Testimony

Long-Term Reliability in ERCOT: Some Critical Issues to Consider

Kenneth B. Medlock III
James A. Baker, III and Susan G. Baker Fellow in Energy and Natural Resource Economics and Senior Director, Center for Energy Studies, Baker Institute, Rice University

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Framing Remarks

Reliability and resource adequacy in the Electric Reliability Council of Texas (ERCOT) have been top legislative, regulatory, and commercial priorities in Texas for the past few years. Since Winter Storm Uri in February 2021, several different proposals have been advanced to increase system reliability. Many of the proposals are focused on aspects of market design,[1] but also include macro-level interventions, such as expanding transmission interconnects to neighboring regions, as well as firm-level actions, such as developing behind-the-meter generation options for large industrial consumers.[2]

In early 2022, the Baker Institute published a detailed examination of various factors that were blamed for the extended power outage in ERCOT during Uri.[3] That research concluded that no single factor was fully responsible. The various factors identified as contributing to the widespread outage included: DC interconnects to neighboring regions that were also experiencing generation outages had to be shut down; demand-response mechanisms were insufficient to mitigate other system failures, given the extremely high system load; all major forms of generation capacity (e.g., coal, nuclear, natural gas, and wind) experienced significant derates; and coordination failures in identifying and mitigating risks along fuel supply chains.

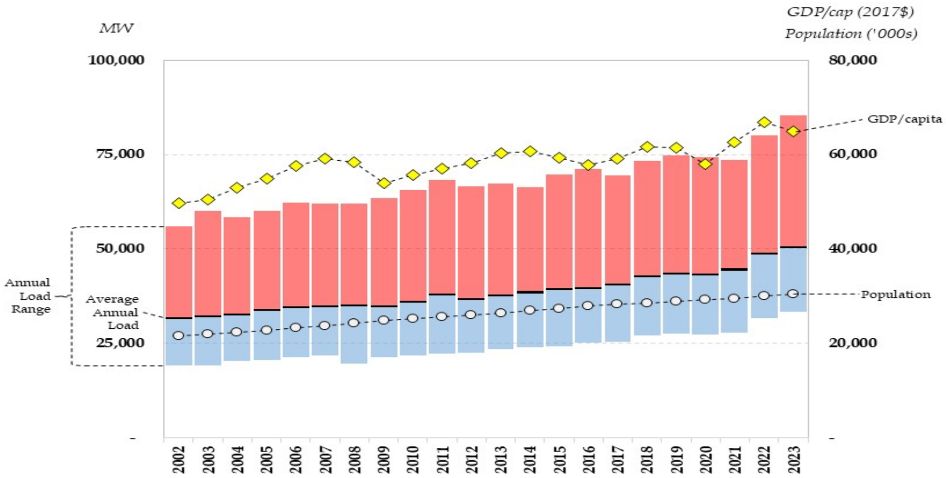
While wind capacity derates in the runup and during Winter Storm Uri could not be solely blamed for the outages experienced, the 2022 Baker Institute study emphasized a need to carefully analyze reserve margins as intermittent generation capacity expands, especially if *long term* grid reliability is to be ensured. Texas is number one in the nation in terms of *existing* wind capacity, as well as number one in terms of *planned* capacity additions for wind and solar power. Aggressive integration of intermittent resources can compromise reliability if it is accompanied by little-to-no addition of dispatchable forms of generation, especially if system load continues to grow. This point was further highlighted in a subsequent Baker Institute study published in February 2024 that was focused on reliability in ERCOT.[4]

ERCOT Load and Generation Capacity

An expanding population and robust economic activity have been key drivers of strong electricity demand (load) growth. For the foreseeable future, Texas' population is expected to continue to grow, and the economy is on solid footing, with added vectors for demand growth from electric vehicle (EV) penetration, cryptocurrency mining, carbon capture and storage (CCS), hydrogen market expansion, and a general trends toward increased electrification. There has even been a push toward electrification of oil and gas operations, which has manifested in very strong regional load growth in high oil and gas producing regions, which is also likely to remain true. The state's electrification of home heating (61.5%) is already significantly higher than the national average (39.8%). So, in many respects, Texas serves as an indicator of what expanding electrification means for electricity system requirements.

