Envisioning State Regulatory Roles in the Provision of Energy Storage

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Abstract

Electricity storage is a growing component of the utility grid. A mix of old and new storage technologies can provide value to the utility grid, and more storage is becoming cost-effective as emerging technologies improve and their cost declines. The Federal Energy Regulatory Commission (FERC) is already taking actions to enable storage technologies to participate and be compensated in wholesale power markets, and many states are already starting to deploy storage, at least in demonstration and pilot programs. The U.S. Department of Energy (DOE) presently identifies nearly 200 electricity storage demonstration projects underway in the U.S. Hundreds more are being planned and developed now, and over 2GW of requests for proposals (RFPs) are in the works, for procuring utility-scale storage to be installed over the next five years. (EnergyStorageUpdate.com, 2014; Sandia Corporation, 2012; U.S. DOE, 2014; Wesoff, 2014).

This paper reviews the current situation for energy storage and explores state regulatory and other policy options, for enabling storage to play a larger role in electricity service provision when and where storage options are cost-effective. The goal for this paper is to identify best practices for state public utility regulations and associated policies that can best reduce or remove any unintended barriers facing cost-effective electricity storage technologies. Electricity storage represents something of a new frontier for state regulators. This paper is intended to serve as a preliminary guide to regulatory issues and an introduction to practical approaches for addressing them.

Regulatory approaches identified include provisions for storage both as a utility resource and as a customer resource, operating behind the utility meter. Six different concepts are presented, including: (1) incorporating storage options into utility integrated resource planning (IRP); (2) gaining and applying maximum information from demonstration and pilot projects; (3) overseeing utility requests for proposals (RFPs) for meeting specific, identified needs; (4) implementing storage-friendly rate designs, including time-differentiated rates; (5) enabling storage operations in microgrids; and (6) mandating storage installations. In addition, recent state commission actions regarding possible changes in the utility-regulatory paradigm are briefly described.

State and U.S. territory energy storage policies and implementation activities are briefly summarized in Appendix A, including: Active Dockets (7 states); Completed Dockets (4 states); Demos & Pilots (39 states, totaling about 350 projects); IRP requirements (6 states); Proposed Legislation (5 states); Microgrid Policies including storage capabilities (9 states) and Plug-In Electric Vehicles Policies (13 states); R&D or Business Incubator Centers (6 states); RPS provisions including storage (8 states plus Puerto Rico); Storage Mandates (in California and Puerto Rico); storage Tax Credits or other Financial Incentives (10 states); and Working Groups or completed public workshops (8 states).

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Any inaccuracies, mistakes, omissions, and oversights in this work are my responsibility. Comments, corrections, and recommendations for future work are always welcome and can be submitted to:

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Table of Contents

Introduction

Many state public utility regulatory commissions are presently making decisions about electric storage technologies, and interest is spreading rapidly.

This paper provides preliminary guidance for those states that are just beginning to consider how regulations might need to be adjusted so that cost-effective electric storage technologies can be installed and operated in order to maximize customer, utility system, and social benefits. The paper also provides a high-level review and summary of state regulatory commission energy-storage dockets, demonstration and pilot programs, and other related policies and implementation activities that are already underway in nearly half of all the states.

Part I of this paper briefly reviews storage technologies, explores the different benefits that electric storage can provide, and reports on the abilities of each technology to produce each of the identified benefits. Basic information is provided, about the major parameters that help define which technologies are useful for different applications.

Part II briefly reviews and summarizes the technical, economic, and regulatory challenges facing electric storage.

Part III focuses on state regulatory approaches capable of enabling storage to actively contribute as a component of electricity infrastructure, in those circumstances where storage can be a cost-effective solution. This review includes how storage can be accommodated in utility rate cases and tariffs and IRP practices for modeling storage. It also explores how storage options might be affected by regulations supporting other practices intended to best match supply and demand, such as responsive loads (Cutter, Haley, et al., 2014; Taneja, 2013). Where there is already enough clarity about benefits exceeding costs, Part III includes ideas about how state commissions might provide pathways that allow for investment cost recovery.

Part IV includes recommendations for future research, intended to answer remaining questions, to help determine the most practical state regulatory approaches.

Appendix A briefly identifies the status of storage policy and implementation activities in the individual states. These include, for example:

- Active dockets including storage issues, in six states;
- Demonstrations and pilot projects in 39 states, totaling about 350 projects;
- IRP requirements for analyzing storage in four states;
- RPS standards including storage provisions in seven states plus Puerto Rico;
- Working groups and workshops investigating and addressing storage concerns in eight states; and
- Storage mandates applying in California and Puerto Rico.

I. Benefits of Energy Storage

A. Itemizing the benefits storage can provide

Energy storage can provide a wide array of benefits to the utility system. The major categories of benefits that have already been identified include:

- Saving costs through integrated resource planning that identifies potentials for postponing or displacing at least some alternative investments in electric distribution, transmission, and generation;
- Producing and delivering ancillary services, including voltage support and frequency regulation;
- Integrating into utility operations higher percentages of variable-output renewable generation, more efficiently and at lower total cost;
- Enabling the more efficient and flexible operations of all generation resources;
- Adding resiliency and greater reliability to the utility grid, particularly in those locations that are most vulnerable to power quality disturbances and outages;
- Providing reliable and fast-response electric supply reserve capacity; and
- Reducing emissions of harmful pollutants from power generation.

This is not entirely new information, but interest is increasing because: (a) many storage technologies are demonstrating increasing performance and reliability at lower cost; (b) many interested parties are becoming more familiar with the many benefits storage technologies can provide; and (c) there are increasing utility grid infrastructure needs that storage could fulfill. The U.S. is already home to approximately 25 GW of electricity storage facilities, but over 95% by capacity, are pumped storage hydroelectricity plants, mostly operational for decades already. Pumped storage hydro plants function primarily as large-scale resources for shifting the time of electricity production and service to loads, to take the best advantage of on-peak and off-peak price differentials. The remaining storage projects, more recently deployed, are (again, by capacity) roughly one-third thermal storage, one-third compressed air, one-quarter batteries, and a few percent flywheels.

Houssin, Tam, and Lott (2014, p. 6) presents approximate data about the power capacity and discharge duration for storage as it applies to producing the major categories of benefits. This information is based on the technical capabilities of different storage technologies. It reports the likely size ranges for storage providing each of the major benefits and the approximate duration each can act as a producer when called upon. As that research explains: (a) storage installations range in capacity through at least seven orders of magnitude, from a few Watts to a few hundred Watts in the smallest battery backup units and uninterruptible power supplies to over one gigawatt in the largest pumped-storage hydro projects; (b) in power quantities, energy delivery from storage facilities ranges from fractions of a kilowatt-hour to as much as several gigawatt-hours; and, (c) in terms of the duration of power supplied, storage installations range from those that produce for only a few seconds to minutes at a time, to others that can serve loads for hours, or even as long as a day, a week, or a month. (See also: IEC, 2011, p. 36; Periera, Grace, and Zhang, 2013, p. 28; and, U.S. DOE, 2013, p. 11-12).

In a similar vein, EnergyStorageUpdate.com (2014, p. 7) summarizes data about roughly 200 operational storage projects from the U.S. Department of Energy *Global Energy Storage Database* (DOE, 2014). EnergyStorageUpdate.com lists the primary benefits that funders, researchers, and developers expect to achieve through energy storage demonstration and pilot projects. Those include roughly one-quarter of all the projects primarily serving energy use time-shifting and another quarter enabling electric bill reductions. Then, about an eighth of the projects provide for renewable energy capacity management and time shifting, and another sixteenth for frequency regulation. The remaining projects, small in numbers, serve a large number of primary purposes, including providing spinning and non-spinning reserve capacity, deferring transmission and distribution system upgrades, providing voltage support, and improving reliability and power quality.

Among the most important benefits storage can provide, the U.S. DOE (2013, p. 4) lists "energy management, backup power, load leveling, frequency regulation, voltage support, and grid stabilization." One important reason for the heightened interest in electricity storage is the need to manage, cost-effectively, increasing quantities of variable output electricity generation, notably wind and solar, which result in large part from state renewable portfolio standard (RPS) requirements (Balducci, Jin, et al., 2013; Bird, Cochran, and Wang, 2014). Already, pumped storage hydroelectric facilities, solar thermal storage, batteries, and compressed-air energy storage, combined with customer demand response and utility load management, are being deployed in various U.S. utility grid systems, to better manage variable output generation (Bird, Cochran, and Wang, 2014, Appendix). And, storage can also provide customer demand response, or what is called "responsive demand," with the caveat that "demand response from load reduction remains cheaper… than energy storage technologies providing the same service" (Bloomberg New Energy Finance, 2014, p. 73; Stadler et al., 2014). DOE (2013, pp. 7, 8) also notes important roles for energy storage, in:

> reducing the need for… [and] augmenting the performance of… transmission and distribution assets… [and] emergency preparedness and… enhancing grid resilience and robustness related to weather outages and other potential disruptions [footnotes omitted].

Balducci, Jin, et al. (2013) also describe an important role for electricity storage in mitigating against and providing supply during grid outages. Furthermore, some storage can prove cost-effective exclusively through price arbitrage, storing electricity generated during periods of generally lower cost and releasing it – generating electricity – during periods of generally higher cost. Essentially, storage can cost-effectively operate by buying and storing energy when it is somewhat cheaper and generating and selling energy when it is more expensive, as long as the value of energy generated exceeds the price of energy stored, after accounting for the efficiency losses associated with the storage system. This buy-low and sell-high strategy can be effective in some markets as often as a few times each day, in response to changing loads and the costs associated with adjusting other generation resources to match demands.

In addition, storage can be helpful in reducing all of the emissions associated with fossil fuel power generation. In particular, storage can reduce the needs for combustion-based spinning reserves, peaking power, and rapid ramping up or down, all of which are often associated with higher emissions rates. Ecofys (2014 p. 12) explains:

[E]nergy storage technologies have little to no local emissions associated with them, which can be extremely beneficial in transmission congestion applications where generation needs to occur in sensitive urban air sheds. To receive similar flexibility from traditional fossil fuel generation would require them to run inefficiently creating greater combustion emissions than normal.

Table 1 summarizes the services that energy storage devices can provide.

Table 1: Summary of Electric Grid Energy Storage Services

Bulk Energy Services • Electric energy time-shifting (price arbitrage) • Electric supply capacity
Ancillary Services • Rapid frequency regulation • Load following and voltage support • Spinning, non-spinning, and supplemental reserves • Black start
Transmission & Distribution Infrastructure Services • T&D upgrade deferral or avoidance • Voltage support
Customer Energy Management Services • Power quality • Reliability • Demand-charge management
Sources: Adapted from Ecofys, 2014, pp. 24-29 and U.S. DOE, 2013, pp. 20-29.

