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Battery Energy Storage Market Feasibility Study

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Prepared by
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Battery Energy Storage Market Feasibility Study

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Abstract

Under the sponsorship of the Department of Energy's Office of Utility Technologies, the Energy Storage Systems Analysis and Development Department at Sandia National Laboratories (SNL) contracted Frost& Sullivan to conduct a market feasibility study of . energy storage systems. The study was designed specifically to quantify the energy storage market for utility applications. This study was based on the SNL Opportunities Analysis performed earlier. Many of groups surveyed, which included electricity providers, battery energy storage vendors, regulators, consultants, and technology advocates, viewed energy storage as an important enabling technology to enable increased use of renewable energy and as a means to solve power quality and asset utilization issues. There are two versions of the document available, an expanded version (approximately 200 pages, SAND97-1275/2) and a short version (approximately 25 pages, SAND97-1275/1).

Acknowledgments

Sandia National Laboratories would like to acknowledge and thank the U.S. Department of Energy's Office of Utility Technologies for their support and funding for this work, and all of the contributing utilities, electricity providers, product suppliers, regulators, industry advocates, and professional and academic associations who responded to the survey.

The principal investigator on this study was Steve Kraft from Frost& Sullivan. The Frost& Sullivan team included David Coleman and Ken Herbert.

We also wish to thank the following individuals for participating in a review panel that provided valuable technical comment before the final study was published.

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Acronyms and Abbreviations

BES	battery energy storage
CAES	compressed-air energy storage
DOE	U.S. Department of Energy
ESA	Energy Storage Association
ESS	Energy Storage Systems
IOU	investor-owned utility
IPP	independent power producer
NUG	nonutility generator
R&D	research and development
RFP	request for proposal
SMES	superconducting magnetic energy storage
SNL	Sandia National Laboratories
T&D	transmission and distribution
UPs	uninterruptible power supply
VAR	volt-amp reactive

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Project Overview

Battery energy storage (BES) consists of modem battery and electronics technologies. BES is now being applied to the needs of the electric power industry. In these applications, BES can be used to increase system reliability, improve power quality, defer capital investments, and improve the economics of power generation and energy consumption. Currently, the BES market is in a developmental stage, as are some of the battery and power conditioning subsystems integrated into BES systems.

Sandia National Laboratories (SNL) and the U.S. Department of Energy (DOE) are both developing BES technology and encouraging its commercialization. This study is a part of those development and commercialization efforts.

To better orient BES development and commercialization efforts to the needs of the BES marketplace, SNL began developing the request for proposal (RFP) for this study in 1995, coordinating RFP development with the Energy Storage Association (ESA). Release of the RFP to the public occurred in Fall 1995.

Among the bidders on the RFP distribution list was Frost & Sullivan, a market research and consulting company. In March 1996, Frost & Sullivan was officially retained by SNL to conduct this study, with research commencing in May 1996.

Goals of Study

SNL had three principal goals in conducting this study. The first was to gather BES industry perceptions, especially among utilities and nonutility generators (NUGs), referred to in this report as "electricity providers." Additional perspectives were also gathered from BES suppliers and suppliers of BES components, utility regulatory agencies, and electric power industry trade and advocacy groups. The perceptions gathered were to include information on desired product features, comparisons of BES with other electricity storage and supply options, and many more qualitative topics. The qualitative findings provide the most interesting results of this study.

The second major goal of this study was to generate an estimate of the electricity provider BES market through 2010. Specifically, this forecast was to include estimates of BES market activity for the years 2000, 2005, and 2010. These forecasts were derived from information gathered from the electricity provider sample and are year-on estimates (as opposed to cumulative) for 2000, 2005, and 2010 only. Therefore, these estimates do not measure any market activity occurring in years other than 2000, 2005, and 2010.

The third major goal was to provide SNL and the DOE with valuable input into its Energy Storage Systems (ESS) program efforts. The ESS Program strives to improve its market and customer orientation, and the results of this study were expected to be of significant aid in that direction.

Study Parameters

This study was limited to the estimation of the BES market at the electricity provider level. Because of resource limitations, a more thorough research of the BES market among end users of electric power, such as large industrial and commercial customers, was not undertaken.

End-user estimates are included in the study, but these are based on BES supplier organizations' perceptions. A market study of BES demand at the electricity end-user level may be undertaken in the future, and such a study is recommended to SNL later in this report.

The study forecast period is another important parameter. The decision was made during the writing of the RFP that this study should provide BES market estimates through 2010. This would give SNL and the rest of the BES industry a chance to review forecasts in time to develop the technologies, organizations, and infrastructure needed to serve and improve forecast future BES demand. The RFP for this study requested year-on BES market estimates, not cumulative estimates.

