The Load-Serving Entity Reliability Obligation

A Market Design Reform to Ensure Electric Reliability in Texas

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Energy+Environmental Economics

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About this Whitepaper

This whitepaper proposes the "LSE Reliability Obligation", a reform to the ERCOT electricity market structure. The LSE Reliability Obligation was filed at the Public Utility Commission of Texas on September 30, 2021 under Project No. 52373 in response to the provisions put forward by Senate Bill 3 of the 87th Texas Legislature.

The basis of the proposed LSE Reliability Obligation is derived from a report published by E3 in 2021 titled "Scalable Markets for the Energy Transition" that provides a foundation for understanding the important dynamics at play in electricity markets across North America, including the need for a forward signal to procure reliability resources.[1]

Other important energy system reforms should be considered in conjunction with the LSE Reliability Obligation, including power-plant and gas-system winterization requirements, updated energy efficiency goals and building codes, and better communication between customers, market participants, transmission and distribution utilities, and retail electric providers.

About the Authors

Energy and Environmental Economics, Inc. (E3) is an energy economics consulting firm with offices in San Francisco, New York, Boston and Calgary with expertise in electricity planning, market design, distributed energy resources, retail rate design, and asset valuation.

Ms. Garza is the former independent market monitor of ERCOT, and currently affiliated with the R Street Institute, a nonprofit, nonpartisan, public policy research organization whose mission is to engage in policy research and outreach to promote free markets and limited, effective government.

E3 and Ms. Garza were retained by the project sponsors to provide unbiased, independent analysis of the ERCOT market design and to provide recommendations for practical reforms that can improve reliability while retaining the core aspects of ERCOT's existing competitive electricity market.

[1] https://www.ethree.com/wp-content/uploads/2021/05/E3-Scalable-Clean-Energy-Market-Design-2021.05.25.pdf

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1. Executive Summary

In the aftermath of Winter Storm Uri, the Texas electricity market has been the subject of a series of discussions aimed at improving reliability. These efforts to reform the market operated by the Electric Reliability Council of Texas (ERCOT) have been wide-ranging and have captured the attention of stakeholders and policymakers at the highest levels. The cornerstone of these efforts was Senate Bill 3, a sweeping law passed by the 87th Texas Legislature directing the Public Utility Commission of Texas (PUCT) to "establish requirements to meet the reliability needs of the power region."[2] To inform these market reform discussions, the project sponsors retained the consulting firm Energy and Environmental Economics, Inc. (E3) and Beth Garza, senior fellow at the non-profit R Street Institute.

As an energy-only market, ERCOT has no formal reliability standard nor any explicit mechanism to ensure there are sufficient resources to meet a specified reliability standard. Implied expectations of electricity scarcity in forward energy prices serve as the primary financial incentive for Load Serving Entities (LSEs) to procure supply and support investment. ERCOT does conduct technical studies of resource adequacy for its system, which have determined that a 13.75%[3] reserve margin[4] would be needed to meet the reliability standard most commonly used in other markets—one loss-of-load event in ten years. However, ERCOT's actual reserve levels have fallen below that benchmark recently.

The LSE Reliability Obligation introduces a formal reliability standard and a mechanism to ensure that there are sufficient resources to meet this standard

Many stakeholders have put forward proposals to improve the reliability of the system, increase financial protection of consumers, or both. Most proposals continue to substantively rely on the existing energy-only market design, merely modifying the way in which the system operator derives the prices of energy or the quantities of real-time operating reserves in the energy market.[5] These are actions that may improve reliability but do not establish an explicit reliability standard. Minor modifications to the current market design are not only insufficient to ensure reliable electricity supplies in ERCOT, but in some cases might inadvertently increase financial rewards for generators that do not consistently contribute to reliability. Instead, this whitepaper proposes a mechanism for directly addressing resource adequacy.

The proposed ***LSE Reliability Obligation*** (described more fully in Section 5) introduces a formal reliability standard and a mechanism to ensure that there are sufficient resources to meet this standard. Load-Serving Entities, or LSEs, are responsible for procuring energy on behalf of customers in Texas (both competitive retail providers and municipal/co-operative utilities) and are the natural vehicle to procure

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2 https://capitol.texas.gov/tlodocs/87R/billtext/pdf/SB00003F.pdf#navpanes=0

3 ERCOT, *Resource Adequacy*, http://www.ercot.com/gridinfo/resource (last visited Sep. 21, 2021) ("The current minimum target reserve margin established by the ERCOT Board of Directors is 13.75 percent of peak electricity demand to serve electric needs in the case of unexpectedly high demand or levels of generation plant outages.")

4 Reserve margin is defined as the percentage buffer of resources needed by the system above and beyond expected peak demand to account for 1) abnormally high load 2) resources outages and 3) operating reserve requirements

5 For example, see https://interchange.puc.texas.gov/Documents/52373_55_1147848.PDF

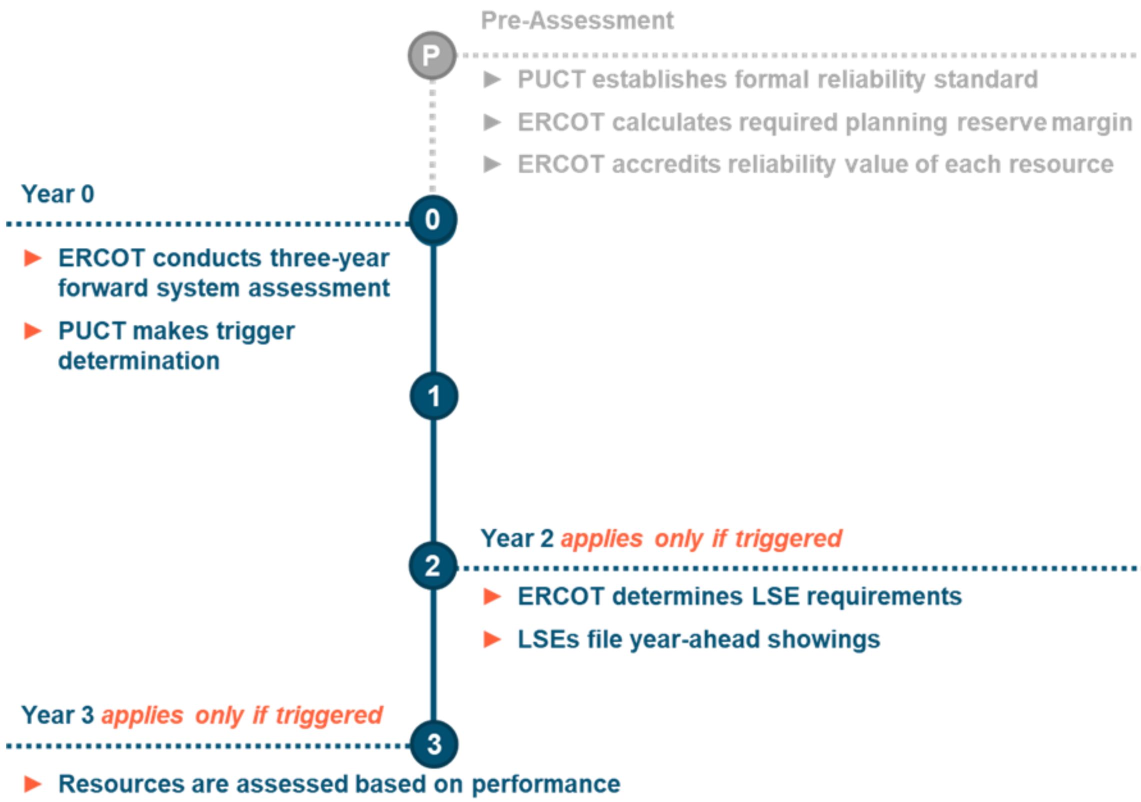
additional resources for reliability, should they be needed. The proposal is designed to preserve the competitive and customer choice elements of the existing ERCOT energy market, while ensuring that there are sufficient resources with the right combination of attributes, namely their ability to perform during reliability events.[6] Key elements of the proposal include:

- **Reliability Standard:** the PUCT determines a formal system reliability standard (e.g., 1-day-in-10-years). ERCOT calculates the required seasonal reserve margin to achieve this standard.
- **Resource Accreditation:** ERCOT will accredit the reliability value of each resource for each season. Resources with dispatch limitations – whether due to intermittency, energy output duration limitations, or fuel supply challenges – would be accredited according to their expected performance during reliability events.
- **System Assessment:** ERCOT will project, on a 3-year forward basis, whether there are sufficient accredited resources to satisfy the seasonal reserve margin necessary to meet the reliability standard.
- **Trigger:** The PUCT will trigger the LSE Reliability Obligation on a 3-year forward basis when ERCOT system assessment projects a likelihood of insufficient resources to meet the reliability standard.
- **LSE Requirement:** If triggered, each LSE would be assigned a seasonal reliability requirement based on its projected firm load during critical system hours. LSEs serving interruptible loads would receive a reduction in their reliability requirement.
- **LSE Showings:** If triggered, LSEs would be required to show sufficient resources (based on ERCOT's resource accreditation) to meet their seasonal LSE requirement on a year-ahead forward basis. Any showing deficiency would be assessed a penalty that would be used by ERCOT to procure accredited resources and correct the deficiency.
- **Performance Assessment:** Resources that are accredited with a reliability value and obligated as part of an LSE Showing would be required to offer into the energy market during designated reliability events, with penalties assessed for non-performance.

A visual overview of the LSE Reliability Obligation process is illustrated in Figure 1.

[6] While resources are often characterized as "dispatchable" or "firm", these distinctions often blurred in a modern electricity system. For example, solar and wind resources can be operated dispatchably. Pairing resources together such as solar and energy storage can create a resource with firm attributes. Ultimately what matters is a resource's ability to generate power when the system needs it the most. No resource is perfect and all resources should be characterized on an apples-to-apples basis based on their ability to generate during these critical hours.

Figure 1: Overview of LSE Reliability Obligation Timing



Many core components of the LSE Reliability Obligation build significantly on experience and policies in other jurisdictions around the world[7] or prior reform proposals to the ERCOT market.[8] The end result is a balanced and comprehensive solution to help ensure electric system reliability for a healthy and prosperous twenty-first century Texas.

[7] For example, see the Australian Retailer Reliability Obligation (RRO) https://www.aer.gov.au/retail-markets/retailer-reliability-obligation

[8] For example, see comments of Golden Spread, a non-profit electric generation and transmission utility in the ERCOT market http://interchange.puc.texas.gov/Documents/40000_283_735592.PDF

2. Introduction and Background

The restructuring of the Texas electricity system in the late 1990s introduced many reforms, notably generation competition and retail choice. It also redefined the role of the Electric Reliability Council of Texas (ERCOT) as the state's independent system operator (ISO).[9] For more than twenty years, competition and retail choice have served Texas electricity consumers well, allowing for some of the lowest-priced electricity in the nation[10] and a rich selection of retail electricity supply products that fit individual customer needs and preferences.[11]

The cornerstone of Texas' restructuring was the creation of an offer-based "energy-only" market design, wherein the lowest priced generators clear the market and receive a clearing price equal to the marginal generator required to serve customer demand. In this system, there is no explicit mechanism to ensure there are sufficient resources to meet a formal reliability standard. Instead, hourly energy prices are allowed to rise to very high levels (much higher than other electricity markets) with the implied expectation that electricity scarcity assumptions influencing forward energy prices will serve as a financial incentive for Load Serving Entities (LSEs) to procure supply and support investment.

While this market structure has promoted competition within Texas' deregulated environment, concerns that it may not be sufficient to maintain reliability are not new. A study commissioned by the PUCT in 2012 found that "involuntary curtailment in an energy-only market may occur more often than customers, regulators, and policymakers find acceptable" and further that "regulators and policymakers must be committed to tolerating price spikes."[12] Around the world, similar market structures are only seen in Alberta and Australia; however, these markets have also been the subject of market design reform discussions and legislation intended to ensure resource adequacy.

