Harnessing the Potential of Energy Storage
Storage Technologies, Services, and Policy Recommendations

May 2017
This report was prepared through a collaborative process by members of EEI's Energy Storage Task Force.

If you have any questions, comments or concerns, please contact:

Alison Williams
Manager, Clean Energy
202-508-5026
awilliams@eei.org

Lola Infante, PhD
Sr. Director, Generation Fuels and Market Analysis
202-508-5133
linfante@eei.org

© 2017 by the Edison Electric Institute (EEI).
All rights reserved. Published 2017.
Printed in the United States of America.
No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage or retrieval system or method, now known or hereinafter invented or adopted, without the express prior written permission of the Edison Electric Institute.

Attribution Notice and Disclaimer
This work was prepared by the Edison Electric Institute (EEI). When used as a reference, attribution to EEI is requested. EEI, any member of EEI, and any person acting on its behalf (a) does not make any warranty, express or implied, with respect to the accuracy, completeness or usefulness of the information, advice or recommendations contained in this work, and (b) does not assume and expressly disclaims any liability with respect to the use of, or for damages resulting from the use of any information, advice or recommendations contained in this work.

The views and opinions expressed in this work do not necessarily reflect those of EEI or any member of EEI. This material and its production, reproduction and distribution by EEI does not imply endorsement of the material.

Published by:
Edison Electric Institute
701 Pennsylvania Avenue, N.W.
Washington, D.C.  20004-2696
Phone: 202-508-5000
Web site: www.eei.org
Executive Summary

Energy storage technologies—including batteries, flywheels, compressed air, thermal storage, and pumped hydropower—are operational across the United States. Use of storage, particularly batteries, is growing at a rapid rate, with an estimated 260 megawatts (MW) installed in 2016 alone, up 300 percent from 2014.¹ Of the more than 24 gigawatts (GW) of operational storage in the United States, including pumped hydropower, electric companies are the largest users and operators—representing more than 98 percent of active energy storage projects.² They are using storage for a wide range of purposes that result in improved operation of the energy grid; increased reliability, resiliency, and operational flexibility; and the integration of more solar and wind power.

While installed costs are still relatively high for many energy storage systems, costs are rapidly coming down for some storage technologies. At the same time, policies, regulations, and markets do not always recognize the benefits and flexibility that energy storage can provide to the energy grid and society. As we look to the future, it is important to revisit policies and regulations to maximize the value achieved by energy storage. Furthermore, with technical improvements in design and control, the value and uses of energy storage will continue to evolve. Therefore, it is important for the nation’s electric companies to continually explore the technical performance of energy storage to ensure appropriate planning and deployment of storage technologies that can best enhance the reliability and resiliency of the energy grid for the benefit of all customers.

To contribute to the discussion, this paper provides an overview of operational energy storage in the United States; its ownership, use by, and value to electric companies; and potential barriers and challenges to greater adoption. Finally, this paper offers policy recommendations on energy storage for policymakers and regulators.

What Is Energy Storage, and Why Is It Valuable?

In simple terms, energy storage provides a way to save previously generated energy and use it at a later time. That energy can be stored as potential, kinetic, chemical, or thermal energy and then can be released in various forms, most commonly as electricity. The ability to bank energy for later use makes energy storage a useful and versatile resource for electric companies and their customers.

For electric companies, the largest users and operators of energy storage in the United States, the primary benefits of energy storage are added flexibility, reliability, and resiliency in operating the energy grid. More specifically, energy storage, deployed at the appropriate scale, can be used in various ways to enhance electric company operations, optimize and support the energy grid, and enhance the customer experience.

Flexibility

Storage allows energy grid operators to better manage constant fluctuations in supply and demand. As electric companies integrate more renewable energy resources, like solar and wind, into the energy grid, energy storage can provide more flexibility by helping to manage these variable resources.

Energy storage can help with renewables integration in two primary ways. First, storage can help to address the variability of renewable energy generation. While weather forecasting is improving, there is still uncertainty about when the wind will blow and the sun will shine. Energy storage provides an option for storing wind or solar energy that may be in excess of immediate demand and saving it until demand is high enough to discharge or release it out of storage. In this way, certain storage technologies can allow a variable renewable energy resource to perform like one that is less variable and measurably reliable.

