Hybrid-Intelligent POWER
“HI-POWER”
HI-Power Concept

Sources

HI-Power provides...

- Plug & Play connectivity
  - Sources
  - Loads
- Intelligent control
  - Source management
  - Load management
    - Load shedding
    - Load scheduling
    - Load prioritization
    - Phase balancing
- Legacy interoperability
  - TQGs
  - PDISE

Loads

Data

Power

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
Power Islands vs. Central Power Buss

- Enables Intelligent control of sources & demands
- Enables Plug&Play addition of gensets, renewables, energy storage
- Saves fuel, reduces cost, reduces emissions
Power for Stryker Brigade

Current Situation

No…
Power Grid
Intelligent distribution
Renewables
Energy Storage

HI-Power Concept

Power line
Intelligent Power grid

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
Direct / Indirect Benefits

• **Power Production:**
  – Fuel Savings
  – Cost Savings
  – Longer life (fewer operational hours per mission)

• **Transportation:**
  – Reduced # of Prime Movers
  – Potential for smaller, less-costly, more fuel-efficient Transport Vehicles

• **Emissions:**
  – Reduction is a by-product of lower fuel consumption

• **Wide Applicability:**
  – FOBs, Division-to-Battalion, Echelons above Division (EAD)

• **Operational Benefits:**
  – Lower Noise
  – Greater redundancy
  – Flexibility
  – Reduced O&S Costs
  – 24/7 Operational Capability
  – Smaller footprint

• **Force Protection**
<table>
<thead>
<tr>
<th></th>
<th>Max Power Draw (kW)</th>
<th>Daily Fuel Usage (gal)</th>
<th>% savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>96</td>
<td>162</td>
<td>-</td>
</tr>
<tr>
<td>Future (w/GRID)</td>
<td>96</td>
<td>139</td>
<td>14</td>
</tr>
<tr>
<td>Future (w/GRID &amp; on/off Control)</td>
<td>96</td>
<td>134</td>
<td>17</td>
</tr>
<tr>
<td>Future (w/GRID, on/off Control, &amp; Right-sizing)</td>
<td>96</td>
<td>129</td>
<td>20</td>
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</tbody>
</table>

Example based on CERDEC Power Assessment of Stryker at Ft. Irwin, CA, and use of TEP ORD Mission Profile
Funding Source: OSD – DDR&E thru Agile Dev. Center
Management: PM-MEP
Program Execution: CERDEC
Funds: 6.3 R&D
Schedule: 6-year program
FY08 – FY13
HI-Power Industry Day 18 July 2007
Power Technology BAA 25 July 2007
White Papers received 1 Oct 2007
$ to NREL for HOMER upgrade Nov 2007
White Paper Evals completed Nov 2007
Request for Full Proposals 26 Dec 2007
Receive Full Proposals 8 Feb 2008
Multiple Contract Awards March 2008
HI-Power Test Bed

**Location:** PM-MEP HQs, Fort Belvoir  
**Timeframe:** FY09 Commissioning

**Mission Loads** (resistive/reactive)
- 96 kW Maximum

**Environmental Control Units**
- 60 kW TQG
- 30 kW TQG
- 10 kW TQGs

**Government-provided loads**  
Simulated Stryker-brigade

**Contractor provides...**
- Power Grid
- Renewables
- Energy Storage
- Intelligent Control

**Mission Profile**
- Government-provided power sources
- TEP ORD

**Measure...**
- Fuel consumption
- Performance
- Size / Weight...
Power Grid

- Plug & Play architecture
- Multiple power sources
- Renewables
- Energy Storage

New Power Paradigm
- Fuel savings
- Cost savings
- Force protection
- Flexible
- Adaptive

Intelligent Control
- Phase balancing
- Load prioritization
- Source management
- Demand management
The NextEnergy Advanced Mobile Power & Energy Program

Briefing to

NRC: Achieving Cleaner Distributed Power Generation

In Remote Locations

David McLean - COO
March 11, 2008

www.NextEnergy.org
The Advanced Mobile Microgrid: Energy Architecture

Sources

- Combustion Engine
- Combustion Engine
- Fuel Cells
- Wind Turbine
- Photovoltaic Cells

New Technologies

- Induction Generator
- Synch. Generator
- Static Power Converter
- Static Power Converter