In the current ERCOT system, there is no explicit mechanism to ensure there are sufficient resources to meet a formal reliability standard

In February 2021, Winter Storm Uri crippled the ERCOT electricity system, knocking out power to over a third of the state's customers, resulting in significant damages and loss of life. The event resulted in the resignation of all sitting commissioners on the Public Utility Council of Texas (PUCT),[13] several ERCOT board members, and the ERCOT CEO.[14] While many of the physical causes of those events may be beyond the reach of electricity market design (e.g., challenges with natural gas delivery), Winter Storm Uri nevertheless drew attention to ERCOT's electricity market design as a contributing factor to the persistent shortfall of generation capacity. Efforts to rectify this situation have been wide-ranging and have captured the attention of stakeholders and policymakers

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[9] https://energy.utexas.edu/sites/default/files/UTAustin%20%282021%29%20EventsFebruary2021TexasBlackout.pdf
[10] https://www.eia.gov/electricity/state/
[11] https://www.puc.texas.gov/industry/electric/directories/rep/alpha_rep.aspx
[12] https://brattlefiles.blob.core.windows.net/files/8245_ercot_investment_incentives_and_resource_adequacy_newell_spees_pfeifenberger_mudge_ercot_june_2_2012.pdf
[13] https://www.texastribune.org/2021/03/16/texas-public-utilty-commission-resignation/
[14] https://www.businessinsider.com/texas-blackouts-public-utility-commission-chair-resigns-deann-walker-storm-2021-3

at the highest levels. The Governor of Texas has made it clear that "maintaining the reliability of the Texas electric grid… must remain [the PUCT's] top priority",[15] while the Texas legislature passed a sweeping law directing the PUCT to "evaluate whether additional services are needed for reliability."[16]

Against this backdrop, the ERCOT electricity market has recently experienced unprecedented development of renewable resources. Wind capacity has increased threefold over the past ten years, while solar capacity has increased by a factor of five over the past five years.[17] This trend is expected to continue as the falling cost of renewable technologies, the presence of tax subsidies, and customer preferences for clean generation resources together favor low-carbon resources such as wind, solar, and energy storage. The rapid development of renewable resources has prompted some to question the reliability of an electricity grid in which renewable energy plays a significant role.[18]

Holistically evaluating the ERCOT market (both past and future), the authors believe the ERCOT system faces three major challenges, each of which is described in more detail below.

- **Challenge 1: Ensuring Sufficient Reliable Generation**
- **Challenge 2: Ensuring Resource Performance**
- **Challenge 3: Adapting to Higher Penetrations of Renewables**

Challenge 1: Ensuring Sufficient Reliable Generation

The existing ERCOT market sends investment signals purely through the expectation of future energy prices. Ultimately, resources rely on energy prices that are higher than the variable cost of energy generation to cover the fixed cost of maintaining existing resources and investing in new resources. Many of these margins were historically achieved during times of scarcity when supplies were tight. ERCOT's current energy-only market design incentivizes investment through the expectation of energy prices resulting from market forces but does not require that a sufficient quantity of resources will be constructed to meet a specified reliability standard.

A number of reforms have been introduced to the market over the past twenty years to enhance the energy market's ability to provide price signals encouraging sufficient investment in reliable generation resources. The most significant of these was the introduction of the operating reserve demand curve (ORDC) in 2014. The ORDC has the effect of increasing the frequency and level of scarcity prices when market conditions are tight. In response to concerns that the initial ORDC construct was insufficient to incentivize necessary investment in new generation, ERCOT subsequently modified the ORDC in 2018 to further increase frequency and level of scarcity pricing in order to increase investment.[19]

These reforms notwithstanding, a review of ERCOT's actual reserve margins relative to the target reserve margin needed to meet a 1-event-in-10-year loss of load standard shows a consistent shortfall over the

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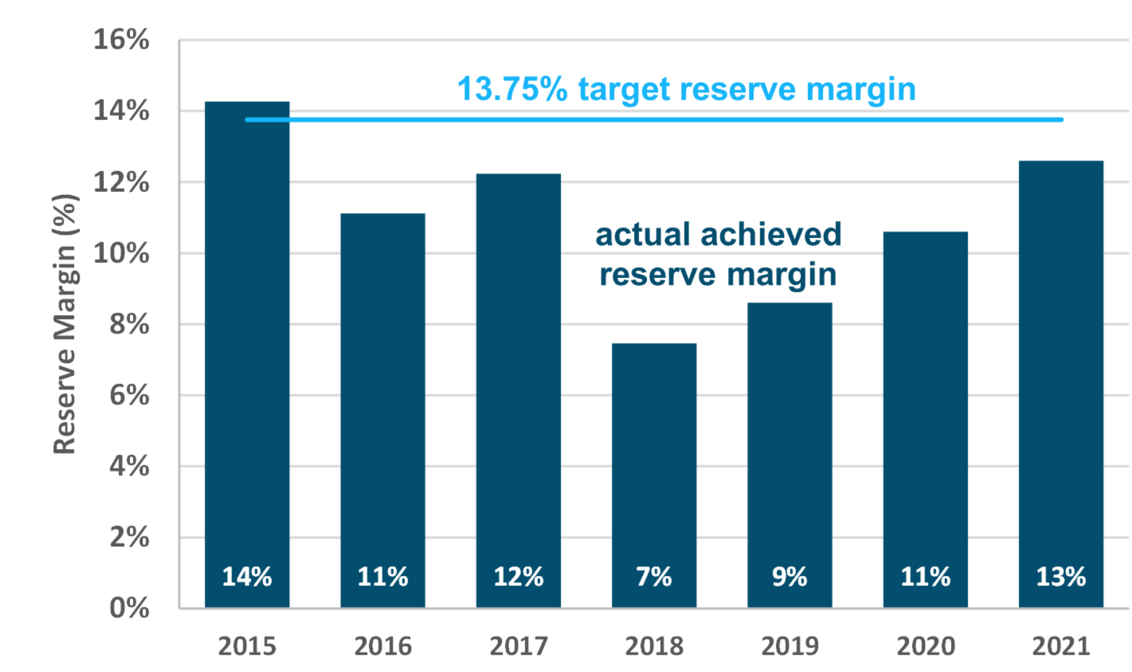
[15] https://gov.texas.gov/news/post/governor-abbott-directs-public-utility-commission-to-take-immediate-action-to-improve-electric-reliability
[16] https://capitol.texas.gov/tlodocs/87R/billtext/pdf/SB00003F.pdf#navpanes=0
[17] ERCOT Fuel Mix Report. http://www.ercot.com/gridinfo/generation
[18] https://www.texastribune.org/2021/02/17/abbott-republicans-green-energy/
[19] https://www.utilitydive.com/news/texas-regulators-direct-higher-plant-payments-amid-capacity-crunch-concerns-1/546540/

past seven years. This means that the ERCOT market can be expected to experience loss-of-load events more frequently than once every ten years.

Figure 2: Historical ERCOT Reserve Margins



Challenge 2: Ensuring Resource Performance

One of the primary issues that led to widespread power outages during Winter Storm Uri was that many existing resources on the system were unavailable to generate electricity due to a variety of factors. Outages of 25 GW of natural gas generating capacity is widely regarded as the single largest contributing supply-side factor in the power outages.[20] The natural gas power plant failures can primarily be attributed to 1) the freezing of critical parts of the plants themselves, and 2) the unavailability of natural gas fuel supplies (an issue that affected both plants with firm pipeline contracts and those without) and 3) grid frequency excursions that caused plants to trip offline, subsequently exacerbating freezing issues.[21] These failures reduced the generating capability of the natural gas fleet by 25 GW (nearly 50% of installed capacity), significantly higher than the 14 GW of outages postulated in ERCOT's "extreme generation outages" planning scenario.[22] In addition, one of the state's four nuclear power plants was offline during the storm, various coal units froze or tripped offline, and production from renewable power plants was below average.

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[20] https://ferc.gov/media/february-2021-cold-weather-grid-operations-preliminary-findings-and-recommendations-ppt
[21] https://energy.utexas.edu/sites/default/files/UTAustin%20%282021%29%20EventsFebruary2021TexasBlackout%2020210714.pdf
[22] http://www.ercot.com/content/wcm/lists/197378/SARA-FinalWinter2020-2021.pdf

It is critical that ERCOT consider the potential reliability challenges of each resource type into its reserve margin accounting, including the potential for unavailability of natural gas generation. Many of the challenges faced by natural gas plants had to do with the reduction in gas production due to freeze-offs at natural gas wellheads. While this portion of the energy sector is outside the purview of ERCOT's market design, it is nonetheless critical that ERCOT consider this risk in any efforts to plan for a reliable electricity system. If the reliability and resiliency of natural gas production and the pipeline system improves due to reforms, ERCOT can and should reflect those changes in the expected reliability of natural gas plants. Until that happens, the evidence is plain that power plants that rely on pipeline fuel cannot be relied upon to provide critical generation services during the winter season to the same extent as plants with on-site fuel storage. Meanwhile, power plants of all types saw freeze-ups at their own equipment. The PUCT has a separate, ongoing proceeding to impose mandatory weatherization requirements on all power plants, regardless of fuel source.[23]

Another important aspect of thermal plant performance is consideration of planned outages due to maintenance. All generators need to ensure that they have sufficient time during the year to go offline and perform routine, necessary maintenance, often for weeks at a time. Generators often attempt to schedule maintenance during the spring and fall "shoulder" months when weather is mild and demand for electricity is low. Recently, there have been instances that despite mild weather/demand, so much generation was offline for maintenance that ERCOT had to publicly request load reductions to avoid emergency actions.[24] SB 3 specifically recognizes this by granting ERCOT authority to "approve or deny… planned power outage during any season for any period of time."[25] Power-plant weatherization and outage coordination are standards-based functions that are internal to the power sector and can help improve the availability of power plants. The improvements that can be hardwired into the system through standard-based regulation should be accounted for in expectations of resource performance.

Challenge 3: Adapting to Higher Penetrations of Renewables

Considering the significant changes to ERCOT's generation mix that are expected to occur over the next decade, market reforms should be robust to *any* future grid mix, including penetrations of higher renewables. Wind and solar generation are inherently variable and uncertain, creating challenges for system operators that must be managed through efficient market operations. Two specific challenges arising from higher penetration of these resources are (1) ensuring sufficient operating flexibility to address intraday variability and forecast error, which can be remedied through reforms to ERCOT's ancillary services and unit commitment procedures, and (2) ensuring there is sufficient installed capacity during periods of low renewable generation, i.e., high "net load", which must be addressed through broader market reforms aimed at investment. The latter is the subject of this paper, though the proposal is complementary with reforms to ensure better same-day or day-ahead operating practices and price formation.

[23] https://interchange.puc.texas.gov/Search/Filings?ControlNumber=51840
[24] https://www.texastribune.org/2021/04/13/ercot-power-conservation-emergency/
[25] https://capitol.texas.gov/tlodocs/87R/billtext/pdf/SB00003F.pdf#navpanes=0

As the presence of variable resources in the electricity system increases, the most challenging periods for reliability will tend to shift away from the traditional gross system peak to the "net system peak" – where net peak is defined as system load minus the output from variable generation resources. This phenomenon is well-documented in jurisdictions that have begun to adapt resource adequacy planning to accommodate high penetrations of renewables. An example is evening hours after the sun has set but when electricity demand is still relatively high. Periods of prolonged low renewable generation that reduce wind and/or solar output for multiple days or during extreme cold weather represent another potential future challenge. Multi-day events of sustained low renewable generation also have implications on the reliability value of energy storage, which is often constructed with a discharge capability of 4-6 hours.

The challenge of financially incentivizing sufficient reliability under an energy-only market framework is also exacerbated under a high-renewable electricity system. Increasing penetrations of variable renewable energy tend to increase volatility in energy markets, which will experience prolonged periods of very low or negative prices (due to excess wind or solar generation) punctuated by infrequent periods of very high prices (due to a dearth of wind or solar generation). While these infrequent periods of high prices can theoretically provide a sufficient economic price signal to firm generation, they create an increasingly uncertain signal for investors regarding whether scarcity pricing will materialize and, if so, for how long. Further, investors must trust that policymakers or regulators will not "roll back" high prices if they do occur either through market repricing or prospective changes in price caps. It also requires acceptance of risk of periods of low electricity reserves. It is important that any future market design provide sufficient, investable, and predictable signals to market participants to procure the appropriate amount of reliability resources.[26]

[26] https://www.sciencedirect.com/science/article/abs/pii/S0301421516306966?via%3Dihub

3. Objectives of Market Design Reform

The market design reforms proposed in this whitepaper are aimed at achieving six key objectives toward the improvement of the ERCOT market design. These are listed below, with a more detailed description of each provided in this section. These objectives were developed based on the industry experience of the authors and their reading of SB 3. The whitepaper evaluates a variety of potential market design reform options based on their ability to help the system achieve each of these design objectives.

