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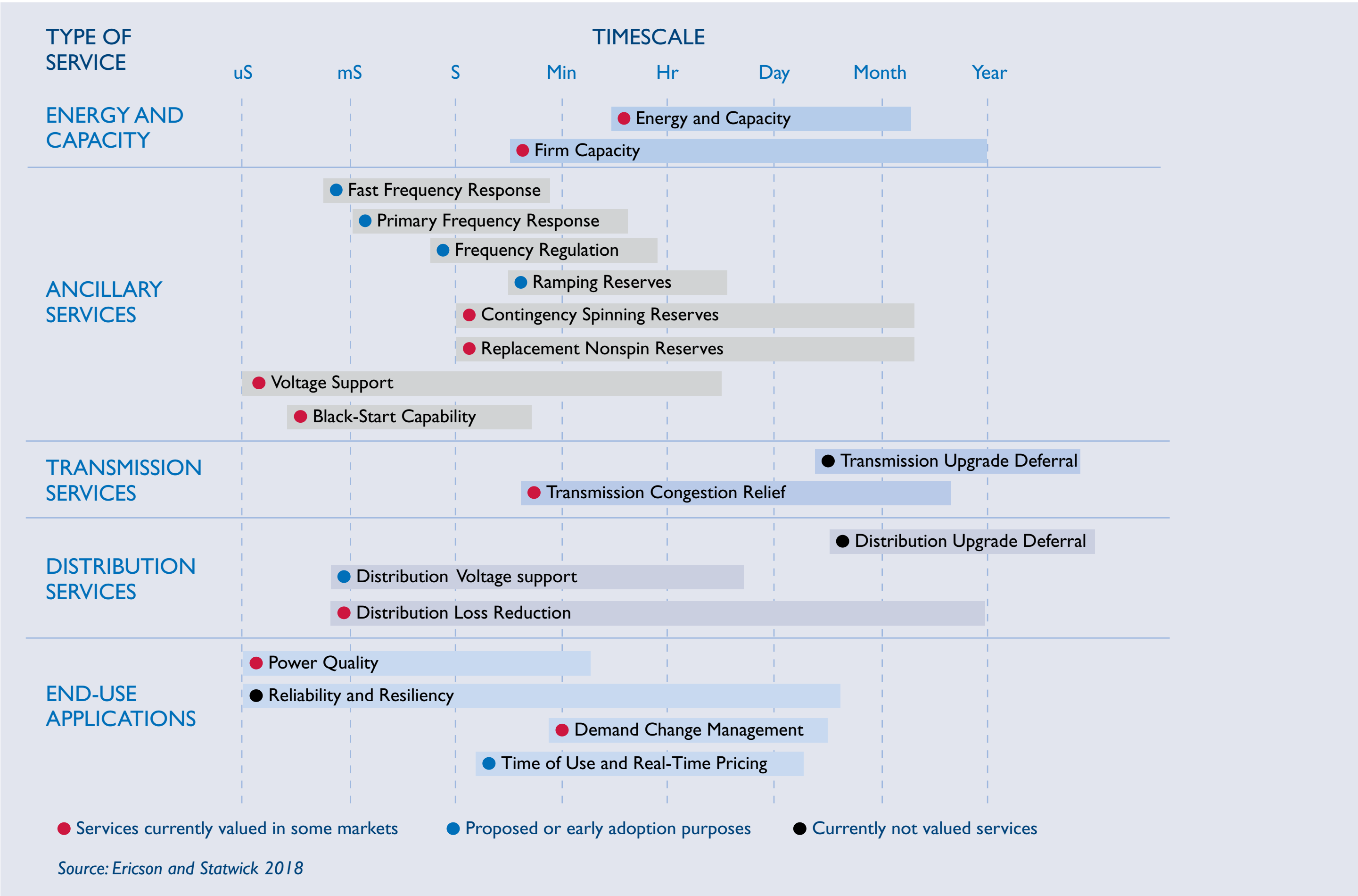
HYBRID RENEWABLE AND BATTERY ENERGY STORAGE SYSTEMS (BESS) AUCTIONS

As prices for clean energy and storage technologies continue to fall and nations race to cut their emissions, integrating higher shares of variable renewable energy (VRE) becomes more urgent and more complex. New opportunities for policymakers, energy planners, and utilities are unlocking a multitude of benefits that come with integrating battery energy storage systems into the grid.

