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Electricity Storage in Regulated Markets: Getting the Rules Right

Electricity storage technologies are stymied by regulatory markets that are unable to fully monetize their benefits. Regulatory changes are needed. These changes include breaking out ancillary services from generation for purposes of planning and bidding, clarifying cost recovery for storage investments, and providing appropriate incentives for customer-based energy storage.

Sydney Kaufman, Paul Komor, Blake Langdon and Paul Vallett

I. Introduction: Why Storage?

Electricity storage can ease the integration of variable generation such as wind and solar energy onto the grid, reduce the need for high-priced peaking power, and increase capacity factors for baseload power plants. Storage technologies are maturing, costs are dropping, and a number of pilot plants are operating or planned across the U.S. Storage technologies' promise, however, is stymied by the very flexibility that makes them so potentially valuable. Electricity storage

provides a service that does not fall cleanly into traditional utility functions (e.g., generation, capacity, demand-side management), and as a result, has struggled to fit into existing electricity regulatory and market structures. This problem is particularly acute in regulated markets.

Depending in part on how storage is designed and operated, it can be classified as peaking capacity, intermediate generation, negative load, positive load, and even a transmission asset.¹ While the variety of potential services is its benefit, it is also a hindrance in

terms of rulemaking. According to one recent report, storage “lacks sufficient regulatory history. . . Utilities do not know how investment in energy storage technologies will be treated, how costs will be recovered, or whether energy storage technologies will be allowed in a particular regulatory environment.”² This regulatory uncertainty is emerging as the principal barrier to wider use of storage technologies.

II. What Services Can Storage Provide?

Storage can be thought of as providing two services: energy (measured in MWh) or power (measured in MW). Energy applications are those that require energy storage devices to store a large amount of energy, be able to discharge at a constant power for 1 to 10 hours, and only need to be cycled infrequently, once or twice per day. Applications that fall under this category include:

- *Load following*: large-scale energy storage devices can be used for following load on the sub-hour to hour time scale. This would partly replace the need for certain generation facilities to be run at partial capacity to provide load following services.

- *Transmission congestion relief*: energy storage can be placed downstream from congested transmission areas and used to store energy when transmission is not congested and then

discharged during times of congestion. This may also allow utilities to delay costly grid updates.

- *Demand side management*: instead of providing interruptible loads, industrial electricity customers can install energy storage that is charged during non-peak times and discharged during peak times in response to a signal from the utility.

- *Renewable time-shifting and capacity firming (long time)*: certain renewable energy resources, such as wind, often generate the most electricity during non-peak demand times. Energy storage devices could store the energy produced during non-peak times by variable renewable resources and reduce the need to cycle base-load generation during these times.

- *Energy arbitrage through time-shifting*: if time-of-use pricing is in place, customers can reduce their energy costs by purchasing and storing energy at low-cost times and using the stored energy instead of buying high-cost, peak electricity.

Power applications generally require devices that provide a large amount of power for a relatively short period of time, from seconds to minutes, and are cycled frequently. The main benefit is for ancillary services such as:

- *Frequency regulation*: energy storage devices can be used to better respond to rapid fluctuations in demand and help maintain constant frequency output.

- *Renewable capacity firming (short time)*: energy storage can respond quickly to ramping events (such as cloud cover or a sudden wind gust). This allows renewable facilities to be treated as more predictable generation sources and prevents the need for other facilities to respond to ramping events.

Another application of storage is to provide power for infrequent peaking generation requirements or as an emergency power plant backup (Table 1).³

III. Storage in Restructured Markets

States with independent systems operators (ISOs) and regional transmission organizations (RTOs) have seen the installation of 18 utility-scale battery and flywheel energy storage facilities over the last few years and have 27 more power-application energy storage facilities planned, totaling over 210 MW. This is in large part due to FERC Order 890, issued in February 2007, which required ISOs to allow “non-generation resources” to participate in an ancillary-services-only market.⁴ In general, this has led to creation of separate markets for Limited Energy Storage Resources (LESR), energy storage technologies designed to provide fast response for frequency regulation services. These have been noted by FERC as providing value to the ISOs. In its ruling approving the new market rules, FERC commented,

Table 1: Summary of Utility-Scale Energy Storage Technologies, Applications, and Status^a

