Union of Concerned Scientists

ISSUE BRIEF

Gas Malfunction

Calling into Question the Reliability of Gas Power Plants

Over the last decade, the United States has made significant progress transitioning the electricity sector toward solar, wind, and other clean sources of energy. In 2022, the nation got more than 22 percent of its electricity from renewable resources, nearly twice the amount of 2012 renewable generation (EIA 2023a). Despite this progress, the power grid has simultaneously become even more reliant on natural gas–fired power plants.[1] While the amount varies by region, gas plants provided 40 percent of total US electricity generation in 2022 and accounted for 43 percent of generating capacity (EIA 2023a). This heavy reliance on gas plants, coupled with an assumption that gas plants are more reliable than they actually are, is a vulnerability for the power grid and for consumers.

Historically, utilities and grid operators often have considered gas plants to be “firm” resources that could generate electricity whenever it was needed. However, as recent evidence has shown, the US fleet of gas plants is susceptible to large-scale failures during extreme weather. For example, recent winter storms in Texas and the Southeast knocked unprecedented portions of the fleet offline, ultimately leading to rolling blackouts for millions of people.[2] Other extreme weather events, such as heat waves and droughts, have also significantly interfered with the operation of gas plants, even if winter storms pose the greatest threat.

As the impacts of climate change intensify, extreme weather events are becoming more frequent and more severe (Cohen, Pfeiffer, and Francis 2018; Cohen et al. 2021; UCS 2018; Marvel et al. 2023). This increases the threat to gas plants and, in turn, to the reliability of the power grid. In a world with a rapidly changing climate and increasingly frequent gas plant failures, we must reassess the role of this resource in ensuring grid reliability.

Winter Jeopardizes the Reliability of Gas

In most parts of the United States, regulators, grid operators, and communities are growing increasingly concerned about the impact of severe winter weather on the energy system. In this context, the Federal Energy Regulatory Commission (FERC), the major regulator of the power grid and other energy infrastructure, and the North American Electric Reliability Corporation (NERC), a separate authority that sets reliability standards in the power sector, have identified five major winter storm events since 2011 that have “jeopardized grid reliability” (Table 1) (FERC 2023). Each event caused significant, unplanned losses of generation capacity due to freezing equipment, disrupted fuel supplies, and other system failures (FERC 2011; FERC 2019; FERC 2021; FERC 2023; NERC 2014). Rolling blackouts ensued in all but one of these events, leaving homes and businesses without electricity or heat on some of the coldest days of the year.

Table 1. Generation Failures and Rolling Blackouts During Five Extreme Winter Storms

Winter Storm	Peak Unplanned Generation Outages Due to Cold Weather (MW)	Peak Magnitude of Rolling Blackouts (MW)	Length of Rolling Blackouts (hours)
2011 Southwest Storm	14,702	5,412	7
2014 Polar Vortex	9,800	300	3
2018 South Central Storm	15,600	0	0
2021 Winter Storm Uri	65,622	23,418	70
2022 Winter Storm Elliott	90,500	5,459	7

All five winter storms knocked significant amounts of generation capacity offline. All but the 2018 storm caused rolling blackouts.
Notes: The magnitudes of the 2021 and 2022 rolling blackouts are summed across multiple balancing authorities. For example, during the 2021 storm, ERCOT peaked at 20,000 MW of rolling blackouts, SPP peaked at 2,718 MW, and MISO South peaked at 700 MW, adding up to 23,418 MW. Lengths for the 2021 and 2022 storms are specific to the balancing authorities that implemented the longest rolling blackouts: ERCOT in 2021 and the Tennessee Valley Authority in 2022.
SOURCE: FERC 2023.

The five events varied greatly in their impact on US generation capacity, as well as the magnitude and duration of the resulting rolling blackouts.[3] Also, the magnitude of the generation outages did not always correspond to the severity of the blackouts. For example, Winter Storm Elliott in December 2022 forced the most generation capacity offline at its worst point—peaking at a historic 90,500 megawatts (MW). However, the rolling blackouts and resulting human toll were far less than those of Winter Storm Uri in February 2021, which prompted blackouts for more than 70 hours despite peaking at 65,622 MW of capacity offline. Texas suffered that storm's worst impact by far due to a variety of factors. Among other things, scant transmission capacity connecting the state's independent power grid to other grids severely constrained the amount of electricity Texas could import from its neighbors.