Figure 3: Key Objectives of Market Design Reform

A more detailed description of each of the objectives of market design reform is provided below.

Reliability

Reliable electricity service is essential for the preservation of life and property and to the functioning of a modern economy. Maintaining and enhancing electricity system reliability is a bedrock principle for any sustainable market design. Maintaining reliability requires both ensuring adequate supplies of energy resources are available to the system operator and ensuring that the system operator can deploy those resources to address operational reliability challenges. Market operators and regulators often set explicit reliability standards for both the forward investment time frame (usually referred to as "Resource Adequacy") and real-time operations. This paper focuses on the Resource Adequacy dimension of reliability.

Resource Adequacy characterizes the sufficiency of resources (i.e., "steel in the ground") to meet a specified reliability standard. Although not mandated/prescribed, ERCOT does have an informal reliability target of "1 loss of load event in 10 years," as described above.[27] However, regulators are free to set an appropriate alternative standard, using regulatory judgement and specific objectives.[28] Determining a specified reliability standard will clearly delineate which events are within and outside of the planning standard. Stated simply, a mandatory ERCOT reserve margin should be established to ensure a bright line of what level of system reliability should minimally be achieved, enforceable through a market design.

Resources contribute to system reliability by generating power during times when the system has highest loss of load probability – for example during periods of high net load, during events with higher than expected generator outages, during periods of low renewable supply, or during periods of constrained fuel supply. The authors believe the market design reform should clearly and directly ensure that there are sufficient resources to meet the specified reliability standard, without reliance on indirect market mechanisms that may not deliver sufficient investment.

Economic Efficiency

Any market design reform should promote economic efficiency, minimizing costs to society. Ensuring that the electricity sector can deliver electricity at a low cost is a core goal of competition and one of the key drivers of restructuring the Texas market over twenty years ago. ERCOT is an industry leader in market designs that maximize efficiency and should continue to prioritize this objective to support economic growth and consumer welfare.

Competition

Another key tenet of the Texas electricity market design is the important role of competition and free market principles. Texas fully embraced this goal over twenty years ago through the restructuring of the generation and retail supply monopolies. Today, the Texas retail market offers a wide range of retail electricity supply options, allowing each customer to choose from over a hundred unique retail electric providers (REPs) that offer products in the competitive-retail market. A key market design principle is to maintain this level of customer choice, allowing customers to contract with retailers that meet their preferences for risk, price, emissions, and other important factors. This entails minimizing the role of "uplift", i.e., costs that are uniformly spread across all customers in a way that reduces the ability of retail providers to differentiate themselves.

SB 3 Responsiveness

In response to the aftermath of Winter Storm Uri, the 87th Texas legislature passed Senate Bill 3, a sweeping and comprehensive set of energy sector reforms.[29] The law addresses many topics, including infrastructure weatherization, load shedding, customer communication, and new ancillary services.

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[27] http://www.ercot.com/content/gridinfo/resource/2015/mktanalysis/Brattle_ERCOT_Resource_Adequacy_Review_2012-06-01.pdf

[28] Alternative reliability metrics include loss of load expectation (LOLE), loss of load hours (LOLH), loss of load events (LOLEV), and expected unserved energy (EUE). For each metric, regulators must decide on the stringency or standard used e.g. 2.4 LOLH. For more information, see: https://www.nerc.com/comm/PC/Probabilistic%20Assessment%20Working%20Group%20PAWG%20%20Relat/Probabilistic%20Adequacy%20and%20Measures%20Report.pdf

[29] https://capitol.texas.gov/tlodocs/87R/billtext/pdf/SB00003F.pdf#navpanes=0

Sections of the law direct the PUCT to "evaluate whether additional services are needed for reliability" and to "procure ancillary or reliability services on a competitive basis" but leave sufficient flexibility to the PUCT in how to implement these directives. The market design proposal put forth in this whitepaper responds directly to the directives of SB 3. Specifically, the portions of the law that this market design proposal addresses are listed below.

Key Provisions from Section 18 of SB 3 – Dispatchable Generation

- Establish requirements to meet the reliability needs of the power system
- Periodically, but at least annually, determine the quantity and characteristics of ancillary or reliability services necessary to ensure appropriate reliability during extreme heat and extreme cold weather conditions and during times of low non-dispatchable power production
- Procure ancillary or reliability services on a competitive basis to ensure appropriate reliability
- Develop appropriate qualification performance requirements for providing services… including appropriate penalties for failure to provide services
- Ensure resources that provide services are dispatchable and able to meet continuous operating requirements for the season in which they are procured
- Winter resource capability qualifications… Include on-site fuel storage, dual fuel capability, or fuel supply arrangements
- Summer resource capability qualifications… include procedures to ensure operation under drought conditions

Key Provisions from Section 14 of SB 3

- Review the type, volume, and cost of ancillary services to determine whether those services will continue to meet the needs of the electricity market in the ERCOT power region
- Evaluate whether additional services are needed for reliability in the ERCOT power region while providing adequate incentives for dispatchable generation
- Modify the design, procurement, and cost allocation of ancillary services for the region in a manner consistent with cost-causation principles and on a nondiscriminatory basis

Other topics in SB 3 related to reliability include, but are not limited to, weatherization standards, customer communication protocols, and critical infrastructure mapping are important for the PUCT to address and should be pursued in tandem. Market design reform does not limit or affect the manner in which these items should be addressed. However, they are not discussed extensively here as they are outside the scope of this whitepaper.

Stakeholder Acceptability

In order for any market design reform proposal to be successful, it must be acceptable to the broad group of stakeholders that it would impact. Groups of important stakeholders include, but are not limited to, residential, commercial, and industrial customers; generators; developers; retail providers; public power utilities; environmental advocates; ERCOT; the PUCT; the Legislature; and the Governor.

Implementation Barriers

All meaningful market design reforms will require approval from the relevant Texas regulatory agencies (the Public Utility Commission of Texas (PUCT) or the Railroad Commission (RRC)). Market reforms that are able to leverage existing regulatory authority have the highest likelihood of swift implementation.

4. Market Design Reform Options

In developing the proposed LSE Reliability Obligation, the authors carefully reviewed many different market designs in use around the world as well as proposed market design reforms offered by a variety of stakeholders. Emerging from that review were a series of "candidate" market design reform options that are described in this section. These candidate options were then evaluated based on the market design reform objectives described in Section 3.

Centralized Capacity Market

A centralized capacity market ensures there is sufficient capacity through centralized capacity procurement, generally carried out by the system operator. In this structure, the system operator determines the total quantity of capacity needed to achieve a specified reliability target and then procures that quantity of capacity via an auction process where individual resources offer bids for capacity and the lowest bids clear the auction. In this sense, the target reliability of the system is an input and the price of capacity needed to achieve that standard is an output. Each load serving entity is required to purchase capacity equal to their pro-rata share of total system capacity requirements, at a single clearing price as determined through the capacity auction. These markets have the benefit of transparency and reduced transaction costs, however, the uniform clearing price has the potential to crowd out the bilateral dealmaking that is core to a more decentralized, competitive-retail market like ERCOT. The centralized framework is most notably used in the Northeast U.S. by PJM, Independent System Operator of New England (ISO-NE), and the New York Independent System Operator (NYISO) electricity markets.

Individual Load Serving Entity Obligation

An individual load serving entity obligation requires each LSE within the electricity system to procure a sufficient quantity of resources to meet their share of total system-wide reliability requirements. LSEs can satisfy this obligation through ownership or contractual relationships with independently-owned resources and can bilaterally trade the reliability attribute of resources with other LSEs. This format is most notably used in the Southwest Power Pool (SPP) electricity market,[30] the California electricity market,[31] and has been recently introduced in Australia National Energy Market[32] due to the challenges imposed by renewable energy. The Mid-Continent Independent System Operator (MISO) has a hybrid model where LSEs procure capacity individually, subject to a systemwide obligation determined by MISO, and MISO holds an auction to clear any residual capacity needs. Under this framework, the reliability standard is an input, determined by the regulator and/or system operator, while cost is an output unique to each LSE based on their contracted capacity. This framework, adapted to ERCOT, is at the core of the LSE Reliability Obligation proposal that this paper makes in Section 5.

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[30] https://www.spp.org/engineering/resource-adequacy/

[31] https://www.cpuc.ca.gov/RA/

[32] https://www.aer.gov.au/retail-markets/retailer-reliability-obligation#:~:text=The%20Retailer%20Reliability%20Obligation%20(RRO,in%20the%20National%20Electricity%20Market.

Targeted Capacity Payments

Targeted capacity payments compensate specific resources with an administratively-determined price for their contributions to the reliability of the system. In effect, this policy creates a subsidy for capacity that results in more of this product than would have occurred in its absence. In this sense, the price of capacity is an input while the output is the ultimate achieved quantity of reliability resources. While targeted payments for capacity are relatively rare in the electricity sector, targeted payments for other electricity products, namely clean energy, are relatively common. In the American experience, such payments typically are expressed in the form of federal or state tax subsidies. Examples of targeted clean energy payments include the U.S. federal investment tax credit (ITC), the U.S. federal production tax credit (PTC), and feed-in-tariffs (FITs) that are common across the globe. To the extent that targeted capacity payments are used, they are often limited to specific technologies on resources in special circumstances – for example, zero emission credits (ZECs) targeted toward nuclear resources at risk of retirement in New York[33] and targeted payments to fuel-secure resources at risk of retirements in ISO-NE.[34]

Strategic Reserve

A strategic reserve product is a centrally procured quantity of capacity that is held outside of the market for use during scarcity or other time periods. The most notable use of this is the U.S. strategic petroleum reserve, which is held by the federal government in the event of sudden and unexpected supply contraction and/or price increases of petroleum products in order to limit shock to the U.S. economy.[35] The strategic reserve is procured by a centralized entity, with costs allocated to all market participants (or taxpayers). The appropriate quantity of strategic reserve to procure is often arbitrary as the product will exist alongside products procured by the competitive market where the sufficiency or deficiency quantity is often unknown to some degree.

Use of this design has been proposed for use within the electricity sector but to-date has been rarely used, with the most prominent examples being used to a small degree in the socialist countries of Sweden and Belgium.[36]

A strategic reserve resource can be used in two ways: 1) fully optimized with the market, bidding and participating identically to all other plants in the market, or 2) held back for use only during times of scarcity, which is practically implemented by only allowing these plants to bid into the market at the price cap. In the first case, the strategic reserve functions as a near-complete substitute for private procurement of reserve capacity. In the second case, the strategic reserve does not distort the functioning of the electricity market, but instead serves as an emergency insurance policy against an extraordinary event that is outside the realm of standard system planning. However, because the resources are dispatched very infrequently and only at the price cap, captive ratepayers are required to bear the entire cost of the

[33] https://www.nyserda.ny.gov/all-programs/programs/clean-energy-standard
[34] https://www.iso-ne.com/committees/key-projects/forward-capacity-market--retain-resources-for-fuel
[35] https://www.energy.gov/fe/services/petroleum-reserves/strategic-petroleum-reserve
[36] https://reader.elsevier.com/reader/sd/pii/S0140988319300453?token=1DD8B026D32FD594E4E92AC0960C871752336E1A7E6B992DA9865026DBA28B3CBD5EC166962EF14D72F2913659AAE8C6&originRegion=us-east-1&originCreation=20210906010817

fleet of reserve capacity in the form of a non-bypassable uplift charge. A strategic reserve is likely the most economically inefficient policy that might be pursued among those reviewed.

