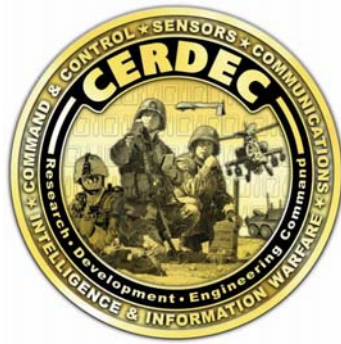


Power Generation and Alternative Energy Branch

US Army RDECOM CERDEC CP&ID Power Division
Aberdeen Proving Ground, MD



PGAE - TR - 11 - 05

Alternative Energy for Defense Conference

Jonathan Cristiani, US Army CERDEC CP&ID

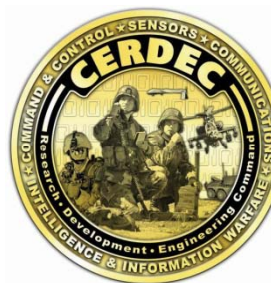
UNCLASSIFIED UNLIMITED DISTRIBUTION

DISTRIBUTION STATEMENT A - DISTRIBUTION A. Approved for public release. Distribution is unlimited. Other requests for this document shall be referred to RDECOM CERDEC, Command Power and Integration Directorate, Power Division, Aberdeen Proving Ground, MD 21005

DESTRUCTION NOTICE- Destroy by any method that will prevent disclosure of contents or reconstruction of the document.

RDER-CCA-PG

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 26 OCT 2011		2. REPORT TYPE Presentation		3. DATES COVERED 26-10-2011 to 26-10-2011	
4. TITLE AND SUBTITLE Alternative Energy for Defense Conference				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Jonathan Cristiani				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. ARMY COMMUNICATIONS-ELECTRONICS RESEARCH DEVELOPMENT AND ENGINEERING CENTER,5100 Magazine Rd.,Aberdeen Proving Ground,MD,21005-1852				8. PERFORMING ORGANIZATION REPORT NUMBER ; PGAE - TR - 11 - 05	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. ARMY COMMUNICATIONS-ELECTRONICS RESEARCH DEVELOPMENT AND ENGINEERING CENTER, 5100 Magazine Rd., Aberdeen Proving Ground, MD, 21005-1852				10. SPONSOR/MONITOR'S ACRONYM(S) RDER-CCA-PG	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S) PGAE - TR - 11 - 05	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT An overview of the CERDEC Alternative / Renewable Energy program is provided.					
15. SUBJECT TERMS alternative energy, renewable energy					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 35	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			



Communications-Electronics
Research Development and
Engineering Center (CERDEC)

Alternative Energy for Defense
Conference

26 Oct 2011



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Jonathan M. Cristiani, Renewable Energy Team Leader
Army Power Division, US Army CERDEC C2D



Overview



- The Need
- Operational Energy Policy and Community
- Technology Focus Areas, Applications, and Objectives
- Emerging Tactical Alt/Renewable Energy System Requirements
- Technology Demonstrations and Transitions



THE NEED!



Fuel cost = \$350,000
per year per soldier

Ref: Time Magazine "Obama
Weighs the Cost of an Afghan
Surge," 25 Nov 2009.

In June 2008, 44
trucks and a total of
220,000 gallons of
fuel lost to IED's

Ref: New York Times "One of the
Nation's Largest Energy Users
Has Ambitious Plans to Cut
Back," 28 May 2010.



Ref: <http://energy.defense.gov>



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



OPERATIONAL ENERGY (OE) POLICY

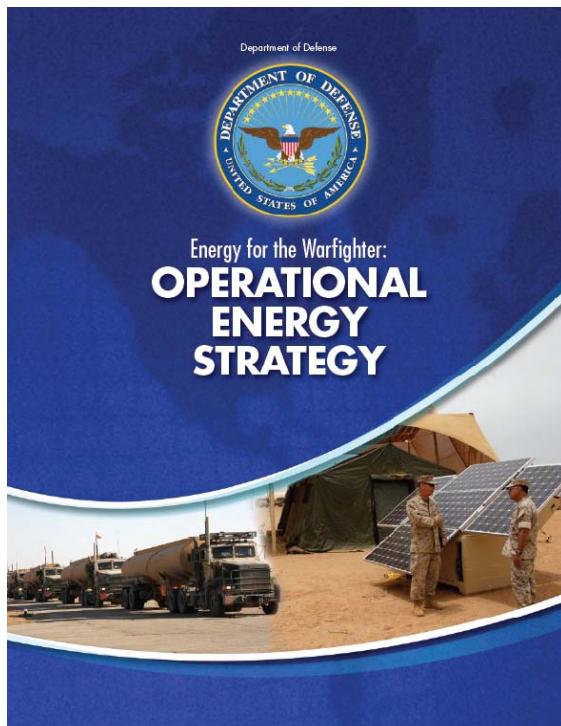
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



