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WHITE PAPER

Fuel Cell Solutions to Meet the U.S. DoD's Energy Strategy

A Perspective On *"Beyond Demonstration: The Role of Fuel Cells in DoD's Energy Strategy"* published by LMI Government Consulting

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This release contains forward-looking statements, including anticipated customer requirements. These forward-looking statements reflect Ballard's current expectations as contemplated under section 27A of the Securities Act of 1933, as amended, and Section 21E of the Securities Exchange Act of 1934, as amended. Any such forward-looking statements are based on Ballard's assumptions relating to its financial forecasts and expectations regarding its product development efforts, manufacturing capacity, and market demand.

These statements involve risks and uncertainties that may cause Ballard's actual results to be materially different, including general economic and regulatory changes, detrimental reliance on third parties, successfully achieving our business plans and achieving and sustaining profitability. For a detailed discussion of these and other risk factors that could affect Ballard's future performance, please refer to Ballard's most recent Annual Information Form. Readers should not place undue reliance on Ballard's forward-looking statements and Ballard assumes no obligation to update or release any revisions to these forward looking statements, other than as required under applicable legislation.

EXECUTIVE SUMMARY

The report "Beyond Demonstration: The Role of Fuel Cells in DoD's Energy Strategy", published by LMI Government Consulting in October 2011, identified a broad range of applications of interest to the U.S. Department of Defense (DoD). Ballard Power Systems (www.ballard.com) is of the view that fuel cell power should be a 'technology of choice' for near-future DoD energy needs. Ballard has several immediate commercial solutions as well as demonstration capability to meet many of the DoD's technology requirements.

Ballard recognizes the important role the DoD has played in the research, development and demonstration of fuel cell technologies across a wide range of applications. Private-public partnerships such as this have been essential in moving the use of fuel cell technology beyond development and demonstration projects to real commercial deployments.

Commercial solutions are immediately available for the following areas:

1) **Backup Power** – *quiet, reliable, extended power for critical operations in the case of disruption to the electrical grid; capable of running on multiple fuels*
2) **Distributed Stationary Power** – *megawatt scale stationary systems sited at the point of demand to provide primary baseload power from hydrogen, with thermal energy created by the system to satisfy heating needs*
3) **Non-Tactical Material Handling and Ground Support Equipment** – *extended range material handling equipment to improve productivity at distribution centers and bases*
4) **Non-Tactical Personnel Transport (Buses)** - *fuel cell buses are clean, quiet vehicles, emitting no greenhouse gas or particulates*

> **"HAVING ASSESSED THE MERITS AND READINESS OF FUEL CELLS FOR DOD USE, WE DETERMINED THAT THE DEPARTMENT SHOULD PROACTIVELY EVALUATE AND ACQUIRE FUEL CELL SYSTEMS..."**
>
> - LMI GOVERNMENT CONSULTING, OCTOBER 2011

Beyond commercial products, Ballard's technology development is focused on cost reduction of the state-of-the-art fuel cell stack technologies as well as enhancing the capability of the technology to enable preferred solutions to modern power needs. The following areas of DoD focus are identified for fuel cell system development and demonstration programs:

1) **Fuel Processor Design and Development** - *multi-fuel, low cost reforming technology (TRL 4)*
2) **Wearable Soldier Power, Unmanned Vehicle Power and Mobile Electric Power** - *a unique solution provides small, scalable, light-weight systems capable of significantly reducing the warfighters' weight burden and offering extended range over battery based systems (TRL4)*
3) **Micro-Grid and Auxiliary Power Units for Land, Sea and Air** – *quiet exportable power for on-board vehicle power, auxiliary power and local micro-grids capable of running on a range of fuel, including diesel (TRL6)*

Ballard Power Systems is considered to be the world's largest and most experienced developer and manufacturer in the proton exchange membrane (PEM) fuel cell industry.

COMMERCIAL STAGE MARKETS

Fuel cell technology offers clean, efficient, reliable power generation to almost any device requiring electrical power. In recent years fuel cell technology advancements have bridged the gaps in terms of functionality and durability so that today many fuel cell products can exceed the technical capabilities of incumbent technologies.

