

HIGHVIEW
POWER STORAGE

2015 Global Large-Scale Energy Storage
Technology Innovation Award



FROST & SULLIVAN



50 Years of Growth, Innovation & Leadership

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Background and Company Performance

Industry Challenges

The key challenge in today's grid scale and large scale energy storage market is the lack of a reliable, cost effective and high capacity storage technology. Moreover, except for pumped hydro, most of the other technologies are still emerging and still in the R&D phase, or only have a few pilot projects ongoing. Battery-based energy storage systems are popular for storage below 1MW. For bulk storage above 10 MW, only a handful of technologies are suitable such as pumped hydro, compressed air, thermal energy storage (TES), superconducting magnetic energy storage (SMES) and liquid air energy storage (LAES); out of these, pumped hydro is a well-established and mature technology. Few projects are in existence for compressed air and thermal energy storage. SMES is still in its infancy. Given these factors, Frost & Sullivan's independent market research suggests that storage companies who can offer energy dense, competitively priced and long life technology will have the best chances for achieving considerable growth in this market.

Technology Attributes and Future Business Value

Visionary Innovation

Large scale and grid scale energy storage has a tremendous potential for growth in the next 5 to 10 years as it is vital for applications such as grid stabilisation, integration of renewable energy, providing spinning reserve, voltage support and frequency regulation. The APAC market for battery energy storage systems and alternative energy storage systems such as flywheels, CAES, TES, etc. is expected to grow at a CAGR of 22-25% and reach around \$2.5 billion by 2020. The Western European market for large scale energy storage technologies (excluding PHES) is expected to witness more than a 50% jump in installed capacity by 2017 as compared to 2010.

Highview Power Storage was founded in 2005 with a vision to introduce a reliable, efficient and cost effective LAES solution in this market. The initial 4-5 years were all about technology development and extensive research in collaboration with the University of Leeds. In 2010, Highview Power set up its first pilot project hosted by Scottish and Southern Energy; a 350kW LAES solution alongside SSE's 80 MW biomass plant in Slough, UK. The company has worked tirelessly to constantly improve its technology and bring down the cost by building close relationships with its supply chain as well as collaborating with global companies such as GE that have wide coverage as well as a sterling brand name in the industry. In less than a decade since it was established, Highview Power has secured over £26 million in private and public funding along with successfully developing, demonstrating and commercialising an innovative technology in its LAES solution.

Industry Impact

Technologies for grid-scale and large-scale energy storage must offer fast regulation, competitive cost and long cycle life. Consumers are constantly looking for higher power and/or energy, lifetime or durability as well as safety and reliability, and none of the existing technologies offer all of these in a package. Moreover, the above 10MW market has only a handful of technologies such as PHES, CAES, TES, and SMES.

PHES is the most well-established and mature technology of them all (around 99% of the bulk storage capacity globally is pumped hydro). By developing the LAES, Highview Power has successfully incorporated the majority of the required features in order to address most of the unmet needs of the industry. LAES has no geographical constraints as compared to pumped hydro and underground CAES, and it uses readily available mature components that have a proven track record in terms of performance, cost and the boast a long lifetime (over 25 years); batteries, on the other hand, require replacing every 7-10 years. Moreover, LAES offers high efficiency (60% in standalone mode and more than 70% round trip efficiency if utilizing the waste heat or cold). Diabatic CAES has an efficiency of 45-55%. Highview Power's system is readily available for commercial deployment and in 2014, in collaboration with Viridor, has been awarded funding for a 5MW/15MWh LAES demonstration project by the UK Government. AA-CAES on the other hand is still under development and a pilot plant by RWE is scheduled to start operation only by 2018. Additionally, LAES offers 400% more energy density than its distant cousin CAES, which has a very low energy density of 2 - 6 watt-hours per kilogram.

Application Diversity

Energy storage has a critical role to play across the entire energy value chain starting from generation to transmission, distribution and finally at the customer level. LAES finds its usage in each stage of this value chain for activities such as peak shaving, integration and managing of intermittent renewable energy, energy arbitrage, regulation and capacity reserve, voltage support, black start and loss reduction. LAES is suitable for projects that require power from around 5MW to 100s of MWs. Projects that require storage for long hours (4, 6 and 8 hours or more) and that are above 10MW are the core focus for LAES. At this capacity, LAES as compared to other technologies (battery based as well as pumped hydro and CAES) offers greater advantages in terms of capital and operational costs and efficiency.

