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2024 ERCOT Market Update

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Introduction

This Market Update provides a summary of:

- The changes that have occurred in the ERCOT market between 2023 and 2024,
- The drivers behind the major market changes, and
- E3's perspectives on the impact of these market changes

This Market Update also evaluates E3's forecast performance for 2024 year-to-date from our most recent off-the-shelf ERCOT forecast.[1] The goal of this evaluation is to identify the extent to which E3's fundamentals-based forecasting approach was able to anticipate the changes in the market, and to understand where any updated outlook adjustments may be needed.

Executive Summary

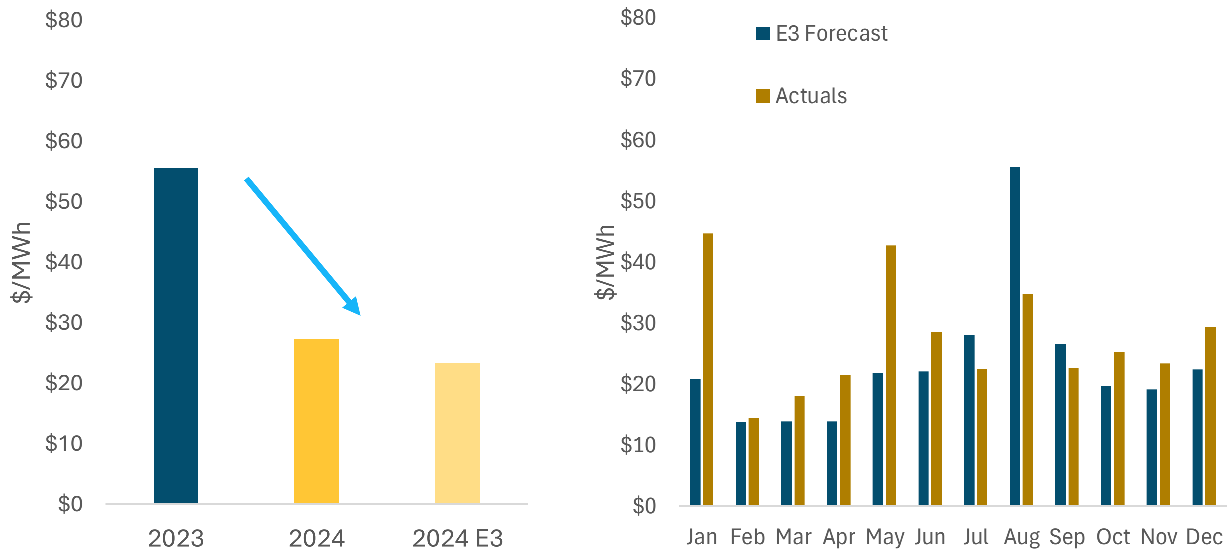
ERCOT saw a dramatic shift in 2024. Day-ahead prices dropped by nearly 50%, from \$55.50/MWh to \$27.33/MWh. This shift was brought on by an increase in almost 10 GW of new solar and storage, while peak loads remained flat year-over-year. Solar and storage impacted price volatility in summer

[1] This forecast (E3's 2024 ERCOT Core Case) was released in May 2024; the off-the-shelf dataset covers the years 2025-2050, but modeling also produced results for 2024, which is what is used as the sample set for comparison to actual ERCOT market results for 2024 year to date. The 2024 comparison is out of sample – and does not use actual wind or solar profiles, gas prices, or load. We compare our forecast against actual data for 2024, including prices, load, renewables profiles, and resource build.

months because the new solar reduced risk of high prices until the sun went down, where storage took over through energy arbitrage.

E3's fundamentals approach to market price forecasting was able to anticipate the drop in prices and volatility in 2024. Our bottom-up approach identified that, in a typical weather year, the incremental solar and storage would mitigate strong pricing. As a result, we forecast that 2024 would settle at $23.23/MWh in ERCOT North, compared to YTD actuals of $27.33/MWh.[2] The shoulder seasons indicate that our fundamentals were very strong as they were very close in price and no outlier events drove additional volatility. The error in the 2024 forecast is mostly attributed to the very cold January in 2024 and the outlier events in May, counteracted by our stronger August than actuals.

Figure 1: E3 Price Forecast Performance Annual and Monthly 2024 Comparison

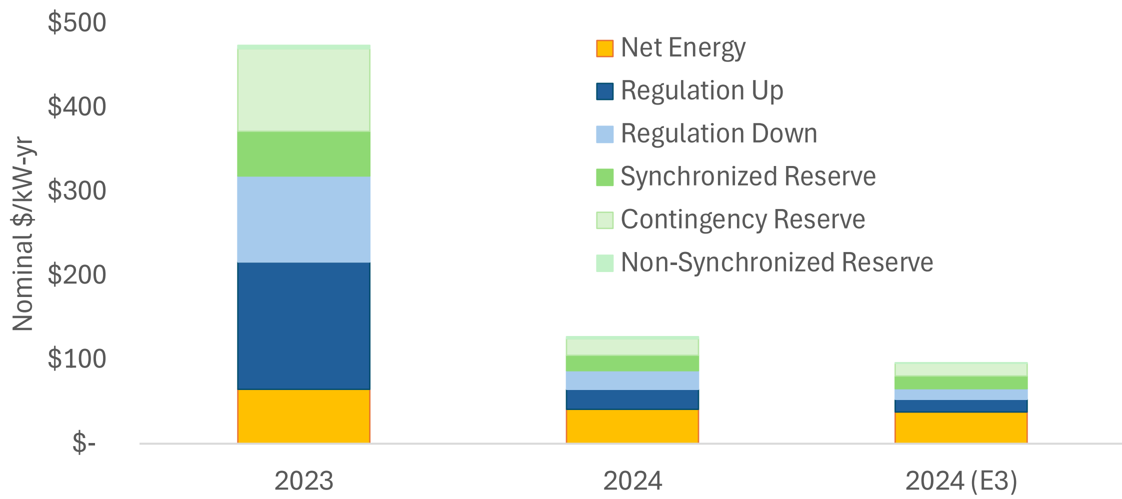


E3 is also focused on providing credible battery revenue forecasts in ERCOT. Because our fundamentals modeling efforts were able to anticipate the shift in market volatility, we were able to capture the large shift in battery storage economics in 2024. In 2023, our RESTORE storage optimization model indicates that a two-hour BESS in ERCOT North could have earned up to ~$475/kW-Year across all AS products and energy. This is in stark contrast to 2024 actuals, where the year may settle at ~$120/kW-year.[3] When using our 2024 out-of-sample forecast, RESTORE

[2] Our 2024 forecast contains forecast loads, renewable profiles, gas prices, and build. This comparison is therefore an out-of-sample comparison.
[3] Data set ends on Dec 15th 2024.

predicted storage revenues of ~$100/kW-Year in ERCOT. The missing $20/kW-year stems from the more volatile January and May of 2024 outlier events.

Figure 2: 2024 Forecast vs Actual 2-hour Battery Revenue Forecasts



E3 Background

E3 is a market-leading consulting firm focused exclusively on the energy industry, completing over 350 projects per year across a diverse client base, producing studies in resource and transmission planning, market advisory and design, strategy and procurement, policymaking, and rates and utility programs—including DERs and load management. This 360-view gives us a holistic understanding of electricity markets and systems from policy and planning to regulation and operations.

As a part of E3's advisory services, we produce market price forecasts (MPF) for every major electricity market across North America.[4] As a part of each MPF, we produce day-ahead (DA) energy prices, real-time (RT) energy prices, ancillary services (AS) prices, resource adequacy (RA)/capacity prices, and renewable attribute (REC) prices. E3 also does extensive work forecasting the long-term build in each market as well as the operations of each asset class, including energy storage. E3 uses its RESTORE energy storage optimization model to gain insight into the economics and operations of energy storage in each market.