The technology readiness level (TRL) of the backup power, distributed generation, material handling and bus products described in this section are ranked at a TRL 6 or 9. These products have demonstrated capability to meet customer requirements at the component, stack and system level. The products are being manufactured in a production environment with control on critical properties to at least the 3-sigma level.

1. Backup Power

Mobile network operators worldwide are increasingly implementing fuel cell solutions to improve network reliability, meet sustainability initiatives and reduce operating expenses. Ballard supplies FCgen™-1020ACS (Figure 1) and FCgen™-1300 fuel cell stacks (Figure 4) to a variety of original equipment manufacturers for integration into their backup power systems, including Dantherm Power, IdaTech, FutureE, M-Field and Palcan Energy Corporation. Through these system integrators, Ballard's fuel cell stacks have been installed at over 600 telecommunications network sites around the world. These systems have seen 7.8 million service hours, operating for more than 600MW hours cumulatively.

Figure 1: *FCgen™-1020ACS fuel cell*

Fuel cells offer advantages over the batteries and diesel generators typically used to provide backup power for telecommunications networks. These systems offer greater reliability over a wide range of operating conditions, lower maintenance costs, longer operating life, reduced size and weight, smaller installation footprint and positive environmental impacts.

Fuel cell systems can play an important role in supporting the DoD's numerous installations and facilities with a 'mission-critical' need for continuous power. The systems are highly durable, even in the harsh environments common to DoD activities. Extended duration is a particular advantage of the systems, as the fuel storage can be sized to match requirements of 24 hours or more.

SUCCESS STORY:

IdaTech's ElectraGen™ systems (Figure 2), powered by Ballard fuel cell stacks, are particularly well suited to meeting the DoD's requirements for a U.S. built system. The systems are fueled with HydroPlus, a mixture of methanol and de-ionized water, which is more readily available than hydrogen and cost comparative to diesel. Earlier in 2011, IdaTech systems began operation in a five year demonstration program with the DoD under the CERL acquisition.

Figure 2: *IdaTech system powered by Ballard fuel cell stacks*

2. Distributed Stationary Power

Fuel cells have the potential to reduce emissions associated with traditional approaches to electric power generation and heat production. PEM fuel cells, in particular, have the unique ability to meet the power demands of distributed generation, being one of the few technologies capable of providing both baseload power and load-following capabilities. As a result of many years of focused development for transportation applications, PEM fuel cells feature the capacity for fast startup and dynamic operation. This allows the systems to closely follow electricity demand, maximizing efficiency.

Figure 3: *1MW CLEARgen™ system installed at FirstEnergy*

A 1MW CLEARgen™ system, the largest PEM fuel cell system in North America, has been installed at FirstEnergy Corp.'s Eastlake plant, near Cleveland, Ohio (Figure 3) for use in a utility load management demonstration project. FirstEnergy Corp. activates the hydrogen-fuelled generator during periods of peak demand, taking strain off the power grid and ensuring uninterrupted power to customers. Results during the first year of operation have been positive.

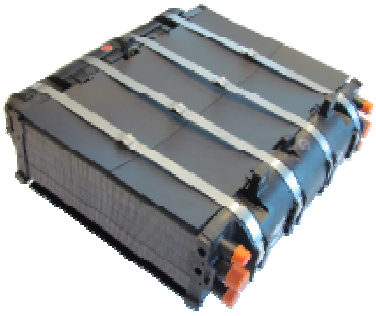

Figure 4: *FCgen™-1300 fuel cell stack*

Ballard's CLEARgen™ fuel cell system is a complete fuel cell power solution, designed to generate clean energy from hydrogen. The system is based on modular PowerBanks that are combined to produce multiple megawatts of zero-emission electricity, with heat created by the system providing hot water and space heating. This system is based on the FCgen™-1300 stack (Figure 4), a cost reduced derivative of established automotive technology.

