



Research Report

EXECUTIVE SUMMARY: **Energy Storage Systems for Ancillary Services**

Frequency Regulation, Voltage Support, Short Duration Renewables Integration, Spinning Reserves, Electric Supply Reserve Capacity, and Load Following: Market Analysis and Forecasts

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Section 1

EXECUTIVE SUMMARY

1.1 Introduction

The analysis in this report focuses on the benefits of using energy storage systems (ESS) to balance the electrical power system at the grid operator level. The key applications in this analysis are: frequency regulation, voltage support (or control), short duration renewables integration, spinning reserves, electric supply reserve capacity, and load following.

In some cases, there is overlap with the long-duration energy storage market. One example is the transmission and distribution (T&D) deferral market, which is an application that provides frequency regulation, load following, voltage support, and in some cases islanding services. Although frequency regulation, load following, and voltage support are ancillary services, the T&D deferral application for energy storage systems is typically classified as a long-duration or “utility-scale” application. In fact, T&D deferral conveniently bundles a number of ancillary services for vertically integrated utilities, but is not a key application in deregulated markets.

Conversely, the individual applications account for the majority of the market opportunities for ESS for ancillary services in deregulated markets. Fundamentally, however, the primary purpose of T&D deferral is to mitigate financial risk on the part of a vertically integrated utility. This is what distinguishes T&D deferral and the bundle of services an ESS asset may provide from the ancillary services markets where load following, frequency regulation, and in some cases voltage support (or control) are bid on in a marketplace.

This “fuzziness” or overlap between the long-duration and short-duration storage markets highlights the importance of a consistent and rigorous research methodology in evaluating, analyzing, and quantifying the value of the ESS market. Pike Research’s approach to evaluating energy storage systems for ancillary services follows the following three-phased methodology:

1. The ancillary services market is evaluated, including market drivers and barriers and conditions of the grid which the ancillary services market serves.
2. The ancillary services market structure is analyzed. Market structures will determine the extent to which energy storage systems can participate in the ancillary services market.
3. The overall market penetration of energy storage systems in the ancillary services market is determined, along with the estimated market penetration of each technology within the market. Only mature or near-term technologies are considered in the 2011-2021 forecast period.

1.2 Barriers and Drivers for ESS for Ancillary Services

Energy storage systems for ancillary services are currently hindered by market barriers that are specific to new technologies, market barriers that reflect market failures, market barriers that relate to technology cost, and market barriers that have to do with supply chain and project management challenges.

- Barriers specific to new technologies:
 - Market structures that prohibit a new technology from receiving revenue from transmission operators, distribution operators, and load-serving entities, even though benefits are accrued by all these parties.
 - Market structures that do not acknowledge the added benefits of quick response technologies.
 - Market structures that do not fully compensate new technology assets in terms of frequency of use. Fast-reacting assets will typically be engaged before slow-reacting assets. High-frequency use can degrade storage assets.
 - Market regulations that are tailored for old technologies and penalize new technologies in the testing phase.
- Displaced cost and benefits; assets may be owned and managed by one party, but some benefits will be accrued by another; independent system operators often work to remedy these types of market failures;
- Difficulty in commoditizing some of the benefits of energy storage
- High capital expenditure
- Technology costs
 - Power management system cost
 - Siting and permitting cost
 - Project management cost

Market drivers for new technologies in the ancillary services market include market signals that establish a preference for new technologies, market conditions that will cause more instability in the grid (though how much instability is uncertain), market structures that acknowledge the performance characteristics of ESS, and legislation that demands energy storage as a means to “hybridize” the grid and reduce the generation capacity burden on the grid.

- Market drivers for ESS for ancillary services:
 - Faster response time than traditional technologies
 - Increased integration of intermittent renewables (wind and solar)
 - Modified rules for fast-response systems in the ancillary services market
 - Inherent instability in the grid
 - Strict power quality obligations
 - Legal requirements for energy storage as a percentage of generation

1.3 Changes in the Ancillary Services Market Since 2010

The major changes in the ESS market since Pike Research published its 2010 report *Energy Storage Systems for Ancillary Services* include policy changes, announcements of new projects, several large-scale projects that are breaking ground or overcoming regulatory hurdles, and announcements of business models and partnerships.