An additional parameter was the number of interviews that could be completed using allocated resources. For this study, 60 to 80 interviews with member organizations within the BES community *were expected,* and *68 were* completed.

Geographically, this study was limited to the U.S. BES market. All of the organizations contacted for this study were asked about their activities in the U.S. market. Their operations outside of the United States are excluded. The market penetration estimates given later in this study include only activity in the United States and its territories, such as Puerto Rico. They do not include any figures for BES export from the United States to foreign markets.

Selection of Respondents

SNL and Frost & Sullivan decided through mutual consultation on the organizations to be contacted for this study. As stated earlier, these organizations included utilities, NUGs, BES suppliers, regulatory agencies, and other organizations whose actions influence the BES market. Table 1 shows the breakdown of the 68 organizations that were ultimately contacted. More specific information on the organizations included can be found in a later chapter of this report.

Table 2 shows the individuals contacted at electricity provider companies for this study by job title and type of electricity provider. Table 2 shows that the electricity provider sample is relatively "engineering-heavy." This is partly due to the nature of the interviewing process. Many of the electricity providers interviewed had existing contacts with SNL or the ESA, and these people provided the initial point of contact for Frost & Sullivan in its research efforts. Because BES is a developing technology, and SNL is a research and development organization, most of these existing contacts tended to fit into technical vocations such as engineering.

Efforts were also made during the study to draw input from other departments within the electricity provider organizations. These contacts account for the number of planning and marketing personnel in the sample.

Surveying Process

Frost & Sullivan relies on primary research to gather the data for its reports. The BES study was no exception. This report was based on information gained from primary research contacts made during the surveying process or in other activities related to the production of the report. Secondary research of preexisting information sources provided little more than answers to technical questions related to BES and battery technologies.

Table 1. BES Market: Organizations Contacted By Type (U.S.), 1996

Organization Type	Number Contacted
Electricity Providera	38
Investor-owned Utilities (IOUs)	24
Independent Power Producers (IPPs)	5
Municipals	2
Cooperatives	3
Federal, State, or District Utilities	4
BES Suppliers	11
BES Consultants	7
Regulatory Bodies	6
Electric Power Industry Groups	6
TOTAL	106

Table 2. BES Market: Individuals Contacted by Utility Type and Job Title (U.S.), 1996

Utility	Job Title	Number Contacted
IOUs:	Chemist	(1)
	Engineer	(5)
	Engineer (Manager)	(1)
	Engineer (Senior)	(5)
	Engineer (Senior Research)	(2)
	Integrated Resource Planner	(3)
	Manager of Advanced Market Development	(1)
	Manager of Conservation	(1)
	Power Quality	(1)
	Product Development Manager	(2)
	Technical Analyst Coordinator	(2)
Municipal Utilities:	General Manager	(1)
	Mechanical Engineering	(1)
Electric Cooperatives	Assistant Manager	(1)
	Engineer	(1)
	Engineer (Planning)	(1)
Federal, State, and District Utilities:	Assistant Head, Planning and Research Division	(1)
	Engineer (Principal)	(1)
	Manager of Electric Transportation	(1)
	Project Specialist	(1)
IPPs:	Director of Technology Research and Development	(1)
	Manager of Power Systems	(1)
	Project Marketing Manager	(1)
	Vice President	(1)
Power Marketer and IPP:	Development Director	(1)

Specifically, the surveying process for the study entailed Frost & Sullivan analysts contacting organizations that had been placed on the contact list on the basis of consultations with SNL and the ESA. In the case of most of these companies, an initial individual contact had been identified based on that individual's past involvement with BES or with SNL.

Once contacted, these individuals were apprised of the nature of this study and asked who at their organization would be best able to provide a response that could be used in the preparation of this report. In many cases, the initial contact provided a response, but, in other cases, the contact referred the research team to another contact or group of contacts. This process continued until a viable respondent was reached at each organization.

At this time, the respondent was faxed the proper questionnaire or interviewed over the telephone. Three basic questionnaires were developed, aimed at three distinct groups within the BES industry: BES suppliers and consultants, electricity providers, and regulatory bodies and industry groups. The questionnaires were developed by Frost& Sullivan in conjunction with SNL.

Writing and Analysis

Upon receipt of the interview results, transcription of the results was performed if necessary. After transcription, the results were collated and analyzed by Frost & Sullivan analysts. At that point, the writing of the report began.

