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Lessons Learned from the February 2021 Texas Power Outage

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Climate change has influenced the means and extremes of weather throughout the world (Ward, 2013). Extreme weather, including storms, cold weather, ice storms, hurricanes, tropical storms, tornadoes and extreme heat, and wildfires (Kenward & Raja, 2014), is expected to increase in frequency, intensity, and duration as a result of the continual increase in global greenhouse gas concentrations causing climate warming (Panteli & Mancarella, 2015). Extreme weather poses multiple threats, including disrupting food and water supplies, increasing mortality, and damaging critical infrastructure.

Electric power infrastructure is especially vulnerable to such threats as damages can result in power outages. Power outages impact hundreds of millions of Americans, costing the U.S. economy tens of billions of dollars each year (Kenward & Raja, 2014). Between 1964 and 2009, weather-related events accounted for 41 of the 57 major grid failures in the U.S. and Canada, with 13 of them being a result of snowstorms (McLinn, 2009). Major grid failures are defined as unplanned events affecting at least 30,000 customers for a downtime of at least 1,000,000 customer hours.

Furthermore, trends indicate a dramatic increase in weather-related blackouts since the 2000s (Panteli & Mancarella, 2015). As technology continues to develop, there has been an increasing dependency on electricity for essential activities and services, including transportation, commerce, communications, health care, water, and emergency response (Ton & Wang, 2015). Considering the importance of the electricity sector and the increasing threats of climate change, there is an urgent need to develop resiliency in North American power systems in response to winter storms to safeguard security, quality of life, and economic activity. This especially became apparent during the Texas winter storm in February 2021. As such, this article reflects on the shortcomings of the system resulting in the Texas power outage and possible recommendations for electric utilities to implement resiliency and reduce the impact of snowstorm-related power outages.

North America is no stranger to snowstorms and accompanying power outages, as demonstrated by the Canada and Northeast U.S. power outage of 1998 (Ward, 2013), the New York blackout of 2003 (Reuters, 2012), the Fairbanks winter storm in 2015 (Putman, 2015), and countless others throughout Eastern and Western Canada (Regnier, 2017; CBC News, 2020). Most of these power outages can be attributed to high winds and heavy precipitation, causing trees and tree limbs to fall and damage electricity distribution lines and poles (Campbell, 2012). The accumulation of ice can also weigh down overhead lines, towers, or poles causing damage (Ward, 2013). The accumulation can also increase the area of overhead lines making them more susceptible to collapse in high winds. 'Galloping' can occur when ice builds up on lines in an airfoil shape leading to high vertical oscillations and subsequent fatigue failure. Additionally, short-circuiting can occur when ice and snow build up on insulators, bridging the insulator and creating a conducting path causing flashover. Cold weather is expected, however, and many electric utilities have plans to restore the system and minimize the impacts of power outages.

On the other hand, the Texas power outage had major implications. In addition to the storm being a rare 'once in a generation' event comprising of a combination of cold air, snow, and ice at a substantial magnitude (Buckingham, 2021), the state made little preparations. Many homes were left without electricity and heat for more than 24 hours (Gold, 2021). One hundred eleven lives were claimed as a result of fires, hypothermia, carbon monoxide poisoning from the use of generators to get warm, and lost power to people on lifesaving medical equipment in addition to road accidents and falls (Whelan, 2021). It is estimated that the Texas storm caused a total of $45 to $50 billion in expenses, including damages to homes, businesses and infrastructure, job and wage loss, medical expenses, and business closures (Steinbuch, 2021).

So, what went wrong? Firstly, the state operates its own power grid and is the only grid operator not under federal jurisdiction (Gold, 2021), exempting Texas from federally required safeguards and rules (Steinbuch, 2021). Texas deregulated the power system in 1999 to establish a free market electrical grid privatizing generation, transmission, and retail. In doing so, the electric industry claimed competition would allow customers to choose energy sources and pay lower rates.

Unfortunately, this means investing in weather protection and maintenance puts electric companies at a competitive disadvantage. While the Public Utility Commission supervises the Electric Reliability Council of Texas (ERCOT), neither are held accountable enough to ensure adequate power supply and customer protection. As a result, despite being the country's leading energy-producing state having an energy portfolio consisting of natural gas, coal, nuclear, wind, and solar, Texas does not maintain a reserve margin to supply more power than expected.

In the 2021 storm, frozen power plants and wind turbines and lack of natural gas supply to run needed power plants forced ERCOT to mandate rolling blackouts (Gold, 2021). Despite warnings of severe weather, several power plants were kept offline for scheduled maintenance, demonstrating system’s poor planning (Worland, 2021). Furthermore, dropping temperatures prompted residents to crank up heaters causing the energy demand to surge above available supplies resulting in more shutoffs (Gold, 2021).