Second, the rapid response time of some types of energy storage makes them effective tools for managing changes in energy output that can occur with some renewables, such as when wind speeds fluctuate or clouds pass over solar panels. In addition to uncontrollable weather changes, there are inherent operational challenges with variable energy resources. For example, when the sun rises, output from solar resources escalates quickly (and vice versa in the evening), resulting in either a steep increase or decrease in output that can make it
challenging to match available resources with load requirements in real-time operations. As some forms of energy storage can respond at their directed capacity in less than one second, the speed of operation is a key consideration when weighing storage as an option for providing both flexibility and reliability.

**Fast-Ramping Energy Storage Can Help Balance Renewable Generation Output**

Some kinds of energy storage can help manage spikes and drops in the output of renewables generation by storing excess energy or releasing it on a moment-to-moment basis. This ability to quickly ramp up or ramp down makes some storage devices especially well-suited for balancing fluctuations in renewable energy output.

**Reliability**

The reliability of the energy grid is enhanced by energy storage in a variety of ways. Storage can provide a host of grid-support or ancillary services—including managing peak load, essential reliability services (voltage and frequency control), reserves, and black start—that are critical to managing the energy grid and maintaining service without interruption.

One use of energy storage is as a resource to help manage peak load—a process also called peak smoothing or peak shaving. Traditionally, peak load is met with resources that are able to start quickly but run for limited times (i.e., peaker plants)—most often simple-cycle natural gas combustion turbine (CT) plants. When properly sized for this use case, energy storage technologies can provide an alternative. Storage systems can be dispatched very quickly and can hold several hours of energy that is generated during off-peak hours at lower cost and then deployed during more costly high-demand periods—a practice known as energy time shifting. Certain types of energy storage can be important tools for grid operators with their ability to meet, shift, or smooth peaks in demand for energy.
Energy storage can help to manage peak energy demand by charging at low demand times of day, such as at night, and then discharging (or releasing energy) during peak periods, like in late afternoon and early evening.

Energy storage can provide two essential reliability services: frequency regulation and voltage support. Frequency regulation is the moment-to-moment reaction to frequency deviations from the standard 60 Hz in the United States. Control is necessary to prevent a cascading failure of the system and harm to computers and other electrical devices that use the system. Some types of energy storage, with near-instantaneous response times, can play a key role in correcting for unintended fluctuations in output from generators that can cause frequency deviations. Voltage support is necessary to maintain proper operation of equipment, prevent damage to connected generators from overheating, facilitate energy transfers, and reduce transmission losses. Energy storage can serve voltage support by providing or absorbing reactive power and by helping to maintain a specific voltage level on the energy grid.

Reserve capacity is another important aspect of grid reliability in which energy storage can play a role. Electric companies are required to keep certain amounts of available generation capacity (known as reserves) that can be accessed quickly in case of disruption or unexpected swings in the demand for energy. Similar to the way it can be dispatched quickly for peak load management, energy storage can be used to help meet or reduce the need for these reserve requirements.

Resiliency

Electric companies constantly plan and prepare for restoring service safely and efficiently in the event of disruptions. To re-energize the energy grid after a power outage, electric companies use black-start resources to restore service quickly. Some energy storage technologies have
particular characteristics that fit the requirements of black-start resources. Storage also provides the short-term benefit of fast response, a crucial attribute for quickly restoring power in a black-start situation, although the duration of discharge may limit the effectiveness of some storage devices for this application.

Energy storage also can serve as a backup energy source to individual loads or even entire substations in the event of a transmission or distribution outage. This may be an effective alternative to a transmission or distribution upgrade or may serve as an interim solution while a long-term plan is implemented. Similarly, storage resources play a vital role in microgrids. These standalone energy systems, which use distributed generation, can operate in parallel with or independently of the energy grid. The value of a microgrid is its ability to maintain service when the broader energy grid experiences interruptions. Electric companies, the U.S. military, several industries, and cities and communities around the country are using or considering microgrids as a way to increase their resiliency and to manage their own energy needs. In all of these systems, energy storage is a vital component.

Customer Benefits

In addition to the many benefits that energy storage can provide to the energy grid, energy storage technologies also can provide services to customers directly on either side of the meter. As mentioned above, resiliency is an important service valued by many types of customers. Other customer uses include the opportunity to maximize the benefits of private solar production to reduce the demand for grid-provided electricity with storage used to smooth production and demand, for example.