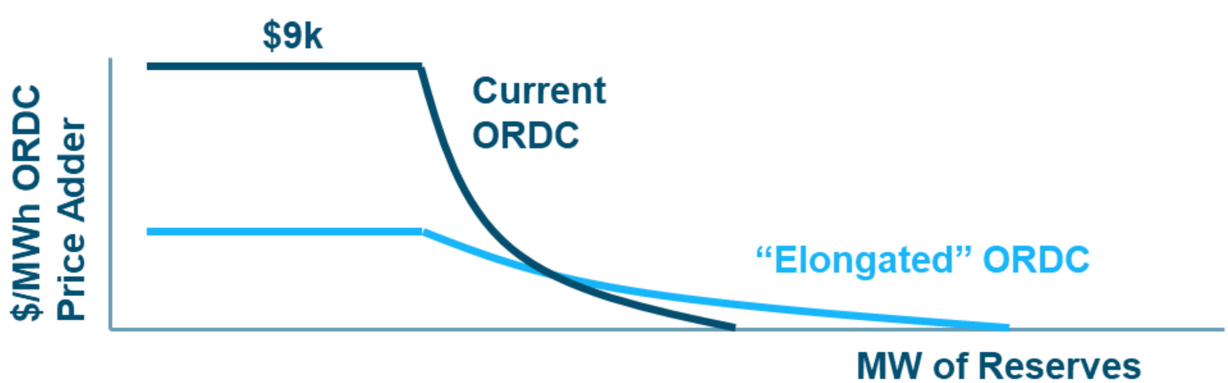
Energy Price Formation / ORDC Modification

Even Texas's energy-only electricity market features a number of administrative factors that impact the clearing price of energy, the costs to consumers, the margins to producers, and the operations and investments in the electricity system. The most common intervention in the market is a price offer cap, which today is set at $9,000/MWh.[37] During the early years of restructuring in Texas, scarcity price formation was solely dependent on the submission of high energy offers, but it eventually became clear that this energy price signal raised competitive concerns and did not incentivize sufficient capacity. To compensate, ERCOT introduced the operating reserve demand curve (ORDC) in 2014 that effectively added a price adder during "tight" hours when supplies were scarce but there was not yet firm load shed. The introduction of the ORDC has increased the energy price signal and resulted in more capacity than would have otherwise been procured in its absence.

ORDC Elongation

The current framework and administrative control of the ORDC has become a subject for energy market reform, with proposals to modify its application in the hope that a reformulation will better support investment incentives for firm generation. One proposal for ORDC reform that has been put forward by a number of stakeholders is an ORDC "elongation", with the scarcity price reduced in the hours with lowest reserves (most scarce) and increased in hours with more reserves (semi-scarce). This potential elongation reform is illustrated in Figure 4.

Figure 4: Illustration of ORDC Elongation



The genesis of this reform is based on the observation that the current ORDC formulation leads to "feast-or-famine" pricing, with the vast majority of energy-market margins occurring in the relatively infrequent hours of severe scarcity. This has resulted in an inconsistent price signal that is seen as a barrier to

[37] https://www.puc.texas.gov/agency/rulesnlaws/subrules/electric/25.505/25.505.pdf

financing new capacity projects. Elongation would lead to more consistent payments for resources by targeting many more hours.

However, an elongation of the ORDC inherently results in a reduction of price during hours when energy is *most* needed and an increase in price when energy is *less* needed. This framework may result in unintended consequences such as increased payments to resources that do not materially improve system reliability. While this market reform may increase the incentive for reliability resources, it suffers from the same challenges as ERCOT's existing energy-only market design in that it is not designed to ensure sufficient resources necessary to meet a specified reliability standard. If the system-wide offer cap in ERCOT is lowered, while incidences of the ORDC adder are increased, even while energy-market revenues are held constant, it would likely *increase* the need for a reliability backstop like the one proposed here.

ORDC Application to Select Resources

Another potential energy market price reform that has been discussed is the application of the ORDC to only select resources, e.g., thermal generators. While these resources may provide more reliability value than variable or dispatch-limited resources such as wind, solar and battery storage, it does not follow that variable or dispatch-limited resources have *no* reliability value. Differentiating payments to resources that are simultaneously providing identical amounts of energy to the system simply based on the technology would create significant market inefficiencies, friction, and distortions. Implementing such a reform would necessarily deviate from a core tenet of non-discrimination shared by all electricity markets across North America, i.e., that resources are paid uniformly for uniform services. The end result would inevitably lead to higher prices for consumers, lower reliability, or both.

Operating Reserve Requirements

Closely tied to energy price formation is the idea of procuring more "operating" reserves – resources on standby on a real-time basis to ramp up in the event of a potential sudden drop-off in renewable generation i.e. "net load variability." This market design modification can also incentivize resources to be more fuel secure, as is being pursued in New England.[38] However, a solution to procure higher operating reserves only works if there is sufficient "steel in the ground" to actually provide the additional reserves. Historical and potential future reliability challenges are primarily driven by insufficient resources overall, not the inability to utilize or commit existing resources on a real-time basis. To the extent that reliability issues are driven by wintertime fuel supply shortages, these are generally physical constraints, caused by either a sudden drop-off in supply (Texas) or maxed out natural gas pipelines (New England). In either case, the solution to the problem is physical investment in new pipelines or fuel storage as opposed to operational changes.

[38] https://www.iso-ne.com/static-assets/documents/2020/04/esi-white-paper-final-with-cover-page-04152020.pdf

5. LSE Reliability Obligation

This whitepaper evaluated all potential market design reform options in Section 4 against the objectives of market design reform described in Section 3. The **LSE Reliability Obligation** proposed in this paper scores highly on a qualitative basis relative to many of the reform objectives, striking an appropriate balance between ensuring reliability and preserving Texas's competitive market structure. This section provides a detailed overview of the LSE Reliability Obligation, while the following section provides a comparison of the LSE Reliability Obligation to other potential alternatives. The whitepaper seeks to provide sufficient detail to make the proposal understandable without being overly prescriptive in the numerous implementation details that must necessarily follow. In each case, it describes the issue at stake, discusses the pros and cons and various design choices, and provides a sense as to the reasonable range of implementation options for each component.

Because LSEs are the primary entities that manage power procurement today, it is a natural extension that LSE should procure reliability services if needed

Load serving entities (LSEs) are the entities responsible for energy procurement on behalf of customers in Texas. They manage price, risk, environmental performance, and other important attributes of an integrated portfolio of supply resources, as well as forecasting and offering incentives to their customers to shape or reduce demand. LSEs include competitive retail electric providers (REPs) in areas of ERCOT open to retail choice, municipal and cooperatively owned utilities, and large industrial customers that procure energy for themselves directly from the ERCOT market. Because LSEs are the primary entities that manage power procurement today, it is a natural extension that LSEs should procure reliability services for their customers if needed.

Overview

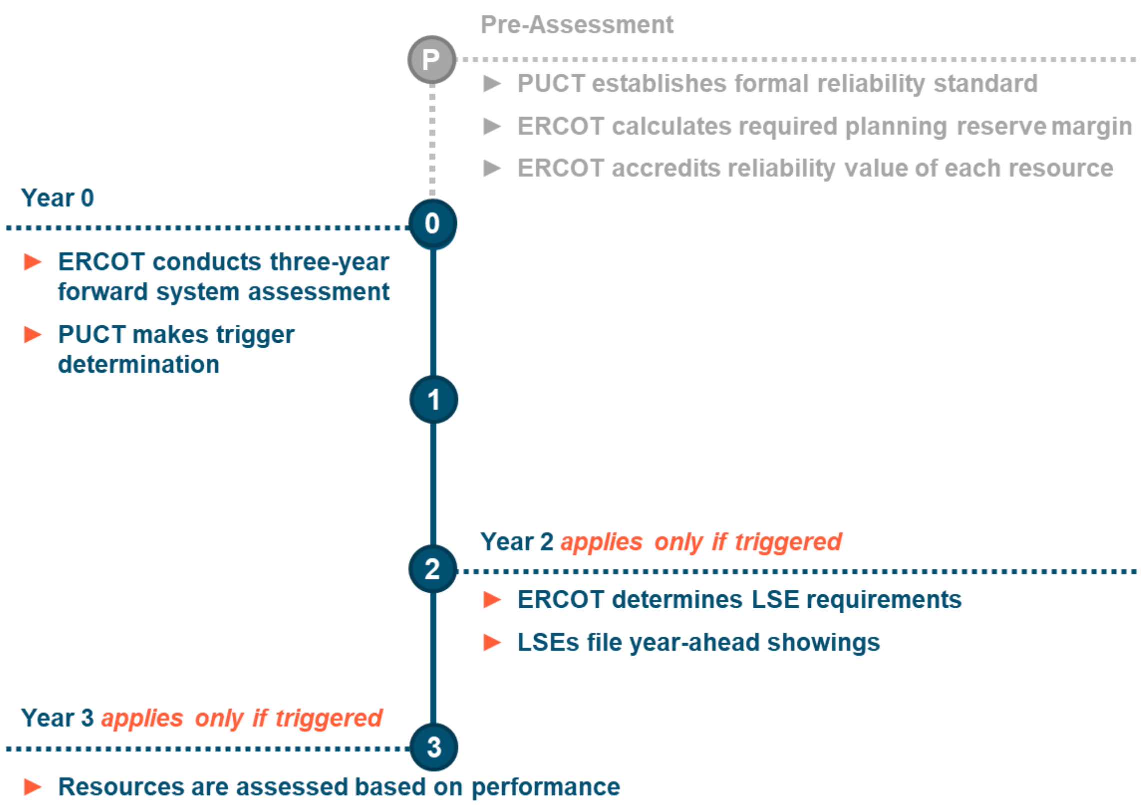
The premise of the LSE Reliability Obligation is the idea that ERCOT and the PUCT should specify a desired reliability standard and develop a market mechanism that intervenes to ensure that sufficient resources are procured to meet the specified standard in the event that the investment signals provided by the energy-only market alone prove inadequate. The key elements of the LSE Reliability Obligation are listed below, with more detail provided throughout the rest of this section.

- **Reliability Standard:** the PUCT determines a formal system reliability standard (e.g., 1-day-in-10-years). ERCOT calculates the required seasonal reserve margin to achieve this standard.
- **Resource Accreditation:** ERCOT will accredit the reliability value of each resource for each season. Resources with dispatch limitations – whether due to intermittency, energy output duration limitations, or fuel supply challenges – would be accredited according to their expected performance during reliability events.
- **System Assessment:** ERCOT will project, on a 3-year forward basis, whether there are sufficient accredited resources to satisfy the seasonal reserve margin necessary to meet the reliability standard.

- **Trigger:** The PUCT will trigger the LSE Reliability Obligation on a 3-year forward basis when ERCOT system assessment projects a likelihood of insufficient resources to meet the reliability standard.
- **LSE Requirement:** If triggered, each LSE would be assigned a seasonal reliability requirement based on its projected firm load during critical system hours. LSEs serving interruptible loads would receive a reduction in their reliability requirement.
- **LSE Showings:** If triggered, LSEs would be required to show sufficient resources (based on ERCOT's resource accreditation) to meet their seasonal LSE requirement on a year-ahead forward basis. Any showing deficiency would be assessed a penalty that would be used by ERCOT to procure accredited resources and correct the deficiency.
- **Performance Assessment:** Resources that are accredited with a reliability value and obligated as part of an LSE Showing would be required to offer into the energy market during designated reliability events, with penalties assessed for non-performance.

A visual overview of the LSE Reliability Obligation process is illustrated in Figure 5.

Figure 5: Overview of LSE Reliability Obligation Timing



Reliability Standard

The PUCT will need to determine an appropriate reliability standard for Texas and in doing so will implicitly decide what events should be included in the system planning standard and what events fall outside the standard. It is important to note that no electricity system plans for perfect reliability, so some firm load shedding should be expected. While the "1 loss of load event in 10 years" standard is common throughout North America, policymakers have begun to explore alternative metrics as shown in Table 1. A standard based on expected unserved energy may have helped to mitigate some of the worst impacts of Winter Storm Uri due to the sheer magnitude of the power outage.

The two components of a reliability standard are 1) the selected reliability metric, and 2) the stringency of this metric. Example reliability metrics are provided below.

