RDECOM

CERDEC
US ARMY– RDECOM

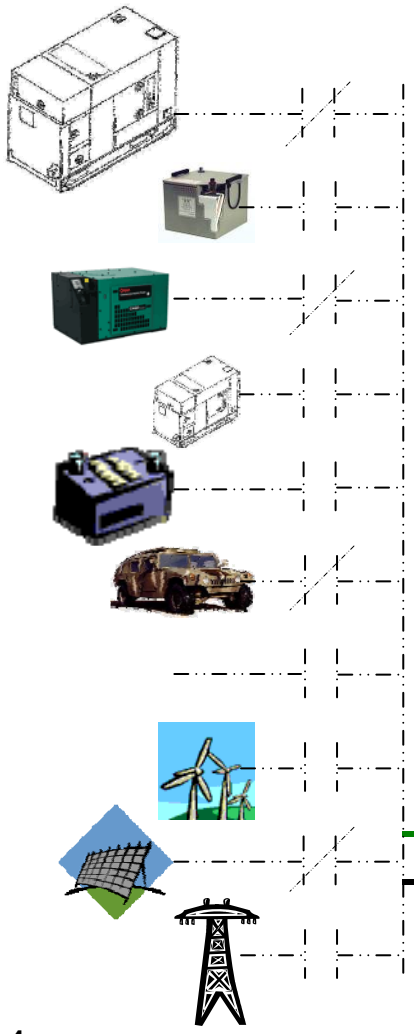
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Hybrid-Intelligent POWER

"HI-POWER"

