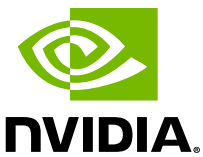
INDUSTRY BRIEF

TOP AI USE CASES FOR UTILITIES COMPANIES



Energy executives face major challenges with autonomous operations, decarbonization, and decentralization due to the shift away from legacy, single points of power generation. This infrastructure is being replaced with distributed clean energy resources, such as wind farms, solar, home batteries, and electric vehicles.

A software-defined grid is needed to manage the complexity of modern grids. Using AI at the edge and high-performance computing (HPC) in the data center, utilities can simulate real-time power flow on the grid, identify potential outages, and dynamically manage distributed energy resources. In this industry brief, we'll cover the top AI use cases for utilities, from power generation, transmission, and distribution to the edge of the grid.

AUTOMATING POWER GENERATIONS

> Industrial Digital Twins

In 2021, the U.S. generated approximately 4,115 terawatt hours (TWh) of electricity, nearly all of which was sold to and used by the residential, commercial, and industrial sectors.[1] Major consumption of electricity includes heating and cooling, refrigeration, lighting, and industrial machinery. Power plant maintenance is critical to ensuring reliable electricity generation, and unplanned downtimes can result in significant monetary losses.

To minimize maintenance disruptions, energy companies are building industrial digital twins of real-world power generation sites. Siemens Energy, a global energy technology provider, created a virtual replica of their heat recovery steam generator (HRSG) using a physics-based machine learning framework and 3D design simulation platform. By accurately and efficiently predicting corrosion with a digital twin, the company estimates utilities could save $1.7 billion annually by reducing inspections and cutting downtime by 10 percent.

Siemens Gamesa is using a digital twin platform for scientific computing to model their offshore wind farms, which generate over 100 gigawatts of energy each year. With a physics-informed digital twin, the renewable energy company is able to simulate wake effects from wind turbines up to 4,000X faster with high accuracy and fidelity. This enables quicker calculations to optimize wind farm layouts, increasing overall production while reducing loads and operating costs.

Energy companies are building physically accurate industrial digital twins to reduce unplanned downtimes through predictive maintenance.

"We're taking 2D drawings of HRSGs, complementing with 3D data, incorporating external variables like temperature and operating conditions, and identifying which parts need to be replaced. That means we don't have to do destructive testing by cutting into the system for 15 days, reducing outage time by 70 percent."

— **Laura Anderson,** Senior Vice President of Controls and Digitalization, Siemens Energy

[1] U.S. Energy Information Administration, Table 7.2a, Electricity Net Generation: Total (All Sectors)

Worley, a leading engineering firm, leveraged Aspen Technology's AI-driven Aspen OptiPlant to develop a 3D conceptual layout of the Gigastack Green Hydrogen project at the Humber UK refinery. Green hydrogen is produced using electrolysis with sustainable processes and used to power industrial plants. Team members from ITM Power, Ørsted, Phillips 66, Worley, and Element Energy carried out remote 3D design collaboration with physically accurate simulations. This is the first industrial-scale green hydrogen project, which would accelerate the UK's net-zero emissions goals and create a framework for successful green hydrogen operations around the world.

> **Autonomous Operations**

Power plants require extensive monitoring for both efficiency and safety. Onsite personnel conduct hundreds of unique activities during walkthroughs. Liquid, steam, or oil leakages left unnoticed can lead to catastrophic accidents, threaten worker safety, and cost millions of dollars in repairs. The energy industry is also experiencing a shortage of workers, which is expected to increase for geographies with declining populations and aging workforces.

Real-time inference at the edge is needed to automate manual plant inspections. Autonomous operations have several building blocks: cybersecurity, edge analytics, visualization, AI, cameras, and sensors. Siemens Energy is developing and deploying AI models with high inference throughput and scalability to help power plant operators manage their facilities. The open-source inference software meets multi-framework and multi-model requirements for unstructured data, including images, video, and audio.

"The first step is process simulation in 2D. From there, we build a 3D digital twin of the industrial facility. From 3D, the next dimension is scheduling, such as construction schedule or time to market. Then, the next dimension is cost estimation. After that, you enter the sixth dimension of sustainability: energy efficiency and emissions. The seventh dimension is operations and maintenance. There's a newly emerging eighth dimension around safety and health to meet OSHA requirements."

