Energy-Storage and Balancing Services for Local Solar Integration: Strong Competitors and Market Challenges

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Summary

This paper tracks recent developments in the battery-storage industry with an emphasis on reports in Q2-2015 and on developments that are particularly relevant for electric utilities and innovators who wish to unleash the potential value of combined solar-plus (demand response and battery) strategies.

The paper is organized around five questions:

1. What are third-party innovators doing in the solar-plus space that presents disruptive risks or business opportunities for utilities?
2. How do predictions in the popular press regarding battery market growth stand up to critical analysis?
3. What recent, market-based evidence points to the promise of battery applications in combination with demand response (DR) strategies?
4. Do recent lessons from the marketplace suggest advances in valuing a "solar-plus" battery or battery/DR play—particularly from the utility perspective?
5. What conclusions can we draw regarding the use of batteries for solar-integration challenges, and in particular, how might utilities engage meaningfully (at the local or regional level) in this new market?

This brief exercise reveals a picture that is more robust than many industry analysts would have predicted, even a few months ago. Three key examples: First, demand charge management in commercial and industrial buildings and processes is now profitable in California using a blend of PV, demand response and battery storage (shorthand below, PV + DR + B). This is due partly to California's new energy storage mandate, AB 2514, which requires investor-owned utilities to procure 1.3 GW of electric and thermal storage by 2020, and by other favorable regulations and rates in that state. Second, improving cost-competitiveness for battery applications in Europe and Asia will have implications for markets worldwide. Finally, Tesla's April 30 announcement for their residential and commercial battery products represented a deep reduction in price from even a few months earlier, and this caught the industry by surprise.

Some utilities that had turned their attention from the battery market due to early project costs and performance issues now are reexamining the opportunities it presents. A crucial question for utilities—and especially those interested in integration with community solar projects—is, what integration needs and ancillary services do they want to provide on site, on the distribution circuit, or in the balancing authority? For the foreseeable future, the answers will no doubt vary greatly, due to particular utility technical considerations, business objectives, and opportunities in this developing market.

1. Disruptive Risks and Opportunities for Utilities

In the second quarter 2015 new battery announcements were coming almost daily, along with variously bullish research reports from Wall Street banks and business analysts. Importantly, all the business and financial analyst reports cited in this study recognize that residential grid defection is *not* a threat to utility operations. On the other hand, Battery and PV costs are falling quickly, and utility revenue erosion is a real risk, with low cost PV, batteries and information technology providing a pathway to reducing a utility costs for a growing segment of customers.[1]

- Competition in the battery market sharply quickened with Tesla's residential product roll out.
- Companies active in the space assert that commercial and industrial scale demand-charge management is profitable in some markets, notably California, with potential beneficial effects on associated circuit-level and system-wide peak load management. Vendors are selling PV + DR + B into this segment.
- The utility sector is demonstrating renewables integration solutions at various scales. Utility companies in Texas, New York and California are proposing or implementing large-scale storage investments.
- Third-party micro-grid developers are demonstrating the capability to integrate conventional distributed generation, renewables, storage, and demand response.
- The daily industry news is well reported via several competing outlets such as GreenTech Media's Grid Edge newsletter, the PV Tech Storage newsletter, and others.

Recent examples using batteries to integrate PV exist across a broad scale, from residential to utility-scale PV plants, include the following:

- General Electric sold an 8 MWh battery to Con Edison Development for use in firming a 10-MW PV plant in California. System reportedly will provide a 2-hour ramp for the PV plant.[2] This is perhaps the most directly relevant example to the question about how to integrate a 10-MW PV plant in order to directly shape the duck curve. In commenting on the project, senior vice-president and COO of Con Edison Development told Greentech Media, "[Battery technology] is no different than the solar industry less than five years ago, or the wind industry 10 years ago.... It needs quite a bit of innovation and cost reduction, but the only way to do that is to start, to make some investments, to use the technology and improve it." [3]
- Portland General Electric's Salem, Oregon Energy Center features a 5 MW battery. Also in Salem, though on a different distribution circuit, Kettle Foods has an approximately 100 kW PV system. PGE staff developed an algorithm to use their battery system to integrate the Kettle Foods PV plant. Since it is on a separate circuit the integration is considered "virtual" and does not represent actual circuit level integration. [4]
- AES Energy Storage released details of its storage portfolio in late April. It has 85 MW of storage operating with construction under way to increase its global storage assets to 260 MW by 2016.[5] As early as 2011 in New York AES had deployed 20 MW of lithium ion batteries to provide wind integration and grid stability services.[6]
- Oncor, the Texas utility, announced it has developed four interlinked microgrids with Schneider and S&C Electric. The microgrids integrate batteries, PV, wind and conventional generators. Oncor is proposing a 5 GW storage investment in Texas valued at $5.2 billion.[7]