Table 1: Overview of Reliability Metrics

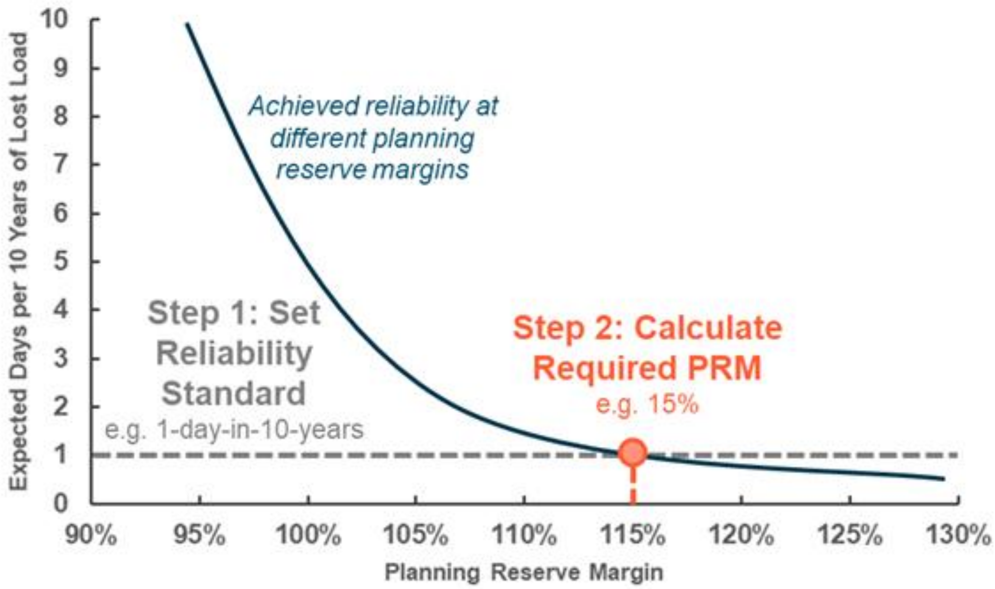
Acronym	Name	Unit	Definition
LOLE	**Loss of Load Expectation**	**days/yr**	The expected number of days per year where load + reserves exceed available generating capacity at least once during the day
EUE	**Expected Unserved Energy**	**MWh/yr**	Average total quantity of unserved energy (MWh) over a year due to load + reserves exceeding available generating capacity
LOLH	**Loss of Load Hours**	**hrs/yr**	Expected average number of hours per year where load + reserves exceed available generating capacity
LOLEV	**Loss of Load Events**	**events/yr**	Average number of loss of load events per year, of any duration or magnitude, due to load + reserves exceeding available generating capacity

The stringency of the standard assigns a numerical target to the chosen metric: For example, 0.05 LOLE (1-day-in-20-years), 0.1 LOLE (1-day-in-10-years), or 0.2 LOLE (1-day-in-5-years).

Once a reliability standard has been determined, ERCOT should calculate the required planning reserve margin (PRM) to achieve that standard, using industry best practices.[39] An illustration of this process is provided below.

[39] Conversion of reliability standard to required reserve margin described on page 3: https://www.ethree.com/wp-content/uploads/2020/08/E3-Practical-Application-of-ELCC.pdf

Figure 6: Translation of Reliability Standard to Planning Reserve Margin (PRM)



Resource Accreditation

Going hand-in-hand with the reliability standard and required planning reserve margin is the determination of a resource's ability to contribute to meeting that standard. Individual resource accreditation would be measured as a percentage (%) value, potentially reducing a maximum nameplate capacity (MW) to reflect a reliability value.

Characterizing a resource's reliability value has historically been a relatively straightforward exercise when most resources were "firm" i.e., always available for continuous periods of time except during forced outages. Resources such as nuclear, coal, and natural gas (with reliable fuel supply) fit this description. However, the determination of effective capacity is more complex and challenging for variable and dispatch-limited resources such as wind, solar, energy storage, or thermal resources with significant limitations such as air permits that constrain runtime, lack of firm fuel supplies, or risks of correlated outages. At its core, the exercise to quantify reliability value should determine if resources are available *when the system needs them the most* during critical scarcity hours.

ERCOT currently quantifies the reliability value of wind and solar toward its planning reserve margin via a *Seasonal Peak Average Solar/Wind Capacity as a Percent of Installed Capacity* metric that is calculated as the average output of solar/wind during the 20 highest system load hours during prior summer and winter seasons.[40] However, this approach does not account for the fact that the most important hours for

[40] ERCOT Protocol Section 3.2.6 http://www.ercot.com/content/wcm/curent_guides/53528/03-110119_Nodal.docx

reliability are increasingly not peak *gross load* hours, but peak *net load* hours.[41] This has been the subject of significant stakeholder comment.[42] When the quantity of renewable energy was small, simple heuristics such as the top 20 hours approach were not materially impactful on the aggregate assessment of system reliability. However, as renewable penetrations have grown, the need for more robust and sophisticated metrics has become increasingly clear to electricity market operators and participants across the country.

ERCOT also quantifies the reliability contribution of thermal resources such as natural gas, coal, and nuclear using seasonal maximum sustainable limits.[43] These values, which are close to the maximum nameplate capacity of the units, do not account for fuel-supply disruptions or correlated winter outages, which can occur in extreme weather circumstances that can affect many plants simultaneously. ERCOT should incorporate this factor into the reliability contribution of thermal resources. In light of Winter Storm Uri, ERCOT should also consider that the security of fuel supply does not affect all plants equally. Geographic location, connectivity to intra- versus inter-state pipelines, connectivity to natural gas storage, and the presence of on-site fuel (or backup fuel) are all relevant considerations that can impact the reliability contribution of thermal resources.

A resource's accredited reliability value should reflect its limitations – from uncertain wind or solar output, energy dispatch limitations or undependable fuel supplies – on a apples-to-apples basis across *all* resources

A resource's accredited reliability value should reflect its limitations – from uncertain wind or solar output, energy dispatch limitations, or undependable fuel supplies – on an apples-to-apples basis between *all* resources. Over the past decade, there has been a growing movement toward the use of the effective load carrying capability (ELCC) metric to quantify the reliability contribution of diverse resources on an equivalent basis. ELCC is a technology-neutral measurement of the equivalent "perfect" capacity from intermittent, energy-limited, or fuel-insecure resources. For example, if the marginal ELCC of wind is 15%, an additional 100 megawatts of wind would provide the same reliability benefit to the system as an additional 15 megawatts of perfectly firm capacity. The ELCC metric stands in contrast to other alternative "rule of thumb" approaches (such as ERCOT's) based on its ability to assess each resource's expected performance during the specific and infrequent hours that are most important for system reliability.

Four of the six U.S. electricity markets with a resource adequacy program or an organized capacity market (MISO,[44] CAISO,[45] SPP,[46] PJM[47]) currently use ELCC or will use ELCC by 2023. The other two electricity

[41] Net load is calculated as gross load minus the contribution of solar, wind, and energy-limited resources such as storage and hydro

[42] http://www.ercot.com/content/wcm/lists/219841/CapacityDemandandReservesReport_May2021.pdf

[43] http://www.ercot.com/content/wcm/lists/197378/SARA-FinalWinter2020-2021.pdf

[44] https://cdn.misoenergy.org/2019%20Wind%20and%20Solar%20Capacity%20Credit%20Report303063.pdf

[45] CAISO Resource Adequacy is administered through the California Public Utilities Commission (CPUC) https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/UtilitiesIndustries/Energy/EnergyPrograms/ElectPowerProcurementGeneration/DemandModeling/ELCC_2_13_19.PDF

[46] https://www.spp.org/documents/61025/elcc%20solar%20and%20wind%20accreditation.pdf

[47] https://www.pjm.com/planning/resource-adequacy-planning/effective-load-carrying-capability

markets (NYISO,[48] ISO-NE[49]) are currently exploring the potential to integrate ELCC into market practices through public stakeholder processes. ERCOT has also quantified ELCC for renewable resources in reserve margin studies, although they are not used in any official capacity and the seasonal peak average methodology continues to be used in quantifying the official reserve margin.[50]

ELCC is also sometimes used to characterize the reliability contribution of firm resources, particularly for smaller systems where a large unit outage can, by itself, significantly increase the potential for loss-of-load. On larger systems, ELCC values for firm resources tend to be quite similar to the Unforced Capacity (UCAP) metric used by many market operators.

An ELCC approach to resource accreditation can be used to accurately capture key reliability limitations of resources including but not limited to:

+ Intermittency of variable renewable resources such as wind and solar, including the potential for multi-day low renewable generation periods;
+ Limitations on the ability of resources to output generation for prolonged periods of time i.e. storage charge duration, hydro reservior limitations, drought conditions, demand response call limitations, or air permit runtime limitations for thermal generators;
+ Fuel supply constraints that impact a resource's ability to generate during critical hours;
+ Geographic considerations, including characteristics such as regional wind and solar patterns and proximity to reliabiltiy fuel supplies; and
+ Forced outage characteristics including the likelihood that a resource will be unavailable to generate during critical hours due to a mechanical failure, including failures caused by extreme weather.

Not only does a recognition of these factors follow industry best practices, but incorporating these factors into resource reliability determination is also directly responsive to Section 18 of Senate Bill 3 that states that ERCOT should "determine… the characteristics of… reliability services necessary to ensure appropriate reliability during extreme heat and extreme cold weather conditions and during times of low non-dispatchable power production." It further states that "resources [should be] able to meet continuous operating requirements" while accounting for factors such as "on-site fuel storage, dual fuel capability, fuel supply arrangements… and drought conditions."

Through an accreditation process, ERCOT would determine the reliability contribution for each resource. Because ELCC calculations are computationally intensive, ERCOT will likely need to group resources into "classes," differentiating resources based on key characteristics. Individual resources within a class can be

48 https://www.nyiso.com/documents/20142/24130223/20210830%20NYISO%20-%20Capacity%20Accreditation_v10%20(002).pdf/b12b55d4-7aa9-644a-d803-05ae8df1877c

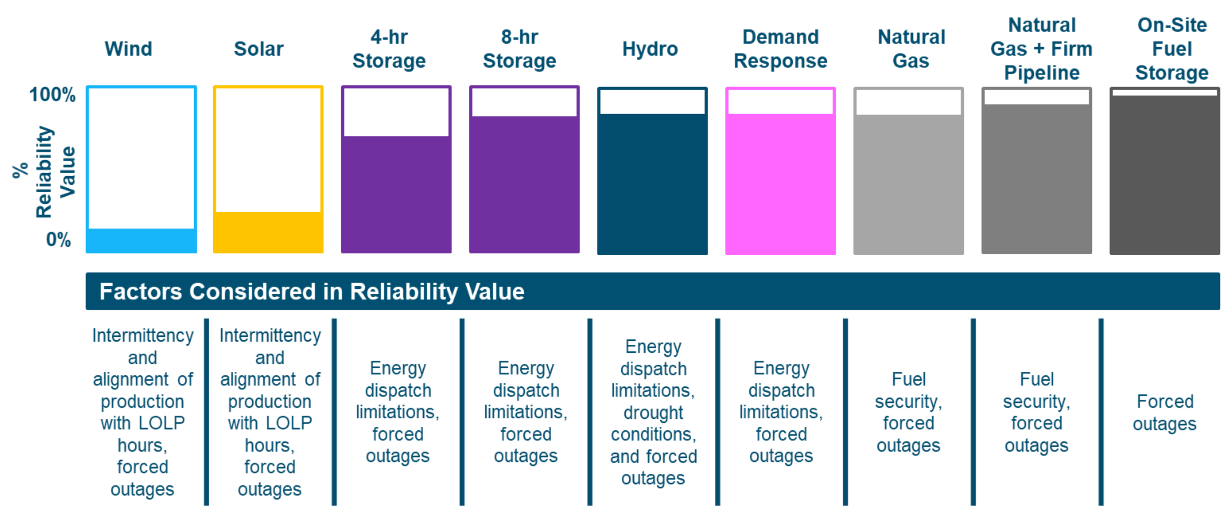
49 https://www.iso-ne.com/static-assets/documents/2020/10/2021_awp_final_10_05_20.pdf

50 http://www.ercot.com/content/wcm/lists/219844/2020_ERCOT_Reserve_Margin_Study_Report_FINAL_1-15-2021.pdf

distinguished based on operating history. While there is no limit to the quantity of resource classes, more classes creates a higher burden for ERCOT and more complication for market participants.

For each resource class, ERCOT would determine a percentage (%) reliability value, that would serve as the basis for de-rating the nameplate megawatt (MW) capacity of each resource. An example list of potential resource classes, illustrative reliability values, and factors that would be considered in determining these reliability values is provided below.

Figure 7: Illustration of Reliability Values by Resource



The recommended approach is notable for its consistency in treatment of all technologies without the need to define overlapping products such as a "firm" requirement or a "fuel security" requirement. Creating distinct products that cannot trade off against one another would create artificial constraints that inhibit competition among resources, a key principle of economic efficiency, an important objective of market reform.

It should finally be noted that resource accreditation is a complex task, with many methodological decisions and dynamics that are beyond the scope of this whitepaper.[51] Some factors that should be incorporated into the reliability assessment may fall outside the ELCC framework due to issues such as data availability. In this case, expert judgment and administrative decisions will be required. Developing a full resource accreditation framework will require a full review of industry best practices, a comprehensive stakeholder engagement process, and investments in new analytical tools and processes. However, ERCOT already has many of these required capabilities and conducts regular planning studies for transmission system analysis and long-term system assessment.

