# Layers of Resilience

## What the Texas energy freeze can teach us about the energy transition

**The Texas freeze demonstrates the importance of implementing layers of resilience into our energy ecosystem. By modernizing and diversifying the energy ecosystem, we can provide secure energy under increasing stresses while also addressing climate change.**

**The serious power interruptions in Texas are not attributable to any one cause or one source of energy but were a culmination of issues starting with infrastructure preparedness through generation to distribution.** Any energy system can operate in bad weather when it is sufficiently planned for those conditions. Power can be reliably generated in the harshest environments on Earth—near the polar circle, in the desert and on blustery seas. Nearly all the problems in Texas were preventable. The Texas situation demonstrates the need to modernize the full energy system to prepare for the simultaneous trends of more severe weather events and growing reliance on electricity. This should not be controversial. We already possess the physical and digital technologies to ensure the resilience and increased security of our energy systems while also advancing the climate change goals of decarbonizing the energy sector.

**Stresses on the energy ecosystem are growing.** The designers who built the nation's first energy grid generations ago expected to deliver power from large, constant, centralized energy sources under mostly predictable conditions. Today, those assumptions are dramatically out of date. First, as with Winter Storm Uri, the energy system is facing more extreme weather events with longer-lasting impacts. Second, energy now pours into the grid from many diverse and sometimes variable sources, such as solar panels on private homes. Third, reliance on electricity is rising as other industries and sectors, like transportation, continue to electrify. Global demand is projected to increase 50% by 2040. Fourth, there are greater potential security risks to the grid.

### TRENDS DISRUPTING THE TRADITIONAL POWER SECTOR

| SEVERE WEATHER | DISPERSED/VARIABLE GENERATION | GROWING DEMAND | SECURITY RISKS |
|---|---|---|---|

**The United States must invest in innovation and modernize its energy ecosystem with layers of resilience to adapt to weather extremes, growing demand and greater risks.** This is not a one-size-fits-all approach. It requires a diverse combination of resources and innovation, including growing renewable energy generation and a reliable, robust supply of baseload electricity from efficient power stations running on natural gas and nuclear energy. It also calls for modernizing the grid with physical and digital upgrades.

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Better use of existing infrastructure, investing in new technologies, and developing sound policy for better planning and coordination between existing sources of electricity and more generating capacity at the margins of the system will help us build these layers of resilience. We can incentivize these goals and decarbonize the energy sector at the same time.

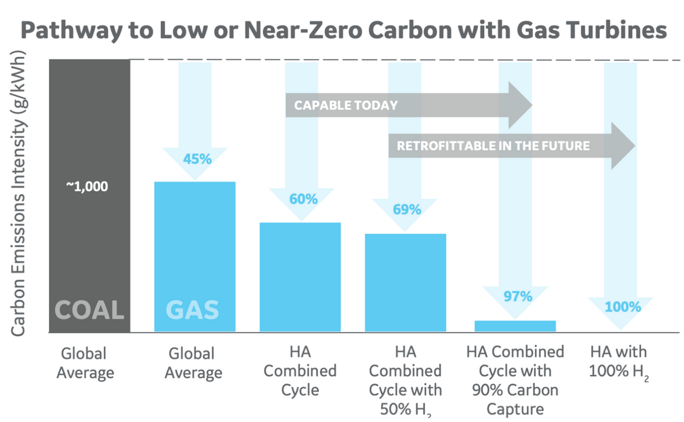
## WIND

**First, wind is a critical tool for making our energy systems more resilient and addressing climate change.** In the final months of 2020, electricity generation from wind turbines in the United States set daily and hourly records. Wind electricity generation reached 1.76 million MWh on December 23, or about 17% of total electricity generation on that day. U.S. total annual Electricity generation from wind electricity generation in the United States increased from about 6 billion kilowatt hours (kWh) in 2000 to about 300 billion kWh in 2019. Wind turbines operate in some of the harshest climates in the country, making up more than a quarter of the electric grid in North Dakota and running through the sweltering heat of the California desert. Turbine manufacturers build cold-weather kits to keep turbines running in extreme temperatures. Thus, wind farms—no matter where they are—are a key part of a diverse toolset to address demand and reduce emissions.


## GAS

**Second, gas power plays an important role in strengthening resilience and addressing climate change.** Gas power can supply large amounts of electricity 24/7 or as needed to balance variable renewables. In many places, adding gas power is the quickest way to reduce emissions reliably because it displaces other, more carbon-intensive sources of energy. (Many peaking plants, for example, run on coal or diesel.) A foundation of reliable gas power also becomes a force multiplier for adding renewables into a system. Because gas turbines can ramp up and dial down output within minutes, they pair well with variable energy sources like wind and enable further decarbonization while preserving resilience. In Texas, gas power plants that were weatherized performed nearly flawlessly through the event between February 14 and February 18.

The industry is installing state-of-the-art gas power that is highly efficient while at the same time supporting efforts to address the most significant near-term concern—methane emissions from gas development. Longer term, there is potential to further decarbonize the industry by using hydrogen as a fuel and by installing carbon capture and sequestration (CCS) technology at power plants.