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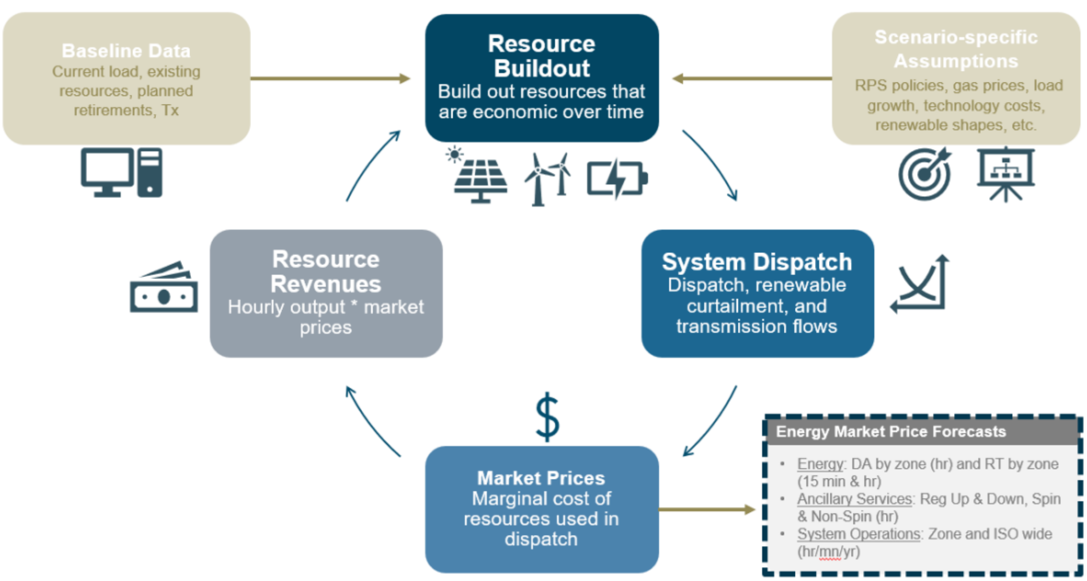
[4] See the release note here: [New Electricity Price Forecasts – Now Available for 2024 in Every North American Market - E3]

To create a MPF for each market, we leverage thought leadership across all practice areas, including resource planning, market design, distributed energy resources, climate pathways, electrification, and asset valuation. The input from the resource planning and electrification groups are important as they provide the forecasting process with generation technology costs and capabilities and expected load increases, respectively.

E3 Approach to Market Price Forecasting: Market Fundamentals Drive Price

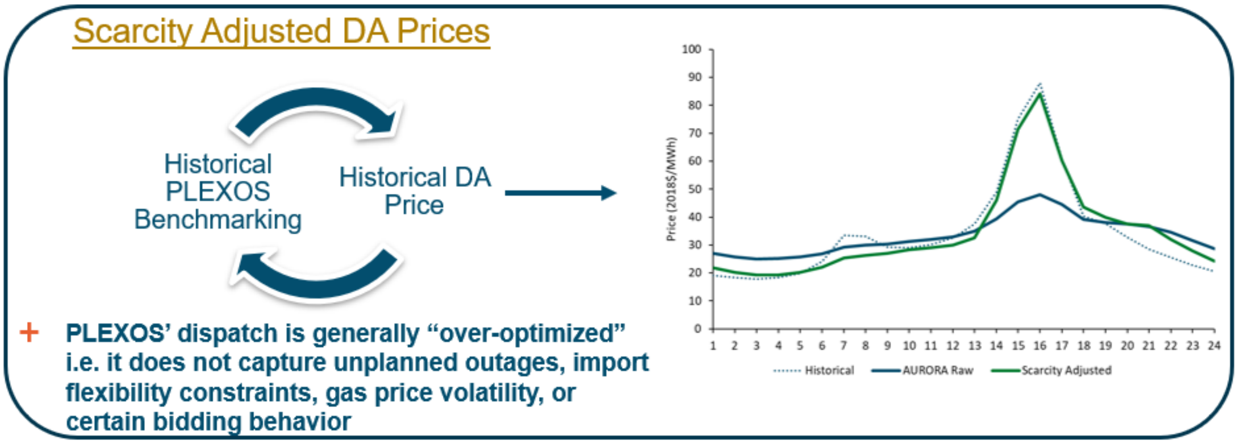
E3 uses a fundamentals approach to market price forecasting. E3 does not rely exclusively on statistics from historical data to forecast future prices but instead uses a “bottom-up” approach based on costs and operations of the grid, which enables us to reflect the dynamic structural changes that are transforming many power markets across North America. To achieve this, we project a long-term resource build that is derived from an initial multi-year capacity expansion that incorporates expected loads, resource costs, fuel costs, policy, and transmission assumptions. This process starts with our demand forecast. For ERCOT, E3 relies heavily on the latest load forecast produced by ERCOT as a baseline. We then adjust this to reflect the E3 view of building and transportation electrification, as ERCOT’s own forecast includes solely transport electrification. E3’s Climate Pathways & Electrification group provides the outlook and shapes of charging based on decarbonization work done by that group. Further, E3 is currently analyzing the potential of large loads in ERCOT and how they may increase load growth from current expectations.

Figure 3: Long-term Resource Build Process



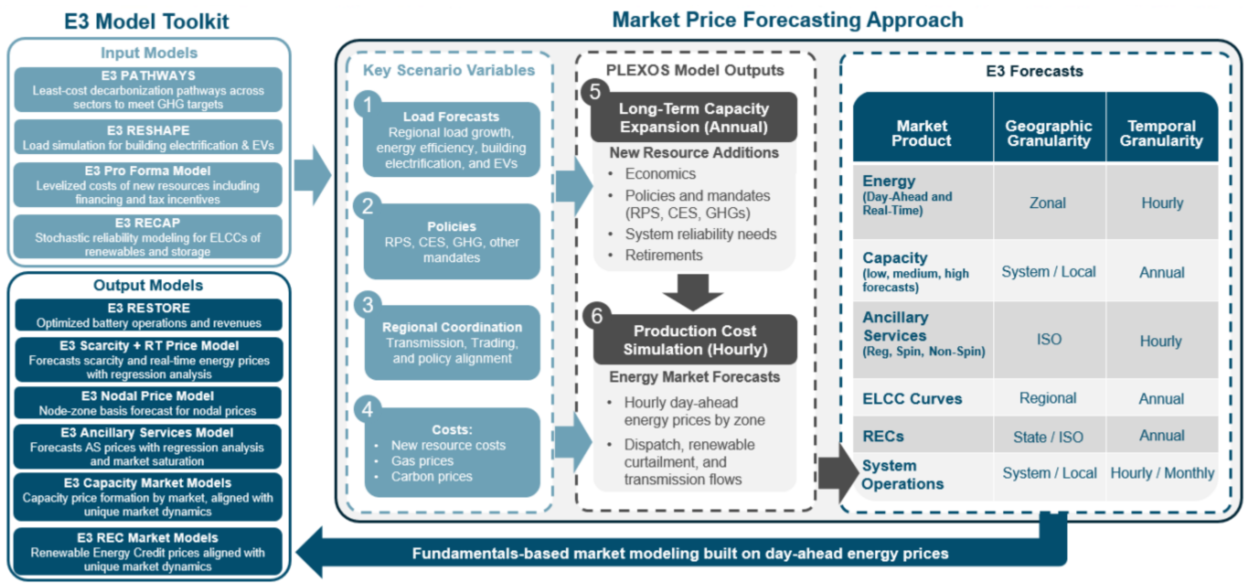
Once the resource build is determined, we utilize production cost modeling to generate hourly dispatch for the market with a security-constrained economic dispatch for the forecast load and long-term generation build. We augment the production cost model with market scarcity to derive the final forecast by analyzing historical relationships between scarcity pricing and available generation vs. load, and then projecting these scarcity premiums on top of the model's 'raw' marginal cost-based prices.

Figure 4: Scarcity Pricing Process



With our final energy market forecast, we then calculate prices for Ancillary Services, Capacity Costs, RECs, and other market outcomes. E3 uses the energy forecast to derive these other market outcomes.

Figure 5: E3's Full Model Framework



E3's approach is designed to be able to anticipate fundamental changes in the market based on pace of load growth and builds, long-term cost trajectories, and policy.