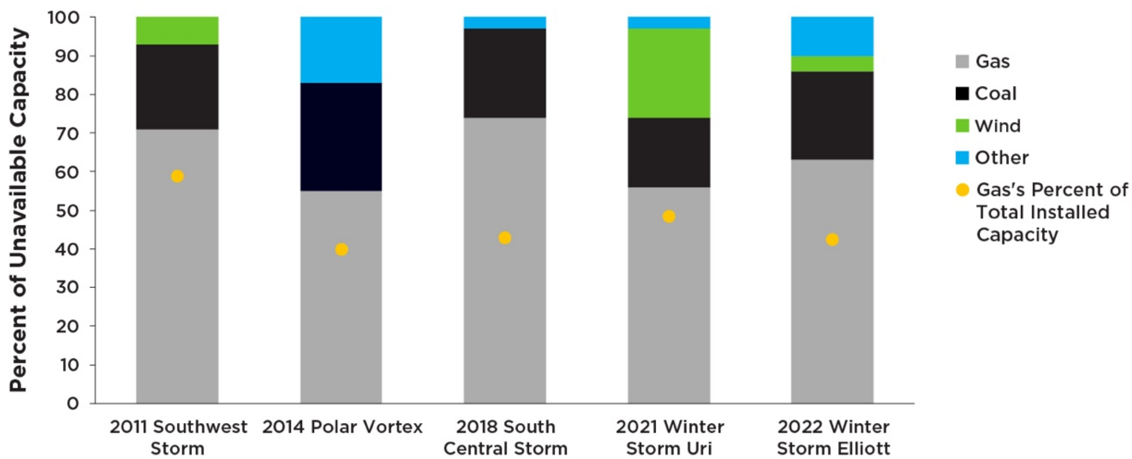
Winter Storm Uri's devastation in Texas was unprecedented in the United States. Total damages have been estimated at $195 billion (City of Austin and Travis County 2021). In freezing temperatures, some households went without electricity for as long as four days (FERC 2021). More than 14 million people either lacked water supplies or were told to boil their drinking water (McNamara 2021). Moreover, follow-up research found an inequitable distribution of the power outages: households in racial minority communities were more likely to have experienced an outage, and those living with disabilities suffered longer and more frequent outages (Shah et al. 2023; Chakraborty, Collins, and Grineski 2023).

Ultimately, the effects of Uri killed 246 people in Texas, about two-thirds of whom died of hypothermia (Svitek 2022). On top of the human toll, the financial costs to communities have persisted long after the disaster and beyond Texas. Utilities significantly raised rates to pass their much higher costs for energy purchased during the storm onto customers, who are now burdened with paying those costs for years to come (Kansas Corporation Commission 2023; Hart 2022).

EXTREME WINTER WEATHER CAUSES GAS PLANTS TO FAIL DISPROPORTIONATELY

While the scale of the five storms and their impacts varied widely, the energy system failures were very similar across them. A key commonality among all five was that gas plants accounted, by far, for the largest source of generating capacity knocked offline. The cumulative gas plant capacity that failed during each event was more than twice that of the second-most-impacted category of capacity (Figure 1). Each storm exposed vulnerabilities of both the gas plant fleet within affected regions and the gas infrastructure that delivered fuel to those plants.

Figure 1. Generation Failures by Fuel Type During Five Extreme Winter Storms



Gas plants accounted for most of the failed capacity in all five recent extreme winter weather events. Gas plants failed disproportionately in comparison with gas's percentage of total installed capacity, indicating that they are more susceptible to extreme winter weather than are other resource types. Notes: (1) 2011 data are specific to Texas's main grid operator, ERCOT; it had the most customers experiencing rolling blackouts. (2) 2014 data do not include wind generator outages because NERC had no mandatory reporting protocol for them. (3) 2018 data are specific to failures caused by freezing issues at generators. (4) In its 2011 report, FERC adjusted wind outages downward to account for expected output based on actual wind speed conditions. It did not do so for the 2021 and 2022 storms. This could have made the wind outages in 2021 and 2022 appear more substantial than they actually were, since grid operators rarely expect wind generators to operate at full output. (5) Gas's Percent of Total Installed Capacity is specific to the areas impacted by the storm.
SOURCES: FERC 2011; FERC 2019; FERC 2021; FERC 2023; NERC 2014; EIA 2023b; SPP, n.d.

