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

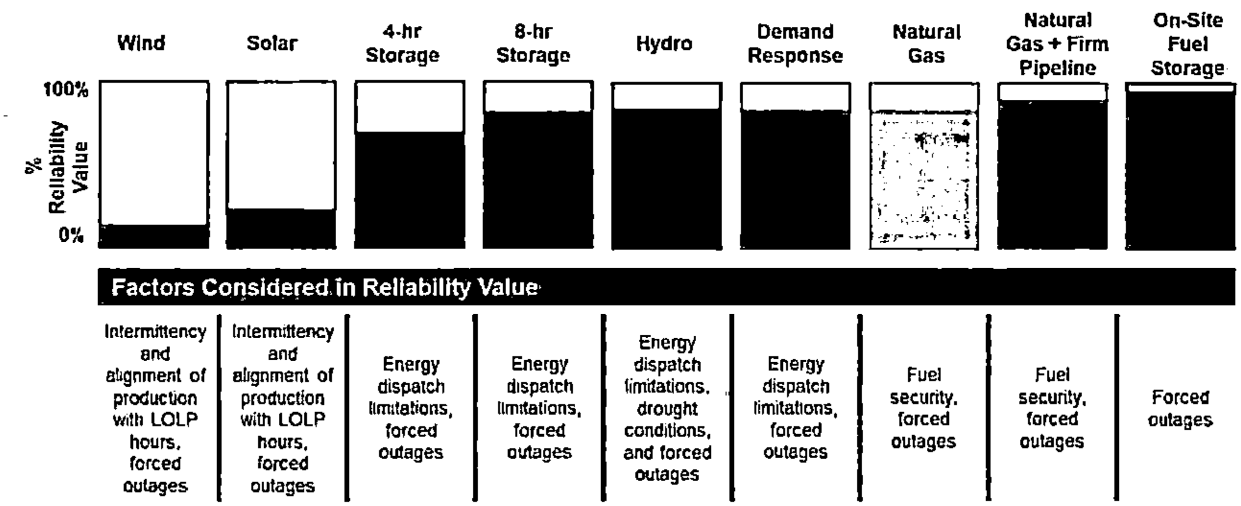
[49] https://www.iso-ne.com/static-assets/documents/2020/10/2021_awp_final_10_05_20.pdf

[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.

[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

LSE Reliability Obligation

Complementary With

- ✓ Performance Penalties
- ✓ Energy Price Formation / ORDC Modifications
- ✓ Increased Weatherization Standards

Mutually Exclusive With

- × Centralized Capacity Market
- × Strategic Reserve
- × Targeted Capacity Payment

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.

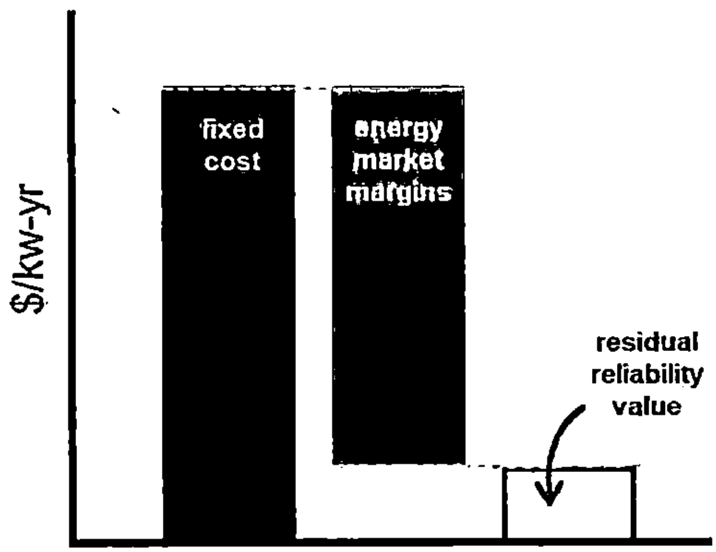
Another potential energy market price reform that has been discussed is the application of the ORDC to only select resources, e.g., thermal capacity. While in theory this may have the benefit of directing reliability payments toward resources that are providing greater reliability benefit, in practice 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

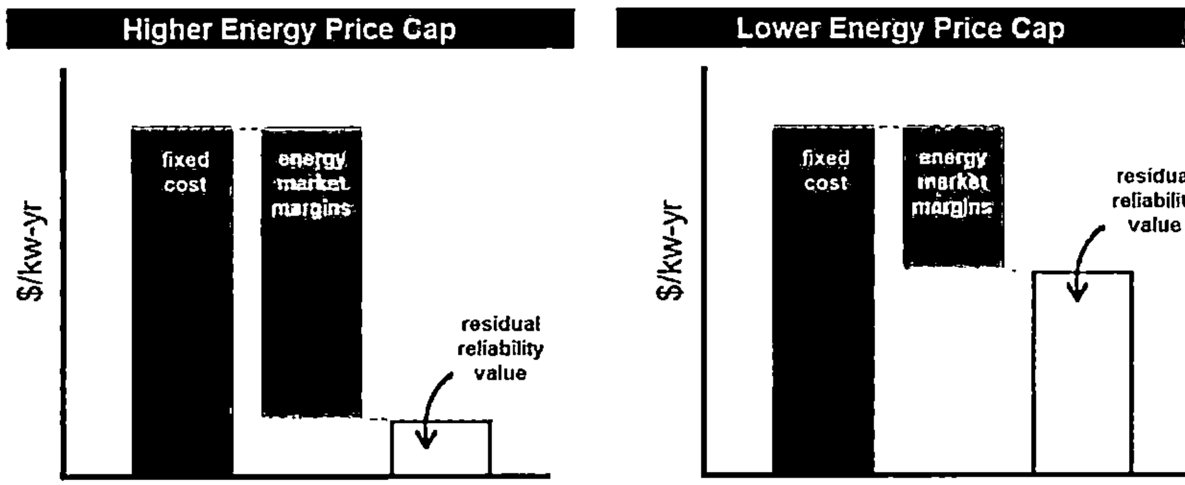


This section qualitatively describes how the value of "residual reliability value" i.e. the cost of the LSE Reliability Obligation may be expected to change under ORDC reforms and increased participation of demand-side resources.

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



a decrease in energy price cap (or other similar energy market reforms) decreases energy market margins and increases residual reliability value and the likelihood of triggering the LSE Reliability Obligation

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