Energy Storage is Used To Support All Parts of the Energy Grid

Energy storage can provide benefits along all parts of the energy grid, including improving operations of generation, transmission, and distribution, as well as serving residential, commercial, and industrial customers. Table 1 (below) provides a list of storage services by customer and technology.

---

3 Black start is the process of bringing a power plant back online without help from the transmission network. It is an essential service to restore power after an outage.
### Table 1. Storage Services by User and Technology

<table>
<thead>
<tr>
<th>Application</th>
<th>User</th>
<th>Major Technologies</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Grid Services</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency Regulation</td>
<td>Electric company</td>
<td>Batteries</td>
<td>Provides safety and decreases fluctuations in load managing the variability in the grid's frequency</td>
</tr>
<tr>
<td></td>
<td>ISO/RTO</td>
<td>Flywheels</td>
<td></td>
</tr>
<tr>
<td>Reserve Capacity</td>
<td>Electric company</td>
<td>Pumped hydro</td>
<td>Contributes to electric company's adequacy/reserve margin requirement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Batteries</td>
<td></td>
</tr>
<tr>
<td>Grid Asset Optimization</td>
<td>Electric company</td>
<td>Pumped hydro</td>
<td>Load levelling and peak shifting of grid assets</td>
</tr>
<tr>
<td></td>
<td>ISO/RTO</td>
<td>Compressed Air</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Batteries</td>
<td></td>
</tr>
<tr>
<td>Spinning Reserve</td>
<td>Electric company</td>
<td>Flywheels</td>
<td>Maintains system frequency stability during emergency operating conditions and unforeseen load swings</td>
</tr>
<tr>
<td></td>
<td>ISO/RTO</td>
<td>Batteries</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Compressed Air</td>
<td></td>
</tr>
<tr>
<td>Transmission &amp; Distribution Upgrade</td>
<td>Electric company</td>
<td>Batteries</td>
<td>Can provide a portion of peak demand that is served by transmission and distribution equipment whose capacity must be increased due to demand growth or whose life is to be extended</td>
</tr>
<tr>
<td>Deferral</td>
<td>ISO/RTO</td>
<td>Pumped Hydro</td>
<td></td>
</tr>
<tr>
<td>Energy Arbitrage</td>
<td>Electric company</td>
<td>Batteries</td>
<td>Allows electric companies to provide/buy power when electricity prices are highest/lowest</td>
</tr>
<tr>
<td></td>
<td>ISO/RTO</td>
<td>Pumped Hydro</td>
<td></td>
</tr>
<tr>
<td>Variable Resource Integration</td>
<td>Electric company</td>
<td>Batteries</td>
<td>Reduces ramp rates and helps electric companies integrate higher levels of variable resources</td>
</tr>
<tr>
<td></td>
<td>ISO/RTO</td>
<td>Compressed Air</td>
<td></td>
</tr>
<tr>
<td>Voltage Support</td>
<td>Electric company</td>
<td>Batteries</td>
<td>Helps manage delivery of reactive power to maintain voltage</td>
</tr>
<tr>
<td></td>
<td>ISO/RTO</td>
<td>Compressed Air</td>
<td></td>
</tr>
<tr>
<td>Other: Black Start, Power Quality</td>
<td>Electric company</td>
<td>Batteries</td>
<td>Suppresses system harmonics, supports system during system restoration, provides dynamic functional equivalent of synchronous generation</td>
</tr>
<tr>
<td>Harmonics, Inertia Response</td>
<td>ISO/RTO</td>
<td>Compressed Air</td>
<td></td>
</tr>
<tr>
<td>Customer Services</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Shifting</td>
<td>Commercial &amp; Industrial</td>
<td>Batteries</td>
<td>Peak shifting of residential or C&amp;I loads to save on energy costs, such as demand charge reduction and time-of-use optimization</td>
</tr>
<tr>
<td></td>
<td>(C&amp;I)</td>
<td>Thermal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Residential</td>
<td></td>
<td>May help reduce grid-supplied electricity</td>
</tr>
<tr>
<td>Load Shifting with Solar</td>
<td>C&amp;I</td>
<td>Batteries with</td>
<td>Same as load shifting, but with the ability to flatten load between battery and solar technologies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>solar</td>
<td>Helps provide steady emergency backup power</td>
</tr>
<tr>
<td></td>
<td>Residential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency Backup</td>
<td>C&amp;I</td>
<td>Batteries</td>
<td>Provides emergency power during outages such as grid failures and weather-related incidents</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flywheel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Residential</td>
<td></td>
<td>Supports local power systems that can disconnect from the larger grid and operate autonomously</td>
</tr>
<tr>
<td>Microgrid Support</td>
<td>C&amp;I</td>
<td>Batteries</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flywheel</td>
<td></td>
</tr>
</tbody>
</table>
Energy Storage: Many Types, Many Uses