The US gas infrastructure system can be grouped into three primary components: production, transportation and storage, and end use, with power plants being the largest group of end users in terms of gas consumed (EIA 2023c). Extreme winter storms can affect all three components, potentially compounding the strain on gas plants and forcing many of them to fail at the same time. The power and gas systems' mutual dependence on each other has exacerbated these so-called correlated outages, but these plant failures can also be attributed to the sheer amount of area affected by the weather events in question. The events have exposed gas plants and gas infrastructure across large geographic areas to extremely low temperatures. Many facilities were unprepared and ill-designed for the low temperatures (Hilbert and Hallai 2021; FERC 2019). Even facilities that *were* prepared on paper often failed when an extreme storm hit (FERC 2021; FERC 2023).

SEVERE WEATHER DIRECTLY IMPACTS GAS PLANTS

A primary cause of gas plant failures is the direct impact of extreme cold weather on plant operations and equipment. Across all generator types, the top direct causes of plant outages in each of the major winter storm events related to equipment freezing, as well as to a second category labeled "mechanical/electrical" (FERC 2023). Equipment freezing is often caused by the freezing of particular components, including valves, water lines, inlet air systems, and sensing lines. Mechanical/electrical are non-freezing issues that occur when cold temperatures affect certain plant components. These issues include wiring failure, mechanical wear of valves, and embrittlement of flexible seal materials like rubber and silicone.

A troubling pattern in the more recent failures, which were largely of gas plants, is that they generally took place when temperatures were *above* the plants' minimum ambient temperature ratings.[4] Across fuel types, 81 percent of the freeze-related outages during Winter Storm Uri in 2021 occurred when the temperature was above the generating unit's minimum ambient temperature rating; that figure was more than 75 percent for Winter Storm Elliott in 2022 (FERC 2021; FERC 2023).

SEVERE WEATHER JEOPARDIZES FUEL SUPPLIES

Issues related to fuel supply are the second significant cause of lost gas capacity during extremely cold weather. Unlike other thermal power plant types, such as coal or nuclear plants, gas plants generally do not store their fuel on site. Instead, they depend on the real-time delivery of gas via pipeline, burning it upon delivery to produce electricity. This distinct characteristic leaves gas plants vulnerable to running out of fuel, since extreme cold weather can interrupt both the production and the transportation of gas. All five storm events involved gas-supply issues (FERC 2021; FERC 2023).

The significant drops in gas production during the 2011, 2021, and 2022 storms arose largely due to such issues as "freeze-offs" as liquids in the gas wells, wellheads, and ancillary equipment froze up and blocked the flow of gas.[5] During the 2022 event, gas production in the Marcellus and Utica shale formations in the Appalachian Basin dropped by 23 and 54 percent, respectively (FERC 2023). Production dropped even more during Winter Storm Uri in 2021: Texas experienced a 70 percent decrease and the lower 48 states saw an overall 28 percent decrease (FERC 2021).

Gas supply issues can also arise even if production does not decrease. The 2014 and 2018 events did not cause significant drops in production even though fuel supply issues arose. In part, these occurred due to pressure drops and other physical issues affecting gas pipelines, but they also resulted from high coincident gas demand from non-power plant end users, such as homes and businesses trying to keep temperatures up. To save money, many gas plant owners choose to sign only "non-firm" or "interruptible" contracts for at least some of their fuel supply and transportation. The contracts of "firm" or "non-interruptible" customers, such as those in the residential sector, are fulfilled before non-firm customers, leaving less gas available to power plants during cold snaps as demand soars for residential heating.

