Energy Storage - Program 94

Program Overview

Program Description

Energy storage is attracting increasing interest from utilities and regulators as a flexible grid asset, able to address issues caused by the increasing penetration of variable renewable resources, as well as increase system reliability. Storage may also provide temporary solutions for regional and local capacity shortages, and may provide relief to localized transmission and distribution congestion.

Advances in storage technology, as well as investment in production capacity, have begun to reduce the price of energy storage technologies, bringing them to the verge of cost-effectiveness in some applications. Nevertheless, the cost-benefit relationship for storage is still marginal in most instances, and cost-effective use of storage requires the user to take full advantage of potential benefit streams. The various applications that contribute to the value of storage have different requirements, however, and the ways in which these requirements are coincident or competitive are yet to be understood.

Many of the solutions provided by energy storage may also be possible through the use of distributed generation technologies fueled by natural gas. Technologies such as fuel cells, microturbines and small reciprocating generators are still relatively expensive in terms of installed capital cost, but low fuel costs and opportunities offered by the application of combined-heat-and-power (CHP) architectures may make them increasingly cost-effective options in the future.

While storage and distributed generation options are rapidly maturing and are beginning to become practical in grid applications, there are still significant challenges to overcome:

- Understanding the performance characteristics, cost, and expected service lifetime, as well as the relative maturity, of various storage and distributed generation technologies in grid applications
- Identifying the additional hardware, software, and user interfaces required to implement storage on the grid
- Defining the technical requirements for various applications of energy storage
- Understanding the possible impact on transmission and distribution system planning, as well as construction and operations
- Assessing the various uses of storage, including the performance requirements, cost break-even points, and valuation
- Understanding the effects of policy and regulation on the adoption and cost-effectiveness of storage applications
- Understanding the environmental impact of storage application

Research projects that address these challenges can help move storage technologies forward and enhance the value of storage to society.

Research Value

Electric Power Research Institute (EPRI) research focuses on facilitating the availability of grid-ready energy storage options for utility applications, as well as informing utilities, regulators, government agencies, and the general public on technical and economic issues, opportunities, and challenges related to the use of utility-scale energy storage and distributed generation.

The EPRI collaborative research environment enables engagement with utilities, technology developers, and other stakeholders to test and evaluate new technologies and products, define functional requirements for energy storage systems, develop tools and methodologies to analyze the effects of storage on the power delivery network and optimize their use, and create approaches that assess the business cases for storage in various applications and regions.
Through this program, utilities, government bodies, storage developers and vendors, electricity end users, and other stakeholders will be better informed about the opportunities and challenges facing electric energy storage and distributed generation technologies and products deployed on the grid.

**Approach**

This EPRI research will be shared with members of the program in a number of formats, and is expected to include the following:

- Strategic intelligence and specific technology assessments of energy storage and related distributed energy resource (DER) options
- Industry white papers to inform stakeholders on the maturity of various storage technologies and the potential of grid-related applications
- Functional requirement documents and technical specifications for grid-connected distributed storage systems that can increase the flexibility of distribution grids as well as the bulk power system
- Deep dives into the cost and performance of energy storage technology options
- Up-to-date case summaries of on-going energy storage demonstrations
- Test reports providing data on the operating envelope, performance, and durability of emerging energy storage systems
- Case studies to define storage operational requirements, suitable locations, and scale, as well as duration requirements of storage solutions for maximizing the expected benefits

**Accomplishments**

In the past, the Energy Storage program has delivered valuable information that has helped its members and the industry in numerous ways. Some examples include:

- EPRI created the *Energy Storage Cost Benchmarking Database 1.0* (EPRI 1024279) in 2012. This interactive cost tool builds on work done in previous years (particularly the *Energy Storage Technology and Application Cost and Performance Database* (EPRI 1021932)) with updated data on the cost, performance, and capabilities of energy storage systems for various applications in an Excel-based software tool. The goal of the database is to develop consistent installed costs, and operations and maintenance costs, for a set of selected energy storage systems providing an identified set of services.
- EPRI released the *Energy Storage Valuation Tool* (ESVT) 3.0 in 2012. The ESVT is a software program that can help utilities and regulators understand when and where grid-connected energy storage systems can be justified in terms of cost and benefit. This tool is continuously refined and updated; the latest version, ESVT 3.1 (EPRI 3002000312), was released in April 2013. In early 2013, EPRI used inputs from the California Public Utility Commission Stakeholder Group for the Energy Storage Order Instituting Rulemaking process to inform the group’s discussion on targets for energy storage adoption in California.
- EPRI published *Electricity Energy Storage Options* (EPRI 1020676), a comprehensive analysis of energy storage applications and technology options that also assesses the potential benefits and markets for energy storage in the United States. The analysis looks at 10 energy storage applications that EPRI determined could serve the bulk of the energy storage market, and includes applications to support wholesale energy services and renewable integration.
- EPRI published *Functional Requirements for Electricity Energy Storage Applications on the Power System Grid* (EPRI 1021936), which lays out the basic functional requirements for distribution-level and customer-side-of-the-meter energy storage products in terms of performance, interconnection, safety, communications, and user interface. This document serves as a reference to both utilities who wish to install energy storage and vendors who wish to build systems for utility applications.
- EPRI released *Substation Energy Storage Product Specification* (EPRI 1024282), a public reference technical specification for substation-scale batteries that provides a set of standardized technical requirements such as footprint, performance, safety, and reliability. This reference specification defines key aspects of a standardized design that addresses utility needs, which defines a target for storage system vendors as well as a reference that utilities can customize to address the needs of their specific service territories and jurisdictions.
Current Year Activities

In 2014, this research program expects to accomplish these objectives:

- Continue refinement of the Energy Storage Valuation Tool (ESVT) to allow faster and more accurate estimates of the value of grid-connected energy storage systems in various scenarios. The ESVT will also be expanded to include electrothermal energy storage systems such as ice storage and controllable hot water heaters. Depending on time and funding constraints, the ESVT may also incorporate value propositions for vehicle-to-grid (V2G) and customer-side-of-the-meter storage systems.
- Extend the methodology for distribution-level analysis of grid impacts of energy storage using OpenDSS or similar tools, and develop case studies that can inform the refinement of reference specifications, enhance the accuracy of value analysis tools, and inform the creation of appropriate algorithms for the control of energy storage.
- Extend the methodology for bulk system-level analysis for the use of energy storage in the grid, using Plexos or similar tools, and to develop case studies that can similarly inform the specification, analysis, and operational algorithms needed for the effective use of energy storage on the grid.
- Create and support an Energy Storage Integration Council, a technical working forum for utilities, vendors, and other stakeholders to discuss important technical interface issues for deploying energy storage on the grid.

Estimated 2014 Program Funding

$4.0M

Program Manager

Haresh Kamath, 650-855-2268, hkamath@epri.com

Summary of Projects

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Project Title</th>
<th>Description</th>
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<tbody>
<tr>
<td>P94.001</td>
<td>Strategic Intelligence and Technology Assessments of Energy Storage and Distributed Generation</td>
<td>This project provides analysis and strategic information on energy storage and DER systems through an online technology assessment database, annual technology assessments, and quarterly strategic intelligence reports. Analysis is undertaken to understand the impacts of energy storage systems, including their costs, benefits, and potential value. The project also includes assessments and evaluations of various technologies. Some of the information may be published in white papers to inform the public, including regulators and other stakeholders.</td>
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<tr>
<td>P94.002</td>
<td>Distributed Energy Storage Options for Power Delivery and End Use</td>
<td>This project provides information and guidelines for using distributed energy storage and distributed generation systems for power delivery and end-user applications such as infrastructure investment deferral and peak management, including shifting. To achieve this, the project conducts analyses, performs laboratory testing and field demonstrations, and prepares case studies of current and emerging battery energy storage systems.</td>
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<tr>
<td>P94.003</td>
<td>Bulk Power Energy Storage Solutions</td>
<td>This project provides information and guidelines for using bulk energy storage to shift low-cost, off-peak energy to high-value, on-peak energy and provide ancillary services, including the integration of bulk variable generation. It includes research and development on technologies such as low-fuel compressed air energy storage (CAES) systems, pumped hydro, and emerging large flow battery systems. The project also conducts analysis and encourages consistent modeling of energy storage with commercial tools.</td>
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P94.001 Strategic Intelligence and Technology Assessments of Energy Storage and Distributed Generation (051547)

Description

Utilities and other stakeholders require strategic, factual, and empirical information on current and emerging energy storage technologies and products, which could bring new opportunities for utility operations and may be used to enhance the integration of renewable generation. Distributed generation and microgrid technologies also represent substantial near-term opportunities in the electric grid, and sound technical information and analyses are required to understand how they can change the electric power enterprise in the near future.