[51] https://www.ethree.com/wp-content/uploads/2020/08/E3-Practical-Application-of-ELCC.pdf

System Assessment

ERCOT would conduct a forward-looking assessment to determine adequate reliability on a 3-year ahead basis. The system assessment would require an accurate and robust forecast of total system loads and resources, making assumptions about future load growth, resource additions, and resource retirements. ERCOT should rely on industry best practices in developing these forecasts, leveraging existing practices at other U.S. ISOs that routinely make these assessments as part of their forecasting processes. Given the inherent uncertainty in many of these assumptions, ERCOT may wish to evaluate multiple scenarios, highlighting key risks and assumptions for the PUCT.

The assessment will also rely on the resource accreditation process, utilizing the reliability value of each resource in assessing system sufficiency. If the assessment forecasts sufficient accredited reliability resources to meet projected load growth plus the required planning reserve margin, the system is projected to be sufficient. If the opposite is true, the system is deficient. In any event, ERCOT should report the full findings of the system assessment, including the potential degree to which the system is expected to be sufficient or deficient and any key risks or assumptions embedded in that assessment.

Trigger

Using the forward-looking system assessment developed by ERCOT, the PUCT would make a decision about whether to "trigger" the LSE Reliability Obligation. If the 3-year ahead system assessment shows a high probability of adequate resource availability, no action would be needed. However, if the system assessment shows inadequate resources, the PUCT could trigger the LSE Reliability Obligation. Factors that the PUCT could consider include load uncertainty, the magnitude of the expected sufficiency or deficiency, the potential for resource additions or retirements during the three-year period, and data or methodological limitations that could impact the assessment.

The requirement for a trigger to activate the LSE Reliability Obligation allows it to be minimally intrusive and disruptive to the current market framework: should the three-year ahead assessment indicate that the system will remain reliable over this period, the current energy-only market will function as it does today without intervention; however, in the event that evidence suggests that the system will be short, the trigger for the LSE Reliability Obligation provides the system operator with some recourse to remedy an expected resource deficiency that the energy-only market alone would not be expected to resolve.

By "pulling" the trigger, the PUCT puts LSEs on notice that they will need to make a showing to demonstrate procurement of sufficient reliability resources to cover their share of total system reliability requirements beginning one year before the compliance season. The 3-year forward timeframe for the trigger would allow LSEs time to develop new resources should that be necessary. The year-ahead forward timeframe for the LSE showing is selected to be far enough out to enable ERCOT to procure resources on behalf of deficient LSEs but close enough to the compliance season that LSE loads are relatively certain.

The LSE Reliability Obligation may benefit from a mechanism to address the risk of load migration after the forward showing. These could include:

- Moving the forward showing closer to the compliance season. This would reduce LSEs' risks associated with load migration but may jeopardize reliability by diminishing ERCOT's ability to remedy any systemwide shortfalls.
- Incorporating a second formal showing closer to the compliance period to rebalance the obligations among LSEs. The principal function of the second showing would be to reshuffle the obligation among LSEs to account for load migration, as opposed to the year-ahead showing which would identify any remaining system-wide deficiencies and rectify them. The potential risk reduction benefits would need to be weighed against the administrative cost associated with a second formal showing.

3-year forward analysis would be conducted for each of the summer and winter seasons, and it is possible that only one season would show a deficiency and trigger a reliability showing for that season.

Trigger Alternative

The proposed trigger feature of the LSE Reliability Obligation was designed to minimize the intrusion and impact of the proposal while still allowing the energy-only market design an opportunity to deliver. However, it is possible that the uncertainty created by the trigger and potential oscillation between on/off states could increase burden and uncertainty for LSEs.

An alternative approach is to adopt the LSE Reliability Obligation without the trigger. In this case, the LSE Reliability Obligation would be perpetually active on a year-ahead basis with respect to each season. The potential benefits of this are twofold: 1) it provides certainty to LSEs about what requirements will be and what value holding accredited reliability resources will provide, and 2) it ensures that reliability does not unexpectedly degrade after the trigger was not pulled which could leave the system deficient without any remedy to rectify. The costs are that this approach would take a potentially more domineering role in the market design of ERCOT. Ultimately, the decision to include or exclude the trigger component is a regulatory judgement call that should be made by the PUCT.

LSE Requirement

The LSE requirement is each LSE's share of total system-wide reliability resources that must be procured in the event that the LSE Reliability Obligation is triggered. Each LSE's reliability requirement is based on their pro-rata share of system load during the periods of the season that drive reliability requirements – which will typically align with peak "net load" hours, where net load is defined as gross load minus renewable and storage generation. This approach assigns reliability requirements to the LSEs with highest loads during the most challenging hours without penalizing loads that consume energy during non-binding or even beneficial times of day (such as the middle of the day when an abundance of solar and wind generation result in very low or negative energy prices).

Peak net load hours are a function of the resources on the electricity system and should be expected to change as the system evolves, namely as renewable generation increases. SB 3 acknowledges the central importance of reliability during the peak *net* load hours,[52] and ERCOT pricing data clearly indicates these hours are when supply-and-demand conditions are at their tightest. An example of this is summer peak net load hours shifting from the middle of the afternoon (when the system has little solar) to the evening (when the system has significant solar). This phenomenon has been well-documented in other jurisdictions experiencing rapid increases in solar penetration.

The LSE requirement should only apply to firm load that is non-curtailable. To the extent that LSEs have load that can be curtailed or interrupted at the direction of the system operator, this would be given credit and exempted from the LSE requirement. Load that is partially curtailable would get a partial credit against the requirement. The partial credit would be determined by ERCOT based on any specific limitations to the load's ability to curtail (e.g., limitations on how often a load curtailment event could occur and how long the load could be offline). Other measures that allow LSEs to shift load away from peak net load periods – such as time-of-use rates or demand response – would also inherently reduce their LSE requirement.

To the extent that LSE requirements are confidential, ERCOT could protect this sensitive information and not disclose individual LSE requirements.

The LSE Reliability Obligation will induce investment in new resources by LSEs that are deficient in their showing obligation in order to avoid the compliance penalty

LSE Showing

In the event that the LSE Reliability Obligation is triggered, each LSE would be required to make a reliability showing on a year-ahead basis. The reliability showing would require that each LSE show that it has a contractual relationship with sufficient reliability resources to meet its LSE requirement. If an LSE shows sufficient reliability resources to satisfy its requirement, the LSE is in compliance. If an LSE is deficient (i.e. shows fewer MW of reliability resources than the MW LSE requirement), it would be assessed a compliance penalty. The penalty should be sufficiently punitive – for example two to three times the cost of new entry (CONE) – to ensure compliance. The LSE Reliability Obligation will induce investment in new resources by LSEs that are deficient in their showing obligation in order to avoid the compliance penalty. In the unexpected event that an LSE is deficient and assessed a compliance penalty, ERCOT could use these funds to procure resources on behalf of the non-compliant LSE to fill any system-wide gap. This attractive feature of the LSE Reliability Obligation ensures that the cost of backstop procurement is borne by the non-compliant LSE as opposed to indiscriminately by all load (as is the case in a strategic reserve approach).

Performance Assessment

Performance assessment is closely tied to resource accreditation and is directly required by Section 18 of SB 3, directing ERCOT to "develop appropriate qualification and performance requirements for providing services… including appropriate penalties for failure to provide the services." Resource adequacy

[52] SB 3, Section 18 (B) (5) https://capitol.texas.gov/tlodocs/87R/billtext/pdf/SB00003F.pdf#navpanes=0

constructs carried out by market operators across the U.S. ensure performance through "must-offer" obligations that require accreditated reliability resources to offer their services into the energy market. It is through this construct that the electricity market can ensure that reliability resources will be available when needed by the system.

Once the showing is complete, LSEs would have no further obligation for reliability resource procurement. However, the resources (generators and interruptible loads) that enter into a contractual relationship with an LSE as part of the latter's reliability showing would then be subject to a must-offer obligation and a performance assessment. In order to minimize impact on the market of introducing a must-offer obligation, the obligation need not be active uniformly throughout the season. Rather, ERCOT would designate the potential for a reliability event at least one day in advance, triggering the must-offer obligation for all reliability-contracted resources, which would then be reqiured to offer all of their accredited capacity into the market for the duration of the event.

The must-offer obligation provides a benchmark to measure the performance of resources, with penalties being assessed on resources that do not fulfill their obligation and potential reliability payments being conferred on resources that exceed their obligations. Many organized U.S. capacity markets including ISO-NE,[53] PJM,[54] and CAISO[55] currently utilize performance mechanisms to ensure resources fulfill their must-offer obligations, with sufficiently punitive penalties that are multiple times greater than the cost of energy generation. It is important to note that the performance assessment and penalties associated with the must-offer obligation are levied on generators and are separate and distinct from any penalties levied on LSEs associated with a forward showing deficiency.

Implementing a symmetric penalty for resources that underperform and compensation for resources that overperform would allow suppliers that own multiple generators to net their reliability positions and capture the inherent diversity expected from a portfolio of resources. In some instances, penalty payments would simply be used to compensate resources that overperform. In instances where the system finds itself in an aggregate net short position, any net penalty payments collected from generators would be returned to LSEs.

The must-offer obligation would apply only to resources that seek and obtain reliability accreditation from ERCOT and then enter into a contractual relationship with an LSE as part of the latter's reliability showing. Resources may elect not to sell the maximum amount that their reliability accreditation permits them to, which would avoid their designation as must-offer resources. This would be a reasonable course for resources to take if they believe that the peformance penalties would impose too consequential a risk given their own commercial view of their potential unreliabilty during critical hours. Resources may also elect to enter into a contractual relationship with an LSE for only a part of its accredited capacity.

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[53] ISO-NE has a pay-for-performance compensation mechanism that penalizes or rewards generators $2,000/MWh based on their actual performance relative to their capacity market obligation during scarcity events. The penalty/reward is slated to increase to $5,455/MWh by 2024.

[54] PJM has a penalty for non-performance during scarcity events or reward for over-performing relative to a resource's capacity market obligation. The financial penalty is tied to net cost of new entry (net-CONE) and is approximately $3,000/MWh (assuming a net-CONE of $100,000/MW-yr).

[55] CAISO has a resource availability incentive mechanism that penalizes resources based on their average offer availability at a price of $3.79/kW-mo. A resource with 90% availability during the month would be penalized $0.379/kW-mo (i.e. $3.79/kW-mo * 10%)

Market Monitoring

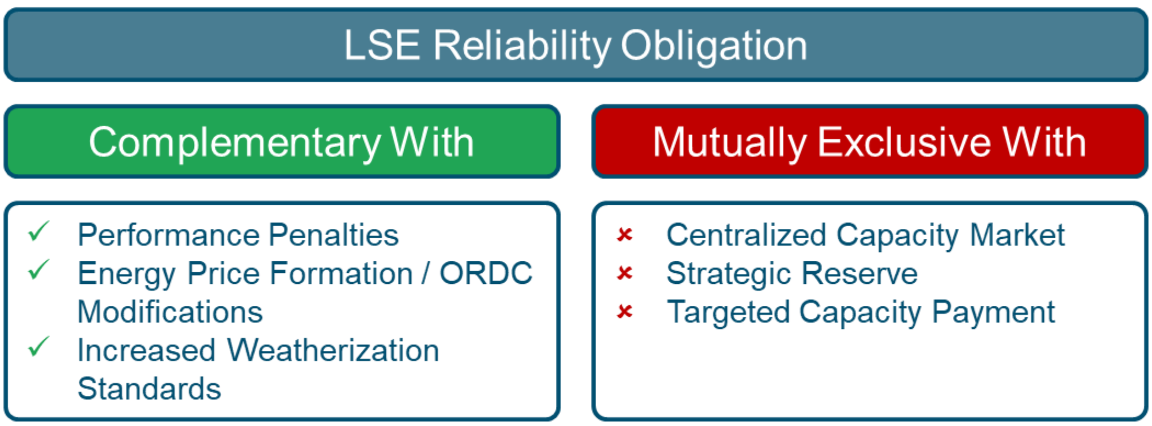
Strong market monitoring protections are needed to mitigate market manipulation by large market participants that are able to exert market power. Electricity markets across the world have extensive experience monitoring various products for manipulation and the best practices that have been developed to deal with these issues can and should be applied to the LSE Reliability Obligation. From the perspective of the LSE Reliability Obligation, LSEs with excess reliability resources should not be able withold these resources from the market in an effort to either drive up the value or to impose compliance penalties on competitors as a way to decrease competition. One potential option to mitigate market power would be to impose a requirement for all LSEs to place bids to buy and sell reliability resources with a maximum spread limit between the offered buy and offered sell price. Similar requirements have been implemented in Australia under a market design related to the one proposed in this paper, known as the Retailer Reliability Obligation.[56]

[56] https://www.aer.gov.au/retail-markets/retailer-reliability-obligation/market-liquidity-obligation

6. Comparison of Reform Options

In order to develop the LSE Reliability Obligation proposed in this whitepaper, the authors reviewed a wide array of potential market design reform options qualitatively (Section 4) and evaluated them against the objectives of market design reform (Section 3). The LSE Reliability Obligation achieves a high rating, on balance, across all objectives. It is particularly noteworthy that it accomplishes the core market-design mandates of SB 3 in a way no other proposal does. However, the implementation of an LSE Reliability Obligation would not preclude some of the other reforms currently under consideration. Figure 8 provides an overview of which reforms may complement the LSE Reliability Obligation and which reforms must be considered as alternatives.