Assumptions and Risk Assessment

All market research or forecast studies contain some form of assumption, whether implicit or explicit. Because these assumptions can have a dramatic effect on the outcome of a study, they should be communicated to the reading audience if possible.

Additionally, assumptions are affected by factors that are difficult or impossible to predict. In this report, these factors are referred to as "risk assessment" items. This section of the report describes both the assumptions and the risk assessment items for this study.

Economic Assumptions

The three principal economic assumptions used in this study are normal economic cycles will continue, normal load growth patterns will apply, and per-kilowatt BES costs will continue decreasing.

Frost & Sullivan defines normal economic cycles as periods of economic expansion punctuated by occasional recessions or periods of stagnation. This is the historical pattern of the U.S. economy over the last 50 years, with expansions lasting 3 or more years and recessions lasting 18 or fewer months.

The second major assumption is the continuation of historical levels of load growth. In times of expansion, load growth is roughly 1.5% per year. If this number were to increase or decrease significantly, a corresponding effect on the need for BES would occur.

Decreasing per-kilowatt BES costs constitute the last major assumption of this report. This assumption is found in the parameters Frost & Sullivan used to frame the questions asked in the electricity provider questionnaire. (This questionnaire is included as Appendix A in an expanded version of this report.) In short, Frost & Sullivan and SNL expect the per-kilowatt price of BES to decrease in constant 1996 dollars from between $700 and $1,100 in 2000 to between $400 and $600 in 2010.

Not every organization in the BES industry agrees with this assumption. However, during the course of the study, Frost & Sullivan found evidence that price reductions of this magnitude are already under way.

Deregulation of the Electric Power Industry

The biggest variable affecting the electric power industry in the United States is the advent of deregulation. Currently, deregulation is occurring in isolated states with high electric costs. Even though some of these states are very large, most of the U.S. electricity market is still regulated.

This may change rapidly. Not only are individual states in the United States examining deregulation, but national deregulation bills have been introduced in the U.S. Congress. If pending national legislation were passed, the entire U.S. electric power market would be deregulated by 2003.

The effects of deregulation depend on my variables, including the recovery of stranded costs and the success the current group of electricity providers has in making the transition into a deregulated environment. The outcome of these issues should influence the BES market in the new deregulated environment.

Frost & Sullivan received much conflicting information on the specific effects of deregulation on the BES market. Some respondents said that deregulation would force expensive BES systems out of the market. Others stated that a greater appreciation for customer service and storage-based economic opportunities would enhance BES's attractiveness.

Network Reliability

Another impact of deregulation has been the concern over the reliability of the transmission and distribution grid in the United States., Two serious disruptions of the western grid in the summer and fall of 1996 caused significant economic side effects and raised some public safety concerns. Fortunately, the worst of these disruptions happened on a weekend, which reduced the potential losses and associated risks.

If disruptions continue or increase, more pressure will likely be placed on electricity end users and providers to implement technologies to improve power quality. In such a case, BES demand will likely increase to meet power quality needs.

Electricity End-User Markets

As previously stated, electricity end-user markets were not included in this study. Despite this exclusion, BES suppliers view electricity end users as their major existing market. To reflect this, Frost & Sullivan incorporated BES supplier estimates of the end-user market into the market penetration estimates found in the Market Opportunities and Forecasts section of this report.

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Summary of Major Findings

Perceptions of BES

The perceptions of the present and future roles for BES differ significantly depending on the group or organization. This section covers the various perspectives provided by the three distinct BES industry groups surveyed for this study: electricity providers, BES suppliers and consultants, and industry groups and regulators.

Electricity Provider Perspective

The electricity providers' perspective can be best categorized as cautiously optimistic. On the whole, electricity providers see roles for BES, especially in distributed generation and power quality, but they expressed significant concerns about BES costs, life span, maintenance, and energy density.

In the future, electricity providers expect to increase their use of BES, but they would like to see the shortcomings of the technology addressed and believe this is necessary before widespread deployment of BES becomes possible. As a result of concerns about the technology's shortcomings, BES is not currently viewed as competitive with most generation technologies. In particular, electricity providers expect combustion turbines to provide better functionality over time than BES. Interest in fuel cells was high, and batteries received considerable support because of their modularity, responsiveness, and especially their environmental friendliness.

BES fares favorably when compared with most planned and existing storage technologies, although it is not viewed by the sample as a central station technology. Central station storage technologies, such as pumped hydro and compressed-air energy storage (CAES), were viewed as too environmentally destructive or too geographically limited. However, respondents with existing pumped hydro units do not see BES replacing those units. Also, some electricity providers viewed their current amount of storage as adequate because of their existing pumped hydro resources.