INTRODUCTION

Innovation in the use of battery energy storage systems (BESS) is revolutionizing power sectors worldwide, notably due to its potential for multiple applications at a wide range of timescales (see Figure 1). BESS can firm up energy supply, shift the timing of renewable energy production, and provide capacity and ancillary services, all of which enhance dispatchability. BESS can also support grid operation and allow system owners to defer grid capital investments. Finally, BESS can help end-users shift load, reduce electricity costs, and in some cases improve quality and resilience.

Figure 1: Potential Battery Energy Storage Services and Timescales[1]



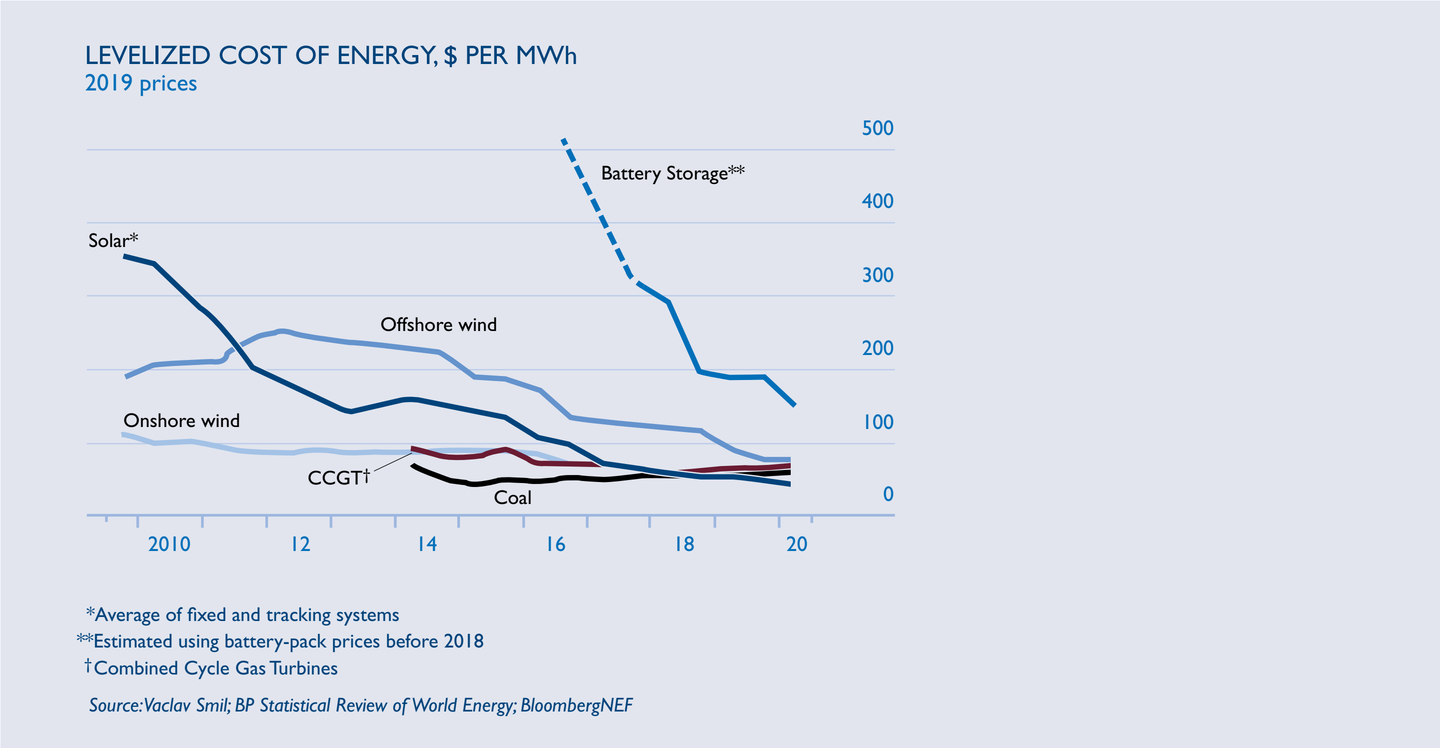
Energy storage has been part of the utility and grid toolkit for many decades.[2] Pumped hydro and seasonal storage are still the most prevalent forms, although newer storage technologies are also becoming more cost-competitive. For example, concentrating solar power (CSP) projects have been awarded via competitive procurements and/or auctions and can provide several hours of storage.