Even firm contracts to supply or transport fuel do not give a gas plant a guarantee that it can get fuel if a winter storm is severe enough. During Winter Storm Elliott in 2022, failed gas deliveries under firm fuel supply and/or transportation contracts led to 16.5 GW of cumulative losses of gas plant capacity. This was even more than the 14 GW of capacity lost due to failures to fulfill gas deliveries under non-firm transportation contracts (FERC 2023).[6]

The mutual dependence of the power and gas systems also presents a vulnerability with its potential to create a feedback loop of failures. Gas plants need fuel to produce electricity, and the gas system needs electricity to supply the fuel. Rolling blackouts can hit gas production and processing facilities, constraining the amount of fuel supplied to the country's primary source of electricity, causing more rolling blackouts, and so on. FERC estimated that power losses caused 23.5 percent of the gas production drop during Winter Storm Uri (FERC 2021).[7]

Summer Also Threatens Gas Reliability

Extreme summer weather can also pose significant threats to gas plants, even if these are typically less severe than those posed by extreme winter weather. Heat waves, droughts, hurricanes, and floods can all affect gas plants, with heat waves and droughts having the most significant impact.

HEAT CAN FORCE POWER PLANT DERATES AND OUTAGES

High temperatures can reduce both the efficiency and the maximum generating capacity of gas plants. High ambient air temperatures decrease the maximum generating capacity of gas plants by reducing the amount of fuel they can burn. In addition, gas plants require cooling; as the coolant (water or air) gets hotter, plants are less able to dissipate waste heat. As a result, they operate at lower power (Dumas, KC, and Cunliff 2019).

Across all types of generation, extreme heat increases the likelihood of power plant output reductions (or "derates") and forced outages (NERC 2023). In summer, high temperatures and prolonged operations often occur simultaneously as heatwaves lead to higher electricity demand; the combination can cause unexpected plant breakdowns. For example, many California gas plants were forced offline or significantly derated over the course of a 10-day heatwave in September 2022 (Regenerate California 2023).

DROUGHT CAN HAMSTRING WATER-DEPENDENT POWER PLANTS

Because many plants use water for cooling, a shortage of cooling water during extreme summer weather can also affect the gas fleet (EIA 2018). In fact, water shortages can force water-dependent plants to shut down entirely. For example, Texas experienced its second-worst drought in the state's history between 2010 and 2015. As a result, one plant operator took three gas plant units, totaling 403 MW, offline for almost a year until rain replenished the reservoir from which they pulled cooling water (ERCOT 2016). Since then, Texas's grid operator, ERCOT, has published drought risk analyses that have repeatedly classified more than 10,000 MW of gas plant capacity as at risk over the following 18 months (ERCOT 2023).

As the impacts of climate change intensify and lead to more frequent and more severe weather events, the risks that drought poses to the gas fleet may increase significantly. For example, a recent analysis found that under a high-emissions climate scenario, the most severe drought could disrupt 20 percent of ERCOT's thermal generation in Texas. The results were mixed when the same study looked at whether climate change could lead to an increase in thermal-generation disruptions in the state due to drought (Turner et al. 2021).

A Reassessment of Gas Plants' Contributions to Grid Reliability Is Overdue

Extreme weather events, in both winter and summer, illustrate the fragility of gas plants. They also highlight the clear need to reevaluate the assumed contributions of these resources to grid reliability. For far too long, programs to ensure the ability of electricity supplies to meet customer demand (often referred to as "resource adequacy") have overvalued the reliability contributions of gas plants.

The methods used to evaluate resource adequacy can have multiple implications. First, the chosen method directly determines the contribution of existing resources, using the result to inform how much the owner of the resource gets compensated for that contribution. Second, when utilities and regulators make decisions about new resource investments, resource adequacy can be a major factor tipping the scales in favor of certain resource types. Finally, and most important, overestimating the contributions of certain resource types can ultimately lead to power outages. This has been the case especially for gas plants, which failed at an unprecedented scale during recent extreme winter storms.

Currently, grid operators use relatively simple methods to determine the contributions of dispatchable resources, such as gas plants, toward resource adequacy. Most grid operators assume that gas plants will be available to generate electricity at their installed capacity (ICAP) or that gas plants will be available at their unforced capacity (UCAP), which takes into account the probability of some forced outages (Box 1). However, neither method accounts for the possibility of widespread, correlated gas plant outages, such as those experienced during the five extreme winter storms.

Box 1. Three Methods for Measuring Reliability Contributions

ICAP, UCAP, and ELCC are the three most common methods grid operators use to determine the reliability contributions of different resource types.

ICAP—"installed capacity"—is essentially a measure of a power plant's maximum generating capacity. In many cases, ICAP values are determined seasonally (e.g., separate values for summer and winter). Many grid operators require testing to confirm that power plants really can produce energy at their ICAP values.

