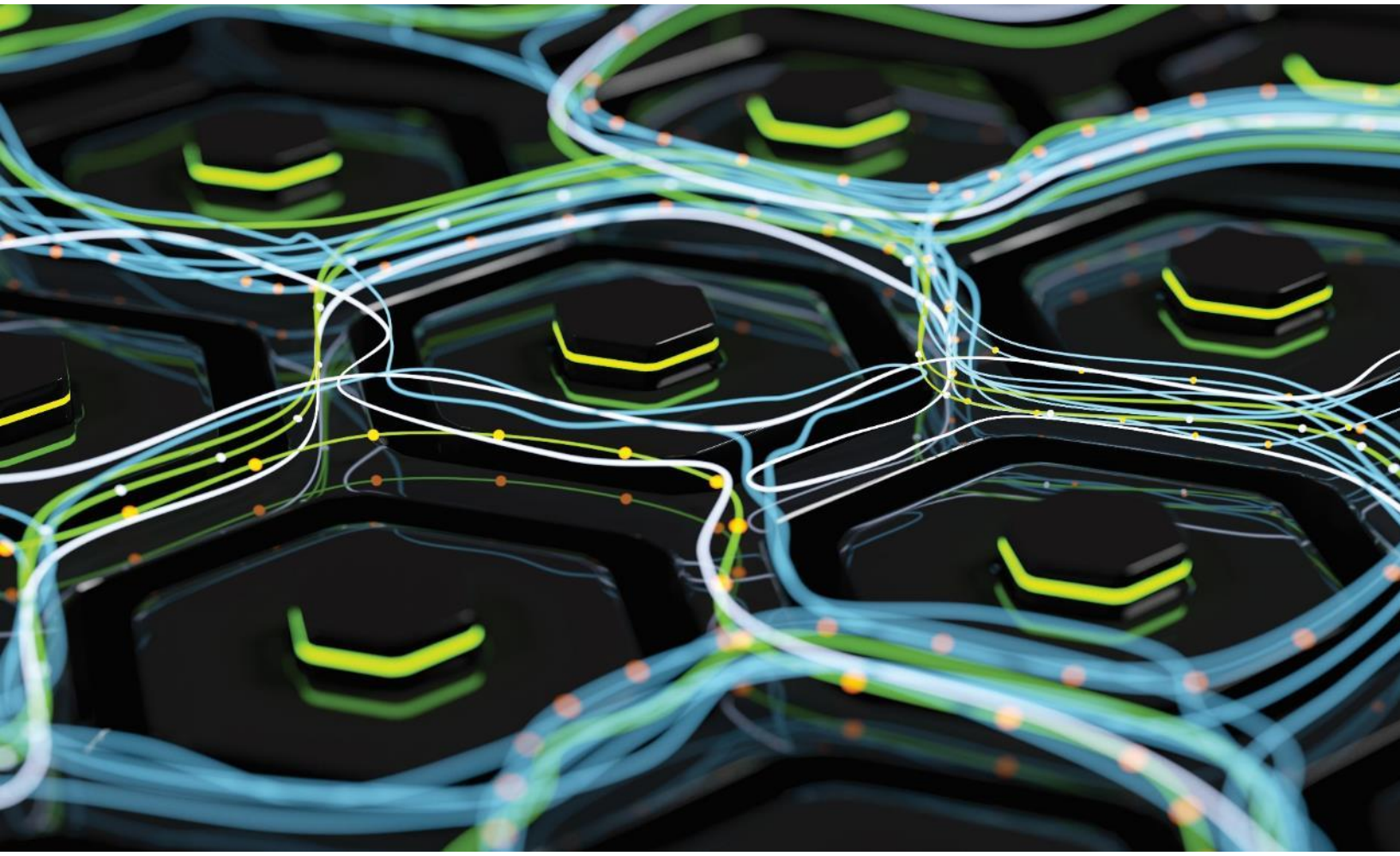
CRA Charles River Associates



Energy and ancillary services value stacking in ERCOT

Historical performance comparison for flexible gas and battery technologies

August 2025

Executive summary

As the electric power markets undergo a significant transition towards intermittent generation in the face of growing demand, electric utilities, developers, and investors must understand the different value streams available to flexible resource additions, which are poised to grow significantly. In this paper, CRA evaluates the performance of six such flexible resources (three gas-fired and three battery storage), using historical energy and ancillary services data from the ERCOT market in its proprietary Energy Storage and Ancillary Service Optimization (ESOP) tool.

