Energy Storage - Program 94

Program Overview

Program Description

The program implements a vision that energy storage systems may be essential when managing large quantities of variable renewable generation as well as peak loads. The program provides the industry with technical and economic information about the options to store energy as a means to manage variability and peak loads while enhancing grid reliability. By enabling wind integration, energy storage can help utilities reduce greenhouse gas (GHG) emissions. Distributed storage systems can create value to utility business operations by improving management of peak loads and mitigating outages, which can improve relationships with end use customers. The program provides valuable information from objective technology assessments, lab tests, field demonstrations, and case studies. The technologies that may be covered include large-scale, bulk storage options such as pumped hydro, nonfuel, adiabatic compressed air storage as well as many types of battery storage technologies such as sodium-sulfur (NaS), lithium-ion (Li-ion), zinc-air (Zn-Ar), zinc-bromine (ZnBr), and other emerging flow battery systems. While the main focus is on electric energy storage, the program also monitors and assess emerging distributed generation technologies based on member needs. The program is an integral part of related research in EPRI's IntelliGrid, Smart Distribution Applications, Electric Transportation, and Renewable Resources Integration programs.

Research Value

With the knowledge acquired through this research program, program members will have access to information that can help them in these ways:

- Objective, unbiased information can help support strategic and corporate planning, renewable portfolio standards, and regulatory inquiries in the area of energy storage and distributed resources.
- Technical characteristics and costs of nonfuel compressed air cycles can aid in planning for increasing and improving wind integration.
- Information to support deployment and planning decisions for electric storage options may help meet needs for grid support and peak management.
- Industry white papers help inform regulators and policy makers on the value and applications of energy storage within the electric grid.
- Members gain best practices for using energy storage for grid asset management, reliability, end-user energy management, and meeting utility renewable and other “green” initiatives.

Approach

EPRI research in energy storage will yield a variety of information and knowledge that will be beneficial to members of the program. This information will come in a number of formats and is expected to include:

- Strategic intelligence reports and specific technology assessments of energy storage and emerging distributed energy resource options
- Industry white papers to inform stakeholders on the role and value of energy storage
- Nieghborhood energy storage systems for end-user peak load management and outage mitigation
- On-line database for all energy storage and distributed energy resource (DER) options
- Best practices and specifications of transportable energy storage systems for grid asset management applications
- Case studies and testing of emerging energy storage systems

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:

- Quarterly strategic intelligence reports and trends to anticipate and plan new deployments of energy storage
- In-depth technology assessments of Li-ion, and other advanced battery systems
- Quantification of the markets and value of energy storage systems along the entire electric utility value chain
- Identification of novel bulk energy storage cycles: e.g., second-generation compressed air systems and nonfuel compressed air systems
- Best practice guidelines for using NaS energy storage for grid support
- Benchmarking the costs and GHG emissions of distributed generation options
- Updated cost and performance of second-generation compressed air storage systems

Current Year Activities

In the coming year, this research program expects to accomplish these objectives:

- Strategic intelligence reports on trends in the energy storage and distributed generation
- Updated market, value, and gap analysis of energy storage systems for utility applications
- In-depth technology assessments of Zn-Air and advanced lead acid batteries
- Definition and specification of neighborhood energy storage systems and technology options
- Specification of transportable energy storage systems and options for grid support
- Online database updates on energy storage systems in www.disgen.epri.com
- Regional case study of a compressed air storage system to assess value and GHG impacts under wind penetration scenarios
- Conceptual design and definition of nonfuel, advanced compressed air energy storage systems