[1] Ericson, Sean and P. Statwick. "Opportunities for Battery Storage Technologies in Mexico." National Renewable Energy Laboratory, https://www.nrel.gov/docs/fy19osti/71995.pdf, 2018.

[2] "A Framework for Utility Procurement of Energy Storage." Global Energy Storage Alliance. https://static1.squarespace.com/static/571a88e12fe131211f1f6e6/t/59d2ae78bce1761a02cffcf/1506979453218/STR_12+GESA_whitepaper_K.pdf

This paper focuses on Lithium-ion (Li-ion) technology, which has a typical storage duration of four hours. Li-ion costs continue to fall, as shown in Figure 2, though other storage technologies may emerge in the future that could make the provision of grid services even more competitive.

Figure 2: Trends in the Levelized Cost of Battery Storage



BARRIERS FOR BESS IN ENERGY MARKETS

Many least-cost plans in emerging markets have not yet factored in the precipitous cost decline and the range of services that BESS can offer. Utility-scale (front-of-the-meter) BESS has already proven to be technically and economically viable in many places and for multiple applications. Storage is now cheaper than simple cycle natural gas plants for reserves of four hours or less.[3] Policymakers and energy planners should review their investment plans to consider new opportunities arising from declining BESS costs and improved storage technologies. For example, Spain recently launched a public consultation to seek inputs for the development of a national storage plan.[4]

Business models for deploying large-scale BESS is still in the nascent stage. There is currently no standardized way of designing electricity products (and auctions) with BESS. This is largely due to the fact that storage can provide a wide range of "products" to the grid, such as energy, capacity, and several types of ancillary services. The selection of products and procurement mechanisms will depend on each system's requirements, other available storage technologies, and the products and services that BESS is designed to offer in each country.[5]

[3] BloombergNEF, "1st Half 2020 Global LCOE Report," p. 18.
[4] "Consulta Pública del borrador de la Estrategia de Almacenamiento Energético." Secretaria de Estado de Energia, Spain, October 2020.
[5] Maurer, Luiz; Patrick Doyle; Eric Hyman; Loretta Bauer; and Pablo Torres. 2020. *Creating a Level Playing Field for Battery Energy Storage Systems Through Policies, Regulations, and Renewable Energy Auctions*. Washington, DC: Crown Agents USA and Abt Associates, Prepared for USAID.

BESS can provide multiple potentially simultaneous benefits across the entire supply chain, known as "value stacking." It is important to make sure that if an auction is for a particular product/service, the process does not preclude storage assets from being used in other productive ways. There are three possibilities to address this challenge. First, utilities or grid operators could run auctions for a given storage capacity and operate it to extract maximum benefits for the system.[6] Second, auctions could be run for one specific product (for example, energy delivered during peak hours), but BESS could offer other products in the market once its contractual obligations have been fulfilled (see the case study on South Australia below). The last option is to run auctions for several products to be provided simultaneously, in a combinatorial model. Bids will be awarded based on the most advantageous package at the lowest cost. This seems to be a promising model to introduce competition across multiple products while maximizing value creation for the BESS assets.