1.4 Ancillary Services Technologies

The principal technologies in the ESS for ancillary services segment are pumped storage and CAES for longer duration applications such as load following, reserve capacity and spinning reserves; sodium-sulfur (NaS) batteries, particularly for frequency regulation, voltage support, and load following; advanced lead acid and lithium ion (Li-ion) batteries for frequency regulation, voltage support, short duration renewables integration, and in some cases, load following and reserve capacity; and finally, flywheels for high-power, short-duration applications such as frequency regulation.

Ancillary services technologies perform a number of applications. Frequency regulation, voltage support, short duration renewables integration, spinning reserve, reserve capacity, and load following are included in the forecasts of this report. Each of these application categories will be significant in terms of market size, and more categories are likely to emerge over time.

1.5 Ancillary Services Market Forecast

1.5.1 Why the Numbers Are Different

There have been six major changes in the methodology that Pike Research uses to forecast the value of the ESS for ancillary services market since our 2010 report was published:

- The load following application has been moved to the ancillary services market forecast from the long-duration energy storage forecast in our report, *Energy Storage on the Grid*, published 3Q 2011.
- Short duration renewables integration has been added as an application in the market forecast.
- Community and residential energy storage systems for ancillary services are included in the forecast, although these are rolled into the overall forecasts and are not broken out on their own.
- The value of the ancillary services market is measured by using the value of power (\$/kW), not energy (\$/kWh). This change was made to reflect the fact that while the grid storage market is focused on delivering energy, the ancillary services market is focused on delivering power.
- The cost figures on which Pike Research's energy storage practice bases its forecast have changed: In December 2010, EPRI revised its methodology and cost figures for technologies within specific applications; Pike Research's energy storage practice now uses the revised cost figures for short duration storage applications for each technology and modifies these as appropriate.
- We have fine-tuned our forecasts for Europe and Asia Pacific. The greater level of granularity now provides a more nuanced interpretation of the ancillary services market in these regions.