B. Difficulties in assessing energy storage benefits

In some ways, storage is difficult to understand because there are so many technology choices. In addition to several different battery chemistry choices (most prominently including lead acid, lithium ion, nickel metal hydride, sodium sulphur, and vanadium or zinc bromide redox flow batteries, also known as regenerative fuel cells), electricity can be stored using mechanical means (such as pumped storage hydroelectricity, compressed air energy storage, flywheels, and even by capturing, storing, and then reusing energy from regenerative-braking in rail cars and large cranes (ABB, 2013; IEA 2014a; Vycon, 2008). In addition, storage is only one of a variety of related, complementary, applications, including demand-response, load management, thermal energy storage, and price-responsive loads.

In addition, many storage technologies can be made portable and be readily moved from one grid location to another: Plug-in electric vehicles (PEVs) integrated with the electric grid using so-called vehicle-to-grid (V2G) intelligent charging, offer movable storage, likely to have two primary locations, home and work (Sanders and Milford, 2014). Plus, electricity can be used to produce storable gaseous or liquid fuels, thus allowing for combustion on demand to produce electricity. Examples include hydrogen produced by electrolysis, and so-called synthetic natural gas made from biomass or municipal wastes (IEA, 2014a). And, last but not least, electricity can sometimes be used to generate storable thermal energy at various volumes and temperatures: At high volume and temperature, stored thermal energy can be used to generate electricity using a steam generator, and at lower volume and temperature it can offset customer demand for space conditioning or domestic water heating. (IEA, 2014a).

Modeling storage is a complex undertaking, though, because the different storage technologies are often modular and can be constructed in wide ranges of capacity, each technology is capable of delivering different quantities of different kinds of benefits over different time periods, and not all benefits can be provided by each type or size of technology. To meet some of the different system needs, grid operators might call on storage facilities as frequently as multiple times per hour or day to as seldom as once per month or less (Ecofys, 2014, p. 11; IEC, 2011, p. 15). Furthermore, understanding storage benefits is even more complex because different functions and applications sometimes compete against one another: Storage operating to capture one value stream will be less available or possibly even completely unavailable to capture another (Wu, Jin, et al., 2013).

Regardless of these several complexities, some electricity storage is already here and more is coming. U.S. DOE (2013, p. 16) summarizes:

> Each technology has its own performance characteristics that makes it optimally suitable for certain grid services and less so for other grid applications. This ability of a storage system to match performance to different grid requirements also allows the same storage system to provide multiple services. This gives storage systems a greater degree of operational flexibility that cannot be matched by other grid resources, such as combustion turbines or a diesel generator. The ability of a single storage system to meet multiple requirements also makes it feasible to capture more than one value stream, when possible, to justify its investment.

Fading fast is the decades-old dictum that electricity is the one commodity that cannot be stored, thus necessitating the continuous adjustment of supply resources, through the precise operation of multiple generators, to match the sum of all customer demands. A new precept is rapidly replacing that conclusion, holding that substantially increasing energy storage resources either are already, or inevitably soon will be, capable of producing and delivering cost-effective solutions to many electricity infrastructure and operating needs.

II. Technical, Economic, and Regulatory Challenges

Various challenges sometimes make it difficult for storage to make further inroads into the electric grid. The challenges most often combine technical, economic, and regulatory issues so that there are substantial overlaps and it is difficult to classify any particular obstacles as being purely one type or another. Challenges include, for example:

- Storage is sometimes capable of producing several kinds of value, which can accrue to different grid participants and are not always monetized in either wholesale or retail markets.
- Different storage technologies are more or less capable of producing each of the different kinds of value.
- Different storage technologies vary in terms of important characteristics, including: (a) maturity and commercial readiness, (b) energy conversion efficiency; (c) initial cost per unit of power and energy; (d) practical scale in terms of capacity and energy, including duration of power provision when releasing energy from storage; and (e) practical locations for deployment.
- Utility planners need new tools or new applications for existing tools, before system modeling can readily determine the costs and benefits of integrating storage in different applications.
- Code officials – environmental, construction, electric, fire – have reliability and safety concerns that need to be addressed for many storage technologies, especially technologies with little, if any, previous track record in commercial operations.
- FERC rules are creating the means for compensating electricity storage for providing certain benefits to the wholesale power grid, but small storage facilities need to be aggregated in order to participate in wholesale markets.
- Storage advocates want to be included in state regulatory decision-making, but face uncertainty about appropriate venues, which might include IRP proceedings, rate cases, and utility request for proposals (RFPs) and resulting purchased power agreements (PPAs).
- Business models require some continuity, but state regulatory models do not necessarily provide the long-term continuity needed, for utilities or independent power producers investing in storage technologies.

A report from Sandia National Laboratory (Bhatnagar, Currier, et al., 2013, p. 3) identifies "regulatory barriers, market (economic) barriers, utility and developer business model barriers, cross-cutting barriers and technology barriers." That report states:

> Energy storage could have a key role to play in the future grid, but market and regulatory issues have to be addressed to allow storage resources open market access and compensation for the services they are capable of providing. Progress has been made in this effort, but much remains to be done and will require continued engagement from regulators, policy makers, market operators, utilities, developers and manufacturers.

Similarly, an International Energy Agency *Technology Roadmap* (2014, p. 5) explains:

> Market design is key to accelerating deployment. Current policy environments and market conditions often cloud the cost of energy services, creating significant price distortions and resulting in markets that are ill-equipped to compensate energy storage technologies for the suite of services that they can provide.

IEA (2014b, p. 46) also notes that today's policy environment is fragmented in ways that make it difficult for some energy storage technologies to compete. IEA explains:

> A key to achieving widespread storage technology deployment is enabling compensation for the multiple services performed… . A patchwork approach to creating an energy storage market will not be able to capture the full value of energy storage technologies.
>
> In unbundled electricity systems in particular, storage technologies frequently do not fit naturally into existing regulatory frameworks, as they provide value across different portions of the market (i.e. a single technology supports both the supply and demand sides, or transmission and distribution).

Bloomberg New Energy Finance (2014, p. 71) reports that "[f]our obstacles stand in the way of further adoption of storage technologies." Bloomberg labels the obstacles: (1) market structure, (2) high cost, (3) unclear application value; and (4) challenges posted by natural gas. In a similar vein, U.S. DOE (2013, pp. 30-31) identifies four "key barriers" to storage, which are: (1) competitive cost, (2) validated performance and safety, (3) an equitable regulatory environment, and (4) industry acceptance. These categories help to illustrate the difficulties in separating the challenges into mutually exclusive categories.

For example, what Bloomberg calls market structure combines aspects of what DOE identifies as an equitable regulatory environment and industry acceptance. These functions reflect the regulatory environment, which manifests itself to storage resources through economic compensation, and is partly an issue because storage resources have technical capabilities that are substantially different from the other generation and demand-management resources which would otherwise be used to manage supply and demand. Bloomberg (2014, p. 71) cites as special technical capabilities for storage "fast ramp-up times and the ability to absorb energy in periods of excess output from intermittent resources."

The challenge of market structure is also related to and overlaps difficulties with application value. What Bloomberg identifies as unclear application value is related to the need DOE identifies, for validated performance and safety information. Based on technical capabilities, some storage applications can provide multiple operational benefits, but utilities and regulators might lack the experience, insights, and rate mechanisms necessary to ensure that storage facilities will receive compensation for all of the different benefits. Therefore, unclear application value can manifest itself as a combined economic and regulatory challenge.

Similarly, high or uncompetitive cost is a technical, economic, and regulatory issue. Even the economic challenges posed by low natural gas prices have a technical relationship, because natural gas competes against storage, both by putting downward pressure on marginal power supply costs and to the extent that gas-fired generators can produce some of the same values as storage.

In addition, commercial readiness can be understood as both an economic and technical problem, with regulatory challenges as a result. Newly emerging technologies carry higher risk premia and make it difficult to accurately forecast installed costs. Bloomberg New Energy Finance (2014, p. 73) points to experience demonstrating "substantial differences between the costs reported by technology developers compared to actual installed costs."

Also, from a regulatory standpoint, energy storage faces many of the same issues as energy efficiency and distributed generation (Berst, 2014b). For example, questions to be addressed include:

- What entities are best suited to be the owners and operators of energy storage facilities, and should they be regulated or unregulated entities?

- Should storage be installed at or near end use loads, like distributed generation, or is it better to be installed in larger facilities, more like central station power plants?

- Should storage be directly integrated with generators, or can it create more value in separate, stand-alone installations?

- Should storage be managed by utilities, by grid operators, by customers or their agents, or by some combination of entities?

- What regulatory incentives are best suited to encourage utilities to optimize storage capabilities at the lowest reasonable cost?

Many storage technologies are still in the early stages of commercialization, such that technical performance is increasing and costs are decreasing as learning-curve improvements proceed. Cost reductions are often achieved through technical improvements and improved economies of scale, in manufacturing and throughout the entire value chain. But, those kinds of improvements might come only through substantial learning-by-doing, which can be accomplished only under a sufficiently accommodating market structure. Regulators face something of a conundrum because early adopters of new technologies typically do pay higher prices, but sales growth also creates market pull, which is often needed to support the learning that results in cost reductions. There is also the added difficulty of accurately estimating the value of accumulated utility system benefits, prior to installing and operating storage devices. Parts III and IV of this report discuss these challenges.

III. State Regulatory Approaches Enabling Energy Storage

State public utility regulatory commissions will make decisions about energy storage facilities in two general arenas. One is for the regulatory treatment and cost recovery for energy storage facilities as a utility resource, and the other is for rate treatment for customer-sited storage resources that operate behind the utility meter.

A. Implementing storage as a utility resource

Currently, in the early stages of incorporating storage, researchers are focusing more attention on the complexities involved in utility planning, procurement, and subsequent cost recovery. For example, Ecofys (2014, p. 2) concludes:

- Complexities in calculating and realizing the value of energy storage provides multiple system benefits that are often not fully quantified, at least partly because of the complexity involved. …

- Energy storage deserves to be evaluated on a par with other resources and integrated into utility resource plans.

- Barriers to energy storage development suggest policy intervention is merited to promote competition among projects and technologies, and promote market design improvements to more fully reflect the value of flexibility services.

- Standardized integration with utility system energy management systems may be lagging and merits development.

For implementing storage as a utility resource, many state commissions oversee IRP procedures and utility competitive procurement practices. Although, as Ecofys concludes (2014, p. 2), no standardized modeling capabilities yet exist for integrating storage in utility system planning, work is proceeding on some promising IRP modeling approaches, designed to enable accurate evaluation of storage-facility benefits. For example, Pacific Northwest National Laboratory (Wu, Jin, et al., 2013) is developing a publicly-available software model capable of "evaluat[ing] the benefits of battery storage for multiple grid applications, including energy arbitrage, balancing service, capacity value, distribution system equipment deferral, and outage xmitigation." Similarly, Jannesar, Kalantar, and Barband (2014, p. 1) propose an analysis technique for determining optimal distribution feeders for installing battery storage, and the best battery storage chemistry to use, based on economic analysis of key factors, including "daily load, rated [distribution line] capacity, load growth, electricity sales tariffs for various consumers and length of feeders." Balducci, Jin, et al. (2013) also demonstrate a screening methodology that can be used to identify promising sites for locating storage resources, based on six criteria including "value assessment, travel time to the site, barriers to land permitting, operational priorities, communication expense, and community interest." Plus, Osterhus and Ozog (2014) propose a method for calculating a distribution marginal price (DMP), similar to the transmission-level locational marginal price (LMP). The DMP model would most accurately and transparently assess the true cost to the utility for both supply-side and grid costs, by customer and specific grid location. And, Haley, Cutter, et al. (2014) use a backcasting model to analyze the benefits that storage might provide by reviewing historical day-ahead and real-time historical costs in the California ISO market. The backcasting technique shows promise for more precisely defining system needs, identifying and comparing the characteristics and capabilities of different technologies for meeting those needs, and producing cost metrics for comparing storage to other competing resources on the basis of cost of new entry (CONE).

