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ERCOT'S 2022 OPERATING RESERVE DEMAND CURVE REPORT

Pursuant 16 Texas Administrative Code (TAC) § 25.505(e), Electric Reliability Council of Texas, Inc. (ERCOT) files with the Public Utility Commission of Texas (Commission) the *2022 Biennial ERCOT Report on the Operating Reserve Demand Curve*, attached to this cover pleading. The report will also be published today on the Helpful Resources page of the ERCOT website under the "Reports and Other" subheading.[1]

Earlier this year, the Commission adopted a requirement that ERCOT publish, by November 1 of every even-numbered year, a report analyzing the efficacy, utilization, related costs, and contribution of the Operating Reserve Demand Curve (ORDC) to grid reliability in the ERCOT region. This is the first such report.

ERCOT stands ready to assist the Commission with any additional information requested. To that end, Kenan Ögelman, ERCOT's Vice President of Commercial Operations, intends to attend the Commission's open meeting scheduled for November 3, 2022.

[1] http://www.ercot.com/gridinfo/resource

October 31, 2022

Respectfully submitted,

/s/ Davida Dwyer

Davida Dwyer
Sr. Corporate Counsel
Texas Bar No. 24052120
(512) 225-7182 (Phone)
(512) 225-7079 (Fax)
davida.dwyer@ercot.com

Nathan Bigbee
Deputy General Counsel
Texas Bar No. 24036224
(512) 225-7093 (Phone)
(512) 225-7079 (Fax)
nathan.bigbee@ercot.com

Davida Dwyer
Senior Corporate Counsel
Texas Bar No. 24052120
(512) 225-7023(Phone)
(512) 225-7079 (Fax)
davida.dwyer@ercot.com

ERCOT
8000 Metropolis Drive, Bldg. E, Suite 100
Austin, Texas 78744

ATTORNEYS FOR ELECTRIC
RELIABILITY COUNCIL OF TEXAS, INC.

2022 Biennial ERCOT Report on the Operating Reserve Demand Curve

October 31, 2022

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Acronyms

DAM	Day-Ahead Market
EEA	Energy Emergency Alert
EOC	Energy Offer Curve
ERCOT	Electric Reliability Council of Texas
ERS	Emergency Responsive Service
HCAP	High System-Wide Offer Cap
HSL	High Sustained Limit
LCAP	Low System-Wide Offer Cap
LOLP	Loss of Load Probability
MCL	Minimum Contingency Level
NFRC	Non-Frequency Responsive Capacity
Non-Spin	Non-Spinning Reserve
ORDC	Operating Reserve Demand Curve
PBMCL	Probability of Reserves Falling Below the Minimum Contingency Level
PNM	Peaker Net Margin
PRC	Physical Responsive Capability
PUCT	Public Utility Commission of Texas
QSE	Qualified Scheduling Entity
QSGR	Quick-Start Generation Resources
RTM	Real-Time Market
RTOFFCAP	Real-Time Off-Line Capacity
RTOFFPA	Real-Time Off-Line Reserve Price Adder
RTOLCAP	Real-Time On-Line Capacity
RTORDPA	Real-Time On-Line Reliability Deployment Price Adder
RTORPA	Real-Time On-Line Reserve Price Adder
RUC	Reliability Unit Commitment
SWCAP	System-Wide Offer Cap
VOLL	Value of Lost Load

Executive Summary

ERCOT provides this biennial report on the Operating Reserve Demand Curve (ORDC) to the Public Utility Commission of Texas (PUCT) in accordance with subsection (e) of PUCT Substantive Rule §25.505, Resource Adequacy Reporting Requirements in the Electric Reliability Council of Texas Power Region:

> *"Operating Reserve Demand Curve (ORDC) report. ERCOT must publish, by November 1 of every even numbered year, a report analyzing the efficacy, utilization, related costs, and contribution of the ORDC to grid reliability in the ERCOT power region."*

The ORDC is a market mechanism that values operating reserves in the wholesale electric market based on the scarcity of those reserves and reflects that value in energy prices. This report analyzes data related to the ORDC with a specific focus on the periods of March 2018 through March 2019; March 2020 through March 2021; and January 1 through September 30, 2022. These time periods were selected to compare the effects of prior ORDC policies against the effects of the changes to the ORDC parameters that were implemented at the beginning of 2022 as part of a host of market-design reforms that have been enacted in response to the Winter Storm Uri Event. These ORDC changes directly affect the data analyzed in this report, while broader reliability actions[1] influence the data indirectly. To effectively assess the efficacy, utilization, costs, and contribution of the ORDC to grid reliability following post-Uri reforms, this report takes the approach of comparing the 2022 study period to two baseline study periods that show the outcomes of previous ORDC policies.

Key observations of this report include:

- **Efficacy:** Changes to the ORDC for 2022 have resulted in higher price signals during periods of lower reserves, to encourage response from the market when there is greater risk to grid reliability. Additionally, prices to incent self-commitment of generation resources are being observed at higher reserve levels, as compared to previous study periods. ORDC prices (referred to as the Real-Time On-Line Reserve Price Adder (RTORPA)) are also playing a more significant role in the accumulated dollars observed in Peaker Net Margin (PNM): a metric that represents the net revenue that a hypothetical peaking Generation Resource could have earned from the Real-Time Market and provides some indication of the historical investment signal for these types of plants.

- **Utilization:** Within the 2022 study period, the RTORPA has reached significant levels more frequently compared to the baseline study periods. This is especially true when comparing equivalent levels of on-line ORDC reserves (referred to as Real-Time On-Line Capacity (RTOLCAP)). Significant RTORPA values are also being observed earlier, at higher levels of reserves.

[1] Such reliability actions include additional Non-Spinning Reserve Service (Non-Spin) procurement, as well as operational procedures for deploying reliability measures.

- **Costs:** For the 2022 study period, the ORDC prices have been a more significant contributor to energy prices in the Real-Time Market compared to the baseline study periods. This includes both an increased average RTORPA value and an increased contribution from the adder to the all-in, Real-Time price for energy represented by this adder.

- **Reliability:** ORDC has created additional incentive for the market to respond to Real-Time, system-wide reliability needs compared to previous study periods. Also, as previously mentioned, the ORDC has provided broader, increased revenues, as measured by the PNM metric, to help incentivize longer-term resource adequacy.

Specific results in the report include:

- The observed reserve level at which RTORPA reaches $10 per megawatt-hour (MWh) has increased to 9,300 megawatts (MW) of total ORDC reserves under the current ORDC policy, compared to 5,770 MW and 6,720 MW under the previous ORDC policies that were analyzed. This has improved the economic signal for marginal generation resources to self-commit and enter the on-line reserve pool at higher reserve levels, thus improving grid reliability before reserves drop to lower levels.
- Since the January 1, 2022 ORDC reform, the fraction of Operating Days during which the four-hour rolling time-weighted RTORPA exceeds $10/MWh has more than doubled with respect to the baseline study periods that were analyzed. Similarly, this has provided opportunities on more Operating Days for marginal generation resources to economically self-commit and enter the on-line reserve pool, providing increased reliability to the grid.
- As intended with the ORDC changes, price signals during times of lower Physical Responsive Capability (PRC) levels have been noticeably higher under the current ORDC paradigm, relative to the previous study periods. This is particularly prevalent when considering PRC levels below 3,500 MW. It is during these times of lower PRC levels when there is greater risk to grid reliability and response from the market participants is most needed. Thus, the current ORDC parameters are more effectively incenting offers of additional capacity and, as a result, PRC at the times of greatest need.
- The time-weighted average RTORPA increased from $0.41/MWh in 2021, excluding Winter Storm Uri, to $6.33/MWh in 2022 through September. This $6.33/MWh is 8.1% of the all-in price for 2022 through September, again indicating that RTORPA is playing a greater role in overall Real-Time Market price formation.
- With the ORDC changes for 2022, RTORPA has significantly contributed to PNM accumulation this year, making up approximately 29% of cumulative PNM through September. PNM accumulation in 2022 through September is approximately $139,000/MW, giving an indication that Real-Time Market prices for 2022 have provided a greater signal for investment in these types of Resources.

