



PUTTING FUEL CELLS TO WORK

NASDAQ:BLDP • TSX:BLD

Fuel Cells: Technology and Feasibility



Green Power For Mobile Lagos, Nigeria 2014

Who We Are

- Ballard Power Systems
 - Recognized global leader in clean energy PEM fuel cell products & services
- Commercial Market Focus
 - Telecom backup power
 - Material Handling
 - Engineering Services
- Positioning for broader value creation
 - Development of continuous power system South Africa and beyond
 - Zero emission fuel cell buses licensing program development in China
 - Additional fuel cell licensing revenue streams ...as market develops
- 355 employees
- Operations
 - Canada, U.S.A University of Maryland, Bend, OR, Mexico, Denmark





Africa Activity & Market Overview

Africa Activity



South Africa

- >300 ElectraGen[™] ME systems deployed on Vodacom network
 - 20 Systems running as Prime power excellent results

O Uganda

- Project >1000 ElectraGen[™] ME 2014 / 2015
- Namibia
 - 2 ElectraGen[™] ME deployed







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Africa Market Drivers



- Our Control of Cont
 - Many countries have unreliable grid / low availability of grid / demand > supply
- 🖪 No Grid
 - Many countries have vast areas where grid has not reached yet
- Theft
 - Huge impact on operational costs and service availability
 - Diesel
 - Batteries
 - Generators
 - Solar panels
- Maintenance Costs
 - Frequent maintenance / no regular maintenance increase operational costs
 - Irregular maintenance drives frequency of equipment replacement
- Noise



Fuel Cells – Why?



- Quiet low noise signature
- Robust Operating range -40C to +50C
- Flexible Shelter, outdoor BTS, rooftop installations
- Power full Up to 15kW
- Autonomy Up to several days / months of uninterrupted power supply
- Iow Maintenance Minimal annual maintenance
- Ost Effective Attractive total cost of ownership
- Clean Energy Low emissions and low noise

What is a Fuel Cell?



- O Chemical reaction that produce DC power
- PEM fuel cell systems require hydrogen gas to produce electricity
- Hydrogen could be supplied either from industrial hydrogen gas cylinders or generated on site as needed.
- Today methanol fuel cell systems are commercially available





	ElectraGen™ ME	
Fuel Type	Methanol/water mix	
Power output	2.5kW or 5kW	Links
Size	1.3m x 0.9m x 1.7m (H)	
Weight	295kg	
Environment	Outdoor Installation	
Communication	Dry contacts and SNMP	





• Value Proposition

- Clean, efficient, reliable, quiet, easy to install, extended run backup
- Ompetition
 - Incumbent backup power technology: generators and batteries
- Advantages over incumbent technologies
 - Lower lifecycle costs
 - Higher reliability
 - Improved availability
 - Lower maintenance costs few moving parts
 - Less theft





- TCO Analysis for a Typical Telecom Collector/Hub Site

 24 hours per day
- General Site profile:
 - Outdoor BTS
 - No Grid
 - Load 3kW @48VDc
- Back-up solution:
 - Battery bank: 200 AH to 400 AH
 - O Diesel generator: 13kVA

TCO Diesel Genset + Battery



DIESEL + BATTERY BACKUP RUNNING 24 HOURS/DAY		TCO PERIOD	5	years
CAPEX				
Genset* + fuel tank		\$20,570		
Rectifiers + Equipment Cabinet +Controller		\$7,000		
Batteries		\$2,000		
Installation		\$791		
CAPEX	TOTAL	\$30,361		
OPEX				
Per hr fuel consumption		2.8	litres/hr	
Fuel cost per Litre (i.e., pure cost for fuel only)		\$0.88	per Litre	
Fuel Transport Cost per Litre		\$0.08	per Litre	
Fuel cost per month		\$684.00		
Generator maintenance		per genset every 250 \$809.28 hours - total cost pe month		every 250 I cost per
ΟΡΕΧ	TOTAL	\$17,919	per annum	
REPLACEMENT/REFURBISHMENT COSTS				
Replacement every 12,000 hours		\$10,285		
Battery Replacement after 3.5 years		\$2,000		
Genset major refurbishment after 8000 hrs		\$791		
REPLACEMENT/REFURBISHMENT COSTS	TOTAL	\$8,422		
TOTAL COST OVER TCO PERIOD	TOTAL	\$162,068.49		
Total Cost per Month over TCO period		\$2,701.14	per month	
Average site load		3	kW	
kwh over TCO period		131,400		
Cost/kwh		\$1.23		
* Genset always 2 on site				