Estimated 2010 Program Funding

$2.5M

Program Manager

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Summary of Projects

Project Number	Project Title	Description
P94.001	Strategic Intelligence, Technology Assessments and Green House Gas Analysis of Energy Storage and Distributed Generation	This project provides analysis and strategic planning information on energy storage and distributed energy resource systems through an online technology assessment database, annual technology assessments, and strategic intelligence reports. Analysis is undertaken to understand the cost, benefits, markets, and impacts of energy storage systems. Specific technology evaluations and assessments are prioritized by members. Industry white papers are prepared to inform stakeholders.
P94.002	Energy Storage and Distributed Generation Options for Grid Support and Reliability	This project area provides specific solutions, information, and guidelines for using distributed energy storage and distributed generation systems for grid support and peak management. To achieve this, the project conducts analyses, performs lab testing and field demonstrations, and prepares informative case studies of current and emerging energy storage systems. Technical results include empirical data on performance, lessons learned, risks, and costs of these systems for use in a utility environment. This project also translates laboratory tests and field demonstration lessons learned into best practices and guidelines for use by grid asset management managers, distribution planners, and energy managers.
P94.003	Bulk Power Energy Storage Solutions	This project area provides information and specific solutions based on non-fuel based compressed air energy storage (A-CAES) systems pumped hydro, and emerging large flow battery systems to improve the value of large-scale variable renewable generation This area also address energy storage based solutions from the ISO / RTO perspective in providing ancillary services.

P94.001 Strategic Intelligence, Technology Assessments and Green House Gas Analysis of Energy Storage and Distributed Generation (051547)

Key Research Question

Utilities need strategic and objective information on current and emerging energy storage and distributed energy resource technologies that could have an impact on utility operations and may reduce carbon emissions.

This information includes technical characteristics, performance and cost information, as well as trends of energy storage and distributed generation options. Analysis is needed to improve the understanding and assess the costs/benefits of a distributed portfolio in a smart grid, including the associated GHG emission impacts of distributed generation and energy storage.

Approach

This project provides analysis and strategic planning information on distributed energy resources (distributed generation and energy storage systems) through: an online technology assessment database; real-time web energy intelligence service; annual in-depth technology assessments; and strategic intelligence reports. Analysis is undertaken to understand the operational value, the costs and benefits, and impacts of energy storage systems. Specific technology evaluations and assessments are prioritized by members; technologies include novel distributed and bulk energy storage technology as well as novel flow battery systems.

Technology assessments of emerging energy storage systems will be performed, including zinc-bromine, new lithium–ion battery chemistries, fuel cells, and advanced ultra-capacitors. In addition, analysis will be

conducted to assess the value proposition of energy storage and distributed generation (DG) systems in current and future Smart Grid configurations. Also, databases will be developed that maintain the latest cost, performance, trends, and GHG footprint of distributed generation and energy storage systems.

This project tracks and benchmarks all distributed generation and energy storage technologies. It also monitors the status and development of all small to large energy storage options for transmission, generation, distribution, frequency regulation, and end-use peak load-shifting applications. Information on the value, role, and key markets for energy storage may also be transferred to external stakeholders via industry white papers, conferences, and collaboration with trade groups such as the Electricity Storage Association.

Impact

Participants in this project could be affected in a number of ways including:

- Having access to timely information on the trends and developments in energy storage and distributed generation.
- Acquiring strategic intelligence on emerging technology that can affect utility business operations.
- Gaining insight into 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 analysis and an online database, and assessments to support corporate strategy and decisions to invest in distributed generation and energy storage initiatives.
- Learning about the quantification of the value of a distributed resource portfolio to utility business operations.
- Getting information to support win-win policies for deployment of energy storage systems.

How to Apply Results

- Research findings will be used by corporate and resource planners as part of their strategic planning function and will help them anticipate technology trends and apply solutions to business issues. Distribution system designers of “smart grids” may incorporate research findings and results into future grid expansion assessments. Results could also be used by regulatory policy and regulatory affairs managers to develop responses to state public commission inquiries related to distributed generation and energy storage costs/benefits and market integration; or inquires related to greenhouse gas emissions and impacts of decentralized generation. Corporate strategic planners may use results to: respond to senior management inquiries;
- 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
- use EPRI research findings to inform policy makers.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Industry White Papers and Technical Briefs: This project will prepare one to three publically available industry white papers or industry technical briefs to better communicate the role and value of electric energy storage systems to the electric enterprise. Topics and key messages will be prioritized by members, but could include: Wind and Energy Storage Integration; Energy Storage in the Smart Grid; Neighborhood Energy Storage Systems and their Value; and Leveraging Energy Storage Technology being developed for Transportation Applications.	12/20/10	Peer Literature

