

BALLARD®

power to change the world

Driving Commercialization of Fuel Cell Mass Transit Buses

*Fuel Cell Seminar
November, 2009*



BALLARD POWER SYSTEMS

BUILDING A CLEAN ENERGY GROWTH COMPANY

WWW.BALLARD.COM

NOVEMBER 2009



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CLEAN ENERGY FUEL CELL PRODUCTS...

▶ OUR COMPANY

- Approximately 335 employees
- World-leading R&D & manufacturing facilities
- Locations in Vancouver, Canada (HQ) & Lowell, MA

▶ OUR BUSINESS

- Design, manufacture, sale & service of hydrogen fuel cell products

▶ OUR CUSTOMERS

- System integrators and OEM's addressing end-user needs: materials handling, telecom backup power, residential cogeneration, and transit buses

▶ OUR FOUNDATION

- *Technology Leadership* – 350+ Patents and patent applications
- *Production Expertise* – Shipped over 100MW fuel Cell Products
- *Expanding Go-to-Market Capabilities* – Powered over 1,000 stationary installations and over 200 heavy and light duty vehicles



The Company

- Design, manufacture, sale & service of hydrogen fuel cell products
- Acknowledged leader in zero emission **PEM fuel cells**

Our Focus




- Power **lift trucks** (~\$1.5 billion addressable market)
- Provide **backup/supplemental power** (~\$2 billion addressable market)
- Power other emerging applications

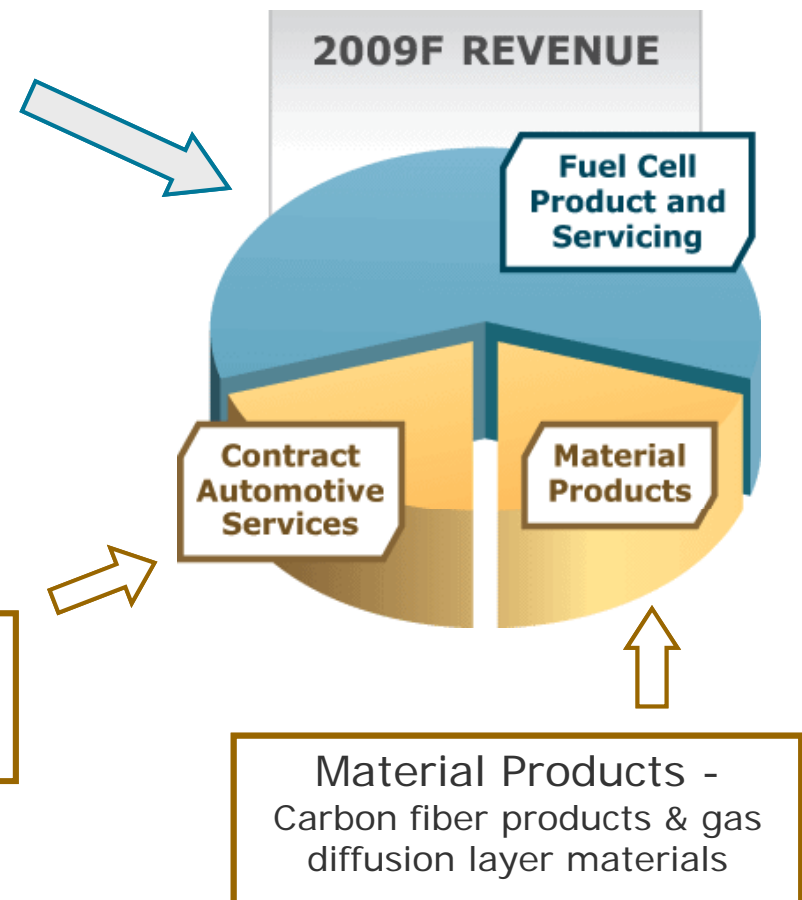
Our Customers

- **System integrators, OEM's, utilities** including:
 - Plug Power
 - Dantherm
 - Motorola
 - ACME Tele Power
 - IdaTech
 - BC Transit
 - Raymond Corp.
 - Exide Technologies

The Opportunity

- To become a **profitable clean energy growth company**
-

Clean Energy Fuel Cell Products	
Stationary Power	Motive Power
	 



Fuel Cell Growth Markets			
Stationary Power		Motive Power	
Backup Power	Distributed Power Generation	Material Handling	Heavy Duty

