ESS Recognized for

2021

Technology Innovation Leadership

North American Long-duration
Energy Storage Industry
Excellence in Best Practices

FROST & SULLIVAN

Best Practices Criteria for World-Class Performance

Frost & Sullivan applies a rigorous analytical process to evaluate multiple nominees for each award category before determining the final award recipient. The process involves a detailed evaluation of best practices criteria across two dimensions for each nominated company. ESS excels in many of the criteria in the long-duration energy storage industry.

Commitment to Innovation and Creativity

The Paris Agreement involves a stringent set of guidelines to support a smooth transition towards sustainable energy use. The initiative requires urgent action to decarbonize the energy sector and mitigate the risk of global climate change. Technological advancements coupled with the gradual decrease in the cost of renewable energy generation have allowed the energy sector to make steady progress in accelerating decarbonisation efforts, including the large-scale and global deployment of wind and solar power-based technologies. However, intermittency issues associated with renewable energy generation lead to grid management difficulties.

The only way to effectively manage the grid in such a scenario is through integrating long-duration energy storage solutions to meet demand during peak hour loads. Traditional energy storage solutions, such as pumped hydroelectric storage, involve large-scale construction and are economically challenging. While lithium-ion (Li-ion)-based energy storage solutions have led to the development of rechargeable batteries suitable for consumer electronics, they are only suitable for short durations and pose environmental and safety issues. Additionally, the availability of critical battery materials such as lithium and cobalt is limited, leading to concerns regarding potential supply chain shortages. It is therefore necessary to make use of cost-effective and readily available materials to deploy technologies that can accelerate the development of long-duration energy storage systems.

Frost & Sullivan notes that iron flow-based energy storage systems have numerous advantages, including easy scalability, no self-discharge, longer cycle life and longer asset life as compared to other battery chemistries. Iron flow batteries can support applications that require increased capacities, uninterrupted power supply, and backup power (e.g., use in industrial corridors and commercial buildings). ESS Inc. (ESS), a US-based energy storage company, is a pioneer in the design, development, and manufacturing of environmentally friendly and cost-effective long-duration energy storage systems. The company manufactures long-duration iron flow batteries using food-grade and earth-abundant iron, salt, and water. The mixture acts as an electrolyte, allowing the company to deliver energy storage systems to the renewable energy infrastructure supporting the bulk shifting of renewable energy from solar and wind, while stabilizing our increasingly fragile electric grid.

ESS's iron flow battery technology makes use of circulated liquid electrolytes for the charge-discharge cycle, based on an electrochemical process called a redox reaction. The company's proprietary battery module design and control system use the same electrolyte (i.e., iron chloride solution) at both the negative and the positive electrodes, eliminating risk of cross-contamination and enabling thousands of cycles of operation without any performance or capacity degradation. ESS's innovative flow battery generation process reduces plumbing requirements by 60%, eliminating the need for cost-intensive and space-consuming cell stack racking. The closed-loop plumbing eliminates electrolyte evaporation loss and allows the batteries to function at a wide range of operating temperatures (-5 to 50 degrees Celsius) and near-atmospheric pressure conditions. The company's unique battery chemistry design makes iron flow batteries stable for unlimited charge-discharge cycles without any contamination, as compared to Li-ion and vanadium flow batteries, which require augmentation after 7,000 to 10,000 cycles.

> *"ESS's iron flow battery technology offers up to 12 hours of energy storage, an operating life of more than 20 years, and minimal capacity fade or degradation as compared to conventional Li-ion batteries, which offer only 4 hours of energy storage during an operating life of approximately 7 years before requiring further augmentation."*
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> ***- Sharath Thirumalai,***
> ***Senior Research Analyst***

ESS's iron flow battery technology offers up to 12 hours of energy storage over a system design life of more than 20 years and more than 20,000 cycles. It has minimal capacity fade or degradation compared to conventional Li-ion batteries, which offer only 4 hours of energy storage over an operating life of approximately 7 years before requiring further augmentation. Moreover, ESS's automated battery module production process facilitates frequent cleaning and rebalancing of the electrolyte, thereby enhancing electrolyte health. Such an approach eliminates the need for frequent downtime due to electrolyte cleaning and rebalancing, resulting in a differentiator and competitive edge versus alternative battery systems.