HI-Power Concept

Sources



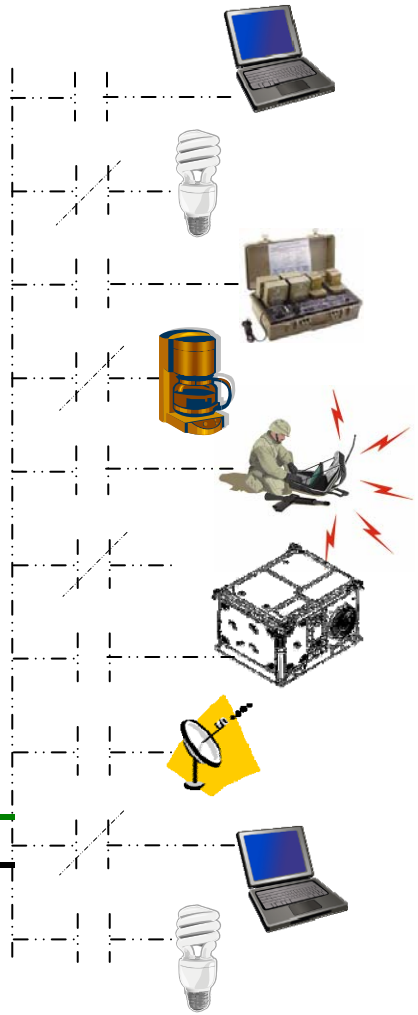
HI-Power provides…

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

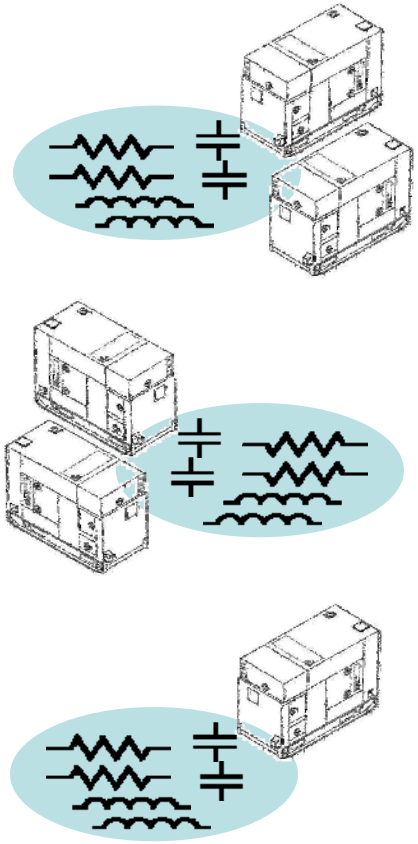
Data

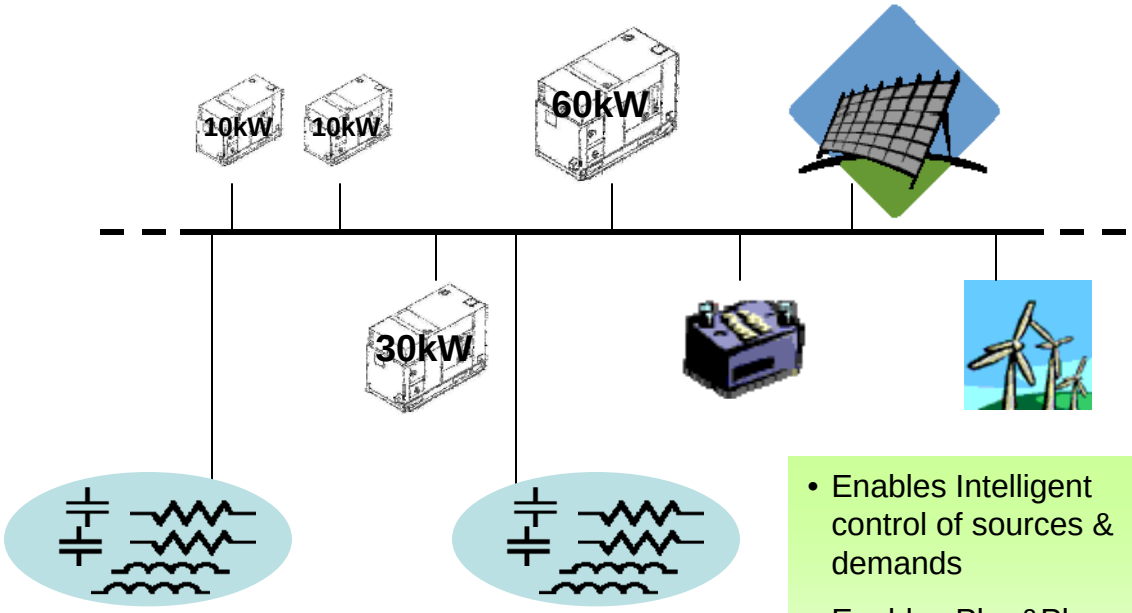
Power

Loads



Power Islands vs. Central Power Buss

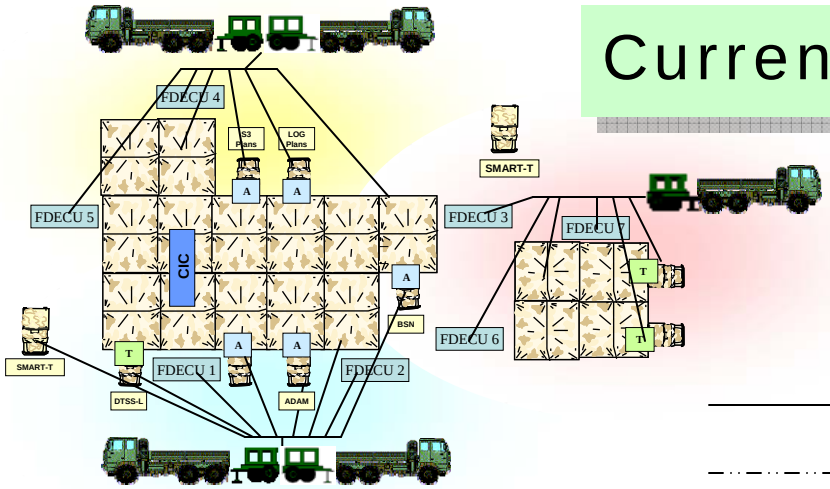




- Enables Intelligent control of sources & demands
- Enables Plug&Play addition of gensets, renewables, energy storage
- Saves fuel, reduces cost, reduces emissions