Compared with advanced storage technologies, BES is viewed favorably as well. BES has a greater storage capacity in terms of hours of storage than superconducting magnetic energy storage (SMES) or flywheels. SMES and flywheels are also less developed than BES, making potential customers more hesitant to support these technologies. Some electricity providers in the sample, however, viewed flywheels as a lower-cost option over the long term.

During the survey process, respondents were questioned four times on the potential applications for which they might use BES. Table 3 and Figure 1 illustrate some of the responses to this question. The responses are arranged alphabetically in the figure, but an examination of the chart shows that power quality and reliability were the most commonly cited applications for BES.

Additionally, electricity providers were asked about the use of BES to provide the ancillary services necessary to maintain power system reliability on an ongoing basis. However, no significant responses were received on this subject. Deregulation appears not to have advanced enough to create more than an academic interest in the provision of ancillary services. Furthermore, a few respondents seemed to feel that the provision of these services has never been a problem in the past and is unlikely to become so in the future.

The final issue addressed was that of organizational structure and BES procurement. Respondents were asked which departments within their organizations were responsible for BES procurement. The results are as follows:

. Investor-Owned Utilities (IOUs):
- Generation
- Energy Supply Planning
- Financial Studies
- Fossil Generation
- Fossil/Hydro
- Integrated Resource Planning
Mechanical Engineering
Power Supply Planning
Research and Development (R&D)
Transmission and Distribution
- Customer Services
- Distribution Engineering
Energy Services Company (ESCO)
(for pertinent IOU)
- Engineering
Grid Customer Services

Table 3. Applications Identified by Electricity Providers (30 Companies), 1996

Application	Times Application Mentioned
Area/Frequency Control	3
Black Start	1
Customer Demand Peak Reduction	5
Distribution Facility Deferral	6
Emergency Shutdown Power	1
Frequency Control	1
Frequency Regulation	2
Generation Capacity Deferral	5
Generation Dispatching	4
Load Conditioning	1
Load Following	1
Load Leveling	10
Out of Step Prevention	1
Peak Reduction	2
Power Quality	14
Reliability	12
Renewable	5
Spinning Reserve	8
Transmission Facility Deferral	5
Transmission Line Stability	2
Transmission Stability Enhancement	2
Transmission Volt-Amp Reactive (VAR) support	2
Uninterruptible Power Supply (UPS)	10
Voltage Regulation	7

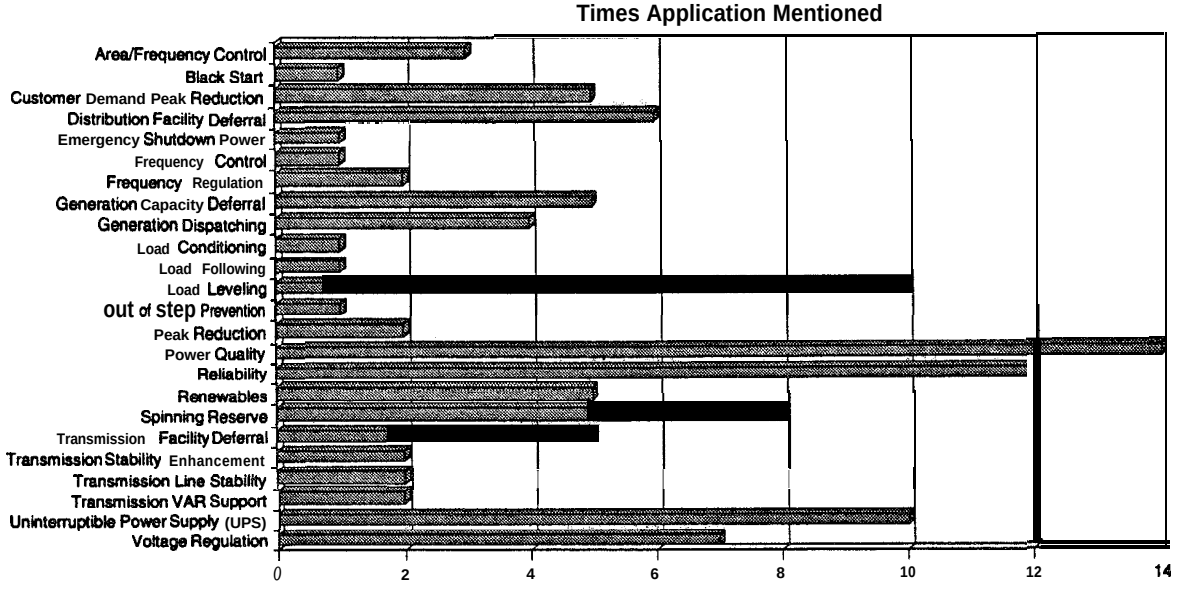

Figure 1. Applications Identified by Elecricity Providers (30 Companies), 19%.