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TCO ElectraGen[™]-ME 5kW



FUEL CELL + BATTERY BACKUP RUNNING 24 HOURS/DAY		TCO PERIOD	5	years
CAPEX				
Fuel cell system (5kW) with internal tank		\$26,641		
Rectifiers + Equipment Cabinet +Controller		\$7,000		
Batteries		\$2,000		
Installation		\$791		
САРЕХ	TOTAL	\$36,432		
OPEX				
Per hr fuel consumption		3.37	litres/hr	
Fuel cost per Litre (i.e., pure cost for fuel only)		\$0.84	per Litre	
Fuel Transport Cost per Litre		\$0.08	per Litre	
Fuel cost per month		\$657.00	per month	
FC maintenance		\$36.00	per month	
OPEX	TOTAL	\$8,316	per annum	
REPLACEMENT/REFURBISHMENT COSTS				
Replacement every 10,000 hours (stack & reformer)		\$15,000.00		
Battery Replacement after 3.5 years		\$2,000		
REPLACEMENT/REFURBISHMENT COSTS	TOTAL	\$13,711.43	per annum	
ECONOMICAL CONCLUSION				
TOTAL COST OVER TCO PERIOD		\$146,569.02		
Total Cost per Month over TCO period		\$2,442.82		
Average site load		3	kW	
kwh over TCO period		131,400		
Cost/kwh		\$1.12		

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- Business case shows that fuel cell is an attractive backup power or prime power solution for telecom sites
- Specifically suited to critical urban hub sites where noise / vibration is an issue
- Well suited to sites where grid quality is poor or non existent

Product Roadmap

ElectraGen[™] ME



Ionger Life

- Stacks and reformer
- 2015/16

O Cost

- Cost reduction programs in progress
 - Objective no price increase
 - Ballard increase low single digit margin sustainability

Modular Cabinet Design

- Allow for larger tank at the bottom
- Split Reformer away from Stacks
 - Allow for larger kW requirements





- Channel Partner appointed in-country
 - Nigeria MP Infrastructure Nigeria / Inala Technologies
- Resources identified and trained by Ballard Engineers
 - Continual process as product evolves
- ¹ 2nd Tier Support available 24/7 from Ballard
- 3rd Tier Support available by Ballard within 24/48 hours
- When required Engineer flown from Ballard to Partner in country
- Strong Fuel Partner Protea Chemicals (Omnia Group)

Protea Chemicals





Refueling



HydroPlus[™] Refueling

- Siphon: < \$20
- Hand pump: < \$200
- Electric pump (needs flooded suction):
 < \$500
- Centrifugal pump (will prime): < \$500
- Custom Refueling Unit: ~ \$10,000



Drum Pump Chile



0017408



Custom Mobile Refueling System

Jiggle Siphon



Siphon Pump, Indonesia





12VDC Pump Jamaica

Deployment / Case Studies

Telecom Backup Power ~ 3,000 Systems Installed





Case Study: Fuel Cell Prime Power System for Vodacom

Customer:

- Vodacom, a leading African communications group
- Location: Johannesburg
- Industry: Telecommunications

Challenge:

- No grid (installation delays)
- Community complaints about generator noise
- Huge theft issues on generators and batteries

Solution: / ElectraGen-ME

- Configuration: 5kW, 48 Vdc
- Fuel: HydroPlus[™] (Methanol-Water liquid fuel)
- Added external 1,000 liter tank

Advantages:

- Small footprint
- Reduced noise
- Reduced emissions
- High efficiency
- Minimal maintenance
- Renewable energy supply
- Running since June, 2012 > 582 days
- Excess of 13,968 hours
- Excess of 18,158 kWh

vodacom



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Case Study: Fuel Cell Backup Power System for Vodacom

Customer:

- Vodacom, a leading African communications group
- Location: South Africa
- Industry: Telecommunications

Challenge:

- Remote location
- Unreliable grid
- Aim to reduce maintenance costs
- Minimize impact on environment

Solution: / Electra Gen-ME

- Over 280 systems deployed
- Configuration: 5kW, 48 Vdc
- Fuel: HydroPlus[™] (Methanol-Water liquid fuel)

Advantages:

- High efficiency
- Improved reliability
- Minimal maintenance
- Renewable energy supply
- Zero emission





BA

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