Until such modeling techniques are more fully developed and verified, and then the operating characteristics of storage options are included in readily-available IRP modeling software, commissions could initiate action by directing utilities to use the best available practices in investigating opportunities for cost effective storage. Another proxy approach that can be utilized now is to carefully review the performance of demonstration or pilot projects, to compare them to peaking generators on the basis of cost and performance.

Commissions could also initiate action by directing utilities to test markets by issuing requests for proposals (RFPs) for technologies to meet specific, identified needs. The needs could be for services in any circumstance where storage could be a cost-effective, full or partial solution, for meeting any combination of generation, transmission, and distribution system requirements (Akhil, Huff, Currier, et al., 2013, Chapter 3). Primary examples could be exploring options for meeting peaking power needs or to investigate non-transmission alternatives (NTAs). In this context, however, it is important for an RFP to describe basic needs, and then allow ample flexibility for prospective vendors to propose various technologies and means of meeting those needs. Akhil, Huff, Currier, et al. (2013, p. 135) describe this as "latitude for variation." Flexibility is important because business models for storage are continuing to adjust and evolve in response to regulated and unregulated markets (Masiello, Roberts, and Sloan, 2014) and, as Ecofys (2014, p. 1) explains,

> Many of the services provided by energy storage are available through other means, including: improved markets (bigger, faster, more liquid); demand management programs; more flexible and efficient conventional generation; and smarter controls on renewable resources. Energy storage must compete with these alternatives, but may be the most economical alternative in many situations.

B. Implementing storage as a customer-sited resource

Customer-sited, behind-the-meter storage equipment most immediately implicates state commission retail ratemaking practices and tariff designs. Commissions can consider rate designs that best reveal the avoided costs that storage facilities can produce for retail customers. For example, increasing numbers of customers are applying storage solutions in response to opportunities to reduce demand charges, while providing additional customer value, most notably through backup and emergency capabilities. Depending on rate design, avoided demand charges alone could create sufficient financial benefits to warrant installing some storage. Plus, time differentiated rates such as time of use, hourly, or critical peak pricing create incentives for operating storage so that energy charges are reduced as much as practical.

A subsequent step for tariff design could be, as a handful of states are presently exploring (see Appendix A), to allow storage to be deployed in microgrid developments serving multiple end-use customers. That would mean enabling wholesale or retail sales, or both, from storage facilities, along with other microgrid generation facilities (see Bower, Ton et al., 2014, p. 42).

C. FERC actions to include storage in wholesale markets

The Federal Energy Regulatory Commission (FERC) has already taken some actions to facilitate inclusion of storage resources in wholesale electricity markets. FERC Rules 719, 745, 755, and 1000 all create opportunities for storage to provide and be compensated for delivering value to wholesale electricity markets (Akhil, Huff, Currier, et al., 2013, pp. 132-133).[1] Thus, in states with restructured electric markets ample opportunities already exist for storage to produce and deliver wholesale power services. (Tweed, 2014). Smaller, customer-sited or distribution system storage is likely to require aggregation, in order to reach a combined size large enough to offset the costs of wholesale market participation. Already, some companies are building business models for aggregating service, which can allow small storage systems to receive payments for producing and delivering wholesale ancillary services.

D. Mandating storage

Finally, similar to what California is doing in response to state legislation or along the lines of what the Puerto Rico public regulatory commission has initiated (see Appendix A), states could begin implementing storage using a proactive, mandatory approach. That could mean setting a minimum requirement for storage capacity or a budget to be spent on storage, with specific facility decisions determined by competitive bidding processes. The object would be to assume that there must be some opportunities for cost-effective energy storage in each utility service territory, but there are obstacles to deployment that need to be overcome. Examples of some of the obstacles to be addressed include long-standing institutional preferences in utility procurement, the lack of widespread, standardized modeling techniques, and financing risk premia. Functionally, a mandatory approach to acquiring storage is similar to other resource portfolio standards provisions, where a performance goal or spending target is set and then competitive markets are used to help achieve the best performance for the most reasonable price.

Some caution is warranted in estimating the life-cycle utility-system benefits storage will achieve. Theoretically, each additional unit of storage tends to reduce the marginal value of costs that storage can reduce or avoid. This is similar to other demand-side options and distributed resources, where avoidable costs tend towards the average, as the quantities deployed increase. Detailed modeling of utility system operations and costs over time will be required in

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[1] A May 23, 2014 ruling in case number 11-1486, by the U.S. Court of Appeals, District of Columbia Circuit, vacated FERC Rule 745 in its entirety, based on a finding that the rule encroached on the states' exclusive jurisdiction to regulate the retail market. The decision was directed towards customer demand-response, however, and it is not entirely clear what the long-term effects might be on electricity storage participating in wholesale or retail markets (Tweed, 2014).

order to assess the quantities of storage necessary to trigger this effect in each operating area. Some promising approaches to such modeling are described in Part IV of this report.

E. Storage in the broader context of electricity industry transition

In addition to these policy actions that would be directly related to storage, more wide-ranging regulatory changes could be coming as a result of related technological and market factors. Hawaii, Massachusetts, and New York public utility regulatory commissions have initiated actions designed to usher in serious communications among utilities, all interested parties, and regulators, about possible future paradigms for business models, industry structures, and regulatory oversight. These are all similar actions intended to place all parties on notice that important changes are in the offing. These actions reflect the opportunity to think not just about energy storage, but comprehensively about business models and associated regulatory policies capable of simultaneously advancing all technology and market options that can prove useful in achieving the most reliable and resilient electricity infrastructure at reasonable cost.

Hawaii PUC (2014, p. 7) directs regulated electric utilities to "continue to evaluate opportunities to retire and replace older, high-cost plants with new resources with valuable characteristics that provide required support services cost-effectively to maintain a reliable electricity grid with high levels of renewable resources." Hawaii PUC's message to electric utilities specifically mentions storage several times, in the contexts of IRP (pp. 8, 9, 11), planning for non-transmission alternatives (pp. 12-13, 16), smarter grid deployment (pp. 13-14, 17), unbundling and redesigning rates and tariffs (pp. 8, 25-26, 27), and developing "virtual power plants" and "integrated energy districts" (pp. 11, 12-13, 14).

Massachusetts Department of Public Utilities (2014) issued an order that "establishes the platform and the incentives for utilities and other businesses to innovate and invest in new technology, to continue to upgrade… current infrastructure, and to increase the use of renewable energy, electric cars, energy storage, and microgrids." Each electric distribution company is directed "to submit a ten-year grid modernization plan... ." (Order, pp. 1-2). These grid modernization plans (GMPs) are to include proposals for "a portfolio of projects that could include…energy storage, vehicle-to-grid, and software and hardware tools that optimize system planning and management." The utilities are directed "to participate as appropriate in relevant state and regional efforts to advance such technologies," with the expectation that "this approach will lead to a significant increase in RD&D efforts for new technologies… and, as a result, considerable benefits to ratepayers" (Order, p. 28). The companies are directed to solicit stakeholder input and integrate that input into their GMPs (Order, p. 51).

New York Department of Public Service (2014) issued an order initiating a procedure intended to "align electric utility practices and our regulatory paradigm with technological advances… ." New York DPS (Order, p. 2) asks:

1. What should be the role of the distribution utilities in enabling system wide efficiency and market-based deployment of distributed energy resources and load management?

2. What changes can and should be made in the current regulatory, tariff, and market design and incentive structures in New York to better align utility interests with achieving our energy policy objectives?

As a prelude to this proceeding in New York, a DPS Staff *Report and Proposal* (2014) cites some of the many ways that energy storage is fast becoming one of the most important game-changers in the electric utility industry. DPS Staff (2014, p. 6) points out that commodity storage is typically an important part of any efficient market and notes that its absence, among other factors, "has been tolerated in electricity markets, but at a cost." DPS Staff (2014, p. 7) further notes that storage is one of the distributed-resource technologies that is presently improving in efficiency while declining in cost. DPS Staff (2014, p. 8) points out:

> It is technically feasible to integrate energy-consuming equipment, as well as distributed generation and storage, fully into the management architecture of the electric grid. The purpose of this inquiry is to examine how the distributed grid architecture that is now technically feasible can be achieved on a wide scale.

Thus, New York DPS Staff (2014, pp. 11-12) calls for development of a new distributed system platform provider (DSPP) model, for modernizing electric utility distribution systems "to create a flexible platform for new energy products and services, to improve overall system efficiency and to better serve customer needs." New York DPS Staff (2014, p. 14) explains:

> Storage is expected to play an essential role in DSPP planning. … [T]he DSPP in conjunction with market participants will identify economic applications of storage, including facilitation of clean intermittent generation.

As these efforts indicate, energy storage technologies are but one among several important changes affecting the business paradigm for electric utilities and all interested parties. Possible changes are related to all kinds of: distributed energy resources; greatly increased customer engagement, demand response and load management; efficient operations of increasing quantities of renewable, variable-output electric generation; greatly increasing energy data analytics; and, perceived needs for increasing grid resiliency and reliability. Such changes are widely perceived as being at least "evolutionary" (DNV-GL, 2014; Harvey and Aggarwal, 2013; Lehr, 2013; Navigant Consulting, 2010) if not "revolutionary" (Fox-Penner, 2010; Galvin and Yeager, 2009; Ustun, Ozansoy, and Zayegh, 2011). Either way, state public utility regulatory commissions will play a key role in any pending electric industry transition.

IV. Recommendations for future research and conclusion

It appears that energy storage is reaching a tipping point, where many technology options offer attractive combinations of improved performance and lower cost. Two key areas remain, though, where ongoing research, including carefully targeted learning-by-doing, can help bridge the remaining gaps between potential opportunities and practical, fully cost-effective applications. Promising research topics include: (1) better understanding how consumer loads might be shaped so that storage can be combined with smarter grid metering, monitoring, and control technologies to leverage the maximum amount of cost-saving opportunities; and (2) improved IRP modeling tools that can more precisely determine when and where storage can provide the greatest system benefits.