One of the key benefits of ESS's iron flow battery technology is its low levelized cost of storage (LCOS). The LCOS of Li-ion and vanadium flow batteries is based on a 10-year lifetime with 350 cycles operating per annum. Energy storage capacity is 4 to 7 hours and costs approximately 0.07 to 0.09 $/kilowatt-hour (kWh) for Li-ion batteries and 0.18 to 0.25 $/kWh for vanadium flow batteries, respectively. ESS's iron flow batteries, on the other hand, offer a lifetime of more than 20 years, and an energy storage capacity of up to 12 hours. The LCOS is in the range of 0.05 to 0.06 $/kWh, a cost reduction of nearly 2 to 3 times

versus conventional battery technologies. The LCOS is forecast to further drop to less than 0.02$/kWh by 2025.

As a result, ESS's iron flow batteries are cost-effective for long-duration energy storage compared to traditional battery systems. Another unique and differentiating attribute is its safety and low environmental impact. The company's iron flow battery chemistry does not use rare earth metals such as vanadium, lithium, cobalt or manganese, reducing the negative environmental impacts associated with the sourcing, production and lack of recycling for conventional batteries.

ESS's battery chemistry, being water-based, presents no flammability or explosive risks, eliminating the need for fire suppression equipment. Iron flow batteries also contain no toxic materials and are substantially recyclable at the end of life. The chemistry's global warming potential (GWP), a metric that calculates greenhouse gas emissions, is approximately 70 to 90 kilograms of carbon dioxide equivalent per kWh (Kg CO_2 eq./kWh) as compared to the GWPs of Li-ion and Vanadium flow batteries, which amount to 250 to 350 Kg CO_2 eq./kWh and 180 to 250 Kg CO_2 eq./ kWh, respectively. Frost & Sullivan recognizes that such capabilities clearly distinguish ESS's iron flow battery technology from competitors, making it an ideal solution for long-duration energy storage that can support renewable energy infrastructure.

Stage Gate Efficiency and Commercialization Success

In 2017, ESS deployed the Energy Warehouse™ product, its first-generation long-duration energy storage platform, for commercial and utility-scale energy storage applications requiring up to 12 hours of flexible energy storage capacity. In 2019, ESS secured $30 million in funding from investors, including Breakthrough Energy Ventures, SoftBank Group's SB Energy, PTT Global Chemical (GC), BASF Venture Capital, Cycle Capital Management, Presidio Partners Investment Management, IPM Group, and Pangaea Ventures. The funding was used to design a larger-format battery module and to begin automating the company's battery module assembly. The larger-format battery module design enabled ESS to launch its utility-scale Energy Center™ platform product in 2020. The Energy Center can be customized to support any project size and configuration with power capacities starting at 3 megawatts and energy durations ranging up to 12 hours. The offering is easily scalable (adding electrolyte can increase energy capacity) while simultaneously ensuring low operational expenditure. The company has contracted for deployment of its Gen 2 Energy Warehouse product across the United States, EU, LatAM and Australia and has begun shipping. Frost & Sullivan recognizes that the company's proven track record of successfully commercializing long-duration energy storage systems is a key factor in setting the company apart from competitors. Frost & Sullivan recognizes such investments reinforce the value and importance of long-duration energy storage, especially in the form of iron flow batteries which can be easily deployed at a large scale to complement renewable energy generation.

Application Diversity

ESS's iron flow battery-based Energy Warehouse and Energy Center solutions are convenient for long-duration energy storage and can be used across a wide range of applications. As industrial end users, energy operators, and distributors are increasingly taking steps to minimize energy costs and adhere to

decarbonisation targets, ESS's solutions are increasingly preferred. The company's offerings are ideally suited for:

- ***Behind-the-Meter applications*** include the deployment of long-duration, iron flow battery-based energy storage systems for industry, microgrids, virtual power plants, commercial buildings, residential areas, educational campuses, and hospitals.
- ***Front-of-the-Meter applications*** include the deployment of long-duration energy storage systems for upstream assets and are maintained by utility operators, renewable energy producers, and transmission and distribution operators. Edelaysen, a Chile-based utility company, has selected ESS technology for integration into its remote grid system. By deploying ESS's solutions, Edelaysen is complementing the use of renewable energy, allowing for the elimination of 75% of diesel generator use in Chile's Patagonia region. Edelaysen expects to save an estimated $3 million in diesel fuel procurement and maintenance costs over the ESS system's lifetime and will reduce emissions equivalent to 12 years of diesel use.

Frost and Sullivan recognizes that ESS's solutions' unique properties allow for use across the energy value chain, helping users become less carbon-intensive. Such an approach is a best practice that differentiates the company from competitors.

