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Report on the Energy Storage Systems Program Executive Meetings Project

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Report on the Energy Storage Systems Program Executive Meetings Project

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Abstract

Under the sponsorship of the U.S. Department of Energy (DOE) Office of Utility Technologies, the Energy Storage Systems Analysis and Development Department at Sandia National Laboratories conducted a series of dialogs with industry regarding the uses and value of storage in stationary applications. The dialogs consisted of meetings with industry executives in which Energy Storage Systems (ESS) Program management solicited input regarding expected changes in the electric utility industry and the long-term research and development in storage technologies and systems that would be most appropriate for the emerging competitive business environment. This report is a compilation of the findings from this Executive Meetings Project.

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These participants include AES Corporation, Arlington, VA; Central and South West (CSW), Tulsa, OK; Indianapolis Power & Light Co. (IPALCO), Indianapolis, IN; Northern States Power (NSP), Minneapolis, MN; Potomac Electric Power Co. (PEPCO), Washington, DC; Public Service Company of New Mexico (PNM), Albuquerque, NM; Southern California Edison (SCE), Rosemead, CA; The Southern Company, Atlanta, GA; Allegheny Electric Cooperative (AEC), Harrisburg, PA; the National Rural Electric Cooperative Association (NRECA), Arlington, VA; Oglethorpe Power Corporation, Tucker, GA; the Salt River Project (SRP), Phoenix, AZ; GNB, Lombard, IL; Kenetech, San Francisco, CA; and Superconductivity Incorporated (SI), Middleton, WI.

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Acronyms and Abbreviations

A&E	architectural and engineering
BESS	battery energy storage system
BG&E	Baltimore Gas & Electric
CSW	Central & South West
DOE	U.S. Department of Energy
DU	distributed utility
EIX	Edison International, Inc.
EMC	Electric Membership Corporation
EPRI	Electric Power Research Institute
ESA	Energy Storage Association
ESS	Energy Storage Systems
FACTS	Flexible Alternating Current Transmission System
FDA	U.S. Food and Drug Administration
FERC	Federal Energy Regulatory Commission
G&T	generation and transmission
GE	General Electric
IOU	investor-owned utility
IPALCO	Indianapolis Power & Light Company
IPP	independent power producer
ISO	independent system operator
NRECA	National Rural Electric Cooperative Association
NSP	Northern States Power
NYPA	New York Power Authority
OPC	Oglethorpe Power Corporation
OUT	Office of Utility Technologies
PEPCO	Potomac Electric Power Company
PNM	Public Service Company of New Mexico
PQ	power quality
PV	photovoltaic
R&D	research and development
RER	Rural Electric Research
SCE	Southern California Edison
SI	Superconductivity, Incorporated
SMES	superconducting magnetic energy storage
SRP	Salt River Project
SWRTA	Southwest Regional Transmission Association
T&D	transmission and distribution
UPVG	Utility Photovoltaic Group

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1. Executive Summary and Recommendations

The U.S. Department of Energy (DOE) Energy Storage Systems (ESS) Program established an outreach team in FY 1995 to assess industry needs for storaage and to determine industry plans in anticipation of deregulation and competition by electric utilities. A two-pronged strategy was invoked: (1) arrange face-to-face meetings with executives representing industrial stakeholders in the ESS Program and (2) encourage an exchange of information concerning energy storage by industry. The outreach team visited 15 organizations representing a cross section of independent power producers (IPPs), investor-owned utilities (IOUs), co-ops, and equipment manufacturers. The team's strategic objectives at these meetings were to (1) determine the level of industrial interest in energy storage, (2) share DOE's plans for the ESS Program, and (3) explore topics for potential government/industry collaborations.

As a result of the meetings, the outreach team achieved the following:

- Greater DOE awareness of the perceptions and needs of U.S. industry concerning energy storage;
- Increased U.S. industry awareness of the federal ESS Program;
- Broader participation in the ESS Program by industrial organizations not previously involved; and
- Stronger links between the ESS Program and new public forums.

Several recurring themes were documented from the industry discussions. These themes, listed below, represent the basis of the message heard from the private sector regarding energy storage and utility restructuring.

- Energy storage market development will require committed and concerted efforts from both U.S. government and U.S. industry.
- Utility restructuring and deregulation has and will continue to have significant impact on utilities' perception and adoption of energy storage systems.
- There are near- and long-term business and market opportunities for companies to pursue that incorporate energy storage, particularly in addressing power quality issues.
- The cost of energy storage systems must be reduced for there to be large-scale use by industry.

Collectively, these themes represent the primary issues and concerns regarding emerging energy storage markets.

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2. Executive Meetings Project Description

Energy Storage Systems (ESS) Program Overview

The DOE conducts technology research and development (R&D) that has the following characteristics: (1) potentially large national benefits and (2) risks that unreasonably jeopardize private-sector companies. The Office of Utility Technologies (OUT) focuses on R&D for electric utilities. The ESS Program within OUT concentrates on analysis, component R&D, system integration, and implementation that promote technological development, acceptance, and adoption of energy storage in utility applications. These Program elements are consistent with the ESS vision of energy storage being highly valuable in enabling the utility of the 21st century, in a competitive environment, to efficiently provide low-cost, reliable, environmentally benign service to a broad spectrum of electricity users. Analysis, component R&D, system integration, and outreach each support a facet of the Program's mission: to conduct focused research and development, in partnership with U.S. industry, on energy storage systems that will help:

- increase U.S. competitiveness by minimizing power quality and reliability problems;
- enhance utility and customer technology choices in responding to restructuring; and
- increase the value of renewable and distributed resources.

In response to changes in the electricity industry, the DOE has redirected the ESS Program, expanding its R&D focus to systems that address the needs of the future deregulated utility industry. To ensure that the direction of the program was suited to the needs of the nation's electricity industry, DOE sponsored a series of meetings with industry executives in which ESS Program management solicited input regarding expected changes in the utility industry and the long-term R&D that would be most appropriate for the emerging competitive business environment.

Project Goals

The Executive Meetings Project had three goals: (1) to communicate to industry the scope and rationale of ESS Program activities relative to DOE's understanding of the needs of the electric utility industry, (2) to solicit energy storage stakeholders' perspectives regarding the changes in the electric utility industry and the likely federal R&D needs that will stem from those changes (and to apply that information to decisions regarding future ESS Program activities), and (3) to encourage ongoing industry participation in a program review group that helps the Program remain focused on activities that meet the nation's needs.

The information exchange was expected to (1) broaden the ESS Program to address the needs of a deregulated industry; (2) lead to a better understanding by both DOE and industry of each other's requirements; and (3) identify well-defined areas and mechanisms through which DOE and industry could collaborate on specific analysis, development, and deployment projects.

Executive Meetings Project Approach

The first steps of the Executive Meetings Project involved preliminary assessment of industry needs and development of an action plan for initiating and maintaining a productive dialogue with industry stakeholders. In selecting the executives to be visited, numerous parameters were considered: type of organization (IOU, IPP, rural cooperative, municipal utility, power marketer, regulator, manufacturer); cost of electricity production; position on wholesale and retail competition; geographic location (northeast, southeast, midwest, southwest, or northwest region of the U.S.); involvement in regional, national, or international activities; receptiveness to meeting solicitation; and level of demonstrated interest in new technologies.

ESS Program representatives contacted the selected organizations to arrange a 2-hour meeting of the DOE Program team (the DOE ESS Program Manager, the ESS Program Manager at Sandia National Laboratories, and an industry expert) and representatives from diverse divisions of the organization visited. Once they had a confirmed meeting date and time, ESS Program representatives forwarded advance copies of a briefing package (Appendix A) for the meeting. The materials included five sections:

(1) an outline of the meeting agenda, meeting objectives, and discussion items; (2) a discussion of the value of storage in a competitive market; (3) an overview of the ESS Program's vision, mission, elements, accomplishments, and goals; (4) a snapshot of the DOE organization and budget relative to the ESS Program; and (5) a list of information resources for utility applications of energy storage systems. The ESS Program team met with 15 organizations around the United States between March and October 1996. The attendance at the meetings ranged from 5 to 30 persons. Each of the meetings contributed to accomplishing the overall goals of the project.

Executive Meetings

The selection of the organizations visited was designed to achieve the most diverse coverage of the parameters discussed in *Project Approach*, above (type of organization, cost of electricity production, position on wholesale and retail competition, geographic location, involvement in regional, national, or international activities, receptiveness to meeting solicitation, and level of demonstrated interest in new technologies). Table 2-1 identifies each of the 15 organizations, their location, their type of business, and the date of the meeting. Figure 2-1 shows the geographic area influenced by these organizations. Each selected organization agreed to assemble a team of senior executives and technologists to meet with the DOE team.

Each organization visited was provided with a discussion agenda (see Appendix A), program documents, and a detailed briefing book before the meeting. The briefing book summarized information of interest to the stakeholder for the meeting. Topics covered included the following:

- Energy storage in a competitive market
- The ESS Program budget
- An overview of the ESS Program
- Energy storage technology milestones
- DOE organization chart
- Contact list
- Recent storage-related publications.

The meetings each lasted about 2 hours and were informal. They began with a brief overview of the ESS Program perspective and activities. The majority of each meeting was dedicated to an open discussion that covered the planned agenda topics and other topics introduced by the participants. The selected organizations all have technologies or business goals that could play a significant role in the eventual adoption of energy storage systems into the electric utility industry.

Findings from the meetings are presented in detail in Chapter 4. Summaries of the meeting minutes can be found in Appendix B.

Information Sought

Each executive meeting addressed the following questions:

- Does a sensible role for the ESS Program exist in industry planning?
- What external influences have exerted themselves on your organization and how do you plan to respond?
- What incentives, risk-sharing, and conditions are required to commit industry support and resources?
- With extensive changes planned for the utility industry, how does your organization plan to adapt?
- Are you willing to work with DOE collaboratively to develop energy storage?
- Are there projects that industry is willing to cost-share to bring applicable technology to market?
- How does your organization plan to respond to electric utility restructuring?

What Was Achieved?

The Executive Meetings Project provided numerous benefits to the ESS Program and improved the prospects for industry involvement in energy storage technology development and demonstration. These benefits, summarized below, represent accomplishment of the goals and objectives that were set out for the project.

1. Increased industry awareness of the ESS Program, especially on the part of the several organiza-

Table 2-1. Organizations Visited

Organization	Type of Business	Date of Visit
AES, Arlington, VA	IPP	September 18, 1996
Kenetech, Livermore, CA	IPP/Manufacturer	May 14, 1996
Central & South West (CSW), Tulsa, OK	IOU	August 5, 1996
Indianapolis Power & Light Co. (IPALCO), Indianapolis, IN	IOU	May 1, 1996
Northern States Power (NSP), Minneapolis, MN	IOU	April 17, 1996
Potomac Electric Power Co. (PEPCO), Alexandria, VA	IOU	April 12, 1996
Public Service Company of New Mexico (PNM), Albuquerque, NM	IOU	August 5, 1996
Southern California Edison (SCE), Los Angeles, CA	IOU	May 17, 1996
The Southern Company, Atlanta, GA	IOU	September 12, 1996
Allegheny Electric Cooperative (AEC), Harrisburg, PA	Co-Op	August 21, 1996
National Rural Electric Cooperative Association (NRECA), Arlington, VA	Co-Op	September 16, 1996
Oglethorpe Power Corporation, Atlanta, GA	Co-Op	September 13, 1996
Salt River Project (SRP), Phoenix, AZ	Co-Op	August 6, 1996
GNB, Chicago, IL	Manufacturer	May 1, 1996
Superconductivity, Inc. (SI), Madison, WI	Manufacturer	May 2, 1996

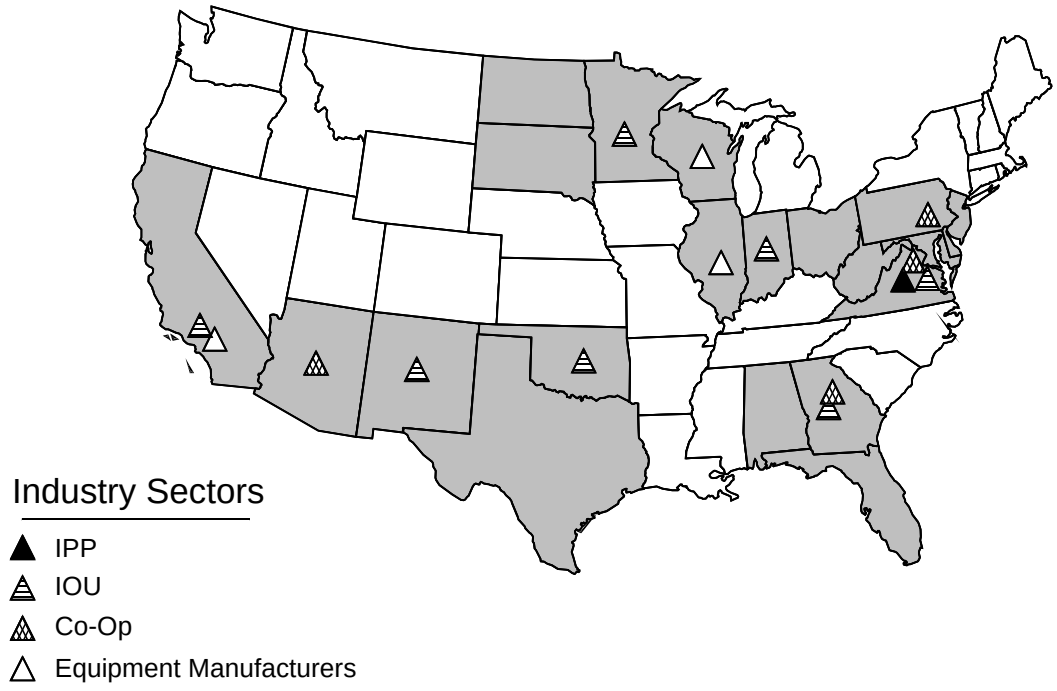

Figure 2-1. Locations of Selected Industry Visits.

tions visited that were not previously involved in the program. Even members of organizations already involved in the ESS Program learned more about the program from the visits, because senior business and technical managers who were not directly involved in the company's storage activities were informed about the Program at the meetings. An added benefit of increased awareness of the Program at the senior level is that it created the potential for greater institutional support of the Program.

2. Increased DOE awareness of industry's interests and needs relative to the ESS Program's activities. Insights were gained into the interests and needs of different industry sectors through the one-on-one meetings. These insights were analyzed and are being incorporated into ESS Program planning. These insights are discussed in Chapter 4.

3. Identified new areas of mutual technology interest. Some organizations identified technologies that could fit into and broaden the ESS Program's research efforts. These included:

- Fast switches (solid-state electronics),
- Flywheel storage systems, and
- Superconducting magnetic energy storage (SMES) systems.

3. The Industry Perspective on Energy Storage

Industry Response

This chapter will present the perspectives expressed by industry executives regarding the questions outlined on page 2-2 and will summarize the key findings from each of four industry sectors: IOUs, IPPs, co-ops, and manufacturers. Several categories of interests emerged from the overall set of comments from the executives. The most frequently mentioned factors are listed with brief definitions.

- **Economics**
  Cost-competitiveness of energy storage technologies compared to conventional and alternative technologies. Investment cost and life-cycle costs associated with energy storage systems.

- **Environment**
  Compliance strategies for minimizing or shifting environmental impacts and the value of achieving such minimization or shifting to the stakeholders and their customers.

- **Federal Cost-Sharing**
  Cost- and risk-sharing incentives that industry needs from federal programs to make otherwise marginal projects viable.

- **Technology Development Needs**
  Technical performance improvements, validated reliability, or breakthroughs needed before technology can be integrated into an industrial setting.

- **Market Barriers**
  Customer acceptance, perceived safety, infrastructure and institutional barriers, and compatibility/integration issues.

- **Industrial Constituency**
  Building a strong industrial advocacy for energy storage systems. Building partnerships and consortia to advance the technologies and system integration.

- **Awareness of DOE Program**
  Industrial knowledge of the DOE ESS Program activities as well as knowledge of related activities at other federal agencies.

Industry Perspective

Overall, the economics of storage systems was the most important factor to the represented stakeholders. However, environmental policy drivers were identified as key to market development of utility technologies. Therefore, energy storage must be at least benign to the environment for utilities to adopt it. Technology development needs and market barriers were next in order of importance, followed by federal cost-sharing and building an industrial constituency.

The meetings also identified a critical list of barriers to the commercialization of energy storage technologies. The primary barriers to widespread use of energy storage were economic issues: high initial costs and unproven benefits. These and other commercialization barriers identified by industrial stakeholders are discussed further in Chapter 4.

Results by Industry Sector Category

The results presented in this report have been aggregated into each of four industry sectors: IPPs, IOUs, co-ops, and manufacturers. Sector categories were assigned without specific acknowledgment of individual organizations. The next few pages contain these aggregated industry sector results. Each profile presents the following information:

- A listing of visited stakeholder organizations;
- Key findings/observations;
- Technology development interests;
- The relative importance of strategic factors; and
- A tabulated summary of relevant business considerations.

Corporate and meeting summaries appear in Appendix B. These profiles are part of the information that

is being used to plan the program and to ensure its continued responsiveness to national needs.

Investor-Owned Utilities

The IOU sector was represented by Indianapolis Power & Light Company (IPALCO), Southern Company, Central & South West Utilities (CSW), Public Service Company of New Mexico (PNM), Potomac Electric Power Company (PEPCO), Northern States Power (NSP), and Southern California Edison (SCE). The views presented here are strictly the views expressed by representatives of the various companies.

Key Findings

- IOUs will participate in collaborative systems analysis and demonstrations of energy storage systems if cost-sharing is attractive.
- Joint venture projects are a part of corporate plans. This may include projects with the U.S. government.
- System cost is the fundamental barrier to adoption. Energy storage systems will have to compete with traditional technologies in terms of $/kW before IOUs will install them. The coming era of competition is likely to reinforce this position.
- If the cost of energy storage can be reduced or if storage systems can position utilities for competition, they will be adopted. However, these benefits must be clearly evident for IOUs to take the risk of new technologies.
- Decisions by this sector are driven almost solely by customer needs.