Fuel cell combined heat and power provides an opportunity for military facility energy reduction. Ballard's experience in residential CHP includes 800 installed Ebara-Ballard units in Japan exhibiting 20,000 hours lifetime. Fuel to useful work efficiencies of more than 90% were demonstrated. Recent work at Ballard's Dantherm Power group is focused on 1.0 kW residential CHP for European markets and are presently in Danish field trails. These units operate well on LPG where pipeline gas is not available.

3. Non-Tactical Material Handling Equipment & Ground Support Equipment

3.1. Non-Tactical Material Handling Equipment

Ballard designs and manufactures high-performance FCvelocity™-9SSL (9SSL) fuel cell stacks for use in the material handling market (Figure 5). The 9SSL stack provides a scalable platform for system integrators and OEMs, ranging from 4-20kW in power, operates on hydrogen and provides durable operation for 10,000 hours.

Figure 5: *FCvelocity™-9SSL fuel cell*

Ballard is the exclusive fuel cell stack supplier to Plug Power Inc. The GenDrive® fuel cell systems manufactured by Plug Power address the complete range of class-1, -2 and -3 forklift trucks for the North American market (Figure 5). Approximately 1,200 Plug GenDrive® systems have been commercially deployed across the US through a number of leading North American distributors and manufacturers, including Whole Foods, BMW, Central Grocers, Coca-Cola, FedEx Freight, Sysco, and Wegmans, as well as at Walmart Canada. These deployments have logged over 4.5 million hours of service.

SUCCESS STORY:

The US DOD has been a strong and influential collaborator in developing fuel cell solutions for material handling market applications. In 2007, Ballard received $5.88M funding from the DoD against the following objectives: (1) executing cost reduction of the 9SSL fuel cell stack and (2) implementing a customer demonstration program that validates the commercial value proposition. Ballard successfully completed the field trial program with Plug Power and Sysco in Michigan (Figure 6) and this program has been a catalyst to other commercial deployments with Sysco.

Figure 6: *Fuel cell forklifts and hydrogen fuelling station at Sysco*

In 2007, Ballard received an additional $2M funding from the DoD to develop a low-cost hybrid solution for forklift applications that combines air-cooled fuel cells with incumbent lead-acid battery technology. This prototype is currently being finalized for testing and evaluation. The Defense Logistics Agency (DLA) Fuel Cell Pilot Project has also been an important contributor to early adoption, highlighting the business case for fuel cells and transitioning the technology to commercial markets. Ballard fuel cells with Plug GenDrive® systems have been installed at the DLA distribution centers in Susquehanna, Pennsylvania and San Joachin, California, as well as at the Joint Base Lewis-McChord in Washington State.

The DoD manages one of the largest distribution enterprises in the world and there are significant productivity gains to be made by adopting fuel cell powered material handling equipment. The best business case will exist in high-throughput operations, in locations that promote investment in hydrogen infrastructure (e.g., California, Connecticut, South Carolina and Hawaii).

3.2. Non-Tactical Ground Support Equipment

Powering ground support equipment (GSE) with fuel cells can reduce emissions, noise, and fossil fuel consumption while increasing energy efficiency. Ballard is actively exploring this application.

Several GSE demonstrations have been completed (Figure 7), including a Harlan tugger prototype developed with DoD funding (Figure 8). A feasibility study, being conducted on behalf of the Vancouver International Airport (YVR), is scheduled for publication in Q4 2011. Project partners include Ballard, Air Canada, Swissport, BAE Systems and YVR. A large scale demonstration of fuel cells for GSE applications is a potential opportunity to advance commercial growth and support DLA initiatives, leveraging on the fuel cell development, cost reduction and hydrogen infrastructure for similar forklift and transport applications.

Figure 7: *Fuel cell powered ground support equipment prototype units*

SUCCESS STORY:

In 2006, Ballard was awarded funding from the DoD to develop a prototype fuel cell system for ground support equipment (GSE) applications. Ballard built and delivered a 12kW fuel cell system fully packaged into a Harlan tugger for testing and evaluation (Figure 8). The prototype was based on Ballard's FCvelocity™-9SSL fuel cell stack for automotive applications and provided one of the earliest platforms for transitioning this technology to industrial vehicles.