Highview Power is focussing its short to medium term growth strategy on providing storage for peaker plants and also to LNG import terminals. Peaker plants are expensive to operate and generate harmful emissions. The company's LAES solution offers an attractive alternative to using combustion turbines with operating costs as low as \$0.3/MWh. The US is a key market with the best prospects for growth in grid scale and bulk energy storage, mainly due to the amount of incentives and regulations that are being put into place. A very good example of this is the proposed settlement by Arizona Public Service (APS) and Residential Utility Consumer Office (RUCO), which if approved would mandate the need for at least 10% of any new peaker capacity being planned as simple cycle combustion turbines to be energy storage.

Moreover, in 2013, California Public Utilities Commission (CPUC) asked Southern California Edison (SCE) to source more than 50 megawatts of energy storage in the Los Angeles area until 2021. SCE is expected to procure approximately 1400-1800 MW of energy storage generation until 2021 and is open to installing any type of technology as long as it fits with their criteria and is reliable and proven. Highview Power, in order to take advantage of this massive opportunity, has already made strides into the North American market by entering into a license agreement with Advanced Emissions Solutions, Inc. (ADES) in December 2014. ADES has also invested \$2.8 million into Highview Power Storage.

Apart from large scale energy storage LAES is also suitable for applications that can integrate industrial waste heat/cold from thermal generation plants, steel mills, datacenters and LNG terminals. The breadth of applications LAES can be used for shows the versatility and flexibility of this innovative technology.

Technology Licensing

Highview Power has developed a unique storage solution and is the only company offering an LAES solution which is ready to deploy. It has over 12 families of patents covering key areas of technology such as thermal storage loops and LNG integration that have been granted or are pending. In 2012, it was granted a patent for its new CryoEnergy System (CES) in both China and South Africa, which has since been granted in Australia and Canada. Highview's Thermal Store patent has also been granted in Australia and the UK, and the LNG integration application has been accepted for grant in the UK. The company also signed a global licensing and technology collaboration agreement in 2014 with GE Oil & Gas to integrate LAES technology in GE's peaker plants alongside its gas turbines. The key advantage offered by LAES is the storage of electricity and improvement in generation efficiency of these plants.

GE's global reach gives Highview a global network with its technical sales engineers able to promote LAES technology globally. Highview Power is also designing bespoke multi MW commercial LAES plants at the request of potential customers and exploring opportunities in other parts of the globe. LAES will aid in providing security of supply, managing peak demand and supporting intermittent renewables for its commercial customers. 2012 also saw the company enter into a license and cooperation agreement with the German industrial gas giant Messer Group GmbH to use LAES alongside Messer's industrial gas plant. This partnership was beneficial to both parties as Highview Power was able to draw on Messer's strong engineering expertise in gas liquefaction technology, a vital component of its LAES offering. Given the major challenge facing the African and sub-Saharan African countries regarding energy demand and supply and thus the potential for growth in this region for energy storage, Highview Power signed a cooperation agreement with Basil Read Energy to commercially deploy LAES in South Africa and sub-Saharan Africa. LAES will provide energy security and peak time energy management to energy intensive industries such as steel mills, mines and refineries.

Brand Loyalty

Technology licensing agreements with multinational companies ensure a global reach for Highview Power's energy storage offering as well as building a strong brand visibility and technological confidence in its LAES solution. Within 5 years of being established, the company set up a pilot plant to showcase its unique LAES solution and in less than a decade gained significant consumer confidence as well as loyalty to sell it to commercial and industrial users. The technology licensing agreements with key companies in different parts of the globe and the sheer amount of public-private funding it has been able to raise, is testimony of the confidence customers place in Highview Power's LAES solution. It has also been in talks with large companies such as Alstom, Rolls-Royce, MAN Turbo and Siemens about its novel technology.

Scalability

Highview Power's LAES solution is modular and easily scalable. The company can design bespoke plants ranging from 5MW to more than 50MW in output. The components and sub-systems used can be readily and locally sourced from large OEMs as it is based on mature processes that have been in existence for a long time in the industrial gas, power generation and turbo machinery sectors. Scalability also leads to significant cost gains. The first of a kind cost of a 50MW/250MWh LAES solution is in the \$2,100/kW-\$2,500/kW range, taking into account the amount of time the system would have to charge and longer hours to charge result in less expensive systems. However, repeat builds result in significant cost reductions. Each time the cumulative volume doubles, value added costs fall by a constant percentage. A 17.5% experience rate is used, based on experience curve rates observed in the construction of combined cycle power plants. This means that each time total production doubles, the cost reduces by 17.5% down to a minimum cost. Thus, the cost of a 10th of a kind system (a mature unit) would be in the order of \$1,300/kW-\$1,500/kW. Capital cost for pumped hydro could vary between \$500-\$2,500/KW and is highly site and project specific. Thermal energy storage on the other hand is highly expensive with initial capital cost in the range of \$3,000-\$5,000/KW.

