GRID MODERNIZATION: A UTILITY'S GUIDE TO RESILIENCE AND FLEXIBILITY

Honeywell

EXECUTIVE SUMMARY

The North American power grid we rely on today was mainly designed for the needs of the mid-twentieth century, long before all-electric homes, central heating and air conditioning, electric vehicles (EVs), electrified industrial processes and energy-hungry data centers arrived on the scene.

The electric infrastructure continues to function remarkably well for its age, but surging demand, severe weather events, cybersecurity threats and the need to integrate more sustainable and distributed energy resources (DERs) pose potential risks to the grid's reliability, resilience and long-term stability.

Replacing the entire grid is not an option, but fortunately, that's not necessary. With digital modernization, utilities can layer intelligent technologies onto existing infrastructure to help improve visibility, automate operations, integrate DERs and extend asset life. Even relatively small updates and modifications can positively impact grid operations.

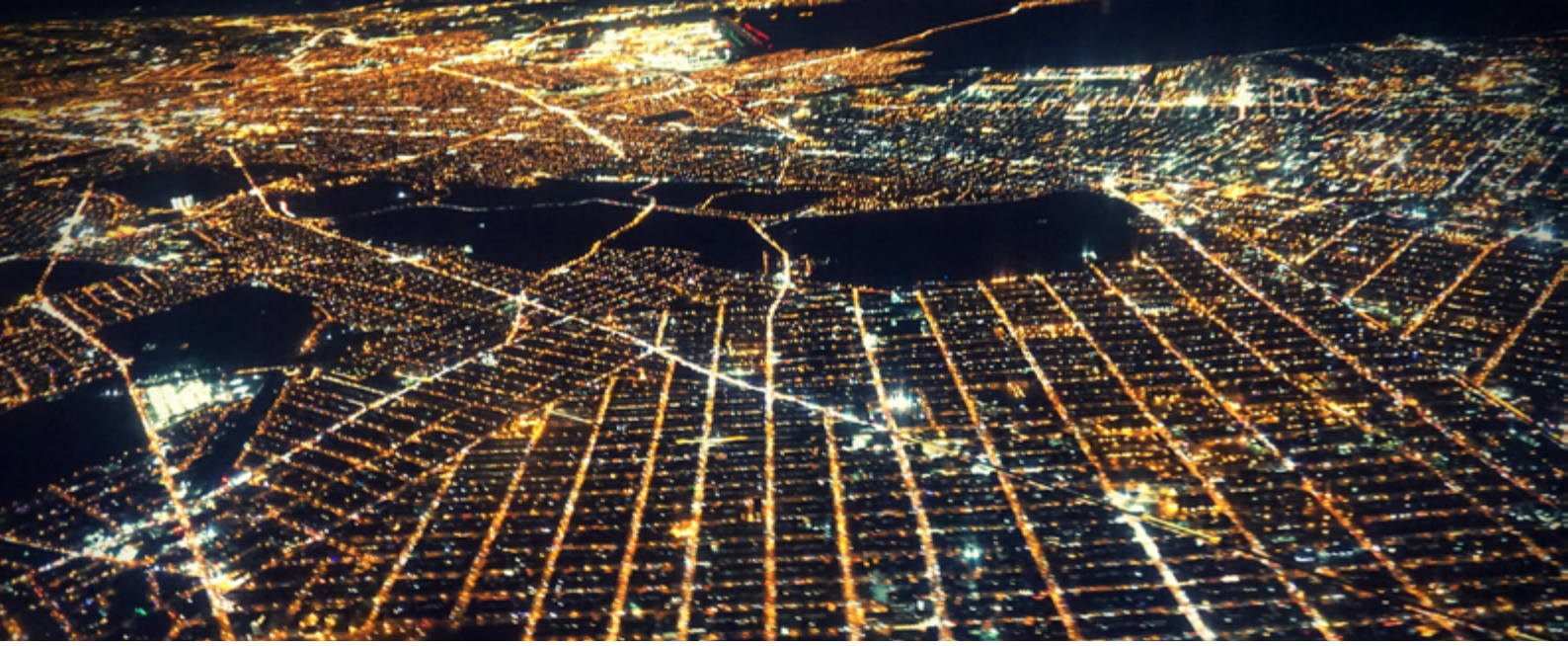
New technologies promise a more efficient and more resilient electric ecosystem but simply adding modern components will not enhance grid operations. Utilities across the value chain require a clear vision of the future that aligns stakeholders around shared goals, guides long-term investment decisions and makes technology deployments scalable, integrated and future ready.