Product Title & Description	Planned Completion Date	Product Type
Annual Technology Assessments: The program will conduct one or two in-depth energy storage technology assessments, with benchmarking and analysis based on staff recommendations and funder priorities. In 2009, updates were competed on advanced lead acid batteries, flow batteries, and Zn-Air batteries. In 2010, options may include supercapacitors using advanced materials, superconducting magnetic energy storage (SMES) using yttrium barium copper oxide (YBCO) wire; or novel bulk storage systems such as electrochemical production of methanol from renewable energy. Also, based on member needs, the project will conduct technology updates on emerging distributed generation systems.	12/31/10	Technical Update
Energy Storage Application Guide and On-line Data Base: This product provides members with a one-stop resource for objective EPRI information on the cost, performance, application, and integration of distributed generation and energy storage systems. It is the program's technology assessment guide, providing summary-level data on technology availability, costs, risks, GHG emission impacts, case studies, and applications. It also includes EPRI's Energy Voyager technology watch tool.	12/31/10	Technical Update
Strategic Intelligence Reports: Strategic intelligence reports provide objective information on current and emerging distributed generation and energy storage technologies that could affect or support utility business operations and reduce carbon emissions. Up to six reports are 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.	12/31/10	Technical Update
High value stationary applications for primary and secondary use of PHEV batteries. : This project will examine and identify several high-value stationary market applications for Plug-in Hybrid Electric Vehicle (PHEV) batteries. The goal is to identify a large stationary market opportunity to increase the production volume and lower the cost of PHEV type batteries. Also as PHEV batteries may outlive the vehicle, research will be conducted to identify the most promising secondary-use applications and develop a utility roadmap and application plan for the realization of this opportunity.	12/31/10	Technical Update

P94.002 Energy Storage and Distributed Generation Options for Grid Support and Reliability (065556)

Key Research Question

Aging grid infrastructure, the inability to install new lines, and requirements for higher reliability are prompting many utilities to consider energy storage and distributed generation options for capital deferral, grid support, distribution planning, and end-user energy management. The program’s portfolio of energy storage and distributed generation systems could be key essential assets in future smart grid configurations. To deploy and effectively utilize these assets in grid configurations, utilities need empirical information on costs, performance, operations characteristics, reliability, risks, and durability. Research is required to better understand the cost, performance and reliability of these options and how current and future grids can accommodate the use of distributed generation and energy storage assets.

Approach

This project area provides specific solutions, information, and guidelines for using energy storage and distributed generation systems for grid asset management and end-user load shifting—including applications for urban load pockets, radial feeders and substations, distribution networks, and communities. It also provides assessments of potential solutions for meeting end-user energy management needs in the areas of

load management and peak load shifting. To achieve this, the project conducts analyses and defines application requirements and specifications. It performs laboratory testing and field demonstrations, and prepares case studies of current and emerging distributed generation and energy storage systems. Technical results include empirical data on performance, lessons learned, risks, and costs of these systems for use in a utility environment. This project also translates laboratory tests and field demonstration lessons learned into best practices and guidelines for use by grid asset management managers, distribution planners, and energy managers. The overall goal of this project area is to advance applications for energy storage to support the grid and provide key information necessary to enable utilities to effectively integrate distributed systems that enhance grid management and reliability by 2012 in various smart grid configurations. In that regard, EPRI's program will seek to engage, leverage, and help transfer energy storage demonstration data and information anticipated to be forthcoming from energy storage demonstration projects to be funded by the industry via the DOE Energy Storage Stimulus Funding Opportunity- Smart Grid Demonstration Recovery Act.