Leading Fuel Cell Products Portfolio



PRODUCTS	Power Level (gross)	Life	Product Positioning
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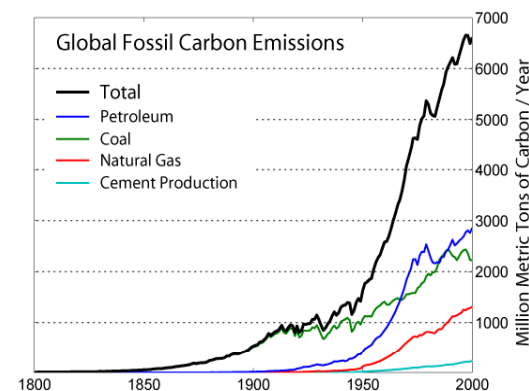
Stationary Power			
FCgen-1020ACS	0.3 – 3.4kW	4,000 hrs	Telecom backup power
FCgen-1300	2.3 – 11kW	10,000 hrs	Telecom backup power

Motive Power			
FCvelocity-955L	4.4kW – 19.3kW	10,000 hrs	Material handling applications
FCvelocity-HD6	75kW & 150kW	6,000 hrs	Bus & other heavy-duty applications



■ Reduced greenhouse gas emissions

- ▶ Demonstrated on a well-to-wheel basis



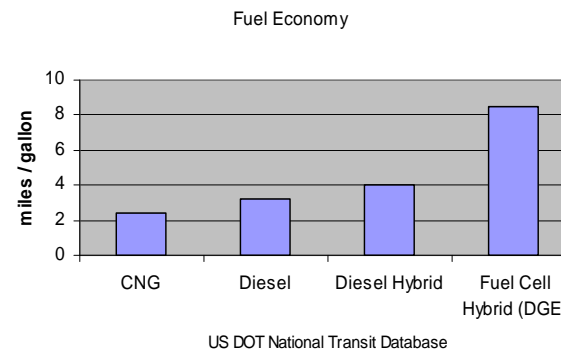
■ Complete elimination of tailpipe emissions

- ▶ Nox, Sox, PM



■ Improved fuel efficiency

- ▶ 1.5-2.5x improvement over conventional diesel buses on an energy equivalent basis



Bus Program Evolution



1991 - 1992



**Phase 1
Proof of
Concept**

1993 - 1995



**Phase 2
Commercial
Prototype**

1996 - 1999



**Phase 3 Fleet
Demonstration
Alpha Sites**

1999 - 2002



**Phase 4 Fuel
Cell Engines
Beta Sites**

2002 - 2009



**Phase 5
Serial
Production**

Power 90 kW /
125 HP

205 kW /
275 HP

205 kW/
275 HP

205 kW/
275 HP

205 kW/
275 HP

Location(s)

Vancouver

Vancouver

Chicago (3)
Vancouver (3)

California

5 Continents
CUTE (30),
Perth (3)
California (3)
Beijing (3)

Lessons Learned

Proof of
concept

Full-size bus
integration

Field service
Site
homologation

System
optimization
Cost reduction -
single motor
concept

International
homologation
Reliability growth
Real world usage



■ FCvelocity™ -HD6 fuel cell module:

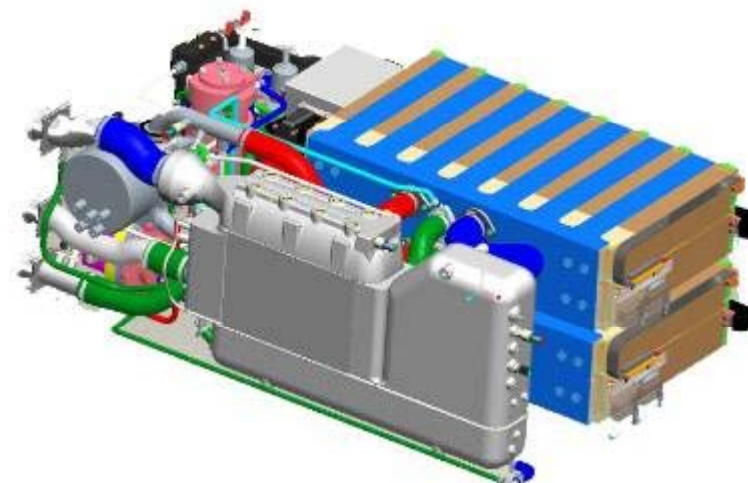
- Featuring state of the art automotive fuel cell stack technology
- Offered with a 12,000-hour or 5-year warranty



HD6 Module

■ Includes:

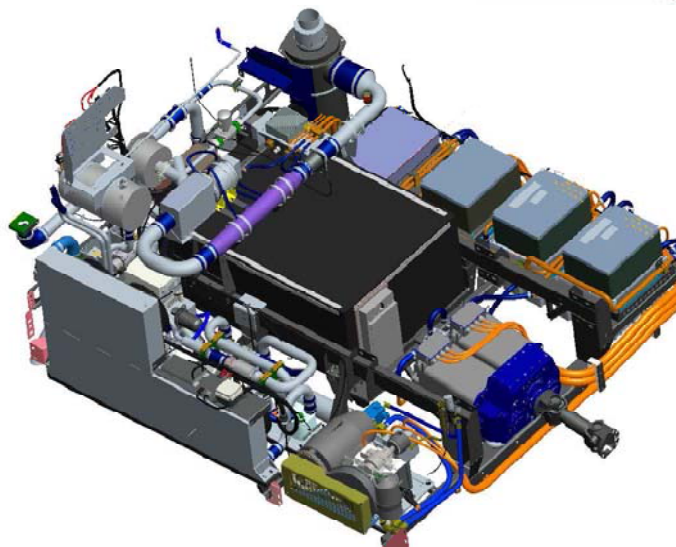
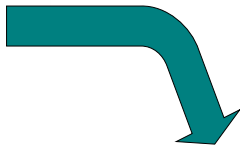
- air humidification system
- hydrogen re-circulation
- condenser for water management
- CAN and power supply connections
- control system



Integration into a Hybrid Drive

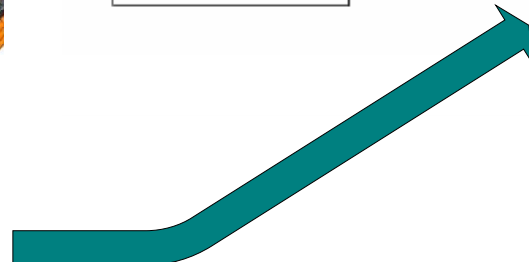
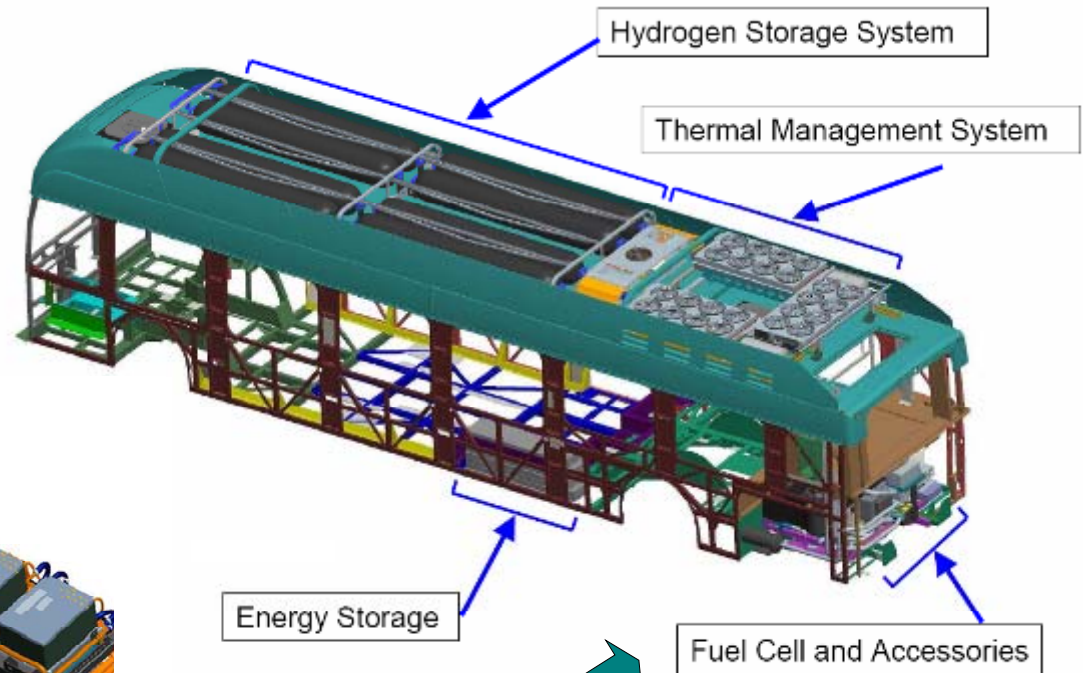


FCvelocity™-HD6



FC Hybrid "Cradle"

Hybrid System Packaging Overview



Courtesy of ISE Corp.



- **Test bus delivered in Q3 2008. Evaluation successfully completed!**
 - ▶ Production buses are currently being delivered
- **All 20 buses will be operational for the 2010 Olympic Games**
 - ▶ Continuing through 2014 in normal revenue service



BC Transit Test Bus Results



Testing completed October 31, 2008

Total kilometers: 8650

Total hours: 338

Parameter	Specification	Results
Range:	400 Km	400 – 550 km
Top speed:	90 kmph	103 kmph
Acceleration – 0 to 50 kmph:	20 seconds	19 seconds
Gradeability – 8% with 30 passengers:	30 kmph	30 kmph
Gradeability – 20% at full GVW:	Restarts from stop	Yes



- **Five fuel cell buses for operation in Central London**

- Using 75kW HD6 Modules due to low speed requirement and benign grades
- First bus to be delivered to Transport for London in December 2009