2024 vs 2023 Actual Data: Large Market Shifts

ERCOT saw a very large shift in fundamentals for 2024 compared to 2023. Massive amounts of solar, storage, and wind came online, gas prices dropped, load remained flat, and weather was significantly more moderate over the summer months. In this section, we analyze:

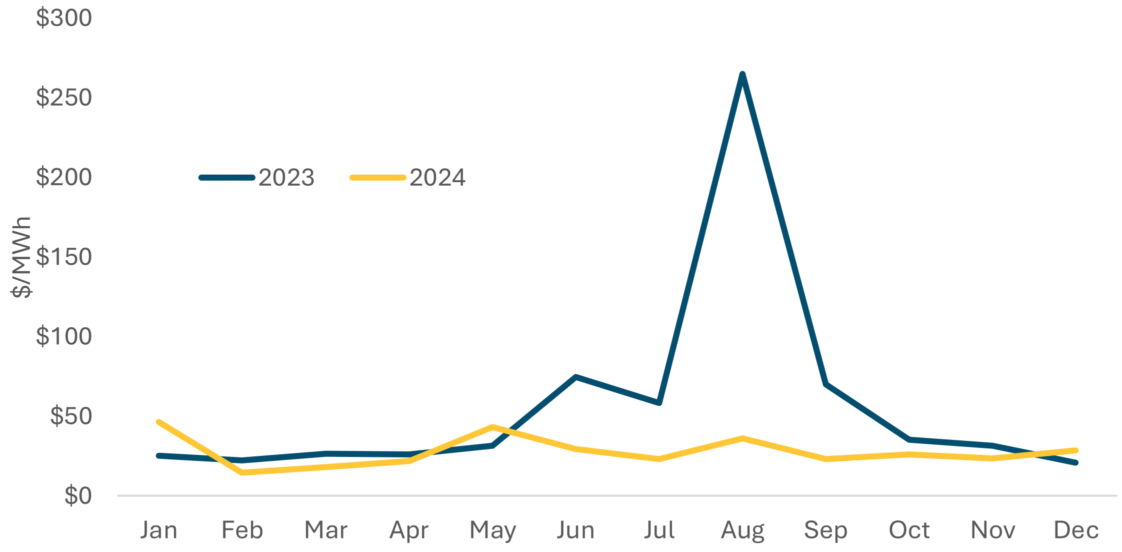
- Year-over-year changes in market prices
- Corresponding year-over-year changes in the largest fundamental drivers of prices
- E3's perspective on these changes

Market Prices[5]

Day-ahead and Real-time

Figure 6 below demonstrates that day-ahead prices in ERCOT came down significantly from 2023–2024. The largest decreases in 2024 compared to 2023 where in June, July, August, and September, with August 2024 having significantly more moderate prices than August 2023.

Figure 6: 2023 vs. 2024 - Monthly Average Day-Ahead Price Comparison (ERCOT North)



[5] December 2024 uses the 15 days of December in the average calculation in all figures.

Figure 7 charts the 2023–2024 comparison hourly average of day-ahead prices. The largest differences to the hourly profile come from midday, beginning in hour 12, with large price differences driven in the evening hours. As described in more detail in the following section, the impact of solar growth is illustrated by this chart as midday prices are depressed until the evening hours.

Figure 7: 2023 YTD vs. 2024 YTD – Daily Profile Day-Ahead Price Comparison (ERCOT North)

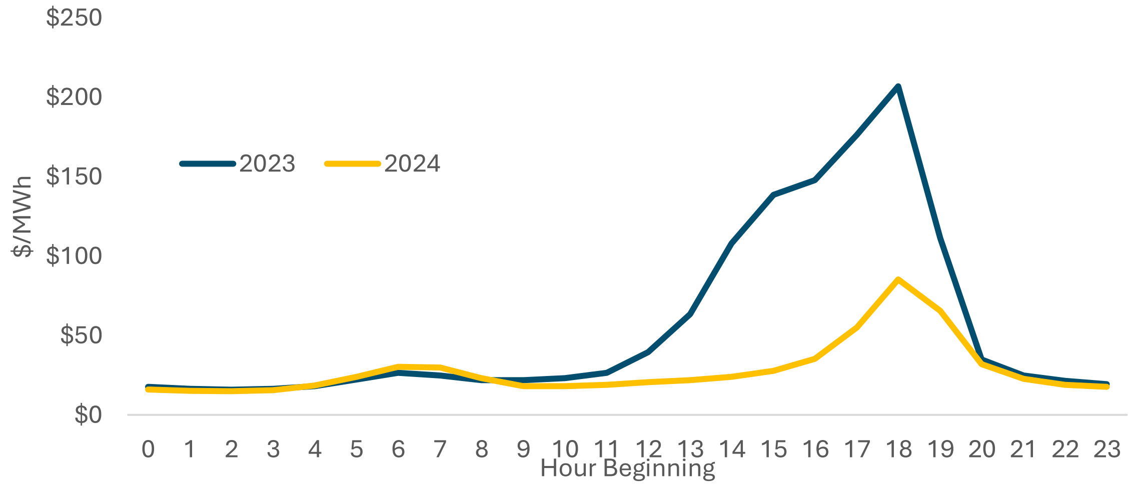
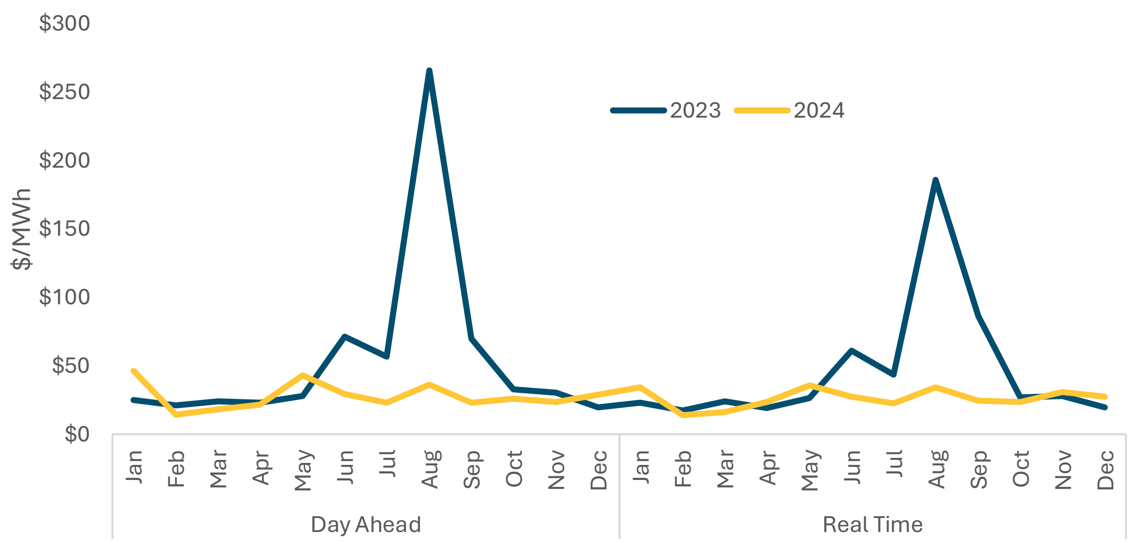


Figure 8 demonstrates the monthly average day-ahead versus real-time prices in ERCOT. Historically in ERCOT, real-time prices have moved at a slight discount to day-ahead price. This trend continued in 2023 and 2024 and was especially prominent in August of 2023. Volatility introduced substantial risk in the market in Summer 2023, which impacted the spreads between day-ahead and real-time as market participants look to hedge their positions.