Impact

Participants may be affected in a number of ways including:

- Obtaining demonstrated capability to use distributed energy storage for grid support
- Procuring, installing, operating, or contracting for energy storage systems in a safe and reliable manner by employing guidelines and best practices
- Gaining risk assessment information—based on validated test data—on the performance, costs, and operation of energy storage and selective emerging distributed energy resource options
- Incorporating the optimal use of distributed energy storage solutions into T&D planning activities
- Understanding the options for deferring T&D capital investments by applying storage solutions for peak management
- Making more informed purchase and deployment decisions of energy storage systems
- Gaining information to support investor relations on green initiatives and corporate strategic planning

How to Apply Results

Research findings may be used by distribution planners for grid operational 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 risks and value to utility business operations. Results can also be used to develop new energy management and demand response solutions for end-use customers.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Best Practices Guidelines for Transportable Storage Systems: The goal of this project is to advance the best practice use of transportable energy storage systems for grid support. The project will provide an update on the lessons learned from field trials of several 0.5 MW / 2 MWh ZnBr transportable energy storage systems, which were deployed in 2009. A best practices guideline will be prepared, which covers procurement, siting, permitting, integration, and operational considerations and use case(s) of such transportable energy storage systems.	12/31/10	Technical Update
Case Studies of Energy Storage in Grid Support Applications: NaS, and advanced lead acid batteries.: This project will provide updates and case studies on the most relevant energy storage demonstrations under way in the United States for Distribution Grid Support. Included will be updates on all the NaS battery demonstrations, as well as advanced lead acid demonstrations under way.	12/31/10	Technical Update

Product Title & Description	Planned Completion Date	Product Type
Case Study and testing of Li-ion battery systems integrated with Residential Photovoltaic systems.: This project will continue to test and evaluate emerging Li-ion energy storage systems that were started in 2009. 5 kW / 20 kWh modules and larger will be first tested at EPRI's Knoxville Living Lab and then migrated to the field for utility testing. Applications of interest are for integrated photovoltaics and also fast charging of PHEVs. We will also plan to test other emerging energy systems like new Zn-Air rechargeable systems.	12/31/10	Technical Update
Neighborhood Energy Storage Systems for Pad Mounted transformer and advanced IUT applications.: The goal of this project is to evaluate advanced distributed energy storage applications in a neighborhood or a community setting, where they are co-located with pad-mounted transformers. In 2009, the program developed a functional specification, requirements, and use case for such energy storage systems and collaborated with a utility stakeholder interest group. Initial technology mapping and screening were also conducted. This year's efforts will advance this application by conducting further technology screening, tests, and evaluations of candidate systems as well as advancing the future application with the Intelligent Universal Transformer (IUT). EPRI will work with members to test and evaluate selected systems and develop a field trial and demonstration / deployment program plan where these storage systems are part of a Smart Grid system.	12/31/10	Technical Update
Tests and evaluation of Emerging Energy Storage and DG Systems: This project will test and evaluate emerging energy storage and distributed energy resource options and characterize their performance and operating envelope and readiness for utility applications. Options will be recommended by EPRI staff and advisors and selected by funders. Activities may include tests of advanced batteries, micro-generation systems, and advanced distributed generation systems. EPRI will seek testing opportunities that leverage with awards provided from the U.S. DOE Smart Grid Demonstrations Recovery Act. The strategic intelligence activities and technology assessments conducted in the program will help identify promising options for possible evaluation. Examples may include:- 1 MW transportable fuel cell system for grid support and utility peak shaving- 3-5 kW residential energy storage system for back-up and demand response- 1-5 kW Honda fuel cell home appliance system- Zn / air modules and early prototype systems for beta testing.	12/31/10	Technical Update

P94.003 Bulk Power Energy Storage Solutions (065557)

Key Research Question

The electric enterprise needs cost-effective and reliable bulk energy storage to help balance supply and demand and optimize the operation of bulk power resources — including nuclear, fossil, and renewable resources. State renewable portfolio standards (RPS) may result in a high penetration rate of variable renewable resources. Utilities need bulk power storage solutions to effectively manage the variability of wind and effectively reap the emissions reduction potential of wind and solar power and the ability to store base-load energy for use during peak times. Presently two technologies are available that may help to achieve these goals: Compressed Air Energy Storage and pumped hydro. Second-generation compressed air energy storage solutions are receiving serious consideration, but they still require use of fossil fuels. This project looks into the options of compressed air energy storage designs without the need to burn fossil fuels, and therefore, there is a need for nonfuel CAES cycles. The industry also needs to re-examine the potential for pumped hydro applications and assess new technology developments in pumped hydro technology. Also,

given new trends and developments in large flow-battery systems, the program will re-examine the use of vanadium, Zn / Br and Zn / Cl redox cycles for use in large bulk storage applications.