BESS has not typically been treated on a level playing field with other storage technologies or with other near-firm/firm sources of energy and capacity. For example, there are examples of BESS being prohibited from participating in variable renewable energy (VRE) auctions or restrictions on utilities or independent system operators owning storage assets. In other cases, the dual role of BESS—either as a load or as a generator—is not properly addressed in the regulatory compact. Government policies, market regulations and grid codes need to be reviewed and adapted to enable BESS to compete with other technologies. In the United States, Federal Energy Regulatory Commission (FERC) Order 841 of 2018 instructed all wholesale markets to review their rules to reduce barriers to BESS' participation in energy, capacity and ancillary service markets. European Union Directive 2019/944 contemplates rules for storage ownership by grid operators. The Government of Colombia provided regulatory clarity on the useof BESS to defer grid expansion prior to tendering those services.[7]

BESS SERVICES INDUSTRY REQUIRES A LEVEL PLAYING FIELD

In the United States, the FERC issued Order 841 to set regulatory provisions for the battery storage industry. Key features included:

- Applies to any type of energy storage, including storage in the grid and behind a consumer's meter.
- Requires market operators to establish market rules and pricing that facilitate participation of storage service providers in wholesale markets.
- Market rules must (a) ensure that a resource using the participation model for storage is eligible to provide all capacity, energy and ancillary services that it is technically capable of providing in the markets; (b) ensure that a resource using the participation model for storage can be dispatched and can set the wholesale market clearing price as both a wholesale seller and wholesale buyer, consistent with existing market rules that govern when a resource can set the wholesale price; (c) account for the physical and operational characteristics of energy storage through bidding parameters or other means; and (d) establish a minimum size requirement for participation in the regional transmission organization/independent system operator that does not exceed 100 kW.

The European Union takes a very similar approach in Regulation 2019-943-EU, which prohibits discrimination against storage services in electricity markets and encourages development of the storage industry as an equal service provider.

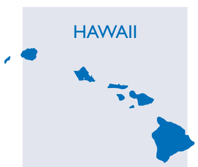
[6] This model, which is akin to a build-operate-transfer arrangement, has been used with transmission assets in countries such as Brazil and Peru

[7] Bowen, T et al. "Grid-Scale Battery Storage: Frequently Asked Questions." Grid Integration Toolkit. National Renewable Energy Laboratory, Prepared for USAID, 2019, https://www.nrel.gov/docs/fy19osti/74426.pdf

In most geographies, renewable auctions only recently started to include incentives for developing and using BESS. Traditionally, auctions for solar and wind incentivized BESS participation. One reason is that most power purchase agreements (PPAs) remunerate generators based on energy delivered, no matter when it is produced. The second reason is that for many renewable energy auctions, only one technology is allowed to participate in each bid, preventing BESS from integrating with other sources of renewable energy.

CASE STUDIES

The following five case studies detail auctions designed to procure grid-friendly electricity contracts, involving smart combinations of BESS and VRE.[8] These case studies do not represent the full spectrum of possibilities as auctions for BESS keep evolving. Policymakers have the dual role of introducing competition and ascertaining that asset utilization is maximized.



Reduce VRE curtailment and replace fossil fuel plants

Power systems around the world can experience high VRE curtailment, particularly as VRE does not always deliver energy when the market requires it. Even if transmission capacity exists, the system operator cannot reliably accommodate all VRE production, which must be scaled back or curtailed. This is particularly troublesome in places that have committed to significantly expand their VRE footprint, such as Hawaii, which plans to generate 100 percent of its electricity from renewable energy by 2045. Pairing batteries with wind and solar systems is one solution to continue deploying VRE. Other solutions include smart inverters with volt ampere reactive (VAR) controllers and synthetic inertia, among other features. Contracts for utility-scale solar power in Hawaii have routinely included BESS since 2017. In 2019, Hawaiian Electric held an auction for solar power with and without BESS, and awarded seven projects for solar power plus BESS with a total capacity of 255 megawatts (MW) and 1,055 megawatt-hours (MWh) of four-hour battery energy storage at prices ranging from $80 to $90 per MWh, while prices for solar-only contracts were about $40 per MWh.[9] Other states, such as Colorado, Nevada, and Arizona, have run auctions that resulted in even more competitive prices for solar-plus-BESS.

