ELECTRIC POWER RESEARCH INSTITUTE

Quick Insights

Declining PPA Prices for Renewables Plus Storage Plants

RESEARCH QUESTION

What are the factors contributing to the decline of renewables + storage power purchase agreement (PPA) prices, and what questions arise when considering recent PPA bids and how they compare to existing generating plants?

KEY POINTS

- Over the past three years, there has been an increase in the number of hybrid renewable generation + storage plants bid in to utility generation solicitations. These bids have featured declining PPA prices from 13.9 ¢/kWh in 2015 to 4 ¢/kWh in 2018. Decreasing prices primarily are driven by observed and forecasted cost declines of underlying renewable generation and storage technologies, and these price decreases are expected to continue.
- Over the past five years, solar photovoltaic (PV) plants have experienced an average annual price decrease of 11%, while battery storage prices fell by more than 50% from 2014 through 2017. Assuming similar price decreases for PV continue, along with a more modest 10% annual price reduction for battery storage, in four years PV and battery storage costs would be ~63% and ~66%, respectively, of what they are today. These lower technology prices are likely reflected in the recent bid prices for the future solar + storage projects discussed.
- Available value streams and prices vary significantly depending on system design, particularly the energy storage component, with both reliability and economic tradeoffs with these design decisions. For instance, the PV-storage ratio affects the economics of a PPA bid. At current costs for PV and storage, while an increase in storage capacity allows more PV energy to be stored and additional value streams to become available, this increase also drives up the plant cost ($/kWh).
- Various resources on a system provide a variety of attributes including energy, capacity, and grid services; a holistic perspective should be taken when considering how announced PPAs support a portfolio of resources

INTRODUCTION

Resource planning and procurement generally have focused on developing a suitable mix of resources that can meet a number of criteria, including minimizing capital and operating costs while meeting resource adequacy standards. Historically, operational reliability was not specifically considered as part of the resource planning process, as the necessity to provide reliability services and meet demand is inherent in conventional generation. More recently, resource planning has included other aspects such as resiliency, sustainability, and public policy drivers, all of which can impact the relative value of different resources. Additional details on these factors are discussed in EPRI's Developing a Framework for Integrated Energy Network Planning (IEN-P).

The PPA prices reported for renewable + storage projects as cost per delivered energy (cents per kilowatt-hour) provide little indication as to the capabilities of the plants in terms of support for grid reliability, resiliency, and flexibility. Within this context, energy system stakeholders, including utilities, are trying to understand how to interpret recently announced renewable + storage bids.

TRENDS IN RENEWABLE + STORAGE PPA PRICES

Figure 1 illustrates renewable + storage PPA contract prices announced over the last few years and compares them to projected values for standalone solar PV projects and different ratios of solar PV to storage capacity as reported by Bloomberg New Energy Finance (BloombergNEF).[1] There is significant variation in price depending on system design, as well as the year in which the project is expected to be brought online.

