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Positively Charged: The Emergence of Battery Energy Storage Among Electric Distribution Coops

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Inside...

Key Points:

- The adoption of battery energy systems among electric distribution cooperatives is set to grow, garnering increased attention through 2018 and beyond.
- Peak demand reduction is driving interest in battery systems among ED coops.
- Electric coops are seeking partnership with leading vendors that can provide strong warranties that guarantee the battery will perform as intended.
- Lithium-ion batteries lead the market, and will likely define the future of battery energy storage in the U.S.

Introduction

Battery energy storage systems are gaining momentum beyond traditional markets in Hawaii, Alaska, California and the Northeast. Growth is dominated by lithium-ion (Li-ion) battery technology, spurred by increasing demand for electric vehicles and stationary uses. Greater market share for Li-ion battery technology is buoyed by an expanding global supply chain that promises greater economies of scale and constant downward pressure on costs. The ability for utilities to maximize the full suite of benefits provided by battery storage systems remains elusive. Despite this, a growing number of utilities are deploying systems based on one or two applications with the intention of taking advantage of the full benefits provided by battery energy storage systems in the future. For example, a small but growing number of electric distribution (ED) cooperatives are utilizing batteries to shave their peak demand. The ability for an ED coop to reduce its demand charge represents a clearly-defined business case that provides a relatively low-risk opportunity to adopt batteries. Use cases will expand as electric coops advance upwards along the battery storage learning curve. Greater understanding of battery energy storage will enhance an electric coop's ability to eventually offer services that improve reliability, resiliency, and strong member engagement.

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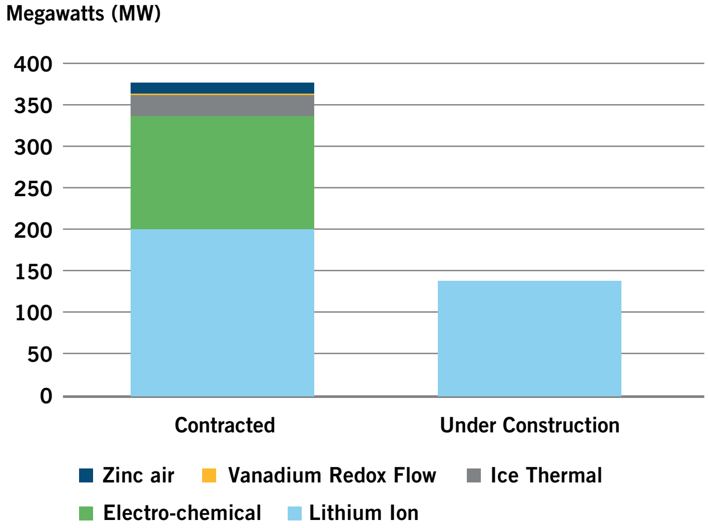
Lithium-ion Battery Storage Technology Remains the Market Favorite

