Photovoltaic plus Storage – Part 2, Projects

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1. Introduction

Part 2 will describe recent major U.S. PV and storage projects and some new twists on residential PV plus storage.

Part 1 of this paper (linked below) is on new technologies for utility-scale PV, utility-scale storage and PV plus storage systems, and the evolution of missions.

https://www.energycentral.com/c/cp/photovoltaic-plus-storage-%E2%80%93-part-1-technology

2. Projects

The projects described below include PV plus storage, PV-only and storage only.

2.1. Arizona Public Service and First Solar

A 65 megawatt (MW) project is making news by coupling PV with battery energy storage systems (BESS), a first for utility Arizona Public Service, which solicited proposals in 2017 for generation sources to provide electricity during peak demand hours.[1]

The solar-plus-storage bid beat out other generation sources, including multiple proposals for natural gas plants. The utility has an agreement with an existing natural gas-fired plant for a total of 570 MW for the summers of 2020 through 2026.

A dramatic drop in the cost of BESS, driven in large part by an increase in lithium-ion battery production to satisfy growing demand for electric vehicles allows a PV + storage project to be competitive with gas peakers plus offer more capabilities. Storage is capable of providing services like frequency regulation, which maintains the grid's electric frequency on a second-to-second basis, and reactive power support, which supports the voltage that must be controlled for grid reliability.

The 65 MW will energize a 50 MW bank of lithium-ion batteries to provide energy between 3 PM and 8 PM as demand peaks. The batteries have a nameplate capacity of 135 MWh, and will be capable of delivering energy for at least three hours. Arizona Public Service signed a 15-year power-purchase agreement with FirstSolar for power from the array. Other terms were not disclosed.

When it's operational at the end of 2021, the 65 MW solar PV array will be able to deliver energy to the grid while the sun is still high in the sky. As evening approaches, the batteries will discharge their energy and continue to provide power for peak demand.

The solar PV array is oversized relative to the storage battery to ensure that it is able to recharge the battery even under less than ideal solar conditions.

[1] David C Wagman, IEEE Spectrum, " Arizona Utility Opts for Solar and Storage to Meet Peak Demand", 5 Mar, 2018, https://spectrum.ieee.org/energywise/energy/renewables/arizona-utility-opts-for-solar-and-storage-to-meet-peak-summer-demand

2.2. Hawaiian Electric and Various Vendors (see below)

Hawaiian Electric Companies said it submitted the contracts for seven new solar-plus-storage projects across its service territory to on January 3 to the state Public Utilities Commission for review. [2]

The gird-scale projects will add approximately 262 megawatts of solar energy and 1,048 megawatt-hours of storage on the islands of Oahu, Maui and the Big Island.

Since the creation of the Hawaii Clean Energy Initiative in 2008, the utility reduced its fossil fuel use by 26 percent. The seven projects, which remain subject to PUC approval, have the potential to reduce the amount of imported oil by 100 million gallons annually, compared to 2008, the utility stated.

In addition, the prices for six of the seven projects are the lowest to date for renewable electricity in the state. The electricity prices for the seven projects range between 8 and 12 cents per kilowatt-hour, which is below the current cost of fossil fuel generation of about 15 cents per KWh.

The seven solar-plus-storage projects are the result of a procurement effort that began in February, they include:

Project Name	Island	Developer	Power Output	Energy Storage	Cost per KWh
Waikoloa Solar	Big Island	AES	30 MW	120 MWh	$0.08
Hale Kuawehi	Big Island	Innergex	30 MW	120 MWh	$0.09
Kuihelani Solar	Maui	AES	60 MW	240 MWh	$0.08
Paeahu Solar	Maui	Innergex	15 MW	60 MWh	$0.12
Hoohana	Oahu	174 Power Global	52 MW	208 MWh	$0.10
Mililani I Solar	Oahu	Clearway	39 MW	156 MWh	$0.09
Waiawa Solar	Oahu	Clearway	36 MW	144 MWh	$0.10

In December, the utility selected an eighth project, a 12.5 MW solar array in West Oahu that will include a 50 MWh storage system. Hawaiian Electric said it expects to submit the contract for this project to regulators in the coming weeks.

2.3. Various Projects in New York (mainly PV)

One would think that the hot bed for PV plus storage would be the east coast, because of their low percentage of cloudless days. However it seems to be the west coast, where most large PV projects have a sizable storage component. This was just reinforced by the New York State Energy Research and Development Authority (NYSERDA) announcing on January 20, solar, wind and battery storage projects totaling 1,654 MW of capacity.[3] These are listed below, and only the first has storage.