Conclusion

Highview Power Storage has successfully created a reliable, energy dense, cost competitive, commercially available and easily scalable LAES solution for the large scale energy storage market, which is very limited in terms of storage technologies currently available. This unique and innovative storage solution is applicable to a wide variety of end user applications and does not suffer from drawbacks such as geographical limitations or safety issues as compared to other technologies such as CAES, pumped hydro and battery energy storage systems. Because of its strong overall performance, Highview Power Storage is recognized with Frost & Sullivan's 2015 Technology Innovation Award.

Significance of Technology Innovation

Ultimately, growth in any organization depends upon finding new ways to excite the market, and upon maintaining a long-term commitment to innovation. At its core, technology innovation or any other type of innovation can only be sustained with leadership in three key areas: understanding demand, nurturing the brand, differentiating from the competition. This three-fold approach to nurturing innovation is explored further below.



Understanding Technology Innovation

Technology innovation begins with a spark of creativity that is systematically pursued, developed, and commercialized. That spark can result from a successful partnership, a productive in-house innovation group, or the mind of a singular individual. Regardless of the source, the success of any new technology is ultimately determined by its innovativeness and its impact on the business as a whole.

Key Benchmarking Criteria

For the Technology Innovation Award, we evaluated two key factors—Technology Attributes and Future Business Value—according to the criteria identified below.

Technology Attributes

- Criterion 1: Industry Impact
- Criterion 2: Product Impact
- Criterion 3: Scalability
- Criterion 4: Visionary Innovation
- Criterion 5: Application Diversity

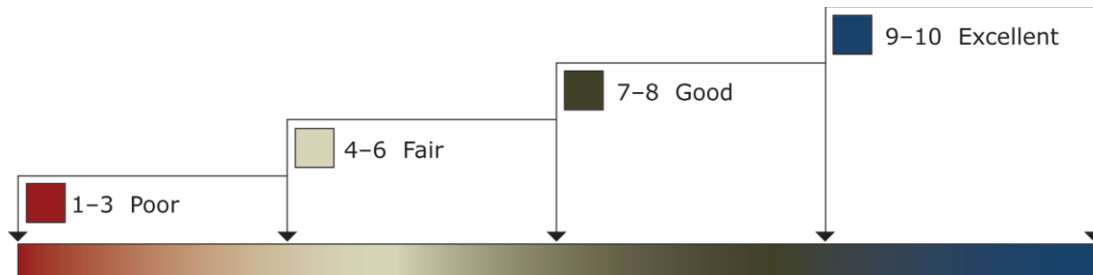
Future Business Value

- Criterion 1: Financial Performance
- Criterion 2: Customer Acquisition
- Criterion 3: Technology Licensing
- Criterion 4: Brand Loyalty
- Criterion 5: Human Capital

Best Practice Award Analysis for Highview Power Storage Decision Support Scorecard

To support its evaluation of best practices across multiple business performance categories, Frost & Sullivan employs a customized Decision Support Scorecard. This tool allows our research and consulting teams to objectively analyze performance, according to the key benchmarking criteria listed in the previous section, and to assign ratings on that basis. The tool follows a 10-point scale that allows for nuances in performance evaluation; ratings guidelines are illustrated below.

RATINGS GUIDELINES



The Decision Support Scorecard is organized by Technology Attributes and Future Business Value (i.e., the overarching categories for all 10 benchmarking criteria; the definitions for each criteria are provided beneath the scorecard). The research team confirms the veracity of this weighted scorecard through sensitivity analysis, which confirms that small changes to the ratings for a specific criterion do not lead to a significant change in the overall relative rankings of the companies.

The results of this analysis are shown below. To remain unbiased and to protect the interests of all organizations reviewed, we have chosen to refer to the other key players in as Competitor 2 and Competitor 3.

| <i>Measurement of 1-10 (1 = poor; 10 = excellent)</i> | | | |
|---|-----------------------|-----------------------|-----------------------|
| Technology Innovation | Technology Attributes | Future Business Value | Average Rating |
| Highview Power Storage | 9.0 | 9.0 | 9.0 |
| Competitor 2 | 6.5 | 7.5 | 7.0 |
| Competitor 3 | 6.0 | 6.0 | 6.0 |

Technology Attributes

Criterion 1: Industry Impact

Requirement: Technology enables the pursuit of groundbreaking new ideas, contributing to the betterment of the entire industry