Deliver energy during peak hours

India experiences electricity transmission congestion and daily production problems that hinder efficient use of renewable energy resources and the ability to meet peak loads. To address those problems, India turned to large-scale solar-plus-storage tenders by soliciting firm power during peak hours. The awards are based on bid prices for firm power during critical hours, with a pre-defined price applied to power delivered at off-peak hours (a kind of feed-in-tariff).

In 2020, the Solar Energy Corporation of India (SECI conducted the world's largest auction for a 1.2 gigawatts hybrid tender combining pumped hydro, BESS, solar and wind power, and offered two time-differentiated price blocks. Two bidders were awarded. Prices ranged from $88.6 to $95.7/MWh[10] for electricity delivered during peak periods and $40/MWh for off-peak periods. The weighted average tariff was about $60/MWh, comparable to average power costs in India. New thermal generation contracts are priced between $70 to $90/MWh.

8 This classification is for illustrative purposes only. Often when BESS is deployed, it may provide multiple services.
9 Figures courtesy of Hawaiian Electric, https://www.hawaiianelectric.com.
10 Those figures do not represent the full levelized cost of energy, since they do not include the 3 percent yearly escalation clause.

India is now reviewing the design of the electricity products to be tendered. The new "round-the-clock" (RTC) approach attempted to have developers bid for a continuous supply using renewables and storage; in May 2020, India awarded 400 MW in the first RTC auction. However, after several amendments prior to the auction, the final product does not yet guarantee dispatchable power. It was a step toward a true RTC in the distant future.[11]

Provide ancillary services

Australia has ambitious goals to green its energy matrix and is blessed with wind and solar resources. However, supplying distant consumer centers with VRE is challenging. Batteries smooth out power flows and provide network stability when VRE production becomes volatile. In 2017, the state government of South Australia awarded a contract for 315 MW of wind power capacity with 100 MW (129 MWh) of battery storage at the Hornsdale Power Reserve. The project included providing 30 MW of the battery's discharge capacity to the plant owner for commercial operation in the wholesale market when power prices are high or when output from the wind farm falls. The remaining 70 MW is reserved for power system reliability. It was the first demonstration of a wind or solar farm providing frequency control ancillary services (FCAS) to Australia's National Electricity Market. It contributed to grid stability, providing a much faster response than fossil fuel generators, and significantly lowered the FCAS market prices.[12]

Defer grid investments

Stand-alone batteries have been used for transmission and distribution deferral in several countries. BESS is located in selected substations to mitigate the impact of transmission constraints and ensuing congestion costs. In this way, grid expansion is deferred once the BESS options prove to be cost-effective.

The island of Nantucket in Massachusetts (United States) has experienced a five-fold increase in the summertime population and the island's transmission cables will soon be unable to support the load growth at reliable levels. Instead of expanding transmission capacity, which would entail a $105 million investment in underwater cable, the local utility installed a 6 MW, 48 MWh BESS. The benefits of the system are estimated at $5.7 million per year, of which $3.4 million results from transmission deferral. The other benefits come from the sale of ancillary services, demand response, and capacity in markets managed by the independent system operator in New England. The estimated internal rate of return (IRR) for the project is 8.1 percent.[13] The existence of a sophisticated market enables BESS to maximize value and revenue generation.

