Ultra ELECTRONICS

combined **strength**

Solid Oxide Fuel Cells to Reduce the Logistics Burden

Saving time, saving money, saving lives while expanding the flexibility and capability of small units

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Outline

- AMI Introduction
- 300 Watt APU
  - Limited User Test & Feedback
- Right Sizing Power Solutions
- Real World Costs

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AMI

ANN ARBOR, MICHIGAN

- Portable Solid Oxide Fuel Cell Systems
  - 50W to 500W continuous power generation
- Acquired by Ultra Electronics in January 2011
- Located in Ann Arbor, Michigan USA
  - Founded in 2001
  - > 65 Full-Time employees

LEADING THE PORTABLE POWER REVOLUTION

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AMI

MANUFACTURING CAPABILITY

- Facilities
  - 48,000 ft^2
  - Multi-purpose (Research / R&D / Production)
- Building Volume Production Capacity
  - Tube Production
  - Cell Fabrication
  - Stack Production
  - System Assembly
  - System Validation

POWDER TO POWER UNDER ONE ROOF

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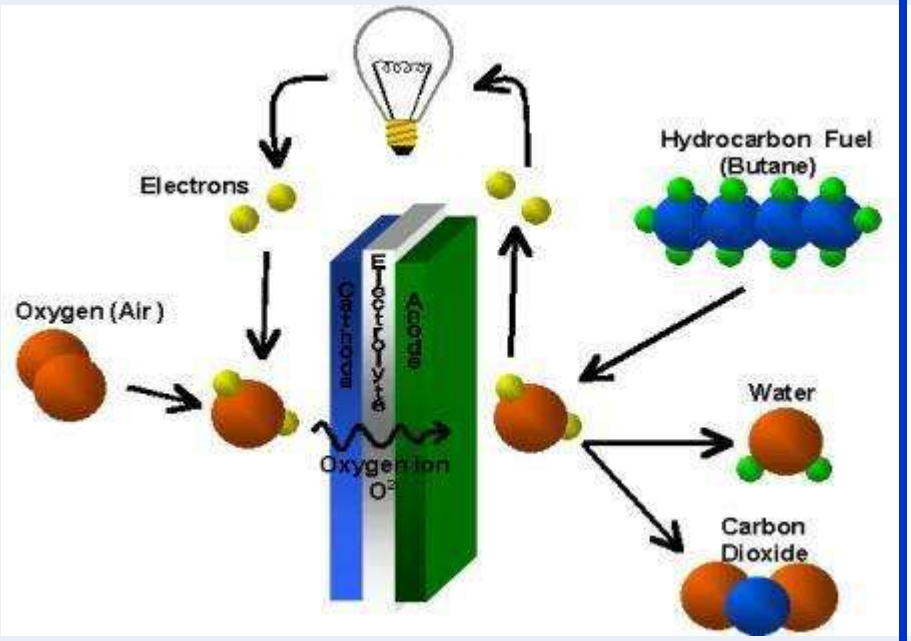
Fuel Cell Technology

Solid Oxide Fuel Cell (SOFC)



AMI SOFC Technology

Rugged and High Performance Solid Oxide Fuel Cells

- Ceramic Fuel Cells
  - Inexpensive raw materials
- Tubular SOFC Architecture
  - Thermal shock – rapid start
  - Mechanical shock - rugged
- High Temperature, 600-800°C
  - ★ Direct hydrocarbon fuels

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Power and Energy Segmentation

AMI TARGETS 50 TO 500 WATT APPLICATIONS

- Increasing power demands of portable devices
- Existing solutions are insufficient
  - Too big for batteries: not replenished by fuel; size and runtime constraints
  - Too small for engines: many moving parts; bulky, heavy, noisy, dirty
- Low capital costs make purchasing accessible

Megawatts	Kilowatts	*AMI Target Segment* Watts	Milliwatts
Utility Generation Tens of thousands of units Huge Capital Cost Decades	**Engines and Generators** Tens of millions of units Large Capital Cost Years	**Portable Power** Hundreds of millions of units Small Capital Cost Life Varies Considerably	**Mobile Power** Tens of billions of units Tiny Capital Cost Hours

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AMI

FUEL CELLS IN OPERATION

- AMI fuel cells have been deployed in the most demanding environments for a variety of applications.

- **RUGGED, LIGHTWEIGHT, RELIABLE**
- **GLOBALLY AVAILABLE FUELS**

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AMI

PORTABLE SOFC APPLICATIONS

- Broad End Markets
  - Man portable power
  - ISR
  - Unmanned systems
- AMI Fuel Cells deliver energy wherever and whenever it's needed most.