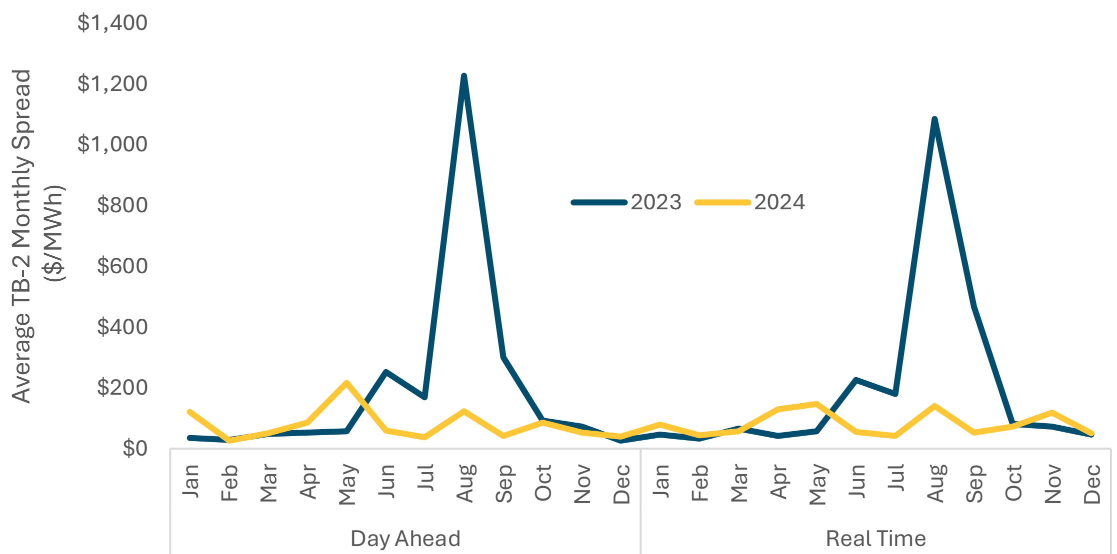
Figure 8: Monthly Average DA vs. RT Prices 2023 to 2024 – ERCOT North



To further analyze the volatility differences across years, Figure 9 below charts the top-bottom two (TB2) hour spread in ERCOT North day-ahead and real-time prices.[6] This represents a proxy value for the energy arbitrage value that a two hour battery could receive from charging in the two lowest priced hours of each day (purchasing energy from the market) and discharging in the two hours of each day with the highest prices. We observe that arbitrage opportunity in both markets reduced in 2024. Moderate weather alongside more energy storage has contributed to this decline.

Due to the uncertainties related to real-time generation dispatch, real-time prices tend to be more volatile. Therefore, energy arbitrage in the real-time market has stood at a premium of 20% above that of day-ahead energy market prices in 2024.

Figure 9: Monthly Average Top-Bottom 2-Hour Spread in ERCOT-North



Ancillary Services

Figure 10 shows the monthly average outcome for each ancillary services (AS) product market in ERCOT. Large energy price premiums in August 2023 drove the significant price spikes in upward AS products that year, but those spikes are not present in the summer of 2024, so AS prices across all markets have been significantly more moderate this summer. The introduction of the ERCOT Contingency Reserve Service (ECRS) in 2023 saw significant initial volatility in that product's price; that volatility has now normalized and reached equilibrium among the other AS products.

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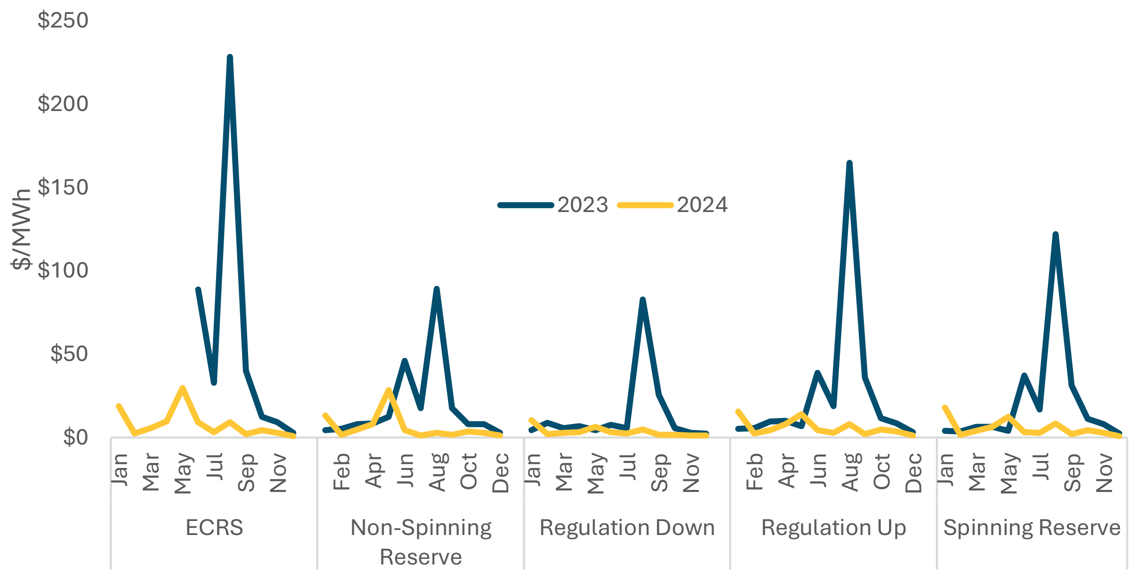
[6] TB2 is defined as the monthly average of the top two hours minus the bottom two hours every day.

Figure 10: 2023 vs. 2024 Monthly Average AS Prices



Like the energy market, Figure 11 shows that daytime hours for AS prices have been significantly impacted by the solar profile and its impact on energy prices. Further, energy storage investments are also impacting AS prices and their price performance during peak early evening hours.

Figure 11: 2023 YTD vs. 2024 YTD – Daily Profile AS Price Comparison

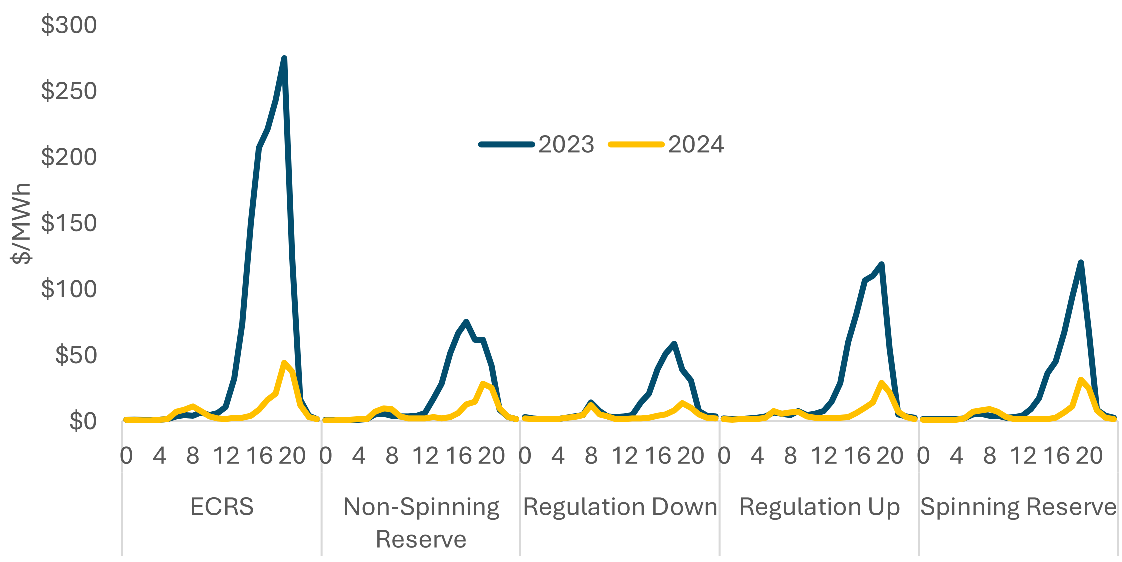
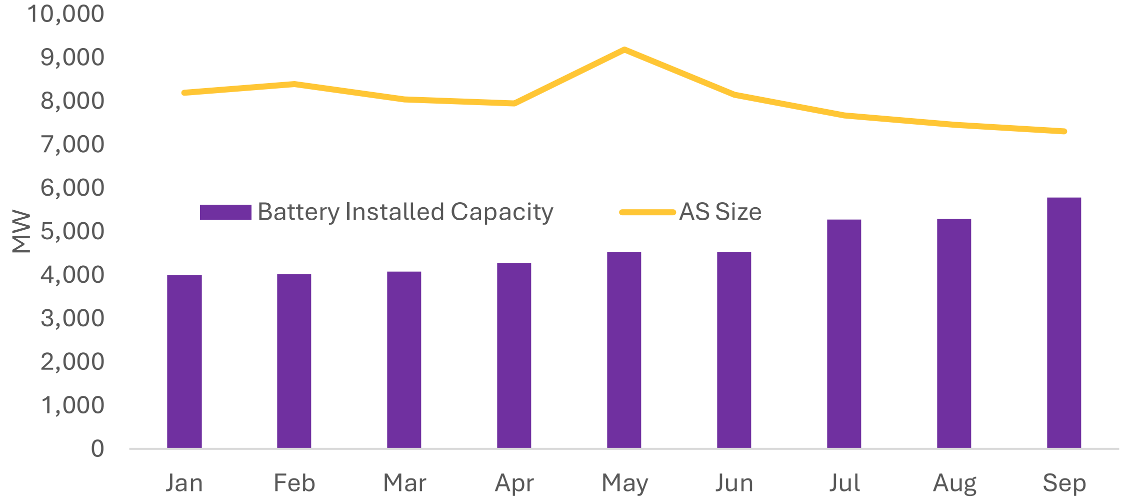


Figure 12 demonstrates that the amount of installed energy storage in ERCOT is approaching the size of the total MW requirements of the AS markets on average. E3 anticipates that this trend will continue, which will put additional downward pressure on AS market prices.