Such information includes technical characteristics, performance and cost information, and trends in energy storage and distributed generation options. Analysis is needed to improve the understanding and assess the costs and benefits of energy storage and distributed resources in a smart grid, including resource planning and the associated impacts of greenhouse gas emissions. The effects of regulatory and legislative actions must also be understood and assessed.

Approach

This project provides analysis and strategic planning information on energy storage technologies systems as well as distributed generation systems. The project updates EPRI's technology assessment database, and also produces annual in-depth technology assessments and quarterly strategic intelligence reports. The project performs a technology watch and tracks, monitors, and summarizes all ongoing energy storage demonstrations. The program also tracks developments and trends in distributed generation options such as fuel cells. In addition, the project monitors the applications of small to large energy storage options for frequency regulation and end-use peak load shifting in transmission and distribution.

Analysis is undertaken to assess the technology, operational values, costs and benefits, and impacts of energy storage systems, including distributed and bulk energy storage systems as well as novel flow battery technologies. This includes benchmarking energy storage and advanced distributed generation technologies. The results are maintained in a comprehensive energy storage system cost database.

The project will apply methods developed by EPRI to estimate the value, benefits, costs, and greenhouse gas impacts of implementing a DER portfolio within a utility planning framework.

The project monitors and assesses regulatory and legislative developments that relate to energy storage, and where appropriate attempts to determine the effects of these policies on the adoption of storage.

This project monitors and reports summary information for all energy storage demonstrations projects underway in the United States, as well as a select number of international projects and demonstrations.

Selected research results and findings will be made publicly available, at no cost, as white papers or technical briefs, to better inform the public, policy makers and other stakeholders about the role, requirements, and value of electric energy storage systems to the electric industry.

Impact

Project participants could benefit in a number of ways, including the following:

- Having access to timely information on trends and developments in energy storage and distributed generation
- Acquiring strategic intelligence on emerging technologies that can affect utility business operations
- Gaining insight into the carbon-reduction impacts of energy storage and distributed generation systems
- Receiving objective information to support strategic corporate planning and answer regulatory inquiries
- Having access to EPRI's energy storage cost/system database, as well as assessments to support corporate strategy and decisions to invest in distributed generation and energy storage initiatives
- Learning how to quantify the value of a distributed resource portfolio for utility business operations
- Understanding the impacts of regulatory and legislative policies on the adoption of energy storage options
How to Apply Results

Research findings can be used by corporate and resource planners as part of their strategic planning function, and could help them anticipate technology trends and apply solutions to business issues. Distribution system designers may incorporate research findings and results into future grid expansion assessments. Results could also be used by regulatory policy and regulatory affairs managers to respond to state public commission inquiries related to distributed generation and energy storage costs, benefits, or market integration, as well as inquiries related to greenhouse gas emissions and the impacts of decentralized generation. Corporate strategic planners can use EPRI research findings and products to

- respond to senior management inquiries about energy storage, distributed generation, and microgrid technologies,
- evaluate the technology and investment risks of distributed generation and energy storage initiatives,
- inform senior management on technologies that could affect or improve business operations, and
- inform policy makers about the opportunities, risks, and technical challenges to storage, distributed generation, and microgrid technologies and products.