Using sub-hourly price data across three historical years, the ESOP model analyzed potential co-optimization of dispatch in the energy and ancillary services markets across the 2021-2023 time period and within different discrete historical weather events. CRA's analysis identified the following major conclusions:

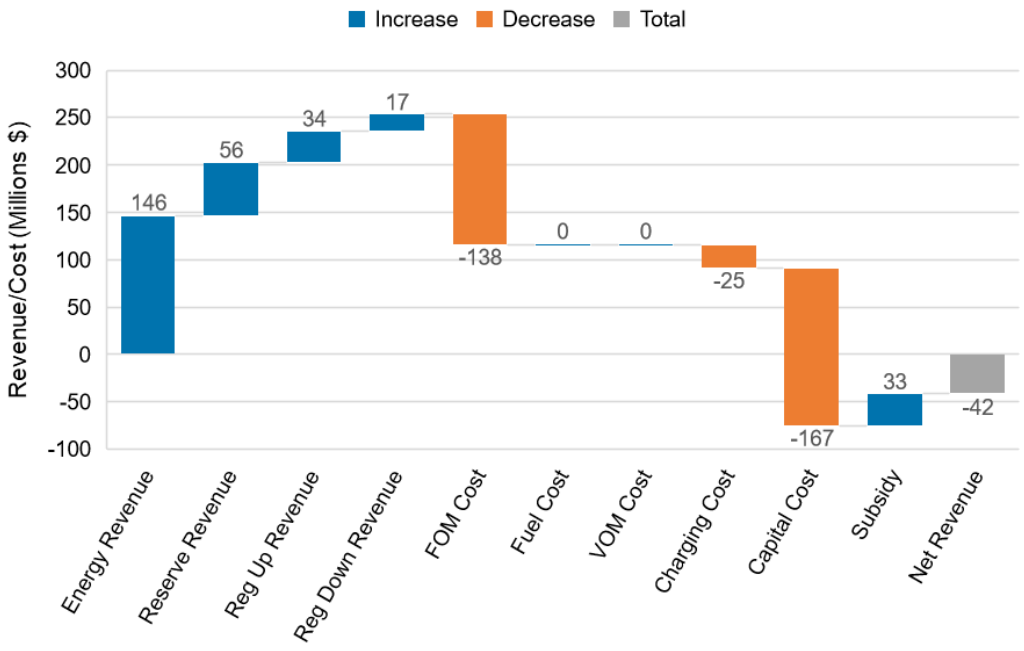
- Overall, the battery storage technologies were projected to generate higher levels of revenue, particularly due to their ability to take part in the ancillary service market when not actively charging and discharging. Roughly 33% of the storage technologies' revenue was projected to come from the ancillary service market, with 60-65% projected to come from energy arbitrage.
- Meanwhile, the lion's share (around 90%) of revenue for the natural gas-fired resources was projected to come from the energy market, and given lower ongoing fixed costs, natural gas resources were projected to generate greater value overall.
- During sustained periods of high prices (such as Winter Storm Uri in 2021), natural gas resources were projected to generate more revenue than batteries, assuming steady availability of fuel supplies. Batteries were at a disadvantage during the sustained high price period, as any charging they undertook was at extremely high prices. As such, the battery technologies would likely rely more heavily on ancillary services revenues during conditions when long-duration dispatchability is at a premium.
- During periods of volatile prices (such as the summer of 2022), both natural gas-fueled resources and battery resources were projected to generate the majority of their revenue from the energy market. Longer-duration battery storage resources showcased their greatest energy market revenue potential during such conditions.
- Resource options that offer modular block size additions can help optimize participation across multiple markets and minimize outage risks.

Overall, while no single technology can offer every desired resource attribute, for a system that values a technology that can provide firm, reliable energy during prolonged periods of grid stress as well as flexible and fast responding energy resource, RICE and other flexible gas resources will often provide the best value. A system that values operational flexibility and has a high level of intermittent generation that is misaligned with system demand, a battery option may provide higher value by allowing operators to be more active in ancillary service markets and take advantage of volatile price periods.