UCAP—"unforced capacity"—starts with a power plant's ICAP value, adjusting it to account for the probability that the plant will not be able to produce electricity when needed. UCAP values are typically calculated using historical operational data to determine the probability of a power plant being offline.

ELCC—"effective load carrying capability"—is a probabilistic measure of a power plant's ability to produce energy when it is needed most. ELCC uses probabilistic grid-modeling tools to determine the expected reliability contribution of a resource or group of resources under a wide range of scenarios.

To address the shortcomings of current methods, the electricity industry has begun exploring more sophisticated ways to assess the reliability contributions of thermal resources, including gas plants (Stenclik 2023). One alternative method is effective load carrying capability (ELCC). For years, many grid operators have used ELCC to assess the reliability contributions of variable renewable resources such as wind and solar.[8] When applied to gas plants, ELCC can account for the risk of correlated gas plant outages due to, for example, extreme winter weather that directly affects gas plants or disrupts the gas fuel supply (Dison, Dombrowsky, and Carden 2022). Thus, some grid operators are considering applying ELCC not just to renewable resources but to *all* resource types, including gas plants (PJM 2023a). This more accurate quantification of the resource adequacy contribution of gas plants is a critical step toward ensuring that the grid is reliable, especially in the face of increasingly extreme weather events.

Gas Failures in Extreme Weather Events Warrant Action

Gas plants have a reliability problem when it comes to extreme weather, particularly during the peak-demand winter and summer seasons. Scientists have linked climate change to a greater likelihood or severity of extreme weather events like heat waves, droughts, and winter storms (Cohen, Pfeiffer, and Francis 2018; Cohen et al. 2021; UCS 2018; Marvel et al. 2023). If the trajectory of worsening extreme weather events continues, they could increasingly threaten the US electricity system, currently dominated by gas plants. Furthermore, as weather events get more extreme, rolling blackouts will become more dangerous because being without electricity during extreme temperatures can be life threatening.

FURTHER INVESTMENT IN FOSSIL FUELS WILL NOT SOLVE THE PROBLEM

The failures of gas plants and the gas system in extreme weather often involve correlated outages and vulnerabilities that are inherent to gas as a fuel source. Among others, these vulnerabilities include the absence of on-site fuel and a high dependence on water, which makes the resource prone to both freezing and drought issues.

Therefore, grid-reliability problems that arise in extreme weather cannot be solved simply by building out more infrastructure, such as gas production wells, pipelines, and power plants. Instead of bolstering grid reliability, the evidence since 2011 suggests that continuing to lean on gas plants will lead to the same types of grid failure in extreme weather. For example, the Mid-Atlantic grid operator, PJM Interconnection, has more generating capacity coming from gas plants than from any other source, and it was set to have a high capacity-reserve margin during 2022's Winter Storm Elliott (PJM 2021). But the dominance of gas plants proved to be a glaring weakness. Gas capacity made up more than 70 percent of the power plant outages and pushed PJM to the brink of rolling blackouts (PJM 2023b).

Nor will the problem be solved by equipping gas plants with the ability to burn diesel or another fossil fuel that can be stored on site. Diesel plants, like gas plants, have also been found to underperform in cold weather, and plant operators have experienced failures in fuel switching during recent winter storms (Murphy, Sowell, and Apt 2019; FERC 2021; FERC 2023).[9] Furthermore, petroleum-based fuels like diesel are heavily polluting and, like gas and coal, they exacerbate global climate change, making their use a misguided, unproductive approach to grid reliability during extreme weather events.

While "weatherizing" or "winterizing" gas plants and other components of the gas system can mitigate near-term reliability risks, these measures are not the ultimate solution to the grid reliability problems the country has experienced in recent years. During Winter Storm Elliott, for example, the owners of almost all power plants that experienced failures had cold weather–preparedness plans in place, as required by NERC's winterization standards (FERC 2023).[10] Most power plants in colder climates, such as those in PJM and MISO's northern territory, are familiar with cold-weather operations and their enclosed designs shield them from the elements (FERC 2019).[11] Yet large amounts of gas plants in those grid operators' territories still went offline unexpectedly during Winter Storm Elliott (MISO 2023; PJM 2023b).