Figure 8: Interactions Between LSE Reliability Obligation and Other Market Reform Options



This section highlights the performance of the LSE Reliability Obligation against other potential market reform options against the stated objectives of market design reform.

LSE Reliability Obligation vs. Centralized Capacity Market

A centralized capacity market produces a single, market-wide clearing price of capacity that is assessed on all loads and may suppress LSE differentiation due to a potential reduction in bilateral contracting. Such a system inherently requires a significant number of centralized, administrative decisions that govern price formation and inherently shifts power away from decentralized LSEs and into a central procurement agency. In addition, a uniform capacity price is paid to every qualifying MW. The LSE Reliability Obligation is more closely aligned with the diverse group of LSEs that provide retail competition in Texas today. The LSE Reliability Obligation allows LSEs to enter into a wide variety of relationships with resources for the purposes of the showing requirement, which include direct ownership, power purchase or tolling agreements, or the unbundled sale of a plant's reliability attributes. In facilitating this kind of trading, it would enable and encourage LSEs to maintain portfolios of resources tailored to meet the needs and preferences of their customers and would be a minimally intrusive construct to ensure sufficient reliability.

LSE Reliability Obligation vs. Targeted Capacity Payments

Targeted capacity payments provide a subsidy to certain resources but do not ensure that the system will achieve a specified level of reliability, unlike the LSE Reliability Obligation. There is a significant chance that the targeted capacity payment will be insufficient to build enough reliability resources or too rich and incentivize more reliability resources than are needed, resulting in high and unnecessary costs for customers. If targeted capacity payments only apply to specific technologies or vintages of resources, this introduces economic distortions that are inconsistent with competitive market principles. If targeted capacity payments are applied only to new generation, it could potentially induce the retirement of existing generation—leaving the system in a net neutral or even potentially worse off position but with higher costs. On the other hand, if targeted capacity payments applied only to at-risk generation that might retire, this could stunt the development of new resources. The LSE Reliability Obligation allows for the appropriate accreditation and trading of all resources on an apples-to-apples basis that provide resource adequacy to the system, in a way that the blunt tool of targeted capacity payments will not be able to achieve.

LSE Reliability Obligation vs. Strategic Reserve

A strategic reserve is a centrally-driven market intervention that is very likely to result in higher costs for customers relative to other capacity procurement schemes. Many strategic reserve constructs would only bid these resources into the energy market at the price cap in order to avoid distortion of price formation for other market participants. However, this is not an economically efficient use of the customer-funded reserve investment and increases operational costs of the system. This approach would have customers pay full freight for brand-new power plants that sit idle nearly all of the time. Meanwhile, if the strategic reserve were optimally bid into the market more consistently, this *would* result in price distortion that would impact other market participants and would likely crowd out private investment in the long-run. Thus, a strategic reserve is not consistent with competitive market principles and does not minimize costs. Further, the costs of a strategic reserve are typically borne by all market participants, regardless of whether each market participant is a contributor to the aggregate need for these resources or not. In this sense, retailers may actually have a disincentive to procure reliability resources, knowing they will be indiscriminately charged for strategic reserve resources regardless. Both academics[57] and a wide array of Texas stakeholders[58] have made clear the potential pitfalls of a strategic reserve approach and extolled the benefits of a market-based mechanism as opposed to a centrally determined interventionist mechanism.

LSE Reliability Obligation vs. Energy Price Formation Reform

Texas has a long history of energy pricing design changes, including alternative price caps and multiple iterations of the ORDC.[59] These mechanisms have fallen short at incentivizing the appropriate amount of

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[57] https://hepg.hks.harvard.edu/files/hepg/files/hogan_pope_ercot_050917.pdf?m=1523367673
[58] https://cgmf.org/blog-entry/435/REPORT-%7C-Never-Again-How-to-prevent-another-major-Texas-electricity-failure.html
[59] https://hepg.hks.harvard.edu/files/hepg/files/hogan_pope_ercot_050917.pdf?m=1523367673

system reliability despite the potential for very large financial rewards for doing so. Modifications to the ORDC are not guaranteed to remedy this problem, and may even have the unintended consequence of incentivizing additional resources that raise energy prices for consumers during some hours but that do not provide energy during the most critical hours. For this reason, a modification to the ORDC alone is unlikely to materially improve the reliability of the ERCOT electricity system. However, the trigger component of the LSE Reliability Obligation is specifically designed such that if energy price signals result in sufficient investment in reliability resources, then the LSE Reliability Obligation would be non-binding with no effect on LSEs or other market participants.

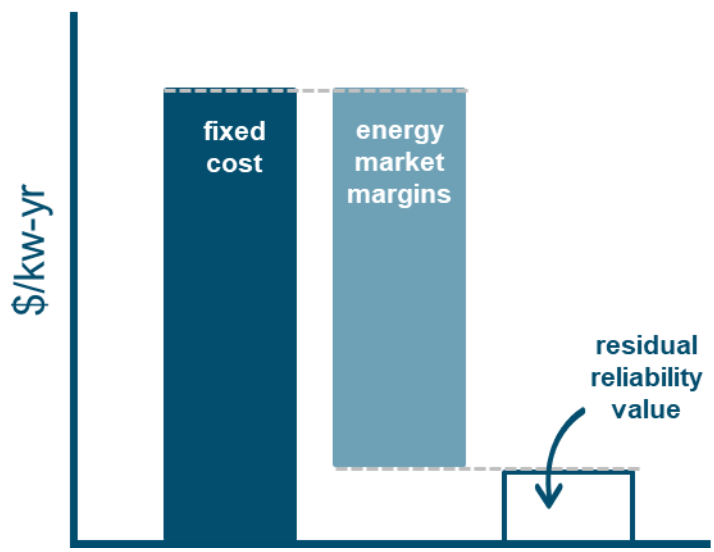
Another potential energy market price reform that has been discussed is the application of the ORDC to only select resources, e.g., thermal capacity. While in theory this may have the benefit of directing reliability payments toward resources that are providing greater reliability benefit, in practice implementing such a system through an hourly energy market would make it impossible to meaningfully distinguish between different types of resources that are all providing energy. Differentiating payments to resources that are simultaneously providing identical amounts of energy to the system based on the technology type, rather that performance, is counter to competitive market principles and would create significant market inefficiencies, friction, and distortions that are discussed in later in the whitepaper. A core advantage of the LSE Reliability Obligation relative to such an energy market price reform is its technological neutrality. The LSE Reliability Obligation credits resources uniformly based on the services they provide to the system, regardless of underlying technology, even though characteristics may vary by technology or resource modifications such as on-site fuel storage.

7. Reliability Value Dynamics

An important question for policymakers, customers, generators, and other market participants is "what does the LSE Reliability Obligation cost?" First, the cost of the LSE Reliability Obligation will be impacted by the reliability standard set by the PUCT. To the extent that the standard is more stringent, this will increase costs. Another important dimension of cost lies in interaction with the rest of the Texas electricity market. If the energy-only market design delivers sufficient resources to meet the specified reliability target, the LSE Reliability Obligation would not be triggered and the cost would be zero. Alternatively, if the energy-only design results in a significant deficiency of reliability resources, the cost borne by the LSE Reliability Obligation would be larger.

The interaction between the LSE Reliability Obligation and the energy market can be represented in part through a well-established relationship between the fixed cost of new resources and the margins these resources expect to earn in the energy market as illustrated in Figure 9. The higher the expected energy market margins, the less "residual" value must be borne by a backstop reliability procurement program such as the LSE Reliability Obligation.

Figure 9: Illustration of Residual Reliability Value

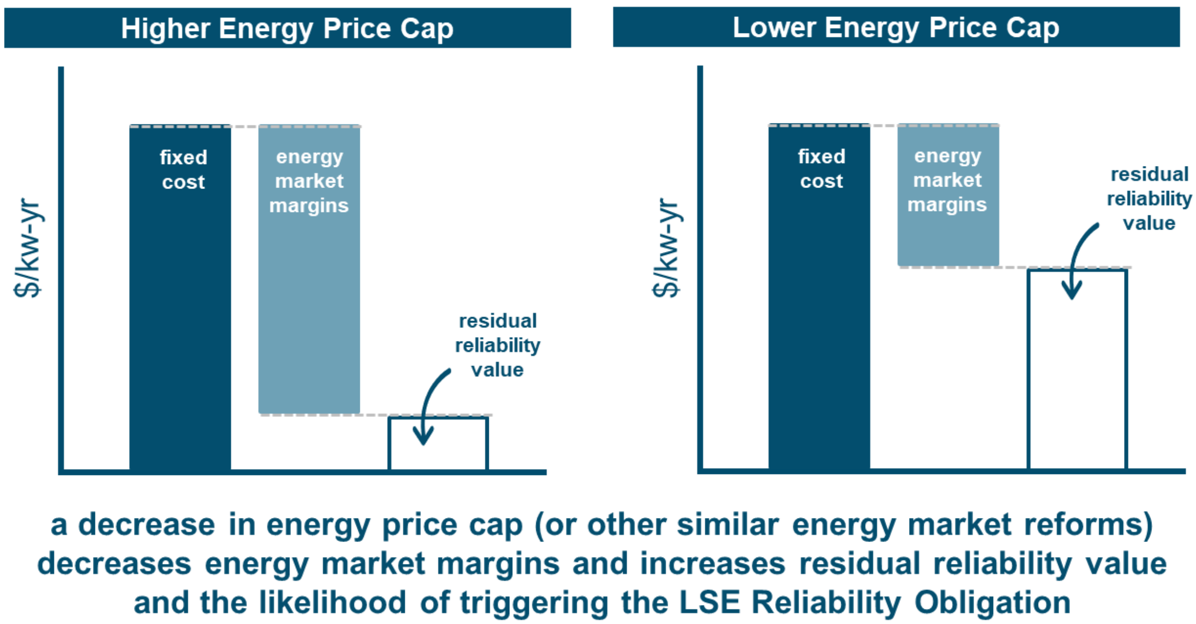


This section qualitatively describes how the value of "residual reliability value" i.e. the cost of the LSE Reliability Obligation may be expected to change under ORDC reforms and increased participation of demand-side resources.

Impact of ORDC Reforms on Residual Reliability Value

The administrative decisions that determine energy price formation, namely the system price cap and the ORDC formula, have a significant impact on the expected energy margins of a resource, and thus impact the residual reliability value. The ERCOT market design today is predicated on the energy-only market design delivering sufficient revenues to eliminate any residual reliability value. To the extent that policymakers modify the parameters of energy price formation, for example by decreasing the existing $9,000/MWh energy price cap[60], this would likely decrease expected energy market margins and increase residual reliability value and trigger the LSE Reliability Obligation. The graphic below illustrates this relationship.

Figure 10: Impact of Energy Price Cap on Residual Reliability Value



Elongation of the ORDC would need to be analyzed for the potential impact on residual reliability value. As previously noted, elongation of the ORDC would likely reduce residual reliability value for some resources that generate in hours when the system is most constrained but might increase compensation for resources that generate during hours when supplies are tight but there is low probability of a loss-of-load event.