Utility-Scale Technology	Description	Status	Operating U.S. Facilities	
			#	MW
Pumped hydro	Water is pumped from lower to higher elevation. When needed high elevation water is released to generate electricity. Energy applications.	Mature – Oldest storage technology. High cycle efficiency and high energy capacity. Limited by geographic and environmental constraints.	42	23,406
Compressed air (CAES)	Pressurized natural gas or air is injected into porous underground formations. Upon release it is either mixed with natural gas or run directly through a turbine to generate electricity. Energy applications.	Mature – Moderate efficiency, may require natural gas. Constrained by need for suitable geology. Only two operating plants worldwide, currently five proposed plants.	1	110
Thermal	Energy is stored through heating molten salts. As the salts cool, heat energy can be extracted and used to generate electricity. Energy applications.	Pilot – Typically paired with concentrating solar power. Demonstrated, but still expensive.	2	38
Batteries	Energy is stored as chemical energy through a reversible electrochemical reaction. Batteries can maintain charge for an extended amount of time, have shorter response times and are not site-specific. Typically have high efficiencies (80-90%). Energy and power applications.	Dependent on technology.	27	91
<i>Lead-acid</i>	Most common and least expensive batteries for electricity storage applications. Power applications.	Mature – Cheap and reliable. Low energy density, short cycle life, negative environmental impacts limit utility scale usage.	12	47
<i>NaS</i>	A molten-metal battery constructed of sodium and sulfur. Energy applications.	Mature – High efficiencies, long discharge duration, reliable. Requires high temperatures, materials extremely corrosive.	7	13
<i>Others</i>	Include lithium-ion, nickel metal-hydride, nickel cadmium, and flow batteries. Energy and power applications.	Pilot – Easily scaled to size of application and extended cycle life. However, need for other equipment – such as electrolyte pumps and sensors – raises costs and complexity.	9	31
Flywheels	Electricity is used to spin heavy flywheels on near frictionless rotors up to large speeds. To extract energy the flywheels are used to spin a generator. Power applications.	Pilot – Long lifecycle as compared to batteries, high power, high efficiencies, and fast response. High cost of rotor materials and control systems limits implementation.	3	9
Superconducting magnetic (SMES)	Electric energy is stored in a magnetic field, obtained by allowing DC current to flow through a material that has been cooled to below its superconducting threshold temperature. Power applications.	Experimental – efficiencies in excess of 95%, lack of moving parts reduce maintenance. Need for refrigeration and low energy density typically makes SMES uneconomical except for specialized needs.	1	3

^a Data based on authors' review of various published and unpublished sources.

“[w]e recognize that these LESRs can assist in the effective integration of wind resources. Further, the integration of LESRs in the regulation service market should improve NYISO's control performance and assist it in meeting or exceeding the NERC control performance criteria.”⁵

PJM, NYISO, and MISO have successfully implemented new market rules that allow for the integration of LESRs in their ancillary market for regulation services, without requiring these resources to also generate electricity. Under these market rules the ISOs purchase regulation services on an hourly basis from the LESR. The resources must be able to respond to automated generation control signals sent by the ISO in response to load fluctuations. This required an investment in new software and infrastructure necessary to take advantage of the fast response of LESRs, but ISOs have shown a need for these services especially in congested areas. For example in 2008 NYISO paid \$100 million for regulation services, indicating that there is an ample market available.⁶ As a result of these changes in market rules, a number of energy storage devices either have been installed or are planned in these ISO service areas.^{7,8}

Other ISOs are currently testing separate regulation markets to meet FERC Order 890. ISO-NE is currently running an Alternative Technology Regulation (ATR) pilot project similar to the LESR market

described above to allow new small technologies to provide frequency regulation. The maximum amount of regulation capacity is set at 13 MW for the total project and a minimum required for participation is 0.1 MW. Unlike the LESR markets, the ATR resources do not bid into the market, but are compensated by the ISO based on the current hourly price of regulation and the resources

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cannot participate directly in the energy market. However, under an innovative compensation structure, the price paid out is based on performance of the unit in following the ISO frequency regulation signals. Partial response to signals results in only partial compensation, which gives the fast-response energy storage devices an advantage over regulation provided by conventional generating facilities.⁹