Transport for London



■ Phase I

- ▶ Ballard's automotive fuel cell stacks have been used for Phase I of the UNDP/GEF fuel cell bus program in Brazil
- ▶ This bus is now commissioned and operating in Sao Paulo



■ Phase II

- ▶ UNDP/GEF Phase II project will incorporate Ballard HD6 modules for an additional three buses



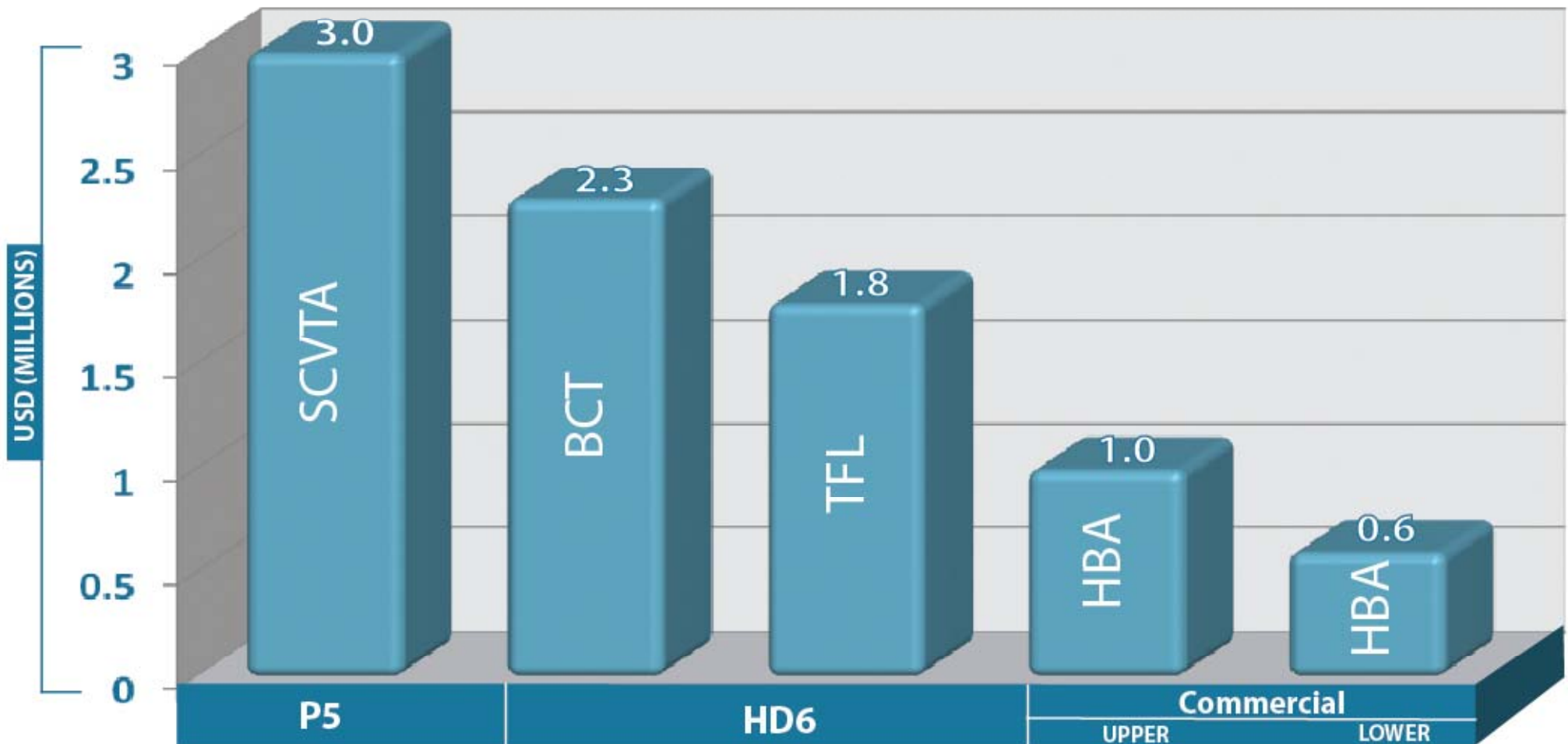
- **GE Global Research has contracted with the FTA to build a light-weight fuel cell hybrid bus**
 - Using a 75 kW HD6 module
 - Operation at the Capital District Transportation Authority in Albany, NY



GE Global Research
United States - India - China - Germany



Vehicle Capital Costs



Heavy-Duty Fuel Cell Module Development

2002-2008

2009-2012

> 2013



Technology
Demonstration
(Phases 1-4)



Pre-Commercial
Trials (Phase 5)

Commercial
Production

Key attribute improvements of each generation

- Performance
- Reliability
- Power density
- Durability (Warranty)
- Cost reduction
- Fuel efficiency
- Cost reduction
- Design for manufacture

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