The Texas economy is vibrant and, given its industrial base, shows no real structural risks of a prolonged slowdown. When coupled with the cost of living, it should be no surprise that the population is likely to continue growing. Hence, the drivers of demand growth are structural and persistent. As indicated in Figure 1, average annual load has increased by 2.2% per year since 2002, amounting to an increase of almost 19 GW. Over the same period, peak load increased by almost 30 GW. This highlights a major point of emerging stress for the grid. Resource adequacy is not about average loads; it is about peak loads. So, flexible, dispatchable resources are needed most acutely in peak periods. Nevertheless, the majority of projected new capacity is set to be intermittent, such as wind and solar, rather than dispatchable, such as natural gas and batteries.

Figure 1 — ERCOT Load, Texas GDP per Capita, and Texas Population, 2002–23

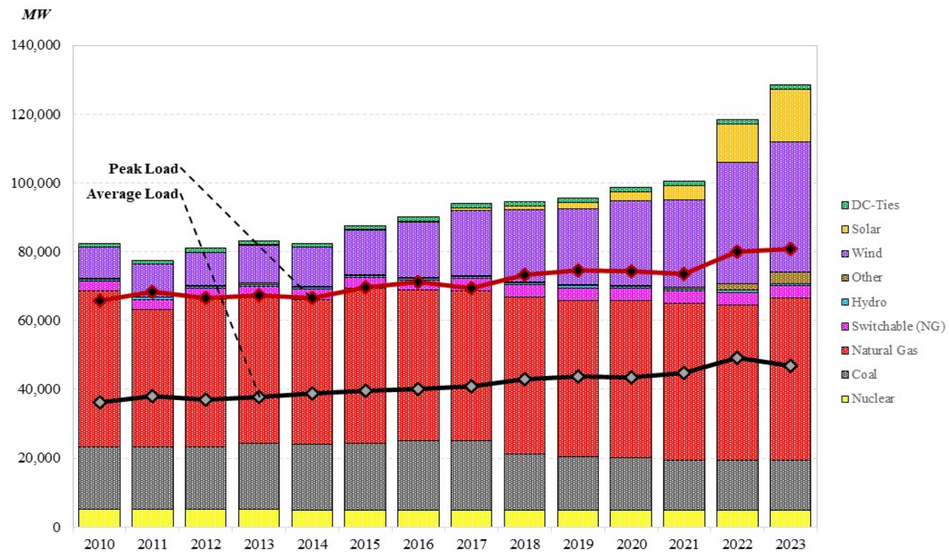


Sources: ERCOT, the Federal Reserve database (FRED), and the U.S. Census Bureau. Figure 1 is a reproduction of Figure 4 in "ERCOT and the Future of Electric Reliability in Texas," available at https://www.bakerinstitute.org/research/ercot-and-future-electric-reliability-texas.

Figure 2 reveals that the ERCOT generation portfolio is large and growing. As of summer 2023, ERCOT nameplate capacity consisted of wind (37.7 GW), solar (15.5 GW), nuclear (5.0 GW), coal (14.4 GW), natural gas (47.1 GW), and hydro/biomass/batteries (4.0 GW), plus DC ties to neighboring regions (1.2 GW) and natural gas capacity that is switchable (3.7 GW) into and out of ERCOT.

While the growth of ERCOT's generation capacity portfolio is impressive, there are valid concerns. Since 2000, wind capacity increased from 160 MW of installed capacity to over 37,000 MW, representing an average annual growth rate of more than 26%. Over the same period, solar capacity increased from 15 MW to almost 16,000 MW, which is an annual average growth rate of over 70%. Given the load growth that has been seen in ERCOT, a simple view of ERCOT capacity would seem sufficient. However, wind and solar are non-dispatchable resources, so their generation at any given moment in time is not controllable. This reveals some interesting challenges that a focus on capacity data alone does not fully capture.

