Texas Winter Weather Power Failure

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*Abstract*—The winter weather event that occurred in North America in February 2021 had a large impact on many aspects of life. In the state of Texas specifically, this weather event created a serious emergency through its major effects on the state’s power network. Here, causes and possible solutions for this and future winter weather events are addressed.

# Introduction

Modern society is dependent on modern technology. As that technology advances, and society’s dependence on technology alongside it, the developed way of life is increasingly centered on applications of electricity. With this in mind, it is clear that the combination of the electrical generation, distribution, and transmission systems, the “electrical grid” as it is known, is an extremely central component of all modern infrastructure, especially in developed nations where electrified technology drives many aspects of daily life. The overarching power systems of the United States for example are incredibly large engineering projects that require intense management and maintenance to stay operational, not including near-constant efforts to understand and implement possible improvements to said systems. Outside of these normal efforts, the grid is a physical system that covers large swathes of land. It is therefore subject to the whims of many natural phenomenon, including the effects of extreme weather conditions, such as winter weather conditions. Below, one such instance of winter weather and its incredible influence on power system of Texas is discussed.

# Texas Event: February 2021

## Weather: Texas February 2021

In February of 2021, a winter weather event occurred across North America. From [1], this event had a drastic impact on local temperatures and precipitation in large swathes of the United States. The impact of this event was especially evident in traditionally warm areas. Of interest here is the state of Texas, which felt the effects of winter weather and whose population was largely unprepared for such an event. The event was caused by a polar vortex, which traveled from the north pole towards the south. This vortex lingered in place over southern central Canada for an extended length of time, perhaps more than a week. As the polar vortex held its position, cold air from the arctic was spilling southward over the central United States towards the state of Texas. While this arctic air made its way into Texas, several smaller weather events in the jet stream also traveled through the effected area. These events added the lift and moisture that allowed a full winter weather event, rife with frozen precipitation, to occur. In Texas, record low temperatures were reached, and temperatures below freezing were maintained for a length of time that is very unusual in the region.

## Overall Grid Impact and Response

The electrical power grid requires a constant balancing act to stay continually operational. The demand, the required power to satisfy the end-user’s electrical needs, and the supply, the amount of power generated or injected into the power system, must stay relatively equal. As mentioned previously, weather can have several tangible effects on the grid. Most notably, weather, and indeed temperature, are major motivating factors in the demand for power, because they change human behavior. For example, changes in temperature create shifts in demand by influencing individuals to heat or cool structures differently. Additionally, the physical impacts of weather issues can reverberate throughout the power grid, having direct effects on the transmission and distribution of power by way of damage to power lines and substations and on the operation of power generation facilities.

 These effects can combine into major failures in the power system, so it is important that the infrastructure and the grid operators are prepared in case emergency action is needed to maintain reasonable service. In the case of the February 2021 winter weather event in Texas, demand sharply increased as more and more consumers used electronic heating to compensate for the cold and as more consumer remained inside to avoid the cold and the inclement weather conditions according to [2]. The increase in demand necessitated an increase in supply; however, several generation locations across the state failed due to the weather, with more continuing to fail. This trend for both demand and supply seemed on track to continue, which may have resulted in a catastrophic failure. A failure of this nature may have resulted in a severe cascading blackout and the possibility of significant physical damages to the hardware of the power infrastructure.

 In order to avoid this failure and damage that, depending on severity, may have taken several months to repair, emergency action was taken by grid operators across the state. Several actions were attempted to correct the grid balance. First, operators attempted to increase supply by pulling from neighboring grids through the few outside connections the Texas grid has. This was unsuccessful, perhaps because the surrounding grids were also in some level of distress from the same winter weather event. Next operators halted the power to large industrial customers, who often agree to have their power connection cut during a crisis. This action did not result in a large enough correction, so the operators were forced to implement a series of rotating outages for many consumers. From [2], as more power generation fell offline, the implemented outages lasted longer than intended as operators were unable to rotate the outages as planned.

## Ultimate Consequences of Weather Event

As discussed in the introduction, reliable electricity is very important to modern day life. As such, the consequences of major, lengthy outages can be severe, especially when compounded by the responsible inclement weather, which disconnected consumers must brave without many of the benefits of electric driven technologies. According to [3], more than 4.3 million homes and businesses in Texas were without power for some time in February 2021. This loss of power alone is a significant damage to the Texas area. The loss is especially evident when considering the inconvenience and monetary loss that must follow any extended loss of power.

The severity of the damages done can perhaps be made clearer by stepping away from the financial and comfort loss in this situation and instead focusing on perhaps the clearest indicator of damage done: loss of human life. According to the Texas Department of State Health Services (DSHS) in [4], more than 150 people lost their lives in a way linked directly to this weather event, many associated with hypothermia. One can only assume that some of these deaths, especially those who passed due to hypothermia could have been prevent had the power losses, which were significantly worsened by power generation failures throughout Texas, been unnecessary or lessened in extremity.

# Generation Failures

Several noteworthy generation failures occurred during this winter weather event. Here, these failures are addressed in three categories: renewable energy sources, natural gas and coal sources, and nuclear energy sources.

## Renewable Energy

From [5], renewables in Texas consist primarily of wind resources with a secondary focus on solar generation. When considering solar generation, the impact of winter weather is clear. Snow and ice covering solar panels, as well as increased cloud cover and precipitation, will have a tangible physical effect on solar generation resources. More of interest here are the wind resources of the state, which make up a considerable majority of Texas’s renewable generation. It was popularized that the issues faced by Texans during the winter weather event were due the intermittent nature of wind and the unreliability of renewable resource generation. This was ultimately not the case. Although numerous wind-based facilities did lose the capability to supply power, the losses were based primarily on mechanical freezing in the turbines themselves, which are evidently not winterized sufficiently to handle the uncommon extreme winter weather events in Texas. Additionally, some losses were based on the inability of normal operations to function in the record low temperatures say [7] and [8].