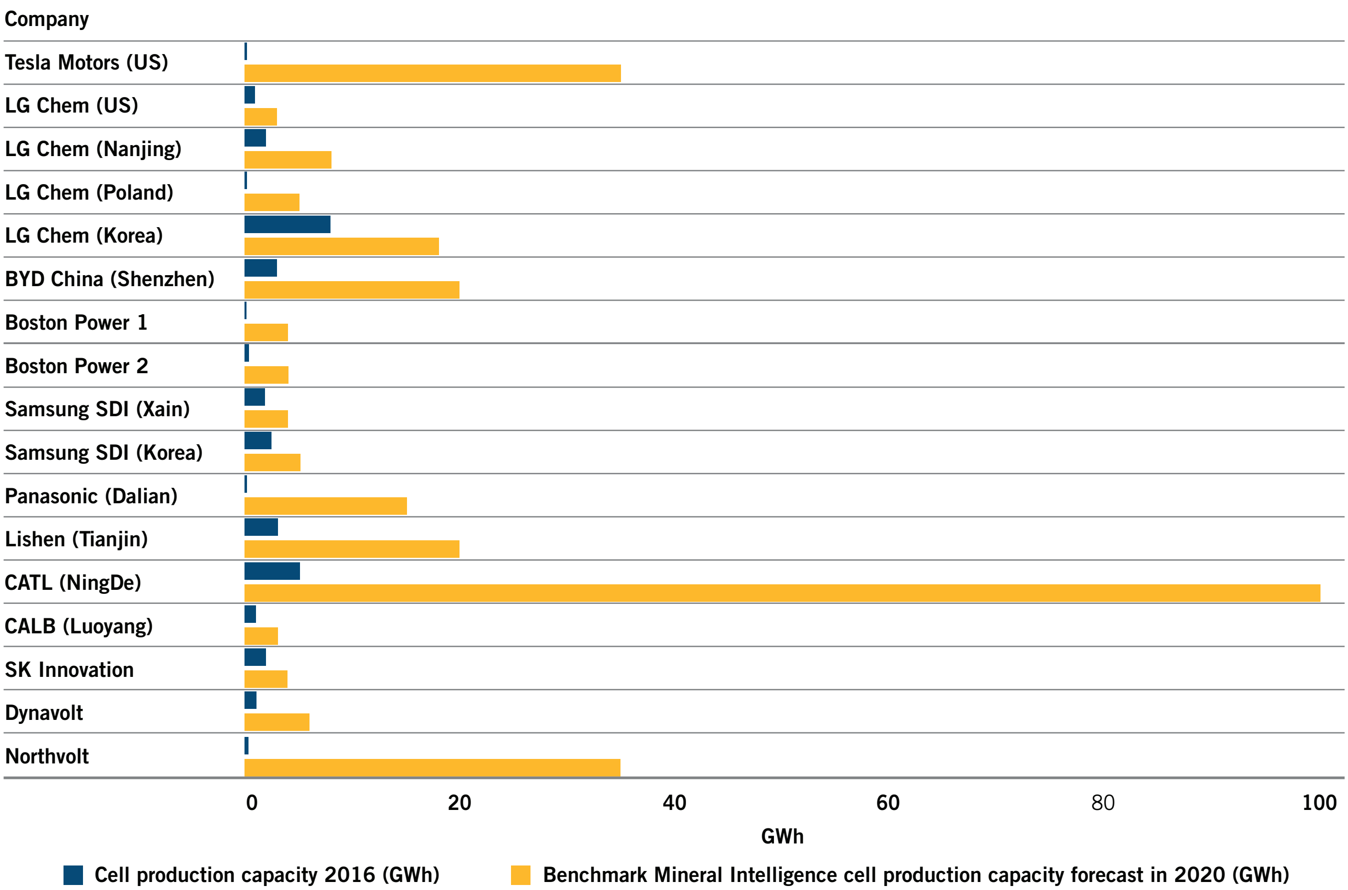
Li-based batteries will define the future of battery storage in the U.S., accounting for roughly 65 percent of all U.S. battery projects that are under construction or have been contracted.[1] (*See Exhibit 1.*) Multiple chemistries are available for Li-ion batteries, making them attractive to electricity providers, especially for applications that require a duration of 4 hours or less.[2] Lithium nickel manganese cobalt (NMC) batteries are the most widely utilized Li-ion chemistry for stationary applications. NMC chemistries demonstrate balanced performance characteristics in terms of energy, power, cost, and cycle life.[3]