Figure 2 — Generation Capacity by Type Plus Peak and Average Load, 2010-23



Source: ERCOT. Figure 2 is a reproduction of Figure 3 in "ERCOT and the Future of Electric Reliability in Texas," available at https://www.bakerinstitute.org/research/ercot-and-future-electric-reliability-texas.

Intermittency, Net Load, and Profitable Dispatchability

Average generation from wind and solar has increased in line with installed capacity (see Figure 4 below). But reliability requires adequate *operable* resources that can be dispatched to meet temporal fluctuations of system demands, so controllability is critical. If resources cannot deliver power on demand, the grid will be exposed to an increasing risk of failure, at which point the need to call on various emergency measures increases. Because wind and solar are not dispatchable, they are not "on-demand" resources. When wind and solar are on, they are typically all on due to meteorological conditions, which results in very low, sometimes negative, wholesale prices. When they are off, due to meteorological conditions, other system resources must be dispatched to compensate and maintain grid stability. Thus, while ERCOT's overall *nameplate* capacity has expanded considerably with the addition of wind and solar, its *dispatchable* capacity has not (see Figure 2). In fact, ERCOT load has exceeded dispatchable capacity with increasing frequency since 2018.

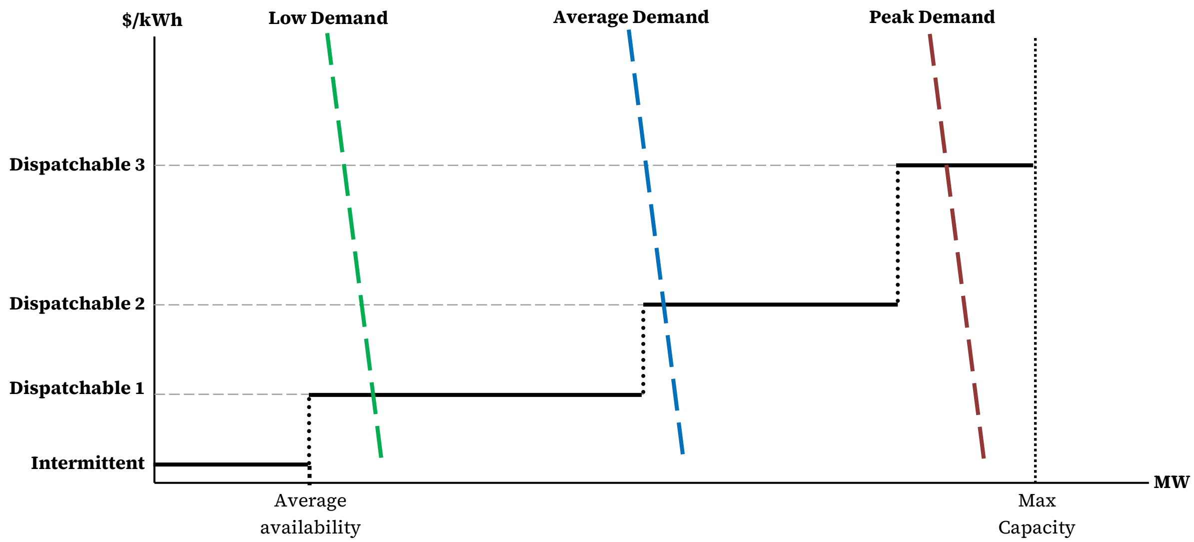
Subsidies have played a significant role in the tremendous growth of wind and solar capacity. Production tax credits and investment tax credits have helped facilitate continued capacity investment, even with an increasing frequency of very low, sometimes negative, wholesale prices. This is a well understood market distortion from subsidies – an over-allocation of capital to the subsidized activity that effectively crowds out capital investment in unsubsidized resources. While there may be a valid justification for such subsidies, such as the presence of an environmental externality, the unintended consequence of this distortion on investment is that *net* load (defined as the difference between load and wind plus solar generation) has become increasingly volatile over the last 15 years.