Key analysis findings

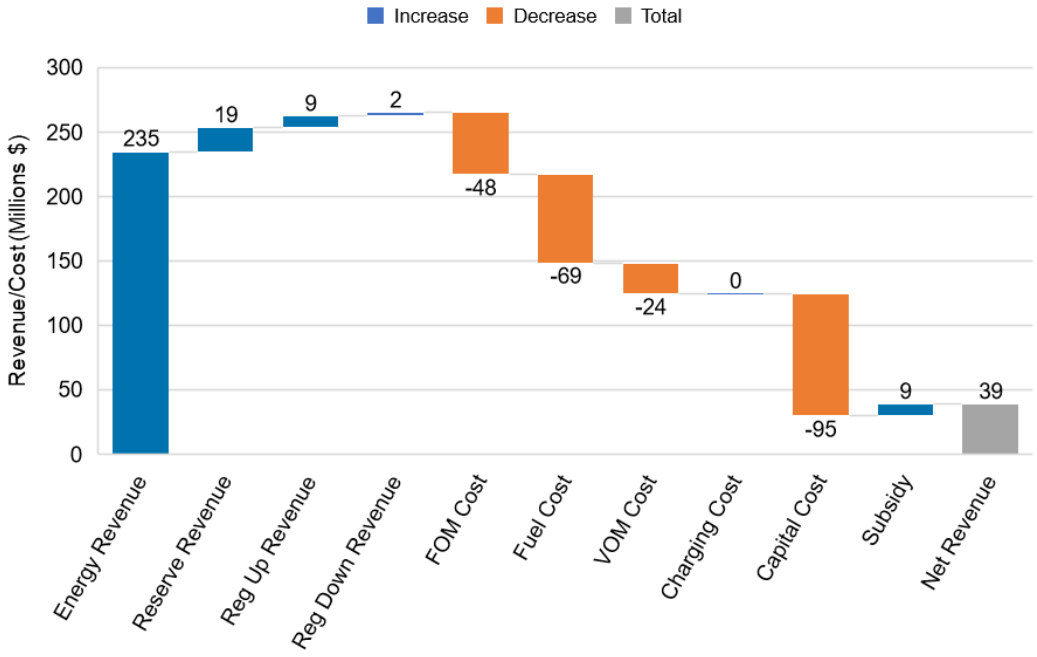
CRA's analysis found that battery storage technologies were projected to generate higher levels of revenue.[1] Their ability to take part in the ancillary service market when not actively discharging allows them to capture more ancillary service value, while the lion's share of revenue for the natural gas-fired resources was projected to come from the energy market. However, due to higher capital cost and fixed cost expectations, the battery resources were projected to generate lower total value. This is summarized in Exhibit 1 and Exhibit 2, which show the costs and revenues for the 4-Hour storage resource and RICE resource, respectively.

Exhibit 1: Detailed revenue and cost components for 4-Hour battery operating in ERCOT West



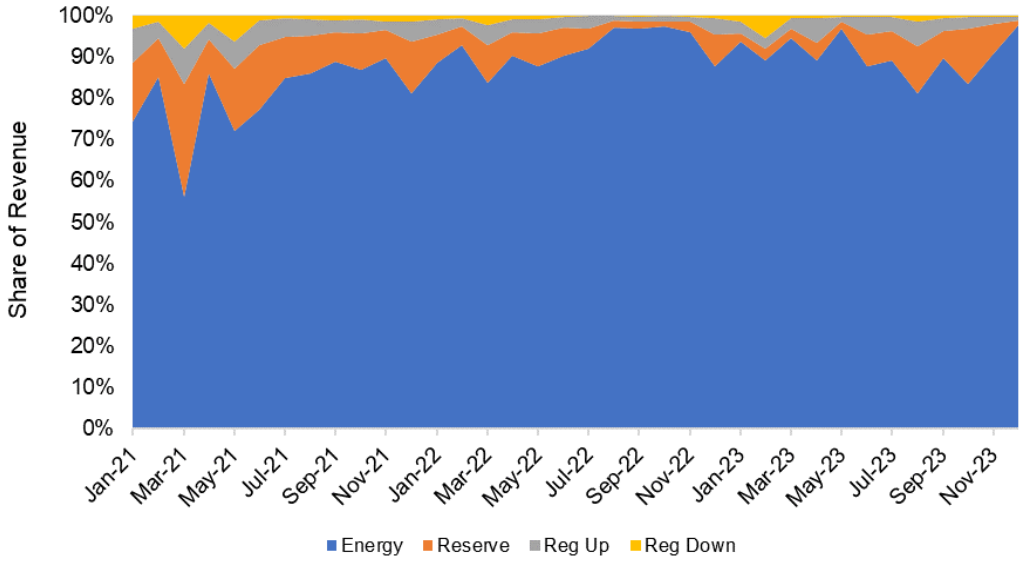
[1] It should be noted the ESOP model assumes perfect foresight of market prices in terms of facility operations, and an actual plant operator would be unlikely to realize the full potential value, particularly given competitive dispatch and system operator calls within the ERCOT market. Nevertheless, the analysis can still provide a relative value comparison of the various technologies.