Figure 8: *Fuel cell powered Harlan tugger*

4. Non-Tactical Personnel Transport (Buses)

Ballard manufactures the 75kW and 150kW FCvelocity™-HD6 fuel cell power module for integration into hybrid buses (Figure 9). Through volume deployments in North America, Western Europe, and South America, Ballard and its partners are demonstrating that fuel cell hybrid buses are on a path toward becoming a cost-competitive alternative to diesel buses. Ballard's FCvelocity™-HD6 modules power the fuel cell bus fleet operated by BC Transit in Whistler, British Columbia. At 20 buses, it is the largest fuel cell bus fleet in the world and reduces greenhouse gas emissions by approximately 2,000 tons per year.

Figure 9: *FCvelocity™-HD6 fuel cell module*

Zero-emission fuel cell-powered buses deliver economic, operational, and environmental benefits, when compared to traditional diesel or diesel hybrid systems. Economic benefits are a direct result of increased fuel cell efficiency and reliability. And fuel cell buses emit only water vapor, eliminating air pollutants such as nitrogen oxides, sulfur oxides and particulate matter. Fuel cell buses can also significantly reduce greenhouse gas emissions on a "well-to-wheel" basis, when compared to conventional technologies.

There is an opportunity to co-locate fuel cell buses at DoD facilities with hydrogen infrastructure in place for other fuel cell installations, such as material handling equipment.

SUCCESS STORY:

Ballard and BAE Systems have partnered in the design and build of a Buy America compliant fuel cell bus (Figure 10). Buy America provisions ensure that transportation infrastructure projects are built with American-made products, creating jobs and strengthening the US economy. Now that a compliant product is available, fuel cell buses are slated for operation at transit agencies throughout the US.

Figure 10: *Buy-America compliant fuel cell bus*

EARLY DEMONSTRATION STAGE MARKETS

Reductions in fuel cell stack and system cost are critical to fuel cell commercialization, Ballard aims to continuously reduce the cost of the product year-over-year while maintaining key characteristics such as durability and reliability. These cost reduced prototype stacks and systems are available for preliminary integration activities and are considered near term product opportunities. Longer-term development activities include further reductions in product cost as well as reductions in volume and weight, which can be achieved through stack design, system design and stack-system integration.

The following collaboration approaches, which include new application demonstrations based on mature technology as well as developing near term technology, are suggested to meet the DoD's technology objectives:

1. Fuel Processor Design and Development

In addition to fuel cell stack technology, Ballard's FuelWorks facility in College Park, Maryland is developing multi-fuel, low cost, fuel reforming technology. This fuel reformer will be capable of handling a range of fuels, including JP8 when used with appropriate liquid phase sulfur removal technology. Previous generations of this technology have been thoroughly field tested on natural gas. Ballard has deployed more than 800 systems to Japanese homes. Product lifetimes of longer than 20,000 hours have been demonstrated. Design evolution is shown in Figure 11. The baseline field tested fuel processor technology (TRL 8) offers a cost of $3,200/kW; however, the lab technology (TRL 4) offers a significant reduction in cost, while the next generation concept (TRL 2) is forecasted to achieve the target cost of $250/kW. With customer interest, Ballard will further develop the lab scale fuel processor from a TRL 4 to TRL 6 for use in APU deployments. This fuel processor technology can be combined with several Ballard fuel cell stack technologies, in some cases without the need for expensive system components such as palladium membranes. The design can also be scaled down for sub kilowatt, low mass, UAV and squad power applications.

1.0 kWe Fuel Processor Design & Cost Evolution			
	2005-2008 Field Tested (TRL 8)	Lab Developed to TRL 4	Next Generation (TRL2)
Length (in)	21.7	18.7	18.7
Major Dia (in)	6.4	5.6	3.4
Volume (Liters)	6.0	4.1	2.9
Structure Weight (lbs)	28.0	15.2	11.6
SR Catalyst Bed (lbs)	1.0	0.4	0.4
WGS Catalyst Bed (lbs)	5.2	2.9	0.7
PrOx Bed (lbs)	1.2	1.0	0.4
Total Weight (lbs)	35.4	19.4	13.0
Parts Count	~ 80	47.0	<30
Welded or Brazed Joints	~ 80	42.0	<20
Cost at 10,000 Units/Year 5.0kW Units ($/kWe)	$3,200	$800-$1000	$200-$250

