The Texas Deep Freeze of February 2021: What Happened and Lessons Learned?

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1. Motivations underlying the research

Extreme freezing temperatures, snow, and ice from winter storm Uri afflicted Texas February 14-18, 2021. Houston, Dallas, and San Antonio saw record-low temperatures of 13, -2, and 5 °F. The power grid operated by Electric Reliability Council of Texas (ERCOT), which serves most Texas power consumers, came close to catastrophic failure. Millions of ERCOT customers suffered blackouts for multiple days. Although true electricity demand was not measured, forecasted demand matched mid-afternoon 4-hour August peak demands, but for 72 consecutive hours.

Scapegoats for the widespread outages included wind generators, thermal generators, natural gas suppliers, Texas opposition to interconnections, ERCOT management, and ERCOT market rules. Although these various factors were blamed for the extended power outage on the ERCOT electricity grid in February 2021, no single problem fully explains the calamity. All forms of generation experienced capacity deratings, but failure to identify and address risks along fuel supply chains was a major contributor. Moreover, the vent highlighted a growing risk associated with expanded intermittent generation resources without sufficient available, dispatchable generation capacity.

2. A short account of the research performed

We analyzed load and resources in the ERCOT market in early 2021 to provide a baseline for the events of winter storm Uri. We then provide a detailed summary of the events before, during, and immediately after the winter storm in order to highlight where failures occurred. This allows a discussion of the deep and growing interdependence of the natural gas and electricity systems in ERCOT, which reveals a potential single point of failure for the entire energy system. We also address resource adequacy and transmission to neighboring regions, recount lessons from previous winter storms that triggered outages in ERCOT, and provide recommendations to address the identified inadequacies.

3. Main conclusions and policy implications of the work

Wind underperformed relative to its nameplate capacity, but this is always true. Wind generation capacity is "rated" at a discount to nameplate capacity based on expected wind resources, and it often outperforms or underperforms relative to that rating. During the winter storm, wind underperformed since output was below what would have been anticipated given the forecasted and actual wind speeds. But Wind's underperformance during the winter storm only mattered for grid stability because resources that typically back up wind were unavailable. This highlights the need to fully evaluate availability of back-up resources in planning scenarios.

Longer term, the increased value of reliability as the fraction of non-dispatchable resources increases needs to be adequately reflected in prices. A resilient, reliable electricity system requires price signals adequate to ensure sufficient investment in all types of capacity and the right mix of generation capacity.

Thermal capacity deratings varied across generation types, and natural gas had the largest cumulative capacity outages. Winterization of thermal capacity, and wind capacity, can be an important first step, especially under a favorable cost-benefit analysis. If all thermal capacity had remained operable

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during Uri, load shed likely still would have been necessary, but remained voluntary, thereby avoiding the EEA level 3 declarations.

Fuel supply issues must be addressed. Variability in wind generation requires flexibility in back-up sources of generation including the supporting infrastructure such as pipelines, storage and processing facilities, and wellhead production. During the February 2021 event, natural gas generation was needed far in excess of a typical February day, but power cuts negatively impacted the fuel supply chain and compromised generation. Fuel supply infrastructures should be mandatorily designated as critical load.

Interconnecting ERCOT with SPP, MISO and WECC might have yielded some short-term benefits. But surrounding regions were also stressed, as existing interconnectors were curtailed multiple times February 15-18. Longer term, increased transmission capacity would alter the location of capacity investments, and the impacts on reliability are uncertain. A study of the long-term effects of expanding interconnections between ERCOT and neighboring regions is warranted.

Assessments of ERCOT's management of the grid need to account for the fact that ERCOT doesn't own, operate, or regulate generation assets. To maintain system stability, it schedules generation and invokes previously arranged voluntary load reductions. During Uri, ERCOT's real-time management avoided catastrophic failure. Long-run planning, however, can be faulted for not adequately assessing the impact of extreme events across the entire energy supply chain. Better coordination among state regulatory agencies would allow long-run planning to extend beyond the electricity market into the various fuel supply chains.

Market structure rules might be improved to ensure adequate reserve capacity. Factors such as the social value of reliability, the value of lost load, and increased demand management need to be more actively integrated in market rulemaking. A full exploration of changes in market rules to cope with zero marginal cost, subsidized, non-dispatchable generation is beyond the scope of this research, but such exploration would usefully contribute to future planning.