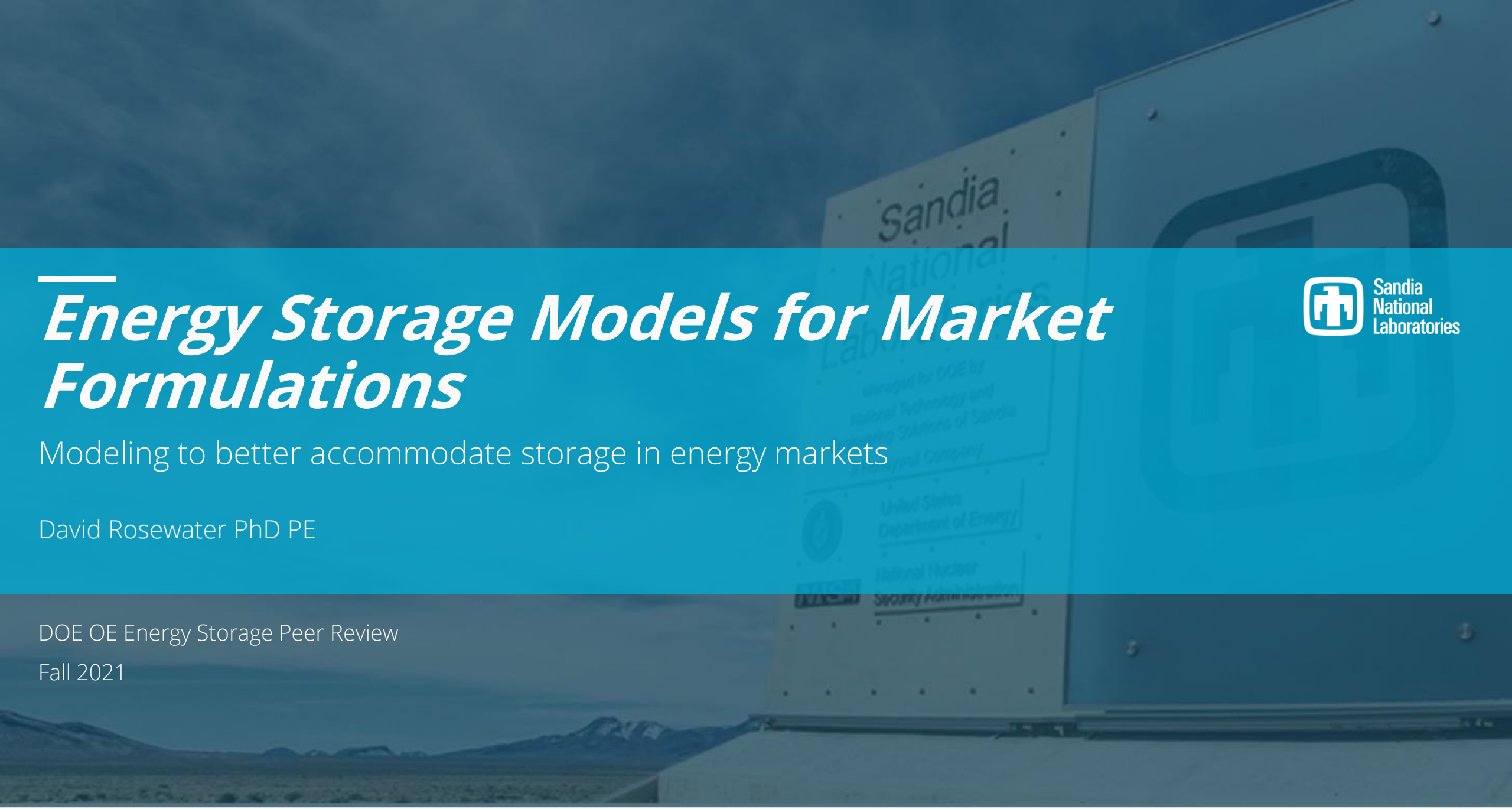

Energy Storage Models for Market Formulations

Modeling to better accommodate storage in energy markets

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DOE OE Energy Storage Peer Review

Fall 2021

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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Abstract