CAISO and ERCOT are both attempting to introduce similar programs to allow LESRs to operate in their current ancillary services market. However, both

regions currently have asynchronous markets for regulation services, meaning that there are separate markets for providing up regulation and down regulation. This is problematic for fast energy storage devices such as flywheels and small batteries which excel at responding quickly to regulation signals and are most effective when used to regulate load quickly in both directions, but can only provide regulation in one direction for about 15–30 minutes. Regulation service is currently purchased in one-hour intervals so LESR would be unable to participate. CAISO determined that a separate market for LESRs would have to be created, however as of March 2010 its pilot program has been delayed.¹⁰ As for ERCOT, it commissioned an energy storage working group in early 2010 and is currently working on implementing new rules for LESR devices. The Public Utilities Commission of Texas has opened an investigatory docket (project 38118) to encourage a broad discussion of energy storage rulemaking with all stakeholders involved.¹¹

In addition to the ISOs' efforts in this area, California has taken the next step and become the first state to pass a law that mandates the use of energy storage by utilities. The law was intended to spur development in the energy storage industry and to address the predicted need for such systems to meet the state's ambitious 33 percent renewable portfolio standard by 2020. As

energy storage technologies are just entering the market, the law does not specify the amount of energy storage needed but instead requires the California public utilities commission to set appropriate targets for load-serving entities through analysis of cost and operations of current energy storage facilities. Each utility must then meet the energy storage procurement targets by the end of 2015 and 2020.¹²

IV. Storage in Regulated Markets

We investigated states that have regulated utilities to determine if there were efforts in state legislature or regulatory bodies to promote energy storage. We found no broad, coordinated legislative or regulatory efforts in those states to mandate, promote, or provide regulatory rules to aid in the development and utilization of energy storage.

In these regions, some municipal utilities have begun to utilize small-scale energy storage devices to address specific concerns in their operating areas, or have implemented measures that benefit consumers who chose to install their own energy storage devices. For example, in Fairbanks, Alaska, a 27 MW nickel-cadmium battery system is used as a backup in the event of a power failure. This is necessary as the town is in an isolated environment and cannot rely on connection to other power grids.¹³ Other municipalities are recognizing the benefit of energy

storage as well. The Iowa Stored Energy Park (CAES) is being developed for use by a coalition of 95 municipal utilities located throughout Iowa, Minnesota, North Dakota, and South Dakota, primarily to store cheaper, nighttime-produced wind electricity and sell it to customers during peak hours.¹⁴ Austin Energy, a municipal utility, has also established a rebate program to encourage commercial

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customers to install thermal energy systems.¹⁵ Some large commercial customers located in regulated markets have also installed thermal storage units to reduce their peak demand and lower their energy costs during summer months. For example, the University of Arizona in Tucson recently installed such a system to partly cover their cooling needs and reduce expenses, with an estimated annual savings of \$560,000.¹⁶

In general, however, regulated markets do not have any clear support for utility- or consumer-scale energy storage technologies. While there are isolated cases and

some small pilot projects, regulated utilities are not exploring the full range of services that energy storage can provide. As evidenced by the increased installation and proposed projects in restructured markets, energy storage can provide significant value to the operation of the electricity grid and their adoption should be supported in regulated markets as well.

V. Recommendations for Regulatory Change

In restructured markets, storage suppliers independent from the ISO and the utilities have seen some success from market changes required by FERC Order 890. These market changes have allowed storage operators to economically benefit from the unique services they can provide. In regulated markets, these ancillary services are not treated separately from generation, making it difficult for storage technologies to be implemented. An independent storage operator has no opportunity to provide its differing services as IOUs typically only issue requests for generation proposals. These factors make investment in and development of storage much more attractive in a restructured market than in a regulated market.

Some of these regulatory and investment concerns can be avoided if the IOUs own and operate the storage facilities. However, IOUs are typically not

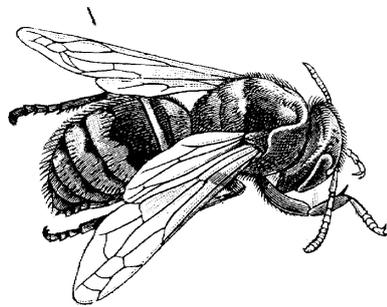
inclined to change their business operations dramatically by integrating storage of their own accord. It is difficult to include energy storage in an IOU's modeling of the electrical system because of the variety of services provided by energy storage. Additionally, IOUs generate revenue from installed facilities, recouping costs from their ratepayers, but there are no provisions to ensure the costs associated with energy storage facilities could be made up through rates. The types of services that storage can provide are new to large grid systems and, with the exception of small pilot programs,¹⁷ IOUs typically have no experience planning for or running a storage facility.