The extent of the damage due to future extreme weather events is uncertain, and the fact that the gas-fired power system could theoretically be weatherized to withstand today's extreme storms does not mean it will withstand tomorrow's storms. Furthermore, a strategy primarily focused on weatherizing gas plants and other gas infrastructure would be an unsustainable, costly investment in a resource that is a primary contributor to climate change and must be phased out along with all other fossil fuels in coming decades.

REGULATORY CHANGES ARE NEEDED TO ADDRESS GAS FAILURES

Regulators and the industry are exploring ways to at least mitigate near-term reliability risks. Early signs suggest that key stakeholders are beginning to recognize the growing vulnerability of gas-fired power in the context of climate change. For example, after Winter Storm Elliott, PJM proposed to adopt an ELCC method of capacity accreditation across all resources, including thermal generators such as gas plants. That would be a significant step toward a more accurate assessment of a gas plant's reliability contributions and vulnerabilities (PJM 2023a). Beyond PJM, FERC is considering more consistent and accurate methods to accredit capacity nationwide, which could lead to clearer, more uniform guidance from the commission on how to quantify the roles of different resources in keeping the lights on (ACP 2023).

NERC has also begun acknowledging the recent reliability shortcomings of thermal generators (NERC 2023). In the aftermath of Winter Storm Uri in 2021, NERC adopted new reliability standards that include better winter-preparedness planning and transparency from power plant owners. The standards will require owners to identify vulnerable plant components and implement freeze-protection measures as a way of weatherizing their generators (NERC 2021).

To hold the owners of gas plants and gas infrastructure accountable in keeping communities safe during the transition to clean resources, some amount of weatherization investment may be prudent. Under FERC's oversight, NERC creates comprehensive reliability standards for electric transmission and power plants, but no such standards cover the gas system that delivers fuel to thousands of those plants. Stronger oversight and the establishment of reliability rules for the gas system, which may trigger weatherization investments, will be necessary to reduce the risks of more Uri-like catastrophes during the transition to clean energy. Critically, any such rules must be accompanied by that transition as the main goal.

Furthermore, the risks of grid failure will evolve as the energy transition progresses and the climate continues changing. Information about when, where, and why gas plants and other resources fail is currently publicly available only in a limited manner, with varying degrees of transparency from state regulators, regional grid operators, and federal authorities such as FERC and NERC. Making high-quality data on grid reliability available and accessible to policymakers, researchers, and the public would help ensure that the grid is better prepared to withstand the wide array of threats to reliability.

Clean Resources Can Help Ensure Grid Reliability

When deciding about new investments for the purpose of meeting grid reliability requirements, regulators and utilities should prioritize clean alternatives to gas plants. These include solutions on both the supply side and demand side of the nation's energy system.

RENEWABLES, STORAGE, AND TRANSMISSION ARE CRITICAL SUPPLY-SIDE SOLUTIONS

A diverse portfolio of renewable energy resources, coupled with energy storage and additional transmission capacity, can contribute significantly to meeting resource adequacy requirements. For example, diversity in renewable technologies (solar, onshore wind, offshore wind, geothermal, and hydropower) together with geographic diversity of these resources can help ensure that output from renewables is sufficiently consistent across a region. When combined with energy storage, renewable energy can be stored for occasions presenting the greatest challenges to grid reliability. At the same time, significant investments in transmission capacity will make it easier to integrate growing levels of renewable energy into the grid and help ensure that energy can be shared across regions. However, grid operators must conduct detailed studies before integrating new energy projects into the grid, and the list of projects waiting to be studied (often referred to as the "interconnection queue") has increased dramatically over the past decade, leading to significant delays in bringing clean resources online (Rand et al. 2023).

The role of gas plants on a deeply decarbonized grid is murky; in contrast, clean energy technologies clearly will play a pivotal role. Many expert studies have indicated that approximately 90 percent of electricity could come from renewable sources while maintaining grid reliability with today's technologies (Denholm et al. 2022; Clemmer et al. 2023). While such studies show that renewable energy and energy storage resources can meet a significant portion of resource adequacy requirements, many analyses keep a significant amount of gas plant capacity online, operating very infrequently to help ensure reliability on a highly decarbonized grid. However, most studies almost certainly overvalue the reliability contributions of gas plants, failing to account for the very real possibility of widespread, correlated gas plant outages.