PROPANE, POWER, PRICE ADVANTAGE

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Energy & Availability = Capability

Energy

BA5590 Military Battery

~170 Watt-hour
~$90

1,000 Watt-hour
$2.47

Fuel Availability

Iraq

Afghanistan

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300 Watt APU

- Volume
  - 15.75” by 8” by 14”
  - 29 L (34 L with fuel sub)
- Mass
  - 11.6 KG
- Performance
  - 300W at 28.8 Volts
  - 200-300 On/Off Cycles
- Fuel Consumption
  - 0.12 kg/hr

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Limited User Testing, Fort Riley Kansas

300 Watt Charger

- 2 days of missions
  - 3 testing lane
  - Multiple mission scenarios
- Immediate feedback from Soldier on system effectiveness

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Limited User Testing, User Feedback

300 Watt Charger

- User Feedback
  - Too big and heavy for Tier 1 operation – make it smaller
  - Easy to use – operation was simple
  - User interface was too hard to read in low light
  - Remove the battery charger and make it a stand along power supply
  - They already buy propane from local sources when they set up in foreign locations
    - User wanted to be able to use local propane sources
- AMI's Response
  - Eliminated battery charger reducing total weight to <25lbs
  - Added display backlight for ease of use
  - Added a fuel line for use with COTS propane tanks
- System scheduled for shipment to Afghanistan in July 2011

300 Watt APU

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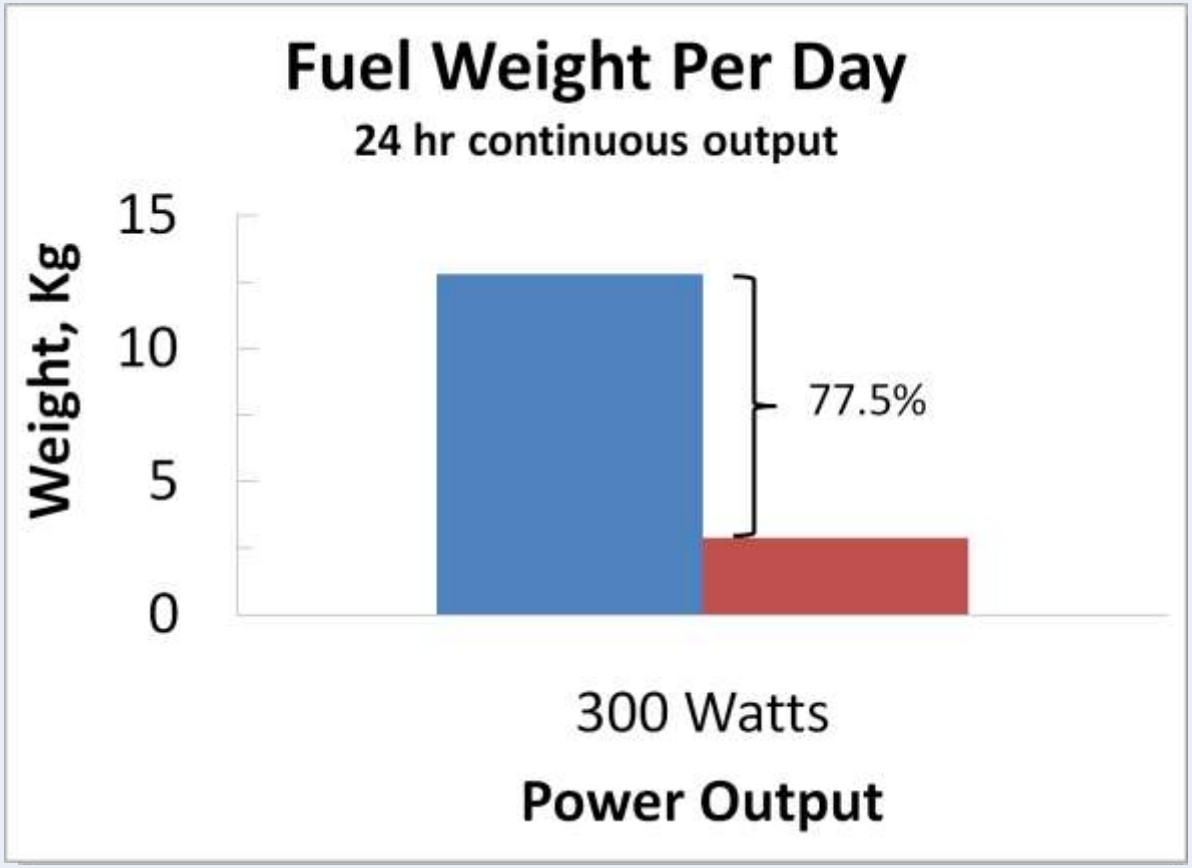
Right Sizing Power Solutions

