Renewable hybrid systems

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Hybrid renewable energy systems combine multiple renewable energy and/or energy storage technologies into a single plant, and they represent an important subset of the broader hybrid systems universe. These integrated power systems are increasingly being lauded as key to unlocking maximum efficiency and cost savings in future decarbonized grids--but a growing collection of National Renewable Energy Laboratory (NREL) analysis indicates there are still challenges in evaluating the benefits of hybrids with the tools used to help plan those future grids.

In comparing hybrids to standalone alternatives, it is important to tackle questions like: Is it always beneficial to combine renewable and storage technologies, instead of siting each technology where their individual contributions to the grid can be maximized? Or are only certain hybrid designs beneficial? Does the energy research community consistently represent the characteristics of hybrids in power system models? And are we using common definitions when studying hybrids and their potential impacts?

The results of this body of work highlight some gaps between what different models show and what many in the energy community have--perhaps prematurely--proclaimed when it comes to the value of hybrid systems to the future grid.

"Hybridization creates opportunities and challenges for the design, operation, and regulation of energy markets and policies--and current data, methods, and analysis tools are insufficient for fully representing the costs, value, and system impacts of hybrid energy systems," said Paul Denholm, NREL principal energy analyst and coauthor. "Ultimately, our research points to a need for increased coordination across the research community and with industry, to encourage consistency and collaboration as we work toward answers."

Finding answers starts with speaking the same language. To help researchers move toward a shared vocabulary around systems that link renewable energy and storage technologies, Murphy and fellow NREL analysts Anna Schleifer and Kelly Eurek published a paper proposing a new taxonomy.

"Our ability to quantify hybrids" potential impacts could be hindered by inconsistent treatment of these systems, as well as an incomplete understanding of which aspects of hybridization will have the greatest influence," Murphy said. "Ultimately, we hope our proposed taxonomy will encourage consistency in how the energy community thinks about and evaluates hybrids" costs, values, and potential."

After a thorough literature review, the team developed a new organization scheme for utility-scale systems that combine renewable and energy storage technologies--only a subset of which can truly be called "hybrids." They came up with three categories based on whether the systems involve locational or operational linkages, or both.

"We found that technology combinations do not represent a meaningful delineation between hybrids and non-hybrids--the nature of the linkages are more important distinctions," Murphy said.

The resulting categories can help inform policy considerations, as they define system characteristics that could challenge existing permitting, siting, interconnection process, and policy implementations. The taxonomy is also helpful in informing model development efforts, as the categories identify the unique characteristics that must be reflected to adequately represent hybrid systems in a model--including the effects of the linkages on both a project"s costs and the values it can deliver to the grid.

In a series of recent reports, NREL analysts homed in on a set of technology combinations and linkages that are consistent with a true hybrid system--co-optimizing the design and self-scheduling of linked technologies to maximize net economic benefits.

To do this, NREL modeled hybrid systems using three different tools that underpin many of the laboratory"s forward-looking power system studies. These analyses focus on DC-coupled solar photovoltaic and battery energy storage (PV+battery) hybrids, which are increasingly being proposed for the power system.

Combining PV and battery technologies into a single hybrid system could lower costs and increase energy output relative to separate systems--but accurately assessing PV+battery systems" market potential requires improved methods for estimating the cost and value contribution in capacity expansion models, including those that utilities use for integrated resource planning.