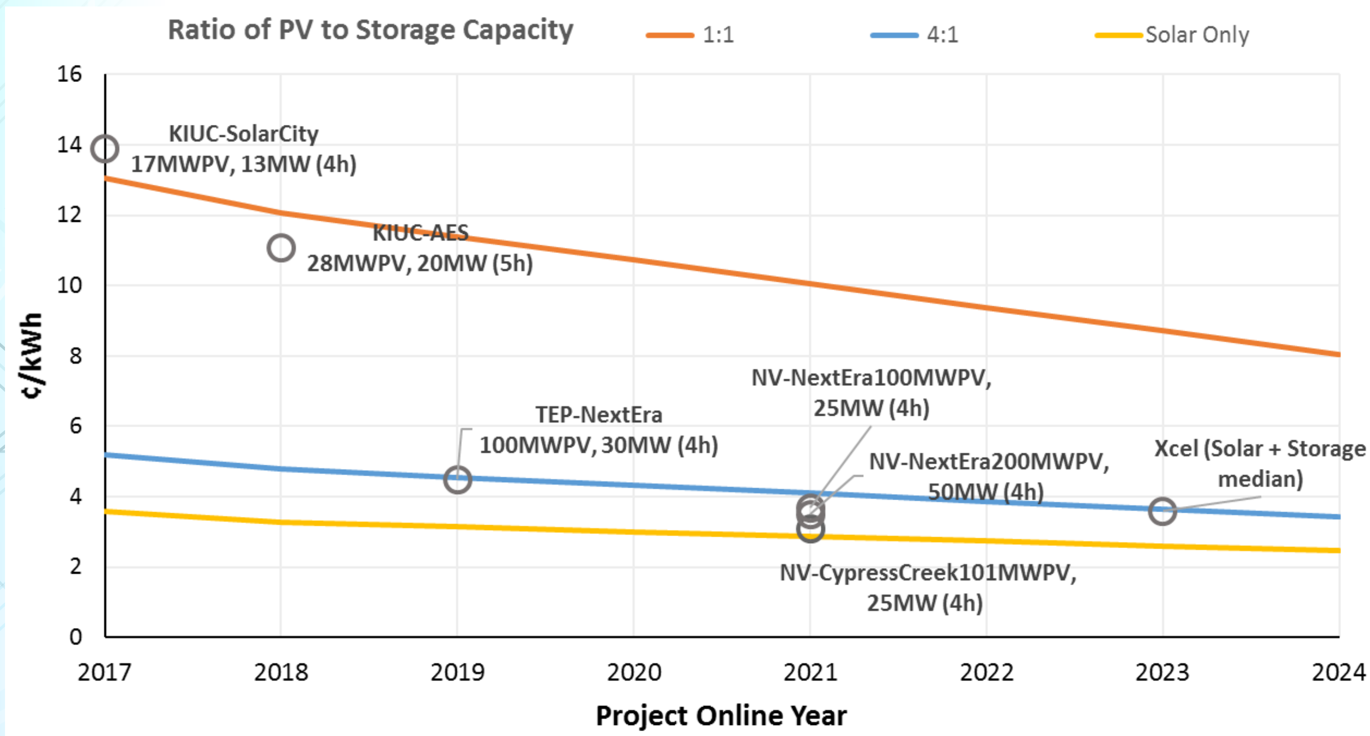

Figure 1: Announced Solar + Storage PPA Prices, 2015 to 2018

The following summarizes these utility generation solicitations and renewables + storage PPAs, illustrating the quickly evolving hybrid resource PPA landscape:

Kauai Island Utility Cooperative (KIUC) [2,3]

A 2015 KIUC contract with Tesla paired 13 MW/52 MWh of storage with a 13-MW solar PV array for 13.9 ¢/kWh. In January 2017, KIUC and AES Corp. announced the pairing of a 28-MW solar array, 20-MW/100-MWh battery system for 11 ¢/kWh, which was reportedly below the cost for power delivered from their oil-fired baseload generation on the

1 Based on BloombergNEF cited costs in "Case Study: $110/MWh Solar + Storage PPA in Hawaii," June 6, 2017.

2 "Hawaii co-op signs deal for solar+storage project at 11¢/kWh," Gavin Bade, Jan. 10, 2017. Available: https://www.utilitydive.com/news/hawaii-co-op-signs-deal-for-solarstorage-project-at-11kwh/433744/

3 "KIUC teams up with U.S. Navy to develop new solar-plus-storage facility on Hawaii's Garden Isle," HJ Mai, Dec 21, 2017 Available: https://www.bizjournals.com/pacific/news/2017/12/21/kiuc-teams-up-with-u-s-navy-to-develop-new-solar.html

island. Most recently, in late 2017, KIUC teamed with the U.S. Navy to develop a new AES solar + storage facility for 10.8 ¢/kWh.