Given the many beneficial attributes of energy storage, electric companies are building, procuring, and operating different types of energy storage systems in various parts of the country. It is important to note that energy storage is not a single technology but rather a host of different technologies with vastly different operating characteristics, cost structures, and benefits. The technology that is deployed in a given location largely is determined by that area’s resources, needs, and market structure.

The energy storage descriptions below are intended to show the wide variety of operating technologies, how they are used, and existing barriers to greater adoption.

Pumped Hydro

Pumped hydro storage systems primarily work in conjunction with major hydropower dams—called an open-loop system. In simple terms, water is pumped from a low area to a higher reservoir during off-peak (i.e., low cost) times. The water is then stored until it is economical to use the resource. At that point the water is released, spinning turbines to generate electricity that is supplied to the energy grid. Many of the pumped hydro systems in the United States were commissioned in the 1960s to 1980s, with the most recent becoming operational in 2012 in southern California. Due to issues such as initial cost and siting difficulties, only a limited amount of new pumped hydro is expected to come online in the coming years.

Batteries

Battery technologies are part of the larger group of electro-chemical storage. There are two categories of battery: solid state and flow batteries. Solid state batteries such as lithium-ion have solid electrodes and solid electrolytes. In contrast, flow batteries, or redox (reduction-oxidation) batteries, operate with two chemical components dissolved in liquids often separated by a membrane, a structure that enables near-instantaneous recharging. Of all of the battery types, lithium-ion is the most popular. Their costs have declined significantly in recent years and, as a result, they are finding applications in electronics, electric vehicles, and industrial operations. Electric companies primarily are using lithium-ion and some lead-acid batteries because of their availability, price, and durability. Battery lifespan varies by type, with solid-state batteries (lithium-ion, zinc, etc.) typically lasting 5-15 years and flow batteries lasting 15-20 years.4

Harnessing the Potential of Energy Storage

**Thermal**

Thermal storage technologies allow for temporary energy storage in the form of thermal energy (heat or cold)—similar to how an insulated mug keeps a drink hot or ice cubes keep a drink cold. The most common form of heat storage is molten salt thermal storage, although there are other forms such as molten glass. Molten salt currently is used in conjunction with parabolic troughs to store heat produced via solar power. In these systems, sunlight is focused via mirrored panels to heat salt to temperatures of up to 1050°F. The molten salt is stored in insulated tanks until energy is needed. To convert stored heat to electric energy, the molten salt turns water into steam in heat exchangers with steam used to generate electricity in a steam turbine/generator. Heat storage often is used for storing power during low demand periods and releasing it when demand increases. It also is used to help manage minute-to-minute fluctuations in renewable generation. Stored heat also may be used in manufacturing processes or building space conditioning systems.

Ice and chilled-water thermal storage use excess low-cost energy to chill or freeze water, which is then deployed in a variety of systems from air conditioning systems to freezers. This cold storage most often is used by customers to reduce electric demand and by electric companies for time shifting.

**Compressed Air Energy Storage (CAES)**

In a compressed air storage system, atmospheric air is compressed and stored under pressure in underground geological sites such as retired mines or salt caverns. When energy is required, the underground compressed air is released, driving an expansion turbine to generate electricity. The estimated useful life of a CAES system is 15-20 years. There is only one large-scale operational CAES plant in the United States: a 110-MW plant in McIntosh, AL. While CAES use remains limited, there are several suitable sites for its expansion across the United States.