In and of itself, fluctuations in net load are not a problem, if there are sufficient dispatchable system resources available to compensate. Electricity system operators have always dealt with fluctuations in available generating capacity. For example, when plant outages occur, available back-up generation resources are called to offset the outage. If, however, back-up resources are insufficient, grid stability can become compromised, and wholesale prices will rise.

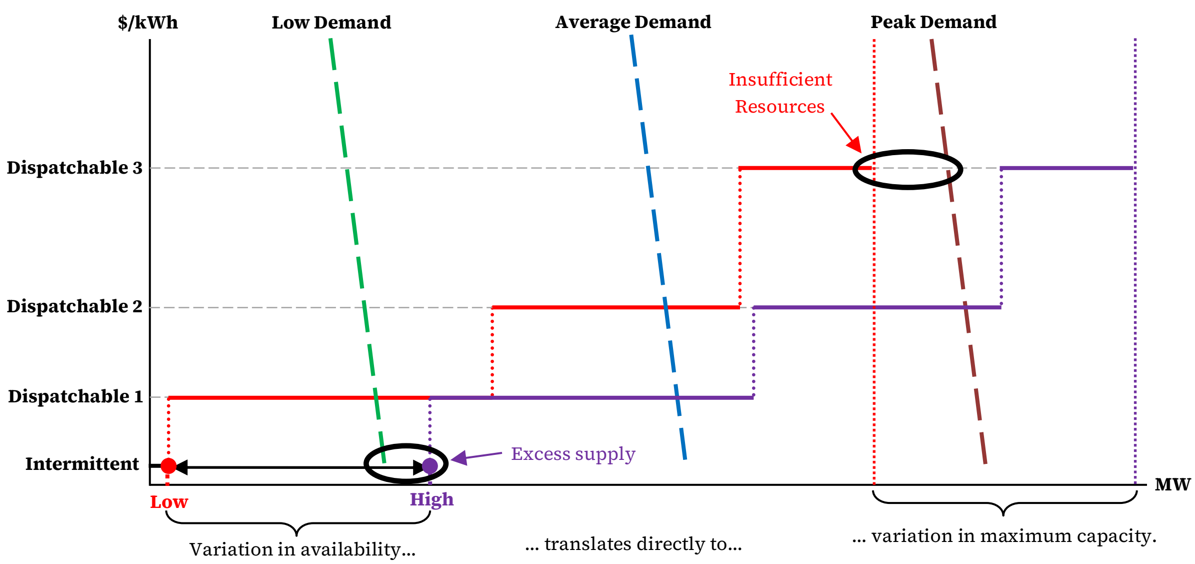
For grids with significant, subsidized wind and solar capacity, this is salient. Wind and solar resources are near zero marginal cost, which places them lowest in the merit order (see Figure 3). Hence, when they are available, they will dispatch to the grid first. This effectively makes the supply stack act like an accordion (see *'Low and High' intermittent resource availability operating capacity configuration* in Figure 3). In the case when intermittent resource availability is low (indicated in red in *'Low and High' intermittent resource availability operating capacity configuration* in Figure 3), additional dispatchable resources are needed relative to what is needed on average (indicated in *'Average' operating capacity configuration* in Figure 3).

Figure 3 — Simplified Supply Stack with Intermittent Resources

'Average' operating capacity configuration



'Low and High' intermittent resource availability operating capacity configuration



Source: Author. A time-lapse visualization, "ERCOT Generation by Resource: A Time-Lapse of Texas Fuel Mix in Electricity Generation," is at https://www.bakerinstitute.org/electricity-texas.