2014 Products

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<thead>
<tr>
<th>Product Title &amp; Description</th>
<th>Planned Completion Date</th>
<th>Product Type</th>
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<tr>
<td>Energy Storage Valuation Tool 4.0: This software product will provide capability to perform business case analysis for grid energy storage for multiple applications and technologies. It utilizes hourly simulation to model the unique capabilities and constraints of energy storage and provides a cost-benefit analysis across various scenarios and ownership perspectives. The 4.0 version of the tool will include customer-side-of-the-meter applications, as well as options to look at thermal energy storage and other new technologies.</td>
<td>06/30/14</td>
<td>Software</td>
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<td>Energy Storage Technical Deep Dive: The product will provide detailed information on the technical performance and cost of specific energy storage technologies, in terms of present status and likely future capability of the technology. Technologies investigated may include advanced lead-acid batteries, lithium ion batteries, high-temperature sodium batteries, flywheels, and advanced compressed air systems. More advanced technologies may also be investigated.</td>
<td>12/31/14</td>
<td>Technical Update</td>
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<tr>
<td>Energy Storage Demonstration Case Studies: This product provides case study overviews of energy storage installations at utilities across the U.S. and around the world. The case studies will include, as available, information about the manufacturer, the sizing of the system (power and energy), the issue that the storage system is addressing, expected modes of operation, performance of the system, and lessons learned. Possible demonstrations to be addressed include U.S. Department of Energy (DOE) demonstrations and utility-sponsored demonstrations nationally and internationally.</td>
<td>12/31/14</td>
<td>Technical Update</td>
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<tr>
<td>Strategic Intelligence Update, March 2014: Strategic intelligence reports provide objective information on current and emerging distributed generation and energy storage technologies that could influence or support utility business operations and reduce carbon emissions. This information will include technology, economic, and policy developments that affect the use of utility-scale energy storage. Four will be produced, with a feature story and summaries of the latest information on the cost, performance, and trends of distributed generation and energy storage options that are available from credible sources in the literature.</td>
<td>03/31/14</td>
<td>Technical Update</td>
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<td>Product Title &amp; Description</td>
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<td><strong>Strategic Intelligence Update, June 2014:</strong> Strategic intelligence reports provide objective information on current and emerging distributed generation and energy storage technologies that could influence or support utility business operations and reduce carbon emissions. This information will include technology, economic, and policy developments that affect the use of utility-scale energy storage. Four will be produced, with a feature story and summaries of the latest information on the cost, performance, and trends of distributed generation and energy storage options that are available from credible sources in the literature.</td>
<td>06/30/14</td>
<td>Technical Update</td>
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<tr>
<td><strong>Strategic Intelligence Update, September 2014:</strong> Strategic intelligence reports provide objective information on current and emerging distributed generation and energy storage technologies that could influence or support utility business operations and reduce carbon emissions. This information will include technology, economic, and policy developments that affect the use of utility-scale energy storage. Four will be produced, with a feature story and summaries of the latest information on the cost, performance, and trends of distributed generation and energy storage options that are available from credible sources in the literature.</td>
<td>09/30/14</td>
<td>Technical Update</td>
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<tr>
<td><strong>Strategic Intelligence Update, December 2014:</strong> Strategic intelligence reports provide objective information on current and emerging distributed generation and energy storage technologies that could influence or support utility business operations and reduce carbon emissions. This information will include technology, economic, and policy developments that affect the use of utility-scale energy storage. Four will be produced, with a feature story and summaries of the latest information on the cost, performance, and trends of distributed generation and energy storage options that are available from credible sources in the literature.</td>
<td>12/31/14</td>
<td>Technical Update</td>
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| **Distributed Energy Resources Hotline and Forum:** The DERHotline@epri.com is intended to provide a forum and mechanism providing answers to the increasing number of questions that EPRI members have about integration and system impacts of DER. This new members-only communication tool will provide a clearinghouse of information on issues related to the integration, operation, and management of distributed generation. It will explore, among other things, unidentified issues as they arise to offer members insights into frontline challenges. This Hotline is a collaborative effort among the Energy Storage (P94), Solar Generation (P187), and Distributed Integration (P174) program areas. This product will provide:  
  - Knowledge sharing, technology transfer, and industry coordination;  
  - Publishing of selected questions and responses in Program Cockpits, database, program newsletters, etc.;  
  - An end-of-year DER Hotline learning report; and  
  - Topical webcasts. | 12/31/14                | Technical Resource     |
P94.002 Distributed Energy Storage Options for Power Delivery and End Use (065556)

Description

Grid energy storage options may provide a number of key benefits to distribution utilities. Storage placed at substations and at the edge of the grid can provide local capacity and backup power, increasing the reliability and resiliency of the grid. They can also enable peak shaving, allowing the deferment of asset upgrades and the ability to serve new loads such as fast chargers for plug-in vehicles. Storage can also assist in the integration of distributed renewable technologies such as solar photovoltaic (PV) panels.