Tucson Electric Power (TEP) and NextEra Energy Resources[4]

In November 2016, TEP released a solicitation for 100 MW of solar with a goal of service by 2019. Without releasing exact pricing, TEP signed a contract in May 2017 for a solar + storage project with a price reportedly below 4.5 ¢/kWh. NextEra Energy is building the plant which includes a 100-MW solar array with a 30-MW/120-MWh storage facility.

Xcel Energy Solicitation

In 2017, Xcel Energy released its Colorado 2017 All-Source Solicitation,[5] which included a request for proposals (RFP) for semi-dispatchable renewable capacity resources. Xcel published the median bids prices received in response to this solicitation, which included bids for wind paired with battery storage at 2 ¢/kWh and bids for solar technologies paired with battery storage at 4 ¢/kWh.

NV Energy[6]

In May 2018, NV Energy announced that it signed three solar + storage PPA contracts totaling 401 MW of solar and 100 MW/400 MWh of storage. Results released by Wood Mackenzie Power & Renewables indicate that two projects will be developed by NextEra Energy Resources (3.5-3.7 ¢/kWh) and the remaining one will be developed by Cypress Creek Renewables (3.1 ¢/kWh).

FACTORS DRIVING DOWN PPA PRICES

Historical and anticipated price declines for technologies, especially solar and battery technologies, are a large contributor to the decreasing bid prices witnessed in recent years for renewable + storage projects. Over the past five years, the annual average price decrease for PV was 11%,[7] while battery storage has seen prices fall by more than 50% from 2014 to the end of 2017.[8] While some estimates indicate that annual battery price declines may become more modest (~10% annually) moving forward, it is thought that larger price decline forecasts were likely used in the bids received in the Xcel solicitation.[9] Even so, if one assumes recent historical price decreases continue for PV and the aforementioned 10% annual reduction for battery storage moving forward, in four years PV and battery storage costs would be ~63% and ~66%, respectively, of what they are today, and these lower prices are likely reflected in the bid prices for future projects.

RENEWABLES + STORAGE CAPABILITIES AND COSTS

While for traditional generating plants two similarly sized and priced plants would intuitively have similar characteristics and capabilities, the capabilities of a renewable + storage project to provide some combination of capacity and grid services depends largely on several factors, including the underlying renewable generation technology, the capacity and duration of the storage, the regional variability of the wind or solar generation, and system control capabilities. The current market value for energy far outweighs other services, but as the generation mix changes, the question arises whether the value of the capacity and grid services provided by a particular plant is accounted for in resource planning and procurement, and how that compares to those services when provided by renewable + storage projects. Understanding the full range of capabilities, and the value of these capabilities today and in the future, is a key step in resource valuation on the supply and demand sides in the shared integrated grid future.

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4 Peter Maloney, May 30, 2017. https://www.utilitydive.com/news/how-can-tucson-electric-get-solar-storage-for-45kwh/443715/

5 Colorado 2017 All-Source Solicitation, Xcel Energy, Aug. 30, 2017. Available: https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Resource%20Plans/CO-All-Source-PII-Renewable-RFP.pdf

6 Xcel Colorado and Nevada Energy's Blockbuster Solar-Plus-Storage Plans, Ravi Manghani, Wood Mackenzie Power & Renewables. June 20, 2018.

7 Wood Mackenzie Power & Renewables, Global PV System Pricing H1 2018: Forecasts and Breakdowns. July 2018.

8 Wood Mackenzie Power & Renewables and Energy Storage Association, U.S. Energy Storage Monitor, Q3 2018. September 2018.