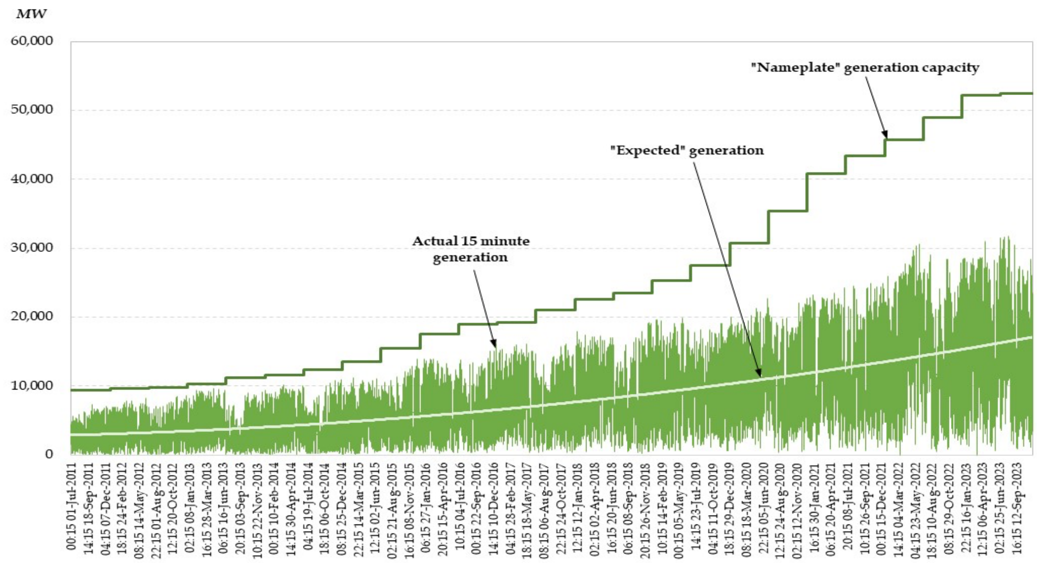
The variation in availability of intermittent resources also diminishes the profitability of investments in back-up, dispatchable resources. [5] This occurs because when intermittent resource availability is high (indicated in purple in *'Low and High' intermittent resource availability operating capacity configuration* in Figure 3), there is a reduced need for dispatchable resources, meaning those generation assets are not called into service, and thus generate no revenue. For profitability of those generating assets to be maintained, the reduction in revenue when intermittent resource availability is high needs to be fully offset by an increase in revenue when intermittent resource availability is low.

Unfortunately, if the evolution of capacity in ERCOT over the last 15 years (see Figure 2) is any indicator, this has not been the case. As seen in Figure 2, dispatchable capacity in ERCOT has not grown with peak loads, increasing the likelihood of resource insufficiency (red in *'Low and High' intermittent resource availability operating capacity configuration* in Figure 3) over time. This places grid balance on the shoulders of other interventions, such as demand-side management programs. Inadequate commercial incentive to deploy additional dispatchable resources, the time it may take to do so, and projections for load growth, collectively signal a burgeoning reliability challenge.

The variability presented in the simplified illustration in Figure 3 is immediately evident from the data on generation from intermittent resources in ERCOT. Figure 4 presents generation from wind plus solar in 15-minute increments covering the period from July 1, 2011 through November 30, 2023. Also indicated are the sum of nameplate generation capacity for wind and solar and the "expected" (or average) generation from both wind and solar over the full time-period.

As indicated in Figure 4, there are periods when wind plus solar generation drops to very low levels, and there are also periods when wind plus solar generation rises to very high levels. So, the variation is substantial.[6] Indeed, the difference between high and low generation from wind plus solar in 2023 was about 30 GWs, which is about 4 times greater than 2011. This reinforces the fact that net load is becoming more volatile, and the need for dispatchable resources in ERCOT to account for the dramatic swings in intermittent resource availability is growing.

