Zero-Emission Fuel Cell Solutions for Rail Applications

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The future of rail propulsion is electric.

- Electric power is the efficient, clean and quiet energy alternative to polluting diesel engines
- Fuel cell propulsion offers the environmental benefits of an electric powertrain with the lower infrastructure cost of diesel
- Hydrogen and fuel cell enable longer distance routes than batteries
Fuel cells offer the benefits of electrification without significant infrastructure investment.

- No requirement for overhead catenary infrastructure
- Central hydrogen refueling avoids cost of electricity-generation plant, transformers, and transmission lines
Fuel cell-powered rail is zero-emission.

- Reduces GHG emissions in urban centers and at railyards
- Meets emission reduction goals and new regulations
- Enable zero-emission trains over non-electrified rail networks.
Fuel cell technology addresses several rail applications.

- Shunt /yard locomotives
- Regional and commuter trains
- Trams and Light rail
- Underground mining
Robust fuel cells meet the demands of rail applications.

Delivering performance, flexibility, range and top speeds demanded by the rail industry.
We have the leading technology.

• World leader in PEM fuel cells
• 2,000 patents & applications
• 320 MW of fuel cell products shipped
• Over 300 heavy-duty fuel cell engines shipped to date
FCveloCity® platform is the world leader for fuel cell heavy-duty vehicles.

- Zero-emission
- Safe (built-in safety features)
- Tested, quality-assured
- Durable (>23,000hrs stack life in service)
- Fuel efficient
FCveloCity®-XD for rail applications

- 100 and 200kW power modules
- Customizable product to meet application architecture constraints
- Designed and tested to rail-specific standards
FCveloCity® enables accelerated and flexible integration.

- Integration ready
- Air and cooling delivery systems
- Onboard controller
- Remote diagnostics
- Applications engineering support
- Integration tool kit
We have product testing capabilities

- Ballard has completed electromagnetic compatibility testing at a module and vehicle level
- The FCveloCity® modules are designed to a minimum of IP55 (IP56 for next generation product)
- Testing to validate the IP rating completed
- FCveloCity® module vibration tested
- Noise level testing
From bus to rail

- 20 years of experience in designing heavy duty fuel cell engines.
- Integration experience with multiple vehicle platform (bus, truck, train...)
- Proven technology with millions of operating hours in revenue service
We have the experience in rail applications

- Light rail with CRRC China
- BNSF Railway shunt locomotive in the USA
- JR East commuter rail in Japan
- Shunt locomotives in India
We are powering the world’s first fuel cell light rail.

- Fuel cell tram line in Gaoming district of Foshan
- Expected to enter in service in 2018
- Speed up to 70km/h with 100km autonomy
- 200kW fuel cell module for rail applications
- CRRC Qingdao Sifang Co, Ltd
We developed a prototype fuel cell powered shunt locomotive.

- Moves railroad cars over short distances
- Refueled at hydrogen station within railyard
- Public-private project partnership with Vehicle Projects, BNSF Railway, US Army Corps of Engineers & Ballard
Hydrogen is the energy source for fuel cells.

• A clean energy carrier and energy storage
• Commercially available
• Can be produced from natural gas, biogas, and electricity (including renewable sources)
• Hydrogen contributes to energy independence
Hydrogen is a flexible fuel.

- Safe and manageable
- Supplied as compressed gas or liquid
- Can also be produced on-site
- Existing infrastructure solutions
- Scalable fuelling infrastructure
Power to change the World®

- Committed to sustainable mobility and clean air for everyone
- Relentlessly developed technology 38 years
- We have leading talent, with >500 people passionate about our mission
- $85m in revenue in 2016, up 51%
We are strategically positioned.

- Customer-centric, diversified & synergistic business model
- Leader in core markets
- Strong balance sheet
- Listed for >20 years on NASDAQ and TSX
- Strategic shareholders:
We have the manufacturing capability.

- Over 30 years experience in manufacturing fuel cells products
- Capacity of 1 million MEAs and 10,000 stacks
- 24/7 operation, 400,000+ hours of data collected annually
- 50+ test stations, 10 environmental chambers
- Testing capabilities <100W to 333kW
Ballard is your partner of choice.

- We listen and deliver
- We deliver quality always.
- We row together.
- We own our commitments.
- We inspire excellence.
The solution for zero-emission rail is clear.

**Fuel cell and hydrogen powered rail:**
the affordable, operable zero-emission solution

**Ballard fuel cell products:**
proven technology, leadership, experience and commitment
Power to Change
the Word®

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