- A 50-kW PV array at Randolph-Macon College in Virginia is being integrated into the Dominion Resources grid using two different battery technologies, including a zinc-iron flow battery.[8]
- RES Americas, Inc. is building a 6 MW battery storage system in Ohio to sell frequency regulation services into the PJM Interconnection market. RES has 27 MW of storage in place and another 28 under construction.[9]
- At end of April Tesla released their battery product announcement. It was widely covered in the trade[10], popular and academic press[11]. Highlights are that a 10 kWh battery system will cost on the order of $5,000 installed, a substantial discount from pre-April pricing in the market[12]. Initial markets for Tesla/Solar City are back-up power for residences and demand charge management for commercial customers. Tesla/Solar City announced they would share revenue from various future grid services contracts with their customers, and invited grid operators to begin discussions about how their forthcoming fleet of distributed batteries can be dispatched to various grid services.[13] [14] Citing large initial orders, Elon Musk stated, "We could easily have the entire (battery) 'Gigafactory' just do stationary storage."[15] Major partnerships initially are focused on commercial, specialized applications.
- Competitors rushed to announce plans to scale up their production to compete with Tesla.[16]
- Summarizing the recent utility-scale activity in the battery market, Solar Industry Magazine noted, "…California's three largest investor-owned utilities, Southern California Edison (SCE), Pacific Gas and Electric (PG&E) and San Diego Gas & Electric, are now installing cost-effective storage solutions. For example, SCE invested in a wind farm in the Mojave Desert that stores wind power in giant lLi-ion batteries. PG&E plans to integrate 74 MW of energy storage through a series of tenders."[17]

2. A Critical Assessment of Storage Market Growth

Near-term growth in the US battery storage market is rapid, though from a small installed base. Greentech Media expects 2015 installed capacity to triple over 2014 levels, which were up 40% from 2013 numbers.[18] Their historic and short-term forecast numbers are:

Year	MW
2013	44.2
2014	61.9
2015	220

Looking out further, CITI Group[19] forecasts a $400 billion market for 240 GW of battery storage in the US grid by 2030. Their forecast includes battery price declines to $230/kWh by about 2022, and $150/kWh by 2030. Their $230 price forecast is equivalent to the cost of pumped hydro storage.

These forecasts were in January 2015, well in advance of Tesla's April 30 announcement of $500/kWh installed residential storage systems, which itself represented steep drop in battery prices. The CITI analysts cite recent cost data. For example, in 2012 a utility in Japan paid ten times as much per kWh – $5,000 USD – for a large-scale system. And, they note that in Japan the price in early 2015 was still on the order of $1000/kWh.

A Sampling of Solar-Plus Technology and Service Providers

Gexpro Energy Services announced in early May their capability to integrate energy management, DR, batteries and solar. Their energy services brochure is at http://www.gexprosupply.com/gexsupply/pdf/Energy_Brochure_Active8GEX031R10-06.pdf

EnerNoc is well positioned to integrate batteries with DR and PV. They have an agreement with Tesla to use their batteries and have unspecified but apparently numerous installations already in California. These range from the 30 kWh scale to multi-MWh installations. Contact http://www.enernoc.com/solutions

EOS Energy Storage http://www.eosenergystorage.com claims to provide solutions at all relevant scales from homes to utility grids, and especially to integrate renewables. Their site presents (in my view) a highly sophisticated understanding of the multiple value plays that storage can accomplish.

Elecyr presents impressive project experience building battery systems and renewables into microgrids and commercial buildings at their site. http://www.hybridpropulsion.com/applications .

