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ENERGY INSIGHTS

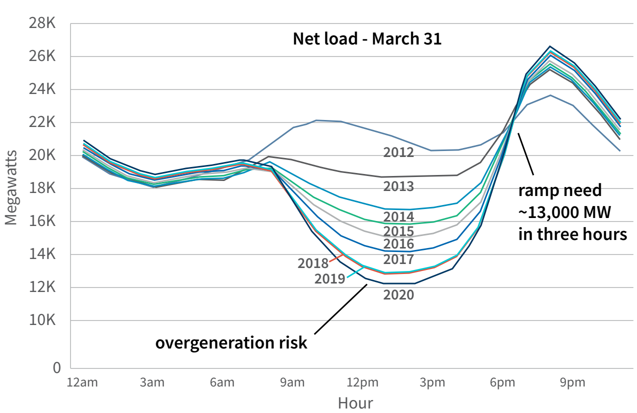
Hybrid Storage — A Worthy Adversary for Conventional Peakers?

For many years, U.S. storage and hybrid "solar + storage" projects have been a solution in search of a problem — and perhaps more importantly, a solution in search of market-based compensation mechanisms reflecting the value-added attributes a battery brings to the transmission ecosystem. Markets have accelerated that evolution, opening doors for storage to play in the bilateral and wholesale realms, even if the benefits of FERC Order 841 (and the recent court decision upholding it) take years to play out in key RTOs and ISOs. Solar hybrid projects have now evolved from beta testing to mainstream solutions — in many cases being as big or bigger than peaking generation facilities — and are fundamentally changing how renewables are evaluated by grid operators, utilities, developers and investors.

Energy storage provides a number of key services to the electric grid, including reliability, frequency regulation and peak shifting. The type of service a specific battery system provides depends on factors such as technology choice, energy capacity, storage duration and warranty terms (which impact how a system can be financed, given an assumed-use case). Reliability is, and should be, paramount to system operators, who require the capacity and flexibility to ensure generating supply will be available to match expected and unexpected demand spikes. Utilities and system operators have historically favored quick-starting, high variable cost, natural gas-fired peaking facilities to meet real-time demand spikes. However, the installed costs of such units, coupled with high heat rates, low capacity factors and emissions constraints leading to incremental costs, necessarily result in significant levelized costs, which are amplified versus other options in a low pricing environment for natural gas. Within this paradigm, energy storage and hybrids have found a problem they can address and, at the same time, prove they are more than a novelty of the electric supply system. In this arena, energy storage is proving to be a reliable, commercially viable, cost-effective and distinct asset class that can be deployed with favorable rates of return on capital.

Economic and environmental benefits of renewables notwithstanding, the intermittent characteristics of wind and solar, coupled with their ongoing proliferation, continue to challenge system operators and market participants. Well-positioned storage can and will significantly mitigate such challenges. California's well established "duck curve" phenomenon, which results in a need for fast-ramping generation late in the day as solar production falls off and demand spikes (see Figure 1), is a prime example of system constraints which continue to be addressed with an uneconomic and patchwork solution. The low and negative prices seen in ERCOT, historically driven (at least in part) by wind generation, are another example for which standalone or hybrid storage could help ease the market's ability to soundly integrate renewables in less distortive ways.

Figure 1. CAISO Duck Curve Evolution: 2012 to 2020



Source: NREL

Given such phenomena — and even as states make significant progress toward renewable energy procurement goals — there is still some amount of high-heat-rate peaking generation that will be required for standby in most geographies.[1] At the same time, utility-scale, hybrid solar assets are starting to offer a more economical solution than fossil-fueled peaking units, and such projects have already gained significant traction in several U.S. power markets. Additionally, as long as the solar ITC can be attached to such hybrid facilities, a further cost advantage is realizable. The peak shifting capability of hybrid solar offers an alternative to fossil fuel generation in real time, ensuring power is available when needed while also enabling states to meet renewable procurement targets comprised predominantly of intermittent resources. While hybrids are not expected to fully supplant peakers in the near term, our expectation is that reliance on peakers will decline from the 5%-7% historical capacity factor observed in recent years. By the end of 2020 CAISO and PJM are expected to have nearly 700 MWs of solar + storage hybrid capacity online.[2] Looking forward, another 38 GW of projects currently sit in the CAISO and PJM queues with targeted commercial online dates ("COD") by 2025. Beyond PJM and CAISO, various non-ISO geographies have also leaned into storage, procuring multi-hour storage solutions for hundreds of MWs of solar hybrid projects. Assuming 25% of the CAISO/PJM backlog achieves commercial operation, an additional 9.5 GW of hybrid peaking capacity could be available by 2025 — and this estimate ignores queue additions that will inherently occur as electrification trends broaden.