[2] HJ Mai, Pacific Business News, " Hawaiian Electric submits contracts for 7 solar-plus-storage projects to state regulators", January 3, 2019, https://www.bizjournals.com/pacific/news/2019/01/03/hawaiian-electric-submits-contracts-for-7-solar.html

[3] Christian Roselund, PV Magazine, " New York governor's Green New Deal starts with 1 GW of large-scale solar", January 21, 2019, https://www.pv-magazine.com/2019/01/21/new-york-governors-green-new-deal-starts-with-1-gw-of-large-scale-solar/

- Excelsior Energy Center: Genessee County, 280 MW of solar plus 20 MW of energy storage
- Horseshoe Solar: Livingston County, 180 MW
- Morris Ridge Solar: Livingston County, 170 MW
- Mohawk Solar: Montgomery County, 90 MW
- North Light Energy Center: Seneca County, 80 MW
- Watkins Glen Solar Energy Center: Schuyler County, 50 MW
- Silver Lake Solar: Wyoming County, 25 MW
- Stillwater Solar: Saratoga County, 20 MW
- Clay Solar: Onandaga County, 20 MW
- Dog Corners Solar: Cayuga County, 20 MW
- Manchester Solar: Ontario County, 20 MW
- Hills Solar: Herkimer County, 20 MW
- Skyline Solar: Oneida County, 20 MW
- Watkins Road Solar 1: Herkimer County, 20 MW
- Bakerstand Solar 1:, Cattaraugus County, 20 MW
- Hannacroix Solar Facility: Greene County: 5 MW

In this procurement exercise, NextEra secured 360 MW of projects – more than a third of the total solar capacity. Regional developers also caught a fair share, with SunEast Development awarded five projects totaling 100 MW.

2.4. PG&E Projects (Storage only)

The following BESS projects are being constructed in PG&E's service territory:[4]

Vistra - Moss Landing: This is a 20-year resource adequacy contract with Pacific Gas and Electric Company (PG&E). Under the contract, Vistra Energy will develop a 300-MW, 1,200-MWh, battery energy storage project at its Moss Landing Power Plant site in Moss Landing, California. This project has been approved by the CPUC. This project will enter commercial operations by the fourth quarter of 2020.

Hummingbird: esVolta has been selected by PG&E to build an energy storage system in Santa Clara County, California. Under the proposal, which has been approved by the CPUC, esVolta will develop, build, and operate the Hummingbird Energy Storage project, a 75 MW / 300MWh lithium-ion battery storage facility. The project is slated to be in service by December 2020.

Tesla - Moss Landing: lithium-ion batteries from Tesla would form the backbone of a 182.5-MW array with a 4-hour discharge duration. The batteries would be located at a

[4] Kyle Field, Clean Technica, "California Looks To Stationary Energy Storage As A Solution To Peaker Plants", November 9, 2018, https://cleantechnica.com/2018/11/09/california-looks-to-stationary-energy-storage-as-a-solution-to-peaker-plants/

Moss Landing substation in Monterrey County. The array could enter service by the end of 2020 and include a 20-year performance guarantee from Tesla.[5]

2.5. SDGE Projects (Storage Only)

SDG&E announced 5 approved grid-scale battery projects across its territory for a total of 83.5 megawatts (MW) with a storage capacity of 334 megawatt-hours (MWh). From the press release:

- Fluence will build a 40 MW/160 MWh lithium-ion battery facility in Fallbrook, Calif. The project is expected to be completed by March 2021.
- Renewable Energy Systems (RES) America will build a 30 MW/120 MWh lithium-ion battery storage facility in San Diego, Calif. The project is expected to be completed by December 2019.
- Powin Energy will build a 6.5 MW/26 MWh lithium-ion battery storage facility in Escondido, Calif. The project is expected to be completed by June 2021.
- Advanced Microgrid Solutions will build a 4 MW/16 MWh lithium-ion battery storage facility in San Juan Capistrano, Calif. The project is expected to be completed by December 2019.
- Enel Green Power will build a 3 MW/12 MWh lithium-ion battery storage facility in Poway, Calif. The project is expected to be completed by December 2021.