Figure 12: Battery Capacity vs Total AS Market Size



Fundamental Drivers

We analyze year-over-year changes in weather conditions, load, renewable production, installed capacity, and gas prices to provide insight into the large decreases in price observed so far for 2024.

Weather

The following histograms in Figure 13 and Figure 14 show the distribution of monthly average temperatures in August and January. They show that 2024 was much milder than Summer 2023, but January 2024 was one of the coldest on record. This contributed to a moderate summer pricing in 2024, but a very strong January.

Figure 13: Average August Temperature

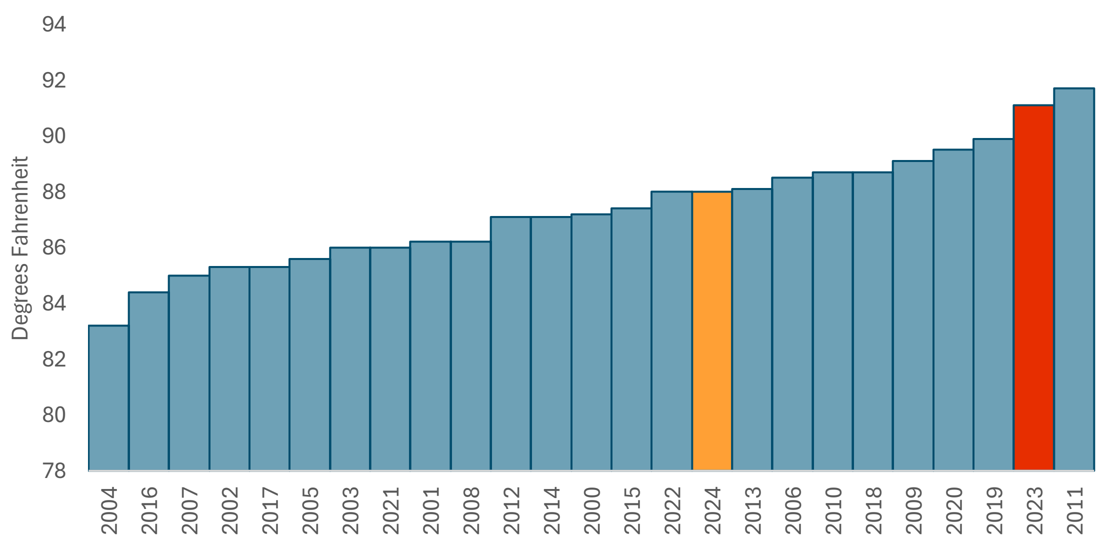
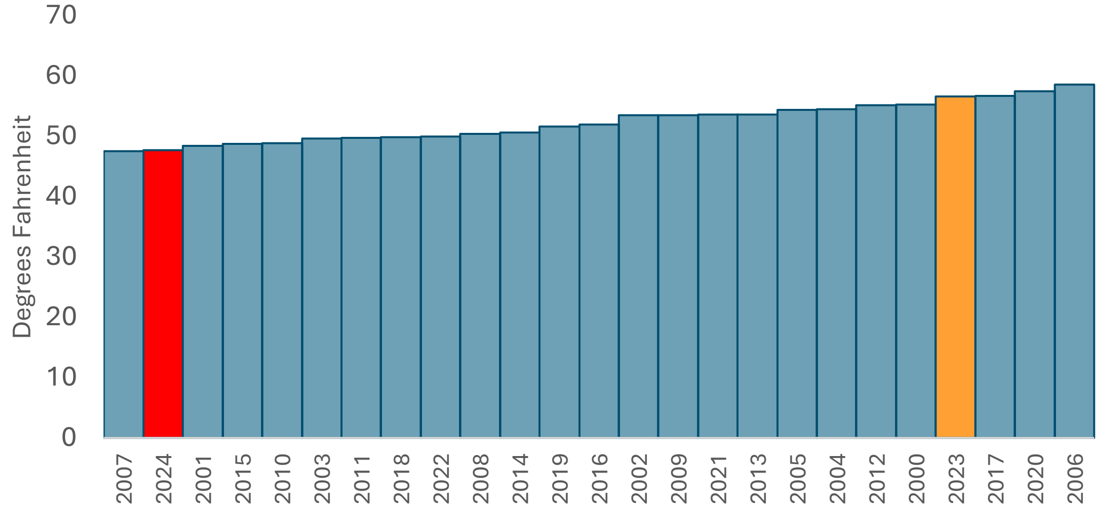


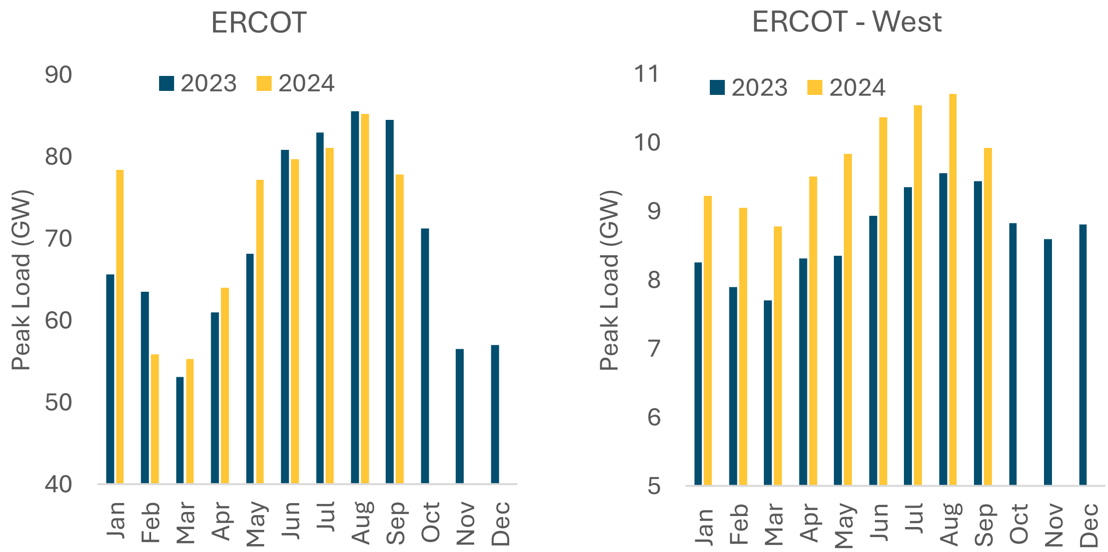
Figure 14: January Average Temperatures



Load

Figure 15 illustrates that in aggregate, peak load was relatively flat year-over-year. However, due to the historically cold January, there was a very large increase in January load. ERCOT West however saw sustained load growth. About one GW of additional load, with a high load factor, has come online this year. This indicates that large loads and early examples of data centers that are looking to locate in ERCOT may have selected to locate in, historically, zones with the lowest prices and most abundant in wind resources. E3 anticipates as a result that load is very likely to set a new peak in 2025 if there is hot summer weather.

