Overview of Energy Storage Applications

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Sandia National Laboratories has been studying Energy Storage Systems since the late 1970's. Sandia started by applying their defense program battery experience to larger stationary systems, eventually joining in the formation of the Utility Battery Group which has since evolved into the Energy Storage Association. Sandia's role, as a Department of Energy funded program, is to look ahead at emerging technologies, perform early R&D and identify applications for Energy Storage Systems that offer significant benefit to the nation's electricity providers and users.

In order to identify applications of energy storage, a two-phase Opportunities Analysis was conceptualized in FY94. Phase I of the project was completed and published in 1995 (SAND94-2605). Phase II of the project is an extension of Phase I to reexamine the identified applications in the dynamic environment of today.

In a preliminary assessment of national benefits, SNL estimated that generation and transmission applications of storage could represent \$17.2B in national benefits. In Phase I of the Opportunities Analysis, the T&D benefits were found to be significantly higher than previous estimates

Phase II of the study, which began in late 1998, includes a refinement of the technical and economic understanding of the role of energy storage in the utility industry given the changing nature of the electricity provider industry. This is work in progress and current information is insufficient to estimate market size with a high degree of confidence, especially from a system supplier's perspective. Activity in Phase II has so far been primarily focused on the need to re-characterize the near and long-term utility application requirements for energy storage.

The group of industry experts participating in the study reviewed the requirements for each of the applications identified in Phase I, modified application names, and combined some applications to better reflect the nature of the electricity industry today. The following applications emerged from this review:

- Rapid reserve,
- Area control and frequency responsive reserve,
- Commodity storage,
- Transmission system stability,
- Transmission voltage regulation,
- T&D facility deferral,
- Distribution facility deferral,
- Renewable energy management,
- Customer energy management, and
- Power quality and reliability.

Participants of the Phase II analysis used the perceived need for the application across the nation, and the potential technical and economic benefits for utilities as criteria to evaluate the applications. From this process emerged the definitions shown in Table 1 for the ten individual applications of energy storage that are in general demand and have high value with electric power producers and their customers. Table 1 also shows the applications organized under headings of Generation, T&D, and Customer. Although utility functions of generation, T&D, and customer service now generally occur in separate business units, the organization of the applications under those headings does not signify that a storage system could or should serve only one application or application type. Storage systems have proven most valuable when they perform multiple functions in more than one of these groups of applications. In fact, in the future many of these applications will be filled by companies without any resemblance to the utility companies of the past.

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This offers both an unprecedented opportunity for the storage industry and a challenge in combining the multiple benefits of energy storage in a single unit.

Rapid reserve, area and frequency control and commodity storage were identified as "generation" applications. Rapid reserve requirements are likely to retain some degree of regulation from a reliability standpoint and will continue to be important in island systems. Frequency control is mostly an issue on small utility systems and has successfully been combined with rapid reserve. Area control prevents the unplanned transfer of power between neighboring utilities. With the selling off of generation assets by conventional utilities, the previous category of generation capacity deferral was incorporated into commodity storage. This activity is likely to be completely unregulated in a normal utility sense and with the recent advent of "mega-storage" systems becoming commercially feasible, this area is ripe for growth.

Transmission and distribution are rapidly becoming the province of the "wires" companies. System stability and voltage regulation are related and storage applications are currently being built to address this area. Transmission and distribution facility deferral continues to rise in importance. It is very difficult to obtain new transmission line approval and the cost of installing new underground cable in existing urban areas is prohibitive. With the demand for electricity growing by greater than 5% per year in these areas, compact, energy dense storage devices have a bright potential future as a distributed resource.

The customer service category includes: renewable energy management, customer energy management and power quality and reliability. Being defined in the "customer service category," however, does not necessarily mean small. As more renewable energy generation becomes available, the need to be able to dispatch these intermittent resources is becoming apparent. Storage will also be required for the renewable source to be given capacity credits. One form of customer energy management is a scaled down version of commodity storage. In areas with high demand charges, storing energy purchased at off-peak rates can significantly cut those demand charges. The power quality problem in the US alone has been estimated at over \$1.5 B per year. Voltage sags as small as 30% from normal for a few cycles can trip motor drives, controllers and other industrial equipment stopping a production line. For high value products, this can be devastating to a company's bottom line. The rise of the information age has brought with it the creation of data centers whose whole purpose is the storing and retrieval of electronically stored information. These facilities cannot afford a power outage, period. One bank is now installing multi-layered backup systems of storage and generation with the goal of achieving five or even "six -9's" reliability. It is anticipated that 20-30 such facilities will be built in the next five years. Some of the traditional utilities are entering the customer service area but this area is also ripe with small private companies providing both the technology solution and the direct customer contact.

The energy storage industry is active. We have seen mergers, acquisitions and partnerships between small energy storage companies and Fortune 500 giants. With the world-wide changes in the electricity provider industry, the increasing use of computer controlled equipment in factories and the rise of the information age with its data reliability requirements, the future of energy storage applications is bright.

Table -1. Definitions and Categories of Electric Power Applications of ESSs

Definition	Category
Rapid Reserve Generation capacity that a utility holds in reserve to meet National Energy Reliability Council (NERC) Policy 10 ¹ requirements to prevent interruption of service to customers in the event of a failure of an operating generating station.	Generation
Area Control and Frequency Responsive Reserve The ability for grid-connected utilities to prevent unplanned transfer of power between themselves and neighboring utilities (area control) and the ability of isolated utilities to instantaneously respond to frequency deviations (frequency responsive reserve). Both applications stem from NERC Policy 10 requirements.	
Commodity Storage Storage of inexpensive off-peak power for dispatch during relatively expensive on-peak hours. In this report, Strategic Storage for Systems Management refers to applications that require less than four hours of storage.	
Transmission System Stability Ability to keep all components on a transmission line in sync with each other and prevent system collapse.	Transmission and Distribution
Transmission Voltage Regulation Ability to maintain the voltages at the generation and load ends of a transmission line within 5 percent of each other.	
Transmission Facility Deferral Ability of a utility to postpone installation of new transmission lines and transformers by supplementing the existing facilities with another resource.	
Distribution Facility Deferral Ability of a utility to postpone installation of new distribution lines and transformers by supplementing the existing facilities with another resource.	Customer Service
Renewable Energy Management Applications through which renewable power is available during peak utility demand (Coincident Peak) and available at a consistent level.	
Customer Energy Management Dispatch of energy stored during off-peak or low-cost times to manage demand on utility-sourced power.	
Power Quality and Reliability Ability to prevent voltage spikes, voltage sags, and power outages that last for a few cycles (less than one second) to minutes from causing data and production loss for customers with demands of less than 1 MW.	

¹ NERC Policy 10, Draft 3, is available for downloading through Word 97 and Acrobat at <http://www.nerc.com/~oc/standards/>