While power was prioritized to hospitals, fire stations and water-treatment plants, there was not enough power to rotate blackouts between communities without critical infrastructure. Many residents went without power for over 24 hours, and while there was enough gasoline supplied at gas stations, there was no electricity to operate pumps (Plus Company Updates, 2021). Additionally, the Texas grid is not connected to neighbouring grids inhibiting the ability to import outside energy when supplies are low, or generators are unable to operate (Krauss, Fernandez, Penn, & Rojas, 2021).

While this may be the longest blackout in Texas history as a result of snowstorms, the state has experienced less severe yet similar events in the past. Texas previously experienced winter rolling blackouts in 2011 and 2014, where cold weather froze equipment and restricted natural gas, causing coal and natural gas units to trip offline (Gold, 2021). Despite warnings from the previous event, operators failed to act to strengthen the electric grid. Furthermore, the average age of electricity infrastructure, including power plants and transmission and distribution lines in the U.S., are over 30 years old and are nearing the end of their 40-year life expectancy (Campbell, 2012).

Several actions can be taken to update and promote resiliency in the electric grid against snowstorms, including hardening and operational measures. The Presidential Policy Direction 21 defines resilience as "the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents." (Ton & Wang, 2015).

The Department of Energy Office of Electricity Delivery and Energy Reliability has developed a Smart Grid Research and Development Program to modernize the electric distribution grid by implementing information, communication, automation technologies, and new operational practices. Measures outlined by the program include hardening the existing electricity infrastructure, updating design and construction standards, employing simulation and assessment tools to analyze and prepare mitigation plans, improving system response and recovery operation, and managing interdependencies between electricity and other critical infrastructure. A holistic approach is required to balance the interplay between the electricity grid's technical, organizational, social, and economic aspects.

Hardening of electrical infrastructure includes the use of heaters and insulation to protect lines and equipment from extreme weather conditions (Krauss, Fernandez, Penn, & Rojas, 2021). Additionally, insulators reduce the risk of short-circuiting caused by precipitation accumulation (Ward, 2013). Other hardening measures include reserve planning, installation of black start capabilities, repair crew mobilization plans, installation of onsite generation units, coordination with adjacent networks, vegetation management, undergrounding distribution and transmission lines, upgrading infrastructure with more robust materials, relocating facilities, and redundant transmission routes (Hussain, Bui, & Kim, 2019).

Operational resilience strategies include estimation of weather location and severity, demand-side management, prompt topology reconfiguration, microgrid island operation, automated protection and controls, monitoring, distributed energy resources (Oboudi, Mohammadi, & Rastegar, 2019), mutual assistance agreements (Campbell, 2012), control and protection schemes (Hussain, Bui, & Kim, 2019), disaster assessment, and risk assessment. Important characteristics system operators should adopt include the situational awareness and decision-making skills to anticipate and respond to power outage events (Panteli & Mancarella, 2015). This can be enhanced with smart grid technologies that monitor the electric system and implement microgrid strategies to isolate affected sections while adapting distribution and generation operations to promote resiliency (Panteli & Mancarella, 2015), (Hussain, Bui, & Kim, 2019).

Microgrids also can provide for critical loads or be used as a black-start resource for generators. Employing smart grid technologies will significantly improve monitoring and response efforts during power outage events. A combination of preventative control actions and operational procedures will help manage power outages. These options are the responsibility of utilities for choosing what practices and technologies to employ.

In Canada, initiatives exist to assess vulnerabilities and develop adaptation plans in response to climate change. In 2005, the Public Infrastructure Engineering Vulnerability Committee (PIEVC) was developed to assess the impact of climate change on Canada's public infrastructure (PIEVC, n.d.). The PIEVC Protocol reviews historical and projected climate change and weather events and establishes the adaptive capacity of individual infrastructure elements for risk identification (PIEVC, n.d.). Additionally, the protocol presents specific actions that can be taken to make adaptations, including changes and adjustments to design, operation, and maintenance.

The Climate Adaptation Guide developed by the Canadian Electricity Association in 2017 is another tool to help electric companies define, design, develop, and deploy climate adaption plans in the electricity sector (Canadian Electricity Association, 2017). The guide provides a framework for companies to utilize in developing company-specific strategies to be incorporated into enterprise risk management processes.

Although many actions can be taken to improve power systems, undertaking a revamp of the grid is costly and unrealistic (Panteli & Mancarella, 2015). Therefore, utilities must take the initiative in analyzing risks and performing cost-benefit analyses to determine practical yet effective updates to their respective systems to improve resiliency. While the weather remains a variable aspect of the power system, the costs associated with inaction are too high. The rare event of February 2021 may have had unavoidable losses and damages, but the state of Texas could do more to minimize the potential risks of such events. Blackouts may be inevitable but operating and planning measures should be utilized to anticipate and react to climate-imposed uncertainty.

A resilient system should be established in efforts to reduce the impact of weather-related events.

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