While this report focuses on the ORDC changes that took effect for 2022, it should be noted that additional market design reform to enhance the long-term reliability of the ERCOT grid is still being considered by the PUCT, as part of PUCT Project No. 52373, *Review of Wholesale Electric Market Design*.

1. Background and Key Events

1.1. Operating Reserve Demand Curve (ORDC) Theory

The ORDC is a market-based construct for valuing operating reserves according to their scarcity. As initially described to the PUCT by Dr. William Hogan, the ORDC is based on the following principles:

> "The key connection [for the ORDC] is with the value of lost load (VOLL) and the probability that the load will be curtailed. Whenever there is involuntary load curtailment and the system has just the minimum of contingency operating reserves, then prices should rise to the VOLL. At any other level of operating reserves, set to protect the system for possible events in the immediate future, the value of an increment of operating reserves should reflect the probability of loss of load."[2]

Due to net load forecast error and other factors, there is uncertainty in the level of operating reserves that will be available in the near-term operational timeframe of the next 30 minutes to one hour. Therefore, there is a probability, referred to as the Loss of Load Probability or LOLP, that operating reserves will fall to the level that would require involuntary load curtailment within that timeframe. When there is involuntary load curtailment, the ORDC should rise to VOLL. At operating reserve levels not requiring involuntary load curtailment, the ORDC should reflect the LOLP multiplied by VOLL such that, as operating reserves increase, the LOLP decreases and the ORDC eventually declines to zero.

1.2. Initial ERCOT Implementation

The ERCOT ORDC is fully defined in the Other Binding Document titled "Methodology for Implementing ORDC to Calculate Real-Time Reserve Price Adder" (the ORDC methodology document). [3] This section provides a brief summary of the complete description found in the ORDC methodology document. To the extent there is any difference between this summary and the ORDC methodology document, the ORDC methodology document controls.

ERCOT's initial ORDC implementation introduced separate price adders for on-line and off-line reserve categories to the five-minute Real-Time Market in summer 2014. The Real-Time On-Line Reserve Price Adder (RTORPA) is associated with Real-Time On-Line Capacity (RTOLCAP), which encompasses all reserves that can be made available to the system within 30 minutes. The Real-Time Off-Line Reserve Price Adder (RTOFFPA) is associated with Real-Time Off-Line Capacity (RTOFFCAP), which refers to reserves that require between 30 minutes and one hour to be made available. Both adders are calculated in terms of VOLL and the probability of reserves falling below

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[2] *Improved Electricity Scarcity Pricing and Operating Reserves*, William W. Hogan, Attachment to Second Supplemental Comments of GDF Suez Energy Resource NA, Inc., Project No. 40000 (Jan. 22, 2013)

[3] Available online: https://www.ercot.com/mktrules/obd/obdlist

the minimum contingency level (PBMCL), where VOLL is equal to the System-Wide Offer Cap (SWCAP), and PBMCL is derived from LOLP and the minimum contingency level.

PBMCL is a shifted version of ERCOT's empirically determined LOLP normal distribution. LOLP, which represents the probability of a Real-Time reserve shortfall, is determined by comparing the Hour-Ahead forecasted level of reserves to the level of reserves realized in Real-Time. The gap between these values, termed reserve error, is assumed to follow a normal distribution characterized by a mean (Mu or μ) and a standard deviation (Sigma or σ). Once per season, ERCOT determines the LOLP distribution by compiling empirical reserve error data going back to the start of the Nodal Market[4] and fitting this data to a normal distribution. The LOLP curve is then shifted by the minimum contingency level to obtain PBMCL, *i.e.*, the probability of reserves falling below the minimum contingency level. Note that while the minimum contingency level described in Section 1.1 matches the reserve level at which ERCOT will begin instructing firm load shed, ERCOT's minimum contingency level was initially set to 2,000 MW to address concerns related to long-term resource adequacy. See Figure 1 for an illustration of RTORPA in terms of LOLP, MCL, PBMCL, and VOLL.

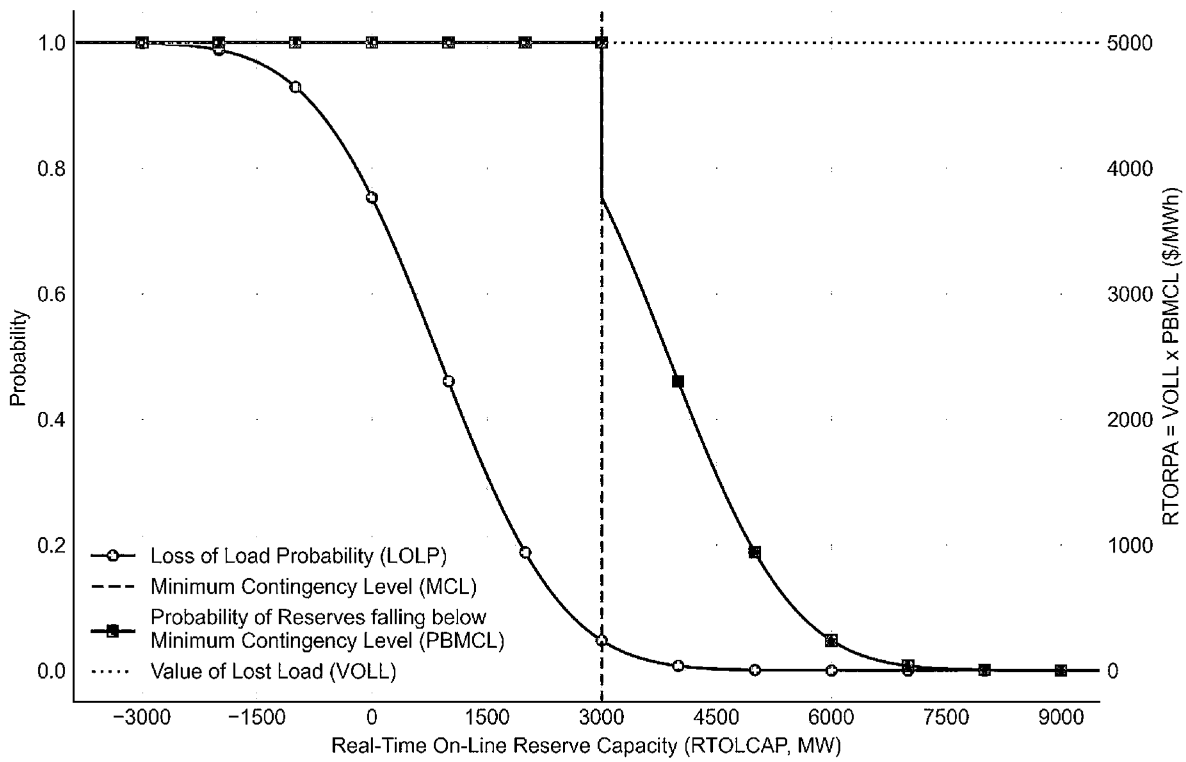

Figure 1: RTORPA, LOLP, and PBMCL. Reserve error distribution Mu and Sigma are set to their most recent values, and RTOFFCAP is assumed to be 0 MW for illustration purposes. Note that multiplying the PBMCL curve by VOLL (currently $5,000/MWh) yields the Operating Reserve Demand Curve (ORDC). RTORPA values may therefore be read from the right axis (assuming System Lambda is zero).

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4 December 1, 2010.