Criterion 2: Product Impact

Requirement: Specific technology helps enhance features and functionality of the entire product line for the company

Criterion 3: Scalability

Requirement: Technology is scalable, enabling new generations of products over time, with increasing levels of quality and functionality

Criterion 4: Visionary Innovation

Requirement: Specific new technology represents true innovation based on a deep understanding of future needs and applications

Criterion 5: Application Diversity

Requirement: New technology serves multiple products, multiple applications, and multiple user environments

Future Business Value

Criterion 1: Financial Performance

Requirement: High potential for strong financial performance in terms of revenues, operating margins and other relevant financial metrics

Criterion 2: Customer Acquisition

Requirement: Specific technology enables acquisition of new customers, even as it enhances value to current customers

Criterion 3: Technology Licensing

Requirement: New technology displays great potential to be licensed across many sectors and applications, thereby driving incremental revenue streams

Criterion 4: Brand Loyalty

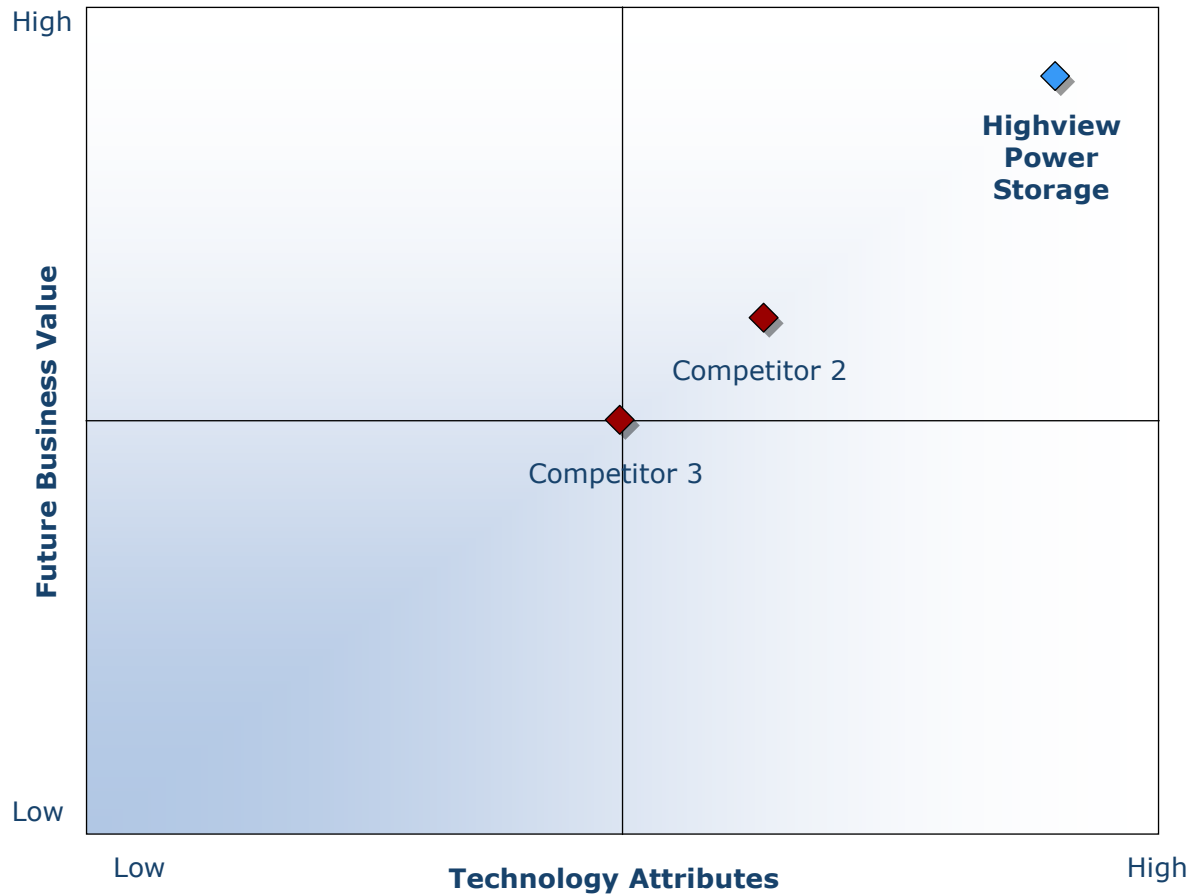
Requirement: New technology enhances the company's brand, creating and/or nurturing brand loyalty

Criterion 5: Human Capital

Requirement: Customer impact is enhanced through the leverage of specific technology, translating into positive impact on employee morale and retention

Decision Support Matrix

Once all companies have been evaluated according to the Decision Support Scorecard, analysts can then position the candidates on the matrix shown below, enabling them to visualize which companies are truly breakthrough and which ones are not yet operating at best-in-class levels.