Exhibit 1: Future Battery Installations by Technology



Sources: Department of Energy Storage Database

Exhibit 2: Global Li-ion Battery Cell Production Capacity 2016 vs. 2020

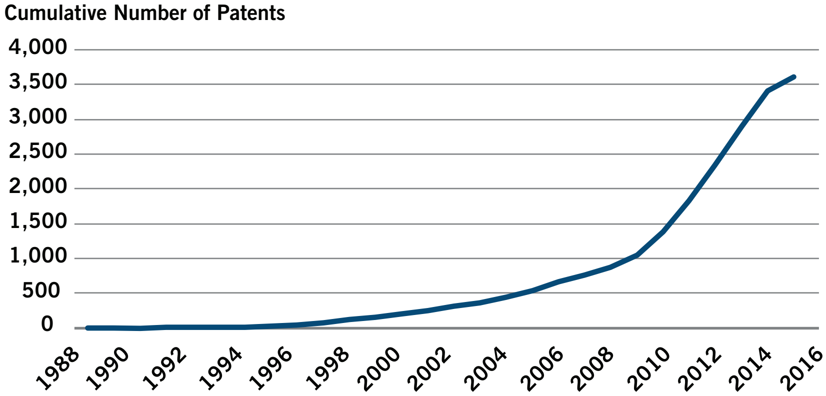


Sources: International Renewable Energy Agency

Global Production Capacity for Li-Ion Batteries Set to Expand

The existing global supply chain for Li-ion batteries is undergoing significant expansion, providing a very strong incumbent advantage, and helping to ensure long-term growth at the expense of other battery technologies. Established players and a number of new entrants, mostly in China, are expanding global Li-ion production capacity. All the major suppliers including Panasonic (Tesla), Samsung SDI, China Aviation Lithium Battery Co Ltd., LG Chem, and SK Innovation are now investing in new production capabilities, driving an increase in global production capacity by a factor of ten from 2016-2020.[4] (*See Exhibit 2.*)

Exhibit 3: Cumulative Patent Activity for Li-ion Batteries



Source: Kittner, N, Lill, F, Kammen, D.M. "Energy storage deployment and innovation for the clean energy transition" Nat. Energy 2, 17125 (2017).

The Cost of Li-ion Batteries Continues to Fall

Increased activity across the manufacturing landscape should lead to greater economies of scale for cells and battery packs. Moreover, many automotive companies are investing billions of dollars into pack assembly.[5] This is forcing battery makers to offer more aggressive prices, and to enter the stationary storage market to diversify their revenue streams.[6]

Innovation remains the most critical component of cost reductions for high-tech products such as Li-ion batteries. Patents for Li-ion batteries, which are considered a valid proxy for innovativeness within a sector, exceeded 3,500 in 2015. (*See Exhibit 3.*) Models that forecast the price of Li-ion batteries based on the previous five years of patent activity and production output suggest the price of Li-ion cells could reach $94 per kilowatt-hour (kWh) in 2020, placing the price of battery packs at $124/kWh.[7] Piercing the $150/kWh price level for battery packs is considered a critical threshold that is expected to accelerate demand for stationary battery systems.

The cost of stationary battery systems fell 55 percent from 2015-2017 due to cheaper cells and lower balance of system costs. (*See Exhibit 4.*) Survey results from market participants suggest the cost of grid level Li-ion systems will likely decline by roughly 10 percent annually through the end of this decade, tracking the observed experience rate for stationary Li-ion battery systems, which ranges from 11-18 percent.[8] Stationary battery systems integrate battery cells into multiple modules that are installed in standard 19-inch wide racks. The racks are placed in a building or specially designed shipping container, where monitoring systems and other balance of system components are installed. This makes up the battery energy storage system, which is controlled by a power conversion system. The capital costs for stationary battery systems include all of these parts, plus any engineering, procurement, and construction costs.[9] Capital costs can be expressed in $/kW by multiplying the system duration in hours by the $/kWh cost.