Power for Stryker Brigade

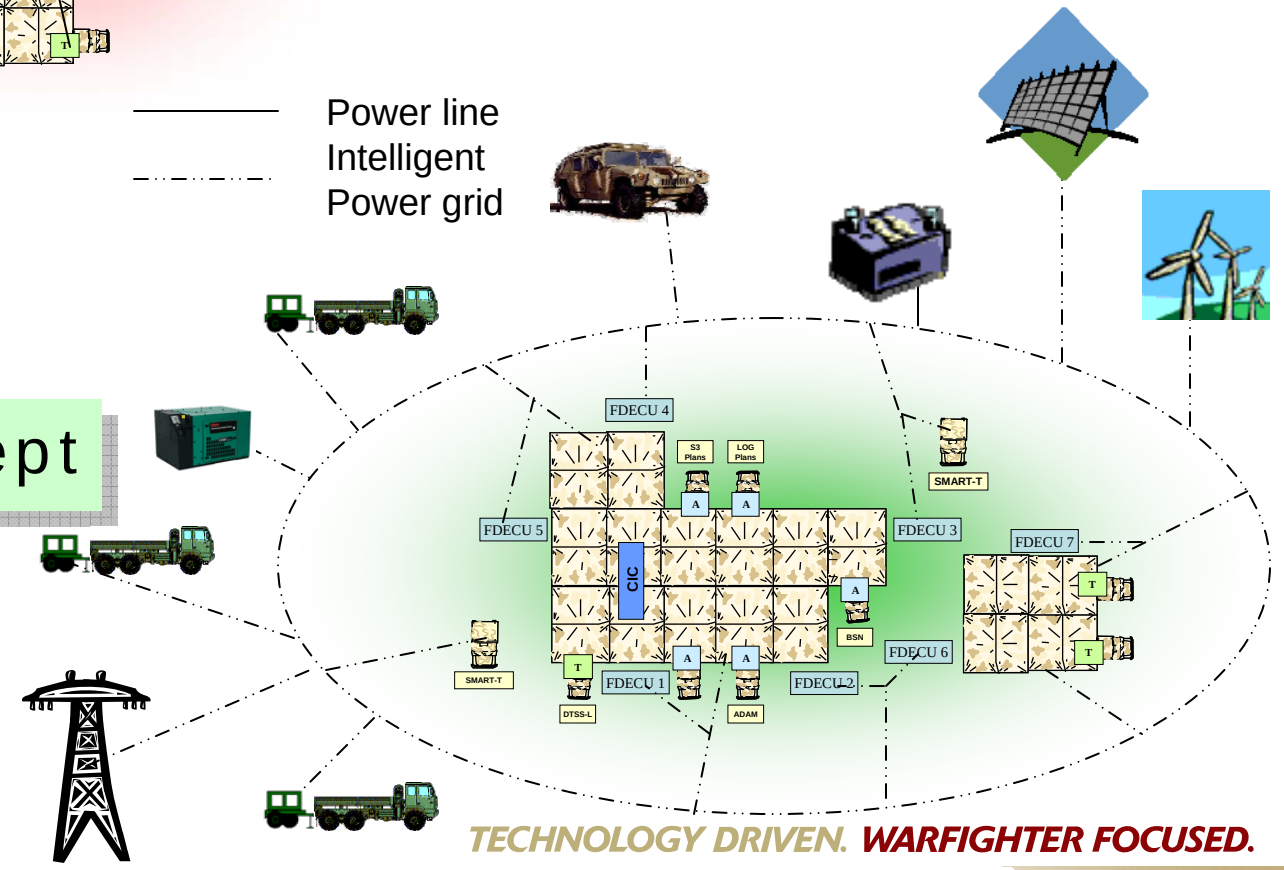
Current Situation



No…
Power Grid
Intelligent distribution
Renewables
Energy Storage

Power line
Intelligent
Power grid

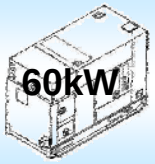
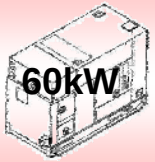
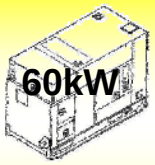
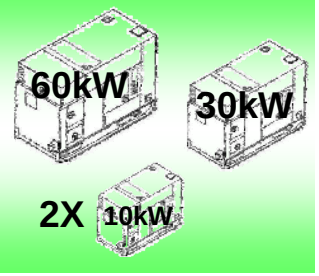
HI-Power Concept