Enphase Energy is the leading micro-inverter vendor. It has now integrated a storage solution into its product offerings. http://enphase.com/energy-management-system/

Schneider Electric is a very large multinational company with deep capabilities in PV, storage, micro-grids and energy management, among many other disciplines. See, e.g., http://www.schneider-electric.us/sites/us/en/solutions/renewable-energy/solutions-intro.page

Solar City and Tesla have a strategic plan to offer a distributed solution in buildings. According to Solar City, it is set grow rapidly. Information at http://www.solarcity.com

Powerit's microgrid control capability provides a capability to "Manage local storage, generation, and energy consumption to minimize demand from the utility, reducing peak charges and impact on the grid." See their site at http://www.poweritsolutions.com/solutions/microgrid_control/

Citi's analysts expect that utility substations and distribution circuits will see the largest share of storage construction. This is an important distinction, relative to a strategy associated with Tesla and Solar City, which is focused on residential and commercial buildings, and fleet aggregation to provide ancillary services. For example, Solar City envisions expansion of the markets for ancillary services. They offered to manage their fleet of distributed batteries to provide ancillary services, and to share revenue with its battery customers. [20]

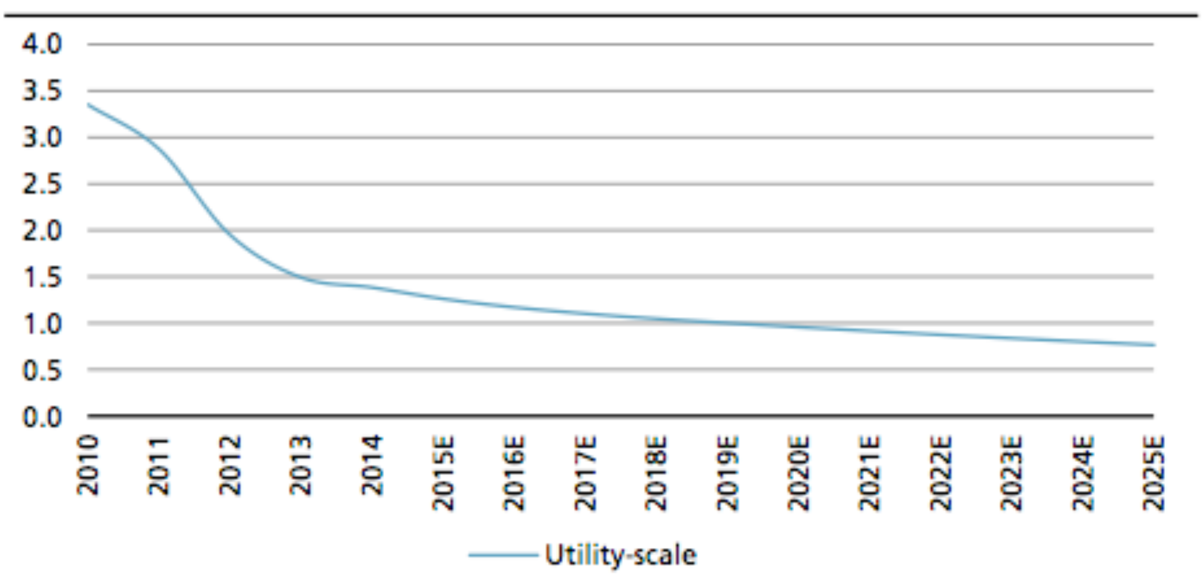
Bernstein Research, a Wall Street investment research firm, features one of the leading solar energy analyst teams. Michael Parker and his team are highly bullish on the economics of PV + batteries. They assert that by 2018 that *unsubsidized* storage + PV in the residential sector will be cheaper than grid power in several major markets (Australia, Japan, Spain), and by 2020 in parts of the US, including California.[21]

In their view, the economics of solar and storage, which are technology products with continually falling costs, will be highly disruptive to the utility sector that is faced with inexorably increasing costs. To make the case even clearer, the Bernstein PV + storage economic model is based on zero public subsidy for either solar or batteries. This is profoundly conservative.

The whole system economics of PV + DR + B, with ancillary services and demand charge management included, will be highly catalyzing for both PV and storage businesses. The economics will drive customers to adopt the combination to secure lower cost energy bills *plus* incremental revenue from ancillary services.

Both the CITI and Bernstein reports are arguably incomplete, omitting the potentially huge economic benefits related to developing the ancillary services markets and demand-charge management. PV + DR + B markets may grow slower, or they may, in fact, grow faster than either CITI or Bernstein expect, especially if the ancillary services markets are rationalized to provide increased revenues to battery owners and battery-based energy-service system integrators.

In early June 2015, the global bank UBS published, “Does the Future of Solar Belong With Utilities?” which strongly discounted the grid defection scenario, popularized recently in the industry press.[22] UBS projected that most solar development would occur at utility scale, and portrayed the combination of PV plus storage as a robust new business opportunity for utilities and utility-like players. Reproduced below is the UBS forward cost-curve estimate for installed capital cost Euro per Watt for utility-scale projects. This closely tracks the SunShot price target for the year 2020.