The value of a particular Resource's reserve contribution depends on how quickly it can be made available to the system. The Mu and Sigma parameters of PBMCL are adjusted between RTORPA and RTOFFPA to reflect this. Figure 2 illustrates the difference between the two adders as a function of reserve uncertainty over the next operating hour. Total reserve uncertainty is assumed to be split evenly between two 30-minute intervals. During the second interval, both reserve categories (RTOLCAP and RTOFFCAP) are available. RTOFFPA is therefore calculated using the full Mu and Sigma and is paid to reserves that fall into the RTOFFCAP category. During the first 30-minute interval of the next operating hour, however, only RTOLCAP is available. RTORPA therefore has an extra term, in addition to the RTOFFPA term, to compensate faster-acting reserves for their additional value. The extra term is calculated using a shortened PBMCL curve that captures reserve uncertainty over the first half of the upcoming operating hour, with Mu scaled by one-half and Sigma scaled by 0.707 to adjust for the fact that only a 30-minute period is being considered, as opposed to a full hour.

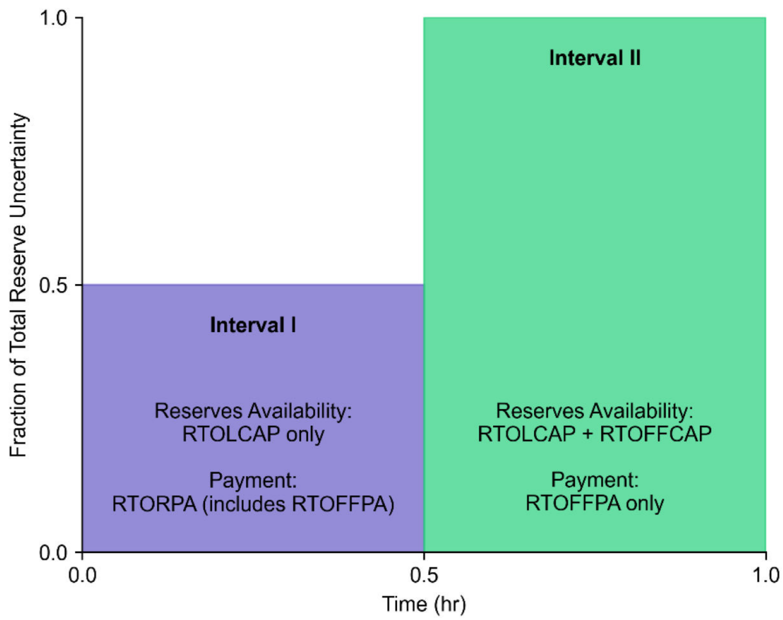

Figure 2: ERCOT ORDC perspective on reserve uncertainty over the next operating hour. During Interval I (the first 30 minutes), only RTOLCAP is available, making it more valuable than RTOFFCAP.

There are two additional relevant details. First, Protocols limit the sum of System Lambda and all Price Adders to SWCAP, *i.e.*, the system-wide offer cap. Thus, RTORPA can only reach SWCAP if System Lambda is zero. Second, there is one additional price adder called the Real-Time On-Line Reliability Deployment Price Adder (RTORDPA). This adder, which is unrelated to the ORDC and calculated after System Lambda and RTORPA are determined, accounts for the price impacts of Protocol-defined out-of-market actions, such as reliability actions like Reliability Unit Commitment (RUC) and Emergency Responsive Service (ERS) deployments.

1.3. Subsequent ERCOT ORDC Adjustments

There have been significant administrative changes to ERCOT ORDC parameters since the initial implementation in June 2014, as illustrated in Figure 3. Mu, the mean value of the LOLP distribution, was administratively shifted upward by 0.25 times Sigma in March of 2019, then by an additional 0.25 times Sigma in March 2020. VOLL (which is set equal to SWCAP) changed twice, from $9,000/MWh down to the $2,000/MWh Low-System-Wide Offer Cap (LCAP) following Winter Storm Uri, then back up to $5,000/MWh on January 1 of this year. Finally, the minimum contingency level was increased from 2,000 MW to 3,000 MW on January 1 of this year. To help isolate the effects of these changes, the analysis presented in this report compares three study periods (which are shaded in Figure 3) selected to highlight three distinct chapters of ORDC history.

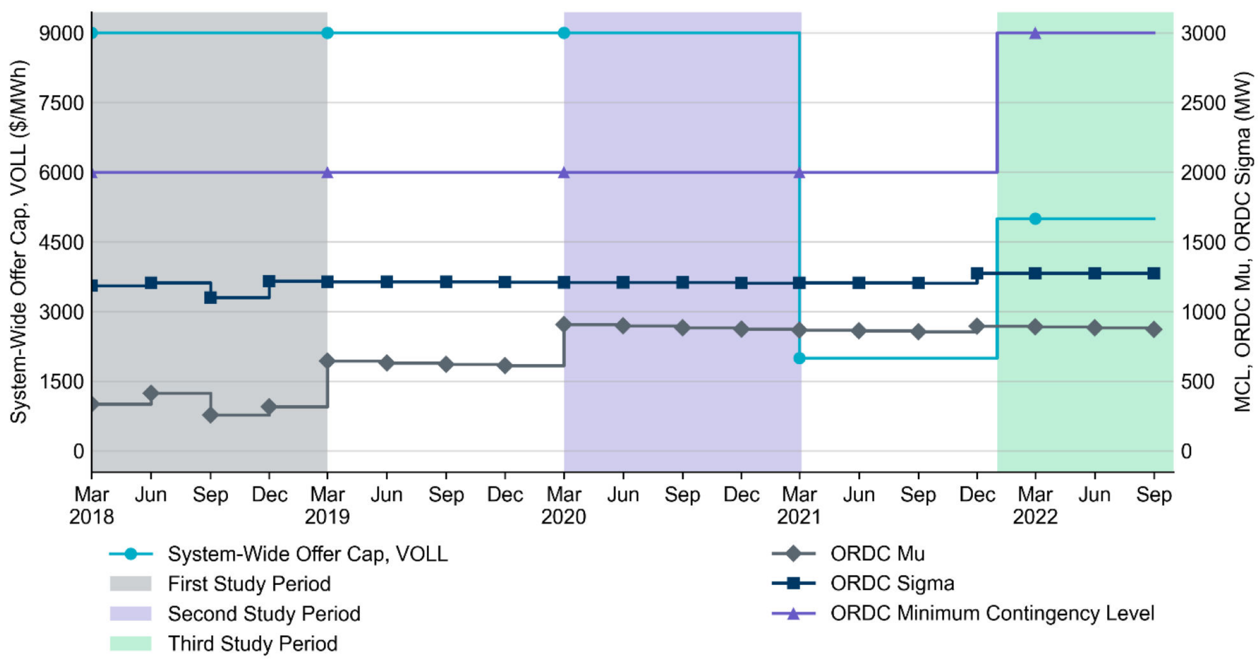

Figure 3: Timeline of relevant ORDC parameters. The System-Wide Offer Cap (SWCAP) price is plotted against the left vertical axis, while the MW values (minimum contingency level, ORDC Mu, and ORDC Sigma) are plotted against the right axis. The three study periods considered in this report are shaded from left to right. (Note that prior to 2019, ORDC Mu and Sigma were calculated by first partitioning reserve error data into six blocks according to time of day; there are therefore six Mu and Sigma values for each 2018 season. The 2018 Mu and Sigma values shown in this figure are averages taken across the six time-of-day values for each 2018 season.)

The first study period extends from the beginning of March 2018 to the end of February 2019. During this period, VOLL was $9,000/MWh, MCL was 2,000 MW, and each season's calculated Mu and Sigma values were used without modification. This period serves as a baseline, capturing ORDC behavior before Mu was shifted or any post-Uri reforms took place.