- Marketing Commercial/Industrial Departments
- Substation Engineering
- Technical and Construction Services
- Transmission and Distribution (T&D)
- Transmission Engineering

. Municipal Utilities:
- Board of Directors
- Bulk Power Business Unit
- City Council
- Generation Business Unit

. Electric Cooperatives:
- Board of Directors
- Engineering
- General Management
- Production

. Federal, State, and District Utilities:
- Distribution Planning
- – Operations and Finance Senior Executives
- – Planning
- – Planning and Research Division
- Power Operations
- Power Quality
- R&D

Transmission and Power Supply

. Independent Power Producers (IPPs):
- Executive Department
- Contracts Department

• Power Marketer and IPP:
- Development Department
- Engineering Department

Respondents were also asked how deregulation of their utility might affect departmental responsibilities for BES procurement. Responses indicated much interest in deregulation as an economic event but showed little appreciation or awareness of possible organizational changes that might result.

BES Supplier Perspective

In addition to electricity providers, BES suppliers and consultants working in the BES industry were contacted to obtain their views on the BES market. In particular, they were questioned on their view of existing BES projects and which markets they serve.

Currently, BES products in the marketplace are based on either flooded lead-acid or valve-regulated lead-acid battery technologies. In the near future, through 2000, most BES suppliers do not expect to move to different battery technologies, although they expect to further refine their power conversion technologies.

Also, no true BES integrators currently exist in the marketplace. This is a disadvantage because it places more pressure on BES customers to obtain the integration services they need or perform them in-house. Few BES suppliers contacted in this study believed they would make the transition to full-service integrator by 2000. Instead, most companies viewed themselves as suppliers of components or developers of BES technologies.

The competitive structure of the BES industry is fairly rigid. Most of the BES suppliers contacted were divisions, subsidiaries, or business units of large battery and electrotechnology manufacturers. As such, these organizations have a great deal of potential resources behind them although they do not operate in a core business of their parent organization.

The remaining small, independent companies are technology developers, not BES suppliers. These companies are not marketing organizations and do not maintain extensive contacts with potential BES customers.

Supplier and consultant perceptions of the BES market were mixed. Depending on the organization contacted, perceptions of the market varied from fairly positive to very negative. Patterns were difficult to detect, although BES manufacturers were more positive about the industry than most consulting organizations.

Perceptions of BES technology also varied widely between those that felt that existing BES technology was adequate and those that felt it was inadequate. As expected, those that supported existing BES technology tended to be organizations that were not aggressively developing advanced batteries and power conditioning equipment. Most respondents agreed that further advances in power conditioning and utility connection equipment could be made.

BES suppliers and consultants also provided Frost& Sullivan with their estimates of the BES market in 2000, 2005, and 2010. These estimates are discussed in more detail in the Market Opportunities and Forecasts section of this report.

Other Industry Perspectives

Regulatory agencies and industry groups provided the other industry perspectives in this study. Input from both types of organizations provides important supporting information to the conclusions reached in this study.

The responses received from regulatory agencies indicate that they do not have an established position on BES. Regulatory agencies receive little information or feedback from utilities, BES suppliers, or other organizations and do not view BES as a major issue. When they do receive information, it is primarily about combustion turbine and renewable technologies.

Moreover, the regulatory agencies stated that as the power industry deregulates, they will likely stop supporting BES technology to the extent that they have in the past. They will probably hesitate in the future to encourage utilities to deploy specific technologies and participate in particular programs. Instead, market-based solutions focusing on economic costs and benefits will likely prevail, and the prospects of regulatory agencies using their influence to champion BES deployment are minimal.

The other industry groups that Frost & Sullivan contacted during this study were various organizations with an interest in the electric power industry and the use of BES. Examples of such organizations are the National Rural Electric Cooperative Association, the Environmental Defense Fund, and the National Association of Utility Regulatory Commissioners. These industry groups had more specific perceptions of BES than the regulatory agencies.

Many of the groups viewed BES as an important enabling technology to facilitate the use of renewable energy or to deal with power quality and asset utilization issues. These groups tended to be more focused on BES and maintained personnel that attempted to keep track of developments in BES markets and technologies.