2.6. Lake County, California (PV only)

Ciel & Terre USA recently announced the completion of a new 252 kW floating photovoltaic power system for the Lake County Special Districts on behalf of Kelseyville County Waterworks Dist. #3. Over 700 floating solar panels were used with SolarEdge solar optimizers for the installation (figure below).[6]

[5] David C Wagman, IEEE Spectrum, "Energy Storage Projects to Replace Three Natural Gas Power Plants in California", 17 July, 2018, https://spectrum.ieee.org/energywise/energy/renewables/energy-storage-projects-to-replace-three-natural-gas-power-plants-in-california

[6] Jake Richardson, Clean Technica, " First California Public Floating Solar Power System Delivered By Ciel & Terre", October 1, 2018, https://cleantechnica.com/2018/10/01/first-california-public-floating-solar-power-system-delivered-by-ciel-terre/

2.7. Portland General Electric and NextEra Energy

A large wind-power project in Northeastern Oregon had been in the planning stage for almost a decade. This project recently added a PV plus storage component. This project will be in Morrow County about 130 miles east of Portland and south of the Columbia River (and Washington-Oregon state line). The project will combine 300 megawatts of wind energy with 50 megawatts of solar power and 30 megawatts of storage. Plans call for the wind farm to be generating power by the end of 2020, with construction of the solar and battery elements to begin the following year.[7]

2.8. Various Rural Projects and Vendors

Under the Solar Utility Network Deployment Acceleration (SUNDA) program, which was run by the National Rural Electric Cooperative Association (NRECA) under a cost share arrangement with the U.S. Energy Department, rural electric co-ops are on track to own or buy 1 gigawatt of solar power generation capacity by 2019.[8]

As of April, more than 120 co-ops had at least one solar project on line. Of those, half said they have plans to add more solar generating capacity.

The accomplishment is no small feat. The consumer-owned structure of co-ops means that they can't make direct use of federal tax credits, which have helped to spur solar adoption among investor-owned utilities. Co-ops often have had to come up with innovative financing arrangements to make the numbers work. In particular, solar adoption has benefited from big drops in the cost of solar PV cells in recent years.

"As the cost went down, solar became more economically feasible," says Tracy Warren, an NRECA spokesperson.

The trade group says that the first system deployed by a co-op under the SUNDA program in 2014 came in at a cost of US $4.50 per peak watt. The most recent SUNDA deployment came in at $1.30 per peak watt.

NRECA released a report in mid-July (link below) that evaluates its SUNDA initiative and offers lessons learned. When the SUNDA project began less than 1% of electric cooperatives had solar PV systems larger than 250 kilowatts and the average solar project in 2013 was about 25 kilowatts in size. Today, the average project exceeds 1 megawatt.

https://www.cooperative.com/programs-services/bts/sunda-solar/Documents/Solar-Revolution.pdf

One electric cooperative on the Hawaiian island of Kauai is making headlines as it pairs solar with battery energy storage to reduce its traditional dependence on diesel for electric power generation. The Kauai Island Utility Cooperative (KIUC) could approach 70 percent renewable generation by the end of 2019. That's after state regulators in

[7] Mike Rogoway, The Oregonian, "PGE will spend $160 million on massive renewable energy project in eastern Oregon", Feb 14, 2019, https://www.oregonlive.com/business/2019/02/pge-will-spend-160-million-to-help-develop-massive-renewable-energy-project-in-eastern-oregon.html

[8] David C Wagman, IEEE Spectrum, "As Economics Improve, Solar Shines in Rural America", 27 July, 2018, https://spectrum.ieee.org/energywise/energy/renewables/solar-expands-in-rural-areas

June approved a 19.3-MW solar facility that is paired with a 70 MWh battery energy storage system.

The KIUC facility will be built by AES Distributed Energy on land leased from the Department of Defense, and is expected to displace 2.8 million gallons of diesel annually. The cooperative signed a 25-year power purchase agreement (PPA) with AES for 10.85 cents per kilowatt hour, one of its lowest-cost generating resources.

The project is the third battery storage project taken on by the cooperative since 2015. Early last year, KIUC and Tesla opened what was billed as the world's first utility-scale solar-plus-storage facility. The Tesla battery array stores up to 52 MWh of energy and discharges energy to the grid during the evening peak demand period.

Last February, AES broke ground on the co-op's latest solar-plus-battery project. Slated to enter service by the end of the year, this facility will include 28 MW of solar PV and a 20-MW five-hour-duration energy storage system.

2.9. The Future

Wood Mackenzie currently estimates that 1.4 GWh of energy storage installed across the U.S. and forecasts 8.8 GWh of front-of-the-meter solar-plus-storage capacity installed in the US by 2023, growing at an 82% CAGR starting in 2018 and led by California, Arizona, Colorado, and Hawaii.[9]

3. Storage Moving into Residential

There are two drivers for using storage in residences: (1) distributed storage or storage plus PV that is centrally dispatched as it were a peaker (virtual power plant), or (2) a cash incentive and/or tariff-based payback received by individual home owners.