Impact of Increased Participation from Demand-Side Resources on Residual Reliability Value

A significant contributor to the current predicament in Texas is that hourly energy prices are very quick to oscillate between periods of sufficiency (where prices are low or even negative) and deficiency (where prices are as high as $9,000/MWh). The periods of deficiency can result in power outages (and associated societal costs) with painful price impacts for the remaining consumers that continue to receive service, however, these periods are also necessary for resources to earn margins to recover capital investment costs. Enabling more demand to be responsive to price would allow some resources to voluntarily curtail during periods of deficiency, avoiding both firm load shed and the high prices associated with such load-shedding events. If these periods were to happen with sufficient frequency, prices would rise above variable cost of generation, increasing margins for the capital recovery of reliability resources while

[60] http://www.energychoicematters.com/stories/20210923y.html

avoiding power outages and very high energy prices.[61] Effectively, more participation of demand will increase energy margins, reducing the residual reliability value and the cost of the LSE Reliability Obligation.

There may be a significant number of customers willing to curtail all or a portion of their load for the right price, however customers often do not respond in this way due to insufficient incentives provided by their LSEs to respond to wholesale market prices and a lack of information or technological ability to do so. Breaking down these barriers should be a near-term goal for the PUCT given the strong relationship between demand side participation and reliability.[62]

[61] https://www.sciencedirect.com/science/article/abs/pii/S030626190900244X

[62] For example, see stakeholder comments of PUCT Project 52373 http://interchange.puc.texas.gov/search/filings/?UtilityType=A&ControlNumber=52373&ItemMatch=Equal&DocumentType=ALL&SortOrder=Ascending

8. Conclusion

Electric system reliability is critical to modern society, both from an economic and a health and safety perspective. The importance of reliability is only likely to increase as more aspects of life become dependent on electricity, including transportation and heating. The current ERCOT 'energy-only' market design provides financial signals for investment in resources but does not *ensure* there are sufficient resources or resources with the right capabilities to meet a specified reliability target. Recent historical events such as Winter Storm Uri and concerns an impending increase in intermittent (wind, solar) and energy-limited (storage) have made these challenges even more acute.

The LSE Reliability Obligation provides a market reform proposal for ERCOT that retains the best elements of the existing design while providing a mechanism to *ensure* that there are sufficient resources to meet a specified reliability standard. The proposal retains a competitive, restructured retail electricity market and provides the opportunity for the energy-only framework to deliver sufficient reliability before imposing additional obligations on LSEs. The proposal is directly responsive to the directive of Senate Bill 3 to "procure… reliability services on a competitive basis," delivering fair and low-cost reliability in a way that is responsive to the diverse set of unique Texas stakeholder interests. The LSE Reliability Obligation represents an important step forward in the evolution of the Texas electricity market and is an important component of comprehensive energy-sector reform.

9. Technical Appendix

This appendix is intended to provide a calculation example of the LSE Reliability Obligation. This calculation is for an illustrative set of LSEs and resources and is not intended to convey actual expected outcomes.

Step 1: Establish Seasonal Reliability Standard and Required Planning Reserve Margin

The PUCT will establish a reliability standard by season. The two components of a reliability standard are 1) the selected reliability metric and 2) the stringency of this metric. While conventional reliability planning in North America uses the loss of load expectation (LOLE) metric at a 1-day-in-10-year stringency, it is possible that other metrics are more suitable for Texas and other systems with exposure to high magnitude events such as winter storm Uri. For more info on reliability metrics, see Section 5.

Because the LSE Reliability Obligation would be triggered on a seasonal basis, the PUCT would need to determine a specific reliability standard for each season, performing separate system assessments accordingly. It is possible that the reliability standard for summer and winter will differ given the potentially different economic and societal impacts of loss of load in each season.

Using the established reliability standard (e.g. 0.1 LOLE), ERCOT will calculate the require planning reserve margin (PRM) required to meet this standard. This analysis will be performed using industry standard loss-of-load-probability modeling. For example, ERCOT could determine that a 15% seasonal PRM is required to meet the established seasonal reliability standard.

Step 2: Establish Resource Accreditation Values

ERCOT will determine, on an ex-ante basis, a percentage reliability value for each resource type based on its ability to contribute to the established reliability standard. These values will be determined using industry best practices, accounting for the many factors described in the body of the whitepaper. These values will differ by season and should be expected to change over time as the energy mix changes. An illustrative set of summer resource accreditation values is provided in Table 2.

Table 2: Illustrative Summer Resource Accreditation Values

Resource Class	Resource Sub-Type	Reliability Value (%)
Natural Gas	Location A: No firm pipeline contract	75%
	Location A: Firm pipeline contract	80%
	Location B: No firm pipeline contract	80%
	Location B: Firm pipeline contract	85%
	Dual-fuel capability with on-site storage	95%
Coal	With on-site fuel	95%
Nuclear	With on-site fuel	95%
Solar	Location A	70%
	Location B	50%
Wind	Location A	15%
	Location B	10%
Storage	4-hr Duration	70%
	10-hr Duration	90%
Hydro	With reservoir	90%
Demand Response	2 calls per year, 2 hours per call	50%
	10 calls per year, 10 hours per call	80%

Step 3: Perform System Assessment

Using a 3-year ahead forecast of expected seasonal loads and resources, ERCOT would then determine whether there are expected resources to meet the target reliability standard. This exercise would be completed by comparing the reliability value of all system-wide resources to the system-wide reliability requirement as illustrated in Table 3 for the summer season.

Table 3: Illustrative Summer System Assessment

Item	Units	Value	Notes
Forecasted System Peak Load	MW	80,000	ERCOT forecast
Required Planning Reserve Margin	%	15%	ERCOT calculation – based on established reliability standard
Total Reliability Requirement	MW	92,000	Forecasted System Peak Load * (1 + Required Planning Reserve Margin)
Forecasted Reliability Resources	MW	85,000	Sum of all forecasted resource installed capacity (MW) multiplied by the reliability value % of each resource as determined in the resource accreditation step
Forecasted Sufficiency (Deficiency)	MW	(7,000)	Total Reliability Requirement – Forecasted Reliability Resources

Step 4: Make Trigger Determination

The PUCT would make a determination to trigger the LSE Reliability Obligation based on the ERCOT system assessment as described in step 3. To the extent that there is a forecasted system deficiency, the PUCT should consider triggering the LSE Reliability Obligation. The PUCT should maintain some regulatory judgement in making the trigger decision. Factors that the PUCT could consider include load and resource uncertainty, the magnitude of the expected sufficiency or deficiency, and data or methodological limitations that could impact the assessment.

The following steps apply if and only if the LSE Reliability Obligation is triggered in Step 4.

Steps 5 – 9 illustrate the triggering of the LSE Reliability Obligation assumes for the summer season. To the extent that a different season's LSE Reliability Obligation is also triggered, these calculation steps would need to be repeated using alternative data. It is likely that LSE Requirement and Resource Accreditation values will differ by season.

Step 5: Determine LSE Requirements

On a year-ahead forward basis, ERCOT would determine seasonal requirements for each LSE based on the expected load during peak net load hours. Peak net load hours would be determined by ERCOT on an ex-ante basis with a percentage allocation given to each hour. The requirement for each LSE would be the weighted average of expected ex-ante loads, with weightings determined by peak net load percentage allocations. An example of this calculation is provided in Table 4. While the calculation here only shows a single day for simplicity, the calculation would actually utilize every hour within the summer season.

Table 4: LSE Summer Load Requirements

Hour	Weighting for Top Net Load Hours	LSE 1 Load (MW)	LSE 2 Load (MW)
1		100	150
2		110	150
3		120	150
4		130	150
5		140	150
6		150	150
7		160	150
8		170	150
9		180	150
10		190	150
11		200	150
12		210	150
13		220	150
14		230	150
15		240	150
16		250	150
17		230	150
18	50%	210	150
19	50%	190	150
20		170	150
21		150	150
22		130	150
23		110	150
24		100	150
	Load Requirement	**200**	**150**

The load requirement for each LSE would then be adjusted downward for any potential interruptible load credits and upward to account for reserve margin requirements. This process is illustrated in Table 5.

Table 5: LSE Reliability Obligation Summer Requirement

Value	LSE 1	LSE 2	Notes
Load Requirement (MW)	200	150	50% * Load in Hour 18 + 50% * Load in Hour 19
Interruptible Load Credit (MW)	0	50	Explicit credit for fully interruptible load as determined by ERCOT
Firm Load Requirement (MW)	200	100	Load Requirement – Interruptible Load Credit
Reserve Margin Adder (MW)	30	15	Firm Load Requirement * 15%
LSE Requirement (MW)	230	115	Firm Load Requirement + Reserve Margin Adder

Step 6: LSE Showings

On a year-ahead basis, each LSE will procure resources to show aggregate reliability based on resource accreditation that meets or exceeds the LSE requirement. An example of this calculation is shown in Table 6, with further explanations of each calculation provided below.

Table 6: LSE Resource Reliability Summer Values

		LSE 1		LSE 2	
Resource	Reliability Value (%)	Installed Capacity (MW)	Reliability Value (MW)	Installed Capacity (MW)	Reliability Value (MW)
Natural Gas – Location A: No firm pipeline contract	75%	60	45	20	15
Natural Gas – Dual-fuel capability with on-site storage	95%	100	95	0	0
Solar Location A	70%	50	35	50	35
Wind Location B	10%	200	20	100	10
Storage – 4-hr duration	70%	50	35	50	35
Total Reliability Value (MW)			**230**		**95**

- Reliability Value (%) from Table 2
- Installed Capacity (MW) = nameplate capacity of resources that each LSE has contracted with to procure their reliability value
- Reliability Value (MW) = Installed Capacity (MW) * Reliability Value (%)
- Total Reliability Value = Sum of all Reliability Value (MW)

Each LSE will then "show" the total reliability value of their resources relative to their requirement. To the extent that there is a deficiency, that LSE would be assessed a penalty. Example calculations are provided in Table 7, with further explanations of each calculation provided below.

Table 7: Summer LSE Showing Requirement

Resource	LSE 1	LSE 2
Total Reliability Value (MW)	230	95
LSE Requirement (MW)	230	115
Sufficiency/Deficiency (MW)	0	-20
Penalty ($)	$0	$2M

- Total Reliability Value (MW) from Table 6
- LSE Requirement (MW) from Table 5
- Sufficiency/Deficiency (MW) = Total Reliability Value – LSE Requirement
  - Negative value represents deficiency
- Penalty ($) = -Deficiency * Penalty Price
  - Illustrative penalty price of $100,000/MW used in calculation

Step 7: Performance Assessment

During the compliance season, performance will be assessed on all resources that are contractually tied to a specific LSEs reliability showing.

Performance assessment for intermittent (wind, solar) and energy-limited (storage, demand response) resources is an emerging topic in electricity sector market design. It is important to note that the illustrations here are one example of many options for how performance assessment could work. Further work on performance assessment likely requires additional research and is outside the scope of this whitepaper.

This calculation assesses resource performance in the top 10 net load hours relative to the accredited value for each resource which can be configured differently. Underperformance is penalized while overperformance is compensated with an additional payment. An example of this calculation is provided in Table 8.

Table 8: Penalty Assessment Calculation

	Natural Gas – Dual-fuel capability with on-site storage		Solar Location A	
Reliability Value (%)	95%		70%	
Installed Capacity (MW)	100		50	
Reliability Value (MW)	95		35	
Top Net Load Hours	Resource Performance (MW)	Net Performance Assessment (MWh)	Resource Performance (MW)	Net Performance Assessment (MWh)
1	100	+5	30	-5
2	100	+5	35	0
3	100	+5	20	-15
4	100	+5	25	-10
5	100	+5	30	-5
6	100	+5	40	+5
7	100	+5	40	+5
8	100	+5	35	0
9	100	+5	15	-20
10	100	+5	35	0
Total Net Performance Assessment (MWh)		**+50**		**-45**
Payment/Penalty Assessment ($)		**$500,000 Payment**		**$450,000 Penalty**

- Reliability Value (%) from Table 2
- Installed Capacity (MW) from Table 6 (LSE 1)
- Reliability Value (MW) = Installed Capacity (MW) * Reliability Value (%)
- Top 10 net load hours determined ex-post by ERCOT
- Net performance assessment (MWh) = [Resource performance (MW) – Reliability Value (MW)] * 1 hour
- Total Net Performance Assessment (MWh) = Sum of all net performance over top 10 net load hours
- Penalty Assessment ($) = Total Net Performance Assessment (MWh) * Penalty Price ($/MWh)
  - Penalty price of $10,000/MWh used in this example