Distributed energy storage technologies such as batteries have progressed immensely in the last decade, improving substantially in performance while dropping in price, as a result of sustained investment driven by the need for better storage technologies for mobile electronics and electric vehicles. Storage developers and integrators are now turning their attention toward developing complete grid storage products that incorporate storage technologies with power electronics, thermal management, and control systems. These products are still relatively immature, but are making rapid strides toward deployment.

Meanwhile, utilities are beginning to address issues related to integrating storage to the grid, including interconnection, protection, communication, grid effects, and operational algorithms. Collaborative research, bringing together efforts from utilities, storage vendors, integrators, and other stakeholders, can accelerate this process towards cost-effective, grid-ready energy storage products, ready for deployment and operation as grid assets in substations, along the feeder, and beyond the meter.

To implement these new products, utilities need empirical information on costs, performance, operational characteristics, reliability, risks, and durability. Research is required to better understand grid integration solutions and tools, including energy storage system capabilities such as performance, efficiency, and cycling capability.

This project focuses on applied research to facilitate the incorporation of energy storage technologies into complete, grid-ready storage systems that can be easily deployed on the grid, as well as methods to ensure the proper integration of such systems into the bulk grid. Research includes testing storage system capabilities and advancing grid-integration tools via case studies and tool development. Research also aims to understand the performance and technical readiness of energy storage technologies to provide desirable utility modes of operation under varying conditions. In addition, research examines the effects of storage on the grid in terms of stability, control, reliability, and understanding what must be done in terms of transmission and distribution (T&D) system planning, construction, and operation to ensure that the physical connection of storage solutions is effective.

Approach

The project will provide information and guidelines for using energy storage systems for distributed applications, including the use of storage to enhance reliability and resiliency of the grid, to integrate distributed renewable technologies such as solar PV, and to temporarily defer investments in local grid infrastructure by shifting the load from peak to off-peak. The project also assesses storage solutions for meeting end-user load-management and peak load-shifting needs, and compares the findings with other options.

In addition, this project develops detailed, application-specific requirement specifications for grid-support storage systems located in substations, along feeders, at the edge of the grid, and beyond the meter, including requirements to ensure seamless integration with existing grid efforts. This effort may eventually lead to customizable, standardized storage systems that members can install and integrate with relative ease.

The project will expand the storage-grid integration efforts conducted by EPRI over the past few years. Research and development (R&D) activities include modeling to understand the effects of storage on the grid in terms of voltage impact, control, and using OpenDSS software to better understand storage operational requirements, and to identify suitable locations and scale for connecting storage.
Impact

Project participants may benefit in a number of ways:

- Obtaining a demonstrated capability to use distributed energy storage for grid support
- Acquiring guidelines and best practices for procuring, installing, operating, or contracting for energy storage systems
- Understanding risks based on validated test data for performance, costs, and operational issues related to energy storage and selective emerging DER options
- Incorporating the use of distributed energy storage options into T&D planning
- Understanding options for deferring T&D capital investments by applying storage solutions for peak management
- Making more informed purchase and deployment decisions for energy storage systems

How to Apply Results

Research findings may be used by distribution planners to develop grid solutions, and by engineers and planners when developing a smart grid implementation. Distribution system designers of smart grids can incorporate research findings and results into future grid expansion plans. Results from case studies and evaluations can be used to assess the risk and value of energy storage to utility business operations. Results can also be used to develop new energy-management and demand-response solutions for end-use customers.

2014 Products

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<tr>
<th>Product Title &amp; Description</th>
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<tbody>
<tr>
<td>Distribution Energy Storage Technology Update:</td>
<td>12/31/14</td>
<td>Technical Update</td>
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<tr>
<td>This report will describe the results of continuing research done to facilitate the creation and deployment of distribution-level energy storage for substation, feeder, edge-of-grid, and customer-side-of-the-meter applications. This research may include updates to previously developed functional requirement definitions, reference specifications, test protocols, and operational guides, as well as testing results for component and system-level testing done at the Knoxville labs.</td>
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| Distribution Energy Storage Integration Update: | 12/31/14 | Technical Update |
| This product will include results from continuing research activities to understand the effects of storage on the grid in terms of stability, control, and reliability. This will include the further development of methodologies to calculate how storage can be used to affect the grid, as well as the effect of location on the value of storage. Case studies are undertaken using tools like OpenDSS to better define storage operational requirements, best locations, scale, and energy duration of storage solutions for maximum impact. |