3.1. Distributed PV plus Storage Virtual Peaker

Sunrun recently won a 20-megawatt bid in the forward capacity auction for ISO New England. This project will use PV plus storage systems at each of 5,000 customer homes across the region. The company is promising to aggregate across those systems to deliver the necessary power to the grid, while also keeping the host customers happy.[10]

3.2. Revisions to Existing Incentive Program

California's Self Generation Incentive Program (SGIP) has been in existence for almost 20 years. In response to the electricity crisis of 2001, the California Legislature passed several bills to help reduce the state's electricity demand. In September 2000, AB 9702 established the SGIP as a peak-load reduction program. In March 2001, the California

[9] Charles W. Thurston, Clean Technica, "Top 10 Global Solar Market Trends For 2019", Jan 22, 2019, https://cleantechnica.com/2019/01/22/top-10-global-solar-market-trends-for-2019/

[10] Julian Spector, Greentech Media, "Sunrun Wins Big in New England Capacity Auction With Home Solar and Batteries", February 07, 2019, https://www.greentechmedia.com/articles/read/sunrun-wins-new-england-capacity-auction-with-home-solar-and-batteries?utm_medium=email&utm_source=Storage&utm_campaign=GTMStorage#gs.nBmKMu1d

Public Utilities Commission (CPUC) formally created the SGIP and the first SGIP application was received in July 2001.[11]

As California's electric infrastructure evolves to 0% greenhouse gas (GHG), some undesirable side-effects occasionally appear. One of these was recently discovered in the SGIP. Currently the California grid meets its peak demand primarily by using gas-fired combustion turbines – either (older) stand-alone units those that are part of combined-cycle plants. Although the power produced by these is very inexpensive, it is also not renewable, and produces relatively large amounts of greenhouse gas.

Facilities that are benefiting from SGIP under certain conditions choose to buy grid-power when the combustion turbines are providing a significant percentage of power on the grid and use their self-generation at other times. Even if the self-generation in question is renewable, the SGIP actually results in a net increase of GHG.

Thus the SGIP is in the midst of a major overhaul. As part of this overhaul the parts of this program that are applicable to residential customers is being expanded.

A CPUC staff proposal for methods to update the SGIP to ensure that it reduced GHG emissions in all or virtually all cases was released in September, 2018. After review and comments by all stake-holders, extensive modifications were made and a new proposal was released on December 31, 2018. Most text below is taken from this new proposal.[12]

One new facility is proposed that may be used by both commercial and residential systems. *GHG signal: A digitally accessible data feed of current marginal greenhouse gas emissions rates (in units of kg/kWh) that updates at regular intervals (e.g. every 5 minutes) combined with additional data feeds that deliver regularly updated forecasts of grid conditions for use in the optimization of dispatch.*

Commercial projects: *Staff proposes a performance-based incentive structure for all new commercial projects, such that 50% of the incentive is paid upfront and the remaining 50% is paid over five years. Project administrators would verify each project's GHG reductions annually and, if the project is found to reduce GHGs less than 5 kilograms of CO_2 per kilowatt hour (kg/kWh) or increase GHGs, the project administrators would reduce the project's annual incentive payment by $1/kg ($1000/ton) of CO_2 over the 5 kg/kWh reduction threshold. Project administrators would provide projects with semi-annual feedback on GHG performance.*

Residential projects: The earlier staff proposal had a requirement to link battery energy storage systems with PV installations, but those requirements have now gone away. The current proposal is for battery energy storage systems (BESS) only. The only additional requirements are for a BESS with a single-cycle round trip efficiency specification of at least 85%, and an approved time-varying rate (tariff). In 2017 and 2018 the PUC staff and their contractors modeled the different possible program elements and found it was possible to eliminate the PV while still retaining the incentive and reducing greenhouse

[11] Itron, 2013 Self-Generation Incentive Program (SGIP) Impact Evaluation Report, www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=7909

[12] Energy Division, California Public Utilities Commission, "Revised Self-Generation Incentive Program Greenhouse Gas Staff Proposal", Distributed Generation Rulemaking 12-11-005 December 31, 2018, http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Demand_Side_Management/Customer_Gen_and_Storage/Revised%20SGIP%20GHG%20Staff%20Proposal_Clean_12-27-18.pdf

gas emissions. There might be some requirements to use the above GHG signal to perform *GHG Signal Co-optimization* (optimize the storage operation to minimize GHG emissions and for the best economics). However for now, I believe that the final decision will be to use the "time varying rate" to do this:

Rates that appear on the list would be time-varying, have TOU periods that are aligned with grid emissions, and have non-trivial price differentials between periods.

I will try to track the development of this program, as I might be interested in participating in it. I'm already on a PG&E Electric Schedule E-TOU, Option B, which might be similar to the "rates" that are on the approved list (peak rate starts at 4:00 PM).