

## **New Product Innovation Award Stationary PEM Fuel Cells North America, 2011**

### **Frost & Sullivan's Global Research Platform**

Frost & Sullivan is in its 50th year in business with a global research organization of 1,800 analysts and consultants who monitor more than 300 industries and 250,000 companies. The company's research philosophy originates with the CEO's 360 Degree Perspective™, which serves as the foundation of its TEAM Research™ methodology. This unique approach enables us to determine how best-in-class companies worldwide manage growth, innovation and leadership. Based on the findings of this Best Practices research, Frost & Sullivan is proud to present the 2011 North American New Product Innovation Award in the Stationary PEM Fuel Cells market to Ballard Power Systems, Inc. (Ballard Power Systems).

### **Significance of the New Product Innovation Award**

#### **Key Industry Challenges Addressed by CLEARgen™ Fuel Cell**

Distributed (decentralized) energy generation systems can help decrease transmission line losses due to its ability to generate energy at locations closer to where it is consumed. Devices such as wind generators and photovoltaic panels often cause voltage and/or frequency fluctuations in the main grid when deployed on a mass scale. On other hand, microturbines that are able to provide CHP (combined heat and power) applications rely mainly on natural gas, which is connected with greenhouse gas emissions. Frost & Sullivan notes that these inherent disadvantages are overcome by using fuel cell technology for decentralized energy generation. Proton Exchange Membrane (PEM) fuel cells use hydrogen to generate electricity in a completely clean, emission-free chemical process. Hydrogen is still considered a fuel of the future. However, before this market scenario becomes a reality, certain key challenges need to be resolved.

Frost & Sullivan independent analysis reveals the market obstacles below:

#### Low fuel cell stack durability

The greatest drawback of the PEM fuel cell is its membrane, which limits stack life time. Membrane durability depends on operating temperature and voltage of the fuel cell stack. Solving this problem will significantly increase the economic attractiveness of fuel cells operating directly on hydrogen.

### High initial costs

Due to low membrane durability and advanced/rare materials that are required for fuel cell manufacturing, this solution's cost is relatively high. Energy produced by the fuel cell is currently expensive, and the analyzed economics of the overall technology are often questionable.

### Availability of hydrogen

Most PEM fuel cells use pure hydrogen as a fuel. Lack of hydrogen distribution infrastructure, expensive onsite production (water electrolysis), and lack of large scale hydrogen storage solutions cause space limitations for PEM fuel cells.

## **Impact of New Product Innovation Award on Key Stakeholders**

The New Product Innovation Award is a prestigious recognition of Ballard Power Systems' accomplishments in the PEM fuel cells sector. An unbiased, third-party recognition can provide a profound impact in enhancing the brand value and accelerating Ballard Power Systems' growth. As captured in Chart 1 below, by researching, ranking, and recognizing those who deliver excellence and best practices in their respective endeavors, Frost & Sullivan hopes to inspire, influence, and impact three specific constituencies:

- **Investors**

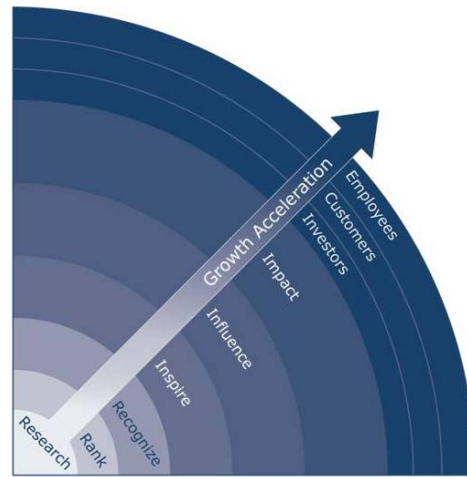
Investors and shareholders always welcome unbiased and impartial third-party recognition. Similarly, prospective investors and shareholders are drawn to companies with a well-established reputation for excellence. Unbiased validation is the best and most credible way to showcase an organization worthy of investment.

- **Customers**

Third-party industry recognition has been proven to be the most effective way to assure customers that they are partnering with an organization that is leading in its field.

- **Employees**

This Award represents the creativity and dedication of Ballard Power Systems' executive team and employees. Such public recognition can boost morale and inspire these stakeholders to continue the best-in-class pursuit of a strong innovation position for Ballard Power Systems.