In this guide, we will explore ways utilities can optimize existing assets, improve grid resilience and deliver safe, reliable, affordable and increasingly more sustainable power to their customers.

Digital transformation is the foundation of a modern grid. Read on to learn how utilities can use digital tools to gain predictive, data-driven insights to better forecast demand, manage distributed energy resources, implement demand response initiatives and create flexible and reliable grid infrastructure.

> **"Utilities are navigating a perfect storm of aging infrastructure, inability to develop generation to offset rising demand and rapid energy transition to alternative/renewable sources. Much of our electric grid is decades old and increasingly vulnerable to extreme weather events, equipment failures and cyberattacks. Digital transformation is the fastest and most economical path to modernization, enabling utilities to enhance grid visibility, integrate distributed and renewable energy, automate operations and better respond to threats."**

Rob Hartway
Senior Director, Digital Solutions
Honeywell Smart Energy & Thermal Solutions



DIGITAL TRANSFORMATION IS FUNDAMENTAL TO GRID MODERNIZATION

Utilities are grappling with the evolution of a grid originally designed for centralized, predictable power generation and one-way delivery to customers. Disruptors such as data centers, electrification, electric vehicles (EVs), renewable energy sources and prosumers — those who both produce and consume energy — introduce unpredictable load patterns and intermittency into the system.

Grid modernization is a priority for power and utility companies, according to IBM's Institute for Business Value. The Institute surveyed nearly 600 senior utility executives and found that 100% have developed grid modernization strategies, though 21% report no progress to date. Almost half list "enhancing grid reliability" as a top goal, on a par with "reducing carbon emissions" and "empowering and engaging customers."[1]

KEY DRIVERS OF GRID MODERNIZATION

Modernizing the grid is no longer a choice; it's a strategic imperative as utilities and power generation companies confront the real challenges of rising energy demand, aging infrastructure, extreme weather events and the need to decarbonize and integrate distributed energy resources.

- Global energy demand continues to grow at unprecedented rates. United States electricity demand is expected to grow 25% by 2030 and 78% by 2050 from 2023 levels. Similarly, experts expect U.S. peak electricity demand to increase by 14% by 2030 and by 54% through 2050.[2]
- Aging infrastructure is impacting grid reliability. Much of the U.S. grid was built in the 1960s and 1970s so it is nearing the end of its projected 50–80-year service life. As of 2023, 70% of transmission lines and transformers have been in service for more than 25 years.[3]
- Extreme weather like ice storms, floods, hurricanes and wildfires can wreak havoc on aging infrastructure and disrupt the grid for extended periods. The average annual number of $1 billion-plus events grew from nine to 23 between 2019 and 2024.[4]
- North American utilities continue to shift toward distributed energy and an increased reliance on renewables introducing dynamics such as variable generation and bidirectional power flow to the grid.

HOW UTILITIES CAN BOOST RESILIENCE

Utilities need to harden the grid to improve resilience against natural- and human-caused threats, such as storms, wildfires and cyberattacks. This includes upgrading poles, transmission lines and substations, along with adding cyber threat detection, response and recovery measures.

They can also build resilience using Distributed Energy Resources (DERs), advanced management systems, microgrids and customer engagement. Growing prosumer participation requires a modern grid that can support active, two-way energy engagements with customers.

Digital including the use of advanced sensors, smart meters and advanced analytics can allow utilities to collect critical near real-time data and transform it into actionable information.

Proven platforms like ADMS (Advanced Distribution Management System), DERMS (Distributed Energy Resource Management System) and SCADA (Supervisory Control and Data Acquisition) use this information to help manage grid resources and provide near real-time control and visibility. As a result, utilities can anticipate issues before they occur, enhance system reliability and performance and support long-term planning and real-time decision making.