The Intersection between 360-Degree Research and Best Practices Awards

Research Methodology

Frost & Sullivan's 360-degree research methodology represents the analytical rigor of our research process. It offers a 360-degree-view of industry challenges, trends, and issues by integrating all 7 of Frost & Sullivan's research methodologies. Too often, companies make important growth decisions based on a narrow understanding of their environment, leading to errors of both omission and commission. Successful growth strategies are founded on a thorough understanding of market, technical, economic, financial, customer, best practices, and demographic analyses. The integration of these research disciplines into the 360-degree research methodology provides an evaluation platform for benchmarking industry players and for identifying those performing at best-in-class levels.

360-DEGREE RESEARCH: SEEING ORDER IN THE CHAOS



Best Practices Recognition: 10 Steps to Researching, Identifying, and Recognizing Best Practices

Frost & Sullivan Awards follow a 10-step process to evaluate Award candidates and assess their fit to best practice criteria. The reputation and integrity of the Awards are based on close adherence to this process.

| STEP | OBJECTIVE | KEY ACTIVITIES | OUTPUT |
|---|--|--|--|
| 1 Monitor, target, and screen | Identify award recipient candidates from around the globe | <ul style="list-style-type: none"> • Conduct in-depth industry research • Identify emerging sectors • Scan multiple geographies | Pipeline of candidates who potentially meet all best-practice criteria |
| 2 Perform 360-degree research | Perform comprehensive, 360-degree research on all candidates in the pipeline | <ul style="list-style-type: none"> • Interview thought leaders and industry practitioners • Assess candidates' fit with best-practice criteria • Rank all candidates | Matrix positioning all candidates' performance relative to one another |
| 3 Invite thought leadership in best practices | Perform in-depth examination of all candidates | <ul style="list-style-type: none"> • Confirm best-practice criteria • Examine eligibility of all candidates • Identify any information gaps | Detailed profiles of all ranked candidates |
| 4 Initiate research director review | Conduct an unbiased evaluation of all candidate profiles | <ul style="list-style-type: none"> • Brainstorm ranking options • Invite multiple perspectives on candidates' performance • Update candidate profiles | Final prioritization of all eligible candidates and companion best-practice positioning paper |
| 5 Assemble panel of industry experts | Present findings to an expert panel of industry thought leaders | <ul style="list-style-type: none"> • Share findings • Strengthen cases for candidate eligibility • Prioritize candidates | Refined list of prioritized award candidates |
| 6 Conduct global industry review | Build consensus on award candidates' eligibility | <ul style="list-style-type: none"> • Hold global team meeting to review all candidates • Pressure-test fit with criteria • Confirm inclusion of all eligible candidates | Final list of eligible award candidates, representing success stories worldwide |
| 7 Perform quality check | Develop official award consideration materials | <ul style="list-style-type: none"> • Perform final performance benchmarking activities • Write nominations • Perform quality review | High-quality, accurate, and creative presentation of nominees' successes |
| 8 Reconnect with panel of industry experts | Finalize the selection of the best-practice award recipient | <ul style="list-style-type: none"> • Review analysis with panel • Build consensus • Select winner | Decision on which company performs best against all best-practice criteria |
| 9 Communicate recognition | Inform award recipient of award recognition | <ul style="list-style-type: none"> • Present award to the CEO • Inspire the organization for continued success • Celebrate the recipient's performance | Announcement of award and plan for how recipient can use the award to enhance the brand |
| 10 Take strategic action | The award recipient may license the award for use in external communication and outreach to stakeholders and customers | <ul style="list-style-type: none"> • Coordinate media outreach • Design a marketing plan • Assess award's role in future strategic planning | Widespread awareness of recipient's award status among investors, media personnel, and employees |

About Frost & Sullivan

Frost & Sullivan, the Growth Partnership Company, enables clients to accelerate growth and achieve best in class positions in growth, innovation and leadership. The company's Growth Partnership Service provides the CEO and the CEO's Growth Team with disciplined research and best practice models to drive the generation, evaluation and implementation of powerful growth strategies. Frost & Sullivan leverages almost 50 years of experience in partnering with Global 1000 companies, emerging businesses and the investment community from 31 offices on six continents. To join our Growth Partnership, please visit <http://www.frost.com>.