A. Research on shaping consumer loads

Consumer demands could be much more adjustable than is presently understood. Taneja (2013, p. 6) talks about "changing the paradigm from load-following supplies to supply-following loads." Taneja (2013, p. 64) cites "research on adapting loads to become flexible consumers of power, including work in data centers, electric vehicles, and home appliances, among others." These are among the targets for future smarter-grid implementation, where energy-consuming operations and appliances could have embedded intelligence that allows some consumer usage to be advanced or delayed in time, depending on grid conditions. Loads already being considered for such smarter operations include "clothes washers and dryers, dishwashers, irrigation, and more" (Taneja, 2013, pp. 74-75). Promise is also shown for joint infrastructure planning, for water and wastewater systems combined with the electricity system. And, "appliances with thermal storage (HVAC, refrigeration and freezing), and devices with battery storage (laptops)" could also be candidates for intelligent integration with the utility grid. (Taneja, 2013, pp. 97-101). The eventual promise could be for an electric grid with a lower total cost of service, supported by "continuous demand response" (Tenaja, 2013, p. 101) and "transactive energy" (Barrager and Cazalet, 2013). Some electricity and thermal storage capability could prove pivotal in enabling that kind of future.

B. Strengthening IRP modeling tools

IRP modeling tools need updating and possibly expanding, in order to accurately review how energy storage systems could operate to reduce system costs. A Navigant Consulting (2014a, p. v) review of IRP modeling reveals:

> The increasing interest in energy storage highlights the urgent need to properly value, integrate, and operate energy storage systems. However, given the limited role that energy storage historically has played in the electric system, many of the traditional utility planning models were not designed to fully assess energy storage alternatives. For energy storage to become widely and cost-effectively adopted, it is critical that stake-holders have the tools and models needed to make informed energy storage decisions.

A particular need in the foreseeable future will be for comprehensive, dynamic modeling techniques that can readily use the greatly increased flow of usage data from smart meters at the substation or distribution feeder level, if not all the way to the microgrid or individual customer level (Bower, Ton, et al., 2014; Elster Solutions, 2014). Lu, Warwick, et al. (2014) demonstrates one simplified modeling approach that shows some promise towards meeting that goal.

C. Conclusion

This report provides only a brief survey of issues affecting energy storage. It is certainly not the last word on the subject, which deserves continued attention. As more experience is gained, modeling and forecasting techniques improve, and technological and manufacturing and value-chain improvements appear, the potential roles for energy storage in providing cost-effective services ought to become clearer. In the meantime, state commissions can begin taking modest steps to help reduce the barriers to such progress.

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Appendix A:

Summary of U.S. State and Territory Energy Storage Policy and Implementation Activities

This Appendix presents a brief summary of U.S. state and territory actions supporting implementation of energy storage. The various actions are cataloged and available sources are provided so that readers can learn more about areas of interest. Not all of the action types involve state regulatory commissions, however. For example, regulatory approvals are not needed for many demonstration projects, state legislation does not always include regulatory provisions, and research and development centers and tax or other financial incentives almost always operate outside of state regulatory arenas.

In addition to the state actions summarized here, some federal actions deserve mention. These include: (a) grants under the American Reinvestment and Recovery Act (ARRA); (b) grants under the Advanced Research Projects Agency – Energy (ARPA-E); (c) new hydropower regulations; and (d) tax incentives.

ARRA – Many electricity storage projects were funded by the U.S. DOE under the American Reinvestment and Recovery Act of 2009.[1] ARRA-funded energy storage activities were primarily supported through the Smart Grid Regional and Energy Storage Demonstration Projects.[2]

ARPA-E – The major project areas for storage included in ARPA-E to date include Advanced Management and Protection of Energy Storage Devices (AMPED), Batteries for Electrical Energy Storage in Transportation (BEEST), Grid-Scale Rampable Intermittent Dispatchable Storage (GRIDS), High Energy Advanced Thermal Storage (HEATS), and Robust Affordable Next Generation Energy Storage Systems (RANGE).[1] In 2015, DOE plans to offer $150 million in awards and "funding opportunities" for technologies related to transportation fuels and energy storage (among others) through an open funding solicitation.

New Hydropower Regulations – New federal regulations seek to expedite approvals for some projects that could be operated to facilitate the blending of variable output wind and solar resources, including some pumped storage hydro projects. Bloomberg New Energy Finance (2014, p. 50) notes:

> [T]he Hydropower Regulatory Efficiency Act of 2013 and the Bureau of Reclamation Small Conduit Hydropower Development and Rural Jobs Act… seek to expedite the licensing of certain types of hydropower projects, including small and conduit projects,

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1 http://energy.gov/oe/information-center/recovery-act

2 http://arpa-e.energy.gov/?q=arpa-e-site-page/view-programs Many of the projects funded through ARRA and ARPA-E are included in the U.S. DOE Global Energy Storage Database (http://www.energystorageexchange.org/).

closed-loop pumped storage and the addition of hydropower generation the nation's existing non-powered dams.

Federal Tax Incentives – The manufacturing of energy storage systems for use with electric vehicles and renewable energy resources has been eligible for advanced energy manufacturing project tax credits, under 26 U.S.C. § 48C. A 30% investment credit has been available for qualifying advanced energy projects, including energy storage systems, but after being fully allocated in 2013, it has effectively expired. Of the total $2.3 billion appropriated, about $30.4 million was allocated to electrical storage projects and $600,000 to electric vehicle battery storage.

In addition, federal legislation, an Energy Storage Act, was introduced but never passed. The bill would have offered tax credits for energy storage. Provisions would include: (a) a 20% tax credit through 2020 for investment in energy storage property; (b) making energy storage property eligible for new clean renewable energy bond (CREB) financing; (3) allow a 30% tax credit for investment in energy storage property used at the site of energy storage; and (4) allow a 30% nonbusiness energy property tax credit for installation of energy storage equipment in a principal residence.

State actions are catalogued under these headings:

- **Active Dockets** – Cases before a state public utility commission that include specific storage-related issues, where final orders have not yet been issued.

- **Completed Dockets** – Cases before a state commission that include specific storage-related issues and where final orders have been issued.

- **Demos, Pilots** – Active demonstration and pilot projects identified in the U.S. Department of Energy *Global Energy Storage Database*.[3]

- **IRP** – States having explicit requirements to study energy storage or storage related capabilities in utility integrated resource planning (IRP) proceedings.[4]

- **Proposed Legislation** – Bills introduced and actively before state legislatures, which address energy storage.[5]

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[3] U.S. DOE *Global Energy Storage Database* (www.energystorageexchange.org/). In addition, some projects were identified through information provided by state PUC commissioners and staff, from trade publications, and from documents and sources provided by the U.S. DOE-funded *Energy Storage Technology Advancement Partnership* (ESTAP), which is a project of the Clean Energy States Alliance (www.cesa.org/projects/energy-storage-technology-advancement-partnership).

[4] A primary source for this information is the U.S. DOE Database of State Incentives for Renewables & Efficiency (DSIRE, www.dsireusa.org). Some state PUC commissioners and staff also provided supplemental information.

- **Microgrids (M), Plug-In Vehicles (PEVs)** – Listing explicit PUC actions towards developing microgrids with energy storage capabilities and programs to promote the use of plug-in electric vehicles, with a focus on grid integration and storage.

- **R&D Centers** – Listing states with state-sponsored research and development facilities and advanced energy technology business incubator facilities.[6]

- **RPS** – Where a state renewable portfolio standard (RPS) or other renewable or clean energy standard includes specific provisions supporting energy storage.

- **Storage Mandates** – Where utility commissions are directing utilities or independent power producers to procure and integrate electricity storage facilities.

- **Tax Credits, Financial Incentives** – Where credits or incentives are explicitly designated for energy storage projects or energy storage manufacturing facilities.

- **Working Groups** – Where states are engaged in collaborative working group discussions aimed at better understanding energy storage and developing a policy action agenda.[7]

A checklist of the states and these actions is presented in Table A-1, and brief summaries by state follow.

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[5] The primary source for this information is the Advanced Energy Legislation Tracker database, maintained by the Center for a New Energy Economy (www.aeltracker.org).

[6] States are listed here only if the state is an active partner or major sponsor of R&D or business incubator facilities. Other states not listed here are home to university or private sector electricity storage R&D activities and some have business incubator activities sponsored by local governments or other entities.

[7] States are listed here only if at least one state government agency is an active partner in a collaborative working group that is tackling energy storage issues, or if a state agency has sponsored a major energy storage workshop, or both. In addition, industry associations in some states are working on storage issues, including the California Energy Storage Alliance (http://www.storagealliance.org/content/about-us) and Texas Energy Storage Alliance (http://energystorage.org/energy-storage/industry-resources/tesa).

Table A-1: Summary of U.S. State and Territory Energy Storage Policy and Implementation Activities

State/ Territory	State/Territory Storage Activity Type										
	Active Dockets	**Completed Dockets**	**Demos, Pilots (#)**[1]	**IRP**	**Proposed Legislation**	**Microgrids (M), Plug-In Vehicles (PEV)**[2]	**R&D Centers**	**RPS**	**Storage Mandates**	**Tax Credits, Financial Incentives**	**Working Groups**
Arizona	✓		✓ (7)								✓
California		✓	✓ (125)		✓	M, PEV	✓	✓	✓	✓	
Colorado			✓ (8)	✓			✓				✓
Connecticut			✓ (3)			M, PEV				✓	
Florida		✓	✓ (3)			PEV					
Hawaii	✓		✓ (15)	✓		M, PEV		✓		✓	
Iowa	✓		✓								
Kansas								✓			
Maine			✓(1)			M, PEV				✓	
Maryland			✓(2)			M, PEV				✓	✓
Massachusetts	✓		✓(5)			M, PEV		✓			
Michigan			✓(8)			PEV	✓	✓			
Minnesota			✓(11)	✓		M, PEV				✓	
Montana								✓			
New Jersey		✓	✓(5)			M	✓			✓	✓
New Mexico			✓(5)								✓
New York	✓		✓(25)		✓	M, PEV	✓			✓	
Oregon	✓		✓(2)	✓	✓	PEV					✓
Puerto Rico								✓	✓		
Vermont	✓		✓(2)	✓		PEV	✓			✓	

[1] See Table Notes on next page.

State/ Territory	State/Territory Storage Activity Type										
	Active Dockets	**Completed Dockets**	**Demos, Pilots (#)[1]**	**IRP**	**Proposed Legislation**	**Microgrids (M), Plug-In Vehicles (PEV)[2]**	**R&D Centers**	**RPS**	**Storage Mandates**	**Tax Credits, Financial Incentives**	**Working Groups**
Washington			✓(7)	✓	✓	PEV		✓		✓	✓
West Virginia		✓	✓(4)					✓			
Wisconsin					✓						✓

[1] Source: U.S. DOE *Global Energy Storage Database*, http://www.energystorageexchange.org/projects. Only states reporting at least one additional activity type are included in this table, and only selected Demo and Pilot projects listed in the *Global Energy Storage Database* are included in the brief descriptions that follow. Numbers in parentheses represent the count of projects in each state that are included in the DOE *Global Energy Storage Database.* States and Territories with demonstrations and pilots that are not listed in this table include: Alabama (1 project), Alaska (5 projects), Arkansas (1), Delaware (1), Georgia (4), Illinois (6), Indiana (2), Kentucky (1), Missouri (6), Nevada (8), New Hampshire (1), North Carolina (8), Ohio (6), Oklahoma (2), Pennsylvania (16), South Carolina (3), Tennessee (6), Texas (19), Utah (3), and Virginia (5). States not listed either in the table or here have no currently-identified demonstrations or pilot projects.