"Unified data platforms can integrate and monetize the wealth of grid data from disparate sources like smart meters, weather stations and renewable energy assets, providing real-time insights for renewable energy integration and grid optimization. With more interoperable systems, customers can more easily integrate their energy resources, such as rooftop solar panels or electric vehicles, into the grid, contributing to the overall resilience and sustainability of the energy system."[6]

Deloitte

FUNDAMENTAL FORCES DRIVING GRID MODERNIZATION

The following are some of the trends creating the need for grid modernization:

Generation

Regulations, growing energy demand and a shift towards extending the life of fossil fuel conventional combined cycle and nuclear plants require investments in digitalization, autonomous operations and cybersecurity.

Decarbonization

Utilities are under enormous pressure to integrate cleaner energy sources like solar, wind and energy storage technologies into the grid, but challenges exist. More than 10,000 proposed solar, wind and battery projects are scheduled to connect to the U.S. electric grid, but the grid lacks sufficient capacity to handle the additional power.[5]

Complexity

As utilities transition to cleaner energy sources the grid must adapt to an evolving energy generation mix. Renewable and distributed energy resources are reshaping demand patterns, reversing traditional power flows and introducing intermittent energy sources. This added complexity requires a smarter, more flexible grid.

Electrification

The rapid adoption of EVs, heat pumps and electrified industrial processes is driving increasing electricity demand, creating new load profiles and placing additional strain on local distribution networks.

Resilience

With the alarming rise in extreme weather, wildfires and cyber threats, grid modernization is critical to help harden infrastructure, automate response and enable reliable service under increasingly volatile conditions.

Consumer Participation

Modern energy users are becoming informed and active participants in the grid. They are generating their own power, responding to real-time price signals and participating in demand response programs. With smart meters and other innovations, the modern grid can foster this engagement through flexibility and two-way communication.

Digitalization

The availability of smart sensors, Internet of Things (IoT) devices and advanced data analytics provides utilities and power generators with near real-time visibility, predictive maintenance and intelligent control, which can turn the grid into a dynamic, self-optimizing system.

DIGITAL MODERNIZATION SHOWS PROMISE

Utilities are spending an average of 9.8% of their annual revenue on grid modernization, which accounts for more than 40% of their total investment in transmission and distribution.[1] Replacing aging infrastructure is costly and often impractical so many forward-looking utilities are focusing on digital modernization, which often provides the quickest return on investment (ROI).

Using digital modernization strategies can help enhance grid management by improving automation, control and forecasting capabilities, which can help utilities respond more dynamically to transient events. Two-way communication between utilities and their customers enables demand response and load management, which is critical given the unprecedented increase in electricity demand.

Digital tools also enable near real-time visibility, predictive maintenance, decentralized energy management and rapid response capabilities. They help utilities manage increasingly complex energy systems that include renewable sources, distributed assets and evolving physical and cyber threats while improving efficiency and reducing downtime.

Digital modernization involves three stages:

Digitization is the process of converting analog information, such as process data, meter readings, paper records or mechanical signals, into digital formats that can be stored, processed and analyzed electronically.

Digitalization refers to the use of digital technologies and computational power to analyze data, automate processes and optimize decision making. In the context of the power grid, it enables near real-time monitoring, predictive maintenance and smarter energy management by turning raw data into actionable insights.

Digital transformation is the strategic shift in how a utility operates, delivers value and engages with stakeholders based on insights gained from digital technologies and data. In the utility sector, this involves rethinking everything from grid operations to customer engagement, using advanced analytics, automation and connected systems.

Utilities are beginning to recognize that digital transformation can improve reliability and customer satisfaction without significantly increasing spending by reallocating investments based on better data and operational insights. According to McKinsey, digital transformation can drive profitability gains of 20%-30% at utilities by enabling more intelligent decisions and more targeted use of resources.[7]

"By necessity, tomorrow's electric grid will be more intelligent, flexible, dispersed and resilient. Utilities will be more digitally connected to a wide range of distributed resources like rooftop solar installations, energy storage resources and electric vehicles. They will be able to balance a complex web of energy producers and customers who will be able to generate, store and manage their own energy while interacting with the grid in near real time."