Source: UBSe

Figure 1. UBS Estimated Solar PV Capex Costs Over 2015-25E (Euro/W, utility scale). Battery cost estimates by UBS is even more bullish than the Citi or Bernstein forecasts. UBS expects a ~ 75% decrease in costs from $360 to $100 Euro/kWh by 2025.[23]

3. Solar-Plus-*Plus*: Battery Applications With Demand Response

Demand response (DR) is typically deployed to reduce utility loads on relatively rare occasions, such as on peak days when grid resources are scarce or when other grid-level issues call for such action. In recent years, new technologies and strategic applications for DR have begun to address renewable energy (primarily wind) integration issues. Such DR strategies typically control loads more quickly, more frequently, and less intrusively than their earlier counterparts. They also may support both load-reducing and load-building responses to address the variability of renewable resources on the grid. The cost of DR has been dramatically lower than the cost of battery storage to date, though DR costs generally are not falling. DR for wind and solar integration may be applied to regional or system-scale grid issues, or it may be used in micro-grid projects. Numerous companies are now addressing the market for hybrid solutions using PV + DR + B.

- Gexpro announced in early May that it would be adding batteries and associated control systems from subcontractor Geli to integrate solar, demand response and energy efficiency to their commercial building energy management business. The initial market objective is to provide demand-charge management for building owners.[24] Gexpro is a former unit of General Electric that was bought by the French electronics firm Rexel in 2006. Their product announcement emphasizes PV systems and claims "… to introduce a new model of delivering energy storage system solutions in packages designed for easy deployment by solar and energy developers…."[25]
- Seattle based Powerit is providing services to integrate demand response, batteries, PV, and thermal storage.[26]
- The company Elycyr announced a new residential PV + batteries product and service offering, to complement its extensive work on microgrids that integrate PV + DR + B + other generation.[27]
- EnerNoc is integrating Tesla battery packs with their energy management and DR capabilities in several California C&I locations.[28] The supermarket chain Slater Bros. Markets in southern CA is using 30-kWh battery packs. At an Amazon data center in northern California, the company is operating a 4.8 MWh battery system along with its demand management software. "EnerNOC already shaves peak load at customer sites by turning down energy use in lights, cold storage units, HVAC systems and the like, both on command for demand response, or in anticipation of expensive peaks in energy use. Adding a battery can expand the scope of those power-shaving capabilities…."[29]

4. What Drives the Value — And For Whom?

The answers to these questions depend on the interaction of internal economic perspective, market structure, energy and demand charge prices, location, and system boundaries. Where these parameters line up well, California commercial buildings for example, the value of including batteries in a PV + DR system is reported to be immediate and profitable. Each of these parameters is discussed briefly below.

- *Customer internal economic perspective*. Consider a C&I building owner who pays both energy and demand charges. Coda Energy (among others) claimed in late 2014 that the combination of PV + DR + B is cost competitive in California when both energy and demand charges are accounted for.[30]

- *Duck curve perspective*. Consider a merchant solar plant that has a PURPA contract to sell its entire output to the utility. Its owner can decide to make on site or buy its integration services from the grid. Given the past and forecasted rapid cost declines and increasing sophistication of third party integrators, it is probable that the hourly integration of large-scale solar plants with batteries is (or will very soon will be) a trivial issue. The more interesting and valuable problem to solve is the duck curve. In a world of significant and widespread solar PV + DR + B market penetration, the duck curve could be flattened.
- *Market structure*. Which ancillary services, if any, are open to participation by a project that has a combination of PV + DR + B? In PJM, for example, the frequency regulation market is wide open to participation by battery installations. Each balancing authority will have different rules and market structures for procurement of third party ancillary services. For example, in Oregon, Portland General Electric (PGE) wants to own utility-scale inverters so that it can dispatch VARs into the grid for voltage support. In California and elsewhere, will the market provide compensation for hour-ahead integration, time shifting the PV output to manage the duck curve, and the range of other ancillary services? The jury is still out on this question, though demonstrations, such as the Community Solar Value Project model, may support the best possible answer.
- *From inside the customer fence, out to the balancing authority*. The economics and market structures change as one moves out from behind the meter. Solar City intends to intermediate between the utilities' ancillary service needs and its fleet of residential and small C&I PV + B. It plans to make money and share its revenue with its PV + B customers. Which ancillary services will eventually be accounted for in this arrangement? This is a question that cannot be answered yet. Or, consider a utility-scale PV plant, with a large battery system that can time shift, black start, load-follow, manage circuit level peaks, inject or absorb VARs. How will the market for these services evolve and open? Again, one cannot yet say, but it is apparent that these capabilities have or will have real value.
- *Utility storage proposals proliferating*. Utilities are becoming more and more sophisticated about these developments. In mid-2014 Con Edison in New York petitioned the NY PSC to build storage into its dense urban network, in lieu of a $1 billion investment in upgrading substation distribution capacity. Two thirds of the storage would be customer-sited, behind the meter, in residential and small commercial facilities.[31] And Oncor, the Texas utility, recently proposed a 5-GW storage program.