[2] Eight states are participating in a Zero Emissions Vehicles (ZEV) Action Plan: California, Connecticut, Maryland, Massachusetts, New York, Oregon, Rhode Island and Vermont (http://www.nescaum.org/topics/zero-emission-vehicles). Rhode Island is not listed in this Table. Michigan also has some PEV tariffs and Minnesota has directed utilities to offer PEV tariffs, but those states are not participating in the ZEV Action Plan.

Arizona

- **Active Dockets:** In Dockets 11-0229 and 13-0168, Navopache Electric Coop requests approval of a load control program, proposed to include electric thermal storage (ETS).
  http://edocket.azcc.gov/edocket/

- **Demos, Pilots**:

  - Solana is a 280MW parabolic trough concentrating solar power (CSP) project with up to about six hours of storage capacity.

  - Ice-storage is used at University of Arizona, integrated with the campus combined heat and power generators. This system has been operating successfully for several years already.

  - Lead-acid batteries installed at an Arizona Public Service substation provide about 1MW of uninterruptible power supply, dedicated to serving a microelectronics manufacturing plant.

  - In 2001 an ice storage system was installed to provide chilled water to Chase Field, home of the Arizona Diamondbacks baseball team, and other Phoenix central business district buildings. The district energy system includes four miles of pipes, serving more than 12 million square feet of building space.

- **Working Group**: Arizona Research Institute for Solar Energy (AZRISE) is hosting an Energy Storage Initiative, with a broad membership base including utilities and the Arizona Corporation Commission.
  http://www.azrise.org/azrise-research-overview/azrise-energy-storage-initiative/

California

- **Completed Dockets:**

  - Rulemaking 10-12-007 (see discussion under Storage Mandates, below).

  - Docket 12-EPIC-01 is about California's "Electric Program Investment Charge." CPUC Decision 12-05-037 for Rulemaking 11-10-003 established the EPIC framework, including funding opportunities for several storage-related projects.
    http://www.energy.ca.gov/research/epic/

  - Rulemaking 12-11-005 exempts storage devices used with current net metering tariffs "from interconnection application fees, supplemental review fees, costs for distribution upgrades, and standby charges."
    http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M091/K247/91247687.pdf

- **Demos, Pilots:**
    - Alameda County is home to a microgrid demonstration at the Santa Rita Jail, which includes a 2MW advanced energy storage system.
    - California's largest energy storage project is the 1.3GW Eagle Mountain Pumped Hydro Storage project.
    - California is currently constructing a 150MW solar molten salt storage facility, expected to power 68,000 homes.
- **Pending Legislation:**
    - Proposed legislation, AB-1258, would require technical analysis of the potential for existing hydroelectric and pumped storage facilities, as specified, to provide additional operational flexibility that could facilitate the integration of eligible renewable energy resources for the state's electrical grid. http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB1258
    - Proposed legislation, AB-66, would direct CPUC to require electric utilities to publish service reliability data, including the "frequency and duration of interruptions [and] … areas with both the most frequent and longest outages." http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB66
- **Microgrids and PEVs:**
    - The CPUC published a white paper stressing the growing importance of microgrid technology and advising the legislature to consider microgrid policy. http://www.cpuc.ca.gov/NR/rdonlyres/01ECA296-5E7F-4C23-8570-1EFF2DC0F278/0/PPDMicrogridPaper414.pdf
    - California was the first and is now one of eight states implementing a Zero-Emission Vehicles (ZEV) Action Plan. The project includes implementation actions for the California Public Utilities Commission and utilities (California, 2013; White, 2014). Together, CPUC, California Independent System Operator (CAISO) and California Energy Commission (CEC) issued a Vehicle-Grid Integration Roadmap (2014), setting forth a plan for enabling electric vehicles to provide grid services. http://www.caiso.com/Documents/Vehicle-GridIntegrationRoadmap.pdf
- **R&D Center:** The California Energy Commission's Public Interest Energy Research (PIER) program funds much of the state's energy storage research. UC-Berkeley, UCLA, and UC-SD all have ongoing energy storage research. http://www.energy.ca.gov/2011publications/CEC-500-2011-047/CEC-500-2011-047.pdf

- **RPS:** California's storage mandate is a provision of the state's RPS.

- **Storage Mandate:**

  - California AB2514 requires the CPUC and publicly owned utilities to evaluate procurement targets for energy storage. http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200920100AB2514

  - Under Rulemaking 10-12-2007, pursuant to AB2514, the CPUC mandated the states three largest investor-owned utilities to implement 1.3 GW of grid storage in California by 2020, the first energy storage mandate in the nation. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M078/K929/78929853.pdf

- **Tax Credits, Financial Incentives:** California's Self-Generation Incentive Program (SGIP) includes advanced energy storage systems. http://www.cpuc.ca.gov/PUC/energy/DistGen/sgip

Colorado

- **Demos, Pilots:**

  - A 1.5MW advanced lead-acid battery is integrated with solar PV at the Solar Technology Acceleration Center (SolarTAC). The system provides ramp control, frequency response, voltage support, and firming for solar power. See Docket No. 11A-713E.

  - Colorado is home to several ice thermal storage projects, ranging in capacity from 24kW to 200kW and serving school and university facilities, the FortZED (Zero Energy Development) microgrid in Fort Collins, and a temperature-sensitive manufacturing process.

  - Three open-loop pumped-storage hydro facilities are being operated in Colorado. They range in size from 8.5MW to 324MW and provide time-shifting arbitrage, VAR support, spinning reserve, and wind energy integration.

- **IRP:**

  - In Docket No. 11A-869E, the Public Service Company of Colorado (PSCO) 2011 quadrennial resource plan application, the Commission approved 450 MW of wind and 170 MW of solar PV. Bids evaluated in this docket included concentrating solar with thermal storage and battery storage, but they were not approved. The Commission directed the utility to "investigate potential storage options for its electric system and present… a report to the Commission" by September 20, 2014.

- Docket No. 07A-447E is PSCO's 2007 quadrennial resource plan application. Storage bids evaluated in this proceeding included concentrating solar with thermal storage, compressed air energy storage, battery storage, and pumped hydro storage. The PUC approved a proposed 250MW concentrating solar system, including thermal storage, but that unit has not been constructed, due to transmission limitations.

- **R&D Centers:** The *Energy Storage Research Group* (ESRG) at University of Colorado at Boulder is funded in part by the Colorado Governor's Office. This research group filed a report on energy storage in Colorado PUC Docket No. 07A-447E (discussed below). Another report at the ESRG website covers smart grid developments in Colorado, including the Smart Grid City project in Boulder, which is the subject of PUC Docket No. 10A-124E.
 http://www.colorado.edu/engineering/energystorage/
http://www.colorado.edu/engineering/energystorage/files.html

- **Working Groups:** Colorado PUC Commissioners held an *Information Meeting* on March 10, 2011, about *Utility Scale Energy Storage*. Presentations about Energy Storage Fundamentals, Compressed Air Energy Storage, Pumped Hydro, Batteries, and Dispatchable Distributed Storage are indexed in the Commission's Electronic Filings system, in Docket No. 11M-001AGENDA.

Connecticut

- **Demos, Pilots:**

  - Iron Edison, a battery manufacturer, manages a 20 kW nickel-iron battery storage project in Danbury, which serves an off-grid renewable energy system.

  - The Rocky River Pumped-Storage Hydro Plant in New Milford, CT, is a 29MW facility managed by Connecticut Power & Light Co. It was originally commissioned in 1929, and is thought to be one of the oldest pumped-storage hydro units in the country.

- **Microgrids:** Under Public Act 12-148, Connecticut sponsors a Microgrids Grant & Loan Pilot Program for public purpose microgrids.
http://www.ct.gov/deep/cwp/view.asp?a=4120&Q=508780

- **Tax Credits, Financial Incentives:** The Connecticut Clean Energy Fund, disbursing about $20 million annually, includes funding eligibility for thermal storage systems.
http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=CT03R&re=0&ee=0

Florida

- **Completed Dockets:** Duke Energy Florida offers rebates for commercial thermal energy storage systems. https://www.progress-energy.com/assets/www/docs/business/eit-thermal-energy-sheet-fl.pdf

- **Demos, Pilots:**

  - A 25 kW zinc-bromide flow battery is being installed in conjunction with a solar PV array, for use in load management and peak shaving.

  - Florida is home to one 3MW chilled water system and another 4.8MW ice system, providing thermal storage for district cooling. The ice thermal storage system at a retirement village is also integrated with emergency back-up generation that can power the pumps to provide cooling for up to 24 hours, in the event of a grid outage.

- **Microgrids, PEVs:** In December 2012, as directed by the Florida Legislature in HB 7177, Chapter 2012-117, FPSC submitted a report on the potential impacts associated with electric vehicle charging, including off-grid solar PV charging. An FPSC Staff workshop on PEVs was included in the research for this report. http://www.floridapsc.com/utilities/electricgas/electricvehicles/09_06_2012/

Hawaii

- **Active PUC Dockets:**

  - Energy storage is anticipated to be a key element in Power Supply Improvement Plans (PSIPs) for Hawaii's investor owned utilities. Those are currently in separate dockets but will be consolidated into a single docket for review. In addition, energy storage is likely to be an important resource in the Distributed Generation Interconnection Plan (DGIP) ordered under the Reliability Standards Working Group docket (2011-0206). http://dms.puc.hawaii.gov/dms/

  - Two Hawaii utilities have issued solicitations for procuring storage. HECO has issued a Request for Proposal (RFP #072114-01) for 60 to 200 MW of energy storage for Oahu, with proposals due 21 Jul 2014. Kauai Island Utility Cooperative (KIUC) issued its RFP for Energy Storage / Dispatchable Renewable Energy on 3 Mar 2014, with written responses due 18 Apr 2014. http://www.heco.com/heco/Clean-Energy/Clean-Energy-Generation/Competitive-Bidding-for-New-Generation http://website.kiuc.coop/content/rfp-energy-storage-dispatchable-renewable-energy