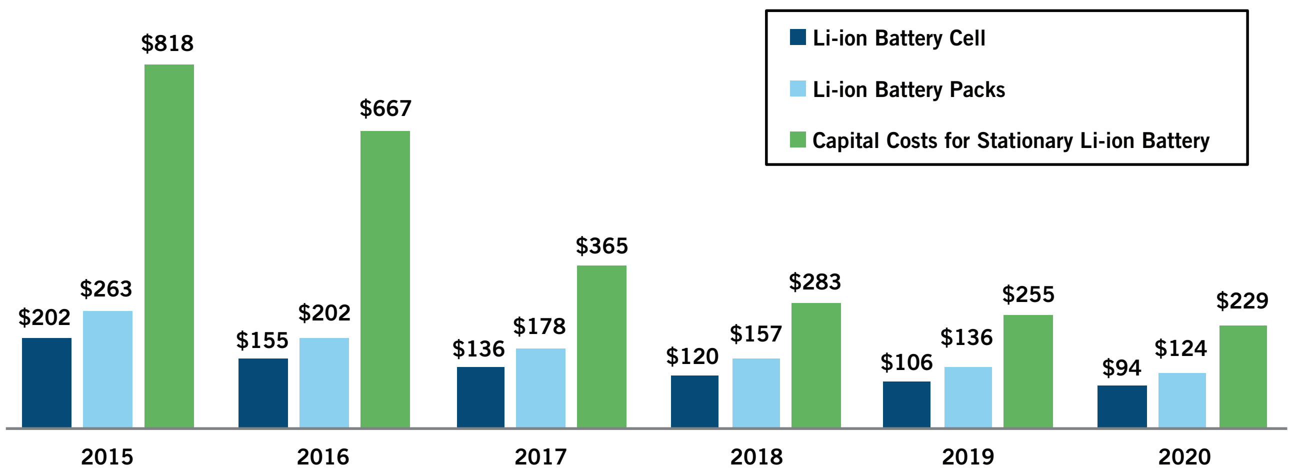
Robust Demand Outlook for Battery Energy Storage Systems

Demand for energy storage from the electric utility sector is expected to grow dramatically through 2020. Investments could expand from $300 million a year to as much as $4 billion.[11] The market for battery storage has evolved from largely pilot-programs, to specific use cases such as frequency control in PJM. Now, batteries are emerging as multi-purpose grid management tools that are increasingly integrated with distribution operations.[12]

Utilities across the country have contracted for 380 MW of future battery storage capacity, roughly two-thirds of this capacity was identified to provide electric supply capacity and energy time-shifting.[13] Though adoption of batteries varies across markets, the move beyond traditional use cases such as frequency control highlights the growing acceptance of battery storage among utilities and regulators. This is in part due to the ability for battery storage systems to support the ramping requirements in regions that experience significant renewable energy generation, and to defer grid upgrades.

Furthermore, with costs falling 10 percent annually over the next several years, storage could emerge as an alternative to natural gas-fired peaker plants, potentially displacing 10,000 MW in the next decade.[14] Recent analysis suggests that the all-in cost for a 4-hour duration Li-ion battery system could be 15 percent cheaper than a conventional gas peaker in 2024.[15] Companies with gas-fired plants might suffer margin compression as utilities increase their use of cheaper renewable sources that are supported with battery storage.

Exhibit 4: Lithium-ion Battery Costs are Falling ($/kWh)



Note: The stationary battery system represents a six hour 10 MW, 60 MWh Li-ion system. The costs shown for stationary batteries include modules, racking, BMS, balance of systems, power conversion system, engineering, procurement, and construction costs. The capital costs for stationary Li-ion systems are total investment divided by the rated output of the system, 60,000 kWh in this case.

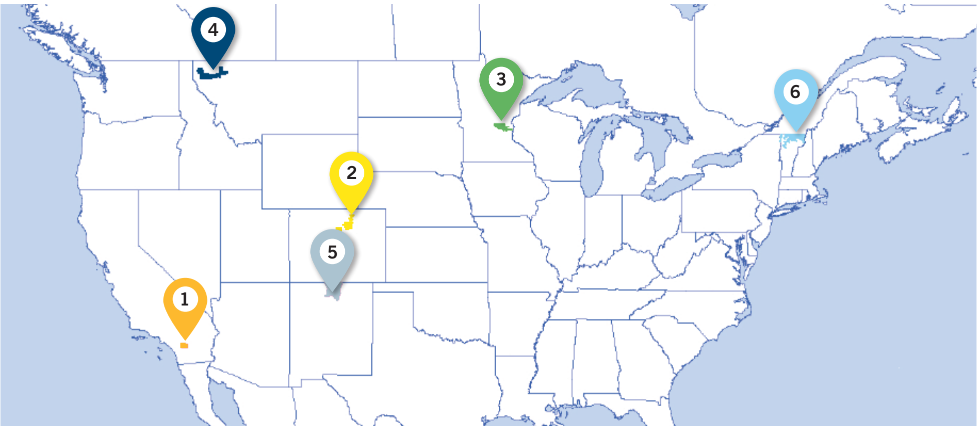
Sources: Nature Energy 2, 17125 (2017), Lazard's Levelized Cost of Storage Studies 1.0-3.0