Colombia identified opportunities to deploy BESS in its long-term expansion plan: the first auction is in preparation and scheduled for 2021. One option under consideration is the installation of 45 MW, one-hour BESS at Silencio substation (110 kV) to provide flexible capacity while maintaining grid stability to better serve the Litoral region. The auction should be awarded to the bidder who offers the lowest revenue requirement, and the economic IRR for the project will depend on the benefits from having the system operator managing the asset.

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[11] Gokhale, N. "Is India's first round-the-clock renewable energy contract really what it claims to be?" *Mongabay*, August 4, 2020.
[12] Viaud, C. "Arena Insight Forum." *Neoen*, November 2018, https://arena.gov.au/assets/2019/02/hornsdale-power-reserve.pdf
[13] *Lazard's Levelized Cost of Storage Analysis*, Version 6.0, 2020, https://www.lazard.com/media/451418/lazards-levelized-cost-of-storage-version-60.pdf

Participate in Capacity Markets

Many power pools around the world run frequent capacity auctions to ensure that the system has enough MW to meet peak load under contingencies. BESS is gaining traction, as it has the potential to replace traditional generation, paving the road to clean energy solutions. Several business models have been adopted.

In the PJM Interconnection, a regional transmission organization in the eastern United States, capacity auctions are technology neutral and allow the participation of storage. It is estimated that BESS resources of 4,000 MW with four hours' duration can provide full capacity value relative to a resource without duration limits, with no reduction in system reliability.[14] This creates significant room for BESS to participate in future capacity auctions.

In March 2020, France concluded a capacity market auction in which it awarded 253 MW of energy storage via seven-year contracts, along with 124 MW of demand response capacity. It was a technology neutral auction, but emissions were capped at 200g of CO_2 per kWh. The payment for capacity resulting from the auction was in the range of €28,000-29,000 per MW-year.

Provide quasi-firm or firm energy

In small, isolated systems, or in systems with weak interconnections to the main grid, it is necessary to procure quasi-firm or firm energy contracts. Firm power auctions can encourage use of BESS in combination with other technologies, renewable or otherwise. It is incumbent on the sellers to manage renewable energy variability and operate multiple technologies—including BESS—in a smart way.

In August 2017, Thailand held simultaneous auctions to procure 300 MW of quasi-firm generation capacity for delivery in 2021, distributed across nine geographic zones with limited interconnection capacity. The solicitation required bidders to offer to operate at 98 percent or more of their proposed capacity during peak periods and 66.3 percent during off-peak periods. There were financial penalties for failure to supply the agreed amounts of power. The auction awarded the 300 MW to 17 bidders, at prices ranging from $60 to $110/MWh and averaging $75/MWh. Three projects were hybrid solar power—one with biogas, one with biomass, and one with battery storage (42 MW of solar power capacity with 12 MW/54 MWh of BESS capacity).[15]

In 2019, Brazil held two technology-neutral auctions for renewable and nonrenewable electric power capacity and firm power in Roraima State. Nine winning bids were selected with a total of 294 MW of capacity (6,420.5 MWh of energy), receiving 15-year PPAs for renewable energy installations and seven-year PPAs for non-renewable power generation. Prices ranged from $170/MWh to $277.48/MWh. Only one of the winning bids considered including short-term duration BESS. The bidder proposed a hybrid solution with 31 MW of palm oil biofuel capacity, 25 MW of solar power capacity and possibly 30 minutes of storage capacity. The storage would provide smoother integration between variable solar and biofuel generation.[16]

This fact sheet was prepared by Tetra Tech ES, Inc. Authors included Luiz Maurer; Kristen Madler from the USAID Energy and Infrastructure Office; and Allen Eisendrath from Tetra Tech.

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[14] Astrape Consulting. "Capacity Value of Energy Storage in PJM," PJM, July 2019 https://www.pjm.com/-/media/committees-groups/committees/mic/2020/20200224-capacity-market/20200224-item-03b-astrape-consulting-2019-capacity-value-of-storage-in-pjm.ashx

[15] Maurer, L. Op cit. 2020.

[16] Maurer, L. Op cit. 2020.