— **Sonali Singh,** Vice President of Product Management, Aspen Technology

OPTIMIZING TRANSMISSION AND DISTRIBUTION

> **Power Grid Simulation**

Contingency analysis and coordinating outage scheduling of substations, generators, transformers, and other assets are critical for utilities to increase resiliency and perform routine maintenance with minimal impact to their customers. Existing electric power system modeling tools, however, use legacy systems that lack accelerated computing to simulate the grid.

Electric Power Research Institute (EPRI), a leading independent, non-profit energy research and development organization, is working with NVIDIA to build digital tools that schedule outages and minimize downtime. Using AI and HPC, utilities can model the electric grid as a connected graph with structures and buses as "nodes" and transmission lines and transformers as "edges." These models are then used to simulate specific grid outages and address emerging challenges with variable renewable energy, distributed energy resources, and shifting power flow patterns.

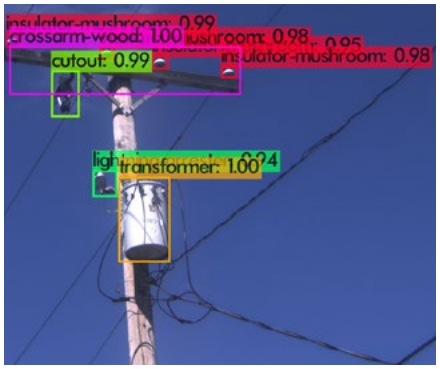
"AI will play a crucial role maintaining stability for an electric grid that's becoming exponentially more complex with large numbers of low-capacity, variable-generation sources like wind and solar coming online and two-way power flowing into and out of houses."

— **Jeremy Renshaw,** Senior Program Manager, EPRI

> Automated Asset Inspection and Vegetation Management

With nearly 185 million poles in the United States, utilities are challenged to maintain a complex ecosystem of field equipment that's critical to reliable energy delivery. Edge AI gives utilities localized insights to monitor the health of their transmission and distribution equipment in real time. AI can also analyze local aerial imagery, lidar data, satellite imagery, and weather data to identify potential vegetation threats to power lines before damage occurs.

Noteworthy AI is using AI-enabled systems to capture and scan images of utility poles and pole-mounted equipment for potential damage that requires repairs or overgrown vegetation that poses a wildfire risk. The startup built, trained, and deployed seven AI models to identify and analyze high-resolution imagery of utility equipment and scaled their image database by 5X in 30 days.



Edge AI can analyze millions of utility poles and pole-mounted equipment for potential damages and signal utilities for repairs, enhancing grid resiliency. Image courtesy of Noteworthy AI

> Substation Safety and Security

IronYun, an AI startup, is streamlining asset inspection in electric substations. Their platform monitors thousands of simultaneous live video feeds and includes the ability to search days or weeks of video footage in seconds. The startup uses intelligent video analytics for safety and security, monitoring substation perimeter access, preventing unauthorized intrusions, and ensuring workers follow protocols.

> Utility Truck Fleet Optimization

During outages and extreme weather events, utilities are expected to quickly and efficiently deploy fleets of trucks to restore power to residents and businesses. When you have hundreds of assets spread over a large geographic territory and limited trucks to roll, choosing when and where to send trucks is a very difficult optimization problem. For example, route planning for only 10 destinations has more than 3 million roundtrip permutations and combinations. With 15 destinations, the total number of possible orderings exceeds a trillion.

Utilities are exploring using AI to optimize vehicle route planning in real time, reduce travel times, cut fuel costs, and improve response times. Logistics solvers that are accelerated by GPUs rely on heuristics—such as tabu search, guided local search, ant colony, and Lin-Kernighan—to achieve optimizations in hyperparameters and batch processing.