Electric Distribution Cooperatives Embrace Battery Storage

Electric cooperatives across Alaska and Hawaii have established a well-documented history of successfully deploying energy storage systems. But, the deployment of battery energy storage systems among electric coops in the lower 48 is a relatively new trend. The vast majority of interest is occurring among ED coops that are deploying batteries to reduce their peak demand.

The remainder of this report summarizes multiple interviews that were conducted with managers and CEOs of electric cooperatives, shedding light on how electric coops are addressing battery energy storage. The electric coops included in these interviews vary by geography, number of members, and the size of battery systems they are evaluating.

Proposed Battery Systems Among Select Electric Coops



Source: CoBank

1
Anza Electric Coop (California)
Battery Technology: Lithium ion
Battery Power: 0.5 – 2 MW
Battery Energy: 1 – 4 MWh
Main use-case: Peak reduction, resiliency
Scheduled completion: Summer 2018

2
United Power (Colorado)
Battery Technology: Lithium ion
Battery Power: 4 MW
Battery Energy: 16 MWh
Main use-case: Peak reduction
Scheduled completion: Summer 2018

3
Connexus Energy (Minnesota)
Battery Technology: Lithium ion
Battery Power: 15 MW
Battery Energy: 30 MWh
Main use-case: Peak reduction
Scheduled completion: 2018

4
Flathead Electric (Montana)
Battery Technology: Tesla Power Wall
Battery Power: 3.3 kW (peak)
Battery Energy: 10kWh
Main use-case: Peak reduction
Scheduled completion: Ongoing pilot

5
Kit Carson Electric Coop (New Mexico)
Battery Technology: Lithium ion or flow
Battery Power: TBD
Battery Energy: TBD
Main use-case: Peak reduction, resiliency
Scheduled completion: 2018

6
Vermont Electric (Vermont)
Battery Technology: Lithium ion
Battery Power: 1 MW
Battery Energy: 4 MWh
Main use-case: Peak reduction
Scheduled completion: 2018

What is driving growth of battery storage among electric distribution cooperatives?

The single largest driver for adoption of battery systems among ED cooperatives is load shaping. The ability to discharge a battery during times of peak demand reduces the demand charge the ED pays to its generation and transmission (G&T) provider, potentially reducing the cost of energy for the ED's members. Utilizing batteries to reduce peak demand charges is likely one of the most clearly defined business cases for battery energy storage across the electric coop space. As coops become more comfortable with battery technology, they are sure to explore other uses that can maximize the value of batteries on their system, and provide new services to their member owners. A leading example is utilizing batteries to improve grid resiliency particularly for large commercial and industrial customers that place a high value on reliable energy.

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Which battery technology are electric coops deploying?

Li-ion battery technology is the most common technology being evaluated among ED cooperatives. The size of systems among the coops interviewed for this paper range from 3.3 - 15,000 kilowatts (KW), with durations from 1-4 hours. Five of the six ED coops are deploying large-scale systems. However, Flathead Electric in Montana is evaluating a Tesla Power Wall system. Some coops are considering flow technology, but the cost of Li-ion systems are expected to decline more rapidly than flow batteries, and expansion of the global supply chain for Li-ion battery systems makes them relatively more bankable. Furthermore, Tesla is the most actively engaged battery vendor in the ED coop space, translating to a higher market share for Li-ion systems.

How are electric distribution coops managing the risk associated with developing a battery system?