MOBILE MICROGRID SYSTEM

EPCC Modules

Loads

- TOC
- Forward Base / Camp
- Installation

Warfighter
Electronic Power Control & Conditioning (EPCC) Module: Concept Design

Integrated Electrical Power Control and Conditioning System
• That concurrently utilizes a wide range of AC and DC power sources that can be easily deployed to any location in the world within 48 hours (supporting deployed military operations / natural disasters / terrorist actions)

Capability
• Produce the electrical power quality needed to operate all loads including critical electronics-based military equipment
• Rapidly manage several concurrent alternative power sources
• Demonstrate reduced vulnerability to attack (i.e. minimize single point of failure scenarios)
• Utilize existing distributed generation strategies, vehicles with exportable power, and renewable technologies to reduce JP-8 use.
EPCC Module: Initial Concept Design

20 ft. ISO Container – Modular Design for easy Maintenance
EPCC Container: Present 8’ x 8’ x 24’ ---- Future 8’ x 8’ x 20’
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250kW/500kW Core Power Electronics + Storage
EPCC Module

Input Port Types
- AC port c/w multi-tap transformer allowing standard voltages from 208Vac to 600Vac (likely to be engineered out).
- AC port at 480Vac directly coupled to the Power Control & Conditioning (PCC) module.
- AC/DC port at 56V to 545V limited to 60kW and 300A.
- DC port at 24Vdc to 80Vdc limited to 24kW and 300A.

Critical Components
- DC/DC converter system delivering 480V to the PCC module.
- Ultra capacitor delivering at least 95kW for up to 5 sec (generator transient mgt.)
- Dual 275kVA/250kW PCC modules.
180kW DG w/o & w/ EPCC Unit: Output Voltage w/Loads*
* Top Photos ------ w/30kVA UPS Transformer @ No Load “Continuous Operation”
* Bottom Photos ------ w/50HP Motor Across-the-Line Start

180kW DG w/o EPCC Unit  --------------  180kW DG w/ EPCC Unit
EPCC Module

Project Schedule

- Refine the baseline design, fabricate, deliver and test the Alpha prototype – to be completed by *March 2008*.
- Refine the Alpha design, fabricate, deliver, deploy and test the Beta prototype – to be completed by *December 2008*.
- Administered as a TARDEC / NAC line item.
- Refine the Beta design to comply with MIL STD 810 and fabricate 1 Gamma prototype – to be completed by *June 2009*.
- Administered as a DLA line item.

Life Cycle Cost Analysis (LCCA)

- Requested by OSD – Science & Technology.
- Will form the basis of the Concept of Operations (CONOPS) Report.
EPCC Module

MIL STD 810

Key Specifications
- Operational High Ambient Temperature: 49°C (120°F).
- High Induced (Transport & Storage) Temperature: 71°C (160°F).
- Operational Low Ambient Temperature: -54°C (-65°F).
- Low Induced (Transport & Storage) Temperature: -62°F (-80°F).
- Thermal Shock: Hi/Lo Ambient Conditions within 5 min.
- 18 test parameters in all including Humidity, Altitude, Fungus, Salt Fog, Sand & Dust, Acceleration (drop test) and Vibration.
EPCC Module

Preliminary Achievable Targets

- Better than U.S. grid power quality with overall efficiency >90%.
- Reduce USACE Prime Power or USAF BEAR Base JP-8 consumption by 20% (fuel savings AND increased force protection – less resupply).
- Estimated low 7 figure $ savings per Brigade or Wing level deployment per year including reduced number of deployment sorties.
- Scalable from 250 kW to 500 kW to 750 kW to 1 MW (50 kW to 1 MW range likely)
- 750 kW unit will still fit in a 20ft ISO container and weigh less than 20,000 lbs (2 will fit on 1 C130).
- $700/kW for an 800 kW unit ($560K) given a production run of 10 units (about the same cost of a new 800 kW BPU at $500K).
- EPCC MicroGrid Controller (MGC) will optimize complete base electrical consumption.

* Numbers are based current level of Tactical Readiness Level (est. TRL 4) so MIL STD upgrades will vary cost.
EPCC Module

Potential Markets
- U.S. Military (CONUS, OCONUS and FOB)
- U.S. Military Coalition Forces
- Homeland Security (natural disaster & terrorist action relief)
- Developing countries – regional electrification
- Developed countries – microgrid / utility grid interface.