In addition to studies showing the reliability benefits of a portfolio of clean energy resources, there are also clear examples of individual renewable resource types making significant contributions toward grid reliability. For example, a recent PJM analysis indicated that the winter ELCC of offshore wind (68 percent) is higher than that of a gas combustion turbine (63 percent) (PJM 2023c). This indicates that, megawatt for megawatt, offshore wind will go further toward ensuring resource adequacy in PJM. On a more tangible level, a different analysis found that, if Texas had had an additional 10 GW of solar during Winter Storm Uri, the rolling blackouts would have been far less widespread for multiple hours every day (Rhodes 2023).

DEMAND-SIDE SOLUTIONS REDUCE AND SHIFT ENERGY CONSUMPTION

Demand-side solutions can also contribute to resource adequacy in lieu of further investments in, and reliance on, gas plants. Energy efficiency, flexible demand, and distributed energy resources can all reduce or shift electricity demand, easing the strain on the power grid (McNamara 2020). For example, a recent analysis found that "virtual power plants"—collections of demand-side resources such as rooftop solar, distributed batteries, electric vehicles, and smart appliances—could meet resource adequacy needs and significantly reduce utility costs (Hledik and Peters 2023). Other studies have demonstrated that demand-side resources can play a significant role in decarbonizing the power grid and maintaining grid reliability throughout the transition to clean energy (Clack et al. 2021).

THE BENEFITS OF CLEAN ALTERNATIVES EXTEND BEYOND GRID RELIABILITY

Undoubtedly, clean energy alternatives to gas plants can play a major role in ensuring grid reliability. Yet clean energy options offer many additional benefits. First and foremost is the reduction in global warming emissions that comes from transitioning away from fossil-fueled resources. As the impacts of climate change intensify and extreme weather events endanger the power grid and broader energy system, it makes little sense to double down on gas plants: associated methane emissions—from extraction to leakage to combustion—only exacerbate the problem.

Furthermore, reducing the country's reliance on gas plants can improve both air and water quality. Burning gas with air in gas plants produces nitrogen oxides (NO_x), sulfur oxides (SO_x), and particulate matter, all of which are harmful to human health (EPA 2023). NO_x is also a precursor to other air pollutants, such as ground-level ozone, a primary component of smog.

Across the country, gas plants are disproportionately located in communities of color (Cranmer et al. 2023), which subjects these communities to increased health risks from gas plant pollution. Reductions in gas combustion can help reduce the levels of these air pollutants and improve health outcomes for historically oppressed communities. In addition, gas extraction can pollute both groundwater and surface water, so reducing the use of gas at power plants would reduce the pollution of water supplies that people depend on.

Finally, demand-side solutions can decrease the amount of new large-scale infrastructure that would be needed—transmission lines, distribution system infrastructure, and generation resources. Not only do demand-side solutions reduce global warming emissions and pollution, but they also reduce the amount of land required to produce energy along with the materials needed for large-scale energy infrastructure.

Policy Recommendations

The United States should not continue its overreliance on gas plants to meet the country's electricity needs, given their demonstrated reliability challenges during previews of what extreme weather looks like in a warming world. Grid planners, regulators, and policymakers must update the US energy system with solutions that reduce reliance on gas plants, bolster grid reliability, and mitigate the impacts of climate change.

FERC should order all electricity grid operators to use consistent methodologies when valuing the reliability contributions of all resources. The owners of gas plants benefit from capacity accreditation methodologies that overestimate the reliability contributions of those plants. This policy change would help facilitate the transition to clean electricity by putting clean energy technologies on a level playing field with gas plants and other thermal generators.

State regulators should not approve new gas plants except in the extremely limited cases when there are no viable clean energy solutions for grid reliability. In making such a determination, state regulators should require utilities to use probabilistic modeling tools to quantify the reliability contributions of new gas plants, taking into account the impact of extreme weather on plant performance. No new gas plants should be built in environmental justice communities.

FERC, grid operators, and state utility commissions should continue reducing market and regulatory barriers to clean energy resources. They should expand efforts to address the interconnection queue backlog of renewable and storage projects, increase interregional transmission planning to enable sharing of clean energy across regions, and allow aggregation of distributed energy resources and demand response to reduce peak demand and overall costs.