Lack of historical data on the operational characteristics and costs of Li-ion battery systems introduces uncertainty when evaluating these systems. To mitigate these risks, ED coops are seeking partnerships with leading vendors and service providers that are fully committed to the utility-scale battery space, and that can provide strong maintenance agreements and warranties for their services and products.

Battery service agreements *– Not all coops will own the battery systems that operate on their network. Entering into a service agreement with a trusted developer allows coops to transfer many of the risks associated with owning a battery asset to the developer. The coop provides the developer with the parameters of what they want the battery to accomplish. In return, developers propose the optimal solution, making the coop agnostic to the specific technology utilized.*

For a typical service agreement, the coop will provide direction to the battery owner on when to charge and discharge the battery. The battery owner does not own the stored energy, but charges the coop a fee every time they call on the battery to discharge. The contract language usually limits the number of cycles per month. The coop will make a business decision that will maximize the value of those discharges, whether it be for peak shaving, voltage support, etc. It is crucial that the service agreement includes language that provides the coop the ability to recoup its costs in the case that the battery is not available to be called on during the coop's monthly peak demand time.

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Output *– Maintaining the required output for the life of the battery system will define the economic success of the project. Developers typically suggest upsizing the battery on the front-end to offset any potential degradation over the first 3-5 years of operations.*

In addition, leading Li-ion battery vendors provide warranties that guarantee the output over the life of the project. Li-ion battery vendors are confident that future costs for Li-ion battery packs will be low enough that they will be able to absorb the cost of replacing a portion of the original battery packs. This type of warranty is particularly helpful for small ED coops, and provides critical support when investing in a relatively new technology.

Integration *– The success of a battery energy storage system depends directly on how effective the owner/operator can communicate with the system, which requires smart grid capabilities and robust power conversion systems. When co-locating a battery and solar array it is paramount to be sure the inverter(s) is capable of communicating with a battery system. Furthermore, installation of an energy monitoring system (EMS) will reduce operating and maintenance (O&M) costs by identifying and troubleshooting individual components that are not operating correctly.*

O&M *– Leading battery vendors will enter into long-term contracts with battery owners to provide O&M services over the life of the project.*

Life-cycle *– Li-ion batteries require special care and recycling once the project has met its useful life, potentially exposing coops to a costly future liability. Leading Li-ion vendors are addressing this risk by providing a guarantee that they will properly dispose of all sensitive materials. The project owner must transport the material to the vendor, and account for these costs when evaluating the project. Upon disposal, the Li-ion vendor provides the project owner with a certificate of disposal.*

Demand Charge *– Project economics for battery systems that are utilized to reduce peak demand rely heavily on the demand charge administered by the ED coop's power provider. Currently a mechanism does not exist that allows coops to mitigate the risk of a potential change in their demand charge. This risk will likely limit the size of projects that ED coops are willing to invest in, and potentially slow the overall growth of battery energy storage systems among ED coops.*

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Are batteries generation or demand management?

The question of whether batteries are considered generation is germane to the relationship between ED coops and their G&T providers, which is dictated by wholesale power contracts. Within most wholesale power contracts, ED coops are limited to a specific percentage of their total energy use that they can self-supply. If batteries are defined as generation within the wholesale power contracts between G&Ts and EDs, this will limit the growth. However, batteries provide multiple benefits beyond energy output. This is a controversial question that will demand more attention as adoption of battery energy storage systems increase among ED coops.

Are there benefits to being an early adopter of battery storage?

There are clear benefits provided to ED coops that are early adopters of battery storage systems in the form of reduced peak demand charges. The first ED coop within a territory to deploy such a system will only need to clip the tip of peak demand, allowing for a shorter duration battery that is less expensive. The later adopters will be targeting a flatter and longer peak, requiring a more expensive battery. However, as the system coincident peak is shaved with the addition of each battery, the benefits provided to the early adopters will diminish as the spike is removed.

Furthermore, G&T coops recoup their fixed cost by socializing these costs across all of their member ED coops. If one member ED coop reduces its peak demand charge with a battery, those costs are spread across the other ED members, thereby increasing their costs. The ability for batteries to shift costs among ED members has the potential to create controversy among the membership, but it does incentivize early adoption provided the wholesale power contracts allow for self-generation.