| Case Studies Evaluating Energy Storage as an Effective Solar Grid Integration Tool: | 12/31/14 | Technical Update |
| This product will present summary information on DOE- and utility-sponsored U.S. energy storage demonstrations as well as standalone commercial projects in a case studies report. Performed jointly with EPRI's Program for the Integration of Distributed Renewables (P174), research will detail the historical contexts, system components and characteristics, performance results, costs/benefits, and lessons learned for a diversity of projects primarily dedicated to meeting solar grid integration objectives. It will also potentially leverage information from EPRI's Energy Storage Valuation Tool (ESVT) to more closely examine the economic outcomes/viabilities of observed projects. |
P94.003 Bulk Power Energy Storage Solutions (065557)

Description

The electric enterprise requires cost-effective and reliable bulk energy storage to help balance and optimize supply and demand of bulk power resources, including nuclear, fossil, and renewable resources. This may include enhancing transmission system effectiveness and shifting low-cost, off-peak generated energy to provide on-peak, high-value energy.

In addition, state renewable portfolio standards (RPS) are encouraging a high penetration rate of variable renewable resources. Bulk power storage may be one option to help utilities manage the variability of renewable resources. This project examines the functional requirements and storage technology capabilities for mitigating the effects of renewable generation variability. It also analyzes the possible impact of bulk energy storage on long-term planning.

Presently, several technologies are at a maturity level that may help meet the requirements, including compressed air energy storage (CAES) and pumped hydro. New concepts in CAES, such as small distributed isothermal systems, must be examined for their potential in this application. Pumped hydro should also be assessed for its ability to provide cost-effective bulk storage. Selected battery technologies, such as flow batteries or advanced intercalation chemistries, may also hold opportunities for these types of applications. In the long run, hydrogen generation, storage, and reconversion to electricity may be a technology worth pursuing.

Approach

This project provides information and specific solutions using bulk storage to improve the value of large-scale variable renewable generation. It also conducts regional impact research and development (R&D) to assess the impacts of storage on the grid and environment.

This work will include an examination of advanced CAES cycles, such as adiabatic systems and isothermal systems, as well as aboveground approaches with heat input. New technologies that may result in higher efficiency, better performance, or lower costs will also be examined.

The project will also define and benchmark non-CAES bulk storage options including flow batteries, sodium nickel chloride (NaNiCl₂), and sodium-ion (Na-ion) storage systems, which may include a 50-MW battery storage system. As storage systems reach a higher level of readiness for deployment, the program will evaluate and compare existing economic and cost-benefit analysis tools that support both bulk and distributed energy storage options.

EPRI plans to collaborate with storage research stakeholders such as Sandia National Laboratories and the National Renewable Energy Laboratory (NREL) to investigate more long-term technologies such as hydrogen for use as bulk storage.

Impact

Project participants may benefit from this project in a number of ways, including the following:

- Increasing the market penetration of variable wind power
- Improving cost-effectiveness and reducing the industry's greenhouse gas emissions profile
- Learning about assessments and timelines for advanced bulk energy storage systems
- Improving their utilization and operation of transmission assets
- Improving their understanding of the system-wide benefits of CAES and other bulk energy storage
- Improving their use of fossil assets by reducing thermal generator ramping and lowering greenhouse gas emissions when using storage for ancillary services and load following
**How to Apply Results**

Research findings could be used by corporate strategic planners, resource planners, and system planners, as well as utility design engineering staff. Planners and operators of bulk power generators may use the results to plan new projects and increase the use of existing baseload or intermediate-duty generation assets. Independent system operators (ISOs) can incorporate project findings into their planning and market development activities.