IOU Technology Development Interests
Energy storage for: • New services such as power quality and peak shaving • Asset utilization for the deregulated part of the business

IOU Philosophy on Utility Industry and Energy Storage				
Utility Industry		*Energy Storage*		
Strategic Focus	***Business Drivers***	***Problems Being Solved***	***Near-Term Opportunity***	***Long-Term Energy Storage Goals***
Reducing Production and Delivery Costs Retaining Customers Increasing Customer Base Diversifying Business	Emerging Competition Unbundling Short-Term Return-on-Investment Requirements	Developing Analytical Tools to Guide R&D Investment and Capital Decisions	Offering Power Quality and Peak-Shaving Premium Power Services Marketing Energy Storage Products for Power Quality and Peak Shaving Providing Ancillary Services	Lower Cost Higher Reliability Increased Profitability

Independent Power Producers (IPPs)

The IPP sector was represented in the executive meetings by the following organizations: AES and Kenetech. The opinions summarized here are those of the corporate representatives at the meetings.

Key Findings

- Gas turbines, photovoltaics, biomass, wind power, energy storage, and alternative-fueled vehicles are among the technologies of interest to this group.
- IPPs are undertaking projects in developing countries (e.g., AES-Argentina, Kenetech-Indonesia). In addition to providing power, they are supplying diverse energy-related spin-off services (architectural engineering, wastewater treatment, environmental remediation, etc.). IPPs, for the most part, are well positioned to capture portions of the market when deregulation makes them available.
- In addition to profitability, corporate image and public relations are drivers for many of these organizations. To address these drivers, IPPs are considering making commitments in renewable energy and environmental mitigation, including consideration of energy storage systems.

IPP Technology Development Interests
Energy storage combined with: • Gas turbines • Photovoltaics • Biomass • Wind power

IPP Philosophy on Utility Industry and Energy Storage				
Utility Industry		***Energy Storage***		
Strategic Focus	***Business Drivers***	***Problems Being Solved***	***Near-Term Opportunity***	***Long-Term Energy Storage Goals***
Developing Third-World Markets Increasing Value of Available Generation	Environmental Concerns Restructuring and Deregulation of Utility Industry Economics Power-Purchase Agreement Effects on Multiple Benefits of Energy Storage	System Reliability and Reputation for Reliability Integration of Storage with Renewable Generation Systems in Developing Countries - Green Generation - Optimized Hybrids	Positioning for Competition - Premium Services - Flexibility	Increased Profits Earning an Environmentally-Friendly Corporate Image

Co-Ops

The co-op sector was represented by Allegheny Electric Cooperative, Inc. (AEC), the National Rural Electric Cooperative Association (NRECA), Oglethorpe Power Corporation (OPC), and Salt River Project (SRP). The views expressed here are those of company representatives at the various meetings.

Key Findings

- Co-ops are very concerned with the cost of energy storage systems.
- Field data from demonstrations are also of great interest to co-ops.
- Several co-ops are planning to install or have installed energy storage systems (Oglethorpe, Metlakatla, Golden Valley, Chugach, Crescent) for a variety of applications. Some of the installations have had cost-sharing with DOE, the Electric Power Research Institute (EPRI), or both.
- Most representatives emphasized that co-ops are more flexible than IOUs and can, thus, respond more quickly to customer needs. Due to this increased flexibility, co-ops can adopt new options like energy storage more easily.
- Co-ops are very concerned with the competitive results of deregulation. They are in favor of wholesale competition and opposed to retail wheeling. Their greatest interests with regard to energy storage are in asset utilization, cost reduction, peak demand reduction to reduce demand charges, and customer service to retain customers.

Co-ops Technology Development Interests
• Fuel cells • SMES • Written pole motor • Photovoltaic (PV)/storage hybrid • Flywheels • BESS

Co-Op Philosophy on Utility Industry and Energy Storage				
Utility Industry		*Energy Storage*		
Strategic Focus	***Business Drivers***	***Problems Being Solved***	***Near-Term Opportunity***	***Long-Term Energy Storage Goals***
Utilizing Existing Assets Retaining and Building Customer Base Responding to Deregulation and Emerging Competition	Cost Quick Response to Customer and Industry Changes	Developing Analysis Tools for Power Quality and Power Management Systems Increasing Field Experience with Storage Systems	Participating in Collaborative Studies and Demonstrations Developing Storage-Supported, Premium Power Services Incorporating Energy Storage as a Flexible Response to Power Quality and Demand Control Needs	Developing New Business Ventures Related to Storage Products Attracting New Customers with Superior Service

Equipment Manufacturers

The equipment manufacturer sector represents a diverse group of companies that manufacture equipment for components of energy storage and related systems. The companies visited included Kenetech, Superconductivity, Inc. (SI), and GNB. The opinions expressed in this section are strictly those of the company representatives who attended the meetings.

Key Findings

- Some manufacturers have invested significantly in developing products and canvassing for markets of energy storage systems.
- Because battery and power electronics manufacturers have large shares of mature markets, they are unlikely to accept risks in new areas until the utility storage market emerges more clearly.
- Manufacturers view power quality as the near-term market for energy storage, and renewable support as a long-term R&D activity with an appropriate federal role.

Manufacturer Technology Development Interests
• System integration (All) • Wind turbines • Power electronics • Valve-regulated lead-acid battery systems (GNB) • SMES & SMES/battery hybrid systems (SI) • High-temperature superconductors (SI)

Manufacturers Philosophy on Utility Industry and Energy Storage				
Utility Industry		***Energy Storage***		
Strategic Focus	***Business Drivers***	***Problems Being Solved***	***Near-Term Opportunity***	***Long-Term Energy Storage Goals***
Promoting Acceptance of Energy Storage Products in U.S. and Global Markets - Developing Nations - Deregulated Utility Industry - Customer End Use	Market Share Environmental Issues Effects of Slow Market Development on Corporate Commitment to Develop Products	Component Technology Development Market Identification System Integration Issues	Developing/Marketing Turnkey Products that Improve Power Quality and Reduce Peak Demand	Developing/Marketing Turnkey Products that Compete with Conventional and Alternative Technologies for a Spectrum of Applications: - Technically Comparable - Cost-Competitive

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4. Summary of Findings

The previous chapter summarized the findings and observations from the executive meetings. This chapter presents aggregated industry sector results and analysis of the results with regard to the private sector perspective on energy storage. The first section of this chapter presents the following cross-cutting categories:

- A corporate perspective on the strategic role of energy storage in business;
- Energy storage market strategy that transitions energy storage technologies from research to commercial products and services;
- The roles of government and industry in fostering partnerships to develop energy storage systems; and
- Communication of storage interests both within and outside a concerted program effort.

Corporate Perspective

The executive meetings succeeded in ascertaining the private sector's interests, objectives, and perceived opportunities with regard to investing in energy storage systems. Most of the stakeholders articulated near-term business interest in energy storage systems. They also indicated that, if the costs of such systems were competitive with those of conventional technologies, they would also have long-term strategic interest. A stakeholder's interest in energy storage was a function of its core businesses, the size of the company, its perception of market opportunities, and its perception of the technology's status of development and cost.

Each company or major division of a company that was visited had a technology strategy that is consistent with its overall business strategy. This strategy is often implicit and must be deduced from management decisions and resource allocation priorities over time. To use technology for a competitive advantage, companies need to be explicit about the role of technologies in their strategies. The discussions with each company were built around a series of questions designed to examine specific corporate strategies and interests. Analysis of the discussions has answered some basic questions regarding the interest of each stakeholder in energy storage systems. These questions include:

- What strategic focus of your company would be served by involvement in energy storage systems?
- What are the business drivers or competitive forces generating your interest in energy storage?
- What are your responses to the changing utility industry?
- What are the near-term market opportunities for energy storage systems?
- What are the long-term, larger markets that could justify significant investment in energy storage systems?

Table 4-1 summarizes the responses to these questions for each of the sectors. The responses clearly show that corporate management is seeking to solve near-term problems with technology solutions that address today's concerns.

The executive meetings verified that there are near-term business and market opportunities for companies to pursue that incorporate energy storage. However, markets for energy storage coincide more with conventional technologies than with other, emerging technologies. Commercialization will depend on the availability and cost of specific systems.

Availability and Cost of Energy Storage System

The DOE has recognized that the use of energy storage systems within the national energy mix will result in significant national benefits. The question remains, however, as to the best avenue to transition these systems from the R&D stage to a commercial reality. Discussions with industry stakeholders clearly demonstrated their business interests both for near-term market opportunities and for long-term strategic planning.

In the near term, power quality will be the most likely market driver for energy storage systems. The relatively low energy requirements of power quality applications reduce the size, weight, and cost of

Table 4-1. Summary of Strategic Role of Energy Storage Systems

Sector	Strategic Focus	Business Drivers	Problems Being Solved	Near-Term Opportunity	Long-Term Energy Storage Goals
IOUs	Reducing Production and Delivery Costs Retaining Customers Increasing Customer Base Diversifying Business	Emerging Competition Unbundling Short-Term Return-on-Investment Requirements	Developing Analytical Tools to Guide R&D Investment and Capital Decisions	Offering Power Quality and Peak-Shaving Premium Power Services Marketing Energy Storage Products for Power Quality and Peak Shaving Providing Ancillary Services	Lower Cost Higher Reliability Increased Profitability
IPPs	Developing Third-World Markets Increasing Value of Available Generation	Environmental Concerns Restructuring and Deregulation of Utility Industry Economics Power-Purchase Agreement Effects on Multiple Benefits of Energy Storage	System Reliability and Reputation for Reliability Integration of Storage with Renewable Generation Systems in Developing Countries - Green Generation - Optimized Hybrids	Positioning for Competition - Premium Services - Flexibility	Increased Profits Earning an Environmentally-Friendly Corporate Image
Co-ops	Utilizing Existing Assets Retaining and Building Customer Base Responding to Deregulation and Emerging Competition	Cost Quick Response to Customer and Industry Changes	Developing Need-Analysis Tools for Power Quality and Power Management Systems Increasing Field Experience with Storage Systems	Participating in Collaborative Studies and Demonstrations Developing Storage-Supported, Premium Power Services Incorporating Energy Storage as a Flexible Response to Power Quality and Demand Control Needs	Developing New Business Ventures Related to Storage Products Attracting New Customers with Superior Service
Mfrs.	Promoting Acceptance of Energy Storage Products in U.S. and Global Markets - Developing Nations - Deregulated Utility Industry - Customer End-Use	Market Share Environmental Issues Effects of Slow Market Development on Corporate Commitment to Develop Products	Component Technology Development Market Identification System Integration Issues	Developing/Marketing Turnkey Products that Improve Power Quality and Reduce Peak Demand	Developing/ Marketing Turnkey Products that Compete with Conventional and Alternative Technologies for a Spectrum of Applications - Technically Comparable - Cost-Competitive

systems, and makes this niche the most significant near-term market for energy storage. A second near-term niche market is for frequency control and spinning reserve of island systems. For remote power, storage will find a role in optimizing renewable/fossil hybrid systems.

The cost of energy storage systems must decrease for widespread adoption of energy storage systems to be realized. Sustained federal and private R&D efforts will be needed to develop cost-effective systems for the utility industry. Utilities and manufacturers will be more likely to participate in R&D and infrastructure investment to make commercial energy storage systems a reality if incentives are in place. Deregula-

tion and increased competition will provide incentives in the near future. Legislative drivers will provide incentives by prescribing time frames and markets for renewable-based energy, thereby accelerating the commercial readiness of renewable systems and related technologies. Close partnership between federal and private sector stakeholders will be the vision for energy storage.

Factors necessary for additional niches for energy storage systems to be created are listed in Table 4-2.

Industry and Government Cooperation

Ever-decreasing private R&D funding is causing companies to focus on near-term R&D and to nearly abandon long-term efforts. Imminent competition in the electric utility industry is increasing the trend toward near-term focus, even though long-term energy R&D is even more important than before. Therefore, industry will be more dependent on federal long-term energy R&D.

Stakeholders at the executive meetings noted that a gap seems to exist between basic research, performed primarily by the universities and national labs, and commercialization, which is clearly the purview of industry. The gap includes such activities as applied research, subsystem validation, and system demonstration. Stakeholders indicated that government-industry cooperation efforts are necessary to fill this gap.

The roles that government and industry play in advancing technology have inherent differences. The government objective is to develop a portfolio of technology options for industry. After a critical assessment, the private sector will decide which options to develop and commercialize. Another primary distinction between government and industry R&D activities is the planning time horizon. Industry's planning time horizon is 5 years or less. Government pursues activities with longer time horizons that the private sector cannot fund on its own. This federal role is especially important for high-risk ventures that are too risky for private industry. As technologies move closer to commercialization, the government's role and cost share decreases relative to industry's.

The government funds research projects that have potentially large benefits to the nation, require resources greater than an individual company can manage, and have technical and market risks with very long time horizons. Industry should play a role consistent with its interests and competency. In the early R&D stages, this role could include activities such as performing systems analyses to help set performance targets and to confirm the project's economic and market rationale. In contrast, industry should be responsible for most of the costs of more mature projects close to commercialization. Industry must be fully responsible for bringing products to the marketplace.

Several models for government-industry partnerships have been successful throughout the last decade. Participants suggested a range of options from very active government participation to more passive options. In general, the view was that a strongly proactive government participation model would be required to attract and sustain the significant private sector commitment required to see energy storage system development through to full commercial status.

The government's mission to serve the public and industry's financial responsibility to serve its stockholders sometimes create obstacles for these partnerships. Attendees of the executive meetings identified the primary obstacles as:

- Uncertainty of the deregulated competitive future of the utility industry and subsequent uncertainty about technologies;
- Too few demonstrations of energy storage systems that are part of a well-defined commercialization plan (DOE should require such a plan as part of any demonstration project); and
- Insufficient public awareness of energy storage validation/demonstration projects.

The executive meetings revealed that the private sector recognized near-term markets as well as longer-term strategic opportunities. In addition, executives thought all stages of new product development from R&D to commercialization would require government/industry risk-sharing and incentives for industry to develop near-term markets.

Table 4-2. Prerequisites for Creation of Additional Niches for Energy Storage Systems

- Cost-sharing between industry and government for R&D projects to provide both short-term and long-term benefits that will allow industry to lengthen its planning horizon while conducting meaningful R&D.
- New legislation, mandates, and/or incentives to overcome initial hurdles to near-term markets and define environmental benefits.
- Publicizing projects to take advantage of value-added public relations by depicting corporate interest in the public good.

Communication Mechanisms

For the ESS Program to achieve its mission, communication must be handled at a variety of levels:

- Articulate objectives to stakeholders
- Advertise partnership opportunities to industry
- Arrange meetings between federal officials and corporate executives
- Establish an industry group to assist in program reviews.

Overcoming Obstacles Through Outreach

The perspective gained through the executive meetings has been invaluable. Several themes have emerged. Table 4-3 contains a summary of these themes.

A variety of obstacles or barriers were brought to the attention of the industry outreach team. These barriers include technology cost and performance; recognition of market imperfections; infrastructure compatibility; federal policy fluctuations; and general lack of awareness by industry and the public at large of the value and benefits of adopting energy storage. These barriers can be overcome with a sustained government/industry partnership that includes a comprehensive effort on several fronts: (1) targeted outreach to set an R&D agenda; (2) analysis to identify the most viable R&D path; (3) sustained R&D to overcome technology barriers; (4) demonstrations and field testing of integrated systems; and (5) targeted outreach activities to overcome institutional and market barriers.

Table 4-3. Common Themes in Findings

- Utility deregulation and increased competition concern utilities and manufacturers alike.
- The federal government must provide vision and leadership driven by national benefits; the private sector must develop and introduce products into the marketplace.
- The cost of energy storage systems will need to be lower for there to be widespread adoption by industry.

5. Recommendations from the Executive Meetings

The ESS Program sponsored a series of meetings with executives from IPPs, IOUs, co-ops, and manufacturers. ESS representatives solicited industry feedback and invited executives to have continued input to the ESS Program.

The meetings helped build ESS constituency; helped guide a program that is already responsive to industry's needs and concerns; and facilitated the formation of future government/industry partnerships.

Chapter 4 presented a specific set of outreach objectives aimed at initiating and maintaining a productive dialogue with industry stakeholders:

- Create a better understanding by both DOE and industry of expectations and plans; and
- Identify well-defined joint areas of work and partnership mechanisms through which DOE and industry can pursue specific energy storage system development and deployment projects.

The recommendations outlined in Table 5-1 are based on the results of the executive meetings.

Table 5-1. Recommendations for Future Activities

Analysis and R&D	Follow-Up
DOE should institute a process for establishing and evaluating projects.	Maintain active contact with organizations that participated in executive meetings.
DOE could use either PV experience or EV America as a model—where utilities agree on specifications that set standards for companies to meet. Utilities can establish a rigorous testing process to verify conformance to the specifications. This process will provide a feedback loop, establish a process, and lay out program needs.	
Include solid-state electronics, SMES, and flywheel technologies in the ESS Program scope.	Establish a review group and communicate input to industry stakeholders.
Focus on activities that will reduce storage system costs and increase reliability.	Publish results of analyses and demonstrations more broadly.

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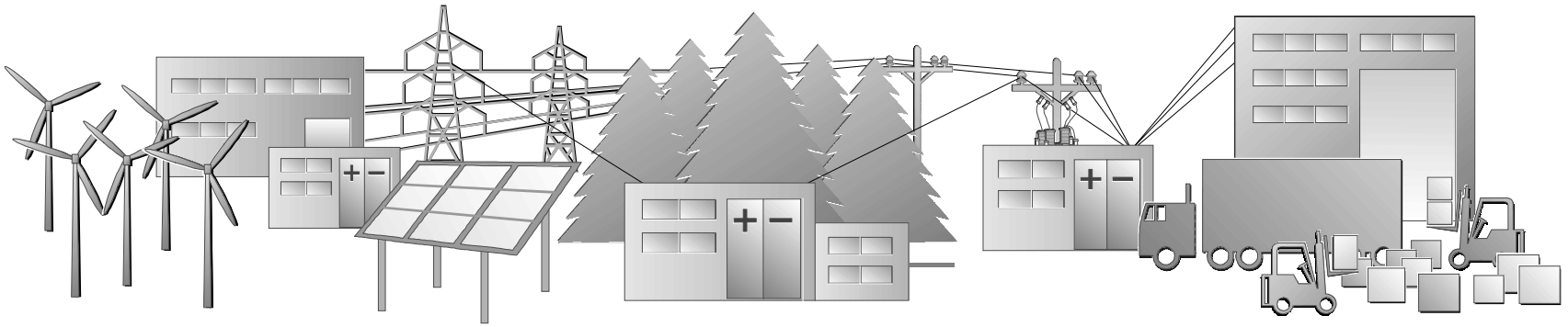
Meeting Materials

U.S. Department of Energy
Energy Storage Systems Program
Executive Meeting



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Section 1
Agenda
Objectives
Discussion Items

Agenda

- Introductions
- Discussion Items
- The Energy Storage Systems Program
- Wrap-Up and Action Items

Meeting Objectives

- Identify critical utility industry issues that will influence R&D in the DOE Energy Storage Systems Program
  - changing industry climate
  - changing DOE role
- Explore utility business opportunities that energy storage technologies provide
  - emerging applications in power quality, spinning reserve, peak shaving, etc.
  - advances in turnkey, modular systems

Discussion Items

- External influences on your business
  - changing utility business environment
  - financial stability of the electric utility industry
  - business opportunities/barriers in domestic or foreign markets
  - environmental drivers
- Your business's responses to the changing utility industry
  - changes you expect to make in your business as a direct result of the changes in the utility business climate
  - market segments that will be important to your business
  - responses to environmental drivers
  - criteria you use to initiate new projects

Discussion Items (cont.)