The following recommendations attempt to address these concerns. They focus on providing options for policy makers who wish to support the implementation of energy storage by: creating separate services markets specifically for energy storage, providing a regulatory structure that clarifies cost recovery mechanisms for energy storage operators and utilities, incentivizing consumer based energy storage, and considering an energy storage mandate.

A. Treat ancillary services separately from generation for planning and bidding

One of the previously discussed obstacles to energy storage

technologies is that the various benefits of the services that storage provides are not easily partitioned into broad categories of generation and load that utilities typically use for planning purposes. Restructured markets have addressed this problem by creating separate markets for ancillary services from both generation and energy storage



technologies, providing a direct economic comparison between the different types of facilities. While regulated utilities do not have a market-based system, it may be possible for utilities to emulate this technique by explicitly splitting off specific ancillary services in their planning process.

For example, ISOs have separate markets available for facilities that wish to provide frequency regulation and load-following services.⁷ In a similar manner, utilities in regulated markets could be required to present different options addressing how they will meet predicted frequency regulation

and load following needs. This would necessitate that utilities determine their need for specific ancillary services and calculate the economic cost of acquiring these services from generation facilities versus storage facilities. This may reveal savings where energy storage devices could provide ancillary services and allow generation facilities to run at more efficient levels.

In addition to planning ancillary services separately from generation, if utilities identify a need for specific services, they could similarly issue a separate request for proposals (RFP) for generation and for ancillary services. This again would allow energy storage technologies to compete directly with traditional generation in only the areas in which it can provide benefit, instead of attempting to treat it as a special type of generation.

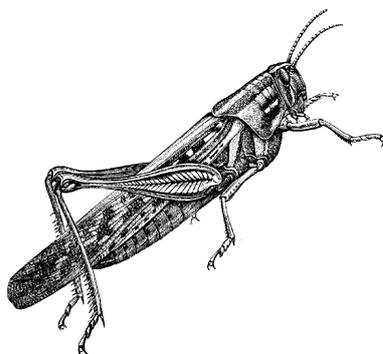
These options are attractive as they do not mandate energy storage usage for utilities, but simply require that they identify the areas where storage may be useful and allow it to compete directly with traditional generation facilities. Utilities may determine that energy storage technologies are not a good fit with their current needs. However, this process would allow utilities to more easily determine and acquire energy storage devices when necessary, such as when variable renewable energy technology penetrations reach a certain threshold value.

B. Provide regulatory direction for energy storage

As energy storage technologies are used in different ways, they do not easily fit into regulatory categories defined by public utilities commissions, designed for traditional generation. As such, current rules do not provide any guidance to utilities as to how energy storage devices would be implemented and paid for. In order to alleviate this concern, public utilities commissions should outline how utilities can recover costs invested in energy storage technologies.

Typically, regulated utilities can only generate profits from investments in necessary infrastructure. In order to be able to recover costs from a project through rates, a utility typically must first obtain a Certificate of Public Convenience and Necessity (CPCN) from the public utilities commission. If the public utilities commission could determine that energy storage facilities are eligible to receive a CPCN, then utilities may be encouraged to consider energy storage to address operational issues with the knowledge that they could earn a return on investments in them. However, CPCNs are usually issued after the utility has shown that investment in the proposed infrastructure or generation facility that provides the indicated service does so at the least cost to the ratepayers. As energy storage technologies are newer, they may not be

considered a “least cost” option for providing services. This may deter utilities from considering initial investments in energy storage technologies. It may then be necessary to allow utilities to recover costs through rates for a secondary type of technology that is emerging onto the marketplace and so may not be strictly least-cost but would still provide a



benefit to the ratepayers and would help utilities learn to use and incorporate emerging technologies, such as energy storage, into their existing operations. An example of this is the Section 123 provision currently implemented in Colorado.¹⁸ As with the previous recommendations, this could help enable utilities investments in energy storage but without mandating their use.

The above recommendation deals with specifying how utilities can pay for energy storage projects, but there are certainly other areas of regulatory uncertainty. In order to identify and address these concerns, all stakeholders should be brought

together to discuss appropriate roles and rules for the operation of energy storage facilities. Texas has already taken this step as its public utilities commission has opened an investigatory docket.¹⁹

C. Incentivize consumer-based energy storage

As indicated, incentivizing energy storage for customers makes technologies like thermal energy storage financially practical for consumers and helps the utility by decreasing peak load. Many IOUs already operate demand-side management programs where large customers are compensated to reduce load when called upon during peak events.²⁰ Clearly, the ability of a customer to shift their load from peak to off-peak provides a similar value to the utility and should be compensated as such.