Sample Scenarios



77.5% reduction in fuel resupply to maintain operations

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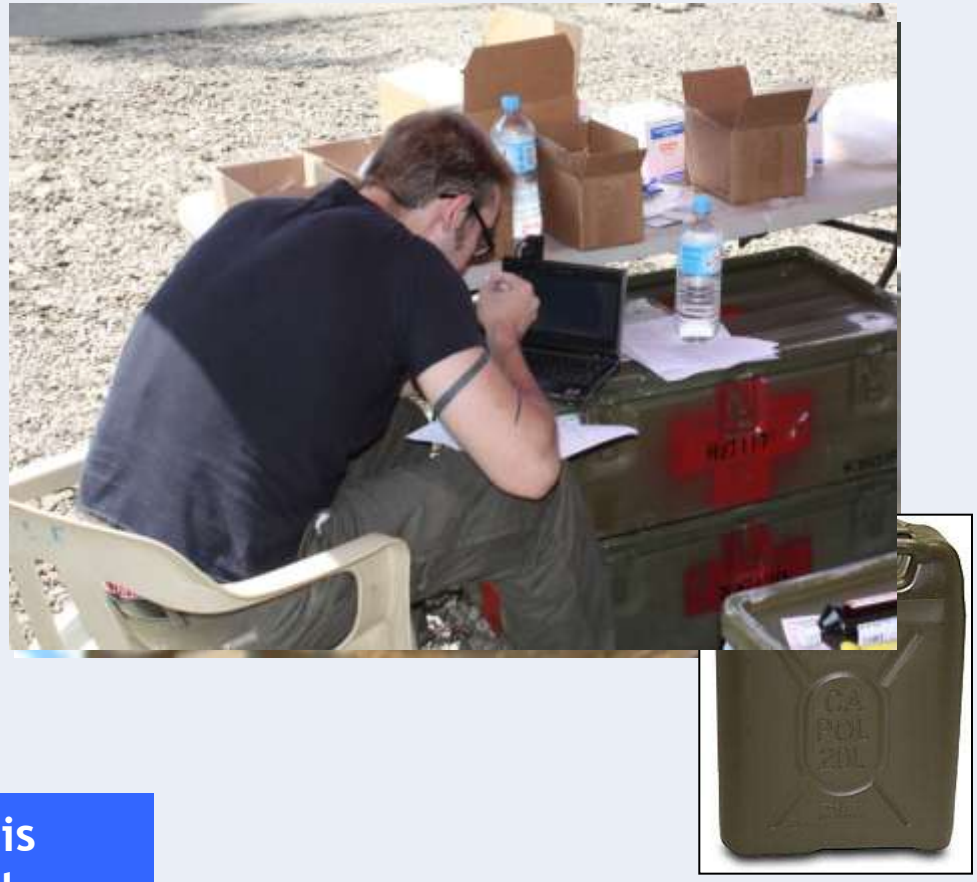
Real World Examples

Right sizing power solutions

- Cobra Gold 2009
  - 3 kw TQG
  - Charging an iPod
- MEDRETE – Dom Rep
  - 5 gallons of JP-8 to run a 3kW generator for a day
  - Powering a single laptop
  - Flown in on a CH-53E
    - $20,000 / flight hour



- **Matching the demand to the supply is critical in maximizing efficiency and lowering operating cost**

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Real World Costs

- "The casualty factor for fuel resupply in Afghanistan is .042 …… for every fuel-related resupply convoy or one casualty for every 24 fuel resupply convoys in Afghanistan. (AEPI Report 2009, Sustain the Mission Project: Casualty Factors for Fuel and Water Resupply Convoys)

- "Due to poor to non-existent roadway infrastructure, and the high risk of enemy activity, Wasa K'wah has not had a convoy ground resupply in nearly three years. "Tech. Sgt. Stacia Zachary

- "The GAO report said that in June 2008 alone, 6.2 million gallons of fuel went for air and ground operations, while 917,000 gallons went for base support activities including lighting, running computers, and heating or cooling." (The Washington Post, December 2009)

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Questions?

Smaller, Better, Greener

Saving time, saving money, saving lives

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