- The tools your company needs to respond
  - specific technologies for specific applications
  - specific performance and cost characteristics of technologies
  - technologies (conventional and emerging) that will compete with energy storage for your investment
  - criteria to compare and rank technological options
  - domestic and international market opportunities for specific energy storage products and services
  - present and future DOE roles
  - benefits from participation in DOE programs

Industry Action Plan

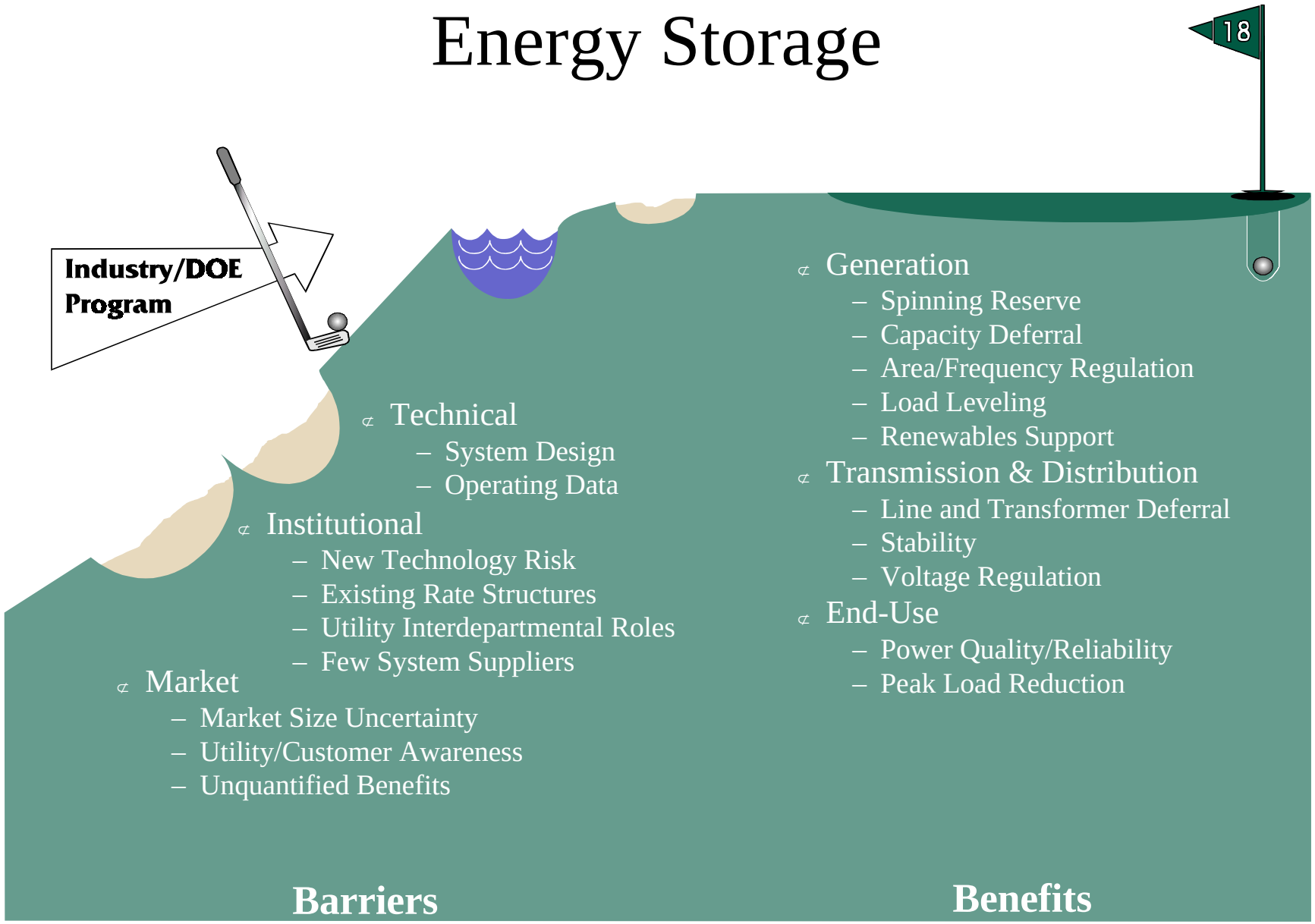
- Join ESS Industry Advisory Group
- Participate in regular ESS Program reviews
- Interact with the Energy Storage Association and other industry-led Energy Storage Groups
- Form new industry-government partnerships for storage technology R&D
- Host utility field evaluation of prototype products
- Utilize technical reports on R&D projects

Section 2
The Value of Storage in a Competitive Market

Why is Energy Storage Important in a Competitive Electric Supply Industry?

- Electricity suppliers will:
  - compete for existing and new customers
  - market new products and services to customers
  - consider new technologies and strategies
- Storage can:
  - provide a physical hedge against price uncertainty
  - offer a cost-effective alternative for control area services
  - earn efficiency benefits for utilities under performance-based regulation
  - supply peak power capacity to meet urgent needs
  - enhance competitive abilities of traditional and nontraditional electricity suppliers
  - convert wholesale off-peak power into on-peak retail power

Barriers to and Benefits of Energy Storage



Competition, Storage, and Business Opportunities

- **Customer service -** storage allows electricity suppliers to provide new premium services that attract and retain customers
- **Risk management -** storage provides electricity suppliers with a hedge against uncertain fuel prices and allows electricity customers to take advantage of the best rates
- **Asset utilization -** storage extends the useful service life of electricity suppliers' and customers' facilities
- **Operating efficiency and reliability -** storage increases the reliability of electrical service and the subsequent operating efficiency of processes that depend on it
- **Environmental compliance -** storage allows electricity suppliers to shift emissions outside of nonattainment areas and provides manufacturers with means to reduce environmental impacts

Examples of Utility Business Opportunities with Energy Storage

- Offer energy storage devices for customer peak shaving or power quality to existing customers
- Incorporate energy storage with distribution sites to offer premium services, attract and retain wholesale and retail customers
- Employ energy storage to manage risk and hedge against uncertain fuel and electricity prices
- Provide energy storage systems for new power marketing and power brokering activities
- Offer energy storage products and services to competing electricity suppliers and their customers

Summary of Energy Storage Applications

Generation

Spinning Reserve
Generation Capacity Deferral
Area/Frequency Control
Renewables Support
Load Leveling

Transmission & Distribution

Transmission Line Stability
Voltage Regulation
Transmission Facility Deferral
Distribution Facility Deferral

Customer Service

Customer Reliability
Customer Power Quality
Customer Demand Peak Reduction

Storage Applications

- Spinning reserve
  - provide temporary reserve power in the event of the failure of a generation unit
- Generation capacity deferral
  - defer installation or upgrade of generation facilities
- Area/frequency control
  - prevent unacceptable changes of electrical frequency and unplanned transfers of power
- Renewables support
  - increase the usability of renewable generation resources
- Load leveling
  - reduce peak demand on an entire electrical supply network
- Transmission line stability
  - maintain synchronous operation of all parts of electrical supply network

Storage Applications

- Voltage regulation
  - maintain consistent voltage at all points in an electrical supply network
- Transmission and distribution facility deferral
  - defer installation or upgrade of transformers or electrical lines
- Customer reliability (uninterruptible power supply)
  - counter the effects of electrical outages that last more than a fraction of a second
- Customer power quality
  - counter the effects of electrical voltage sags and surges or outages that last for only a fraction of a second
- Customer demand peak reduction
  - reduce customers' peak power demand on the electricity supplier

Examples of Power Quality Applications

Power quality improvement can save U.S. industry $400 billion annually.[1]

- A paper mill served by Niagara Mohawk determined that a 15-second service interruption could result in hours of downtime and that costs in 1992 exceeded $1 million in lost production.
- Commercial and industrial customers in Pacific Gas and Electric Company's service territory estimated that the cost of a single 30-second interruption in electrical service to their businesses in 1990 was $3.5 million.

Storage could offer savings that exceed $32 billion annually.

- Sandia National Laboratories estimates that battery energy storage could eliminate about 2 percent of power quality failures by the year 2010.[2] If batteries, flywheels, SMES, and supercapacitors all accomplish similar results, storage could eliminate 20 percent of the power quality failures, saving $32 billion annually.

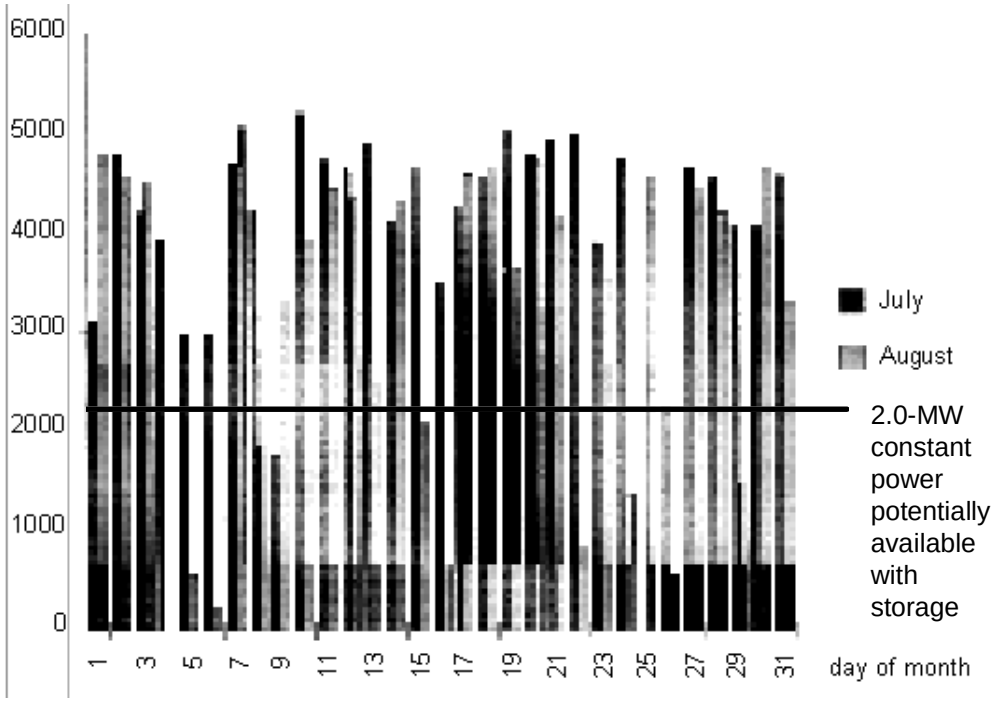
[1] Power Quality in Commercial Buildings, Electric Power Research Institute, 1995.

[2] Butler, P., Battery Energy Storage for Utility Applications: Phase I - Opportunities Analysis, Sandia National Laboratories Report, SAND94-2605, October 1994.

An Example of Renewable Generation Support

Addressing the Variability of Renewable Generation

Storage can buffer the variability of renewable generation. A wind farm in the Sacramento Municipal Utility District produces between 0 MW and 5 MW of power. If this facility could provide constant power, it would have greater economic value.

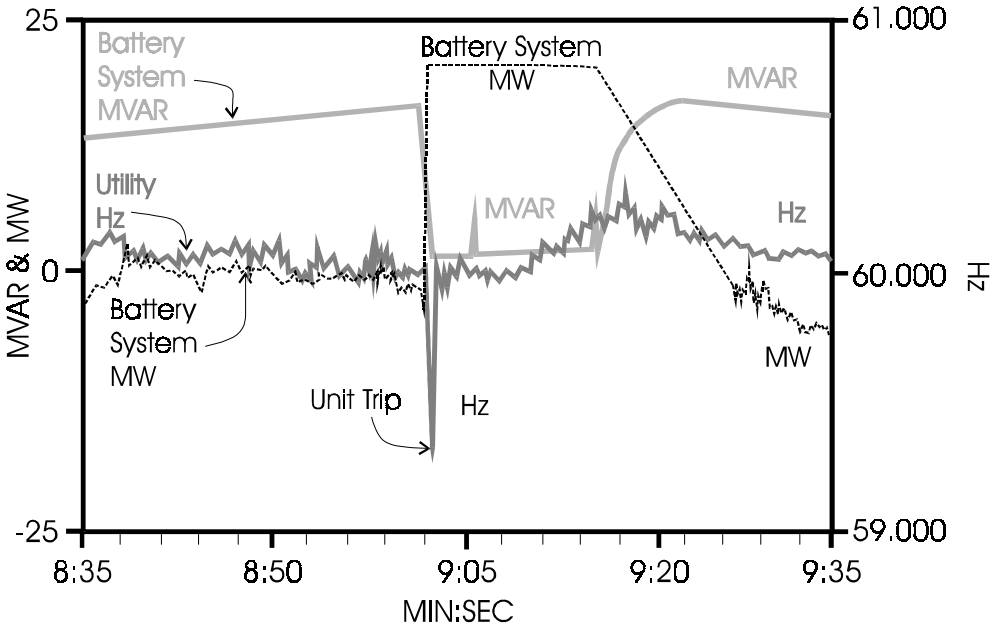


Wind Farm Output at 6pm -- July and August 1994

Source: Data from 5-MW Solano Wind Farm, Sacramento Municipal Utility District (SMUD)

An Example of Spinning Reserve and Frequency Control Applications

In the 1970s, projections of industrial growth prompted the Puerto Rico Electric Power Authority (PREPA) to install electrical generation that was later ill-suited to demands that actually occurred. The choice forced PREPA to use load shedding to control electrical frequency. The practice cost residents, industry, and tourists unacceptable amounts of frustration and dollars. In the 1980s, analyses determined that 100 MW of battery energy storage could provide spinning reserve and frequency control for PREPA and save nearly $50 billion in generation costs between 1990 and 2018. In the 1990s, PREPA began commercial operation of the first of five proposed 20-MW/14-MWh battery energy storage systems at its Sabana Llana substation. PREPA and its customers now enjoy the rapid spinning reserve and frequency control that the system provides.[1]

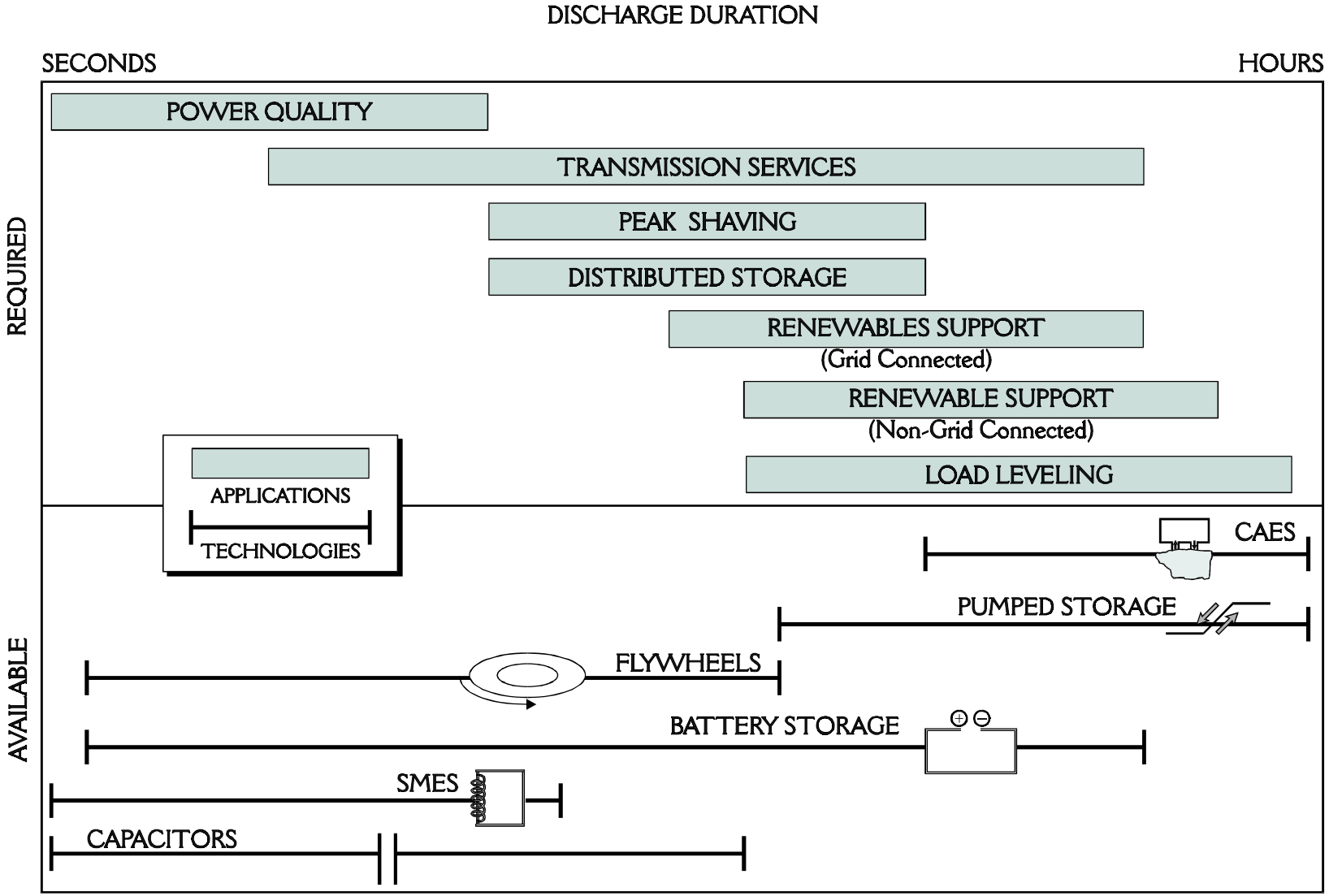


Frequency Control by PREPA's Battery Energy Storage System[2]