BES Market Opportunities and Forecasts

BES Market Definitions

As stated earlier, this report was restricted to a study of the U.S. market for BES. For purposes of this study, the U.S. market consists of the 50 states and Puerto Rico. In addition, this is a study of the BES market among electricity providers, with information on electricity end-user BES markets provided by BES suppliers and consultants.

In all, 21 electricity providers returned enough information for Frost & Sullivan to use their responses in estimating BES market penetration and activity in 2000, 2005, and 2010. These 21 electricity providers represent between 27 and 33 percent of the U.S. electric power industry's 1994 capacity in terms of megawatt-hours sold, megawatt-hours generated, revenues from electricity sales, and generating capacity. Thus, even though the number of utilities may seem small compared to the industry as a whole, these companies make up a large proportion of the U.S. electric power industry.

The responses from the 21 utilities were compiled and extrapolated to the U.S. industry as a whole. The extrapolation used a formula based on the percentages of industry output and capacity. These results were then deflated to counteract the natural tendency of respondents to exaggerate future behavior. Such exaggeration has been encountered by Frost & Sullivan in the past and is especially prevalent in studies such as this, with long forecast periods.

A similar extrapolation method was used to compile the electricity end-user BES demand estimates that Frost & Sullivan received from BES suppliers and consultants. These figures are presented with the electricity provider estimates (Tables 4 and 5) to give a clearer picture of the entire BES market in a given year.

BES Market Penetration Estimates

Table 4 shows the estimated penetration of BES in the electricity provider industry. Sales are projected to climb from about $24 million in 2000 to about $287 million in 2010.

Table 5 shows the estimated penetration of BES for electricity end users. These results are based on projections given to Frost & Sullivan by BES suppliers. BES revenues in this segment are forecast to be about $372 million in 20Q0 and about $434 million in 2010.

Table 4. BES Market Statistics Among Electricity Providers (U.S.), 2000,2005, and 2010

Year	MW	($ Million)
2000	27	24
2005	215	129
2010	573	287

Note: All figures are rounded.

Table 5. BES Market Statistics Among Electricity End Users (U.S.), 2000,2005, and 2010

Year	MW	($ Million)
2000	496	372
2005	605	443
2010	965	434

Note All figures are rounded.

Primary Market Drivers

The principal drivers of the growth anticipated in BES market penetration among electricity providers and end users include the following:

- Power quality
- Distributed generation
- Technological advances in BES
- Improving customer focus of electricity providers
- Environmental benefits of BES
- Fuel supply issues
- Increasing use of renewable

Power quality was already identified by respondents as the major application for BES. This application will probably become even more important as electronics are increasingly used in businesses and global competition places a greater emphasis on avoiding downtime. BES is already used in this application in the form of existing uninterruptible power supply (UPS) systems and serial power systems.

Distributed generation is another driver of the BES market. BES's modularity makes it more appropriate for deployment in distributed sites. Although not many distributed generation projects are currently being conducted, the number of these projects should increase in the future.

Respondents expect technological advances to occur in BES. Addressing some or all of the technology's current shortcomings should make BES more attractive compared to other options.

Currently, most electricity providers function in a regulated monopoly environment in which customers are allotted by geographic location. This is different from the future deregulated environment where electricity providers will probably have to be more customer-focused to survive. This customer focus should include efforts to address local power quality and reliability issues, areas in which BES can serve a constructive role.

BES is a technology that does not produce noise or harmful emissions. It can be used in settings and environments where current generation technologies would be difficult or impossible to site. Electricity

providers cited these benefits as some of the major advantages of BES.

Another advantage of BES cited by electricity providers is the elimination of fuel supply issues associated with generation technologies. This is because BES, by definition, does not require fuel.

Growth in the use of renewable energy should also drive the BES market. BES can be used in conjunction with renewable energy sources to "firm" electric power delivery from these sources. For example, BES could store power generated from solar generation to maintain a constant power output even at night.

Conclusions and Recommendations

Conclusions

Frost & Sullivan has based the following conclusions on the responses obtained from organizations and individuals interviewed for this study and from interactions with the BES community related to this study.

BES Cost Reductions Desired

The first and foremost conclusion of this study is that an overwhelming consensus exists among the electricity providers surveyed that significant reductions in BES cost profiles are needed.

In particular, issues pertaining to the capital cost of BES are considered paramount. Currently available per-kilowatt BES costs run two to three times the per-kilowatt cost of combustion turbines. Although the two technologies are not directly comparable, they are similar enough in the minds of electricity providers that the disparity in cost reduces market interest in deploying BES systems.

