Integrating battery storage into electrical grids can sometimes increase emissions due to market forces

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An electricity market analysis found adding battery storage to enhance grid reliability caused power generation markets to favor coal over natural gas.

Integrating battery storage into electrical grids may seem like a straightforward way to improve reliability and reduce greenhouse gas emissions. However, the economics behind electrical grid reliability complicate the impact, requiring more careful implementation to ensure reduced emissions.

"Green technologies may not always be green in practice. We need to understand these complicated interactions to assess tradeoffs and also to develop deployment strategies that match our goals," said Johanna Mathieu, an associate professor of electrical engineering and computer science at the University of Michigan.

In most of the United States, utilities deliver electricity while separate power plants generate it. Power plants sell the electricity they generate through competitive markets run by Regional Transmission Organizations, also known as Independent System Operators, which determine wholesale electricity prices for each node in the power grid.

The Federal Energy Regulatory Commission (FERC) created and regulates these Regional Transmission Organizations to guard against market manipulation and guarantee all types of power suppliers—whether sourced by coal, natural gas, nuclear power or renewables—would have access to the electricity grid.

Grid operators must ensure that demand constantly meets supply, as a mismatch can lead to brownouts or blackouts for customers. Power plants can bid a portion of their capacity to be available to grid operators

for "frequency regulation" so that they can adjust their supply to meet demand.

This means power plants actually provide two services that they are compensated for separately—providing energy and enabling grid reliability. Some batteries participate only in grid reliability markets.

"We argue that power plants should be considered multi-product firms. Focusing on either the electricity generation or reliability market might lead to incorrect or incomplete conclusions about plant behavior," said Catherine Hausman, an associate professor in the Ford School of Public Policy at U-M.

In a collaboration between power systems engineers and energy and resource economists, UM researchers explored the impact of changes in electricity reliability markets—often referred to as ancillary services markets—on electricity generation markets, affecting the mix of resources on the grid and associated greenhouse gas emissions.

The study, published in *The RAND Journal of Economics*, uses real electricity market data from PJM, the largest Regional Transmission Organization in the U.S., to analyze the spillovers between the two markets, or the impact of one on the other.

For the period studied between 2012 and 2014, changes in the need for grid reliability services changed the mix of power sources providing energy in the electricity market.

Specifically, a reduced need for grid reliability services, which is comparable to the addition of batteries, increased emissions as the power generation market shifted to favor the more CO_2-intensive coal over natural gas. A shift to cause increased emissions is not always the outcome, but it is a possibility to consider when implementing batteries

to maintain grid reliability.

Previous simulation-based engineering research assessed the impact of battery integration on greenhouse gas emissions, but this analysis is the first to use real data and incorporate methods from economics.

"Integrating engineering and economics methods and insights generated a much deeper understanding of this problem than if we had worked on this problem in our own siloes," said Mathieu.

This work can inform policy as electrical grids continue to integrate renewable energy sources and energy storage, by working to design the system and operations to ensure battery storage has a positive impact.

More information: Jesse Buchsbaum et al, Spillovers from ancillary services to wholesale energy markets, *The RAND Journal of Economics* (2024). DOI: 10.1111/1756-2171.12459

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