**Flywheels**

Flywheel storage systems use electricity to power a machine, acting as a motor that spins a series of rotors. As the rotors turn, electric energy is stored as kinetic (or rotational) energy. When electricity is needed, the flywheel turns the machine now acting as a generator, converting the kinetic energy into electricity that is fed to the energy grid. To maintain efficiency, flywheels often are contained in a vacuum on magnetic bearings to reduce friction. Flywheels generally are low maintenance, have a long life, and respond quickly, making them

---

6 PowerSouth CAES: http://www.powersouth.com/mcintosh_power_plant/compressed_air_energy.
useful for electric companies as spinning reserve capacity as well as frequency and voltage support. Additionally, many data centers in the United States rely on flywheel storage to mitigate short-term energy disruptions.

Current Deployment

Of the more than 24 GW of operational energy storage in the United States, pumped hydro is by far the most common, representing more than 93 percent of installed storage capacity by size. The next largest segment is thermal storage, followed by batteries, compressed air, and flywheels. While pumped hydro storage dwarfs other energy storage technologies when considering all operational storage in the United States, batteries are driving the storage market today in terms of the number of projects. Large-scale or universal solar power plants have given rise to a handful of large thermal energy storage systems, making this storage technology the largest player by size in recent years.

Comparison of Energy Storage Projects By Technology Type

Electric Companies Are Primary Users of Storage

Electric companies are the largest owners and operators of energy storage. They use energy storage facilities through the assets they own directly and also through those that they procure via long-term contracts, or power purchase agreements. Many large-scale storage projects—including pumped hydropower storage and thermal storage projects—would not be economical
without a guarantee of use by electric companies in the form of a long-term contract. According to the U.S. Department of Energy, electric companies represent more than 98 percent of energy storage projects in the United States, including pumped hydropower, and are a significant contributor to the sector’s rapid growth. Looking only at newer energy storage technologies, and excluding large-scale pumped hydropower storage projects, electric companies remain the largest users and operators, representing 75 percent of U.S. energy storage capacity.

Of the 22 electric company-owned storage projects commissioned in 2015 and 2016, all but one was a battery storage system. Lithium-ion systems represented 98 percent of the battery projects, making electric companies a significant contributor to the adoption of the fastest growing energy storage technology in the United States.  

**Map 1. Operational and Planned Energy Storage Projects**

![Map of energy storage projects](image)


---

7 U.S. Department of Energy, Global Energy Storage Database.
Storage Costs Are Declining

Energy storage costs are as varied as the technologies themselves. Broadly, however, energy storage costs are falling. Batteries are the most common type of energy storage deployed today. Within this category, prices vary widely depending on the specific technology, the stage of development and commercialization, and the way the technology will be used. Advances in technology, as well as economies of scale, have helped to drive down lithium-ion battery costs in recent years. The median cost of lithium-ion batteries fell by more than 10 percent from 2015 to 2016.⁹

On a levelized cost basis, storage costs are projected to continue to fall for batteries and flywheels between now and 2020.¹⁰ Costs are expected to drop most dramatically for batteries—especially lithium-ion and flow batteries. According to Lazard’s industry survey, over the next five years, lithium-ion battery prices are expected to drop by 50 percent, flow batteries are expected to drop by 40 percent, and lead-acid batteries are expected to drop 25 percent.¹¹ If these price declines are realized, the three types of batteries could become more widely deployed.

The economic viability of storage depends on the way its value is calculated and the way services it provides are compensated.

Levelized costs are the most prominent comprehensive cost figures for evaluating the economics of energy storage technologies, but this is an imperfect—and often not useful—metric. Although levelized cost analysis provides one means of comparing different storage technologies and competing technologies, levelized costs do not account for the multiple ways storage can be used and, therefore, do not capture the multiple value streams from which energy storage could benefit.

The stacked value of energy storage is determined based on the specifications and uses of the individual project, making it difficult to compare costs across energy storage projects. Some storage technologies, for example, are more appropriate for integrating renewables; others are more appropriate as peaking plant replacements or for providing ancillary and essential reliability services.

---

⁹ Lazard’s Levelized Cost of Storage Analysis—version 2.0.
¹⁰ Ibid.
¹¹ Ibid.
Ultimately, the decision to build and finance energy storage depends on the type of storage, the way the storage system will be used, its size, and its location. Further, the economic viability of storage depends on the way its value is calculated and the way services it provides are compensated (in terms of use cases), as well as on the commercial backing of the technology provider.

