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High Temperature PEM Fuel Cell/Lithium Ion Hybrid Power Source for Ground, Air and Sea Platforms

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EnerFuel Fuel Cell/Li-Ion Hybridization

- Fuel cell sized for average power, battery for peaks
- Smaller fuel cell and battery
- Reduced fuel cell and battery cost
- Maximizes fuel cell and battery longevity
- Rapid startup

*Controls electronics, buck converter, and power conditioning
Fuel Cells & Batteries Enhance Each Other

Power / Energy Comparison

- **EnerDel** Fuel Cell
- **Li-ion Batteries**

Cost Comparison

- **EnerFuel**
- **Fuel Cell**
- **Li-ion Batteries**

Energy Density

Power Density

Energy Cost

Power Cost

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EnerFuel High Temperature PEM Fuel Cell Technology

- SIMPLE
- EFFICIENT
- LIGHT WEIGHT
- FUEL FLEXIBLE
- APPLICATION FLEXIBLE

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Simple

- Air cooled fuel cell stack, no radiator and liquid cooling system
- No liquid management problems
- No humidification of inlet air necessary
- Inherently suited to low cost mass production
• Efficiency greater than 42% (including power conditioning)
• Startup*: 50% power in less than 1 minute
• Startup*: <280 Wh (1.0 MJ) from +20°C
Light Weight

- Near-term commercial product: 133 W/kg
- With aggressive weight reduction: >150 W/kg

\[ \text{Fuel Cell Stack} \rightarrow 4\text{kW} @30 \text{ kg} = 133 \text{ W/kg} \]
Fuel Flexible

- Can accommodate low quality reformate (CO ≤ 3%)
- Can use low cost reformer w/ minimal cleanup stage
- Possible fuel choices: methanol, NG, diesel, JP8

*H₂ rich gas
Application Flexible

- APU, backup power, primary power
- Tolerate wide range of environmental temperatures
- Less susceptibility to freezing
- Low thermal & acoustic signature
Transition to Commercialization
HT-PEM Fuel Cell System Status

Specifications
- TRL-6 equivalent
- 57 kg
- >40% efficient
- $80k
Near-Term Product Goals

• **Weight & Cost**
  – Consolidate control/power electronics into single module
  – Stack material replacement and component reduction
  – Projected weight of: 30kg
  – Projected fuel cell cost: $9k*

• **Timeline**
  – Commercial ready product by end of 2011

* Minus margin, battery, or reformer
Company Overview
The EnerFuel Team

- Senior staff of 10 with an average fuel cell experience of 12 yrs
- Majority of senior staff legacy of energy partners

- Staff composition:
  - Mechanical Engineers
  - Systems Engineers
  - Electrical Engineers
  - Material Scientists
  - Computer Scientist
  - Chemical Engineer
  - Industrial Designer
  - Chemist
  - Technicians with close to 20 years individual fuel cell experience
  - Business professionals
HT-Fuel Cell System 1kW to 15kW

NG or LPG
Reformer Core
EnerFuel Technology

Initial Market Application
Backup Peak Shaving
APU & EV Range Extender
Fuel Cell Vehicle

Provides Point of Use Energy storage and Backup for the Electric Grid
• Increases grid efficiency
• Increase grid reliability
• Reduces carbon emissions

Key to Mass Market EV
• Increases driving range
• Reduces vehicle cost

Commercialization Timeline:
Proof of Concept - 2008
First Article Test – 2010
Product Qualification – 2012
Incorporation into OEM vehicle - 2013
Prototype Vehicle Range Extender Specifications

EnerFuel Fuel Cell PHEV

- 3 kW fuel cell system
- 20 kWh net capacity
- 60 to 80 mile range extension
Q&A

Please Visit Booth 111 for Additional Information

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