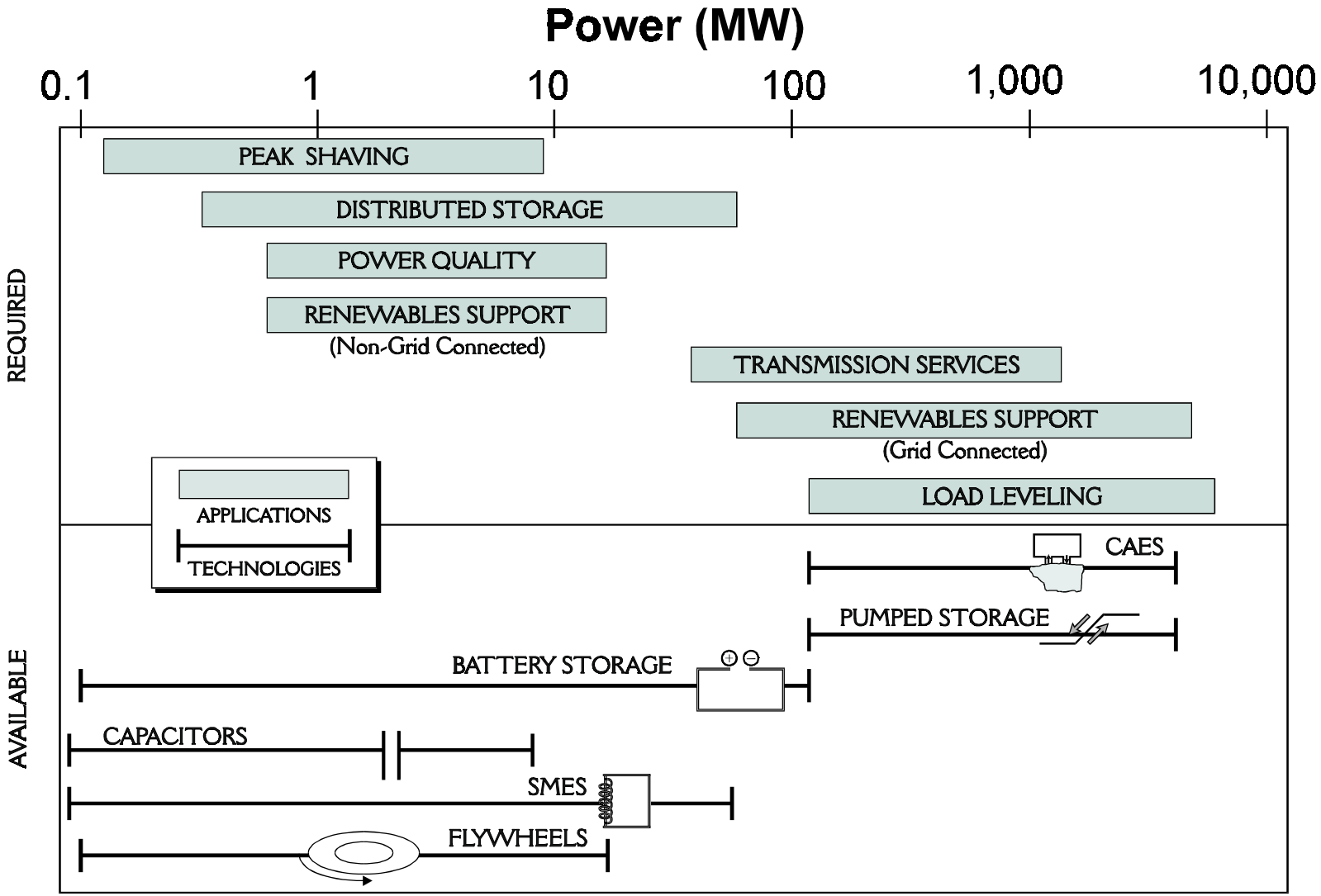
[1] Taylor, P., Torres, W., and Akhil, A., "Spinning Reserve in Puerto Rico Doesn't Spin -- It's a Battery," Electrical World, McGraw-Hill, April 1995.

[2] Ramos, R., and Reyes, C., "Operating Results of PREPA's 20 MW BESS," paper presented at the Fifth International Conference on Batteries for Utility Energy Storage, San Juan, Puerto Rico, July 18-21, 1995.

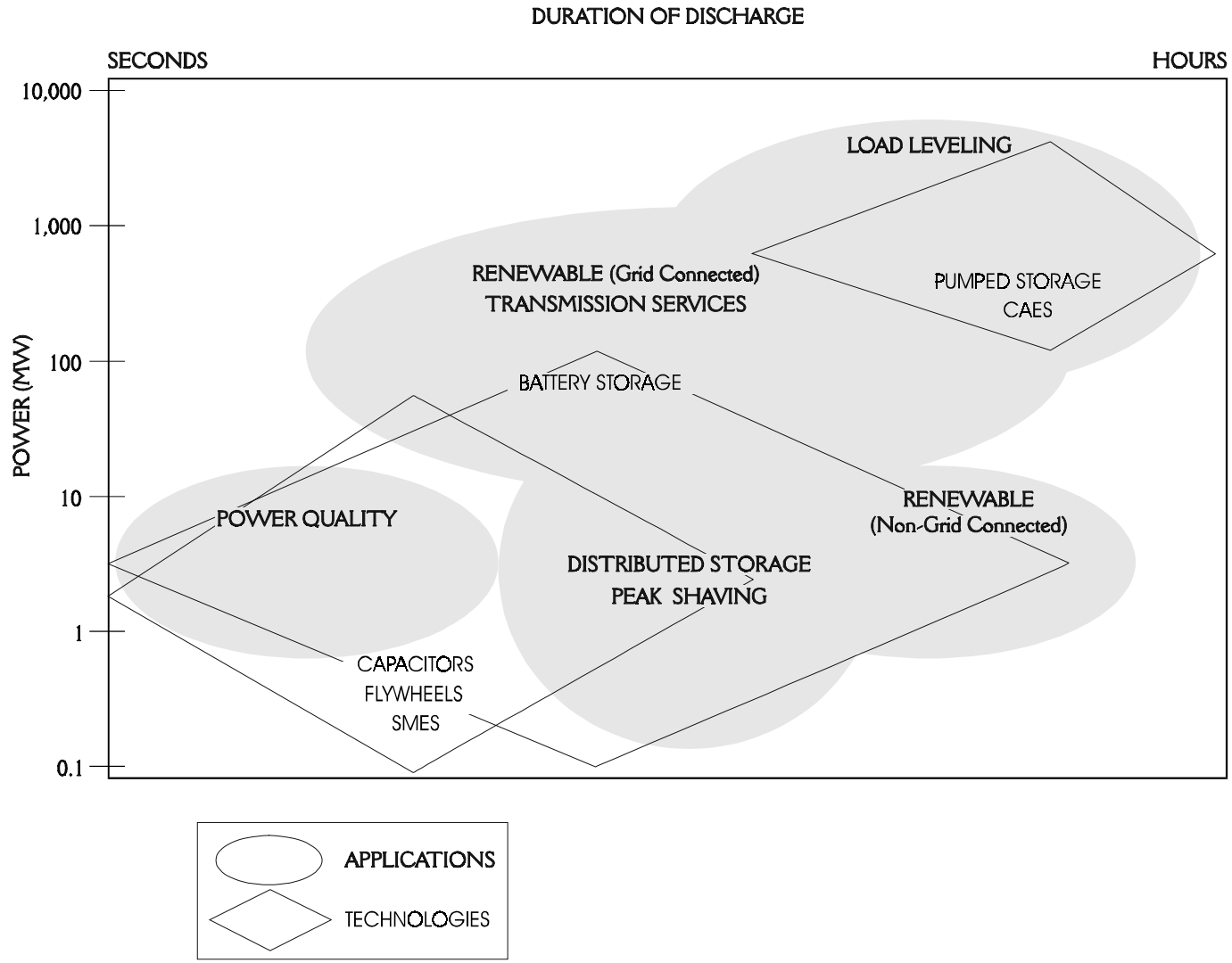
Discharge Duration of Storage Applications and Technologies



Power of Storage Applications and Technologies



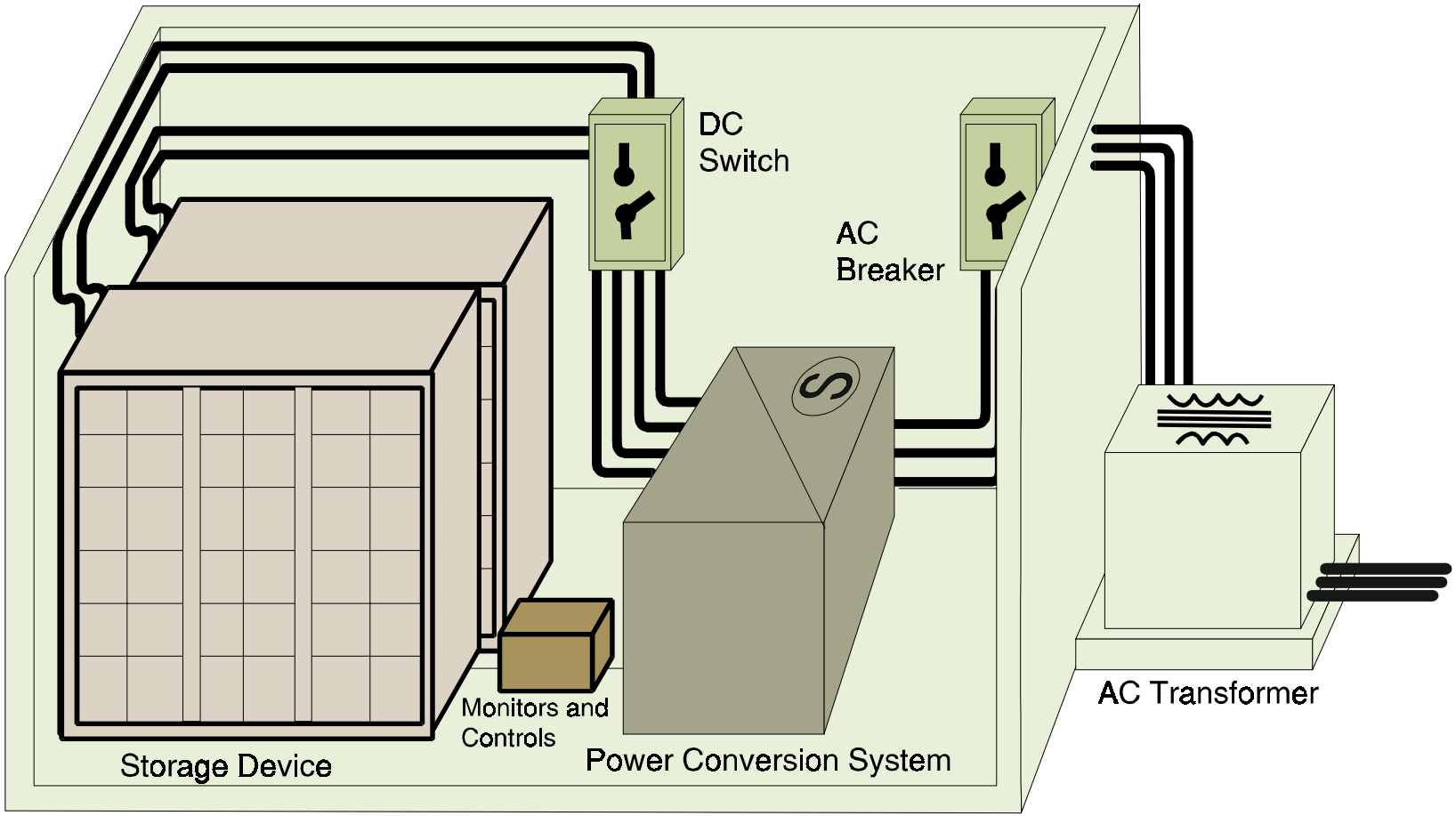
Energy and Power of Storage Applications and Technologies



A/E Designed Utility Battery Storage Systems

- Berlin Power and Light - 1987
  - used for spinning reserve and frequency control
  - rated at 8.5 MW/60 minutes or 17 MW/20 minutes
- Crescent Electric Rural Cooperative - 1987
  - used for peak demand reduction
  - rated at 500 kW/1 hour, 300 kW/2 hours, or 200 kW/3 hours
- Southern California Edison (Chino) - 1988
  - used for load leveling and transmission line stability
  - rated at 10 MW/4 hours
- Puerto Rico Electric Power Authority - 1995
  - used for spinning reserve and frequency control
  - rated at 20 MW/40 minutes

Storage System Components



Energy Storage System Development Status

Technology	Availability	Lead Time	Modularity	Energy Capacity
Batteries	Architect/Engineer designs	months-years	no	med-high
	Turnkey Systems	weeks-months	yes	low-med
Compressed Air	Architect/Engineer designs	years	no	high
Flywheels	Under Development	weeks-months	yes	high
Pumped Hydro	Architect/Engineer designs	years	no	high
Superconducting Magnets	Architect/Engineer designs	months-years	no	high
	Turnkey Systems	weeks-months	yes	low
Combustion Turbines	Turnkey Systems	months	yes	fuel-limited

Advanced Energy Storage System Products

- AC Battery: PM250, 250 kW/40 minutes
  - installed at Pacific Gas and Electric - 1992
  - used for demand peak reduction
- AC Battery: PQ2000, 2000 kW/10 seconds
  - installed at Pacific Gas and Electric - 1996
  - installed at Oglethorpe Power Corporation - 1996
  - used for power quality
- Superconductivity, Inc.: SSD, 700 kW/2 seconds
  - installed at Central Hudson Gas & Electric - 1992
  - used for power quality
- GNB/GE Team: BESS, 5 MW/10 seconds or 3.5 MW/1 hour
  - installed at GNB Manufacturing smelter - 1996
  - used for reliability and power quality, demand peak reduction

Products in Development

Power quality ■ SMES Device - Intermagnetics General Corporation ■ SMES for Anchorage - Babcock & Wilcox
Power quality and peak shaving ■ NaS-Pac™ Battery System, 300 kW/2 hours - Silent Power, Inc.
Power quality, peak shaving, and distributed storage ■ Zinc/Bromine Battery System, 33 kW/3 hours - ZBB Technologies, Inc. ■ Zinc/Bromine Battery System - Power Cell Corporation ■ Advanced Battery Energy Storage System - Manufacturer TBD ■ Transportable Battery Energy Storage System - AC Battery Corporation
Distributed storage ■ Flywheel Energy Storage - American Flywheel Systems ■ Secure Bus™ System - Manufacturer TBA
Load leveling ■ CAES System - Manufacturer TBD

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Section 3
Energy Storage Systems Program

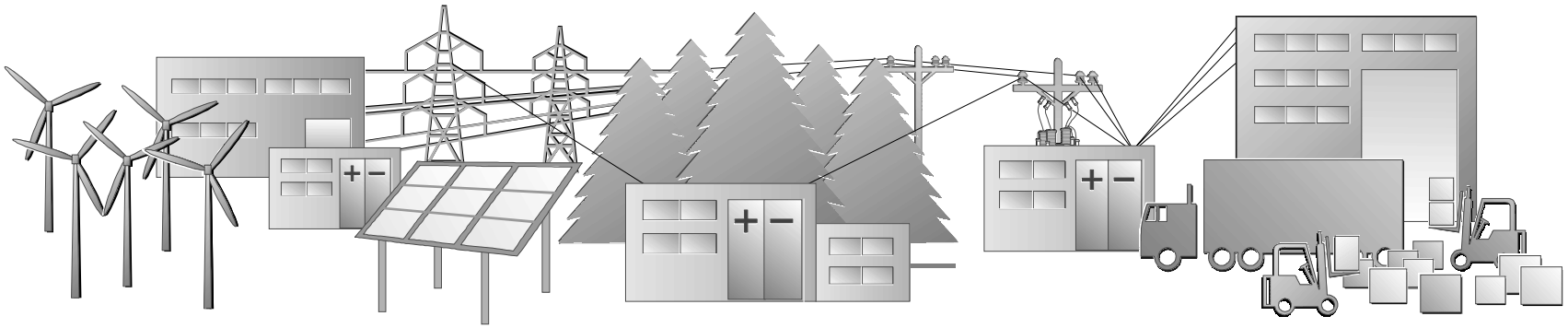
Our Mission

Conduct focused research and development, in partnership with US industry, on energy storage systems that will help

- increase the economic competitiveness of U.S. industry by minimizing power quality and reliability problems;
- enhance utility and customer technology choices in responding to restructuring; and
- increase the value of renewable and distributed resources.

Our Vision

Energy storage will be highly valuable in enabling the 21st-century utility, in a competitive environment, to efficiently provide low-cost, reliable, environmentally benign service to a broad spectrum of electricity users.



The Paradox

At the same time that economic, technical, and institutional changes are *increasing the need* for energy storage technologies, utilities are *decreasing investment* in long-term research.