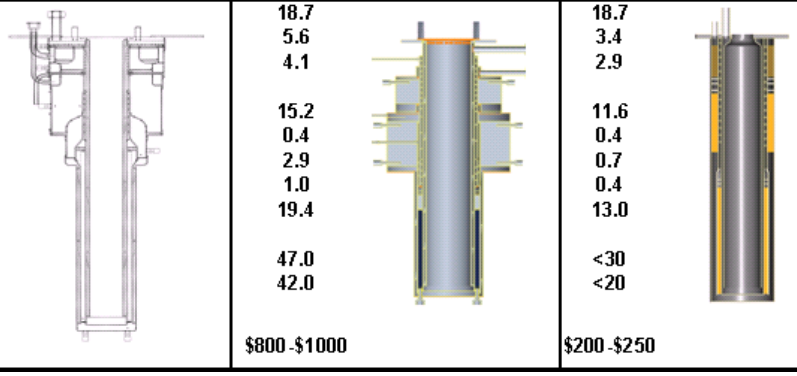

Figure 11: *Fuel processor design evolution and cost reduction*

2. Wearable Soldier Power, Unmanned Vehicle Power and Mobile Electric Power

Ballard's air-cooled stack design, the FCgen™-1020ACS (TRL9) currently used in backup power applications, is generating significant use due to an innovative cooling and humidification strategy that allows for system simplification and low system cost.

Based on this stable fourth generation stack product, Ballard has developed a prototype light-weight, low-power air-cooled fuel cell stack the FCgen™-micro (Figure 10) for early evaluation. The FCgen™-micro offers a 40% increase in power density on a weight basis compared to the full scale FCgen™-1020ACS and was developed from a TRL 2 to 4 over six months with the capability to produce prototype stacks in a production relevant environment.

Figure 12: *55W FCgen™-micro*

Ballard's FCgen™-micro is a scalable, low cost, hydrogen fuelled concept that allows for a simple system design, ideal for volume and weight constrained systems such as soldier power, unmanned aerial or ground vehicles (UXVs) and mobile electric or squad power. This stack design does not require humidified reactant gases and is designed to utilize a combined oxidant and coolant delivery system, allowing for a significant reduction in the number of system components and overall product cost when compared to a conventional liquid-cooled system.

The overall strategy for soldier power, UXV's and mobile electric power is to offer a single power scalable platform that is compatible with a range of fuels, including chemical hydrides, reformed fuels and pure hydrogen; this would simplify fuel distribution and training programs for deployment of this technology. The current focus is on a 50W system that can be scaled to 200W; however analysis indicates that this stack concept can be scaled from 20W to 2kW.

Figure 13: *Prototype PEM fuel cell micro-generator (45W net, 250Wh energy storage)*

The next phase of development for the FCgen™-micro is to develop the 50W soldier power concept to a TRL 6 system demonstration and investigate multiple fuel source and processing systems that enable light weight fuel storage. Initial analysis indicates that this fuel cell platform can offer equivalent power to the Li145 lithium-ion battery with more than a 50% reduction in weight for a 72 hour mission and 25% reduction in cost over 1000 hours of service, when combined with sodium borohydride as a fuel source. Figure 13 illustrates a prototype PEM fuel cell system that incorporates Ballard's FCgen™-micro and a sodium borohydride fuel cartridge

Scaling this fuel cell technology to higher power for use with UXVs as well as mobile electric power offers the potential to significantly enhance operational capabilities, providing reduced size, weight, noise profile and increased power density over conventional systems. A significant benefit fuel cells provide UXVs is extended range and fuel efficiency over a dynamic duty cycle when compared to batteries and typical generators. From a system perspective, the stack and reformer design are significant contributors to the overall system weight and volume; with customer interest further reductions in stack and reformer weight are possible for UAV applications.