The second study period covers March 1, 2020, through March 3, 2021, after both of the aforementioned Mu shifts were in effect, but prior to post-Uri ORDC reforms. Winter Storm Uri itself, which occurred during this period, is excluded from all analysis unless otherwise stated, because this outlier period would misleadingly skew the results and minimize the ability to draw insights from the data.[5] The sustained high prices of Uri obscured normal ORDC function: when RTORPA and/or RTORDPA would otherwise cause System Lambda plus Price Adders to exceed SWCAP, the otherwise applicable adders are reduced to maintain a total price that does not exceed SWCAP.

Due to Uri's sustained high prices, SWCAP (and therefore VOLL) was reduced to the LCAP of $2,000/MWh from March 4, 2021, until the end of that year. With VOLL at $2,000/MWh, it is once again difficult to assess typical ORDC behavior due to the cap on System Lambda plus Price Adders—there are numerous intervals with relatively low reserve levels where RTORPA was prevented from reaching a higher value because System Lambda was already at or near the lower SWCAP. Thus, this period is also excluded from study.

The third study period extends from January through September of this year. Two significant changes occurred on January 1: SWCAP (and therefore VOLL) were set to $5,000/MWh when LCAP expired, and the minimum contingency level was shifted from 2,000 MW to 3,000 MW as part of post-Uri conservative operations.

To summarize, the three study periods described in this section and shaded in Figure 3 were selected to facilitate comparison between three administratively different chapters in ORDC history. The first two study periods provide baselines against which this year's ORDC impact may be compared.

2. ORDC Impact on Reserves

2.1. Real-Time On-Line Reliability Deployment Price Adder Impact on Real-Time On-Line Capacity

To assess ORDC impacts on Real-Time system-wide prices and reserves, we can subtract the Reliability Deployment Price Adder (RTORDPA) from the widely used system-wide price signal "System Lambda plus Price Adders" to obtain "System Lambda plus RTORPA." Figure 4 below illustrates the relationship between this ORDC-influenced system-wide price and RTOLCAP, with one subplot per study period. In each subplot, System Lambda plus RTORPA is plotted against RTOLCAP. The shaded area represents all possible values RTORPA could assume independently: the upper bound represents the case where RTOFFCAP is zero (and the RTOFFPA component of RTORPA is therefore at its maximum value), while the lower curve is created by setting RTOFFCAP arbitrarily large (resulting in an RTOFFPA component of $0/MWh). Note that RTORPA prevents the sum of System Lambda and RTORPA from falling below the lower bound of each shaded region. Moving from left to right, the graphs below show that this lower bound has increased in the second and third study periods, with the right subplot illustrating the strong relationship between this price signal and the level of on-line reserves during 2022. ORDC reform has driven System Lambda plus RTORPA substantially higher this year compared to the previous two study periods and has resulted in the RTORPA being utilized more frequently as a significant component of prices in the Real-Time Market at various levels of reserves.

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[5] The excluded Winter Storm Uri period lasts from the night of February 14 until the morning of February 19.

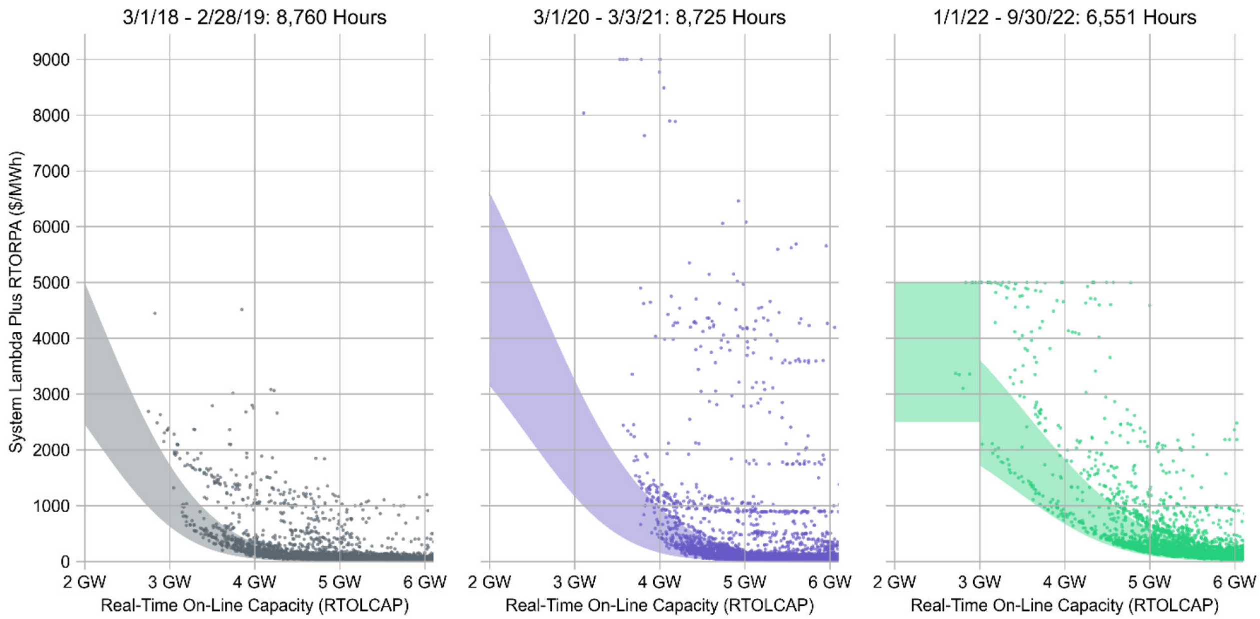

Figure 4. System Lambda plus Price Adders versus RTOLCAP during the three study periods of interest (from left to right). The shaded area represents all possible RTORPA values: its lower bound reflects the scenario where RTOFFCAP is arbitrarily large, while its upper bound represents RTOFFCAP = 0 MW.

2.2. Real-Time On-Line Reliability Deployment Price Adder Impact on Spinning and Non-Spinning Reserves

While RTORPA is only paid to on-line reserves (the RTOLCAP category), it is useful to consider its impact on total on-line and off-line reserves as they affect grid reliability. Total reserves may be expressed as RTOLCAP plus RTOFFCAP; this sum is known as R_{SNS} within the ORDC methodology. Figure 5 below illustrates the sensitivity of R_{SNS} to RTORPA in the $0.01/MWh to $30.50/MWh range for each of the three study periods. For each study period, SCED intervals were divided into RTORPA bins $1/MWh in width, and the average R_{SNS} value was calculated for each bin. For example, the top-left point shows that between March 1, 2018, and February 28, 2019, for all SCED intervals when RTORPA was between $29.50/MWh and $30.50/MWh, R_{SNS} was about 5,100 MW on average. From the first study period to the second, the significant rightward shift shown in figure 5 below indicates higher reserve levels at the same prices. As might be expected from this year's ORDC reform, there is an even larger increase in reserves when comparing the second study period to the third. While the plot for the third study period exhibits greater variability, it is also the steepest overall: RTORPA appears to increase more rapidly as R_{SNS} declines, within the range shown. The bin centered on $10/MWh merits additional consideration: as previously shared with the PUCT by Brattle and Astrapé, ERCOT has estimated that a $10/MWh RTORPA value is sufficient to cover the start-up costs of a marginal combustion turbine with a four-hour minimum-runtime.[6] In other words, RTORPA values at and above approximately $10/MWh are expected to provide sufficient incentive for these types of Resources to self-commit. Drawing a horizontal line

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[6] "Impact Assessment of ORDC Changes," PUCT Control Number 52373, Item Number 246, received 2021-11-05.

through Figure 5 at $10/MWh, we see that the average R_{SNS} for RTORPA between $9.50/MWh and $10.50/MWh was 5,770 MW during the first study period, 6,720 MW during the second period, and 9,300 MW during this year's study period. To the degree price signals do encourage increased self-commitment at higher reserve levels, this improves reliability and allows the system to better respond to variability and uncertainty that may be observed.