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

Benefits of Establishing a Grid & Intelligent Control for Stryker

	Max Power Draw (kW)	Daily Fuel Usage (gal)	% savings	
• Current	96	162	-	3X 60kW 
• Future (w/Grid)	96	139	14	2X 60kW 
• Future (w/Grid & on/off Control)	96	134	17	2X 60kW 
• Future (w/Grid, on/off Control, & Right-sizing)	96	129	20	60kW 30kW 2X 10kW 

11 Example based on CERDEC Power Assessment of Stryker at Ft. Irwin, CA, and use of TEP ORD Mission Profile

Programmatics

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

Program Status

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

Government-provided loads
Simulated Stryker-brigade

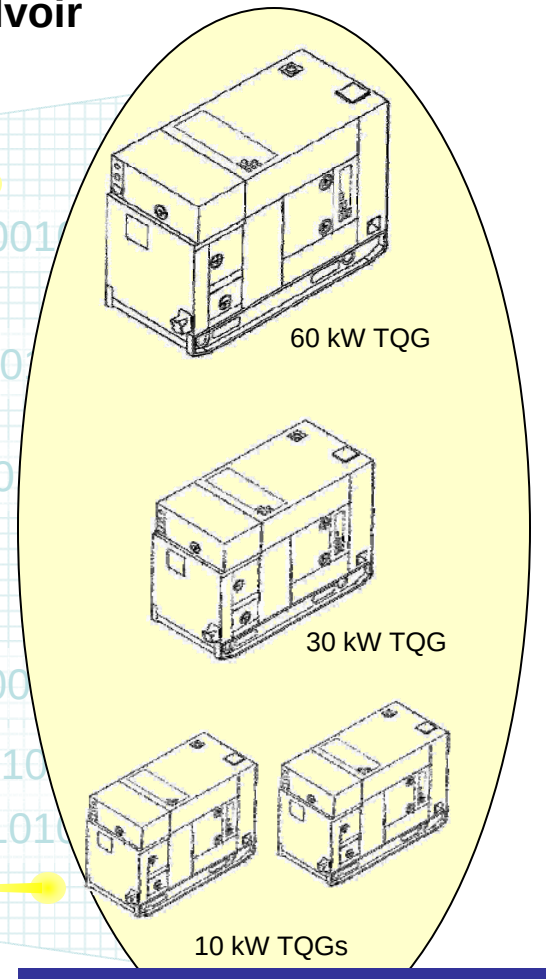
Mission Loads (resistive/reactive)

Environmental Control Units

96 kW Maximum

TEP ORD Mission Profile

Contractor provides…
- Power Grid
- Renewables
- Energy Storage
- Intelligent Control



Government-provided power sources

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

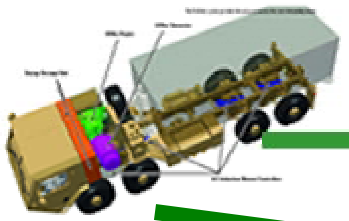
The Advanced Mobile Microgrid: Energy Architecture

Sources

New Technologies

Combustion Engine	Induction Generator
Combustion Engine	Synch. Generator
Fuel Cells	Static Power Converter
Wind Turbine	Static Power Converter
Photovoltaic Cells	Static Power Converter