Maintenance costs are also of interest to electricity providers. These costs include not only the actual costs of maintaining a BES system but the perceived costs as well. These perceived costs can best be thought of as the "headaches" that respondents expect from a BES system. For example, several electricity providers said in their responses that even though the organizations had no direct experience with BES, they had heard that the maintenance issues associated with maintaining the batteries in a BES system made the cost prohibitive.

As stated earlier, significant BES cost reductions are one of the assumptions of this study. Although a large proportion of the BES supplier community does not share SNL's expectation that these cost reductions can be realistically delivered, evidence uncovered in the study indicates that significant downward pressure on BES prices has already begun.

BES Performance Improvements Desired

The results of the survey also show that electricity providers desire improvements in BES energy density, maintenance characteristics, and life span.

These technical issues are secondary to BES cost issues, although they are important in their own right. Energy density affects capital cost and the use of BES in some applications and sites. Maintenance issues center on improvements in BES battery technology. To better offset high capital costs and be more competitive with other distributed generation technologies, current expected BES life spans of 6 to 10 yr must be improved.

BES Market Targeting and Segmentation

Results of this study indicate that potential BES markets are not currently targeted or segmented. This affects both product and technology development. The BES industry seems to be trying to develop BES markets across a wide range of applications even though markets may not actually exist.

The area of ancillary services demonstrates this dynamic. Responses to queries about the need for BES in ancillary services indicate that the electricity provider sample views ancillary services neither as an area of concern nor as a potential market for BES. Almost no feedback was received from electricity providers on ancillary services, even when they were directly questioned on the subject. Despite this, the BES community is expending considerable intellectual energy on this area.

Despite the lack of responses, it cannot be assumed that utilities have not given any thought to the ancillary services issue. This is especially true given that many of the electricity providers surveyed are industry leaders within the U.S. electric power industry. As such, their opinions on this subject are likely based on sound data and cannot be dismissed.

On the product side, the lack of targeting spreads BES marketing efforts thinly over a broad array of

applications and prevents BES from better penetrating applications where it has been more successful. The only truly targeted product available in the BES market is AC Battery's PQ2000 system, designed to provide cheap, short-term, backup power to ride customers through a 10- to 15-second outage. Other products still suffer from trying to be all things to all people, therefore pleasing nobody.

BES Educational Efforts

Despite the fact that this study concentrated on electricity providers, organizations, and individuals with past involvement in BES projects or forums, the survey of the BES-related educational level of the organizations revealed that respondents were not entirely knowledgeable on recent developments in BES.

An example of the level of education is shown by the high number of individuals that mentioned load leveling as a BES application in Table 3. Studies conducted over the past several years have shown that load leveling is a marginal BES application at best. clearly, educational efforts within the BES community must be enhanced.

Bias Toward Generation Technologies

A significant bias toward generation technologies was also found within the electricity provider industry. Often, respondents made comments that equated BES to generation technologies, usually leading to negative perceptions of BES compared to these technologies. In reality, BES is not a generation technology but a complementary storage technology. This bias toward generation technology is largely an educational issue. However, other dynamics are at work.

Electricity providers were questioned on what their preferred electricity supply options might be in the future and what would happen if BES were to match the cost of these preferred options. Even in this situation, some respondents stated that they would continue to favor more "familiar" options over BES. However, other respondents expressed a dramatically heightened interest in BES under such circumstances.

Organizational Obstacles to BES Procurement

The organizational structures of both electricity providers and BES suppliers create some barriers to BES market penetration.

On the utility side, the need to coordinate and fund BES purchases among disparate customer service, transmission, distribution, generation, and engineering business functions creates serious problems for BES manufacturers and technology developers. Developers and suppliers must identify and contact key decision makers and then develop and maintain relations over the sales or development cycle. These are extremely difficult tasks given the opaque nature of many utility organizations.

On the BES supplier side, the existing group of suppliers is largely made up of large battery and electrotechnology companies that receive a minute portion of their revenues from the BES market. The BES units of these companies compete for resources with other company units that are more related to the core business of those firms. This makes large BES development expenditures difficult to justify and leads to a situation in which BES suppliers try to make existing products and technologies fit the new BES market, often without success.

Communications in the BES Industry

The results of this study indicate that communications within the BES industry are inadequate on several levels. Specifically, the low level of BES knowledge and education exhibited in many of the responses gathered during this study shows that educational communications within the BES community need to be improved.

Also, significant impediments to clear and understandable communication between BES suppliers and developers and electricity providers exist. This is probably more important than the educational issue because it significantly affects the fundamental way in which many industry parties relate to and perceive each other. These communications difficulties may be hindering the proper development of the BES market.