3. Micro-Grid and Auxiliary Power Units for Land, Sea and Air

Compared to diesel generators, fuel cells for main or auxiliary power offer reduced fuel consumption as well as reduced acoustic and thermal detectability. Fuel cells for use as auxiliary power units (APUs) or micro-grid power also offer efficient on-demand power over a wide power range, whereas diesel generators often run inefficiently and waste valuable fuel when power requirements are low.

There is a movement to use renewable technologies such as solar, wind, wave and geothermal for micro-grid applications. A significant issue with renewable power systems is, due to their unpredictability, they cannot be relied on to meet 100% of the power demand. Combining a fuel cell system with a power grid based on renewables can resolve the issues of intermittent renewable power and allow renewable power systems to provide a very high percentage of the power demand.

Figure 14: *Prototype APU incorporating Ballard fuel cells*

Ballard has developed a prototype APU (Figure 14), based on the mature FCvelocity™-9SSL fuel cell stack product (TRL9). Utilizing mature stack technologies avoids excessive product development costs, reduces the risk at demonstration sites and allows for more system integration and packaging optimization. With further DoD collaboration, TRL 6 advanced stack technology that leverages Ballard's FCvelocity™-HD6 module (TRL9, Figure 9) can be integrated to offer further reductions in cost, weight and volume. This advanced product is ready for mobile or stationary demonstration and is capable of operating between 5kW and 150kW. The core stack technology was developed for automotive applications and is therefore designed to provide high, compact power with capability to maintain power through the shock and vibration of a typical drive cycle.

Stationary fuel cell micro-grid applications that are required to run on reformed fuel, such as natural gas or JP8, are possible when combined with an appropriate fuel cell stack and reforming technology. Prototype stack concepts (TRL 4) that leverage the FCgen™-1300 stack architecture integrate advanced technology to tolerate the fuel impurities found in reformed fuels. This stack technology combined with advanced reformer technology (TRL4, Figure 11) could be prototyped to a 25kW demonstration system capable of running on a number of fuels and has the potential to be scaled for higher power applications. This system concept also has applications for onboard power for ship propulsion or port-based systems to power cranes or ships when docked.

Using reformed fuels in APU and micro-grid power applications efficiently uses the available fuel; however combining a renewable based grid with hydrogen energy storage and hydrogen production via an electrolyzer using excess power can also provide a reliable and renewable power solution.

CONCLUSION

Over the last 20 years Ballard has established its world leadership position in the fuel cell industry by researching, developing and manufacturing zero-emission proton exchange membrane fuel cell products. To date, Ballard has shipped more than 100MW of fuel cell products for motive and stationary market applications and continues to grow each year.

Direct customer experiences have validated the significant economic value and performance benefits of fuel cell solutions in a variety of applications and vertical markets. And the business cases for Ballard fuel cell products are continually being strengthened through product cost reductions, which are a key focus of our ongoing product development activities.

As demonstrated throughout this paper, Ballard's proprietary fuel cell technology is highly flexible, making it suitable for a wide variety of applications identified by the DoD as areas of interest. Ballard's business focus is on commercial opportunities in backup power, distributed generation, material handling and bus applications, resulting in products that are highly functional and ready for full deployment by the DoD today. In other emerging markets, Ballard has invested in concept development and is pursuing opportunities with the DoD to deploy these prototypes in demonstration programs.

Product / Application Matrix:

	FCgen™-micro	FCgen™-1020ACS	FCgen™-1300	FCvelocity™-9SSL	FCvelocity™-HD6	CLEARgen™
2010 Average Sales Price	n/a	US$650-2,600/unit	US$2,800-11,200/unit	US$2,000 – 10,000/unit	US$337,500 – 675,000/unit	US$3,500/kW
Rated Power	50-200W	450W-3.6kW	2.4-10.5kW	3.8-21kW	75, 150kW	500kW to multi-MW
TRL	4	9	6	9	9	9
Portable (Soldier, UXV, man-portable)	✓					
BUP		✓	✓			
MH / GSE		✓		✓		
APUs			✓	✓	✓	
Buses					✓	
Micro-Grid					✓	
DG / Micro-Grid						✓