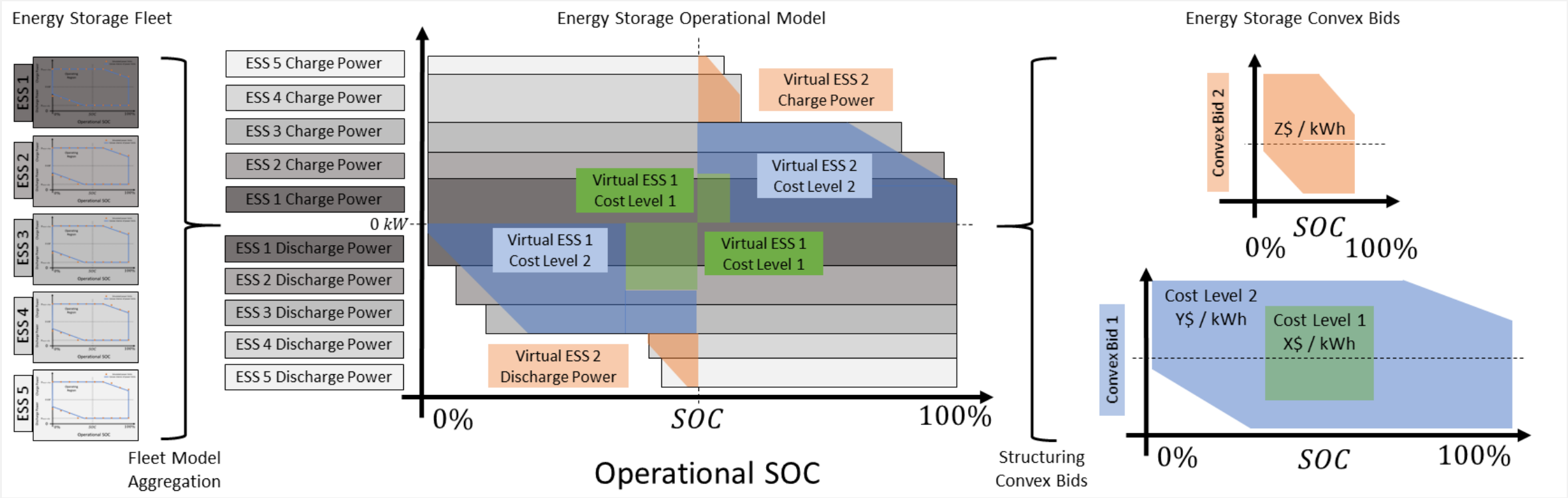
Energy markets are not currently structured to accommodate the physical characteristics of energy storage. Including energy storage dispatch in optimal economic dispatch or unit commitment requires that it be performed over a time horizon, increases its complexity, and may result sub-optimal dispatch depending on the model used.

The state-of-the-art is to avoid this by making BESS self-schedule where they often assume their operation cannot affect prices. This approach is computationally efficient but can distort the market at high levels of penetration.

With infinite computational resources a market operator could take non-convex BESS model parameters as energy market bids and could directly optimize operation. This idealized approach provides a benchmark performance for perfect information but is not feasible at scale.

We have developed a bid structure for energy storage that provides most of the performance improvements of perfect information with the computational efficiency of the state-of-the-art.