Grid operators, along with federal and state regulators, should provide the public with detailed, easily accessible information about power plant outages. This includes state public utility commissions and regional grid operators, as well as federal authorities such as FERC and NERC. More transparency will enable the public to better understand the causes of such outages and help in holding power plant owners accountable for preparing for, and responding to, these threats to grid reliability.

Policymakers should increase regulatory scrutiny of the gas system to reduce the risk of failures in extreme weather—and, in the event that failures do occur, ensure that they do not lead to widespread gas plant outages. A new regulatory structure for gas system reliability should focus on managing the transition away from gas, with the clear intention of phasing out the fossil fuel.

Gas plants can be unreliable, especially during extreme weather events, which are growing increasingly frequent and intense as a result of climate impacts from heat-trapping emissions, which come from gas plants themselves. This cycle must end. It is increasingly clear that consumers cannot trust gas when it is needed most, and the transition to clean energy provides an opportunity to build a more reliable power grid while simultaneously addressing climate change.

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ENDNOTES

1. "Gas" in this document refers to what is traditionally called natural gas. Also, the document refers to natural gas-fired power plants as gas plants.

2. Grid operators implement rolling (or "rotating") blackouts when electricity demand exceeds available electricity supply. These are a way of preventing more widespread blackouts that would take much longer to recover from. Power outages due to rolling blackouts differ from those related to disruptions of the distribution grid, the most common cause of power outages.

3. FERC and NERC did not report fuel-type breakouts of peak generation outages. Figure 1 shows the fuel-type breakouts of cumulative generation outages during the events.

4. Ambient temperature is the air temperature to which any equipment or system is exposed.

5. Gas producers can also reduce, or "shut in," production preemptively to avoid freeze-related damage. To use Winter Storm Uri as an example, shut-ins aimed at preventing "imminent freezing issues" accounted for 18 percent of the gas production decline by volume, versus 11 percent attributable to freezing issues at well and gathering facilities. The "Multiple Issues" category complicated the breakdown of causes; it accounted for 21 percent of the production decline and included the two above causes as well as other causes like poor road access and loss of power (FERC 2021).

6. FERC did not explain this particular finding. However, it did find that although a significant portion of gas plants had firm contracts for fuel *transportation*, a much smaller portion had firm contracts for fuel *supply*. For example, out of a sample of 155 generators, 61 (39 percent) had at least 75 percent of their gas fuel requirement under firm gas transportation contracts. However, only 25 of those 61 generators (16 percent of the sample) had at least 75 percent of the fuel needed for their peak winter operations under firm supply contracts (FERC 2023).

7. These were losses of power due to both rolling blackouts and other weather-related outages. FERC said it could not distinguish between the two because they happened at the same time and because gas infrastructure was not designated as a critical load to be shielded from rolling blackouts.

8. The concept of ELCC originated well before the advent of renewable generation (Garver 1966). However, ELCC was not commonly used to assess the capacity value of thermal generation.

9. Twelve out of the 14 generators in ERCOT that attempted to switch fuels during Winter Storm Uri failed or were subsequently derated. The strategy had a better success rate during Winter Storm Elliott when only 12 percent of the generators throughout the event area failed. However, only about a third of the fuel-switching-capable generators during Winter Storm Uri and a fifth during Winter Storm Elliott even attempted to switch fuels. Switches from gas to oil, or to a distillate oil like diesel, accounted for most of the ERCOT generators that tried to switch during Uri, as well as most of the generators that successfully switched during Elliott.

10. More than 90 percent of the power plant owners/operators that experienced unplanned outages, derates, and failures to start during Winter Storm Elliott had cold-weather preparedness plans in place, which included inspection and maintenance of freeze-protection measures. However, FERC identified areas of needed improvement because lower percentages of plant owners/operators took some pre-storm measures (e.g., less than 60 percent verified fuel supply inventory, and less than 40 percent increased staffing) (FERC 2023).

11. Enclosed-design plants differ from "open-frame" plants, which leave key plant components exposed to the elements. In the United States, open-frame plants are common in warmer climates. They are designed to avoid excessive heat buildup but are more vulnerable to freezing (FERC 2023).

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