Prudence Hoffman
Business Development Director, Autonomy (X)
Honeywell Climate Impact Team

CORE COMPONENTS OF A TOMORROW'S POWER GRID

The aim of the next-generation power grid is to experience fewer disruptions and enable it to recover quickly and automatically in the event of outages. This means the power grid of the future will need to fundamentally operate differently than the existing grid infrastructure. In addition to deploying digital modernization efforts, tomorrow's power grid will also include characteristics such as:

DEPLOY ADVANCED INFRASTRUCTURE

Advanced infrastructure enable near real-time monitoring, control and optimization. Smart meters and sensors provide precise data on energy consumption and grid conditions, enabling utilities and customers to make more informed, data-based decisions. Automated substations and grid controls streamline switching, voltage regulation and outage management. Technologies such as dynamic line rating optimize and adjust capacity limits in response to near real-time environmental conditions.

IMPROVE GRID INTELLIGENCE AND AUTOMATION

Systems like ADMS and DERMS enable real-time control, coordination and optimization of distributed energy assets. These systems often operate in conjunction with Energy Management Systems (EMS) and SCADA platforms, which provide centralized visibility and operational control. As power generation resources become more distributed, automation will help utilities maintain balance and grid stability.

INTEGRATE DISTRIBUTED ENERGY RESOURCES

Effective integration of DERs will increase system resilience and enhance grid responsiveness. As the energy landscape shifts from centralized generation to a more decentralized model, the modern grid must be capable of seamlessly accommodating a diverse mix of distributed resources including rooftop solar panels, wind turbines and energy storage systems. These resources help reduce peak demand, lower greenhouse gas emissions and improve the grid's ability to respond to disruptions. Virtual power plants (VPPs) aggregate multiple DERs and enable them to function as one power source.

BOLSTER OPERATIONAL SECURITY

Modern grids require protection from both cyber and physical security threats. Protecting the grid's operational technology (OT) assets – which consists of devices and systems that enable the grid to operate including SCADA systems, programmable logic controllers (PLCs), sensors, actuators, distributed control systems (DCSs), automated metering infrastructure (AMI), access control systems and video networks – is essential to help prevent disruptions. This includes a rigorous OT cybersecurity incident response plan as well as using tools that can help identify assets, vulnerabilities and threats. The North American utilities industry requires mandatory compliance with the NERC-CIP cyber standards and non-compliance can result in significant and costly fines. The modern grid also requires solutions that can comply with regulatory requirements for access control at power generation plants or remote, unmanned distribution facilities and managing the unique fire and life safety challenges of lithium-ion batteries used in energy storage solutions.

ENHANCE RESILIENCE

Technologies like microgrids and islanding capabilities allow critical infrastructure to operate independently in emergencies. Demand response programs and emerging innovations like Vehicle-to-Everything (V2X) can further enhance flexibility and allow the grid to respond dynamically to stress and disruption.

ADD FINANCIAL MECHANISMS AND MARKET DESIGN

As energy systems become more resilient, decentralized and digital, financial models must also evolve and become more participative. Dynamic pricing models enable customers to adjust consumption based on grid status to improve efficiency and reduce costs. Emerging innovations like peer-to-peer energy trading allow customers and prosumers to buy, sell and trade energy locally.

FIVE KEY STEPS TO GRID MODERNIZATION

Successfully modernizing the grid will require a comprehensive strategy that addresses technical, operational, regulatory and market dimensions. Here are five key steps utilities need to take to build a smarter, more resilient and future-ready grid.

1 CONDUCTING ASSESSMENTS, PLANNING AND FORECASTING

Understanding the grid's current state and future needs is the first step in the modernization process. Conducting a detailed asset inventory and health assessment will help identify aging infrastructure, vulnerabilities and opportunities for upgrades. It's important to engage in load forecasting to assess future needs for infrastructure capacity investments. Stakeholder engagement and regulatory alignment can allow plans to align with regulatory requirements and utility priorities.

2 LEVERAGING DATA INSIGHTS WITH RENEWABLE AND DISTRIBUTED ENERGY RESOURCES

Integrating DERs and renewables into grid operations requires a strong digital backbone supported by core near real-time control systems. EMS and microgrid control systems help manage localized generation and demand in a dynamic environment. Utilities can also use advanced data analytics and solutions that use artificial intelligence to support predictive maintenance, load optimization and system reliability. Advanced Metering Infrastructure (AMI) 2.0 provides the basis for high-resolution data collection and two-way communication with customers and forming the basis for more responsive, customer-centric grid operations.