- **Completed PUC Dockets:**
  - Hawaii PUC Order 31901, dated 31 Jan 2014, directs Hawaii's investor owned utilities to include in net metering rules a clarification, stating that "a customer that installs a battery back-up system must also obtain an interconnection review…to ensure…proper interconnection" (Order, pp. 10-11).
  - Hawaiian Electric Company (HECO) evaluated energy storage in its recent resource plan case. The Commission rejected the utility's proposal, but energy storage was evaluated.
- **Demos, Pilots:**
  - Five projects using advanced lead-acid batteries from 1.5MW up to 15MW are demonstrating the use of battery storage to firm wind and solar facilities, provide power ramping management, and reduce the need to curtail variable output renewable energy.
  - Six Lithium battery technologies are demonstrating different services, including integrating with a microgrid and demand response to reduce peak loads at a utility substation, combining a level-2 PEV charging facility with a nearby solar array, performing ramping management and supporting grid integration for one wind farm and two solar arrays, and running an off-grid commercial scale water pumping system.
  - A 1.2 MW ice thermal storage project is providing load-shifting for a major department store.
  - A concentrating solar power, parabolic trough system uses thermal storage to firm a 2 MW solar project.
  - Two redox flow battery projects are being integrated with customer-sited solar PV and other on-site alternative energy sources, plus demand management.
- **IRP:** Hawaii PUC has issued a series of orders, that collectively provide key policy, resource planning, and operational directives to the Hawaiian Electric Companies (HECO Companies), including implementation through future IRP cases. http://puc.hawaii.gov/news-release/puc-orders-action-plans-to-achieve-states-energy-goals/
- **Microgrids, PEVs:**
  - Hawaii State Energy Office supports EV charging infrastructure throughout the state. The Maui EV Alliance supports EV planning activities on Maui. Hawaii was the first state in the U.S. to establish special license plates for EVs. These

will help any first responders, who must use special precautions in case of accidents involving EVs, and the plates exempt EVs from many parking fees and entitle EVs to the use of high-occupancy vehicle lanes. Hawaii also has provisions requiring places of public accommodation with over 100 parking places to include at least one space reserved for EVs and equipped with a charging station.
http://energy.hawaii.gov/testbeds-initiatives/ev-ready-program
http://energy.hawaii.gov/testbeds-initiatives/ev-ready-program/laws-incentives
http://maui.hawaii.edu/eva/home/

- Camp Smith, in Central Oaho, is part of the federal multi-agency Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) program. A microgrid project is proposed for Schofield Barracks. On the Big Island, Parker Ranch has proposed building a microgrid to serve residents in the Waimea/Kohala area. The effort is called Paniolo Power Company ("paniolo" is the Hawaiian language word for "cowboy").
https://share.sandia.gov/news/resources/news_releases/spiders/
www.paniolopower.com

Iowa

- **Active Dockets:** In January 2014, Iowa Utilities Board initiated Docket No. NOI-2014-0001, *Inquiry on Distributed Generation and Soliciting Comments*. The Docket is open for considering all "policy and technical issues" associated with distributed generation, including energy storage.

- **Demos, Pilots:** The Iowa Stored Energy Park was planned to be an innovative, 270 Megawatt, $400 million compressed air energy storage (CAES) project. After eight years in development the project was terminated because of geological limitations. However, much was learned about developing a utility-scale, bulk energy storage facility and coordinating it with regional renewable wind energy resources in an Independent System Operator (ISO) marketplace. A Sandia National Laboratories report (Schulte et al., 2012, *Lessons from Iowa*, Report No. SAND2012-0388) provides details about the project and lessons learned.
http://www.sandia.gov/ess/publications/120388.pdf

Kansas

- **RPS:** The Kansas *Renewable Energy Standards Act* (Section 66-1257) was amended in April 2012 to include storage connected to any renewable generation, "including, but not limited to, batteries, fly wheels, compressed air storage and pumped hydro."
http://www.kslegislature.org/li/b2013_14/statute/066_000_0000_chapter/066_012_0000_article/066_012_0057_section/066_012_0057_k/

Maine

- **Demos, Pilots:** VCharge Maine ATLAS (Aggregated Transactive Load Asset) is a distributed, aggregated thermal storage resource, with thermal storage equipment installed and operating in multiple Portland, Maine, residences. The project demonstrates frequency regulation, electric energy and renewable energy time shifting, and reliability improvements.
http://goodcleanheat.com/service/#maine

- **Microgrids, PEVs:**

    - Maine Public Utilities Commission presently has an open docket in Case No. 2011-00138, regarding a request for approval for non-transmission alternative (NTA) pilot projects for specific areas in the Central Maine Power Company (CMPCo) service territory. Proposals under consideration include storage facilities. See docket document no. 153, *Interim Report, Boothbay Smart Grid Reliability Pilot Project*.
    http://www.maine.gov/mpuc/online/documents.shtml

    - CMPCo includes electric vehicles in its own fleet, and offers an EV grant program to commercial customers in the Portland, Maine, area.
    http://www.cmpco.com/electricvehicles/

- **Tax Credits, Financial Incentives:** CMPCo offers rates for electric thermal storage (ETS), with fixed- or variable-price options. CMPCo also offered an ETS rebate program to help customers deploy ETS equipment, but it expired at the end of 2013.
http://www.cmpco.com/ETS/
http://www.cmpco.com/ETS/SeparateMeters.html

Maryland

- **Demos, Pilots:** Maryland is home to two lithium-ion battery projects. In Laurel, MD, a 300kWh battery is integrated with a PV system and PEV charging stations. In Rockville, MD, a 10kW battery is part of a software system *Distributed Energy Management & Aggregation Platform* for better integrating distributed generation with smart-grid strategies.

- **Microgrids, PEVs:** In February 2014, Maryland Governor Martin O'Malley formed a *Resiliency Through Microgrids Task Force*, staffed by the Maryland Energy Administraiton, to study the statutory, regulatory, financial, and technical barriers to the deployment of microgrids in Maryland. The Task Force report, which includes some recommendations relevant to energy storage, was published in June.
http://energy.maryland.gov/MicrogridsandGridResiliencyinMaryland.htm

- **Tax Credits, Financial Incentives:** Maryland Energy Administration manages a Game Changer Program that provides Energy Innovation Competitive Grants. A 2013 grant is supporting an islandable, solar microgrid project including an advanced energy storage system for operating in the event of a conventional power grid outage. http://energy.maryland.gov/Business/gamechanger/

- **Working Groups:** Maryland has a *Clean Energy Center*, created in response to state legislation and with a board appointed by the Governor. The Center is a public corporation designed to encourage the development and deployment of clean energy technologies. It includes a *Maryland Clean Energy Technology Incubator Program*. One of the Center's major areas of interest is energy storage. The Center supports research and development, and offers financial incentives.
http://mgaleg.maryland.gov/2008rs/bills/hb/hb1337e.pdf
http://www.mdcleanenergy.org/about_us

Massachusetts

- **Active Dockets:** In its June 12, 2014, Order in Case No. D.P.U. 12-76-B, Massachusetts Department of Public Utilities opened an *Investigation… into modernization of the electric grid*. Energy storage is one of the technologies expected to provide enhanced reliability and resiliency in the future.
http://www.mass.gov/eea/energy-utilities-clean-tech/electric-power/grid-mod/grid-modernization.html

- **Demos, Pilots:**

  - Two zinc-bromide flow batteries are being developed in Massachusetts. One will be integrated with a solar PV array and another with a wind turbine. Both will provide time shifting up to about six hours, lower peak demands, and reduce costs of power interruptions.

  - A 1GW open-loop, pumped-storage hydro facility in Northfield, MA, uses a man-made upper reservoir.

  - A 175kW heat thermal storage system in Concord, MA, provides for frequency control and load shifting.

  - Two other storage projects in Massachusetts are announced. One is a 100kW lithium-ferrous-phosphate battery and the other a 500kW zinc-bromine redox flow battery.

- **Microgrids, PEVs:**

  - Massachusetts Executive Office of Energy and Environmental Affairs manages a *Community Clean Energy Resiliency Program* that is focused on public purpose

microgrids for vital facilities.
http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/resiliency-initiative.html

- Massachusetts has an Electric Vehicle Initiative (MEVI), including an Electric Vehicle Incentive Program (MassEVIP) with incentives available for municipalities and employers, plus state rebates for the lease or purchase of electric vehicles. In addition, special EV license plates were unveiled in 2012. Massachusetts was the second state, after Hawaii, to offer such plates, to "help emergency responders who are first on site after a car accident… [because EV's] require the use of special safety techniques."
http://www.mass.gov/eea/energy-utilities-clean-tech/alternative-transportation/mevi-home-page.html
http://www.mass.gov/eea/agencies/massdep/air/grants/massevip.html
http://www.mass.gov/eea/pr-2012/120424-pr-ev-plates.html

- **RPS:** Massachusetts' portfolio standard includes a solar carve-out. A 2013 report for the State's Department of Energy Resources explores the use of solar plus storage for producing T&D related benefits, increasing resilience, and supporting microgrids.
http://www.mass.gov/eea/docs/doer/rps-aps/solar-consultants-report-final-task-3b-093013.pdf

Michigan

- **Demos, Pilots:**
  - Detroit Edison is installing 20 community energy storage (CES) devices in its service territory. The CES devices with centralized communications capabilities will provide ancillary services, renewable resource integration, peak shaving, and demand response, plus testing for the secondary-use of electric vehicle batteries.
  - An automotive assembly plant has a solar PV system integrated with 750kW of advanced lead-acid batteries. Another automotive facility uses 1.4MW of ice thermal storage for load shifting in its office and research facility.
  - A project is demonstrating the use of automotive lithium-ion battery packs for 25kW residential microgrid service. The general concept is to remove used batteries from vehicles, once the performance declines enough to make the batteries unsuitable for automotive use, and then repackage them for a second-life of service, providing uninterruptible backup and grid power balancing.
  - Ludington Pumped Storage facility, rated at 1.872GW, is one of the largest in the world. Jointly owned and operated by Consumers Energy and Detroit Edison, Ludington began commercial operation in the mid-1970s. Ludington is now operated in part to store wind energy that is produced off-peak and then deliver

that energy during on-peak periods (see RPS, below). Generators are presently being refurbished and upgraded in a six-year project, which will raise capacity to 2.172GW by 2018.

- **Microgrids and PEVs:** Five Michigan PSC regulated utilities and one Michigan Municipal Utility offer PEV charging rates with time-of-use pricing to encourage off-peak charging. The state established a plug-in electric vehicles web portal in 2011, called Plug-in Michigan. The website includes links to Michigan utility PEV tariffs and incentives. http://www.pluginmichigan.org

- **R&D Centers:** Michigan has two major advanced energy technology business incubator centers that have received state funding and support; Grand Valley State University's Michigan Alternative and Renewable Energy Center (MAREC) and the NextEnergy Center. Both of these centers currently have business incubator tenants working on electricity storage technologies, Energy Partners, LLC, at MAREC and Nextek Power Systems, at NextEnergy. NextEnergy is a partner in the federally funded Advanced Energy Storage Systems Initiative.
  http://www.gvsu.edu/marec
  http://www.nextenergy.org/energystorage/
  http://gvsu.edu/marec/module-news-view.htm?newsId=D230E92B-F5A7-35B7-7E7B1B8200A9AC2F
  http://nextekpower.com/technology

- **RPS:** Michigan's renewable portfolio standard provides extra "Michigan Incentive Renewable Energy Credits… for each megawatt hour of electricity generated from a renewable energy system during off-peak hours, stored using advanced electric storage technology or a hydroelectric pumped storage facility, and used during peak hours" (MCL 460.1039(2)(c); http://legislature.mi.gov/doc.aspx?mcl-460-1039).

Minnesota

- **Demos, Pilots:**

  - The Xcel Energy Wind2Battery project is a 1 MW sodium-sulfur battery, operating in conjunction with an 11 MW wind project. http://www.xcelenergy.com/staticfiles/xe/Corporate/Renewable%20Energy%20Grants/Milestone%206%20Final%20Report%20PUBLIC.pdf

  - Minnesota is home to several advanced lead-acid battery storage projects. Two are integrated with solar PV arrays and others are serving needs for peak demand management, demand-charge reduction, and backup power.

