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Savings in Action: Lessons from Observed and Modeled Residential Solar Plus Storage Systems

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This NREL study used data from a new-construction residential community equipped with rooftop solar and storage (S+S) in Arizona to analyze the factors that determine customer electricity cost savings and emissions impacts of S+S in the real world.

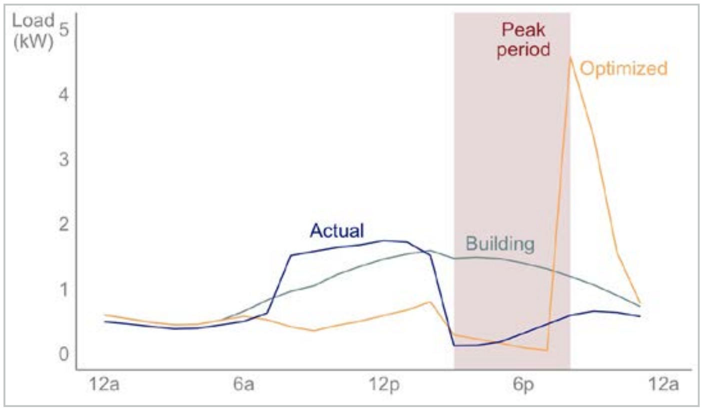
The electric grid is rapidly evolving as small-scale, demand-side resources such as S+S play increasingly important roles in grid operations and decarbonization. Maximizing the potential of S+S involves incentivizing customers to adopt and use those resources in ways that benefit the grid through customer cost savings.

Cost savings depend on numerous factors, including the characteristics of different technologies, the algorithms that control these devices, system performance, customer behavior, electricity rate structures, and climatic factors. This study analyzed the impacts of these variables on cost savings. The study also used differences in modeled data and real savings to explore ways to improve S+S optimization models.

Key Findings

Rate structures play a central role in the grid and customer value of demand-side resources.

In the Arizona case study, the local utility enrolled all households in the community in an experimental distributed generation (DG) rate designed for customers with S+S. The DG rate benefited the grid by helping reduce customer grid demand during grid peak periods. However, the DG rate created demand charges (dollars per kilowatt of peak electrical demand) that the S+S algorithms struggled to reduce. These challenging demand charges nearly eroded the entire customer cost savings from S+S adoption. Design of future rate structures will need to find a balance between providing benefit to the customer and benefit to the grid.



Average hourly gross (Building) and net (Actual and Optimized) loads across five homes for weekday hours between May and November. Actual net loads increase towards the end of the peak period due to the battery running out of charge.

Certain customers can benefit more from demand-side resource adoption than others.

Electricity cost savings varied significantly across households in this case study, due to household-level factors including total electricity demand, demand profiles (e.g., more use during on-peak hours), and differences in home square footage.

Modeled battery dispatch and sizing reveals opportunities for additional cost savings.

Demand charges are based on the highest hourly net load across all peak hours in a month. The battery system can reduce demand charges by discharging during peak hours. The battery dispatch algorithm attempted to reduce net load to zero during peak hours, but this strategy runs the risk of running out of stored energy before the end of the peak period. Modeled results show that current battery systems in the community could further reduce demand charges by moderating their discharge during the peak demand period rather than attempting to reduce demand to zero.

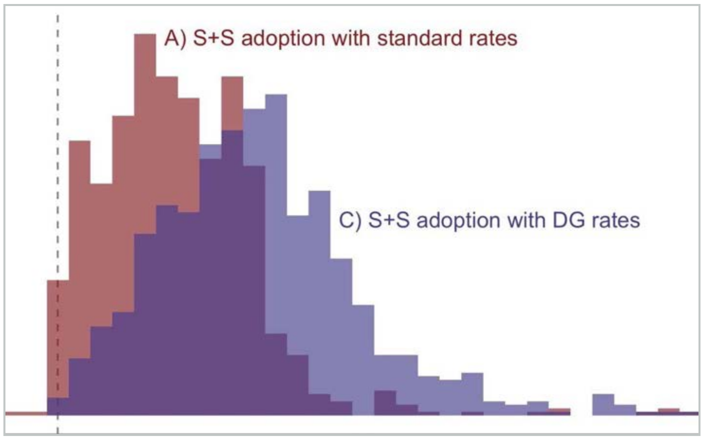
Under the experimental DG rate, which has a high demand charge and low energy cost, the modeled cost-optimal battery sizes are slightly smaller than those currently installed.

Indeed, modeling suggests certain electricity rates may entirely eliminate the rate incentives to adopt solar and/or storage. Again, this outcome reflects the challenge of designing rates that incentivize demand-side services without eliminating incentives for demand-side resource adoption.

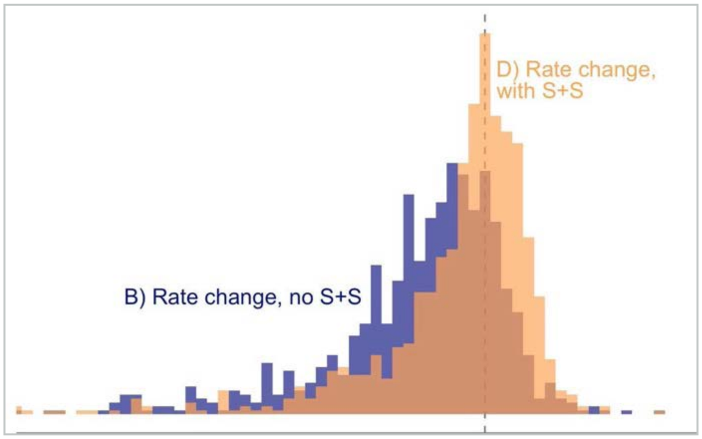
Optimal dispatches can reduce grid emissions and maximize bill savings.

Though not an explicit goal of the community in this case study, the research found that grid emissions reductions can be a co-benefit of deploying S+S. The study's analysis quantified the emissions impact of the actual and modeled battery systems, and determined the optimal battery dispatch that benefits both customers and reduces grid emissions. However, achieving the modeled emissions reduction would require granular, real-time emissions information to allow the battery dispatch to mirror the highly variable grid emissions rates.

Importantly, accounting for grid emissions has minimal impact on utility cost savings, suggesting emissions-reduction strategies need not be at odds with bill savings strategies. Policymakers and rate designers could leverage this fact by implementing measures to incentivize developers to dispatch demand-side resources to simultaneously reduce grid emissions and maximize customer savings.



Results show that, holding rates constant, S+S adoption can provide customer savings at both the standard and experimental DG rates.



Switching to the experimental DG rate is better for customers with S+S than customers without it. However, the majority of customers see a bill increase when switching to the experimental rate.

More Information

For more information, download the full technical report: O'Shaughnessy, Eric, Dylan Cutler, Amanda Farthing, Emma Elgqvist, Jeff Maguire, Michael Blonsky, Xiangkun Li, et al. 2022. *Savings in Action: Lessons from Observed and Modeled Residential Solar Plus Storage Systems*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-82103. https://www.nrel.gov/docs/fy22osti/82103.pdf.

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NREL/FS-6A20-83518 • July 2022