Need for More BES Innovation

The BES industry suffers from a lack of innovation in terms of products, marketing, communications, educational efforts, and technology. Results of this study show that marketing and product development efforts need to be more tightly focused; educational and communications efforts need to be expanded and improved; and new technologies need to be developed, especially on the battery side of the industry.

Some BES projects have been successful. The Puerto Rico Electric Power Authority (PREPA) system is foremost among them. The PREPA system was actually chosen over combustion turbines, which seem to be the greatest threat to BES's success. However, even in the PREPA case, the utility itself had to perform the project integration, using equipment from several manufacturers, including some that will not offer those products in the future.

The result is a successful system, but one that no BES supplier is likely to provide to customers. Because nobody but PREPA has "ownership" of the product in use at PREPA, no organization is marketing it. This is the case even though the PREPA frequency regulation/spinning-reserve application is one that many utilities in the United States need and might be interested in.

Both SNL and the ESA are being more aggressive in expanding their industry outreach for both communications and educational efforts. BES prices are falling, and some promising developments in various advanced battery technologies have been made. More effort must be undertaken, but progress is being made on many fronts.

Recommendations

Improving BES Economics, Storage, and Energy Density

Listed in this section are the major issues that electricity providers raised when discussing their misgivings about BES. Frost& Sullivan recommends that every effort be made to upgrade battery performance in terms of hours of storage and energy density. Also, reducing capital and maintenance costs is a major issue that should affect BES purchases at the utility level. Applications for current BES technology exist, but the costs are too high to take _, ... advantage of most of them. Frost & Sullivan expects that meeting the full demands of the electricity provider industry will probably entail developing a new generation of BES technologies. Therefore, BES developers and suppliers should examine the feasibility of such development and whether they want to be a part of such an effort.

Improving Communications Within the BES Community

The previously discussed communications problems within the BES industry are complex and stem from the rivalry between various vendors and developers and the technologies they are backing. Also contributing to some of these problems are the nature and organization of the utility industry and of BES suppliers.

While realizing the constraints, Frost & Sullivan recommends that SNL make greater efforts to expand the level of communication within the industry and discourage some of the dissonance and acrimony Occurnng in some parts. With a developing technology such as BES, the dissonant environment may confuse and alienate potential *customers* and other important parties.

Strengthening Industry Partnerships

Frost & Sullivan recommends that SNL strengthen its industry partnerships to achieve the long-term goals that SNL has identified for itself. Past BES projects have been affected by the partners having incompatible or unidentified goals.

The decommissioning of Southern California Edison's Chino facility left much of the electricity provider industry with a negative perception of BES. Had greater efforts been made to synchronize goals among the various parties with stakes in the Chino facility, the results might have been more positive for the BES industry.

In the future, Frost& Sullivan recommends that SNL spend more time and effort identifying and synchronizing its goals with those of its partners. This should limit some of the negative consequences stemming from projects such as the Chino project.

Focusing on BES Applications and Product Development

Current BES marketing and development efforts are too broad in focus. Marketing and development need to be more narrowly focused to gain better efficiencies and produce better results. Frost & Sullivan recommends that SNL accurately identify the applications that need to be served by BES and develop technologies and programs needed to serve those applications. In addition, SNL should select and encourage partners to take advantage of those technologies and programs in the development of focused products for the BES industry.

Performing Additional Market Research

Commercializing a developing technology is difficult. In the case of BES, this difficulty is heightened by the turmoil within the U.S. electric power industry and the pressure for results that many important BES research and development organizations, including SNL, are experiencing. Given these factors, Frost& Sullivan recommends that SNL and its partners perform additional research to understand the market.

The following topics seem promising areas for market research:

- BES demand in electric cooperatives
- BES demand among electricity end users
- Identification of high-priority BES applications
- Identification of project opportunities for the placement of BES systems
- Identification of key decision makers at target companies
- Identification of desired BES product features

In particular, the studies of the electricity end user and possibly the cooperative markets appear to be valuable. However, there also appears to be no shortage of potential research topics.

Market Summary

The BES market is currently developmental, and because of the factors that have been discussed in this report, the industry faces significant challenges. Nonetheless, the results of this study indicate that a market for BES at the electricity provider level does exist. This market is currently self-perpetuating at the national level, but at a lower than desired level of activity.

Projects such as those currently planned in Puerto Rico and Alaska should continue into the foreseeable future. With the development of better BES technologies and the resolution of concerns and issues, the BES market has the potential to be significantly larger.

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