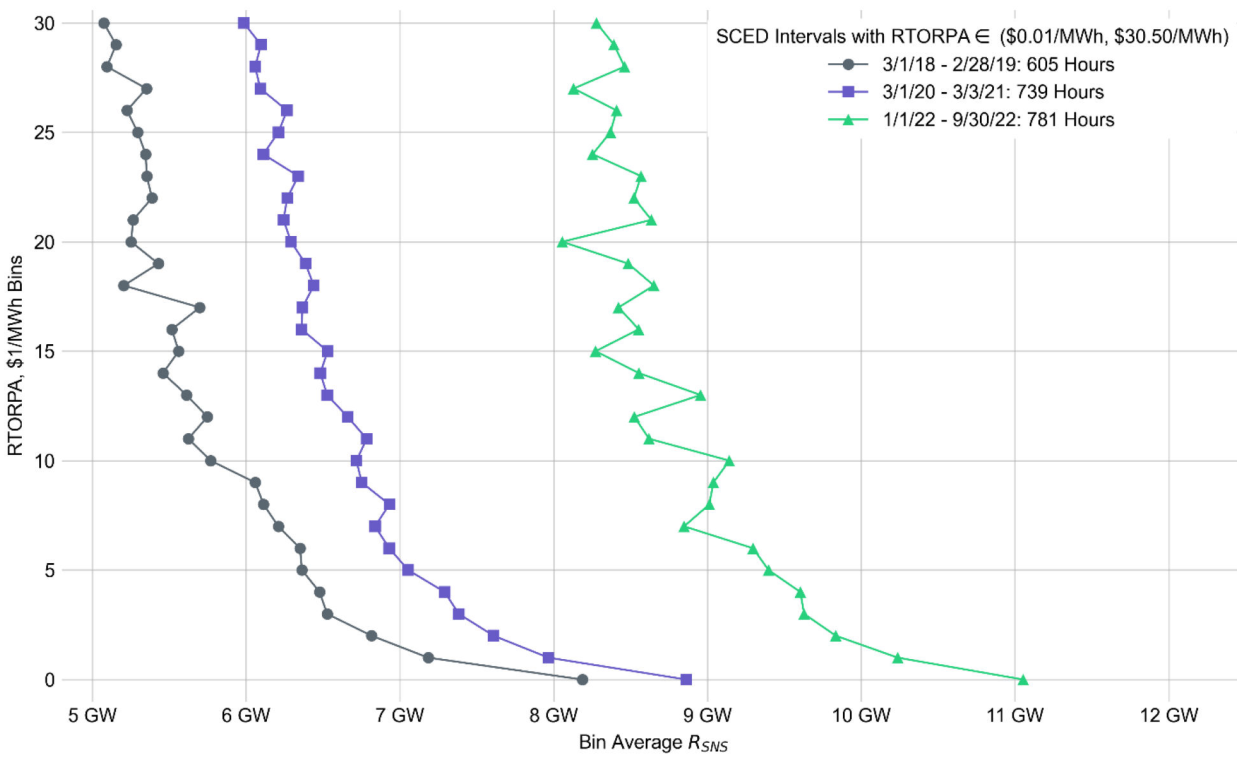

Figure 5. RTORPA in $1/MWh bins versus bin average Spinning and Non-Spinning Reserves (R_{SNS}).

2.3. Real-Time On-Line Reliability Deployment Price Adder Impact on Self-Commitment Incentives

As mentioned previously, the ORDC plays an important role in spurring the self-commitment of marginal Resources, incentivizing them to enter the reserve pool and contribute to on-line reserves. Ideally, this can help avoid out-of-market actions such as Reliability Unit Commitments (RUCs). To determine whether it is economic to commit a particular Resource on a given day, a Qualified Scheduling Entity (QSE) must compare the Resource's start-up costs to its expected revenue over the course of its minimum run time. As described in the previous section, ERCOT has estimated that a $10/MWh RTORPA value is sufficient to cover the start-up costs of a marginal combustion turbine with a four-hour minimum run time. Figure 6 below illustrates the fraction of days during each study period where the four-hour rolling time-weighted average RTORPA exceeded $10/MWh. These are days where a Resource with a four-hour minimum run time could have received at least $10/MWh on average, from RTORPA payments alone, by self-committing at an appropriate time.[7] This year the fraction of days meeting the $10/MWh over 4-hour price-duration criterion is just under 25%, more than double that of the previous study period. Although this year's study period has the fewest total days of the three, it contained more days satisfying the price-duration criterion than the other two study periods combined. Following the January 1 ORDC reform, RTORPA has provided many more opportunities for marginal combustion turbines to economically self-commit and enter the on-line reserve pool, with any increase in self-commitment leading to increased reliability to the grid.

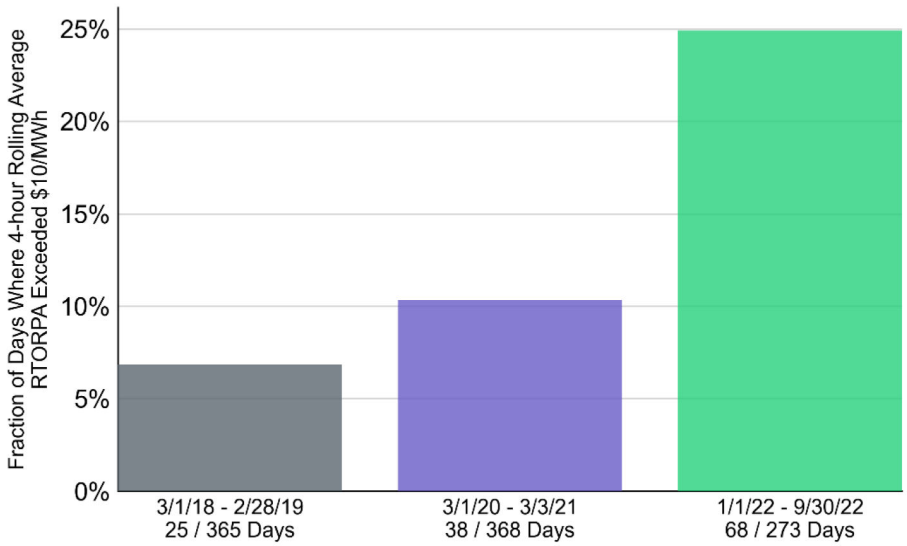

Figure 6: Fraction of days where 4-hour rolling time-weighted average ORDC adder exceeded $10/MWh.

2.4. ORDC Impact on Physical Responsive Capability (PRC)

While ORDC price adders are paid to reserves according to the RTOLCAP and RTOFFCAP categories, Real-Time operations such as Ancillary Service deployments and Energy Emergency Alert (EEA) events are driven by a measure of operational reserves called Physical Responsive Capability (PRC). PRC is closely related to RTOLCAP, but the two reserve measures differ in a few ways. PRC excludes Non-Frequency Responsive Capacity (NFRC) as well as off-line Quick-Start Resources that may be able to respond quickly to grid conditions but are not synchronously connected. Generally, PRC also limits calculated reserve headroom to 20% of each Resource's High Sustained Limit (HSL). A Resource's HSL is the maximum sustained energy a Generation Resource may produce or the maximum power consumption of a Load Resource. When system conditions tighten and reserves become scarcer, RTOLCAP and PRC tend to converge: NFRC decreases, on-line Generation Resources are dispatched at levels closer to their HSLs, and Quick-Start Generation Resources (QSGRs) come on-line. We therefore expect some sensitivity of PRC to RTORPA during

[7] It is worth noting that a QSE cannot know what RTORPA prices will materialize over the next four hours in advance; in other words, only with perfect knowledge of the future could a QSE self-commit a Resource on every day for which it is economical to do so. Also, even if RTORPA payments are expected to cover a Resource's start-up costs, a QSE would only commit that Resource if anticipated LMPs are sufficiently high compared to its Energy Offer Curve (EOC).