- Increased Need
  - aging systems need upgrading or replacement
  - electric utility competition is emerging
  - environmental constraints are being imposed on electricity generation, transmission, and distribution
- Decreased Investment
  - regulatory changes are increasing investment risk
  - private sector R&D investment declined by 32 percent over last 10 years
  - base R&D funding at EPRI has declined by $70 million since 1992

Resolving the Paradox

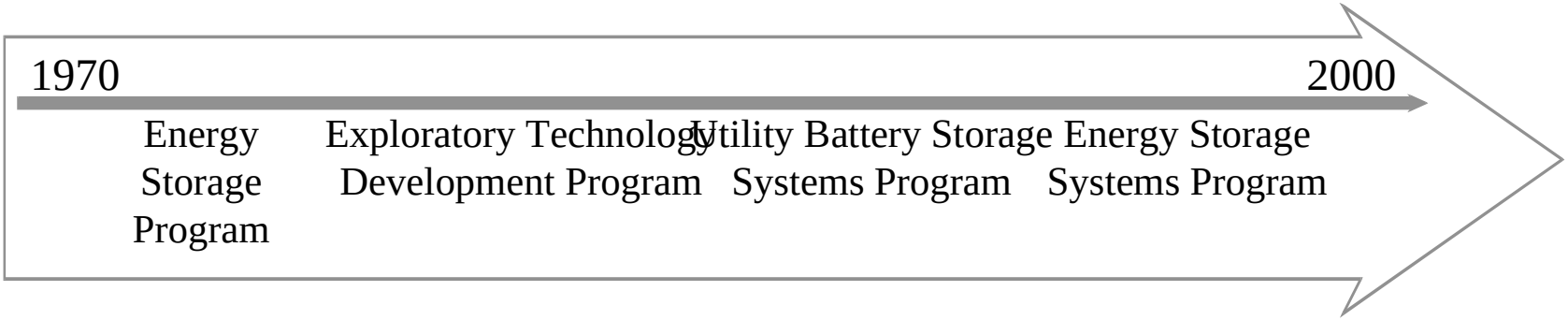
- DOE can contribute to a resolution by:
  - performing research that industry cannot do by itself
  - supporting leveraged development of integrated energy storage systems
  - exchanging information with industry for maximum benefit

ESS Program Objectives

- Work with industry in developing cost-effective energy storage components;
- Develop integrated systems that improve power quality and reliability, and reduce the environmental impact of electricity generation and distribution;
- Analyze utility needs and match them with improved energy storage technologies;
- Increase industry awareness of the benefits of energy storage systems and options for providing it.

Long-Term DOE Commitment to Storage

1970s	Extensive development of storage subsystem technologies
1980s	Emphasis on battery storage subsystems
1990s	Integration and demonstration of turnkey systems
2000	Development of storage devices and power electronics for a portfolio of storage technologies



Milestones in Battery Storage

1972	First 50-kWh laboratory sodium/sulfur battery tested by Electricity Council Research Center
1982	Absolyte VRLA battery developed and commercialized by Gould, Inc. (GNB)
1986	Nickel hydrogen batteries for terrestrial applications developed and commercialized with COMSAT and Johnson Controls. 17-MW spinning reserve and frequency regulation battery system began operation at **BEWAG**
1987	300-kW demand peak shaving system installed at Delco-Remy manufacturing plant 500-kW battery system for peak shaving brought on line at **Crescent Electric Membership Co-op**
1988	10-MW Battery Storage Plant completed by **Southern California Edison** at Chino
1991	Utility Battery Group (renamed Energy Storage Association [ESA] as of 1996) founded by seven investor-owned utilities
1993	250-kW AC Battery prototype testing conducted in San Ramon California at **PG&E** Absolyte IIP VRLA battery developed and commercialized by GNB
1994	Power quality battery system development agreement initiated by DOE and Omnion 12-kWh preproduction sodium/sulfur battery developed with Silent Power 100-kWh zinc/bromine battery developed with Johnson Controls and ZBB Technologies
1995	20-MW spinning reserve and frequency regulation system began operation by **PREPA**
1996	3.5-MW emergency power storage system completed by GNB/GE at Vernon

ESS Program Elements

Component Research and Development

Storage Components

Power Electronics Components

ComponentsTechnology Capability and Compatibility Studies

Analysis

National Benefits Studies

Utility/Renewables Applications StudiesControl

Integration and Implementation

Renewable Storage Systems

Transportable Systems

Reliability SupplyInternational Initiatives

Information Exchange

Utility and Industry Outreach

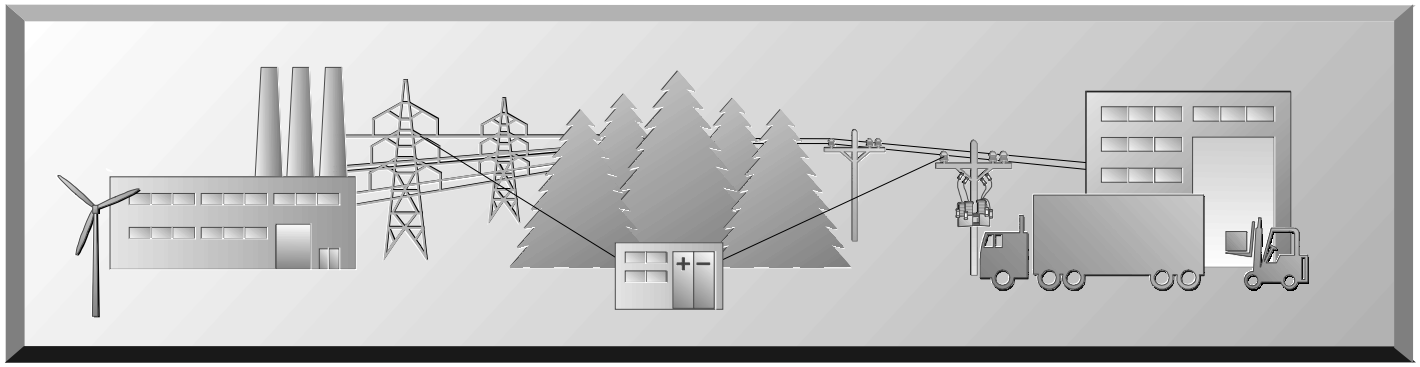
Institutional and Regulatory Initiatives High-

ESS Program Goals

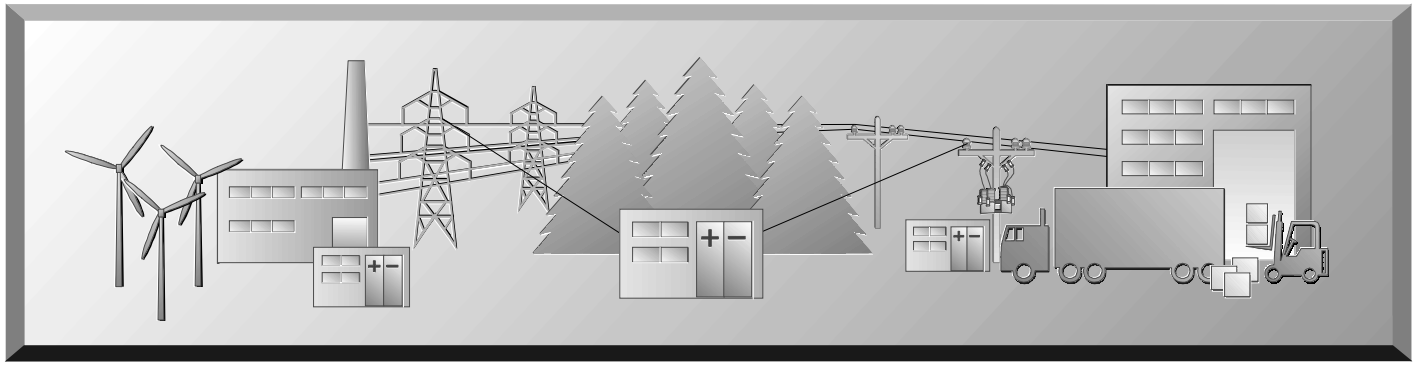
Component R&D	
1998	PCS Magnetics Development
	VRLA Reliability Improvement
2000	Charge Controller with Renewables
	SMES Cold Switch Development
Integration and Implementation	
1996	PQ-2000
1997	Transportable Battery System
1998	SecureBus™
	Renewable Storage System
1999	National Energy Storage Test Center
2000	Advanced Battery System
Analysis	
1997	Market Feasibility Study
	SMUD Renewables Study
	Flywheel Technology Study
2000	Storage Technology Compatibility Study
Information Exchange	
1997	Utility Executive Briefings
1998	Regulatory Agency Briefings
1999	National Energy Storage Design Center
Each	Technical Reviews and Reports

National Results of ESS Activities

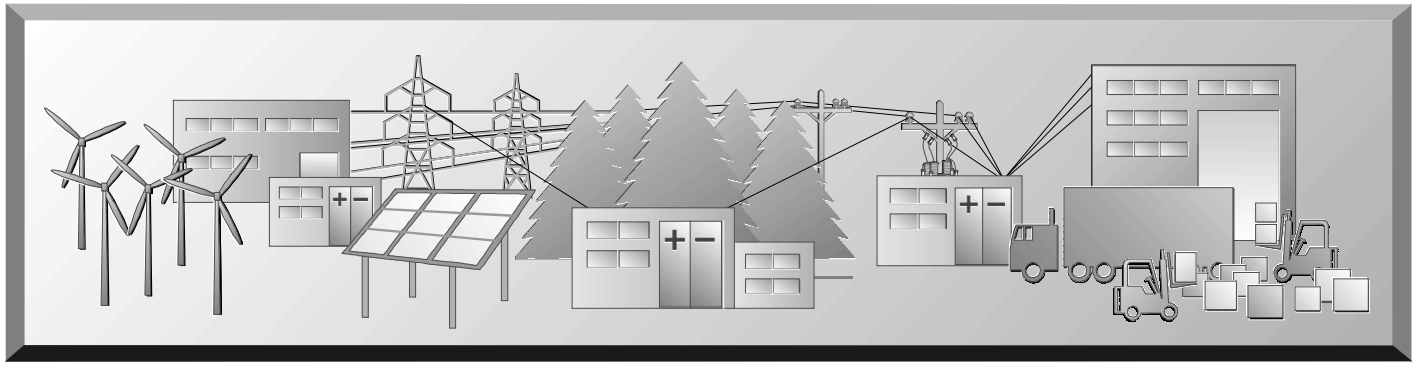
1995



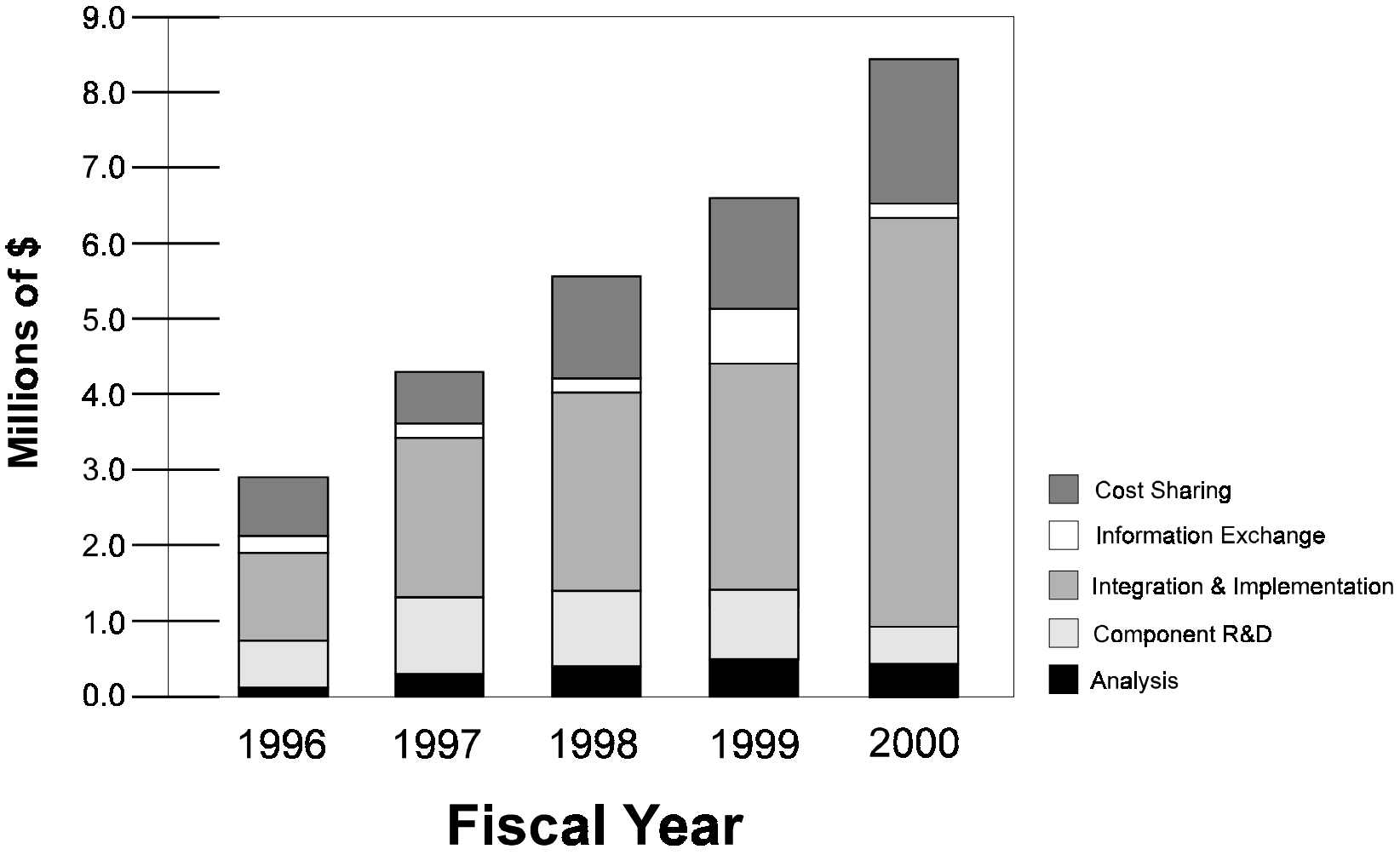
2000



2010



Estimated ESS Program Budget Requirements



Why Should We Consider Storage to Improve an Electricity System That Has 99.9 Percent Reliability?

- Examples of What 99.9 Percent Means:
  - One hour of unsafe drinking water per month.
  - Two unsafe landings per day at O'Hare.
  - 16,000 pieces of mail lost by the United States Postal Service every hour.
  - 20,000 incorrect surgical operations per week.
  - 50 newborn babies dropped at birth by doctors every day.
  - 22,000 checks deducted from the wrong account every hour.
  - 32,000 missed heartbeats per person per year.
- Because the 0.1 percent difference is important

-- Jeff Dewar, QUI International

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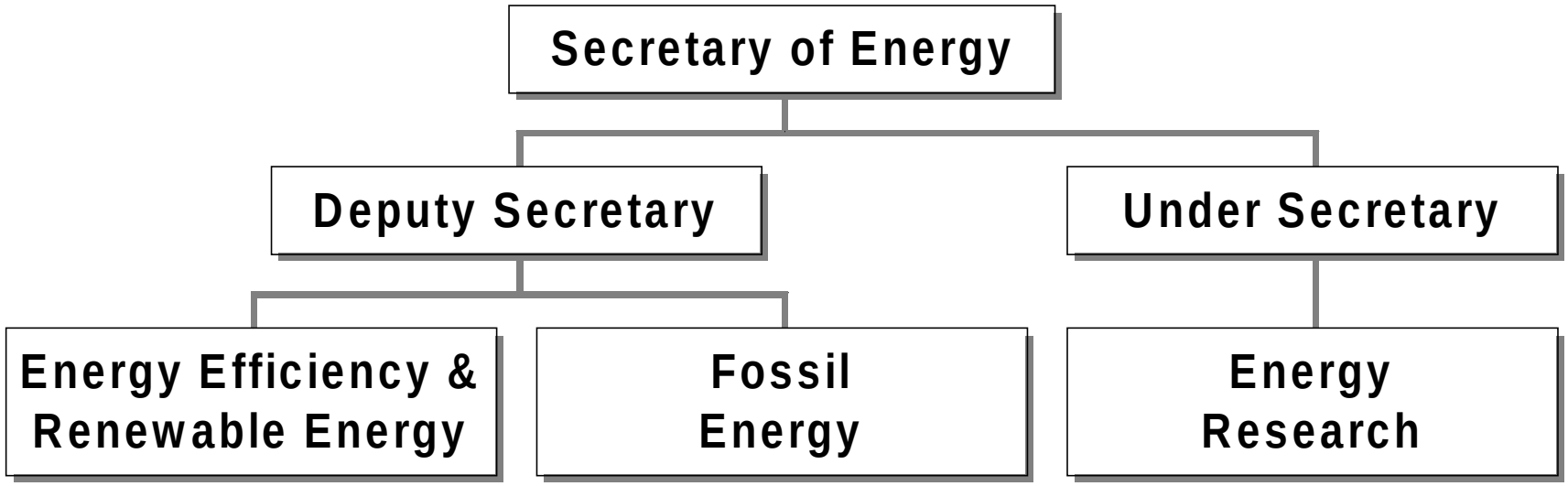
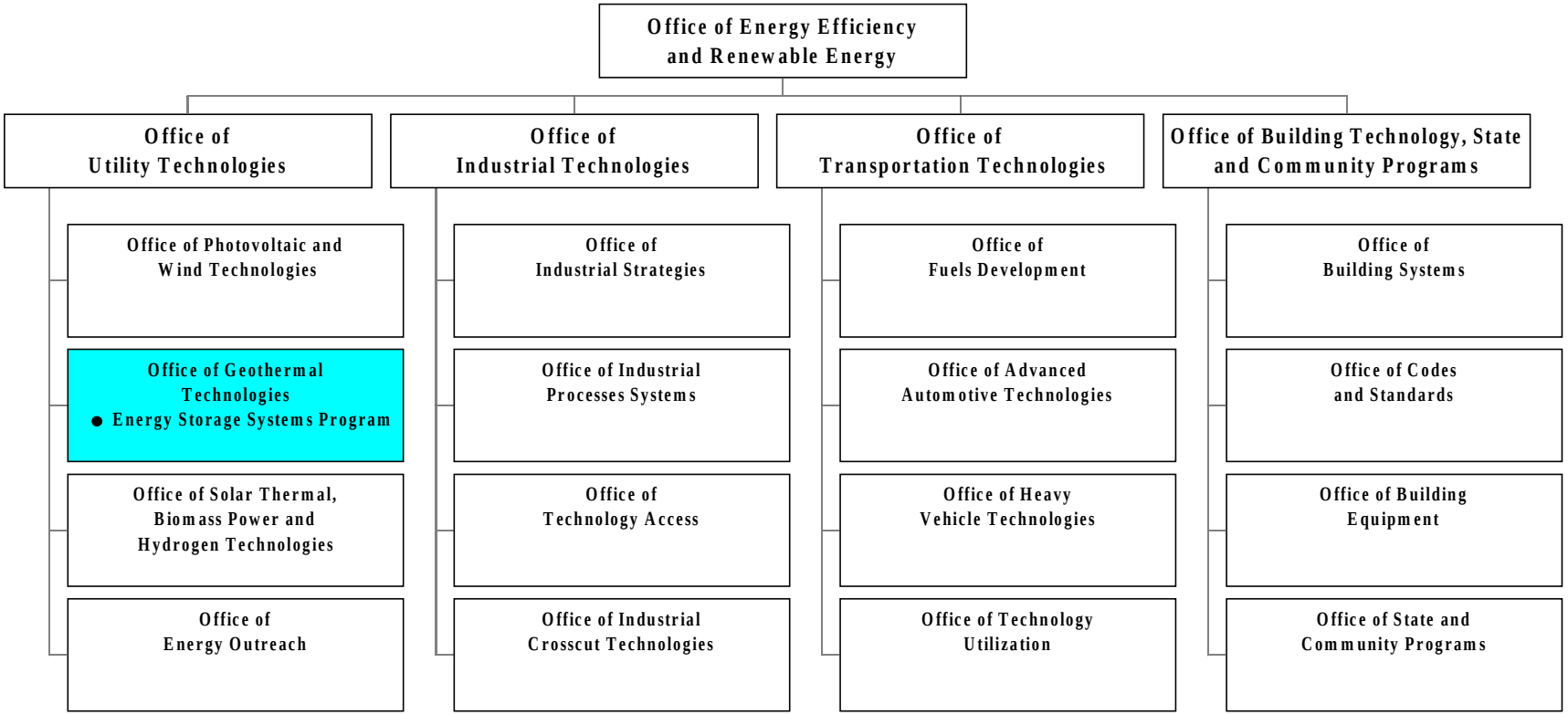
Section 4
DOE Organization and ESS Program Budget