**Challenges To Wider Deployment Of Energy Storage**

Despite its growing popularity, energy storage continues to face challenges that are preventing these technology options from achieving their market potential and maximizing the benefits they can provide to customers and society. Today, the main challenges for energy storage are: the relatively high cost for some technologies; limited public knowledge regarding technical performance; regulatory requirements; and market rules that can make it difficult for these technologies to participate in the markets on a comparable basis with other resources. In combination, these factors are impacting the acceptance and adoption of some energy storage technologies.

**Cost**

High costs are still a challenge to wider deployment of energy storage solutions. Although the costs of some technologies are declining, energy storage devices remain expensive relative to other technologies providing only one service. While some storage technology costs are decreasing rapidly, it is critical to remove other barriers to energy storage adoption, so that the full range of benefits of energy storage can be realized as these resources become more and more prominent.

For electric company and wholesale market applications, energy storage is financed either through electric company investments to improve system reliability and to reduce the need for transmission and distribution upgrades, or through participation in electricity markets (wholesale energy, capacity, and ancillary services). Although energy storage devices are able to provide multiple energy grid services and to participate in different markets, they often cannot capture all value streams due to existing market performance requirements and code-of-conduct restrictions. The ability of energy storage to become cost-competitive and meet these performance requirements would help them to monetize all value streams and realize their full economic potential.

**Technical Performance**

Widespread adoption of energy storage systems depends upon greater information and certainty about their performance. Experience with some of the newer technologies is limited,
so there are incomplete or unreliable data on their performance in various situations and at different scales. Electric companies and markets need to have a high level of confidence in the performance and technical characteristics of their assets so they can optimize the management of the energy grid.

Technical issues go beyond the storage technologies themselves. Equally important is the way in which storage is connected to the energy grid. Storage interconnection may be a challenge in some areas, and infrastructure and regulations may need to be upgraded to accommodate two-way flows of electricity so storage can charge and discharge energy on the grid. The technical aspects of storage interconnection are being tested in pilot programs in many parts of the country. Further deployment of energy storage will require that interconnection also be addressed from the regulatory perspective.

**Regulatory Challenges**

Because existing regulations were developed at a time when pumped hydro was essentially the only form of energy storage, they do not account for the particular characteristics and intrinsic flexibility of some newer storage technologies:

- **Classification and Flexibility:** Classification rules at the state and federal levels may need to be updated to accommodate resources like storage that are able to provide multiple services. Updating these rules will help to ensure that how a resource is classified (e.g., as generation, transmission, distribution, or load) does not hamper or preclude its ability to provide other services on a comparable basis with other resources. Market rules should be clarified or modified so that all resources that are capable of providing a product are able to participate in that market. Market products should be defined in a technology-neutral way so that market products and rules are geared toward the service needed rather than toward specific resource types. This will help to ensure that product requirements and eligibility are tied to the underlying operational needs of the system and not the characteristics of specific types of generation. The Federal Energy Regulatory Commission (FERC) and Regional Transmission Organizations (RTOs) already are working toward modifying existing rules so that classification rules accommodate multiple uses and allow energy storage devices to maximize their applications and, thus, enhance their energy grid and societal benefits.

- **Ownership:** In certain areas of the country that have restructured their electricity markets, electric companies may not be allowed to own generation assets. Access restrictions derived from existing asset classification rules (when, for example, storage is classified as a generation asset), mean that electric companies in some parts of the country may not be allowed to invest in energy storage devices. Yet, electric companies
are responsible for ensuring the reliability of the energy grid. Their inability to own energy storage in some cases takes away an option to enhance the reliability and resiliency of the nation’s energy grid to the benefit of all customers. For example, electric companies—with their extensive knowledge of the electric system—are in the best position to be able to identify the most valuable applications and the optimal locations to site resources on the energy grid. The location matters when it comes to the deployment of distribution system assets, including energy storage. The same resource can help or hurt the reliability and resiliency of the energy grid depending upon where it is located—by alleviating congestion, for example. This is not only important for reliability, but it also has a direct impact on costs as new technologies have the potential to defer or to reduce the need for incremental investments or, on the contrary, require additional investments in new capacity or distribution upgrades.