Exhibit 2: Detailed revenue and cost components for RICE operating under West spot gas prices



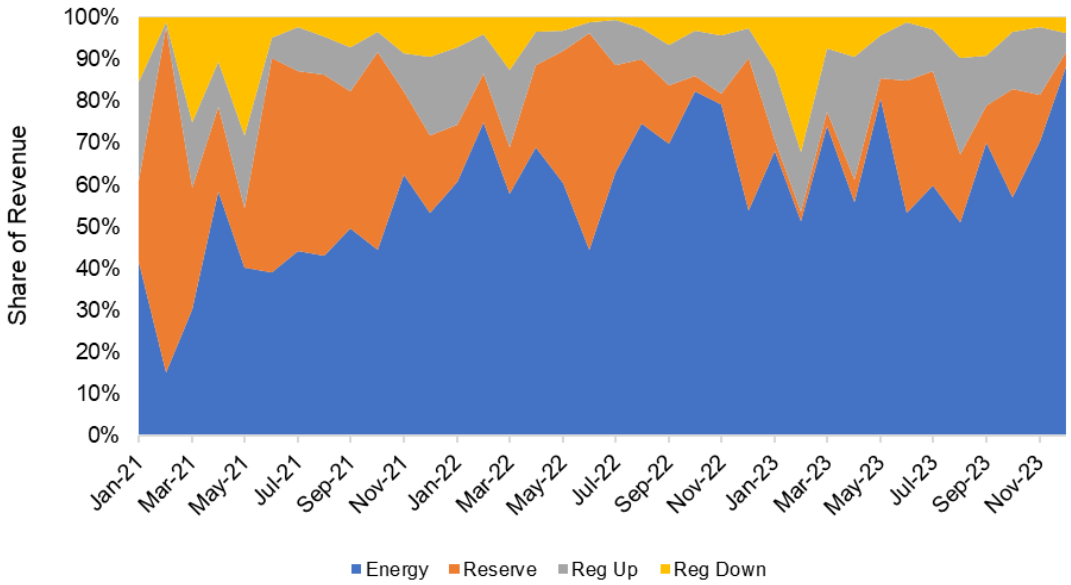
For the most part, the natural gas fired technologies were projected to receive the vast majority of their revenue from the energy market, with ancillary revenue fluctuating between 0% and 20% over the years. This is shown in Exhibit 3 for the RICE resource, though this pattern is replicated by the other gas-fired technologies.

Exhibit 3: RICE revenue share by market, under spot gas prices



Battery technologies, however, were projected to have a more diverse revenue stream, with only 60-65% of revenues coming from the energy market. This is in part due to batteries' ability to provide ancillary services when not in a state of operation, providing a lower cost threshold to generate profit in these markets than a gas resource would. This flexibility allows batteries to be more active in ancillary markets. This is shown for the 4-hour battery in Exhibit 4.

Exhibit 4: 4-Hour battery revenue share by market, operation in ERCOT West



About CRA's Energy Practice

Charles River Associates is a leading global consulting firm that offers strategic, economic, and financial expertise to major corporations and other businesses around the world. CRA's Energy Practice provides services to a wide range of industry clients, including utilities, ISOs, RTOs, large customers, and investors. The Energy Practice has offices in Boston, New York City, Washington DC, Toronto, London, Houston, Los Angeles, Salt Lake City, Dusseldorf, and Munich. Learn more at **www.crai.com/energy**.

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