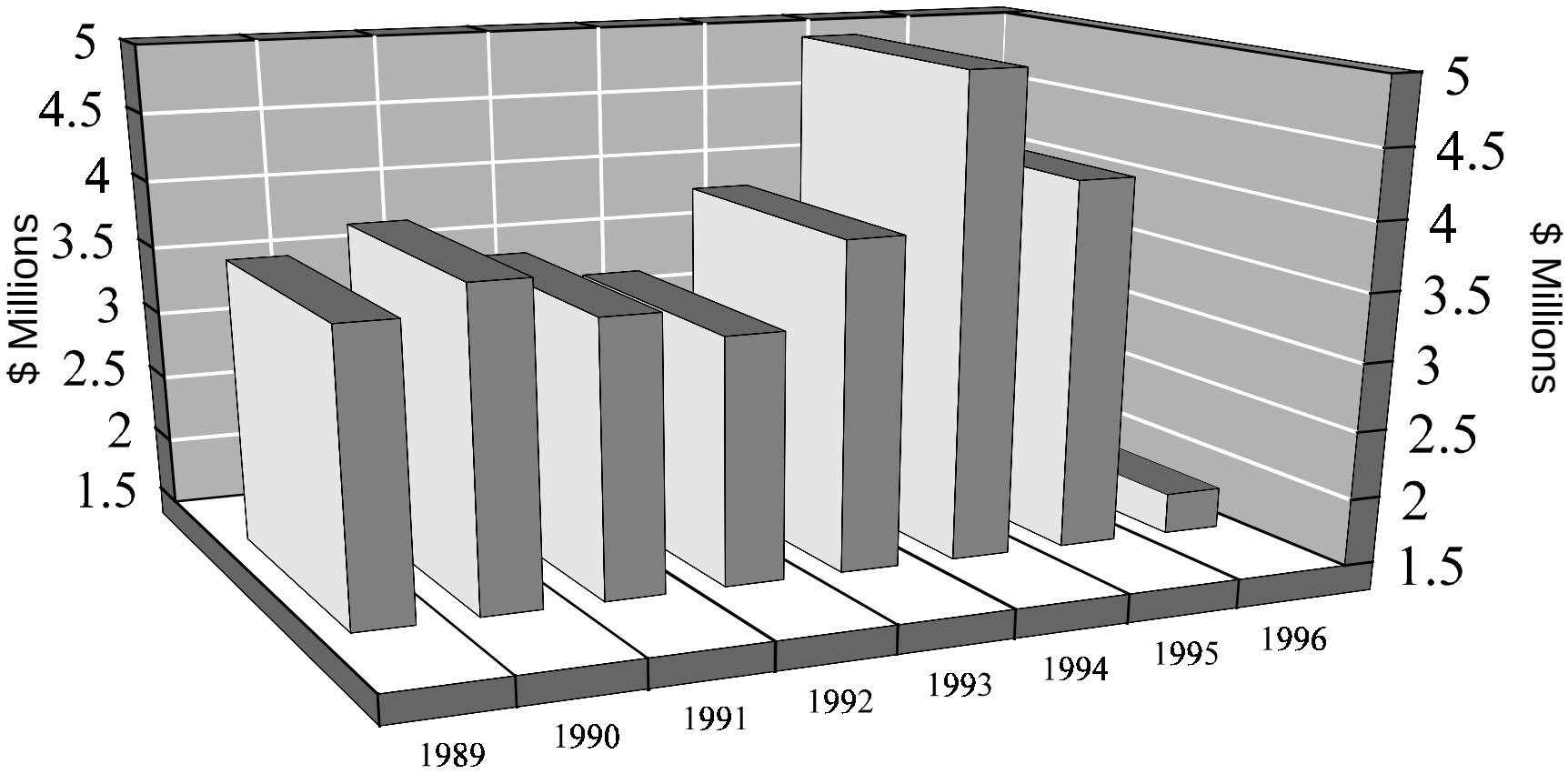
U.S. Department of Energy



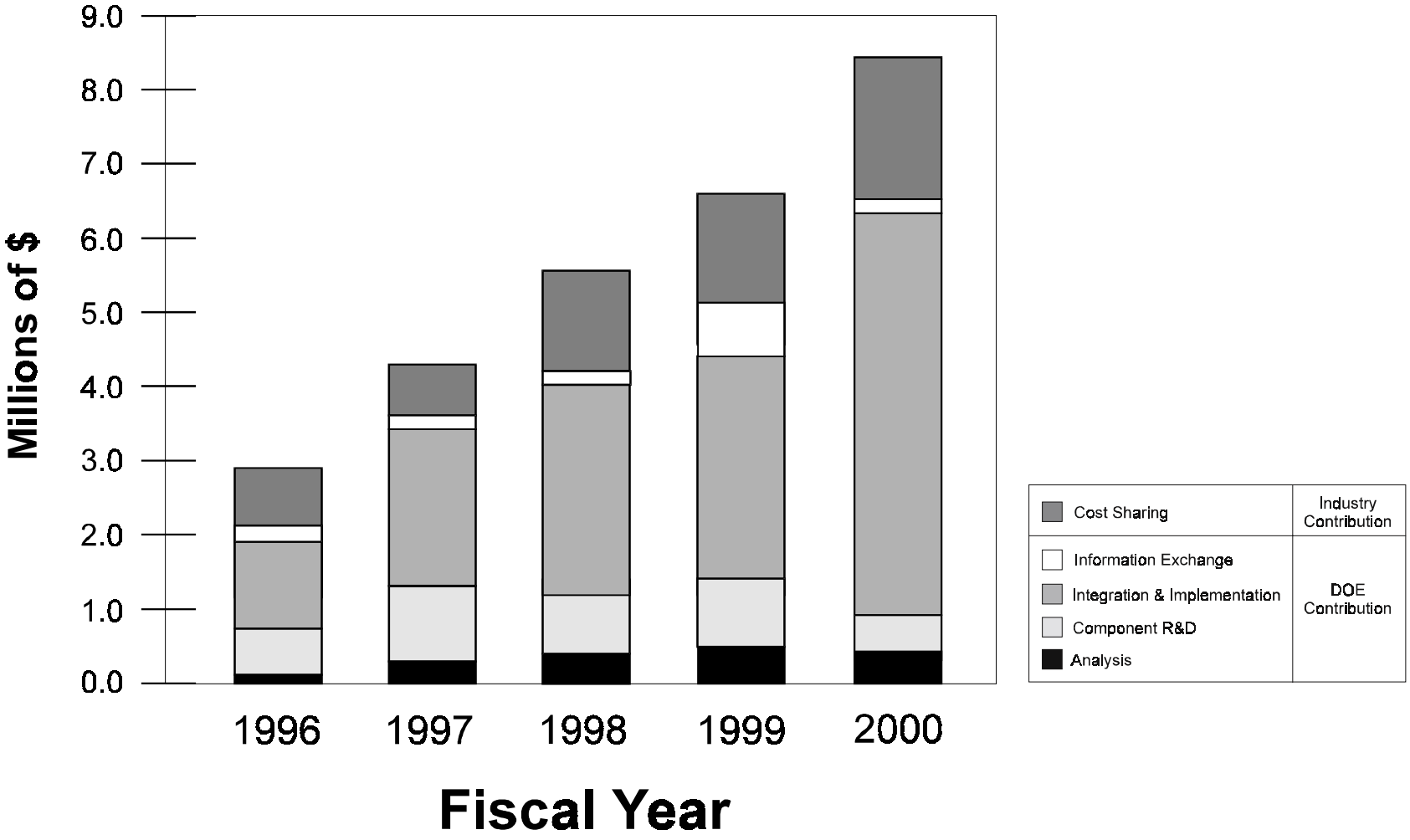
DOE Energy Efficiency and Renewable Energy



DOE Storage Program Funding History



What it Will Take to Achieve ESS Goals



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World Wide Web Sites

- U.S. Department of Energy Home Page
  - http://www.doe.gov
- U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy
  - http://www.eren.doe.gov
- Sandia National Laboratories, Energy Storage Systems Program
  - http://www.sandia.gov
- Energetics, Incorporated
  - http://www.vsecorp.com/energeti.htm
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B

Meeting Summaries

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Appendix B
Meeting Summaries

AES
1001 North 19th Street
Arlington, VA 22209
(703) 522-0073
September 18, 1996

Meeting Participants:

John Ruggirello, President, AES Enterprise
Ann Murtlow, VP, AES Enterprise
Jay Geinzer, VP, AES Consulting

Corporate Summary:

AES Corporation, headquartered in Arlington, Virginia, extends into 35 countries, including Argentina, China, England, and Pakistan. AES markets power principally from electric generating facilities that it develops, owns, and operates. AES has grown to encompass 19 power plants in 6 countries representing more than 4,332 MW and more than $2.3 billion in assets. Founded by CEO Dennis Bakke and Chairman Roger Sant, AES currently has six divisions: AES Americas, AES Electric, AES Enterprise, AES Transport, AES Chigen, and AES Shady Point. AES has almost 1,300 employees throughout the world.

In 1995, electricity sales accounted for 97 percent of $672 million in revenues. Electricity sales represented 95 percent of total revenues in 1994. AES is exploring business opportunities in North America, India, Pakistan, China, and other areas in Southeast Asia, South America, Europe, the Middle East, and Africa.

Meeting Results:

AES representatives said that the company, at present, does not fund research and development (R&D). Its present U.S. focus is generation. Abroad, AES's focus is spread between generation and transmission, and AES executives believe that the timing of product emergence with constraints on distribution and transmission capacity will be crucial to the adoption of storage as reserve margins diminish. This situation may contribute to an increase in the demand for storage and storage technologies.

Executives of the company compared the evolving electric utility industry in the U.S. to the situation in Argentina. Both the electricity and gas industries restructured simultaneously there. While AES representatives were quick to add that economic and environmental drivers here are different from those in Argentina, both markets are extremely price competitive. During restructuring, AES was forced to mothball several units that were not profitable. AES noted that, as occurred in Argentina, niche opportunities can obscure and delay the actual direction of the market.

AES cautioned against using Argentina (or the U.K.) as direct models of what to expect in the U.S. The gas industry is already deregulated here. Argentina's smaller size lends itself to more uniform behavior than in the U.S., where problems are more regional. AES does believe, however, that Argentina is a better model to study than the U.K.

For now, AES sees several issues emerging in U.S. restructuring. While reliability is important, 100 percent is not necessary except for with a few sensitive customers. Reliability will come with a price after deregulation and restructuring. AES plants are presently more than 90 percent available, but AES recognizes the importance of power quality (PQ) for some industries.

Any decision to build a base load plant is based on economics, not demand. Any construction based on demand will be delayed until the early 2000s. There is presently an excess in generating capacity.

AES is interested in renewables, but they are a tough sell in the capital markets. Now hydro is the principal interest of AES.

AES thinks that cheap Midwest coal-generating plants will be shut down in 2002-2003 because of environmental regulations. Utilities will be forced to build new, clean generation, probably gas. The costs of combined cycle plants are decreasing (<$400/kW) and will be very attractive in the future. Coal plants cost about $1000/kW today and have a long (3-6 years)

lead time compared to the 1.5-to-3-year lead time for combined cycle plants.

Kenetech/US Windpower
6952 Preston Avenue
Livermore, CA 94550
(510) 455-6012
May 14, 1996

Meeting Participants:
Bill Erdman, Director, Electrical Engineering
Mike Benkhe, Manager, Power Systems

Corporate Summary:

The Kenetech Corporation, based in San Francisco, California, developed and constructed utility-scale wind-powered electric power plants and independent power projects. Until recently, the company operated and maintained more than 4,500 wind turbines, more turbines than any other company in the world. In 1996, after meeting with the Energy Storage Systems (ESS) Program, Kenetech declared bankruptcy. The power conservation system portion (and other segments of the business) are regrouping to form new, separate entities.

Kenetech and its subsidiaries designed, built, financed, operated, and maintained power plants that use environmentally preferred technologies—principally wind, biomass, and natural gas—and provide energy conservation and management services. Kenetech's mission was to develop alternative energy.

Kenetech was involved in both domestic and international research and demonstration projects. In the Ukraine, Kenetech was working with the government to supply 5,000 windmills to help accelerate the closure of the Chernobyl nuclear plant. Because of the extreme budgetary constraints under which the Ukrainian government was operating, Kenetech agreed to take its profits in rotor blades and other windmill parts manufactured in former Soviet military factories. These parts were to be used to repair and maintain windmills in the U.S. and Europe.

Meeting Results:

Participants from Kenetech saw the industry in a state of flux and detected an unwillingness on the part of utilities and manufacturers to make commitments to energy storage. They reported that Kenetech had looked seriously at integrating energy storage technologies with renewables but, time and again, were faced with the problem of economics. In today's uncertain environment, a 3-year investment is considered long-term and high-risk. With the current cost of energy, storage is not a feasible idea, whether combined with renewables or not. Kenetech case studies, however, have not evaluated multiple applications of energy storage systems.

Kenetech representatives felt that the nation and U.S. industry are "on the right track" to promote energy storage; a remaining barrier is economics. Their view remains that the widespread application of storage is unlikely to happen soon, but that storage will eventually find its niche. Representatives do not see delamination as detrimental to independent power producer (IPP) contracts. Utilities do not yet see the potential for energy storage, and IPPs are unlikely to take steps to develop it. Manufacturers may develop storage technology, and there may be a role for DOE.

Kenetech also raised the issue of significant differences between domestic and international energy markets. While the U.S. is gas-rich and its energy costs are low, in Europe energy costs are high, and Asia is in dire need of increased power capacity. These circumstances create an enormous demand for power and the potential willingness to pay a premium for that power. Such demand creates a ripe business opportunity for U.S. industry, but difficult business, technical, and political barriers remain.

Purchase power agreements prohibit multiple benefits from accruing to any one party. These complex business relationships and uncertainty in the utility industry are preventing any one entity from clearly identifying or realizing the economic benefits from systems providing multiple benefits.

Central and South West (CSW)
Two West Second Street
P.O. Box 21928
Tulsa, OK 74121-1928
(918) 594-2000
August 5, 1996

Meeting Participants:
Rick Walker, Director,
Research & Development, New Markets
Dave McNabb, Research & Development,
New Markets
Paul Hassink, Manager, ERCOT

Corporate Summary:

CSW is a public utility holding company that has four subsidiaries: Central Power and Light Company, Public Service Company of Oklahoma, Southwestern Electric Power Company, and West Texas Utilities Company. These companies provide electric service to close to 4.4 million customers in a diverse area covering approximately 152,000 square miles. The area covered by CSW is the second largest area served by any electric utility system in the U.S. CSW also has a subsidiary in Great Britain. Revenues in 1995 totaled over $3.7 billion, a 3.1 percent increase over 1994, and net income was $402 million.

CSW is enthusiastic about the coming industry restructuring and competition in the electric utility market. CSW has been extremely active in working with other utilities to promote the principles of fairness and equality in competition in the electricity markets.

While CSW is very much interested and active in promoting wholesale competition, it does not support retail competition. It argues that such competition would be damaging to the interests of the consumers, the stakeholders, and the bondholders of U.S. electric utilities. CSW's central point of opposition concerns the issue of stranded assets. CSW's annual report is quoted as saying, "We (CSW) shall strongly oppose attempts to impose retail competition on our industry without just compensation for the risks and investments the industry undertook to serve the public's demand for electricity. We do not oppose fair competition, but we do oppose confiscation under the guise of competition."

Meeting Results:

CSW is offering a "Customer Choice and Control" Program with real-time pricing for industrial and residential customers. The Program, first tried in Laredo because of transmission limitations, will be implemented in Austin next. CSW is curious as to how many customers might consider using this type of sophisticated control or storage.

Participants in this meeting felt that energy storage systems may be "competing" with renewable energy technologies for a place in the utility industry (if storage is not an integral part of the renewables system). Utilities will look at the economic benefits and consider renewables and storage as separate distributed utility technologies. CSW has a renewables demonstration project. BP Solar, CSW's British subsidiary, is planning to market an integrated photovoltaic (PV), battery, and power conversion system.

Storage technologies will also need to compete with traditional technologies, such as gas turbines, to gain a foothold in the market.

In light of competition between technologies, CSW expressed interest in obtaining cost and performance data for energy storage systems that would allow comparison to fuel cells, fast switching capacitors, or statcons. Also, CSW felt that utilities would need to see how each storage technology mates with specific applications. CSW is convinced, though, that the entry market for storage is PQ.

The representatives stressed that the value of the technology will depend on the situation. For example, with PQ, CSW might offer a tiered rate structure and provide a customer-side-of-the-meter technology for a premium at customer sites where high PQ is essential. Because its customers do not yet have a sophisticated understanding of PQ issues, CSW provides key account managers to give guidance. Right now, storage systems would not be their recommendation to most customers because of cost. However, as costs drop, their recommendations may change.