Growth Potential

Accelerating decarbonization in energy-intensive applications requires a transition from fossil fuel-based electricity generation to renewable sources with greater energy efficiency. As renewable energy penetration increases, long-duration energy storage solutions such as ESS iron flow battery systems will be a key enabler for unlocking the full range of renewable benefits. The expansion of green hydrogen use cases could also become a driver for long-duration storage growth – absorbing excess renewable generation to power hydrogen electrolyzers. Another area is energy storage as a service, which could further broaden access to capital-constrained customer segments such as universities, municipalities and public sector institutions. Frost & Sullivan recognizes the ability of ESS's innovative battery technology to accelerate its growth potential while simultaneously enabling end users to achieve their decarbonization targets.

Conclusion

Currently, intermittency issues associated with renewable energy generation are not adequately managed by traditional energy storage systems. Challenges include shorter storage duration (<4 hours), environmental and safety issues, and a reduced lifetime due to system contamination and degradation. ESS Inc. (ESS)'s innovative iron flow battery technology is a cost-effective, one-stop solution that complements renewable energy generation by enabling long-duration energy storage (up to 12 hours), an operating life of more than 20 years, and the elimination of capacity fade or degradation of the energy storage system. Moreover, the battery is safe, nearly 100% recyclable, and does not use components that pose negative environmental impacts associated with sourcing and production.

With its strong overall performance, ESS Inc. earns Frost & Sullivan's 2021 Technology Innovation Leadership Award in the North American long-duration energy storage industry.

What You Need to Know about the Technology Innovation Leadership Recognition

Frost & Sullivan's Technology Innovation Award recognizes the company that has introduced the best underlying technology for achieving remarkable product and customer success while driving future business value.

Best Practices Award Analysis

For the Technology Innovation Leadership Award, Frost & Sullivan analysts independently evaluated the criteria listed below.

Technology Leverage

Commitment to Innovation: Continuous emerging technology adoption and creation enables new product development and enhances product performance

Commitment to Creativity: Company leverages technology advancements to push the limits of form and function in the pursuit of white space innovation

Stage Gate Efficiency: Technology adoption enhances the stage gate process for launching new products and solutions

Commercialization Success: Company displays a proven track record of taking new technologies to market with a high success rate

Application Diversity: Company develops and/or integrates technology that serves multiple applications and multiple environments

Business Impact

Financial Performance: Strong overall financial performance is achieved in terms of revenues, revenue growth, operating margin, and other key financial metrics

Customer Acquisition: Customer-facing processes support efficient and consistent new customer acquisition while enhancing customer retention

Operational Efficiency: Company staff performs assigned tasks productively, quickly, and to a high-quality standard

Growth Potential: Growth is fostered by a strong customer focus that strengthens the brand and reinforces customer loyalty

Human Capital: Commitment to quality and to customers characterize the company culture, which in turn enhances employee morale and retention

About Frost & Sullivan

Frost & Sullivan is the Growth Pipeline Company™. We power our clients to a future shaped by growth. Our Growth Pipeline as a Service™ provides the CEO and the CEO's growth team with a continuous and rigorous platform of growth opportunities, ensuring long-term success. To achieve positive outcomes, our team leverages over 60 years of experience, coaching organizations of all types and sizes across 6 continents with our proven best practices. To power your Growth Pipeline future, visit Frost & Sullivan at http://www.frost.com.

The Growth Pipeline Engine™

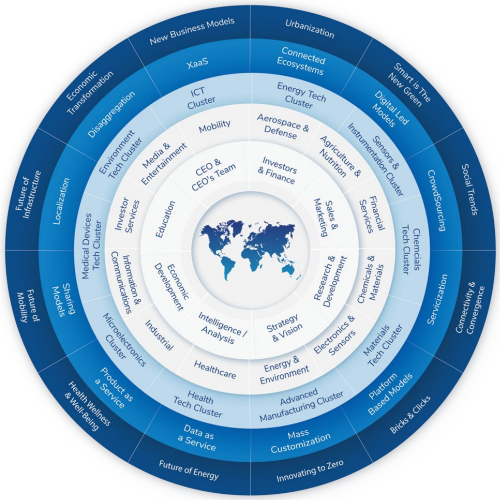
Frost & Sullivan's proprietary model to systematically create on-going growth opportunities and strategies for our clients is fuelled by the Innovation Generator™. Learn more.

Key Impacts:

- **Growth Pipeline:** *Continuous flow of Growth opportunities*
- **Growth Strategies:** *Proven Best Practices*
- **Innovation Culture:** *Optimized Customer Experience*
- **ROI & Margin:** *Implementation Excellence*
- **Transformational Growth:** *Industry Leadership*

The Innovation Generator™

Our six analytical perspectives are crucial in capturing the broadest range of innovative growth opportunities, most of which occur at the points of these perspectives.



Analytical Perspectives:

- Mega Trend (MT)
- Business Model (BM)
- Technology (TE)
- Industries (IN)
- Customer (CU)
- Geographies (GE)