**Chart 1: Best Practices Leverage for Growth Acceleration**

### Key Benchmarking Criteria for New Product Innovation Award

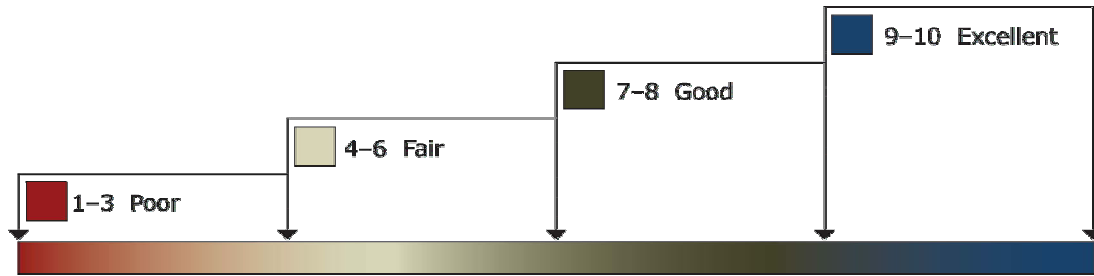
For the New Product Innovation Award, the following criteria were used to benchmark Ballard Power Systems' performance against key competitors:

- **Innovative Element of the Product**
- **Leverage Leading Edge Technologies in Product**
- **Value Added Features/Benefits**
- **Increased Customer ROI**
- **Customer Acquisition/Penetration Potential**

### Decision Support Matrix and Measurement Criteria

To support its evaluation of best practices across multiple business performance categories, Frost & Sullivan employs a customized Decision Support Matrix (DSM). The DSM is an analytical tool that compares companies' performance relative to each other with an integration of quantitative and qualitative metrics. The DSM features criteria unique to each Award category and ranks importance by assigning weights to each criterion. The relative weighting reflects current market conditions and illustrates the associated importance of each criterion according to Frost & Sullivan. Fundamentally, each DSM is distinct for each market and Award category. The DSM allows our research and consulting teams to objectively analyze each company's performance on each criterion relative to its top competitors and assign performance ratings on that basis. The DSM follows a 10-point scale that allows for nuances in performance evaluation; ratings guidelines are shown in Chart 2.

**Chart 2: Performance-Based Ratings for Decision Support Matrix**



This exercise encompasses all criteria, leading to a weighted average ranking of each company. Researchers can then easily identify the company with the highest ranking. As a final step, the research team confirms the veracity of the model by ensuring 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.

**Chart 3: Frost & Sullivan’s 10-Step Process for Identifying Award Recipients**



**Best Practice Award Analysis for Ballard Power Systems**

The Decision Support Matrix, shown in Chart 4, illustrates the relative importance of each criterion for the New Product Innovation Award and the ratings for each company under evaluation. To remain unbiased while also protecting the interests of the other organizations reviewed, we have chosen to refer to the other key players as Competitor 1 and Competitor 2.

**Chart 4: Decision Support Matrix for New Product Innovation Award**

<i>Measurement of 1–10 (1 = lowest; 10 = highest)</i>	<b>Award Criteria</b>					<b>Weighted Rating</b>
	Innovative Element of the Product	Leverage Leading Edge Technologies in Product	Value Added Features/Benefits	Increased Customer ROI	Customer Acquisition/Penetration Potential	
<b>Relative Weight (%)</b>	<b>20%</b>	<b>20%</b>	<b>20%</b>	<b>20%</b>	<b>20%</b>	<b>100%</b>
<b>Ballard Power Systems, Inc.</b>	<b>9</b>	<b>9</b>	<b>8</b>	<b>9</b>	<b>9</b>	<b>8.8</b>
Competitor 1	8	7	8	6	7	7.2
Competitor 2	7	8	6	6	5	6.4

**Criterion 1: Innovative Element of the Product**

Ballard Power Systems has developed the CLEARgen™ Proton Exchange Membrane fuel cell system (PEMFC) for distributed energy generation (DG) applications; this is a commercially available grid scale system ready for installation. Ballard’s product offerings for DG applications starts with a modular PEMFC device with 500 kW capacity, and can be easily scaled-up to multiple megawatts by adding modules in parallel to increase the power output of the whole system.

Proton Exchange Membrane fuel cells (PEMFC) require a hydrogen input that is used in a chemical reaction to produce electric energy. This necessitates the installment of a hydrogen storage system, which is currently expensive and occupies a significant amount of space.

Ballard is maximizing the use of hydrogen that occurs as a by-product in certain chemical processes, for example in the chlor-alkali industry. Such hydrogen can be easily captured and used as a low-cost fuel for a company’s PEMFC system. Other DG systems that produce energy on a constant basis (microturbines, gas engines) rely mostly on fossil fuels and are a source of high emissions and noise levels, making them less attractive in the long term. Other fuel cell types (SOFC solid oxide fuel cells, MCFC molten carbonate fuel cells, PAFC phosphoric acid fuel cells) can be also used for decentralized energy generation applications. However, they operate on natural gas that is reformed to obtain hydrogen. Besides the disadvantage of operating on fossil fuels, these also require high operating temperatures (~800 degree C), which makes this process less flexible.

Another important application of Ballard's CLEARgen™ PEM fuel cell is in solar or wind farms. In such cases, a fuel cell operates in conjunction with an electrolyzer that converts excess electricity into hydrogen, which can be stored on-site. This hydrogen can be then used for the production of electricity at peak periods, which in turn will help even out the fluctuating power output characteristic of intermittent renewable energy generators or cater to peak power needs occurring during the day. Such capability can be currently provided only by grid scale electric energy storage systems, which are still under development and therefore expensive.