VEHICLE MOBILE GENERATORS



MOBILE MICROGRID SYSTEM

EPCC Modules

Loads

TOC

Forward Base / Camp

Installation

Warfighter

NEXTENERGY

Economic Security through Energy Diversity

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

Integrated Electrical Power Control and Conditioning System

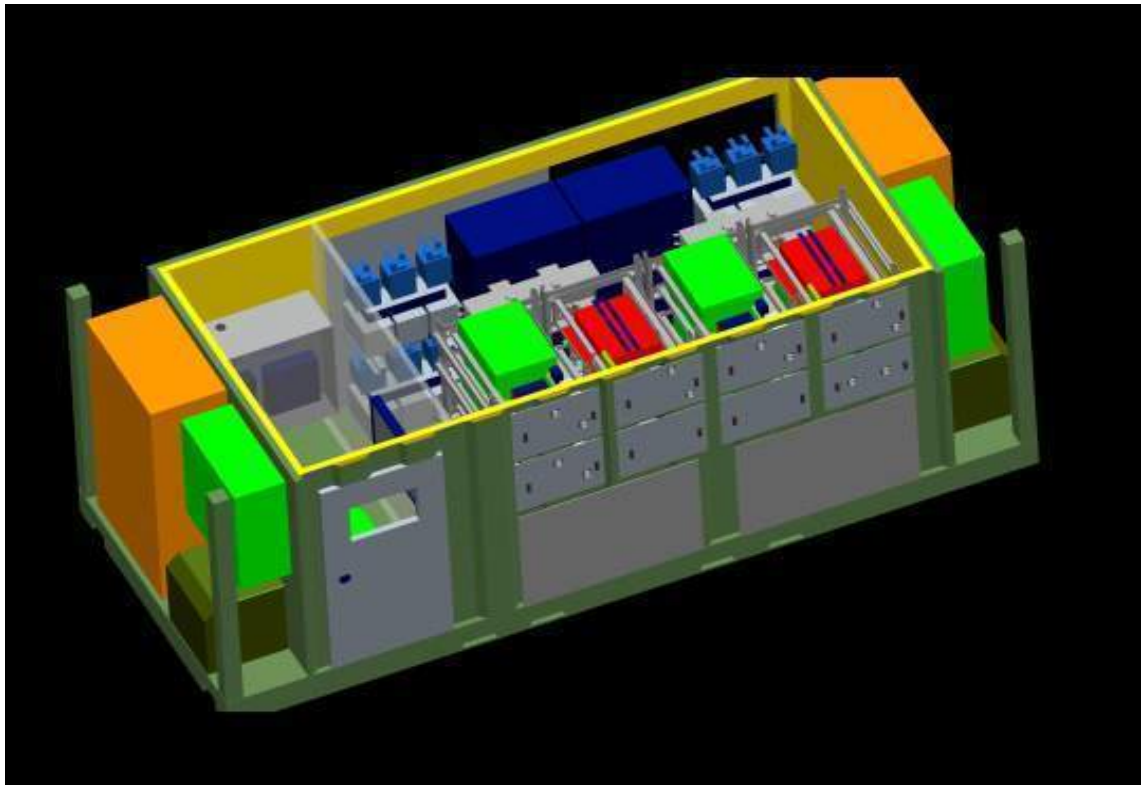
- That concurrently utilizes a wide range of AC and DC power sources that can be easily deployed to any location in the world within 48 hours (supporting deployed military operations / natural disasters / terrorist actions)

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.