## Natural Gas and Coal

Natural gas, followed distantly by coal, are the most utilized fossil fuels for power generation in Texas. Natural gas is in fact the number one supply resource used in the state. Thus, although there may have been some coal failures, the former power generation source will be discussed here. The natural gas generation failed due to a confluence of winter weather effects and resulting secondary effects. Although some issue may have risen from freezing inside natural gas power generation facilities, it seems that the failure to add to the power supply stems more from a lack of fuel. Indeed, the state of Texas is a large producer of its own fossil fuels—and therefore does not historically store large quantities as more can be pulled from the ground quickly when needed. So, as the weather conditions made it very difficult for normal operation of natural gas drilling, the state did not have enough fuel to produce as much power as during normal operational conditions. This situation was exacerbated, according to [7] and [9], by consumer use of natural gas as fuel for emergency heating and is cyclic in nature: as more generation fell off the grid, more fuel production lost power.

## Nuclear Energy

Another significant source of production in Texas is nuclear power. One of two nuclear reactors at the South Texas Nuclear Power Station, halving the power supplying capability of the station. This event is notable as nuclear generation is generally resistant to weather events; so, one would expect shutdowns due to winter weather to be rare. From the NRC incident report in [10], the cause of the shutdown in this case was an automatically triggered response to low steam generator levels. This low steam level was the direct result of the mechanical loss of two feedwater pumps, number 11 and 13 of the plant. Although the official NRC event report still hold the cause of the pumps’ failure to be unknown, it has been indicated that the fault rests on the failure of pressure sensing lines connected to the pumps on the secondary side of the facility. This failure is stated in [11] to be a cold weather-related failure, perhaps freezing-related mechanical failure. It may be that some connection outside the facility were not fully insulated like those inside.

# Solutions

## Inherent Solutions

It seems that, to avoid losses in power generation during similar extreme winter weather events, there are three obvious steps, however unfeasible, that may prove effective. Each will be enumerated here, with their respective implementation struggles and a final plan of action, in the proceeding sections.

The first possible step would be to decrease the overall demand for power in Texas. One way to do this would be to increase the efficiency of the end-use of power. Increasing the efficiency of power usage should allow for a lesser magnitude of overall power consumption, demand. Therefore, in theory, Texas could lower its demand sufficiently enough that, in future weather events, the power supply, even should numerous facilities fail, is sufficient to maintain continuous power to consumers with no disconnection actions.

Second, the state of Texas could increase its level of connectivity to surrounding grids. Historically, the operators of Texas’s power grid have intended to stay as far separated from outside grids as possible. Thus, by adding more connections to neighboring system, Texas would be better prepared for the importation of power in times of need.

 Finally, the third, and perhaps most obvious solution, is to improve the winterization of existing and future power generation, transmission, and distribution equipment. From the example set by the generation failures 2021 winter weather event, it is clear that winterizing the state’s means of power generation could be especially important. Specifically, Texas could implement increased winterization standards on renewable, nuclear, coal, and natural gas facilities, along with the interconnections that drive said facilities.

## Feasability

Having read all three suggestions in the previous section, it may be clear that none of the three are fully feasible for real world implementation. Decreasing demand in a manner sufficient enough to impact supply versus demand during extreme events, especially through an increase in efficiency, may be very unlikely. It is also very unreliable, as it depends heavily on technological development and implementation, both of which are complex systems driven primarily by human concerns. To address the second suggestion, the state of Texas is unlikely to increase its connectivity. This approach to minimize risks of system-wide failures in Texas has been suggested before. Historically, it has always been denied because for political reasons. Namely, the state’s populace, or at least their administrative representation says [12], hold a strong inclination to avoid connections and keep Texas as physically independent from other US states and other nations as possible. The final suggestion is unfeasible as a whole due to the significant amount of work, managerial, design, and physical efforts, and the monetary cost required to initiate and complete such a project. The effort required and the costs should be evident when considering the scale of the electrical infrastructure of the state of Texas. Managerially, the amount of communication needed between power generation owners, grid operators, end-users, and the bodies controlling the land containing physical aspects of the system, which must be dug-up to winterize the existing system, are potentially numerous. This may increase possible implementation difficulty immensely.

## Suggestions Moving Forward

The first suggestion is completely unreliable. While it would be nice to be able to confidently say that the efficiency of end users will increase so significantly, one can only hope for that occurrence; so, the first suggestion is more of a hope and is not a plan of action that can be taken. The second suggestion is also untenable because, as seen in the February 2021 event, winter weather having significant effects on the whole of Texas is likely large enough to also affect the surrounding power grids negatively as stated in [2]. Additionally, it seems unlikely that the historic stance of the state legislature will suddenly shift on this issue. Thus, the course of action suggested here is primarily focused on a modification of the third suggestion above. Namely, winterization should occur but not over the entire system as a single project. The system should instead be broken down into a set of tiers. Each tier is to be assigned with its own priority level; then, winterization should occur according to priority. To develop these priority rankings, more study will be necessary. The computation of the rankings should include a multitude of considerations, perhaps chief among them reliability, cost, resource requirements, man power, and impact on system resiliency in winter weather according to simulation. Although significant research is needed to accurately and intelligently decided on an order of approach, it may be suggested to begin with addressing nuclear winterization, as it seems to be a more isolated, straightforward event and is generally very resilient in the face of weather conditions, and to end with fossil fuel resources, as their failures depend heavily on the production of fuel which extends the requirements for an increased to effective winterization.

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