9 Source: *Ibid.*

A number of factors beyond standard plant valuation metrics need to be considered in order to properly interpret and evaluate technology bid and PPA price announcements. For instance, while the LCOE (expressed in dollars per kilowatt-hour) accounts for energy production over the life of a resource, it does not capture controllability and flexibility of the resource, which have the potential to provide reliability and economic value to a project. Limitations in the understanding of a renewable + storage generation plant's ability to provide bundled capacity and grid services, and continuing energy-system evolution, require thoughtful appraisal of proposed plants, with key considerations outlined in the following:

KEY QUESTIONS TO CONSIDER WHEN INTERPRETING PPA ANNOUNCEMENTS

1. What are the business or policy incentives behind the PPA?

   PPAs can include business or policy incentives that impact the resulting bids, including special qualifications or scoring incentives that support local policy objectives. For example, in Xcel's 2017 solicitation, projects that combined battery storage with renewable generation had an increased likelihood of more favorable review by the Colorado Public Utility Commission under Section 123 (40-2-123).[10] On the federal level, PV + storage bids have an opportunity for the battery system to capture the solar investment tax credit (ITC) if it receives more than 75% of its energy from the PV system.

2. What are the needs of the bulk system in the planning horizon and what is the intended role of the proposed renewable + storage plant?

   What is the primary system need, or mix of needs, that the plant will fulfill over the planning horizon of the solicitation? What role does storage play in the project, and does it allow the plant to provide grid services, in support of bulk-system and/or local needs?

3. How is the proposed renewable + storage plant designed?

   The design of the plant will depend on the system needs as well as the potential modes of operation. Several value streams can be associated with energy storage, depending on its design, and there are both reliability and economic tradeoffs with these design decisions. For instance, the PV-storage ratio will affect the economics of a PPA bid. At current costs for PV and storage, when the storage capacity increases at a plant, more energy can be stored from PV; however, this increase drives up the $/kWh, as shown previously in Figure 1.

4. Assuming a known and fixed plant design, what other variables affect renewables + storage plant costs?

   Even when the plant design is known and fixed, there are other variables that can affect plant costs and PPA prices, including the timeframe in which the plant is expected to be constructed and the expected changes in technology costs between the time of the bid and the time of construction. Unique contractual and business models can also impact plant costs and PPA prices after the plant design has been decided.

These questions indicate the complexity in understanding renewable + storage PPAs compared to traditional fossil resources, and the need for ongoing R&D to better answer these questions.

NEXT STEPS/ONGOING EPRI RESEARCH

EPRI ongoing research projects are evaluating several of the questions raised above. Those projects include:

Integrated Grid: Energy Storage and Distributed Generation (EPRI Program 94)

- Development of Storage Value Estimation Tool (StorageVET)[11] and *Energy Storage Valuation 2017* report[12] with the ability to run scenarios to simulate and optimize customized renewable + storage projects in support of economic evaluations.

10 2017 All Source Solicitation 30-Day Report. Xcel Energy. December 28, 2017. https://www.documentcloud.org/documents/4340162-Xcel-Solicitation-Report.html

11 https://www.storagevet.com/

12 Energy Storage Valuation 2017: Update on Methods, Interim Results, and Storage VET (3002010849)

- Expansion of StorageVET methodologies to include customer, distributed, and bulk hybrid resources on a consistent basis, through a government-funded cross-program effort.
- Engagement with utilities, energy storage developers, and the research community to develop common valuation metrics through the Energy Storage Integration Council (ESIC).

Transmission and Distribution Sector: Transmission Operations and Planning (EPRI Programs 39, 40, and 173)

- Evaluation of resource adequacy implications, capacity contributions, flexibility requirements, and black start capabilities of renewables and storage.
- Development of tools to determine the impact on system frequency response and ancillary services requirements associated with high penetrations of renewables.
- Study of bulk system operations with high penetration of renewables and storage.
- Market operations and design with increased levels of renewables, with a recent focus on storage participation in these markets.

Generation Sector: Renewables Technology (Program 193)

- Analysis of the cost and value of various solar + storage configurations in the utility, commercial, and residential markets.

Environment Sector: Energy, Environmental, and Climate Policy Analysis (EPRI Program 201)

- Insights documents on modeling storage investment and dispatch in capacity modeling tools, including: Insights on the Complementarity of Storage and Renewables, Interpreting Storage Results in Capacity Planning Models, and Modeling Storage Investment and Dispatch with US-REGEN.

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