NEXTENERGY
Economic Security through Energy Diversity

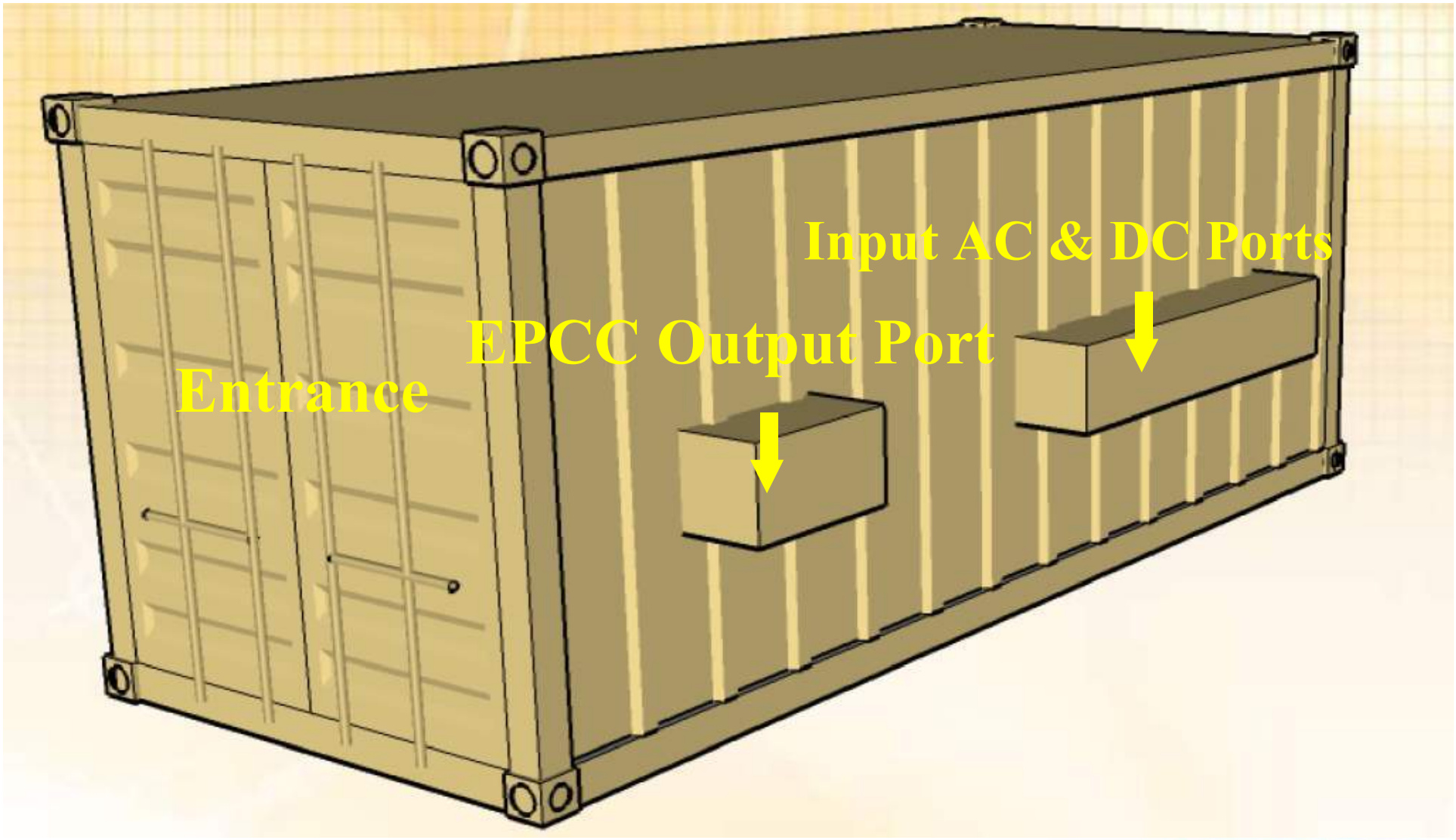
EPCC Module: Initial Concept Design



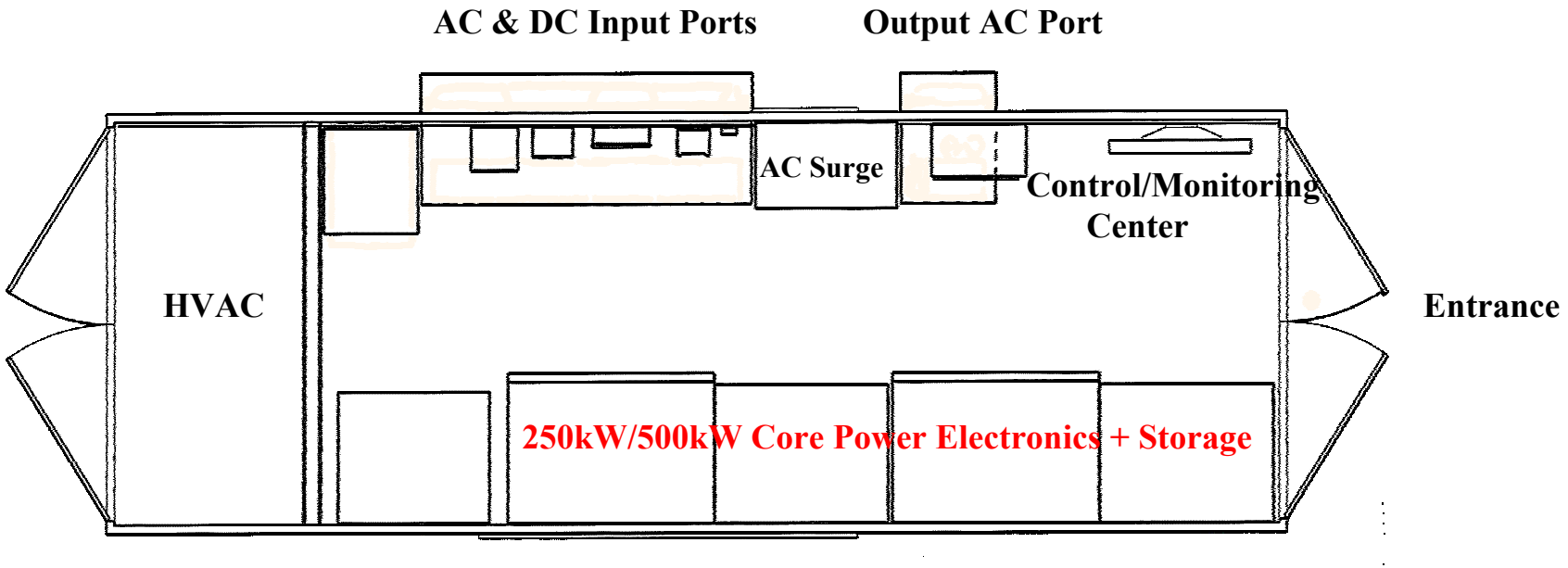
20 ft. ISO Container – Modular Design for easy Maintenance

NEXTENERGY
Economic Security through Energy Diversity

EPCC Container: Present 8’ x 8’ x 24’ ---- Future 8’ x 8’ x 20’



EPCC Container: Present 8’ x 8’ x 24’ ---- Future 8’ x 8’ x 20’



NEXTENERGY