- **Interconnection and Operation:** Electric companies are responsible for interconnecting and operating new energy storage devices safely and reliably. In studies analyzing the impact of these new interconnections, energy storage devices generally are assumed to charge and discharge at levels and times that are inconsistent with actual operations. Integration of distributed energy resources, such as battery storage, into electric transmission and distribution operations is complex and requires the adoption of additional distribution automation technologies. Like all resources that interconnect to the energy grid, energy storage devices should be required to define the parameters under which they will operate. For instance, it should be clear what service(s) the energy storage system will provide, where it will operate (i.e., transmission or distribution system), when it will be available and for how long (duration), and how these systems will accomplish those tasks coordinating with electric systems operations. In addition, regulations should be clarified or revisited to allow for energy storage. For example, historically, regulations addressed consumption at generating plants with net deliveries to the energy grid. These types of regulations are being applied to storage devices, but are ill-suited to accommodate energy storage systems that receive electricity to store for later discharge to the energy grid.

FERC, RTOs, and individual states should continue to work toward removing barriers that artificially limit the ability of energy storage resources to provide the services they are technically capable of providing. This would allow energy storage to monetize multiple value streams and maximize its full potential for customers and society.
Policy Recommendations

Expanding deployment of storage requires overcoming a number of technical, economic, and regulatory challenges. As research, testing, and use continue to drive down costs, policy and regulatory changes can help to allow energy storage resources to achieve their full potential and improve storage’s contributions to markets. Policies and regulations do not always recognize the many benefits energy storage can provide.

Below are some policy recommendations for policymakers and regulators to keep in mind when considering energy storage:

- Deployment of energy storage should be done in a safe, secure, reliable, and cost-effective manner that recognizes the benefits of storage, including reliability benefits, whether in front of or behind the meter.
- All electric companies should have the ability to own and make investments in energy storage regardless of regulatory model.
- Regulations and standards should recognize the flexibility of the various types of energy storage and the best ways each can be used and allow the use of energy storage technologies, on a comparable basis with other resources, regardless of whether they support generation, transmission, distribution, and/or demand-side operations.
- Regardless of market design and regulatory environment, market products like ancillary and essential reliability services should be defined in a technology-neutral way so that market products and rules are geared toward the service needed rather than toward specific resource types.
- The specific benefit attributes applicable to various energy storage technologies are dependent on which services the particular storage technology is capable of providing. Realizing the full benefits of energy storage will depend on the resource’s ability to provide multiple services and to be compensated fairly for services provided. Regulations and standards should allow for the provision of multiple services without compromising safety, security, and reliability.
- Whether transmission-level, distribution-level, or direct customer interconnection is implemented, system impacts should be assessed using criteria appropriate to the technology, the intended uses of the device, and the electric system in which the device is to be utilized.
• Whether owned by electric companies, customers, or third parties, energy storage, when deployed in the distribution system, should follow the same guiding principles as all other similarly situated resources:
  o Ensure energy storage systems are connected safely.
  o Ensure fair, economically viable compensation of services, which will depend on regulatory framework and market design.
  o Ensure that retail ratemaking avoids cost-shifting to customers who do not own storage devices.
  o Enable full participation by electric companies in the ownership and/or operation of distributed storage as determined by the electric company and to support its business model, including maximizing the visibility and control of distributed storage by electric companies.
  o Encourage optimal location and other technical specifications, when possible, to increase the value that distributed storage provides to the distribution system.
  o Ensure, for planning and operating purposes, visibility by electric companies, impact assessment, and some level of company input into and control of the energy storage resources that are connected to the distribution system.
  o Encourage appropriate coordination among the transmission and distribution systems (and federal and state regulators) to the extent that distributed storage will impact the transmission system.

Moving forward, it is important to recognize the multiple values and varied uses of energy storage so that these technologies can help to enhance the flexibility, reliability, and resiliency of the energy grid for the benefit of all customers.
The Edison Electric Institute (EEI) is the association that represents all U.S. investor-owned electric companies. Our U.S. members provide electricity for 220 million Americans and operate in all 50 states and the District of Columbia. EEI also has dozens of international electric companies as International Members, and hundreds of industry suppliers and related organizations as Associate Members.

Safe, reliable, affordable, and increasingly clean energy enhances the lives of all Americans and powers the economy. As a whole, the electric power industry supports more than 7 million jobs in communities across the United States and contributes 5 percent to the nation’s GDP.

Organized in 1933, EEI provides public policy leadership, strategic business intelligence, and essential conferences and forums.

For more information, visit our Web site at www.eei.org.