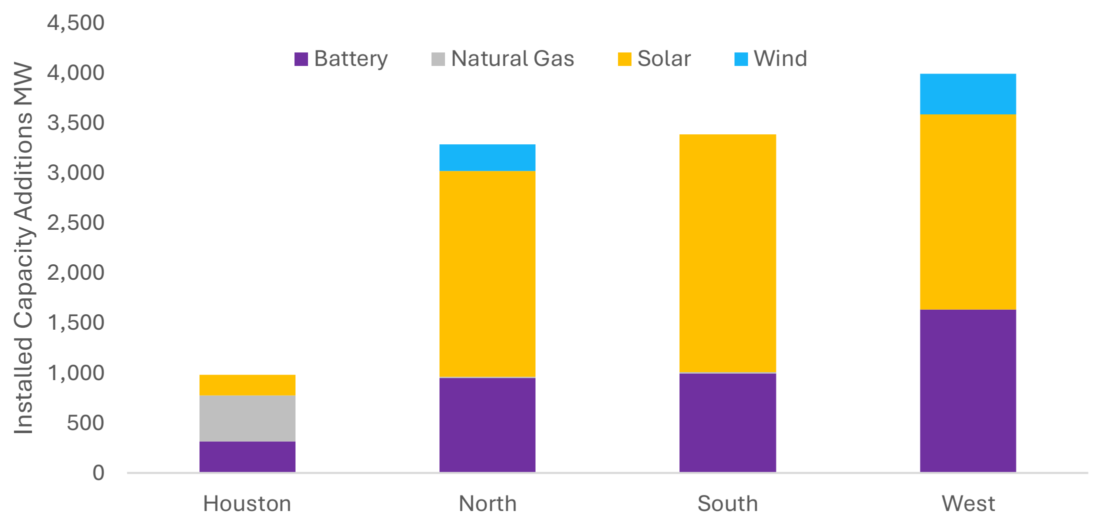
Figure 15: Monthly Peak Load (GW) – ERCOT West sees 1 GW additional peak load



Capacity Additions

Figure 16 shows that solar saw the largest amount of growth in terms of MW additions in 2024 versus 2023. The ~6,500 MW of new solar played a large role in moderating summer prices and shifting peak pricing hours later into the evening after sunset. Batteries also increased substantially, adding ~3,800 MW. Batteries also played a large role in limiting AS prices and capturing arbitrage spreads in the early evening peak hours, further mediating peak prices. 2024 has seen small amounts of wind and gas added.

Figure 16: Capacity Additions in ERCOT (MW) by Region[7] 2024 over 2023

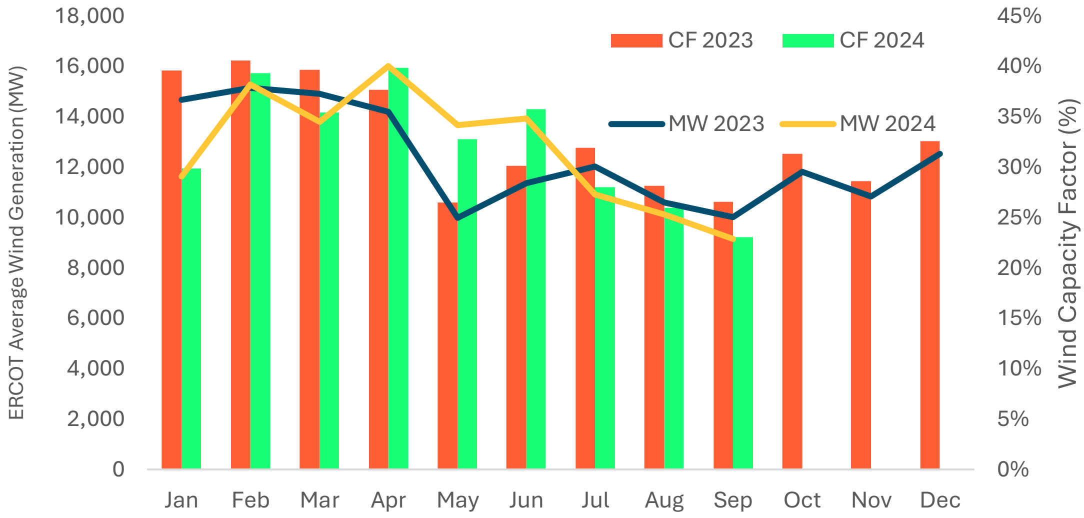


Renewable Production

Wind production was relatively stable on average across ERCOT. Figure 17 highlights that, while some months had different production, overall capacity factors were similar on similar amounts of installed capacity.

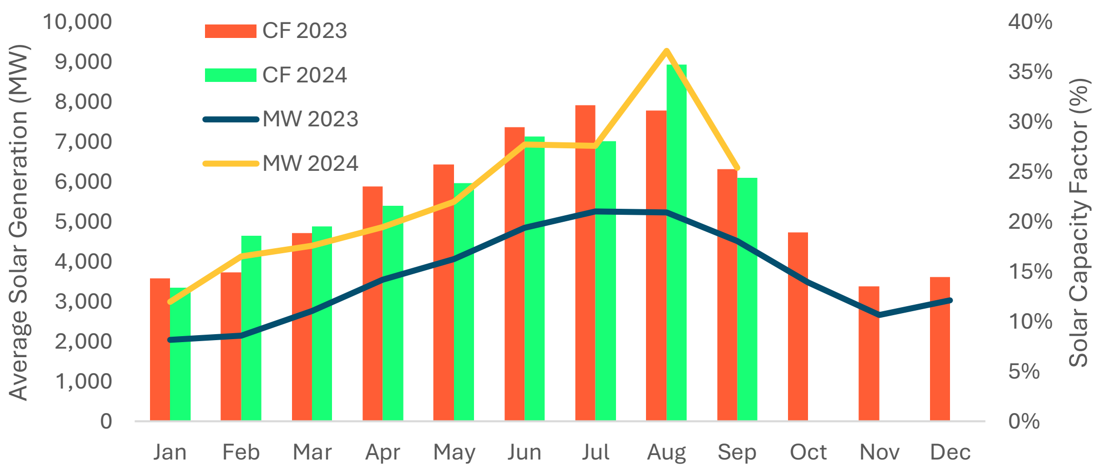
[7] Valid through September 15, 2024.

Figure 17: Monthly Average 2023 vs. 2024 ERCOT Wind Production and Capacity Factor



Unlike wind capacity, solar generation increased substantially between 2023 and 2024. Despite relatively similar capacity factors, overall solar production across the year far outpaced 2023 due to rapid increases in installed capacity. Generation in August was further magnified by increased year-over-year capacity factors that month.

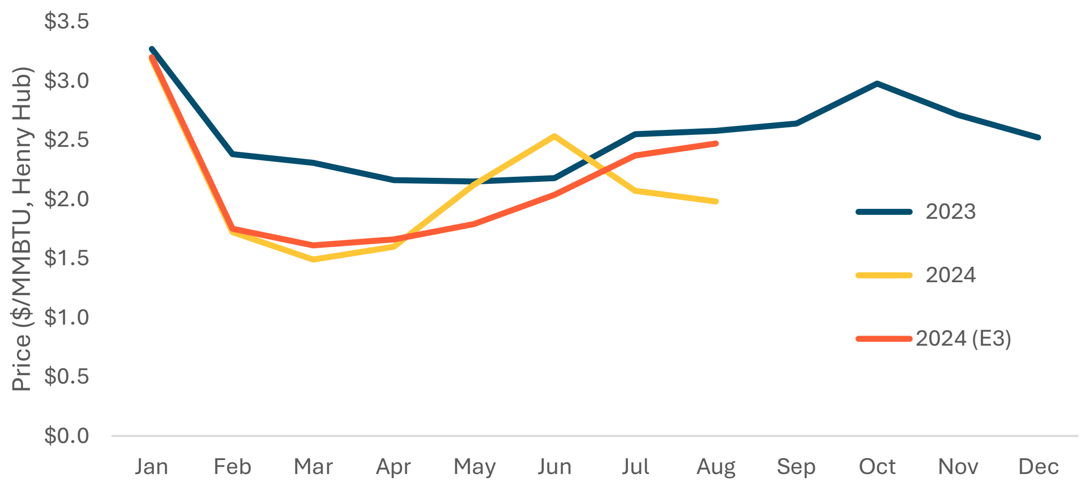
Figure 18: Monthly Average 2023 vs. 2024 ERCOT Solar Production and Capacity Factor



Gas Prices

Gas prices in ERCOT (as measured at Henry Hub) have been lower in 2024 than 2023, by an average of 15%. Prices in August were even lower, with a decrease of 23% compared to August of last year. Seeing the large drop in gas prices to start the year, E3 incorporated lower gas prices into the inputs to our May 2024 release, based on forwards for 2024, which by May were already down for the rest of the year. Our forecast for 2024 on average has performed well, anticipating $1.5-2.5/MMBTU.