Economic Security through Energy Diversity

EPCC Module: Alpha System

NEXTENERGY
Economic Security through Energy Diversity

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.

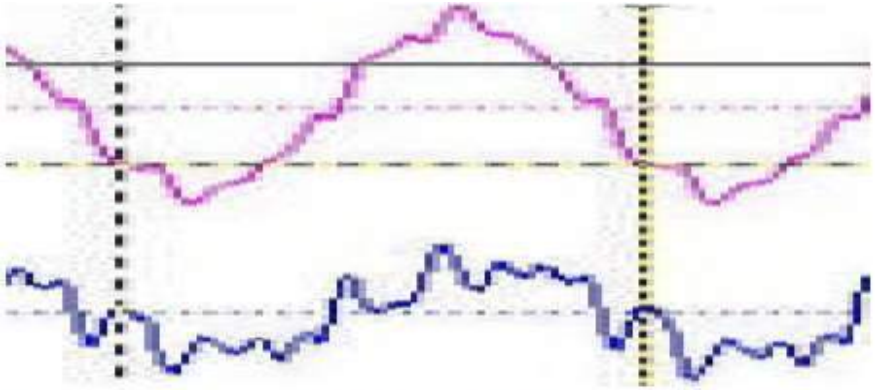
NEXTENERGY
Economic Security through Energy Diversity

180kW DG w/o & w/ EPCC Unit: Output Voltage w/Loads*

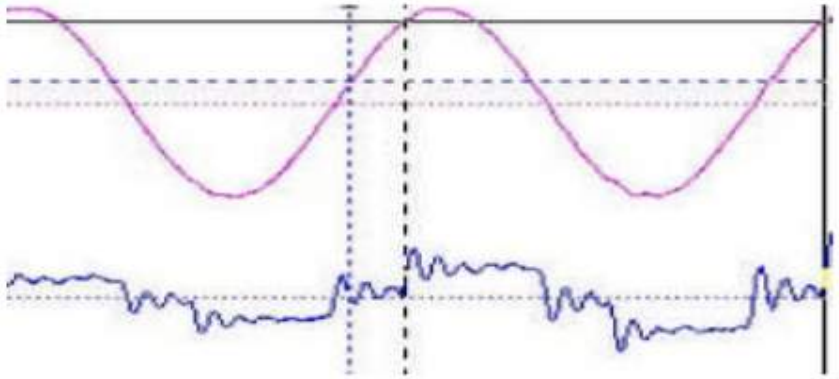
**** Top Photos ------ w/30kVA UPS Transformer @ No Load "Continuous Operation"***