The simplest way, from the consumer's perspective, to incentivize energy storage is to have time-of-use pricing or demand charges based on the customer's peak load. Under this rate structure, significant savings can be realized if the customer shifts expensive peak-time loads, such as cooling, to non-peak times through energy storage devices. With only a flat rate charge for electricity there is minimal incentive for customers to install their own storage devices – even though utilities could benefit from reduced peak loads. However, providing support for consumer energy storage is most likely not a sufficient reason to justify the

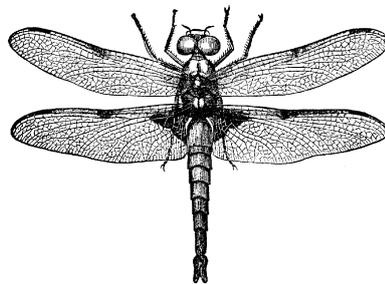
significant investment in new equipment necessary for implementation of these new pricing structures, and such a move would likely have to already be planned. While time-of-use pricing is seeing increased usage with the implementation of newer Smart Grid electric meters, these are generally limited to small pilot programs.²¹

An alternative to changing pricing schemes is to offer a credit to the consumer based on the amount of peak kilowatts shifted to non-peak times. This incentivized system can sometimes be within the structure of an already enacted energy efficiency measure. This was accomplished recently in Texas where the public utilities commission ruled that energy storage devices were included in the utilities' applicable energy efficiency technologies. The pricing was structured such that customers are paid \$80 for each kW that can be shifted away from peak times per year.^{22,11}

D. Mandate energy storage

The above recommendations focus on ways to enable energy storage through a more direct comparison of the services that it can most readily provide as compared to traditional generation. A more straightforward approach to supporting storage would be to mandate a certain amount of storage for utilities, much like California has done with the recent energy storage law discussed

previously.¹² While this will certainly aid in the utilities' implementation of energy storage technologies, there are a few concerns with this approach. Setting appropriate storage procurement targets is problematic without clarifying what technologies and specific services the storage is to provide. For example, 15 MW of flywheel



storage could readily provide high-value fast frequency regulation service that would only count for a small amount of the peak load for the utility, thus not making it an attractive option under the mandate despite the value of the service it can provide. California's public utilities commission has yet to determine storage targets for each utility and it will be informative to observe what levels of storage they deem appropriate and whether different technologies that address different services will be treated the same.

VI. Closing Comments

The promise of storage technologies will remain stymied

in regulated markets unless regulators change the rules. The four changes proposed here are solid first steps in helping to ensure that storage plays an appropriate rule in meeting future electricity demand. ■

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❖ M E E T I N G S O F I N T E R E S T ❖

<i>Conference</i>	<i>Date</i>	<i>Place</i>	<i>Sponsor</i>	<i>Contact</i>
2011 Energy Sustainability Conference	Aug. 7–10	Washington, DC	American Society of Mechanical Engineers	www.asmeconference.org
3rd Annual China Smart Grid Conference	Sept. 14–16	Shanghai, China	China Decision Makers Consultancy	http://www.cdmc.org.cn/smartgrid
Managing Aging Transmission & Distribution Infrastructure	Sept. 28–29	Chicago	EUCI	http://www.euci.com/events/index.php?ci=1377&t=0
13th Annual Financing US Power	Oct. 27–28	New York	Platts	http://www.platts.com/ConferenceDetail/2011/pc131/index
Asia Smart Grid 2011	Nov. 2–4	Suntec, Singapore	Energy Market Authority of Singapore	http://www.asiasmartgrid.com.sg/
AWEA Wind Energy Fall Symposium	Nov. 2–4	Carlsbad, CA	American Wind Energy Association	http://www.awea.org/events/fall_symposium_f2011.cfm
GridWise Global Forum	Nov. 8–10	Washington, DC	GridWise Alliance	www.GridWiseGlobalForum.org
Energy, Utility & Environmental 2012	Jan. 30–Feb. 1, 2012	Phoenix, Arizona	EUEC	http://euec.com/index.aspx
Offshore Wind Power 2012	Feb. 7–8	Boston	Green Power	+44 (0)20 7099 0600
Russia Power	March 5–7	Moscow	PennWell	http://www.russia-power.org