Figure 4 — ERCOT Wind plus Solar Generation, 15-Minute Intervals, 7/1/11–11/30/23



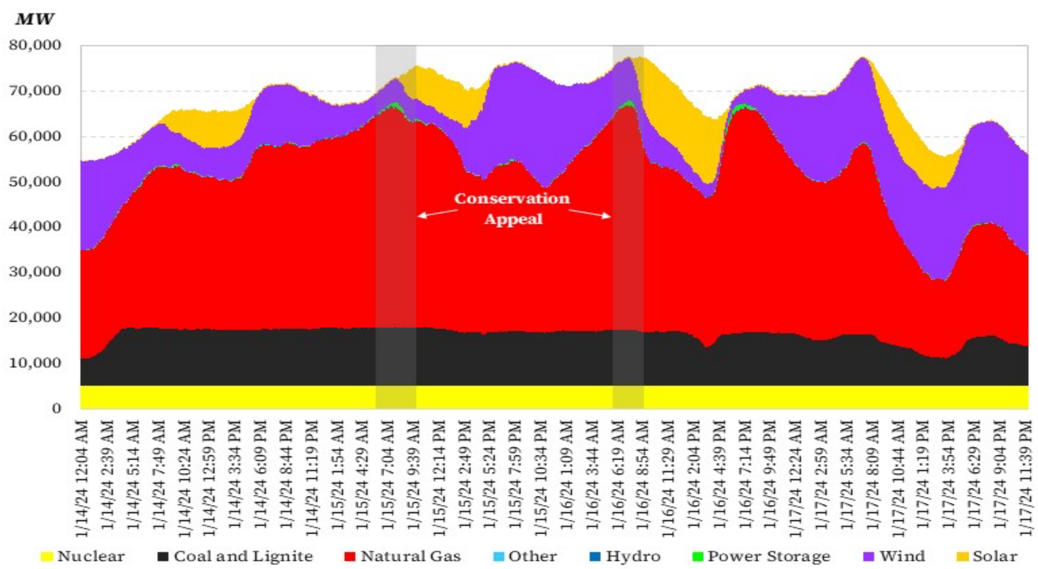
Source: ERCOT. Figure 3 is a reproduction of Figure 8 in "ERCOT and the Future of Electric Reliability in Texas," available at https://www.bakerinstitute.org/research/ercot-and-future-electric-reliability-texas.

We saw a real time demonstration of the importance of dispatchable generation capacity in January 2024. As indicated in Figure 5, the availability of dispatchable natural gas capacity (red) was sufficient to compensate for fluctuations in wind (purple) and solar (orange) generation during a high load period. Importantly, while natural gas was the "on-demand" dispatchable resource that balanced the system, *any* system configuration with sufficient, dispatchable generation capacity would have kept the lights on during the extreme winter event of January 2024. Dispatchability is key.

Intrastate Transmission Constraints

As identified in the recent Baker Institute report, "ERCOT and the Future of Electric Reliability in Texas," there is also a geographic inconsistency between load growth and generation capacity investment across ERCOT. This is not likely to self-correct, given that the drivers of load growth are centered around new industrial activity and population growth in high-load areas in the Texas Triangle, and capacity investments continue to be heavily focused on intermittent resources located in regions outside the Texas Triangle. Increasing the intermittent capacity in ERCOT presents one challenge, as detailed above, but the location of that capacity presents another challenge related moving the electricity that those resources generate to locations where it is needed.

Figure 5 — Generation by Source, 5-Minute Intervals, 1/14/24–1/17/24



Source: ERCOT Dashboard, data collected real time.

Analysis of locational marginal prices (LMPs) reveals that the market is already signaling the presence of periodic binding constraints related to patterns of generation, capacity investment, load growth, and transmission. Proper accounting and subsequent internalization of these signals is important for informing the optimal siting and configuration of investment in new generation capacity, transmission, and storage with respect to load. Indeed, the analysis presented in the aforementioned Baker Institute study highlights the linkages between intrastate transmission constraints, resource adequacy and the importance of dispatchable resources, and reliability, and presents several potential solutions.

Potential "Insurance" Solutions to Enhance Reliability in ERCOT

Risk premiums are often discussed as potential tools for correcting market distortions and providing price signals to market participants about a particular course of action, either through investment or operations, in various situations. This incentivizes risk-averse actors to internalize the costs of their actions. As the risk associated with a particular course of action rises, the risk premium also rises. This is at the core of how insurers price insurance policies on different activities, with riskier activities requiring higher premiums. To adequately warrant against undesirable outcomes, risk must be priced into the activity.