**** Bottow Photos ------ w/50HP Motor Across-the-Line Start***

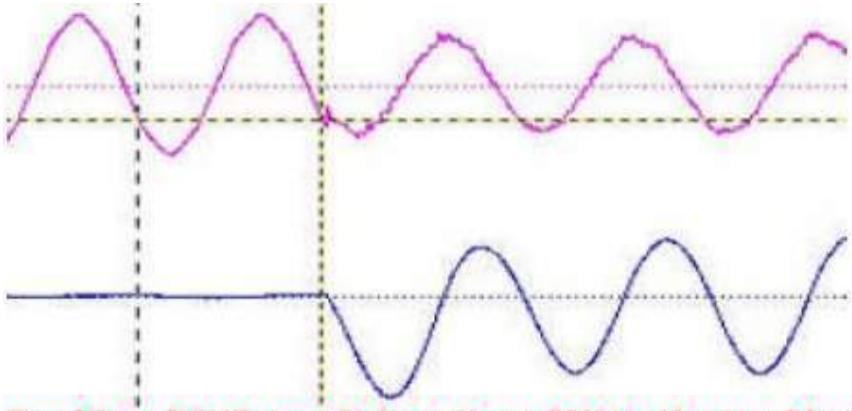
180kW DG w/o EPCC Unit ---------- 180kW DG w/ EPCC Unit



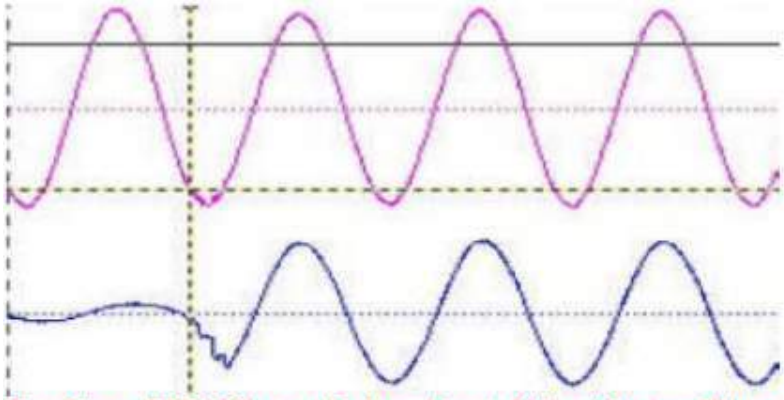
Top View: Distorted DG Output Voltage w/o EPCC Unit
Bottom View: DG Response to Non-Linear Load Current



Top View: Non-Distorted EPCC Output Voltage Waveform
Bottom View: Identical Non-Linear Load Current at EPCC



Top View: DG Output Voltage Sag (~35%) w/ System Motor Load Surge Current w/o EPCC Unit
Bottom View: ~50HP Motor Inrush Surge Current on DG



Top View: EPCC Output Voltage Sag (~5%) w/ System Motor Load Surge Current
Bottom View: ~50HP Motor Inrush Surge Current on EPCC Output

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.

NEXTENERGY
Economic Security through Energy Diversity

EPCC Module

MIL STD 810

- Environmental Test Methods for Aerospace and Ground Equipment (original USAF June 14, 1962).
- Design criteria MIL STD 810F Notice 3 (May 5, 2003).

Key Specifications

- Operational High Ambient Temperature: 49C (120F).
- High Induced (Transport & Storage)Temperature: 71C (160F)
- Operational Low Ambient Temperature: -54C (-65F).
- Low Induced (Transport & Storage) Temperature: -62F (-80F).
- 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.

NEXTENERGY
Economic Security through Energy Diversity

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.

NEXTENERGY
Economic Security through Energy Diversity

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.

NEXTENERGY
Economic Security through Energy Diversity