- Renewable inverter output smoothing
- Load demand and renewable forecasting
- Fault and anomaly detection
- Distribution state estimation
- Conversion through voltage reduction (CVR)

Smart Grid / Micro Grid
- Optimal scheduling and dispatch of DERs
- Device/system level synchronization
- Volt/volt-ampere reactive optimization (VVO)
- Peak demand management
- Integration, modeling, aggregation, monitoring and control of DERs
- DER forecasting

Equipment Providers
- Device protection
- Thermal overage protection
- Equipment transients protection
- Intelligent device control

Independent Operators
- Arbitrage (including price forecast)
- Demand response
- Baseline computation
- Community optimal dispatch
REALIZE THE FUTURE OF ENERGY

Looking ahead, Veritone believes the future of energy is “Inter-energy:” Interconnected green generation and storage assets supplying energy on-demand across autonomous energy microgrids.

Veritone’s AI technology will make possible an interconnected, on-demand, secure, green, and autonomous electrical grid. In this new world, anyone can get the power they need when they need it—whether in their home, their workplace, or their EV—and the electrical grid is now fully autonomous, controlled and optimized by Veritone AI. This new grid will use plug-and-play renewable energy and storage assets with embedded synchronized controllers to move energy between grid participants, dynamically adjusting as demand, supply, pricing, and weather conditions change.

TO LEARN MORE:
Reduce energy consumption and cost while improving grid performance and resilience as you make the transition to renewables. For more information, visit veritone.com/energy

REFERENCES
ABOUT VERITONE

Veritone (Nasdaq: VERI) is a leading provider of AI technology and solutions. The company’s proprietary operating system, aiWARE™ powers a diverse set of AI applications and intelligent process automation solutions that are transforming both commercial and government organizations. aiWARE orchestrates an expanding ecosystem of machine learning models to transform audio, video, and other data sources into actionable intelligence. The company’s AI developer tools enable its customers and partners to easily develop and deploy custom applications that leverage the power of AI to dramatically improve operational efficiency and unlock untapped opportunities. Veritone is headquartered in Denver, Colorado, and has offices in California, London, and New York. To learn more, visit veritone.com/energy.