One example of this buildout is 8minute Solar Energy's California-based Eland project, scheduled to come online in 2023. Eland is a 400 MWac facility, co-located with an ambitious four-hour, 300 MW battery solution. Eland is contracted with LADWP and Glendale Water and Power at a $19.97/MWh base PPA price with a $19.65/MWh storage adder, bringing the bundled price to $39.62/MWh. Given the relatively new and unique characteristics of the 8minute project and offtake, we highlight some key observations:

— We understand the project's ~$20/MWh storage adder is applicable to all megawatt-hours delivered by the solar facility, not just those megawatts discharged by the storage asset. The structure of this adder is relevant, as some market participants will evaluate the levelized cost of storage with an emphasis specifically on those megawatt hours which are being shifted, whereas in this case it is blended over all megawatt hour delivered to market.

1 "Dispatchable" refers to units that are on standby and able to turn on as required by system operators.

2 Based upon nameplate capacity of PJM & CAISO solar + storage projects.

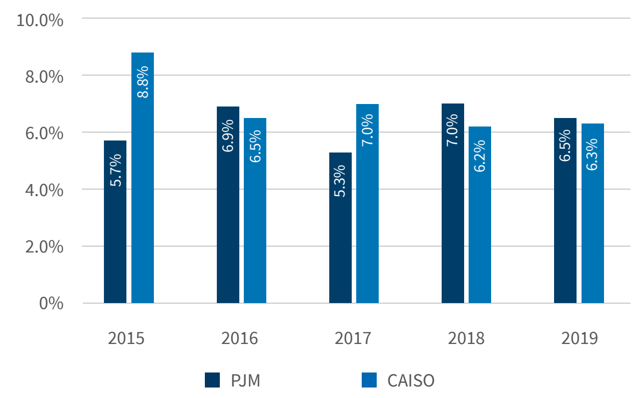
— When comparing solar hybrid PPA prices — especially headline numbers that are frequently quoted in the trade press — attention must also be paid to the storage system's duration as measured by megawatt hours to megawatts, as well as the ratio of megawatt storage to megawatt solar, to affirm just how much energy can actually be shifted during a given period.

— By contracting for a later COD, developers seize an opportunity to ride the technology cost and efficiency curves down and up, respectively

Ultimately, the goal of utility offtakers and regulators is to deliver reliable power at the least cost to ratepayers while also satisfying public-policy mandates set forth by legislators and utility commissions. Assuming two generation resources are capable of reliably delivering megawatts, a utility's decision to select one over the other comes down to a comparison of levelized costs —i.e., the least to consumers. A comparison of two resources, such as hybrid solar and a fossil fuel peaker, can be broadly distilled down to two variables: (i) the absolute magnitude of various fixed and variable production costs, plus return on capital, and (ii) the lifecycle MWh of production across which these costs can be spread.

Historically, peakers have been dispatched sparingly in the United States, due both to marginal economics and to air permit restrictions. Evaluating market data since 2015 (see Figure 2), we observe that peakers have substantively operated 5%-7% of the year. While an oversimplification, from the offtaker's perspective, the less a traditional peaker operates, the less production is available for the amortization of capital expenditures and fixed operating costs, including tolling charges. The dynamic capabilities of hybrid peaking systems, on the other hand, match the production profile of co-located solar generation facilities which are typically structured such that stored megawatts are available to be discharged during high demand hours. Such flexibility creates a construct whereby hybrid peakers can ultimately achieve project values equal to or greater than traditional peaking assets, which are only utilized during a fraction of a year.

Figure 2. Historical Peaker Capacity Factors: CAISO and PJM



Source: Ventyx Energy Velocity Suite

Hybrid assets pair the on-peak baseload characteristics of a utility-scale solar asset with the dynamic capability to shift power around the clock to times when demand is high or market supply is low. This flexibility allows hybrid assets to be more competitive on a relative basis vs. peakers, especially (but not only) in a high-irradiance region, as they spread fixed and capital costs over significantly more production hours which can electively be shifted. We illustrate this below with a focus on a levelized cost metric, as measured in dollars per megawatt hour.