SCED intervals in which PRC is low. Below, Figure 7 plots uncapped RTORPA (calculated directly from the ORDC without applying SWCAP to System Lambda plus Price Adders) against PRC for SCED intervals where PRC was below 4,500 MW.[8] Only the second and third study periods are shown here, on the top and bottom subplots respectively. The fraction of SCED intervals with PRC below 4,500 MW is similar between the two study periods: 35.6% and 38.5%, respectively. The average PRC across this low-PRC range is also similar: 3,863 MW during the last study period compared to 3,962 MW this year. The most significant difference between these two sets of SCED intervals is in average RTORPA: $6.29/MWh for the second study period, but $22.36/MWh this year. These summary statistics are summarized in Table 1. Figure 7 illustrates that this year's increase in average RTORPA is concentrated in SCED intervals with PRC below 3,500 MW. In other words, following ORDC reform, we observe stronger reserve price signals specifically during periods with lower levels of operational reserves. This was a primary goal of the ORDC reform as it is during these times of lower PRC levels when there is greater risk to grid reliability and response from the market participants is most needed and should be incented through prices.

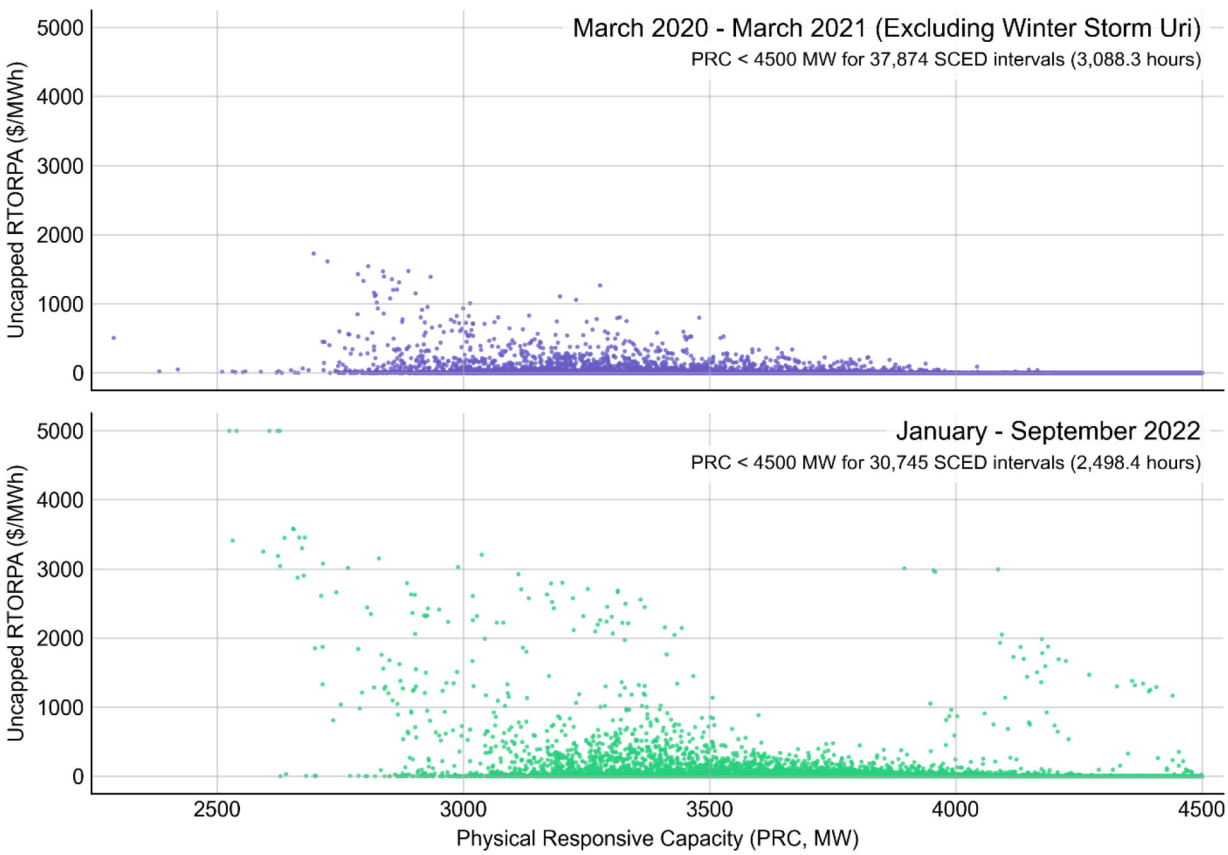

Figure 7: Uncapped RTORPA (calculated without applying SWCAP to System Lambda plus Price Adders) vs PRC for the second and third study periods. Only SCED intervals with PRC below 4,500 MW are shown.

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[8] The 4,500 MW threshold was chosen to focus on SCED intervals with relatively low PRC, where there is increased reliability risk and increased operator scrutiny may be expected.

Study Period	SCED Intervals with Low PRC (PRC < 4,500 MW)	Fraction of Total Intervals with Low PRC	Average PRC Across Low-PRC Intervals	Average RTORPA Across Low-PRC Intervals
March 2020 – March 2021	37,874	35.6%	3,863 MW	$6.29/MWh
January – September 2022	30,745	38.5%	3,962 MW	$22.36/MWh

Table 1: Summary statistics for SCED intervals with PRC below 4,500 MW.

3. ORDC Impact on Prices

Generators and loads in the ERCOT system are settled at Settlement Point Prices (SPPs) every 15 minutes. SPPs are a combination of Locational Marginal Prices (LMPs) for energy, the RTORPA, and the RTORDPA. Figure 8 illustrates the contributions of each of these price components by month going back to October 2020. Real-Time Hub Average Prices have been significantly higher in 2022 than in 2021.[9] Due to ORDC reform, the time-weighted average RTORPA is also higher in 2022: $6.11/MWh, or 8.1% of the all-in price, in 2022 through September compared to just $0.41/MWh, or 1.0% of the all-in price, in 2021.

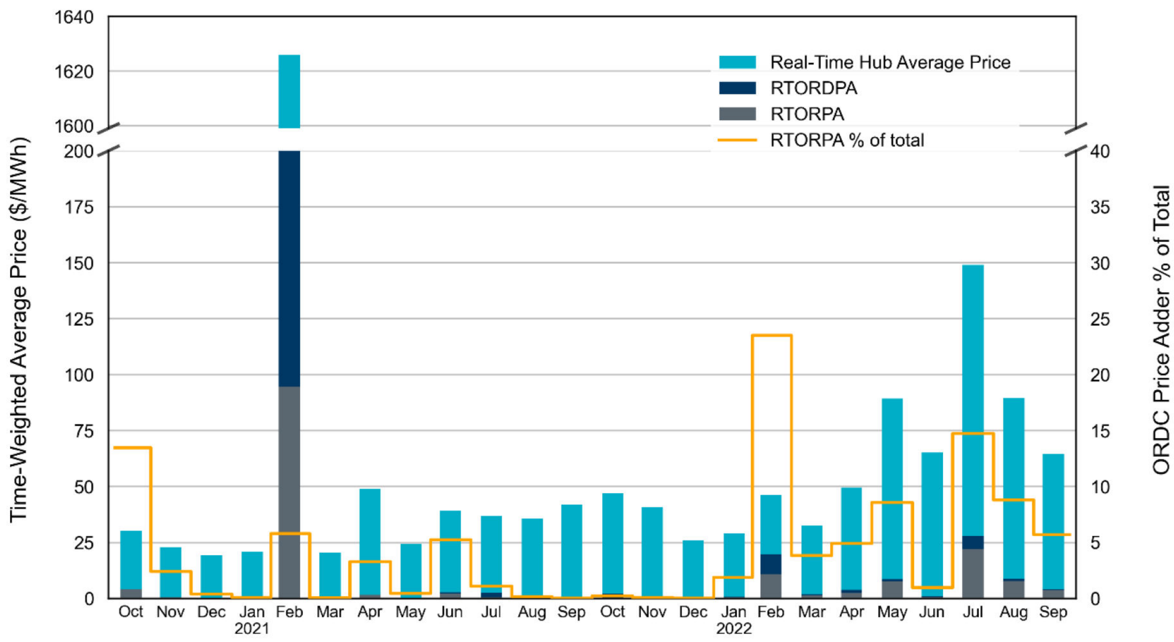

Figure 8: Relative contributions of ORDC and Reliability Deployment Price Adders to total Real-Time Energy Prices by month This graph includes data from Winter Storm Uri.