### **Criterion 2: Leverage Leading Edge Technologies in Product**

The decentralized power generator system introduced by Ballard has been designed to have a lifespan of 15 years to 20 years; the fuel cell stack inside the system has a lifetime of 20,000 hours. However, researchers from Ballard are constantly improving upon their existing products. They are currently working on developing new materials and optimizing the system to be able to increase the fuel cell stack lifetime to about 40,000 hours. Doubling stack lifetime will significantly reduce system operation and maintenance costs, as well as overall system costs for the end user. Today, the cost of Ballard's PEMFC system is approximately \$3000 per kW installed. The company is further reducing this cost by improving automated manufacturing to allow for the production of higher volumes. These product development activities have enabled cost reduction of their system by 65% over the last 3 years, making Ballard the frontrunner in the PEM fuel cells industry. Frost & Sullivan believes that other competing companies in this space have not been able to achieve commercialization of low cost products that deliver high performance.

### **Criterion 3: Value Added Features/Benefits**

The CLEARgen™ PEM fuel cell system can work in combined heat and power mode (CHP) to deliver electric energy and useful heat at the same time. This heat can be further used for recreational purposes (heating swimming pools) or/and space heating. Competing companies that deliver other kinds of fuel cells for decentralized power generation application rely on other kinds of fuels (such as natural gas) that are a source of CO<sub>2</sub> emissions. Such solutions score lower in terms of sustainability in the long term.

### **Criterion 4: Increased Customer ROI**

By using the CLEARgen™ system, Ballard customers will become independent power producers and reduce their electricity demand from the grid; for instance, during peak time when electric energy prices are the highest. In addition, chemical reactions occurring in the fuel cells are completely carbon dioxide (CO<sub>2</sub>)-free, making PEMFCs the only clean decentralized power generator that can operate non-intermittently. Such a system can also work as a combined heat and power (CHP) device, which means that PEMFCs, while generating electricity, can also be used to provide heat for space heating applications.

## Criterion 5: Customer Acquisition/Penetration Potential

Utilities have a need to meet environmental standards, such as the renewable portfolio standard requiring a certain percent of energy (depending on state or country) to be generated from clean sources. Due to the production of electricity via chemical process instead of combustion, the CLEARgen™ PEM fuel cell system fits very well into environmental standards, making this technology attractive from the utility companies' point of view. Ballard's experience and strong competitive position in the market have inspired fuel cell system manufacturer Plug Power to purchase its PEM fuel cell stacks from Ballard exclusively through the end of 2013.

## Conclusion

Rising crude oil prices, climate change and greater emphasis on greenhouse gas reduction has resulted in increased interest in renewable energy generation. Among various renewable energy technologies, PEM fuel cells appear as a superior solution that can deliver electric and heat power on a continuous or intermittent basis without any greenhouse gas emission. Ballard's technological expertise has enabled it to commercialize PEM fuel cells for distributed energy generation. Based on the aforementioned factors as measured and benchmarked through Frost & Sullivan independent research, Ballard Power Systems is therefore the recipient of the 2011 Frost & Sullivan New Product Innovation Award.

## The CEO 360-Degree Perspective™ - Visionary Platform for Growth Strategies

The CEO 360-Degree Perspective™ model provides a clear illustration of the complex business universe in which CEOs and their management teams live today. It represents the foundation of Frost & Sullivan's global research organization and provides the basis on which companies can gain a visionary and strategic understanding of the market. The CEO 360-Degree Perspective™ is also a "must-have" requirement for the identification and analysis of best-practice performance by industry leaders.

The CEO 360-Degree Perspective™ model enables our clients to gain a comprehensive, action-oriented understanding of market evolution and its implications for their companies' growth strategies. As illustrated in Chart 5 below, the following six-step process outlines how our researchers and consultants embed the CEO 360-Degree Perspective™ into their analyses and recommendations.

Chart 5: 360 Degree Perspective™ Model



### Critical Importance of TEAM Research

Frost & Sullivan’s TEAM 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 seven of Frost & Sullivan’s research methodologies. Our experience has shown over the years that companies too often make important growth decisions based on a narrow understanding of their environment, leading to errors of both omission and commission. Frost & Sullivan contends that successful growth strategies are founded on a thorough understanding of market, technical, economic, financial, customer, best practices, and demographic analyses. In that vein, the letters T, E, A and M reflect our core technical, economic, applied (financial and best practices) and market analyses. The

Integration of these research disciplines into the TEAM Research methodology provides an evaluation platform for benchmarking industry players and for creating high-potential growth strategies for our clients.

**Chart 6: Benchmarking Performance with TEAM Research**



## 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 50 years of experience in partnering with Global 1000 companies, emerging businesses and the investment community from more than 40 offices on six continents. To join our Growth Partnership, please visit <http://www.frost.com>.