5. Utility Review of Solar-Plus Risk and Opportunities

This review of recent developments in PV + DR + B, and particularly in battery-market development, suggests that two facets of the integration problem—economics and market reform—will each condition how batteries and DR can contribute to a solution. Improving economic performance will likely drive the market reforms. A third consideration, technical performance, is actually well solved by some utilities and third party providers. Further, the growing availability of technology and energy-services companies appears ready to solve both technical and market challenges.

Economics will favor a scenario where DR is combined with batteries, at least for the near term. Powerit's dispatchable DR costs are in the range of $125 to $250 per kW. Batteries today ordered from Tesla cost on the order of $500/kWh (at residential scale), installed. Various microgrids reported in the trade press already deploy dispatchable DR, batteries, PV and other generation. Discussing his business model, the Powerit CEO was quite bullish on the role of DR just based on these economics.[32]

Commercial and industrial building demand management is now a market for cost-effective DR + storage. Though sited on the customer side of the meter, these installations may produce aggregate diversified peak load management. Because this energy service is now profitable in some higher cost markets, e.g., California, we should expect rapid growth, helping to further reduce the total costs of the PV + DR + storage scenario.

Battery costs will continue to fall and the decline may accelerate. Falling costs, perhaps to the point of $100/kWh for battery storage could pressure the DR business model. Cost reductions should be expected for at least ten years, as the competition quickens between Tesla and the other manufacturers.

Tesla's announced business model to share ancillary service grid revenue with its solar and battery customers will most likely be replicated in any regulatory market that supports this strategy. Competition will further decrease battery prices and the economic rent that DR producers can charge. Which markets will emerge, for which ancillary services, bears close watch.

The evolution of renewables-integration solutions also depends in part on sending the right economic signals from the policy side. For example, regulators in states with relatively fast-growing solar penetration have been slow to realize the full capabilties of PV + DR + B to address both extremes of the duck curve. Markets will be shaped by economics, including all-in technology costs, utility tariffs, and policy leadership.

Market reforms. A critical goal is for ancillary service markets to be rationalized to enable PV inverters, batteries and DR to capture the full value they can provide to the grid. Only a few of the dozen or so value streams are now available, and in only a few markets, but the California and New York market reforms are beginning to open up other grid services. An example is that DR + storage can compete for frequency regulation contracts at utility scale in PJM. Each of the California IOUs is developing various opportunities for storage and DR to be integrated into their grids at substantial scale.

In conclusion, this high-level review of the storage-market press and market drivers indicates both disruptive danger and business opportunity for utilities, as well as for third-party providers. The market is quickly reshaping the imagination of what could be possible over the next few years. Skepticism may be justified if one focuses narrowly on the predominant past and present market conditions. However, that skepticism should be tempered by an appreciation of the technology-based nature of the battery industry, the latent desires of many customers to embrace distributed energy resources, and the dynamic competition that these forces will engender.

About the Author

Chris Robertson is a Portland, Oregon-based business consultant and entrepreneur, focused on the need to accelerate the transition to a sustainable energy economy, powered by renewable energy systems. He completed this work as an associate to Cliburn and Associates, LLC.

About the Community Solar Value Project

The Community Solar Value Project aims to increase the scale, reach, and value of utility-based community solar programs by using strategic solar technologies, siting, and design, and by integrating suitable companion measures, such as demand-response (DR) and storage into broad program designs. Such measures can address solar variability, so that costly distribution-engineering solutions and regional-level ancillary services can be minimized. Market development for this new model also is being addressed. The project is led by the San Francisco-area energy consulting and analytics firm Extensible Energy, LLC, with support from Cliburn and Associates, LLC, Olivine, Inc., and Navigant Consulting. Utility participants include the Sacramento (California) Municipal Utility District (SMUD), Public Service of New Mexico, and other utilities nationwide. The project is powered by SunShot, under the Solar Market Pathways program of the U.S. Department of Energy.

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Disclaimer

Endnotes

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