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Conclusion

Battery storage is here to stay - as costs fall, adoption will rise. Utilities are playing a larger role in adopting battery systems as integrated grid management tools that can provide electric supply capacity, defer grid upgrades, and support the integration of renewable sources of power. Electric coops are advancing the industry forward, grounded by a clearly defined business case centered on reducing their peak demand. ED coops will migrate up the battery learning curve, and implement new ways to maximize the value of their battery systems and offer new services to their member owners. The adoption of battery energy systems among electric cooperatives is set to grow, garnering increased attention through 2018 and beyond.

References

[1] Energy storage capacity in the U.S. increased by over 600 megawatts (MW) in the last four years, dominated by electro-chemical battery technology. Electro-chemical batteries - Li-ion, flow, lead acid, electro-chemical capacitors, and sodium based systems – accounted for 75 percent of all new storage technology installed in the U.S. from 2013-2017. Pumped hydro, capacity has remained flat for years, there are currently 2 contracted projects with a combined capacity of 1,700 MW. Electro-mechanical storage systems, including compressed air and flywheel technology, have only grown by 24 MW or 17 percent since 2013. Thermal storage technology is experiencing lumpy growth, driven by a small number of large-scale molten salt storage projects.

[2] The most common lithium batteries utilized for stationary systems include nickel manganese cobalt oxide (NMC), manganese oxide (MO), nickel cobalt aluminum (NCA), iron phosphate (FP), and titanate oxide (TO). The difference in each technology is mostly in the cathode material, and chemistry choice is driven by performance or operational objectives, and costs. (See IRENA report page 65 for more detail.)

[3] Aquino, T., Roling, M., Baker, C., Rowland, L. "Battery Energy Storage Technology Assessment: Platte River Authority. HDR, November 29, 2017.

[4] IRENA (2017), Electricity Storage and Renewables: Costs and Markets to 2030, International Renewable Energy Agency, Abu Dhabi.

[5] Ibid.

[6] Curry, C. Lithium-ion Battery Costs and Market: Squeezed margins seek technology improvements and new business models. Bloomberg New Energy Finance, July 5, 2017.

[7] Kittner, N. Lill, F. & Kammen, D.M. Energy storage deployment and innovation for the clean energy transition. Nat. Energy 2, 17125 (2017).

[8] Schmidt, O. Hawkes, A., Gambhir, A. & Staffell, I. The future cost of electrical energy storage based on experience rates. Nat. Energy 2, 17110 (2017).

[9] The units for installation costs are $/kWh, calculated as the total investment in equipment divided by the rated output of the system, which is 60,000 kWh in this case. See Lazard's LCOE studies 1.0, 2.0, and 3.0. This is based on survey results reported in Lazard's Levelized Cost of Storage studies from 2015-2017. The numbers reported are average values for a 10 MW, 60 MWh Li-ion battery installed at the distribution level of the grid. Installation costs only include the upfront capital investment in racking equipment, battery modules, the battery management system, the balance of system costs, the power conversion system, and engineering, procurement, and construction costs.

[11] Morgan Stanley. "Renewable Energy Storage: The Next Big Power Play". March 6, 2017. https://www.morganstanley.com/ideas/renewable-energy-storage-solar-electric-grid.html

[12] Doosan Gridtech. "Making Utility-Integrated Energy Storage a Used, Useful and Universal Resource". September 2017.

[13] U.S. Department of Energy Storage Database accessed on January 4, 2018.

[14] Herring, G. "Power surge expected for US energy storage markets in 2018 and beyond". S&P Global Power, January 3, 2018.

[15] Selmon, E., Wynne, H. "Can Grid Scale Energy Storage Compete with Gas Fired Peakers? Not Yet, But Coming Soon." Sector & Sovereign Research, February 5, 2018 http://www.ssrllc.com/publication/can-grid-scale-energy-storage-compete-with-gas-fired-peakers-not-yet-but-coming-soon/

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