[9] One key driver of higher 2022 prices is higher fuel costs. In the ERCOT grid, system-wide prices are typically set by marginal natural gas generators.

As mentioned previously, the self-commitment incentive provided by RTORPA is most important when Physical Responsive Capability (PRC) is low and additional reliability actions may become necessary. Figure 9 illustrates the price contributions of LMPs, RTORPA, and RTORDPA specifically during intervals when PRC was less than 3,500 MW. As can be seen in the figure, the increase in RTORPA's contribution to total prices is particularly pronounced for intervals when PRC was relatively low. This year through September, when PRC was below 3,500 MW, the time-weighted average RTORPA was $115.63/MWh or 22.7% of the all-in price. Last year, these values were $7.62/MWh and 2.4%, respectively. This provides a clear indication that RTORPA is being utilized more frequently as a significant component of prices in the Real-Time Market at various levels of reserves, but particularly during periods of greater reliability risk when PRC is relatively low.

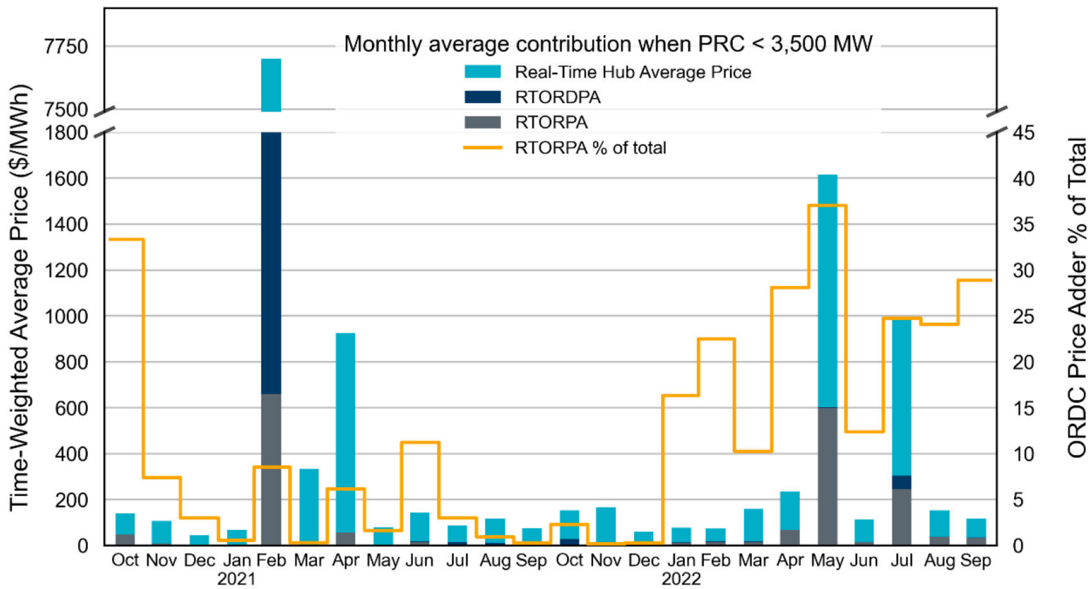

Figure 9: Relative contributions of ORDC and Reliability Deployment Price Adders to total Real-Time Energy Prices for SCED intervals below 3,500 MW PRC by month. This graph includes data from Winter Storm Uri.

It is difficult to assess all pricing impacts of the ORDC because some of these impacts only manifest indirectly. For example, the RTORPA's impact on the value of reserves is carried through to Real-Time Ancillary Service Imbalance payments and charges assessed to QSEs. Higher anticipated Real-Time reserve demand prices also indirectly affect the Day-Ahead Market (DAM) Ancillary Service Market Clearing Prices for Capacity (MCPCs), as the Real-Time prices for reserves drive expectations and potential opportunity cost for QSEs pricing their Ancillary Service offers. While these impacts have not been explicitly analyzed in this report and would be difficult to quantify given other recent changes in grid operation, they would be expected to have some impact, particularly for QSEs who are offering significant Ancillary Service quantities in the DAM.

4. ORDC Impact on Peaker Net Margin (PNM)

Peaker Net Margin (PNM) represents the net revenue that a hypothetical peaker Generation Resource could have earned from the Real-Time Market and provides some indication of the historical investment signal for these types of plants. This value accumulates throughout the year and is reported on the ERCOT website daily. The PNM threshold is administratively set in PUCT Substantive Rule §25.509(b)(6)(C). Once the PNM threshold is met, ERCOT will transition the System-Wide Offer Cap (SWCAP) from the High System-Wide Offer Cap (HCAP) to the Low System-Wide Offer Cap (LCAP) for the remainder of the year. PNM is calculated using SPPs, and is therefore sensitive to Real-Time LMPs, RTORPA, and RTORDPA. Figure 10 below indicates that monthly PNM totals are larger overall in 2022 than in 2021 (excluding February 2021). The contribution from RTORPA is markedly higher this year.

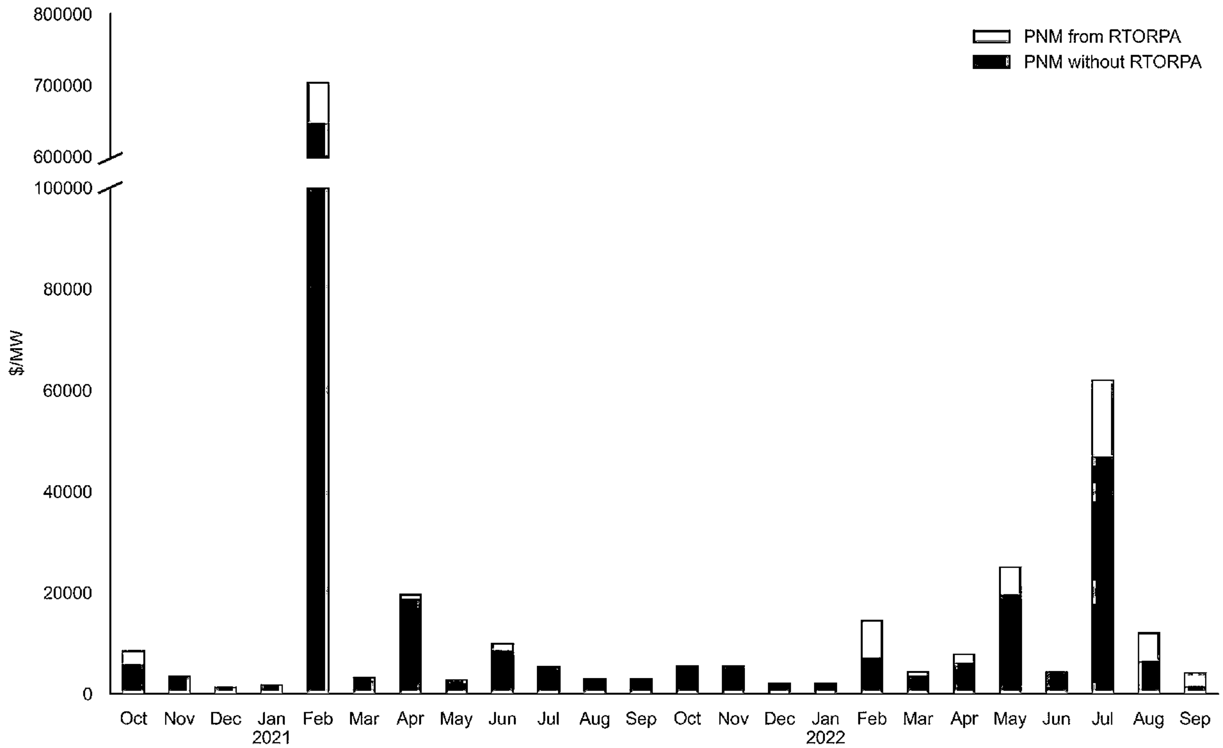

Figure 10: Peaker Net Margin with and without the ORDC Price Adder by month. This graph includes data from Winter Storm Uri.