Approach

This project area provides information and specific solutions based on nonfuel, advanced compressed air energy storage systems (CAES), pumped hydro, and large battery storage systems to improve the value of large-scale variable renewable generation. Research areas prioritized by members, will include:

- Advanced, nonfuel, compressed air energy storage (CAES) systems
- Technical Update on pumped hydro storage: costs, resource potential, sizing, siting, permitting, and historical operating experiences including an update on trends in new pumped hydro technologies
- Large (100 MW) flow battery systems- update and cost assessment
- Regional analysis of energy storage for renewable energy integration under upcoming state RPS requirements
- Energy storage for frequency regulation and ancillary services

Impact

Participants may be affected by this project in a number of ways including:

- Improving the market penetration of variable wind power — improving cost-effectiveness and reducing the industry's GHG emissions profile
- Learning about assessments and timelines for advanced bulk energy storage systems
- Improving the utilization and operation of transmission assets
- Improving the understanding of the system- wide benefits of CAES and bulk energy storage
- Improving the use of fossil assets and lowering GHG emissions when using storage for ancillary services

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 as well as increase the utilization of existing base-load or intermediate-duty generation assets. Independent system operators (ISOs) can apply findings into their planning and market development activities.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Advanced, non-fuel, Compressed Air Energy System Definition: This project will continue to advance the development of a nonfuel, advanced compressed air energy storage (A-CAES) system, with the goal of enabling a demonstration by 2013. In 2009, a concept design of an A-CAES system was developed, including trade-offs of thermal storage media/options. In 2010, the designs will be further optimized, refined, and updated with the focus on plant requirements for wind and renewable integration. Testing of the most optimal thermal media materials and containment will be undertaken to develop scale-up information. Modeling of the cycle will provide design information for transient operation inherent with thermal storage systems. The development plan and demonstration plan will be updated. A Project Task Force will guide efforts to conform with industry needs and requirements. The goal at the end of 2010 will be to have the design basis to proceed with more preliminary engineering and planning for technology demonstration and the value proposition for wind integration.As a separate effort and task, the cost and availability of large flow batteries will be re-examined and benchmarked against the non-fuel compressed air system for	12/31/10	Technical Update

Product Title & Description	Planned Completion Date	Product Type
application in wind integration.		
Pumped Hydro Resource Update: This project will provide an update on the current use and scale of pumped storage in the United States, including the value and GHG reduction impacts as a proxy for understanding the impacts of future bulk storage deployments. The update will provide information on how bulk storage is currently being used and deployed to gain insights into future storage system requirements. The update will also include a status report and information on trends in new pumped hydro facility deployments, planning studies, emerging new technologies, and issues. Based on member interest and funding, the opportunity will be examined for using municipal water systems as small pumped storage options.	12/31/10	Technical Update
Meeting Regional RPS Mandates with Energy Storage Systems: This project will continue work begun in 2009, examining the regional opportunities, role, and value of energy storage systems for improving renewable penetration and market integration, including the role that storage can play in reduction of the electric sector's carbon footprint. In 2009, the ERCOT region was examined for bulk compressed air energy storage systems. In 2010, we will conduct an analysis to: 1) better understand how much energy storage is needed by region to support high renewable generation scenarios; and 2) the trade-offs and needs for bulk vs. distributed energy storage systems. Regions to be examined may include CAISO, PJM, MISO, and NYISO, depending on available funding.	12/31/10	Technical Update
Energy Storage Systems for Frequency Regulation and Ancillary Services: This project will examine the needs of the independent system operators (ISOs) and the markets and energy storage systems capable of meeting and serving the ancillary services markets.It will include a review of ISO pilots, activities and trends for requesting the use of energy storage to serve these markets. In addition to the EPRI report, a public white paper will be prepared. Webcasts and a workshop may be considered based on member interests and funding.	12/31/10	Technical Update