CSW identified a possible "enhancement" of a transmission line with a storage system between 500 and 1200 MW for voltage, frequency, mechanical stability, and reserve power. It can envision a transmission and distribution (T&D) or PQ project if it could leverage funding with the U.S. Department of Energy (DOE) or the Electric Power Research Institute (EPRI). It is interested in integrated systems and considers the drivers (after cost) to be power and energy density and weight.

Indianapolis Power and Light Company (IPALCO)
P.O. Box 1595
Indianapolis, IN 46206-1595
(317) 261-8222
May 1, 1996

Meeting Participants:

Thomas Roush, Power Quality Consultant
Daniel Melvin, Power Production Planning
Sohail Alyasin, Planning Engineer, Power Production Planning
Herman Schkabla, Power Production Planning
Stephen Powell, Manager, Engineering and Production Services
Jerry Fogleman, Industrial Applications Engineer

Corporate Summary:

IPALCO, an investor-owned utility in Indiana for 66 years, has a customer base of about 400,000 residential, commercial, and industrial customers in and around Indianapolis, Indiana. It has a production capacity of over 2,800 MW, and its rates for electric and steam service are among the lowest in the United States for investor-owned utilities (IOUs). Revenues for 1995 topped $709 million.

IPALCO is eagerly awaiting a competitive market for electricity and has published an extensive white paper outlining its plan for nationwide electric competition. John Hodowal, CEO and Chairman of the Board of IPALCO, said, "We've made a commitment to promote competition in one of America's last regulated strongholds—the electric utility business. We will continue to work for federal legislation that will ensure true competition, customer choice and nondiscriminatory access to power suppliers."

Meeting Results:

Representatives from IPALCO expressed interest in using electric vehicle batteries for PQ operations. According to their data, 90 percent of all problems last less than 30 cycles or ½ second. IPALCO's Power Supply Planning Group did a distributed generation study to examine storage options, including portable batteries. The Commercial Sales Group has been investigating the use of BESSs and the use of ice storage to improve load factor and are considering a role for EPRI's Flexible Alternating Current Transmission System (FACTS) technology to address transmission issues. IPALCO believes that customers will own storage and be convinced that it is a better deal than traditional technologies. Because there is no guaranteed return of investment, no one is likely to commit capital, but some may be interested in leases. IPALCO believes that overcoming the barriers to widespread use of storage involves convincing customers that there is a potential return.

Participants in the meeting expressed concern over the limiting effect of the fluctuations in the DOE's year-to-year funding of multimillion-dollar programs. They felt it allows for no solid long-term R&D. Their concern was magnified by their belief that some independent force is necessary to conduct R&D besides vendors. They are concerned over who will fund R&D, especially since EPRI funding is decreasing. To IPALCO, capital investment reduction takes priority over long-term R&D investment. IPALCO hopes that the DOE will be there to support R&D for electric utilities.

If policies of reducing long-term R&D investment become industry-wide, the gap in R&D would create a potentially profitable entrepreneurial opportunity for private firms. The fear remains, though, that such an initiative would come from abroad and put U.S. industry at a distinct disadvantage. IPALCO currently has no energy storage projects or research under way due to the area's low price (4.94¢/kWh) and abundance of electricity and excess capacity. IPALCO representatives indicated that additional analytical tools are necessary to study the cost-effectiveness of storage and other advanced technologies.

Northern States Power (NSP)
512 Nicollet Mall
Minneapolis, MN 55401-1927
(612) 330-5500
April 17, 1996

Meeting Participants:
George Aandahl, Life Cycle Optimization (LCO) Consultant, Generation Services
Skip North
Wendy Brandt
Kevin Lawless
Denise Zurn
Jerry Larsen
S.K. Suman
George Aandahl
Brian Amundson
John Boylan
Bill Feyo
Ernie Hiatt
Tom Kulas
Ellen Lamb
Therese Lavalle
Dan Nordell
Mary Santori
Dave Zuck

Corporate Summary:

NSP, founded in 1916 and headquartered in Minneapolis, Minnesota, is a major utility with growing domestic and international nonregulated operations. NSP and its wholly owned subsidiary, Northern States Power Company-Wisconsin, operate generation, transmission, and distribution facilities providing electricity to about 1.4 million consumers in Minnesota, Michigan, Wisconsin, North Dakota, and South Dakota. The two companies also provide 400,000 customers with natural gas in Minnesota, Michigan, Wisconsin, and North Dakota and provide a wide variety of energy-related services throughout these service areas.

From a service area requiring only 70 MW of power, NSP has grown to operate two nuclear plants and five major coal plants as well as hydroelectric plants, wind turbines, and several facilities that burn refuse-derived fuel along with oil, wood, and gas. Coal generates about 47 percent of the electricity, while renewable sources like wind and hydroelectricity account for 3 percent; refuse-derived fuel and waste wood, 1 percent; and nuclear, 31 percent. NSP consumes about 11 million tons of coal and 2 tons of nuclear fuel every year.

Meeting Results:

During the meeting, NSP representatives stated that they have no immediate interest in installing energy storage, but are keeping abreast of developments in the field. This perspective stems in part from natural gas's low price, easy availability, and environmental friendliness.

NSP has worked closely with EPRI in the past and was even considering superconducting magnetic energy storage (SMES) for load leveling, but decided not to pursue the option further. At one time, NSP focused on long-term R&D; however, in the past 5 years imminent competition and the need for increased cost-consciousness has shifted the focus of R&D away from long-term issues to more near-term ones. NSP representatives emphasized their belief that the DOE's role in long-term R&D is *highly critical* in the sense that long-term perspective is vital to continued technological advancement. Cost is a critical issue, and storage options must be inexpensive relative to traditional technologies before NSP will consider their adoption. The cost of ancillary services must be considered as well. Corporate executives considered $400-500/kW a cost goal.

One concern voiced during the meeting was whether deregulation and unbundling will eliminate (instead of create) opportunities for energy storage. NSP is uncertain what the emerging energy service industry will include in its new packages of services. In other industries, entrepreneurs have always found niches, but NSP has not yet identified any specific business opportunities for storage. NSP thinks utilities want SMES and flywheel technologies incorporated into their capacity.

NSP has instituted several changes in their operations as a result of utility restructuring. In addition to a merger, which has superseded all other business considerations, NSP has established generation and delivery business units in preparation for the coming restructuring.

Potomac Electric Power Company (PEPCO)
1900 Pennsylvania Avenue
Washington, DC 20068
(202) 872-2000
April 12, 1996

Meeting Participants:
Brad Johnson, Manager, Corporate Planning
Robert Stewart, Sr. Engineer, Advanced Market Development Programs
Steve LoVecchio, Coordinator, Energy Management
Robert Meyers, Manager, Engineering Economy
Karen Parhem, Energy Policy Specialist

Corporate Summary:

PEPCO is an investor-owned electric utility that has served the electricity needs of more than 1.9 million people in the Washington, D.C., metropolitan area for 100 years. PEPCO's service area, which covers over 640 square miles, includes Washington, D.C., and major portions of Montgomery and Prince George's counties in Maryland. PEPCO is also involved in the wholesale sale of electricity to Southern Maryland Electric Cooperative, Inc. PEPCO, unique in the sense that its consumer base and service area have virtually no heavy industry, prospers in a region that is almost solely made up of government, service industries, and commercial ventures.

PEPCO's operating revenue for 1995 was almost $1.8 billion, with income totaling $230 million. That is expected to increase dramatically with the merger of PEPCO and Baltimore Gas & Electric (BG&E) in the first quarter of 1997 into Constellation Energy Corporation, a direct result of the upcoming utility restructuring and deregulation. Constellation is expected to have total assets exceeding $15 billion and revenues of nearly $5 billion. The combined service areas of BG&E and PEPCO will be approximately 4.5 million people, 1.8 million customers, and over 545,000 gas customers.

It is the goal of both companies that Constellation Energy be a stronger, larger company that is well positioned to compete successfully in the increasingly competitive electricity market.

Meeting Results:

Representatives of PEPCO felt that restructuring would lead to extremely competitive business in generation; transmission would continue to remain highly regulated; and distribution would have greater flexibility and more growth potential than before. PEPCO executives also voiced the opinion that, in addition to changes resulting from restructuring, environmental drivers pervasive throughout the industry would lead to increased energy efficiency, more use of renewable energy, and consideration of the use energy storage technologies.

Participants saw increased utility industry competition as significant enough to decrease investment in the short term. The price of storage technologies still prohibits widespread penetration. PEPCO's current strategy is to obtain as much as possible from existing assets and to define a process to determine where to use increasingly scarce resources. Representatives want a research process that will assist decision-makers in determining what technologies to develop.

The following equations illustrate how PEPCO has changed its business approach from a regulated industry approach to a more market-oriented approach:

Regulated: Cost + Profit = Revenue
Market Oriented: Revenue – Cost = Profit

Company representatives encouraged DOE to establish a process that encourages a phased approach to energy storage development and deployment. PEPCO suggested that the ESS Program look to PV development as a model.

Action Items:

Provide a list of projects, both technical and programmatic, dealing with energy storage.

Public Service Co. of New Mexico (PNM)
Alvarado Square, MS-0510
Albuquerque, NM 87158
(505) 241-2700
August 5, 1996

Meeting Participants:
Jerry Neal, Premium Power Services Development
Roger Flynn, Electric Services
Rich Braziel, Industry Marketing
Dwight Clark, Director, Business Development
Larry Ratliff, VP, Engineering & Technical Services

Corporate Summary:

PNM is a combined gas and electric utility serving about 1.2 million people in 100 communities throughout the state of New Mexico. In addition to its retail gas and electric business, PNM also sells power on the wholesale market, operates a water utility in Santa Fe, New Mexico, and offers a wide variety of energy-related services.

About 51 percent of PNM's gas and electric customers reside in the Albuquerque metropolitan area, with the other 49 percent residing in the large portion of the state that makes up the rest of PNM's service area.

In January 1995, PNM officially reorganized into four strategic business units, each targeted at a specific part of the company's customer base. PNM *Electric Services* serves retail electric customers and PNM *Gas Services* delivers gas products and services to New Mexico customers: PNM *Bulk Power Services* manages the generation and transmission system, providing electric power to retail customers in New Mexico and to wholesale customers throughout the region. PNM *Energy Services* is applying PNM's management experience and technical expertise to developing a variety of new, energy-related opportunities.

Meeting Results:

PNM representatives believe that PQ is more viable than distributed utility (DU) storage, and sees the need for PQ as independent from competition, whereas the general energy market will be driven by costs and economics. PNM representatives think that reliability will decrease in a competitive retail market because of the FUD Factor (Fear, Uncertainty, Doubt), but that there is a potential market for substation energy storage devices.

Participants felt strongly that the ESS Program should mirror broad industry needs. When studying the applicability of a technology, the ESS Program should conduct analysis first, then decide whether to fund a project or not. The process should be to determine the project's cost-effectiveness, its broad applicability, and its ability to find a niche in the market. The ESS Program should not partner or fund a utility whose vision is not in line with that of the Program.

PNM is particularly concerned with the limitations of the existing transmission grid in light of the coming competition. While an efficient market requires a perfect grid, transmission is not perfect and the U.S. is unwilling to build transmission (because of concerns about lifestyle, environment, electro-magnetic fields, etc.).

Because most customers do not understand the limits of the transmission system, they demand perfection that will create new markets. Storage and other technologies (i.e., EPRI's FACTS) can help get more out of existing transmission systems and offer options to installing new transmission facilities.

PNM representatives provided the San Juan/Peruvian pipeline as an analogy to how congestion pricing and dispatch will affect electricity transmission with tomorrow's independent system operators (ISOs). They believe that by the turn of the century the electric utility market will be driven not by generation but by T&D.

They believe that after a few years, regulations will be in place to prevent competitors from exploiting each other's improvements but, at present, companies are trying to be innovative in ways that improve their systems yet protect their business interests. Currently, that belief is part of the philosophy of the SecureBus project. This project originally began as an initiative with a SMES device, but manufacturers could not provide a SMES device within appropriate cost requirements, so the focus of the project was shifted to batteries.

The SecureBus, a collaborative project with the ESS Program, is intended to be installed at microelectronics and robotics labs at SNL. PNM wants to develop the SecureBus as a profitable business venture and recover the costs of the demo unit quickly. They believe they can sell the SecureBus for less than AC Battery sells their PQ2000. They expect system cost breakdown to be 20 percent batteries, 40 percent control electronics, and 30 percent balance of plant.
Primary drivers for any electric power product will be footprint and manpower. PNM believes power pro-

ducers and their customers need technologies that reduce manpower costs.

PNM is installing a peaking unit at a substation and listing it as a transmission asset with the Federal Energy Regulatory Commission (FERC). How long regulators will allow such a designation is uncertain. The installation also raises the question of whether rotating generators will be regulated by FERC in the future.

Southern California Edison (SCE)
P.O. Box 800
2244 Walnut Grove Avenue
Rosemead, CA 91770
(818) 812-7631
May 17, 1996

Meeting Participants:
John D. Leeper
Richard N. Schweinberg
Gary W. Dishaw, Senior Research Engineer
Naum Pinsky, SCE Electric Vehicle Program

Corporate Summary:

SCE is the second largest electric utility in the U.S. and serves over 11 million customers in a territory of 50,000 square miles. The largest subsidiary of Edison International, Inc. (EIX), SCE is a 109-year-old regulated utility whose generating capacity exceeds 22,000 MW and whose assets exceeded $18 billion in 1995.

A recent corporate reorganization resulted in four distinct utility business units: (1) Customer Solutions; (2) Distribution, which manages 88,000 miles of circuits; (3) Generation; and (4) Power Grid, which is responsible for the maintenance of 12,000 miles of bulk power transmission lines and 900 substations.

EIX is responding to California's evolving regulatory changes and is investigating new business ventures that will be viable within a new structure. For example, EIX is heavily involved in the development and promotion of the broad acceptance of electric vehicles in California and nationwide. SCE provides the necessary utility infrastructure to support recharging the batteries. The EIX Affiliate, Edison EV, supports the installation of recharge equipment at residential and commercial sites.

Meeting Results:

SCE expressed interest in the amount of funding that the ESS Program would be able to devote to demonstrations, and suggested that the program might be able to leverage funding through coordination with the newly formed Energy Storage Association (ESA) (formerly the Utility Battery Group). SCE has been active in energy storage since the mid-1980s; it built and operated a 40-MWh battery energy storage system in Chino (with EPRI) and is one of the founding members of the ESA. However, deregulation and competition are now realities in California and the utility is not planning to continue operating the Chino plant.

SCE is divesting its fossil generation facilities. The participants suggested that storage might be able to provide ancillary services if and when the support of the 18,000 MW of fossil generation on the coast is no longer available or is too costly to support utility power grid stability. SCE expects to have a competition transition charge that will allow recovery of stranded asset costs until the year 2002. It expects to have high revenues with only moderate or low profit margins.

SCE believes that the distribution company or its competitor will be able to deliver end-use services. Open access that is scheduled to begin in 1998 will make the competition more aggressive, and SCE expects a significant change in its source of earnings. In 1996 most earnings came from regulated ratepayers; in 2006, earnings from unregulated affiliate business will significantly increase. SCE believes that PQ is becoming of greater interest to large commercial and industrial customers and that storage could play a significant role if the cost comes down. SCE expects that storage could be located at substations to provide PQ service at the bus or at a customer's point of common coupling.

SCE, despite its historical involvement in energy storage, is skeptical that storage system costs will come down far enough to compete with other technologies. However, they are encouraged that the ESS Program is meeting with utilities and manufacturers and being proactive. SCE thinks that storage availability is a desirable option to fully satisfy customer and utility needs in a more flexible T&D system.

The Southern Company
64 Perimeter Center East
Atlanta, GA 30346-6401
(770) 393-0650
September 12, 1996

Meeting Participants:
Kerry Bowers, Manager, End-Use Research
Kamyar Vakhshoorzadeh, Principal Research Engineer, Advanced End-Use Technologies
Jeff Burleson, Manager, Technology Research
Bruce Rauhe, Senior Research Engineer, Advanced End-Use Technologies

Corporate Summary:

The Southern Company is the umbrella organization for five electric utilities in the southeast U.S. and is currently the largest producer of electricity in the country, generating over 146.2 billion kilowatt-hours at its U.S. facilities in 1995. The Southern Company operates more than 30,000 MW of electric generating capacity in the U.S., the most of any electric utility in the country, and worldwide it operates more generating capacity than the entire country of Australia. It is also a leader in environmental research, including electric vehicles, and is a major contractor to the DOE Clean Coal Technology program.

The Southern Company provides energy to a 120,000-square-mile service area stretching from Georgia through the panhandle of Florida to Alabama and Mississippi, a region of the country with a population of about 11 million people. Through its international division, the Southern Company supplies electricity to consumers in Argentina, England, Chile, the Bahamas, and Trinidad and Tobago.

Net income for 1995 was $1.1 billion while revenues were about $9.2 billion on assets of more than $30 billion.

Meeting Results:

The Southern Company has stated that it approves of competition, but does have concern about the industry's transition to competition from its current highly regulated state.

The Southern Company is quite involved with renewable energy sources, including biomass, photovoltaics, and wind, as well as energy storage options, including flywheels. The company hopes that the flywheel, combined in renewable energy systems, will help improve the overall efficiency and availability of the new systems. The Southern Company estimates that early flywheels will be able to store up to 4 hours of useful energy for several days.

Southern's expectations are similar to those of ESS. Within Southern, there are people who operate across the spectrum from regulated to deregulated. While they see potential for energy storage, they believe the multiple benefits of systems are not well understood. PQ, corporate executives agree, is a key application. However, they noted that the spinning-reserve benefits derived from an energy storage system are zero for interconnected utilities with excess generation. The Southern Company believes that the greatest opportunities for storage right now are in third-world countries. Southern is involved in electricity infrastructure projects in several developing nations. Both the ESS and private industry need to demonstrate storage feasibility to architectural and engineering (A&E) companies building in developing countries.

The Southern Company believes that, in the short term, utility investment will become even more conservative. Only the deregulated part of industry will be enthusiastic about new business opportunities. There will be many nontraditional utility entrants into the retail arena.