Below, Figure 11 illustrates the accumulation of PNM for 2021. The most noteworthy observation is related to Winter Storm Uri: over 90% of the yearly PNM accumulated in the week surrounding the storm. The PNM threshold of $315,000/MW-year was reached on February 16, 2021. Typically, the SWCAP would be set to the LCAP on February 18, 2021; however, the PUCT directed a postponement of this transition until March 4, 2021. 2021 was the first time the PNM threshold was met. In 2021, over five times more PNM accumulated than any previous year. The RTORPA made up about 8% of the total PNM for 2021.

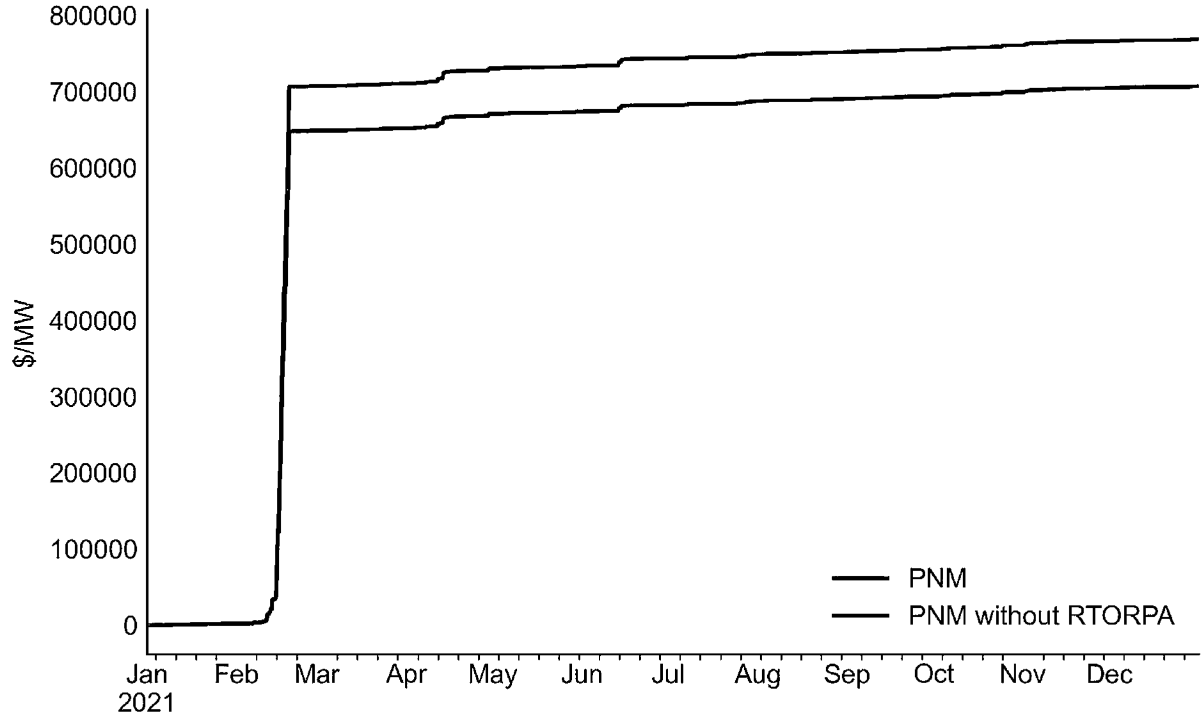

Figure 11: Cumulative Peaker Net Margin with and without ORDC Price Adders for 2021. This graph includes data from Winter Storm Uri.

PNM accumulation in 2022, illustrated in Figure 12 below, has been more similar to previous years than 2021. While dwarfed by 2021, 2022 through September has had the next highest PNM since the implementation of the ERCOT nodal market in late 2010. PNM accumulation in 2022 through September is approximately $139,000/MW. Comparing this to an estimated cost of new entry of $93,500/MW-year for a new combustion turbine, this provides an indication that Real-Time Market prices for 2022 have provided some level of investment signal for these types of Resources.[10] With the ORDC changes in place, RTORPA has made up approximately 29% of the total PNM accumulated in 2022 through September.

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[10] The estimated cost of new entry was taken from the "Estimation of the Market Equilibrium and Economically Optimal Reserve Margins for the ERCOT Region for 2024," prepared for ERCOT by Astrapé Consulting and is available on the ERCOT website.

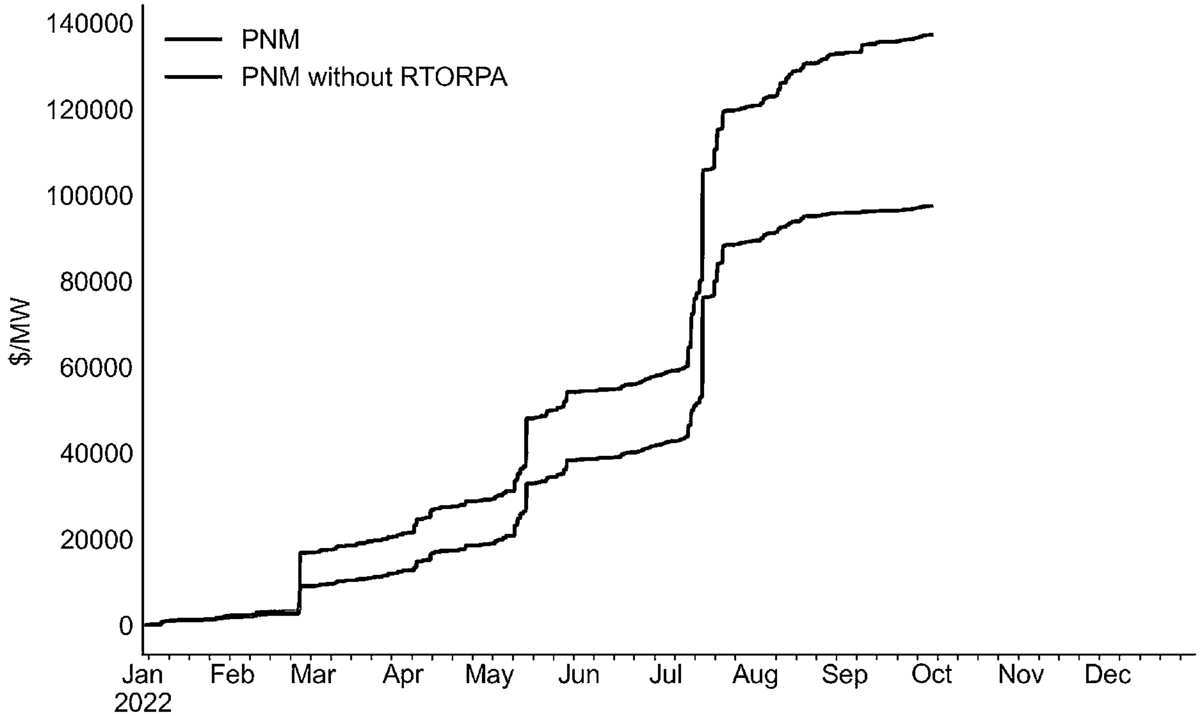

Figure 12: Cumulative Peaker Net Margin with and without ORDC Price Adders for 2022.