Already, work is underway to make a gas power plant in Hannibal, Ohio, run on a hydrogen blend as early as 2022. There are plans to transition the plant to run on 100% green hydrogen over the next decade. Most recently, Secretary of Energy Jennifer Granholm testified in her confirmation hearing about the importance of hydrogen and CCS to decarbonize emissions in the future.

## GRID

**Third, and perhaps most significantly in the case of the recent Texas outages, the country is long overdue for modernizing the physical and digital grid.** We need robust transmission and distribution networks to make sure homes and businesses have electricity when they need it. Physical upgrades to our electrical grid can help bring power online from wind and solar farms across the country. Since there is an element of variability, these upgrades can also help better orchestrate and balance transmission over existing networks. They also can improve efficiency during periods of extreme demand and stress for all types of energy and reduce the emissions and environmental footprint of the entire energy ecosystem every day.

**Grid upgrades exist today that can smooth variability and increase efficiency, ensuring electrical grids continue to maintain the voltage and frequency of the AC power traveling their lines.** This stability of voltage can become harder to maintain as more energy sources come online, sometimes far from where people live, and as power travels further to reach its destination. GE is using a number of solutions to solve these challenges at multiple points in the system. The synchronous condenser, for example, can be used to bolster the voltage on transmission lines connected to large wind farms. GE's own Fixed Series Compensator (FSC) technology is helping utilities cost-effectively send power over longer distances with lower losses, increasing efficiency and stability.

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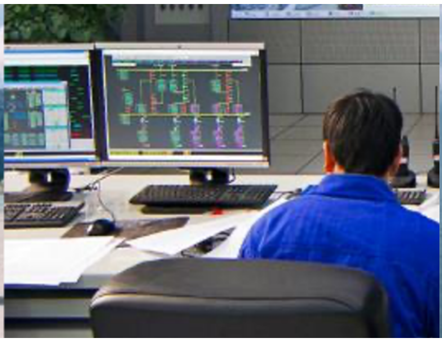
While grid operations are helping to bring about a more diverse and decarbonized future, so too is the grid equipment itself. A synthetic "green gas" developed by our scientists is revolutionizing high-voltage equipment by offering grid operators an alternative to insulating SF6 gas, an extremely potent greenhouse gas.

**Software innovation is also key to a more resilient grid.** It enables existing infrastructure to utilize more capacity and send more electricity safely through the same power lines. Software can help the hardware mentioned above better manage the transmission and distribution of electricity from diverse and variable sources in real time, and it can provide a holistic view of the full energy ecosystem. It also can help operators prepare for potential problems by predicting issues and forecasting risks. Finally, software can help protect the grid against cybersecurity threats. GE has developed industry-leading software solutions for all key parts of the transmission and distribution system: real-time grid orchestration, predictive and forecasting software and system-wide representations of grid operations through digital twins—virtual models of the grid.

In Texas, the grid was not capable of responding quickly enough to rapidly changing conditions. It faced the twin threats of spiking demand due to the severe weather and sudden loss of supply from generating assets tripping offline due to frozen instruments and equipment. Just as overloading an outlet with appliances can trip a circuit breaker in a home to prevent damage or fire, imbalances between supply and demand on the grid can result in rolling blackouts. The system is forced to move assets offline to avoid the more catastrophic damage that could be caused by generating assets falling out of sync. This is where physical and digital upgrades can work to address resilience. Texas' painful experience presents a compelling opportunity for the United States to support these investments and research to improve resilience while addressing climate change.

**Additional improvements for both the grid and the broader energy transition are on the horizon.** Scientists at GE Research are working on AI to improve the performance of wind turbines, looking at 3D printing to take wind blade design to the next level and engineering new efficient generators for offshore wind farms. Beyond renewables, GE and other scientists are improving hydrogen combustion, carbon capture and sequestration. They are developing new, smaller modular nuclear reactors. These advances are all part of a comprehensive technology portfolio to reduce our carbon footprint, while making cleaner power more accessible than ever before.



**With an ecosystems approach, we can address climate change, decarbonize energy and add layers of resilience at the same time.** Nothing that happened in Texas should alter our path toward addressing climate change and decarbonizing the energy sector. It's a myth that we can only have one or the other: decarbonized energy or grid reliability. As we invest to address climate change, we can modernize the energy ecosystem and make it more resilient at the same time.

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For example, we should support policies and incentives to reduce emissions as quickly as possible among baseload power sources, make permitting more predictable to improve the role offshore wind can play, and encourage investment in modernizing the grid.

Policies that support such a "technology-neutral" approach focusing on how to reduce emissions as quickly as possible through a diverse investment in technologies such as renewables, grid and efficient gas power will succeed in reducing emissions, lowering energy costs and strengthening the energy system while also adding capacity. On the other hand, policies that pick winners and losers or prejudge certain technologies are more likely to fail. With this ecosystems approach, we can create jobs across the energy sector and promote technology and innovation in the United States that can be used both here and around the world. Investment in resilience today should put Texas and the rest of the country well on the path to reaching these goals.