MANAGING THE GRID EDGE WITH AI SOFTWARE

> Smart Meters

New smart devices are using computing at the edge to optimize real-time power flow. Utilidata, a leading grid-edge software company, is developing a **software-defined smart grid chip** with NVIDIA. The smart grid chip will be combined with edge AI to enhance grid resiliency, integrate distributed energy resources (DERs)—including rooftop solar, home batteries, and electric vehicles—and accelerate the transition to a decarbonized grid. Utilities, clean energy companies, and electric vehicle providers are exploring applications for the platform in anomaly detection, meter fingerprinting, fault location, e-contracts, meter-to-meter and meter-to-grid communications, and more.

> Smart Homes

Homeowners, renters, and builders looking to reduce monthly utility bills and carbon footprint are building new homes that operate as **smart energy hubs**. Anuranet, an energy infrastructure startup, launched the Bullfrog Energy Ecosystem to connect the electric grid to smart panels, breakers, meters, and home display control screens. Powered by a tiny embedded AI supercomputer, the energy platform helps improve home energy usage, predict grid outages, improve load shedding, optimize microgrids, and carry out accurate demand forecasting.

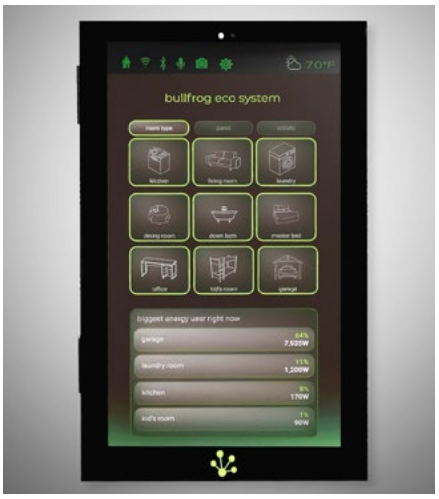
AI models can use historical, real-time, macroclimate, and microclimate data to continuously calculate probabilities of generation output from renewable sources. At the same time, they can predict precise workload demand across the grid with the added complexities of residential solar panel systems and electric vehicles.

> Call Center Virtual Assistants

Customer service, a key metric for electric utilities, relies on 24/7 service availability. Higher-than-normal demand volatility due to unexpected outages can cause surges in call volume from affected customers. However, AI and data analytics can enhance the overall customer experience and help control operating expenses.

In call centers, utilities can use AI as virtual assistants to augment agents. AI-powered assistants can answer commonly asked questions, transcribe and translate customer calls, recommend next actions, send outage alerts, and escalate issues to the appropriate contacts—all while reducing the volume of live traffic.

Data analytics can be utilized to present the customer support agent with a real-time, 360-degree view of the customer, including past usage, peer comparison, and rate guidance, which reduces call times and customer frustration. Ongoing customer analytics help by providing proactive alerts of anomalies in usage and recommendations for



Smart homes use speech AI to help homeowners monitor their energy usage, improve their consumption habits, and reduce their monthly bills. Image courtesy of Anuranet.

> "With the increase in distributed energy resources—especially batteries, solar, and electric vehicles—those technologies can pose a management problem or opportunity to utilities. We're working with NVIDIA to move that central computation out to the edge of the grid, so we can manage those resources in real time and integrate them into real-time power flow dynamics from the substation to the end of the line."
>
> — Marissa Hummon, CTO, Utilidata

best-fit rate programs, preventing surprisingly high enterprise and residential energy bills and decreasing customer service calls and management escalations.

By leveraging conversational AI solutions based on NVIDIA's platform, MinervaCQ built a call center assistant that operates in real time to help agents solve customer problems. This helped Enel X increase first-contact resolution by 12.5 percent, reduce handle times by 44 percent, decrease onboarding time for new agents by 75 percent, and improve customer satisfaction score (CSAT) gaps by 50 percent.

THE FUTURE OF AI FOR GRID MODERNIZATION

The energy industry is at an inflection point of modernization. The drive for decarbonization is adding vastly more complex and unpredictable challenges to an aging infrastructure. Renewable resources are by nature less predictable in output, more numerous, and more distributed in location than conventional generation methods. AI, HPC, and edge computing enable utilities to modernize the electric grid, from power generation through transmission and distribution to the grid edge—lowering costs, enhancing resiliency, increasing reliability, and speeding up the transition to clean energy.

NVIDIA