Southern Company representatives emphasized that energy storage proliferation depends largely on restructuring, the outcome of which is uncertain. This issue is a pivotal one, especially since the industry must understand customer needs when it develops products. Unprofitable customers may suffer as a result of restructuring, but the situation may create a new set of products. The ESS should focus on end-use, premium, on-site systems. In Southern's view, PQ and peak-shaving applications of energy storage systems show the greatest near-term promise.

Allegheny Electric Cooperative (AEC)
212 Locust Street
Post Office Box 1266
Harrisburg, PA 17108-1266
(717) 233-5704
August 21, 1996

Meeting Participants:

Bruce Erickson, Staff Engineer
Steven Giles, Principal Engineer
Craig Frank, Manager of Energy Services and Marketing, Pennsylvania Rural Electric Assoc.

Corporate Summary:

Incorporated in 1946, Allegheny Electric Cooperative, Inc., based in Harrisburg, Pennsylvania, is a generation and transmission (G&T) cooperative that provides wholesale power to 14 co-ops in Pennsylvania and New Jersey. Allegheny acts as a wholesale power supplier for the co-ops. Through them, it serves over 600,000 rural residents.

Allegheny's member cooperatives own and maintain about 12.5 percent of the electric distribution lines in Pennsylvania, covering nearly one-third of the state's land area in 41 counties. These lines represent one of the largest nongovernment investments in rural infrastructure in the country and are an essential component of business and industry.

Today Allegheny gets electricity via hydro power and nuclear power in addition to more traditional means. About 70 percent of the energy Allegheny supplies to its members is nonpolluting, with 220 MW coming from nuclear power, 21 MW from hydro, and 45 MW from the New York Power Authority (NYPA) and other sources.

Meeting Results:

Allegheny is considered a "high-cost wholesale co-op," a situation that company executives want to change. Company representatives indicated that PQ and power management combined in an energy storage system could justify a storage system, especially to serve large industrial customers who are extremely vulnerable to power problems. Officials see an energy storage system as a bridge to a traditional diesel generator backup. Some companies with interruptible service credits have installed on-site generation to ensure service interruptions do not interfere with production. Companies that already have diesel systems could optimize system dispatch with a storage system (reduced fuel costs, lower emissions, etc.) and, what is more important, add PQ to the list of benefits. Diesels alone do not respond quickly enough to give PQ benefits. A diesel/storage hybrid could use the storage for instantaneous PQ response and switch to diesel in long-term outages. Allegheny already offers load management premium incentives for interrupted loads, etc., to customers and especially at locations like an extruded plastics company, where a combination of curtailable service credits and avoided demand charges have allowed distributed generation units to pay for themselves quickly. Paybacks for storage systems may work in a similar fashion.

The nature of Allegheny's contracts with IOUs, from whom it sources power, is such that distributed storage at delivery points of about 500 kWh might allow Allegheny's customers to reduce demand during peak times. Cumulatively, operation of systems could reduce Allegheny's demands on IOUs and reduce monthly charges. Results should be similar to how Crescent EMC uses energy storage.

Allegheny executives expect that the utility industry will change significantly within 5 years. After retail competition comes to Pennsylvania, load management may not have the same value in the resulting restructured market. Allegheny believes that at present co-ops have more ability to react quickly than IOUs. Co-ops have no obligation to public utilities commissions. Co-ops can draw up a proposal, present it to the board, and implement it within 30 days. They are investigating options with which they can respond to changes brought about by Board action, especially ways to take care of traditional customers, the most rural, most inaccessible customers. They are considering storage and they are investigating applications for the written pole motor for PQ. They have been monitoring the technical and economic progress of fuel cells and they are interested in learning more about the status of SMES.

Allegheny is very sensitive to the "hot buttons" of customers and is willing to respond in whatever way necessary. Allegheny gave several examples from Florida, the Northwest, and Georgia to justify this sensitivity from a business perspective. Allegheny is interested in hosting demonstrations of energy storage systems with the ESS Program if a suitable project can be identified.

Allegheny believes storage may be desirable because co-ops have many new customers with limited T&D facilities with delivery points in a range of 500 kW to 4 MW. To Allegheny, small, dispersible technology

makes sense. Allegheny could use a 500-kW/1-hr storage system in a load management role. Allegheny thinks storage must compete with combined cycle generation at $450-600/kW. A payback time of 3-4 years is acceptable. PQ will be customer- and end-use-driven, not utility-driven.

NRECA
4301 Wilson Boulevard
Arlington, VA 22203-1860
(703) 907-5842
September 16, 1996

Meeting Participants:
Martin Gordon, Senior Program Manager, Energy R&D
John Neal, Administrator, Energy R&D

Corporate Summary:

The National Rural Electric Cooperative Association (NRECA) is a not-for-profit partnership of over 1,000 consumer-owned utilities. NRECA is the largest electric utility network in the country, providing power to over 30 million consumers in 46 states, and serving more than 75 percent of the United States.

Glenn English, CEO of NRECA, has identified several areas of concern that electric cooperatives should be focusing on: low density of consumers per mile; lack of balanced commercial and industrial loads; poor load profile; and inherently high costs of serving sparse populations in rough mountainous terrain and wide-open plains. NRECA's Rural Electric Research (RER) Program is designed to find solutions to these issues and bring those solutions to the forefront. NRECA is working to level out service and power quality as well as increase their customer base.

NRECA and electric co-ops in general were among the first to embrace the idea of wholesale competition and transmission access. However, they have urged FERC and other regulatory bodies to allow the effects of wholesale competition to sink in and to be fully evident before rushing into federally mandated retail competition (wheeling). English is quoted as saying, "This is not the time to plunge into an undefined phase of retail competition with uncertain effects on consumers." English does not believe that universal service and total deregulation can coexist.

Meeting Results:

NRECA representatives indicated that 99 percent of the nation's electric cooperatives are members. They pointed out that co-ops have about five customers for each mile of line as contrasted with the 60 customers per mile that IOUs have and the 40 customers per mile that municipal utilities have.

To a large extent, co-ops have limited (or no) engineering staff and depend on contractors. Co-ops fund research through EPRI and NRECA. Eighty percent of the R&D budget goes to EPRI, 20 percent to NRECA. NRECA has an R&D budget of about $4.5 million/year. As a result of the kind of R&D co-ops requested, the highest R&D cost at NRECA is for distribution engineering.

As a national organization of co-ops, NRECA is exceptionally sensitive to the cost of producing, delivering and buying, but has an obligation to provide high-quality power to customers of all types. NRECA is similarly sensitive to the cost of emerging technologies (such as energy storage), and stated that if a *cost-effective* customer-side-of-the-meter storage technology were available, it would be interested. Co-ops would be very interested in storage technologies that improve power quality or reduce demand from outside suppliers during peak time.

At co-ops, the customer is more important than ever. Co-ops are making a transition from serving their traditional customers to attracting industry. One industrial co-op customer has almost all of its production cost in electricity; the new Motorola plant in Virginia will be served by a co-op. These changes and the increasing prevalence of personal computers are making power quality a critical issue. NRECA has new customer service initiatives in power quality, wastewater treatment, security, cable, and telecom as possible future business ventures. Premium power services may be a viable business for co-ops.

NRECA stressed that a co-op *is* the people it serves. Most of the board members are business people who are interested in new opportunities, but some co-ops serve only one or two large loads and need to respond to their needs. This situation may promote co-op interest in certain types of storage, especially since co-ops are more willing to take risks (than IOUs) if the economics are favorable.

NRECA is particularly interested in becoming involved in cost-sharing studies with the DOE that will deal with energy storage options and has asked the ESS to do a presentation at the NRECA RER task force meeting in January 1997.

Co-ops already have a significant number of load-management systems, of which storage systems could easily become a part. In this respect, co-ops have sites for technology demonstrations built into their existing structures. Perhaps one or more of these sites could host a DOE/NRECA cost-shared project to assess cost-effective energy storage for electric membership corporations (EMCs).

Oglethorpe Power Corporation (OPC)
2100 G. Exchange Place
Tucker, GA 30085-1349
(770) 270-7600
September 13, 1996

Meeting Participants:
Nelson Hawk, VP & Group Executive, Marketing
Norris Garmon, Manager, Commercial & Industrial Services
Chuck Ward, Power Quality Engineer

Corporate Summary:

Oglethorpe Power Corporation, an electric G&T co-operative incorporated in 1974, is headquartered in Tucker, Georgia. The corporation provides wholesale electricity on a not-for-profit basis to 39 of Georgia's 42 EMCs. These 39 EMCs have provided reliable and economical service for over 50 years to more than 2.3 million customers living on about two-thirds of Georgia's land area. Oglethorpe is the largest G&T in the United States in terms of operating revenue, assets, kilowatt-hour sales, and consumers served. Oglethorpe's 1995 assets topped $5.4 billion and revenues were $1.1 billion.

Oglethorpe owns close to 125,000 miles of transmission lines comprising the largest distribution network in the state. Oglethorpe supplies 3,338 MW of owned or leased generating capacity and purchases the remainder from other power suppliers.

Meeting Results:

Oglethorpe representatives pointed out that co-ops are more flexible than IOUs (or even municipals who respond to a city council). Because co-ops are regulated by their members, they can do anything that the board accepts. It is easier to adopt new options like storage.

In response to the upcoming utility industry deregulation and transition to a competitive market, Oglethorpe has decided to restructure its products and services into three distinct operating companies. Oglethorpe Power, which will remain a cooperative, will retain the power generation functions; Georgia Transmission Corporation, a new entity, will take over Oglethorpe Power's transmission business; and Georgia System Operations Corporation, a new entity as well, will assume system operations and power dispatch functions. This restructuring is expected to be completed by early 1997. Oglethorpe already competes for new loads of 900 kW or greater.

Oglethorpe representatives felt that new energy service opportunities provide the best opportunities for energy storage technologies. They are already providing real-time pricing and energy audit services.

Meeting participants mentioned their interaction with ESA (Chuck Ward was the ESA President in 1996) and EPRI. The meeting participants expressed interest in interacting with the ESS Program on a more consistent level and are interested in grants for analysis to determine specific storage needs.

Oglethorpe believes that power producers will be increasingly concerned with responding to a broader spectrum of customer needs—for example, by providing one-stop, "brand name" energy services it believes power producers will team up with manufacturers to develop, demonstrate, and market. Presently, Oglethorpe does not provide financial services for new projects but may do so in the future.

Oglethorpe has been trying to provide a wider range of energy services for about 6 years and is interested in pursuing several novel options. At the time of the meeting, Oglethorpe was in the final stages of installing and starting up an AC Battery power quality system at a customer site. The system will provide 1 MW of power for up to 10 seconds. This first commercial installation of the product was partially funded with tailored collaboration from EPRI. Oglethorpe thinks that studies of the cost/benefit ratio for PQ applications would be valuable. Further, Oglethorpe believes that systems must cost less than $1,000/kW to be competitive.

Oglethorpe makes a point of giving credit for new energy services to the member co-op that provides power to the end user. After the AC Battery PQ project, Oglethorpe is interested in investigating PV/storage installations for rural hunting lodges, farms, and homes near the swamps (where a single customer is driving the need for an entire line). PV/storage could also work well for irrigation systems that have small motors to drive the rotary arm or for lighting/cooling in chicken houses (where there is a lot of roof area). Oglethorpe is investigating the written pole motor and fuel cells. NRECA has a 200-kW phosphoric fuel cell on loan from DOE at Seminole for 1 year that is of interest. Oglethorpe believes that renewables show promise, but their market price is currently too high.

Oglethorpe is currently finding it challenging to fund R&D projects. Oglethorpe is a member of the fuel cell commercialization group (molten carbonate), the

Utility Photovoltaic Group (UPVG), and ESA. Oglethorpe is interested in active participation in the ESS Industry Users Group.

Oglethorpe expressed concern that small companies that develop new technologies may not be able to effectively manufacture low-cost products.

Salt River Project (SRP)
P.O. Box 52025
Phoenix, AZ 85072-2025
(602) 236-5900
August 6, 1996

Meeting Participants:

Ernie Palomino, Principal Engineer, R&D
Dave Slick, Manager, Resource Analysis
Jan Miller, Manager, R&D
Gary DeShezo

Corporate Summary:

Serving more than one million electric customers, the Salt River Project (SRP) was designed as a major multipurpose project supporting the Salt River Valley. The largest water supplier in Arizona, SRP, through the Theodore Roosevelt Dam, also supplies water for domestic and agricultural use to about 400,000 customers within a 375-square-mile area. Revenue from electricity resales this year was $102 million, about 8 percent of electric operating revenues.

Construction began this year on the Mead-Phoenix Project, which will interconnect the greater Phoenix area with southern Nevada. SRP is project manager and 19-percent owner of the Mead-Phoenix, but the $275 million project is cost-shared between SRP, the Western Area Power Authority, and 12 other utilities and municipalities.

As a leader in the regional transmission group field, SRP moved aggressively with the Southwest Regional Transmission Association (SWRTA), one of the first groups of its kind, to link public power utilities, IOUs, and power marketers. SWRTA's mission is to focus on the rules for access and on planning, coordination, dispute resolution, and pricing principles.

SRP is currently weighing the prospects of both wholesale and retail competition within the electric utility industry. SRP's stated goal is to promote the interests of their electric customers and investors.

Meeting Results:

In response to customers' concerns about power quality, SRP is involved in flywheel R&D with Arizona State University as well as distributed utility generator studies for T&D effects. SRP is focusing on a transportable battery energy storage system (BESS) that is being developed with EPRI. The transportability of the system is not as important to SRP as its ability to provide either power quality or power management functions. Power quality is the issue that has the attention and concern of end users, so it is the primary issue for SRP. There is certainly an interest in flywheels, but cost remains a large barrier to acceptance.

Representatives from SRP mentioned that most of their capital investment is going into distribution systems and that there are currently no plans to add generation capacity. SRP communicated a general willingness to work with energy storage options if the costs were lower.

Corporate representatives from SRP stated their need for technology assessment tools that compare the current and near-term attributes of technologies. Such tools would allow SRP to choose technology options that are appropriate to their existing and projected needs. Right now, engineers at SRP believe that a storage system with an output voltage of 15 kV would be an appropriate next step from the systems that presently output 480 V. Such growth, though, requires upgrades, and SRP's willingness to invest in upgrading their system is undetermined. Robust technology assessment tools could help SRP determine the threshold at which upgrades would be possible.

GNB
829 Parkview Boulevard
Lombard, IL 60148-3249
(630) 629-5200
May 1, 1996

Meeting Participants:
Bob Maresca, VP, Power Control Business Unit
George Hunt, Director, New Business Development

Corporate Summary:

GNB, whose parent company is Pacific Dunlop Limited, based in Melbourne, Australia, is one of the world's largest manufacturers and recyclers of lead-acid batteries. GNB Technologies has plants in North America, Australia, and New Zealand and manufactures, distributes, and recycles lead-acid batteries for industrial, automotive, heavy duty and specialty applications all over the world.

GNB Technologies, based in Atlanta, Georgia, has revenues of about $1 billion, about 20 percent of Pacific Dunlop's total revenues for 1995. GNB has been building batteries for over 100 years and is closely connected with Ford Motor Company, supplying batteries to their automotive, truck, and tractor division; the U.S. Navy, supplying power to their submarines; and the U.S. Air Force, supplying batteries to the Peacekeeper missile silos.

GNB has formed a relationship with General Electric (GE) for several BESS projects and has attended meetings of the ESA since its inception.

Meeting Results:

GNB and GE collaborated to install and operate a BESS in GNB's lead-smelting facility in Vernon, California. The system provides backup power to the smelter's environmental control systems, reduces peak demand, and improves power quality. The GNB/GE team is also installing a BESS for Metlakatla power in Alaska to provide peaking support, spinning reserve, and frequency control.

GNB believes that demand for quality power in a deregulated utility environment and competition within the industry will drive battery storage demand.

A participant in the meeting commented that utilities are interested in energy storage, but no one wants to be the first to invest heavily in such new technology. Decision-makers consider the cost of storage, but are not looking at the return on investment potential; they are asking about $/kW but neglect to add value into the equation. GNB believes that the utilities' approach to decision-making will eventually evolve into a market-oriented approach. However, GNB voiced serious concerns as to whether utilities would achieve that transformation quickly enough for battery energy storage to get a real foothold in a utility market.

Battery manufacturers, because they have large, stable, existing markets for their products, may not persist in developing utility storage systems if the market emerges too slowly.

Superconductivity Incorporated (SI)
2114 Eagle Drive
Middleton, WI 53562-2550
(608) 831-5773
May 2, 1996

Meeting Participants:

Paul Koeppe, President & CEO
Michael Gravely, EVP, Marketing & Business Development
Warren Buckles, Director, Engineering

Corporate Summary:

SI is a leading company applying superconducting technology to electric power systems for improved power quality. It is also a leading producer of low-temperature superconducting magnets that provide megajoules of energy in a fraction of a second.

SI manufactures micro-superconducting magnetic energy system (micro-SMES) products that protect sensitive power electronics equipment by sensing momentary incoming electrical power disruptions or voltage sags and instantly providing supplemental power. Once the utility's electrical power has been stabilized and returns to normal, the micro-SMES returns the equipment to the utility power source.

Meeting Results:

SI has worked with other DOE programs, namely Superconductivity, and is no longer working with Argonne National Laboratory; however, it does have several commercial products available for sale and lease. Military establishments are prime customers; for example, Tinker Air Force Base uses a hybrid storage system that contains SMES and batteries that share an inverter.

SI is successfully addressing magnetic field requirements of the U.S. Food and Drug Administration (FDA). The most widely used SI product is a 1-MJ SMES contained in a trailer with an inverter and appropriate cryocooler equipment. The initial product mitigated the effects of voltage fluctuation (for up to 1 second), while the newest SI product provides the same voltage protection as well as power factor correction and harmonics cancellation. The new system contains a modular inverter the cost of which is one-third that of the previous unit's inverter and is 6 to 8 percent more efficient.

SI is also distributing a product called PQ30, a battery-based system as opposed to a SMES-based system. The system offers 10 to 1,000 kVA for 30 seconds. SI is hoping to replace the batteries with a lower-cost SMES device within 5 years.

SI formed a partnership with the South African utility ESKOM. ESKOM is purchasing units and providing marketing services for the product.

SI is continuing to work with the U.S. Air Force and U.S. Department of Defense (DoD) on future military and government applications. SI expressed continued interest in DOE's continuing participation in long-term R&D.

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