In ERCOT, risk premiums should capture the value of reliability to market participants. The prices needed to ensure resource adequacy and other services for reliability would incorporate these reliability premiums, effectively serving as reliability "insurance." For instance, to the extent that variability in intermittent resources introduces a reliability risk, an appropriately assessed risk premium is needed to compensate investors for providing the necessary market response capabilities.

Arguably, the Texas electricity market is inadequately insured. Fortunately, there are a portfolio of insurance options available, but policy will ultimately influence which options can be profitably exercised.[7] Potential options include:

- Investment in dispatchable forms of generation that can be called upon when intermittent resources are not available while load is high.
- Investment in storage capacity in utility areas and/or alongside industrial consumers to facilitate a reduction of purchases from the grid during periods of high demand.
- Investment in production area storage capacity alongside wind and solar generation to allow a "smoothing" of sales from intermittent resources and promote a more efficient use of transmission capacity.
- Expansion of transmission capacity to alleviate existing constraints, fully recognizing that the frequency and severity of constraints matter for the economic feasibility of the transmission capacity investment.

- Development of future generation capacity closer to load centers to avoid grid-level bottlenecks.

In closing, it should be noted that no market structure can be void of risk because there will always be unexpected incidents and low-probability events that can compromise any system. But allowing structural risks to reliability that can be avoided at a reasonable cost is unacceptable. Therefore, appropriate market design and sufficient regulatory oversight are critical. This opens the door for policy discussions that include, but are not limited to, implementing market structures and/or incentives that ensure adequate backup capacity as well as imposing sufficient penalties for underperformance by generators under specific obligations. In the end, resource adequacy and reliability are in the best interests of producers and consumers alike, as they establish a platform for sustainable long-term growth.

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[1] See "Resource Adequacy in ERCOT: How Long-term Market Design Reforms Could Enhance Reliability," available online at https://www.bakerinstitute.org/research/resource-adequacy-ercot-how-long-term-market-design-reforms-could-enhance-reliability.

[2] Transmission interconnects to neighboring regions is the focus of the "Connect the Grid Act" introduced by Congressman Greg Cesar (D-Texas) in the 118th Congress. Behind-the-meter generation options was among the topics discussed at the *Texas Electricity Policy Summit – A Consumer Focus: Demand growth, reliability, and investment*, held at the Baker Institute April 9, 2024.

[3] See P. Hartley, K. B. Medlock III, and S. Y. (Elsie) Hung, "The Texas Deep Freeze of February 2021: What Happened and Lessons Learned?" *Economics of Energy and Environmental Policy* 12, no. 2 (2023): 5–29. An earlier, longer analysis is available at https://www.bakerinstitute.org/research/ercot-froze-february-2021-what-happened-why-did-it-happen-can-it-happen-again.

[4] See P. Hartley, K. B. Medlock III, and S, Y. (Elsie) Hung, "ERCOT and the Future of Electric Reliability in Texas," February 7, 2024, https://www.bakerinstitute.org/research/ercot-and-future-electric-reliability-texas.

[5] It is important to also note that demand response mechanisms and price caps also play a role in increasing uncertainty about profitability of investment in dispatchable resources, as do siting restrictions, permitting costs, and transmission costs to market. The latter three also impact profitability of wind and solar. The former two are often justified based on net welfare gains to consumers. Demand response simulates dispatchable resources; price caps limit the price impacts of generation shortages.

[6] This point is expounded in "ERCOT and the Future of Electric Reliability in Texas."
[7] At the time of this writing, the full impact of the Texas Energy Fund (https://www.txenergyfund.texas.gov/) is yet to be seen, but there has been significant interest expressed by project developers. It is one pathway to internalizing a reliability premium. Other pathways exist, but that goes beyond the focus here.