Consider a theoretical investment in a 200 MW hybrid solar asset in CAISO and PJM. Assuming an initial capital investment of approximately \$2,300/kW[3] (including mid-life battery replacements), a market-specific capacity factor, and an unlevered hurdle rate range of 7%-10%, a hybrid solar asset would have a levelized all-in cost of \$82/MWh to \$100/MWh for CAISO and \$118/MWh to \$144/MWh for PJM.[4] Comparing this to a theoretical 200 MW fossil peaker with capital costs of \$700/kW shows the advantage of hybrid solar, even under a range of unlevered hurdle rates and capacity factors assumed for the natural gas-fired peaker.[5]

Under substantially all new-build scenarios, hybrid solar pencils out to be a more competitive offering than peaking

3 Derived from EIA study and other publicly available information.

4 Initial capital investment and capacity factor assumptions have been adjusted for CAISO and PJM in accordance with localized adjustments to labor costs and resource potential.

5 Initial capital investment has been adjusted for both CAISO and PJM in accordance with localized adjustments to labor costs.

Figure 3. Peaker Levelized Cost Sensitivity — Comparing Hurdle Rates and Capacity Factors

Hurdle Rate	CAISO 2.5%	CAISO 5.0%	CAISO 7.5%	CAISO 10.0%	PJM 2.5%	PJM 5.0%	PJM 7.5%	PJM 10.0%
7.0%	$375	$212	$157	$130	$354	$197	$145	$119
8.0%	406	226	167	137	383	211	154	125
9.0%	437	241	176	144	413	226	163	132
10.0%	469	257	186	151	443	241	173	139

LEGEND: Hybrid In-the-Money; Both Cost Competitive; Historical CF Range

fossil generation. While the growth of hybrid solutions has been largely environmentally and regulatorily driven to date, the economic and competitive impact of these systems can now be observed in the difficulty that conventional power developers have faced in recent periods — specifically in justifying a merchant existence or securing long-term offtake to merit the construction of new, natural gas-fired peaking generation. When combined with the challenging effects of natural gas oversupply and grid congestion, we anticipate that meaningful development of new gas-fired peaking generation will not be commonplace in these (and most other) ISOs going forward.

The amount of hybrid capacity already in development and/or contracted (via PPA or build transfer agreements) across the United States is a signal of things to come. PJM and CAISO are certainly not the only markets diving into the hybrid solar market. Nevada has proposed at least two large solar hybrid projects: the "Gigawatt 1" project developed by Capital Dynamics with Switch as the offtaker,[6] and a 350 MW solar hybrid project being developed by NV Energy with Google providing the offtake.[7] In the southeastern U.S., RWE is developing a 195 MW / 80MWh solar hybrid project with Georgia Power as the offtaker[8], and FP&L is developing a 409 MW / 900 MWh solar hybrid in Florida.[9] For power & energy markets looking to stabilize the electric grid as more intermittent renewable energy resources come online, hybrid solar assets are not only the more environmentally friendly option — they are also the more cost-effective investment decision. Indeed, hybrid projects may prove to be a key operating model which delivers a solution that both eases the complexity of integrating renewables into the grid and justifies the displacement of peaking facilities over the next generation.

6 https://www.prnewswire.com/news-releases/switch-and-capital-dynamics-break-ground-on-massive-solar-and-battery-storage-developments...
7 https://www.pv-tech.org/news/google-and-nv-energy-propose-major-solar-plus-storage-project-in-nevada
8 https://www.power-grid.com/2019/11/07/germanys-rwe-sells-solar-power-to-georgia-power/
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CHRIS LEWAND
Senior Managing Director
Power & Renewables Global Leader
+1 303.689.8839
chris.lewand@fticonsulting.com

CHRIS POST
Senior Managing Director
+1 303.689.8888
chris.post@fticonsulting.com

MARC ATLAS
Managing Director
+1 303.689.8874
marc.atlas@fticonsulting.com

RJ ARSENAULT
Managing Director
+1 617.520.0276
rj.arsenault@fticonsulting.com

ALEX VAN TUYN
Director
+1 212.841.9381
alexander.vantuyn@fticonsulting.com

STEPHANI CARLILE
Director
+1 303.689.8857
stephani.carlile@fticonsulting.com

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