Figure 19: Natural Gas Prices



Key Perspectives on Fundamentals

ERCOT prices on average have displayed less volatility in 2024 than in 2023. This abrupt change in prices is attributed to multiple drivers. These drivers include reduced summer temperatures this year impacted the magnitude of summer peak loads. Around 10 GW of solar and storage was added to the fleet, along with some incremental wind and gas. The solar and storage build, combined with no increase in the summer peak load, substantially mitigated price volatility. Reduced energy prices and added storage also had a large downward impact on AS prices. Gas prices also were lower in 2024 compared to 2023.

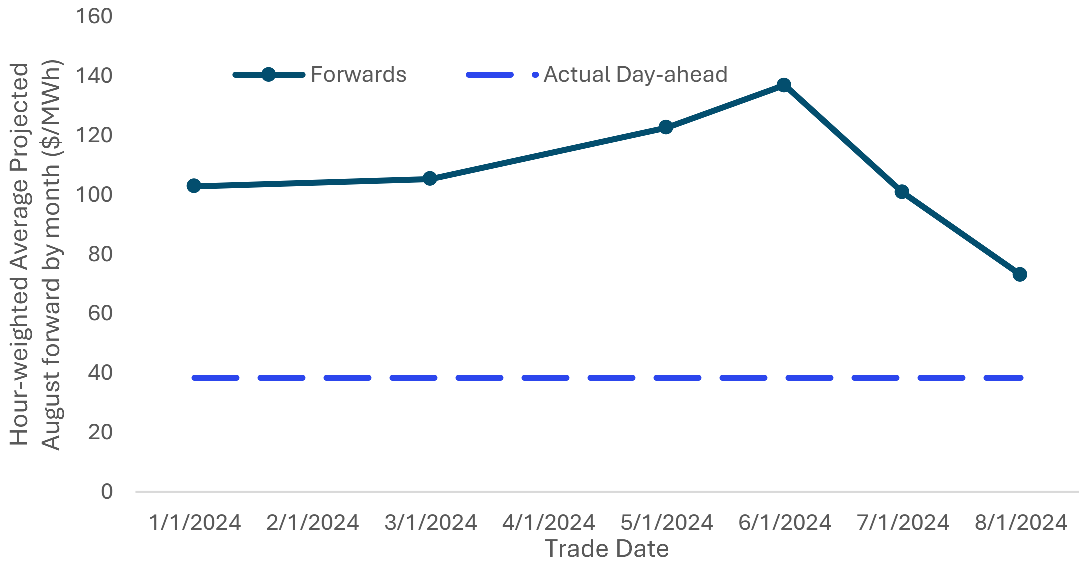
2024 Summer Expectations

As a part of E3's forecast process, we analyze recent market reports and forward market trading to see how these align with or disagree with our fundamentals forecasts. In this section we will review what ERCOT's MORA view was for August, alongside trends in the Forward market.

The MORA report was quite accurate and incorporated the latest builds and load forecasts. As of June 2024, ERCOT projected a 16.3% probability of elevated resource adequacy risk for August, for hour-ending 9pm CDT. The impact of the increase in solar was heavily reflected in this, causing the timing of the highest risk hour to occur later in the evening than in ERCOT's projections for prior years. 16.3% reflected a small concern of supply adequacy shortfalls.

The forward market however remained elevated, likely due to the recent memory of the very high 2023 settlement, and perhaps to an underappreciation of the impact that such a large solar and storage capacity addition would have on market prices. Forward prices started to shift over time: on June 1, 2024, Amerex's forward price (for the month of August) was approximately $137/MWh averaged across ERCOT's four Load Zones and on-peak/off-peak periods. As August approached, forward prices came down: by the end of July, projected prices for August were approximately $73/MWh on average across ERCOT, over $50/MWh lower than August forwards had been in June. These final prices ($73/MWh) still ended up being almost double what the final settled day-ahead actuals were.

Figure 20: Forward Market Trading August 2024



E3 2024 Forecast Deep Dive

E3's May 2024 release of the ERCOT forecast was calling for $55/MWh day-ahead prices on average for August 2024, as we anticipated a significant reduction compared to 2023 based on solar and battery builds in comparison to load. At the time of forecast development, forwards and market expectations were still elevated. However, the fundamentals of large solar and storage increases kept our model from reaching strong levels of tightness. E3 also utilizes a median weather year, meaning that 1-in-2 years will typically have peak loads that fall below the forecast we use, and the other 1-in-2 years will be above it. Figure 21 below shows the forecast performance of the E3 forecast using all out-of-sample[8] gas, wind & solar profiles, installed capacity, and load. Our median weather year combined with the fundamentals was able to stay on track with normal months this year. January, as discussed earlier, was an extremely cold outlier. May also had some irregular price action with large planned outages and over 1 million customers without power in the aftermath of

[8] Unpublished part of our 2024 forecast, as our forecast starts from the 2025 year.

Hurricane Beryl. June, July, and September prices were well calibrated in E3's forecast. E3's forecast was slightly too high for August, anticipating slightly more volatility than materialized.

Our E3 price forecast trended well overall with 2024, barring two unpredictable gaps in January and May. January was on average the second coldest January in Texas for the past 20 years causing high peak loads for electric heating (including customers with resistance heating demand). May was also an abnormal month marked by storm outages.

Figure 21: E3 2024 Out of Sample Price Forecast Comparison

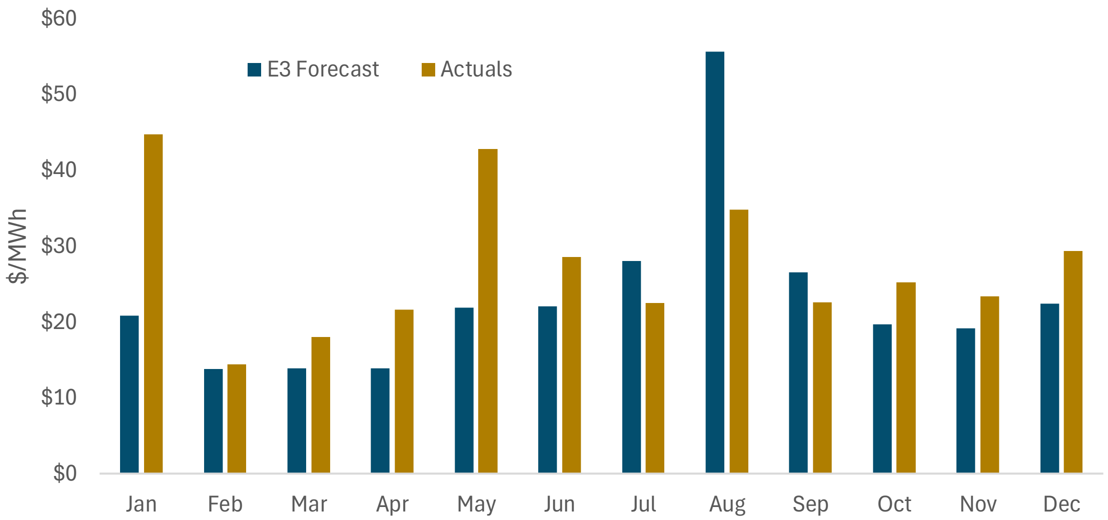


Figure 22 shows that our ERCOT North forecast error severely dipped in January, which did not account for severe January weather. Since that anomaly, our error has begun to converge close to zero ending the year at an average error of $4.5/MWh.