Methods



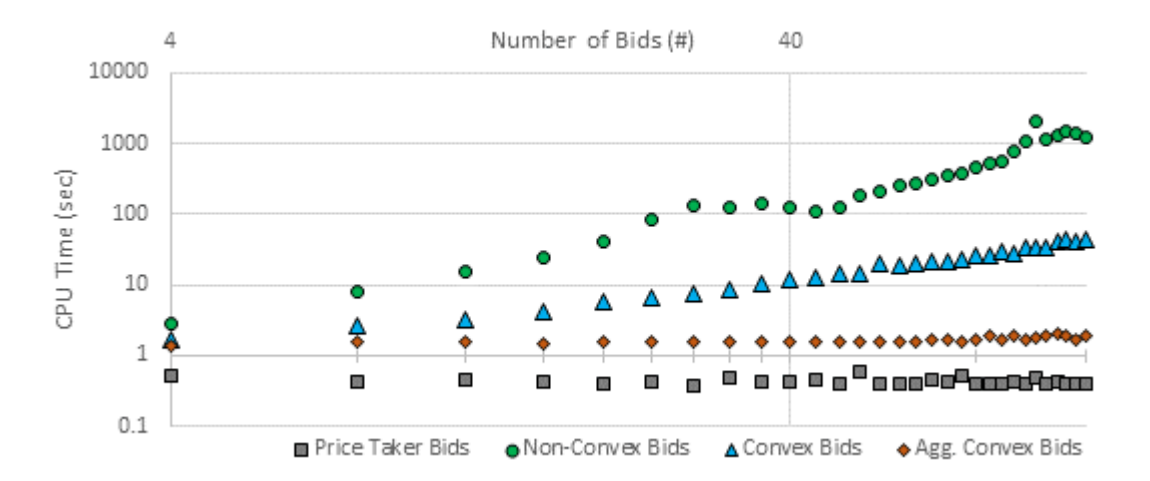
The capabilities of a fleet of energy storage systems can be represented by a convex region in dimensions of energy (x-axis) and power (y-axis).

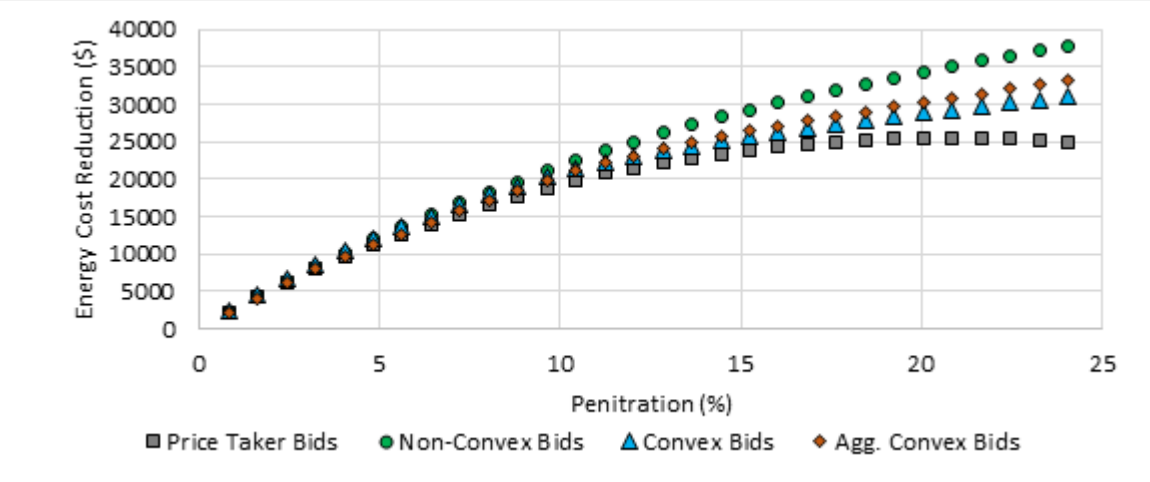
These capabilities can then be aggregated/disaggregated as needed to bid into different markets.

Results

In a simplified, simulated energy market the price-taker modeling assumption holds below roughly 10% market penetration.

Beyond that level, the aggregated convex bid structure is shown to provide most of the performance of the non-convex bid (ideal), with scale-free computation time.





Conclusions and Future Work

We have developed a bid structure for energy storage that provides most of the performance improvements of perfect information with the computational efficiency of the state-of-the-art.

David Rosewater, "Convex market-bid aggregation for optimal dispatch of heterogeneous energy storage fleets" submitted to IEEE Transactions on Smart Grid in April 2021, submission rejected in June 2021.

Peer-review feedback / future work

- The price-taker modeling assumption is not necessary the best baseline for performance.
  - We are reformulating the baseline dispatch algorithm to using a real ISO bid structure (e.g. from MISO).
- The simulated energy market used in the analysis may be too simple to capture computational issues that could arise with the propped method.
  - We are updating the analysis from optimal economic dispatch to unit commitment using a modified GMLC – RTS grid topology.

Funding for this research was provided by the DOE OE Energy Storage Program.
Thank you to Dr. Imre Gyuk for supporting the research to integrate energy storage resources into energy markets.