3 INTEGRATING DEMAND RESPONSE PROGRAMS

Demand response is a powerful tool for balancing load, reducing peak demand and increasing grid resilience. Utilities can use flexible demand management programs to incentivize customers to reduce or shift usage during periods of high usage or pricing volatility. These programs can help defer costly infrastructure investments.

4 IMPROVING PHYSICAL AND CYBERSECURITY

As threats to the grid increase, utilities need to harden infrastructure against physical and cyber-attacks by deploying automated fault detection and isolation systems. Designing and building microgrids can create continuity of service during emergencies or disruptions. On the cybersecurity front, adopting NERC CIP (Critical Infrastructure Protection) standards provides a structured framework for defending against cyberthreats. Physical security measures, such as perimeter security controls, video systems, access control systems and intrusion detection, are also essential.

5 COMPLYING WITH POLICIES, REGULATIONS AND MARKET REFORMS

Utilities and policymakers must work together to support performance-based regulations that reward outcomes like reliability, decarbonization and customer engagement. Pilot programs can encourage innovation and mitigate the risks associated with emerging technologies. At the same time, market mechanisms that foster flexibility and ancillary services can unlock new value streams and grid services from distributed assets.

GRID MODERNIZATION STRATEGIES IN ACTION

CASE STUDY: AMI METER UPGRADE

Honeywell successfully partnered with a large investor-owned utility to modernize its metering approach and overhaul business operations. Honeywell helped the utility upgrade 2.7 million AMI meters, 200,000 gas modules and 5,000 gas meters. The three-year project involved extensive planning, installation and service by Honeywell team members.

The project improved energy data collection for strategic planning and the ability to address unforeseen challenges, such as high-voltage service requirements. Honeywell's consultative and partnership-driven approach enabled the project to be executed efficiently and safely, fostering trust and collaboration with the utility company.

CASE STUDY: HYBRID CONTROL SOLUTION

A large Eastern U.S. electric utility turned to Honeywell to help optimize operations across multiple solar and wind farms. Honeywell implemented hybrid control solutions that combine on-site and cloud SCADA infrastructure, advanced analytics and energy storage systems to improve efficiency, reliability and compliance.

By deploying solutions like Experion® SCADA, Battery Energy Storage Systems (BESS), ControlEdge™ programmable logic controllers and advanced analytics tools, the utility was able to integrate its renewable energy assets and improve asset utilization. It also realized benefits like faster implementation and reduced cost.

BEST PRACTICE: VERIZON PARTNERSHIP

Honeywell and Verizon have joined forces to integrate 5G connectivity into Honeywell's smart utility meters. The effort will modernize energy grid management and enhance operational efficiency for utility companies.

By leveraging the reliability and security of Verizon's cellular network, Honeywell smart meters can transmit data on energy usage, grid performance and equipment health. This real-time information feeds into utility platforms like Honeywell Forge Performance+ to enable precise forecasting of energy demand and strengthen grid resilience.

BEST PRACTICE: QUANTUM TECHNOLOGIES

Through its majority stake in Quantinuum, Honeywell is ready to help utilities future-proof their digital transformation and complement their cybersecurity strategies as the grid becomes more decentralized.

Quantum-secure encryption offers a powerful layer of protection against threats, positioning utilities ahead of evolving regulatory mandates that will require quantum-resilient systems. By securing SCADA and AMI networks with next-generation encryption, utilities can scale distributed energy resources safely and build trust in a connected grid environment.

CHALLENGES AND MITIGATION STRATEGIES

Grid modernization will require significant investment and a clear vision of the future shared by utilities, technology providers, regulators and policymakers. Upgrading the grid's physical infrastructure is essential; so is embedding intelligence across the electric power ecosystem through digital transformation.

Digital transformation is the logical starting point for grid modernization. Without a resilient digital backbone, utilities won't realize the benefits of clean and distributed energy integrations.

By embedding intelligence into the grid through sensors, smart meters, data analytics and connected control systems, utilities can gain near real-time visibility into their operations, enabling faster decision-making, predictive maintenance and more efficient use of existing assets.