- **IRP:** Minnesota's 2013 omnibus energy legislation directed the State Department of Commerce to develop the framework for a Minnesota Sustainable Energy Future plan. The Department was directed to commission several studies, including one on utility-managed, on-site energy storage and another on solar thermal markets.

- *White Paper Analysis of Utility-Managed, On-Site Energy Storage in Minnesota* reviews energy storage technologies and applications in Minnesota, including both battery and thermal storage. The study team modeled costs and benefits of battery-based, stand-alone storage and storage integrated with solar photovoltaic (PV), and considered operational use cases for both residential and commercial customer sites. The report analyses key barriers to implementation, and provides recommendations to address key gaps to energy storage implementation.

- The *Solar Heating and Cooling in Minnesota* report analyzes the potential costs and benefits of solar thermal projects, assesses technical and policy issues and the levelized cost of energy for both the commercial and residential sectors, analyzes the statewide solar thermal technical potential, and includes recommendations to break down market barriers. http://mn.gov/commerce/energy/topics/resources/energy-legislation-initiatives/studies-and-reports/

- **Microgrids (M), Plug-in Vehicles (PEV):**

  - A 2013 report for the Minnesota Department of Commerce provides an in-depth look at microgrid development for energy assurance, including recommendations for addressing barriers and pathways for facilitating microgrid development. http://mn.gov/commerce/energy/images/MN-Microgrid-WP-FINAL-amended.pdf

  - The University of St. Thomas is selected for a 2014 Xcel Renewable Development Fund grant to develop a microgrid research and testing center that will include battery storage. http://www.stthomas.edu/news/st-thomas-receives-1-5-million-xcel-energys-renewable-development-fund-build-microgrid-research-testing-center/

  - As a part of Minnesota's new omnibus energy bill, HF2834, the state is requiring investor-owned utilities to offer an off-peak residential EV charging rate. https://www.revisor.mn.gov/bills/text.php?session=ls88&number=HF2834&session_number=0&session_year=2013&version=list

- **Tax Credits, Financial Incentives:**

  - The Made-in-Minnesota Solar Incentive Program is a 10-year, $15 million per year program for 2014-2023. It will encourage investment in solar technologies with thermal storage applications and foster growth in domestic solar markets.
    http://mn.gov/commerce/energy/
    https://www.revisor.mn.gov/statutes/?id=3.8852
    https://www.revisor.mn.gov/laws/?id=85&year=2013&type=0

- Conservation Applied Research and Development (CARD) Grant Program is operated by the Minnesota Department of Commerce. CARD's purpose is to identify new technologies or strategies to maximize energy savings, improve the effectiveness of energy conservation programs, or document the carbon dioxide reductions from energy conservation projects. One of the CARD projects funded in 2013 is for a field test of large battery charging technologies. http://mn.gov/commerce/energy/topics/conservation/Applied-Research-Development/

Montana

- **RPS:** Montana's RPS includes provisions for compressed air energy storage (CAES), fuel cells powered by renewable fuels, flywheels, hydroelectric pumped storage, and batteries.
  http://psc.mt.gov/Energy/
  http://leg.mt.gov/content/Committees/Interim/2013-2014/Energy-and-Telecommunications/Meetings/June-2013/Overview.pdf

New Jersey

- **Completed PUC Dockets:**
  - In 2003, New Jersey Board of Public Utilities (NJBPU) established its Office of Clean Energy. The New Jersey Clean Energy Program (NJCEP) "promotes increased energy efficiency and the use of clean, renewable sources of energy… ." An Energy Storage Stakeholder Group functions as one of the committees under NJCEP (see Working Groups category, below). http://www.njcleanenergy.com
  - In a June 2013 Order in Docket No. EO07030203, NJBPU changed the NJCEP Renewable Energy Incentive Program (REIP). The Order raises the threshold for NJBPU approvals for rebates under the REIP from $50,000 to $100,000 (see Tax Credits, Financial Incentives category, below). http://www.nj.gov/bpu/pdf/boardorders/2013/20130619/6-21-13-8I.pdf
- **Demos, Pilots:**
  - The Yard Creek Pumped Storage facility is New Jersey's largest storage installation, at 4MW. During on-peak hours, it provides energy regulation and spinning reserve. http://www.energystorageexchange.org/projects/231

- New Jersey is home to three lithium-ion battery projects, of 250kW each.
  http://www.energystorageexchange.org/projects/1228
  http://www.energystorageexchange.org/projects/1225
  http://www.energystorageexchange.org/projects/1224

- **Microgrids (M), Plug-In Vehicles (PEVs):** New Jersey is developing microgrid systems at critical infrastructure facilities. An Energy Resilience Bank is being created to provide access to financing.
  http://www.state.nj.us/governor/news/news/552013/approved/20131009a.html

- **R&D Centers:** The Center for Energy, Economics, and Environmental Policy (CEEEP) at Rutgers University is contracted by the NJBPU to perform cost-benefit analyses, develop program evaluation plans, develop RFPs for evaluation services, and evaluate the cost of utility renewable energy programs in New Jersey.
  http://ceeep.rutgers.edu

- **Tax Credits, Financial Incentives:**

  - Energy storage technologies are eligible for support through the New Jersey Renewable Energy Incentive Program (REIP). NJBPU proposed allocating $5-10 million through FY2017 for competitive incentives for storage integrated with renewable energy and focusing on emergency services for critical facilities.
    http://www.njcleanenergy.com/renewable-energy/programs/energy-storage

  - The NJBPU Renewable Energy Market Manager conduct a February 2014 survey to gauge interest in a storage incentives program and learn about proposed types of storage systems. The Market Manager is developing a REIP renewable electricity storage incentive proposal, with an anticipated offering of $3 million.
    http://www.njcleanenergy.com/files/file/Staff%20Straw%20Proposal%20-%20FY15%20CRA%20052314.pdf
    http://www.njleg.state.nj.us/legislativepub/budget_2015/BPU_response.pdf
    http://www.njcleanenergy.com/files/file/Renewable_Programs/REIP/Energy_Storage_WG_Presentation_07_23_2013.pdf

- **Working Groups** –The New Jersey Energy Storage Working Group first convened in July 2013. The Working Group issued a proposal in January 2014, focusing on using storage to shift renewable generation to more optimal times of the day and frequency regulation to support higher levels of intermittent renewable energy.
  http://www.njcleanenergy.com/files/file/Energy_Storage_Straw_Proposal-012814.pdf

New Mexico

- **Demos, Pilots:**

    - Advanced microgrid technologies, including storage systems, are being demonstrated at Mesa del Sol and Los Alamos, through partnerships between Sandia and Los Alamos National Laboratories, Japan's New Energy and Industrial Technology Development Organization (NEDO), and Public Service Company of New Mexico (PNM).
http://www.losalamosnm.us/utilities/Pages/LosAlamosSmartGrid.aspx
http://energy.sandia.gov/?page_id=2636
https://www.smartgrid.gov/sites/default/files/pdfs/project_desc/NT02872%20RDSI%20Fact%20Sheet%20Chevron_3.0.pdf
http://energy.sandia.gov/wp/wp-content/gallery/uploads/DETL_Factsheet_SAND2010-3643_Aug2011.pdf

- **Working Group:** New Mexico Renewable Energy Task Force is studying energy storage. A Task Force report (2013) lays out state action options, including: creation of an Energy Storage Advisory Council; coordination with other Western states for regional energy storage; evaluating existing incentives for manufacturing energy storage, including software and controls; and supporting a large-scale energy storage demonstration project.
http://www.emnrd.state.nm.us/ECMD/RenewableEnergy/documents/NMTaskForceReport20131118.pdf

New York

- **Active Dockets:** In Docket 14-M-0101, New York Public Service Commission has initiated a collaborative review process, *Reforming the Energy Vision* (REV). The Commission states, "This initiative will lead to regulatory changes that promote… wider deployment of "distributed" energy resources, such as micro grids, on-site power supplies, and storage."
http://www3.dps.ny.gov/W/PSCWeb.nsf/All/26BE8A93967E604785257CC40066B91A

- **Demos, Pilots:**

    - New York currently has 25 demonstration and pilot projects, announced, under construction, and operational. Two of the largest projects, the Lewiston Pump-Generating Plant on Niagara Falls and the Blenheim-Gilboa Pumped Storage Power Project, are rated at 240MW and 1.16GW respectively. Many smaller demonstration projects using various storage technologies are planned for New York City, Rochester, and Syracuse.

    - Long Island Power Authority (LIPA) has issued an RFP for new peaking and distributed generation, including energy storage and demand response resources,

plus up to 150 MW of energy storage resources that can assist black start operations by serving as a load.
http://www.nybest.org/sites/default/files/resources/LIPA%20FUNDING%20OPPORTUNITY%20ALERT.pdf

- **Pending Legislation:** Bill A1380-2013, would provide tax credits, including for energy storage systems manufacturing. A similar Bill, Senate Bill 2522, passed the State Senate in 2014 but was not approved by the State Assembly.
http://open.nysenate.gov/legislation/bill/A1380-2013
http://open.nysenate.gov/legislation/bill/S2522-2013

- **Microgrids:** New York State Energy Research and Development Administration (NYSERDA) is directed by Governor Cuomo to consult with other state agencies and interested parties to study and offer recommendations for encouraging microgrid systems, with a final report due in 2014. NYSERDA is developing a "New York Microgrids Prize," expected to provide funding support for about 10 microgrids.
http://www.nypa.gov/Press/2014/030414a.html

- **R&D Center:** New York Battery and Energy Storage Technology (BEST) Consortium provides support for energy storage businesses in New York State, including access to financing, research capabilities, potential partners, technology developers, manufacturers, and other private sector and government resources. BEST stakeholders have developed an *Energy Storage Roadmap for New York* (2013).
http://www.ny-best.org/About_NY-BEST
http://ny-best.vm-host.net/sites/default/files/type-page/4254/attachments/NY-BEST%20Roadmap_final-1.pdf

- **Tax Credits, Financial Incentives:** NYSERDA delivers energy efficiency programs state wide, funded by a systems benefits charge. Under NYSERDA's Existing Buildings Program, energy storage can receive a performance-based incentive ($600/kW downstate and $300/kW upstate).
https://www.nyserda.ny.gov/Energy-Efficiency-and-Renewable-Programs/Commercial-and-Industrial/CI-Programs/Existing-Facilities-Program/Performance-Based-Incentives.aspx

Oregon

- **Active PUC Dockets:** Docket LC57 reviews PacifiCorp's 2013 IRP Action Plan. In that docket, Oregon Department of Energy (ODOE) recommends a suite of energy storage demonstration projects, and proposes that PacifiCorp should include comprehensive treatment of energy storage in future IRPs.
http://edocs.puc.state.or.us/efdocs/HAC/lc57hac84953.pdf