Figure 22: Rolling Hourly Average Forecast Error 2024

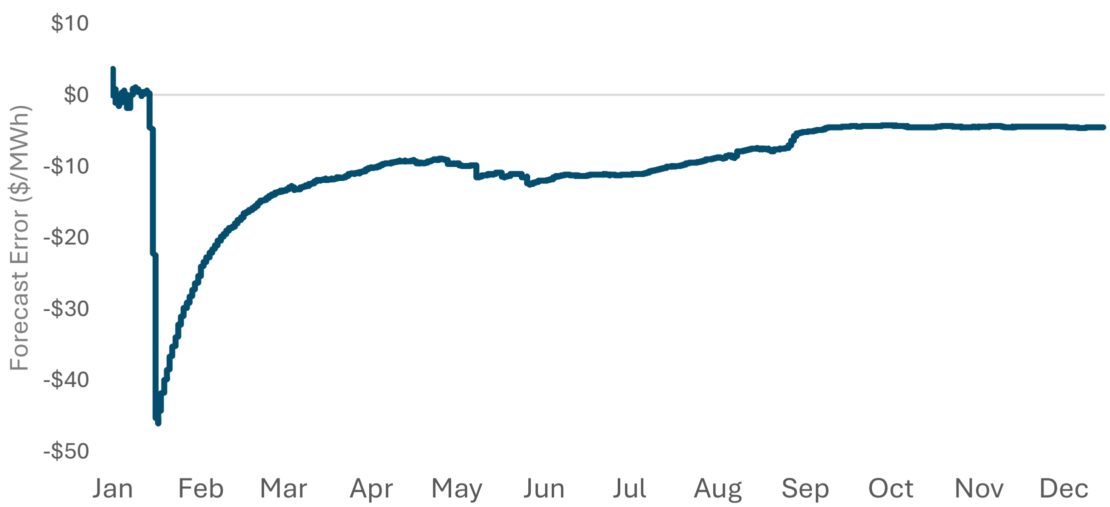
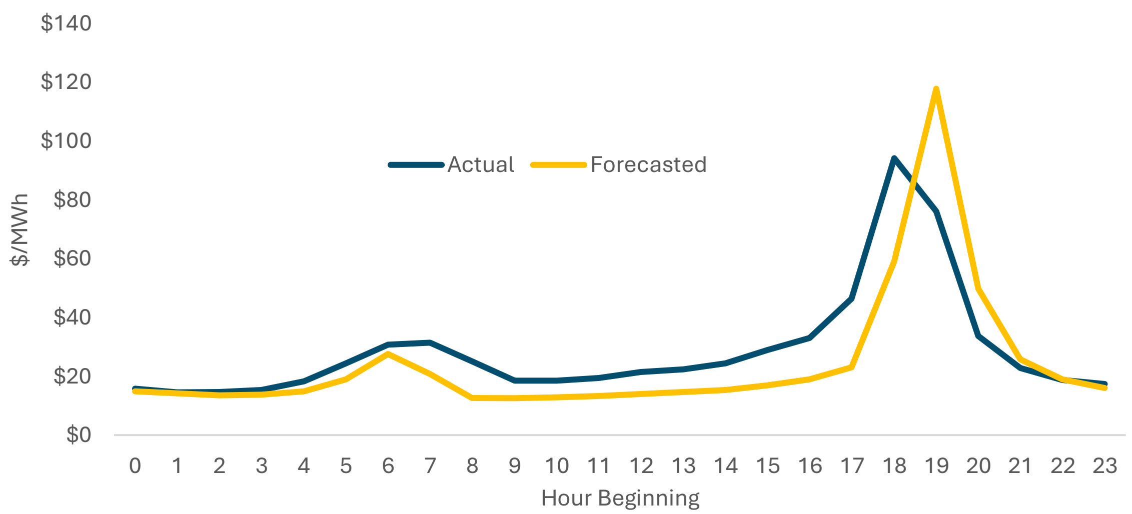


Figure 23 shows that we had slightly more depressed midday pricing than actual, but fully captured the impact of solar so far this year. Our evening ramp is in line with the magnitude occurring this year and captures the handoff of solar to wind in the evening. Actuals wind profiles play a large role in this shape and how fast wind picks up in the evening. Continuing to analyze renewable shapes will be key to continued forecasting accuracy in ERCOT.

Figure 23: Forecast vs. Actual 2024 YTD Daily Profile

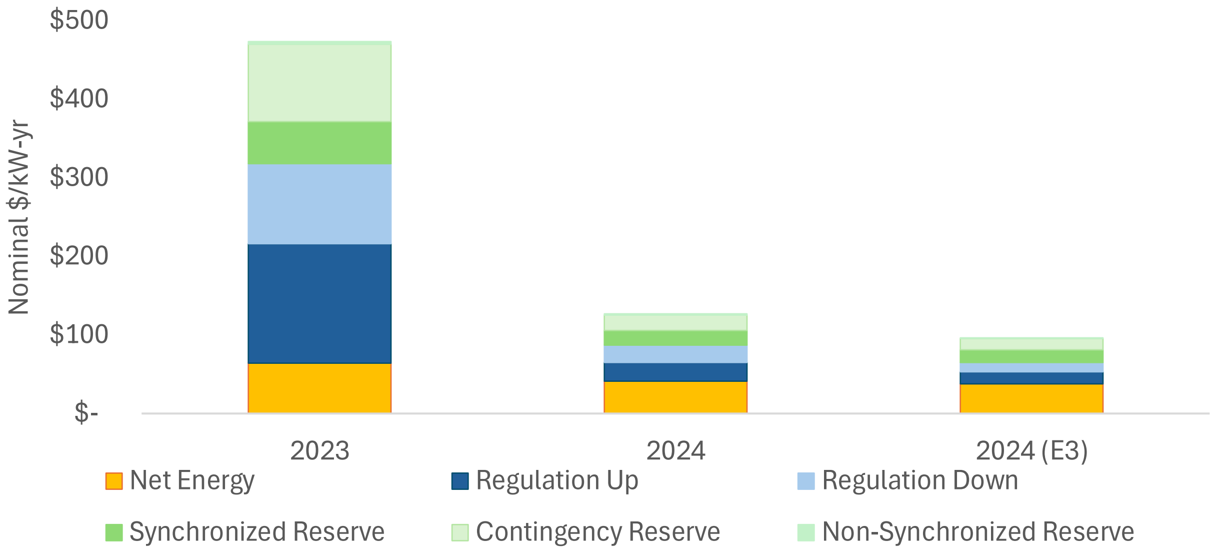


Storage Predictions

Energy storage performed exceptionally in 2023 in ERCOT. August 2023 was particularly prosperous for ERCOT where scarcity price formation produced most revenues. Using E3's RESTORE model, Figure 24 shows that a two-hour BESS in ERCOT North could have earned up to ~$475/kW-Year across all AS products and Energy. This is in stark contrast to 2024 actuals, where the year may settle at ~$127/kW-year.[9] When using our 2024 out-of-sample forecast, RESTORE predicted storage revenues of ~$100/kW-Year. The main differences compared to the actual prices are premium ECRS pricing and other AS pricing in the outlier January and May months. The net energy arbitrage value in the E3 forecast was very accurate. AS value was slightly low because AS prices came in slightly higher than forecast.

[9] Data set ends on Dec 15th 2024.

Figure 24: 2023 vs 2024 Annualized Storage Revenues Comparison



E3 Key Perspectives

Overall, the E3 fundamentals approach proved to be strong in anticipating a large shift in trend in 2024. Our modelling process captured the impact of large solar and storage additions in a median weather year. As a result, our approach remains unchanged. Areas where we will focus in the next forecast will be in updating assumptions, including utilizing new renewable profile data. Based on the data observed in 2024 we will increase the ERCOT West load outlook and overall loads in ERCOT to reflect updated expectations. E3 has also been improving AS price forecast techniques and anticipate improvements in this area when also combined with more ERCS historic data.

About E3

Founded in 1989, Energy + Environmental Economics (E3) is a fast-growing energy consulting firm that helps utilities, regulators, policy makers, developers, and investors make the best strategic decisions possible as they implement new public policies, respond to technological advances, and address customers' shifting expectations. E3's Asset Valuation and Markets practice leverages decades of experience and insight across all our practice areas to help clients identify market opportunities, quantify future revenue streams, and make investment decisions. We support the full spectrum of market players – from large utility holding companies and multi-billion-dollar private equity firms to leading developers, financiers, and technology companies – and our investment grade, bankable analyses have supported billions of dollars of deployed capital. For more information on E3's forecast of the ERCOT market and storage integration, see our market forecast here: ERCOT Price Forecast – 2024 First Edition – Core Case | Energy + Environmental Economics (ethree.com).

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