Utilities can mitigate the impact of high up-front costs through public-private partnerships that share risk and accelerate deployment. Interoperability issues between legacy and new systems also may pose a barrier, underscoring the need to adopt open standards, such as IEEE 2030.5.

In addition, many utilities face a workforce readiness gap, which can be addressed through targeted training, training simulators and reskilling programs to equip employees with the digital and technical skills needed for tomorrow's grid.

"Over the past few years, utilities have faced a sharp and largely unanticipated surge in electricity demand, driven by factors like data center growth, electrification and extreme weather. Infrastructure projects often take years to complete, but the demand spike is happening now. In response, utilities are increasingly turning to digitization and grid intelligence to make smarter decisions and maximize the capacity of existing grid infrastructure. With limited time and constrained physical assets, the challenge is clear: how to push more power through an aging grid that wasn't designed for today's loads, and do so with speed, efficiency and reliability. Digital modernization is the answer."

Travis Debenedetto
Global Leader, Power and Utilities
Honeywell Power Generation

CONCLUSION

North America's electric grid is stretched to its limits by surging demand for power and the threat of disruption caused by extreme weather, aging infrastructure and sophisticated cyberattacks on critical infrastructure. Modernization is no longer optional – it's an imperative that cannot be deferred.

Modernizing the U.S. grid is projected to carry a $7 trillion price tag, underscoring the magnitude and scope of the task at hand.[8] While physical upgrades are essential, digital transformation usually can offer a more affordable – and immediate path – to improving grid performance.

Success will depend on developing a proactive, data-driven approach grounded in innovation and cross-sector collaboration. With deep expertise and a portfolio of intelligent, ready-now solutions, Honeywell is helping utilities build a foundation for a secure, flexible and sustainable grid capable of meeting tomorrow's demands.

The path forward is clear. We need to act now, modernize boldly and lead with intelligence.

HOW HONEYWELL CAN SUPPORT YOUR DIGITAL FUTURE

Honeywell helps utilities meet today's challenges and modernize the grid, making it ready for tomorrow. With more than a century of industrial automation and domain expertise, Honeywell brings proven technologies and advanced digital capabilities to help utilities address their most pressing challenges.

From advanced metering infrastructure and smart meters that enable near real-time visibility, to integrated SCADA systems and microgrid controls that enhance operational responsiveness, Honeywell optimizes performance across the grid. Solutions like Honeywell Forge for Utilities Performance+ empower data-driven decision-making, while energy management, energy storage, demand response systems as well as physical and cybersecurity solutions enable greater flexibility, resilience and control.

For more information or to request a consultation, visit Clean Energy Solutions.

REFERENCES

[1] IBM, "Power grid modernization—Strategies and tactics for resilience and energy transition | IBM," Biren Gandhi, Zahid Habib, Sally Jacquemin, Spencer Lin, March 21, 2025. [Access August 15, 2025]

[2] American Public Power Association, "Electricity Demand Expected to Grow 25% By 2030: ICF | American Public Power Association," Paul Ciampoli, May 20, 2025. [Accessed August 15, 2025]

[3] Smart Electric Power Alliance, "The Aging US Power Grid: Navigating Toward Modernization | SEPA," Cara Kuuskvere, Weston Dengler, September 19, 2024. [Accessed August 15, 2025]

[4] National Centers for Environmental Information, "Billion-Dollar Weather and Climate Disasters | National Centers for Environmental Information (NCEI)," January 10, 2025. [Accessed August 15, 2025]

[5] Fast Company, "The outdated power grid is nearing a crisis point. Here's how to prevent it - Fast Company," Adele Peters, May 23, 2024. [Accessed August 15, 2025]

[6] Deloitte, "Grid expansion and modernization | Deloitte Insights," Stanley Porter, Jim Thomson, Christian Grant, Craig Rizzo, Kate Hardin, Jaya Nagdeo, May 13, 2024. [Accessed August 15, 2025]

[7] McKinsey & Company, "The digital utility: New opportunities and challenges | McKinsey," Adrian Booth, Niko Nohr, Peter Peters, May 12, 2016. [Accessed August 15, 2025]

[8] LinkedIn, "The $7 Trillion Dilemma: Can the U.S. Grid Handle Explosive Demand Growth? | LinkedIn," Glen Spry, February 21, 2025. [Accessed August 15, 2025]

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