- **Demos, Pilots:**

  - Portland General Electric's Salem Smart Power Center (SSPC), under construction in Salem, Oregon, is a 5MW, 1.25MWh facility designed to increase distribution system reliability, aid in integrating renewable resources, and decrease peak-price risk.
    http://www.energystorageexchange.org/projects/40
    http://www.pnwsmartgrid.org
    http://www.portlandgeneral.com/our_company/energy_strategy/smart_grid/salem_smart_power_project.aspx

  - A 150MW pumped-storage hydro project is proposed for Crook County, OR.
    http://www.energystorageexchange.org/projects/726

- **IRP:** Oregon Public Utilities Commission (PUC) IRP guidelines define energy storage as a Class I demand-side management (DSM) resource. Utilities are directed to forecast over a 20-year planning period available balancing reserves supplies and the needs for ramping required to respond to load variation and variable-output generation. After identifying existing supplies and forecast needs, utilities are directed to evaluate on a consistent and comparable basis all resource options, including PEV battery storage.
  http://apps.puc.state.or.us/edockets/docket.asp?DocketID=15929
  https://apps.puc.state.or.us/orders/2012ords/12-013.pdf
  http://apps.puc.state.or.us/edockets/docket.asp?DocketID=18259

- **Proposed Legislation:** Proposed House Bill 2805 would direct the Oregon PUC to include in electric utility rates prudently incurred costs associated with storage facilities, including pumped storage hydroelectric, compressed air energy storage, hydrogen storage, flywheel systems, and others. Proposed in the 2013 session, this bill did not pass the House or Senate.
  http://gov.oregonlive.com/bill/2013/HB2805/

- **Working Groups and Workshops:**

  - On March 19, 2014, the Oregon PUC held a joint workshop with ODOE, regarding energy storage in the Oregon, the Northwest, and the U.S. today, and how to remove technical, economic, and policy barriers. Panels covered a range of federal, state, and local current or proposed energy storage projects and energy storage value streams.
    http://www.oregon.gov/energy/Pages/energy-storage-workshop.aspx

  - The ODOE also maintains a web page about energy storage.
    http://www.oregon.gov/energy/Pages/energy-storage.aspx

Puerto Rico

- **RPS:** Puerto Rico's storage mandate applies to all new grid-connected, variable-output renewable energy systems.

- **Storage Mandate:** In December, 2013, The Puerto Rico Electric Power Authority (PREPA) and the island's main utility, the Autoridad de Energía Eléctrica (AEE), released a set of minimum technical requirements (MTRs) that govern new renewable energy projects. The Island intends to increase contributions from renewable energy from about one percent at the time of the MTRs announcement to about six percent by the end of 2014. All new variable-output renewable energy projects seeking to interconnect with the grid will now face MTRs for energy storage, to support grid integration.
  http://www.greentechmedia.com/articles/read/puerto-rico-mandates-energy-storage-in-green-power-mix

Vermont

- **Active Dockets:** Vermont Public Service Board Docket 8098 is for a request for certificate of public good by Green Mountain Power, for a project in Rutland, VT, called the Stafford Hill Solar Farm. The project is slated to include a 3.4MWh electricity storage system in conjunction with a 2MW solar array. The storage system will be operated to facilitate and maximize renewable energy integration with the electric distribution grid, with secondary applications for regulation services and backup power for critical facilities. The project received funding from the U.S. DOE and Vermont's Clean Energy Development Fund and Sandia National Laboratories is a research partner.
  http://energy.gov/sites/prod/files/2014/03/f13/Mar2014EAC-Gyuk.pdf
  http://psb.vermont.gov/sites/psb/files/orders/2014/2014-02/8098%20Fourth%20Procedural%20Order%20re%20Notice%20of%20Amendment.pdf

- **Demos, Pilots** –

  - A 250kW advanced lead-acid battery installation in Burlington, VT, is designed to offset curtailment from the local utility, for an industrial manufacturer.

  - Two ice storage projects provide approximately 55kW of load-shifting capability for as much as six hours, for retail stores in Rutland, VT.

- **IRP** – The Vermont Energy Investment Corporation (VEIC) and National Association of State Energy Officials (NASEO), conducted a study on storage in IRPs, and recommends that future IRPs incorporate modeling for PEVs.
  https://www.veic.org/documents/default-source/resources/reports/naseo-ev-july-2013.pdf

- **R&D Centers**— Norwich University, the University of Vermont, and Vermont Law School, are partners with Sandia National Laboratories to study smart grids and energy storage applications and provide training for utility personnel. http://energy.sandia.gov/wp/wp-content/gallery/uploads/Sandia-VT-M-1-Summary-Report_2012-2370P.pdf

- **Tax Credits, Financial Incentives:**

  - Vermont was awarded approximately $69 million through the U.S. DOE Smart Grid Investment Grant (SGIG) program to deploy smart grid technologies, including storage. The statewide SGIG application, known as eEnergy Vermont, was filed jointly by Vermont Transco on behalf of all Vermont distribution utilities, the Vermont Public Service Department, and Efficiency Vermont. http://publicservice.vermont.gov/topics/electric/smart_grid/eenergyvt

  - Vermont's Clean Energy Development Fund issued a request for proposals (RFP) in 2013 for an Electrical Energy Storage Demonstration Program. The Stafford Hill project (see Active Dockets, above, is a designated grant recipient, with additional funding support from the U.S. DOE. http://www.vermontbusinessregistry.com/bidAttachments/10128/CEDF_Storage_RFP_Final.pdf

Washington

- **Demos, Pilots** –

  - The Bainbridge Island Storage Project is a joint venture between Puget Sound Energy, Primus Power, and Pacific Northwest National Labs, with funding from the BPA Technology Innovation program. The centerpiece of this project is a 500kW zinc bromide redox flow battery. http://www.energystorageexchange.org/projects/1236

  - The 1MW Modular Energy Storage Architecture (MESA) project, a partnership between Snohomish County Public Utility District (PUD) and 1Energy Systems, demonstrates integrating renewable energy and improving reliability. http://www.energystorageexchange.org/projects/289

  - The 314MW Keys III Pump-generating plant is an open-loop pumped hydro storage facility representing the largest energy storage project in Washington, and has been storing energy to meet peak demand since 1973. http://www.energystorageexchange.org/projects/183

- **IRP** – In 2011, the Washington State UTC requested that utilities include energy storage as a resource option in their next IRP. In 2013, the Washington State

Legislature passed HB1296, which requires IRPs developed by electric utilities to include assessment of energy storage systems.
http://www.wutc.wa.gov/rms2.nsf/177d98baa5918c7388256a550064a61e/112f993e187ec7b68825797400679954
http://www.wutc.wa.gov/rms2.nsf/177d98baa5918c7388256a550064a61e/4b0c052bf4e679fe88257c7700773244
http://apps.leg.wa.gov/documents/billdocs/2013-14/Pdf/Bills/House%20Bills/1296.pdf

- **Proposed Legislation** – Washington Senate Bill 6541 would provide performance based incentives for distributed renewable energy, including a bonus for systems incorporating energy storage.
http://apps.leg.wa.gov/documents/billdocs/2013-14/Pdf/Bills/Senate%20Bills/6541.pdf

- **Microgrids, PEVs:**

    - The Washington Department of Commerce administers the Vehicle Electrification Demonstration Grant Program. Eligible applicants are state agencies, public school districts, public utility districts, or political subdivisions of the state. Grants can be awarded for projects involving the purchase or conversion of existing vehicles to PEVs for use in an applicant's fleet or operations.
http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx#wa

    - Washington Utilities and Transportation Commission has approved an Electric Vehicle Charger Incentive Program for residential customers of Puget Sound Energy, in Case No. UE-131585. The incentive is "$500… toward the installation of no more than 5,000 'Level 2' electric vehicle chargers at existing residential electric service locations as part of a customer's participation in a 32-month pilot end-use study… ."
http://www.utc.wa.gov/docs/Pages/DocketLookup.aspx?FilingID=131585

- **RPS:** HB1289 provides extra renewable energy credits for energy storage output of renewable sourced energy.
http://apps.leg.wa.gov/documents/billdocs/2013-14/Pdf/Bills/House%20Bills/1289.pdf

- **Tax Credits, Financial Incentives**:

    - Washington State Department of Commerce will disburse $15 million in competitive grants to utilities implementing projects that integrate renewables through energy storage and information technology, improve reliability, and reduce the costs of intermittent renewable or distributed energy.
http://www.commerce.wa.gov/Programs/Energy/Office/Pages/Clean-Energy-Funds.aspx

- Public lands used for installing, maintaining, and operating EV infrastructure are exempt from leasehold excise taxes until January 1, 2020. Additionally, the state sales and use taxes do not apply to EV batteries; labor and services for installing, repairing, altering, or improving EV batteries and EV infrastructure; and the sale of property used for EV infrastructure.
  http://www.commerce.wa.gov/Programs/Energy/electric-vehicles/Pages/EVPolicyandLaw.aspx
  http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx#wa

- **Working groups:** Washington participated in the workshop with Oregon in 2014. http://www.oregon.gov/energy/pages/energy-storage-workshop.aspx

West Virginia

- **Completed Dockets:** On June 24, 2014, in Case No. 14-0273-E-CS-PW, the WV Commission granted permission to the Beech Ridge Wind Farm to add a 32.4MW lithium-ion battery to its facility.
  http://www.psc.state.wv.us/WebDocket/default.htm

- **Demos, Pilots:**
  - A 98 MW wind farm at Laurel Mountain is equipped with a 32MW lithium-ion battery, for providing flexible operating reserves.
  - Charleston Energy Storage Project is a 1MW sodium-sulphur battery, providing peak-shaving and transmission upgrade deferral benefits. This battery is not presently in service, due to as yet unidentified problems. In Milton, WV, a 2MW sodium-sulphur battery provides load leveling and alleviates transformer loading during peak periods. These batteries are transportable, so that they could be moved at a future date, if needed at another location.
  - A "super circuit" microgrid project in Morgantown is planned, but not installed. A 24kW lithium-ion battery has been proposed, for integrating variable output generation and reducing the scope and severity of outages.

- **RPS:** West Virginia's renewable portfolio standard includes provisions for accepting credits produced by "alternative energy resources," including pumped storage hydro. http://www.dsireusa.org/solar/incentives/incentive.cfm?Incentive_Code=WV05R&re=1&ee=0

Wisconsin

- **Proposed Legislation:** Wisconsin AB901-2014 would have directed the Public Service Commission to contract for studies of the costs and benefits of energy storage and solar thermal devices installed in residential and commercial properties and managed by public utilities serving the properties. The bill did not pass. https://docs.legis.wisconsin.gov/2013/proposals/ab901

- **Working Groups:** University of Wisconsin-Madison is home to the Wisconsin Energy Institute and Energy Storage Systems Test Laboratory. The Institute's 2014 Energy Summit, 29 Oct 2014, features Wisconsin Public Service Commission Chairman Phil Montgomery and California Public Utilities Commissioner Carla Peterman. Theme of the 2014 Summit event is *A Global Energy Outlook – Meeting Needs for Future Cities and Communities*.
https://energy.wisc.edu/search/node/storage
https://energy.wisc.edu/events/energy-summit