**2014 Products**

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<tr>
<td><strong>Bulk Storage Technology Reference Guide and Update (2014):</strong> This report will describe</td>
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<td>Technical Update</td>
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<tr>
<td>the results of research done to facilitate the creation and deployment of bulk energy</td>
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<tr>
<td>storage options for bulk grid and transmission applications. This research may include</td>
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<td>updates to previously developed functional requirements definitions, reference</td>
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<td>specifications, test protocols, and operational guides, as well as testing results for</td>
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<td>component- and system-level testing.</td>
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<td><strong>Analysis Methodologies and Tools for Energy Storage in the Bulk Power System:</strong> This</td>
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<td>Technical Update</td>
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<td>product will deliver the results of research organized to help understand the effects of</td>
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<td>energy storage in integration of large amounts of renewable resources on the bulk grid.</td>
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<td>This will include the development of standard methodologies for understanding the value</td>
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<td>of storage in the context of the bulk grid, as well as case studies using these methods</td>
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<td>logies to understand the value of storage in specific contexts. It will also focus on the</td>
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<td>sensitivities of such analyses to various study parameters.</td>
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<td><strong>Operational Algorithms for Bulk Energy Storage:</strong> This product will deliver the results</td>
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<td>Technical Update</td>
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<td>of research organized how energy storage must be operated to ensure integration of large</td>
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<td>amounts of renewable resources on the bulk grid. This will include the development of</td>
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<td>operational procedures and algorithms to optimally operate storage for the bulk grid.</td>
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<tr>
<td><strong>Compressed Air Energy Storage Technology Status Update:</strong> This product will be a review</td>
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<td>Technical Update</td>
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<td>of 2014 and past CAES projects, including system design, cost, and value expectations</td>
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<td>(where possible), as well as a technology update and updates on CAES projects (either by</td>
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<td>T&amp;D utilities or merchant providers.</td>
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Supplemental Projects

Battery Storage Systems and Applications Demonstration (072067)

Background, Objectives, and New Learning

Energy storage technology is an important potential option for utilities, system operators, and end users to increase reliability and reduce the cost of electricity. It may be especially important as a flexibility asset to address the integration of variable generation resources such as wind and solar. Storage may also be a tool to improve asset utilization at the distribution level, and if it can be produced at a very low cost, it can be used for diurnal energy arbitrage.

However, the widespread use of energy storage is unlikely without some additional development on the technology. Costs for storage must be reduced; to an extent, this is already occurring, thanks to heavy technology investment from the consumer electronics sector and now the automotive sector in support of electric vehicles.

In addition, product vendors must step forward to create complete energy storage systems from the underlying battery technology, with the end goal of “plug-and-play” standardized storage products that utilities will know how to install with minimal special effort required.

On the utility side, there must be well-understood practices for interconnection of storage to the grid, as well as appropriate control technologies that can enable multiple value streams to justify the capital and operations cost of storage. The key research objectives of the proposed demonstration are to:

• Deploy a prototype system built according to a specification developed collaboratively by utilities

• Bring together data and experiences from other, existing lithium ion-based energy storage demonstrations, with a consistent approach to data analysis and understanding of integration efforts

• Develop and use standardized analytical tools and methodologies to determine the impacts that energy storage can make on the grid and the benefits that can be derived from its use

• Understand the total cost of ownership for energy storage systems across the operational lifetime

• Recognize and assess the differences in performance between different storage technologies

• Create information required to develop standardized interconnection, control, and integration practices for energy storage to allow relatively simple integration of energy storage projects.

• Produce information that can inform regulatory action that may ultimately make multiple value streams possible.

Project Approach and Summary

This project will be based on the experience of many storage installations, applications and technologies. Owners of existing storage technologies are encouraged to participate with the expected benefit of gaining the experience form a variety of all installations. In addition this project will procure an energy storage systems based on the EPRI Specification in 2011 together with select host utilities.

There will be three levels of participation in this demonstration project.

"EPRI-Lease System Hosts" will receive an energy storage system procured by EPRI for a field demonstration of approximately two years, with intended installation in Q4 2012 or Q1 2013. EPRI-Lease System Hosts will be required to design and implement the system interconnection with their system.

"Self-Provided System Hosts" will provide their own energy storage systems intending to comply with the EPRI Specification.
Benefits

Benefits of this demonstration may include improved technical understanding of Li-ion energy storage technology, which may increase grid reliability, enable increased penetration of variable renewable energy resources, manage peak demand which may lead to deferring additional investments in generation and delivery infrastructure, and may reduce end-user electricity prices.

Funder benefits may include understanding of the value and technical capability of an early deployment of energy storage technology, with the potential to aggregate several beneficial impacts of storage on grid and market performance; and, understanding the Li-ion technology's potential to serve both utility and plug-in electric vehicle applications.