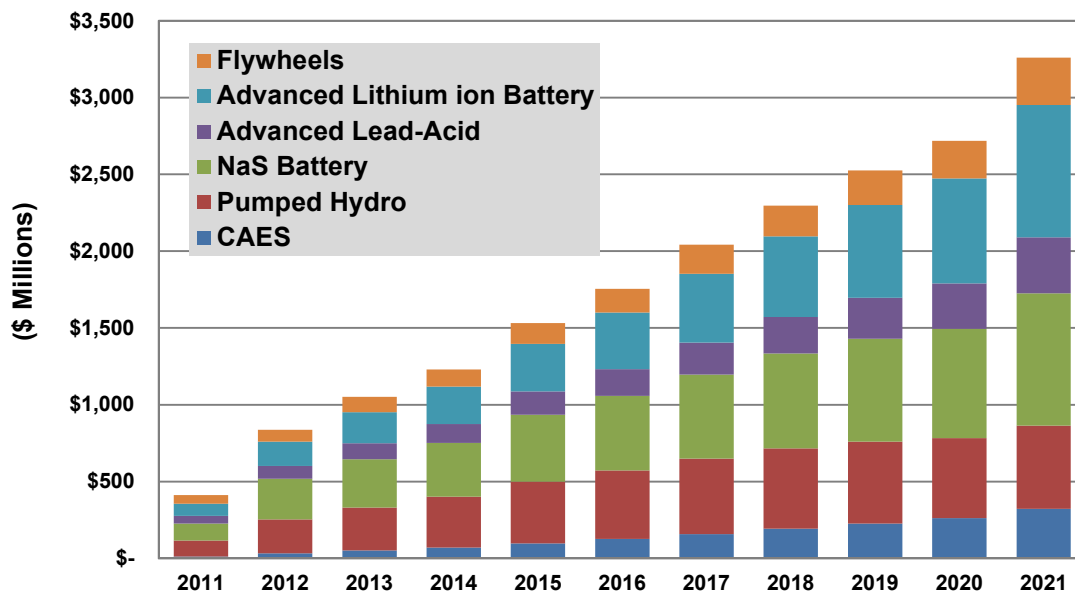
1.5.2 Ancillary Services Forecasts

The ESS for ancillary services market will be limited to the applications in this space with suitable market structures. Consequently, ESS for ancillary services will largely be limited to deregulated markets, at least in the initial period of adoption. In addition, the value of the ESS for ancillary services market, at least in the early years of the forecast period will be limited to a few key applications that are highly sought and have existing market structures. Although there is a great deal of discussion within the industry about "stacking" applications, there are only a handful of applications that benefit from market mechanisms. Therefore, until markets "catch up" and recognize the value of the performance characteristics of ESS, a select few applications will drive the market.

The key markets for ESS for ancillary services over the forecast period will be North America, Europe, and Asia Pacific, particularly for frequency regulation, load following, spinning reserves, and short duration renewables integration (in the case of Asia Pacific). The market for ESS for ancillary services is expected to reach a little over \$3.2 billion by 2021.

Highly responsive, flexible technologies will perform better than slower or niche technologies unless these can reach a threshold of market penetration to counter performance or niche application disadvantages. That said, the potential market for ancillary services is vast and will continue to grow as global generation capacity increases (as a result of new electrification and capacity additions to existing networks, as well as increased instability resulting from renewables integration). As ESS technologies continue to develop, are demonstrated, and are deployed, potential market share for ESS within ancillary services will increase over time.

Chart 1.1 Installed Revenue by ESS for Ancillary Services by Technology, World Markets: 2011-2021



(Source: Pike Research)

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SCOPE OF STUDY

Pike Research has prepared this report to provide participants in the emerging energy storage and ancillary services market (equipment and hardware vendors, utilities, software companies, installation and service providers, and other system component manufacturers) with a study of the global market potential for energy storage systems within the ancillary services market, including lithium ion batteries, flywheels, advanced lead acid batteries, CAES and pumped hydro, and sodium-sulfur batteries.

The report's purpose is not to provide an exhaustive technical assessment of all of the technologies and industries that may be related to energy storage deployments, but rather a strategic examination of the market focusing on business models, key technology issues, regulatory factors, customer demand dynamics, and the competitive landscape. Pike Research strives to identify and examine new market segments to aid readers in the development of their business models. All major global regions are included. The forecast period extends through 2021.

SOURCES AND METHODOLOGY

Pike Research's industry analysts utilize a variety of research sources in preparing Research Reports. The key component of Pike Research's analysis is primary research gained from phone and in-person interviews with industry leaders including executives, engineers, and marketing professionals. Analysts are diligent in ensuring that they speak with representatives from every part of the value chain, including but not limited to technology companies, utilities and other service providers, industry associations, government agencies, and the investment community.

Additional analysis includes secondary research conducted by Pike Research's analysts and the firm's staff of research assistants. Where applicable, all secondary research sources are appropriately cited within this report.

These primary and secondary research sources, combined with the analyst's industry expertise, are synthesized into the qualitative and quantitative analysis presented in Pike Research's reports. Great care is taken in making sure that all analysis is well-supported by facts, but where the facts are unknown and assumptions must be made, analysts document their assumptions and are prepared to explain their methodology, both within the body of a report and in direct conversations with clients.

Pike Research is an independent market research firm whose goal is to present an objective, unbiased view of market opportunities within its coverage areas. The firm is not beholden to any special interests and is thus able to offer clear, actionable advice to help clients succeed in the industry, unfettered by technology hype, political agendas, or emotional factors that are inherent in cleantech markets.

NOTES

CAGR refers to compound average annual growth rate, using the formula:

$$\text{CAGR} = (\text{End Year Value} \div \text{Start Year Value})^{(1/\text{steps})} - 1.$$

CAGRs presented in the tables are for the entire timeframe in the title. Where data for fewer years are given, the CAGR is for the range presented. Where relevant, CAGRs for shorter timeframes may be given as well.

Figures are based on the best estimates available at the time of calculation. Annual revenues, shipments, and sales are based on end-of-year figures unless otherwise noted. All values are expressed in year 2011 U.S. dollars unless otherwise noted. Percentages may not add up to 100 due to rounding.

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