DoD Operational Energy Policy Changes



OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE FOR OPERATIONAL ENERGY PLANS AND PROGRAMS



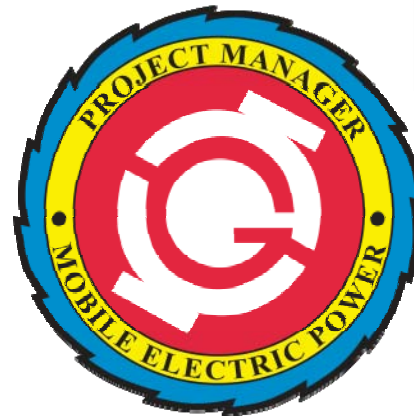
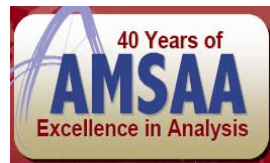
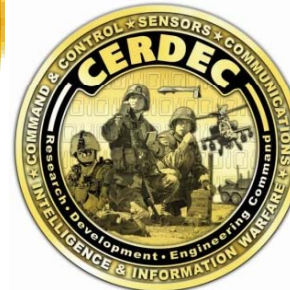
Ref: <http://energy.defense.gov>

- Department of Defense (DoD) Directive 5134.15 dated May 17, 2011 established the ASD(OEPP)
- The Operational Energy Strategy released by ASD(OEPP) lays foundation for defense systems energy management:
 - Document/track energy consumption of weapons systems
 - Energy key performance parameter or “e-KPP” for all programs of record
 - Use of fully-burdened cost of fuel in lifecycle cost analyses
 - Accelerate rapid acquisition of technologies that benefit operational energy in near term and accelerate transition to programs of record

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



DoD Operational Energy Research Dev Acq Community



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



ALTERNATIVE/RENEWABLE ENERGY (A/RE) TECHNOLOGIES, APPLICATIONS, AND OBJECTIVES



CERDEC Renewable Energy Team

Mission Summary



Enabling Technologies

- Hybrid Power
- Photovoltaic (PV), Solar Thermal, & Wind Energy Harvesting
- Waste-to-Energy (W2E) and Gas to Liquids (GTL)
- Waste heat recovery, Heat-actuated Cooling, & Co-generation

Applications

- Tactical Mobile Power
- Vehicle-mounted Auxiliary Power and Environmental Control
- Energy Security for Base Operations
- Waste abatement

Objectives

- Fuel Efficiency
- Force Protection
- Improved Mobility
- Reduced Signature
- Reduced Logistics



CERDEC Renewable Energy Team

Solar PV Module FY14 Objectives



All performance metrics reported for AM1.5 insolation and standard, temperature, and pressure (STP) ambient conditions.

	Current	Threshold	Objective	Pacing Technology
Architecture	Foldable Rigid Ruggedized Thin Glint Free* Rollable*	Foldable Flexible Ruggedized Thin Glint Free Rollable Chemically Resistant	Foldable Flexible Ruggedized Thin Glint Free Rollable Chemically Resistant	Packaging Fabrication processes Encapsulation/coating
Power density	35-40 W/kg or 50-80 W/m ²	40 W/kg or 100 W/m ²	75 W/kg or 150 W/m ²	Material selection Novel PV chemistry Encapsulation/coating
Conversion efficiencies	5 to 8 %	10%	15 %	Material selection Novel PV chemistry
Cost	\$15 per Watt	\$3.50 per Watt	\$2.50 per Watt	Material selection Fabrication processes

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



CERDEC Renewable Energy Team

Wind System FY14 Objectives



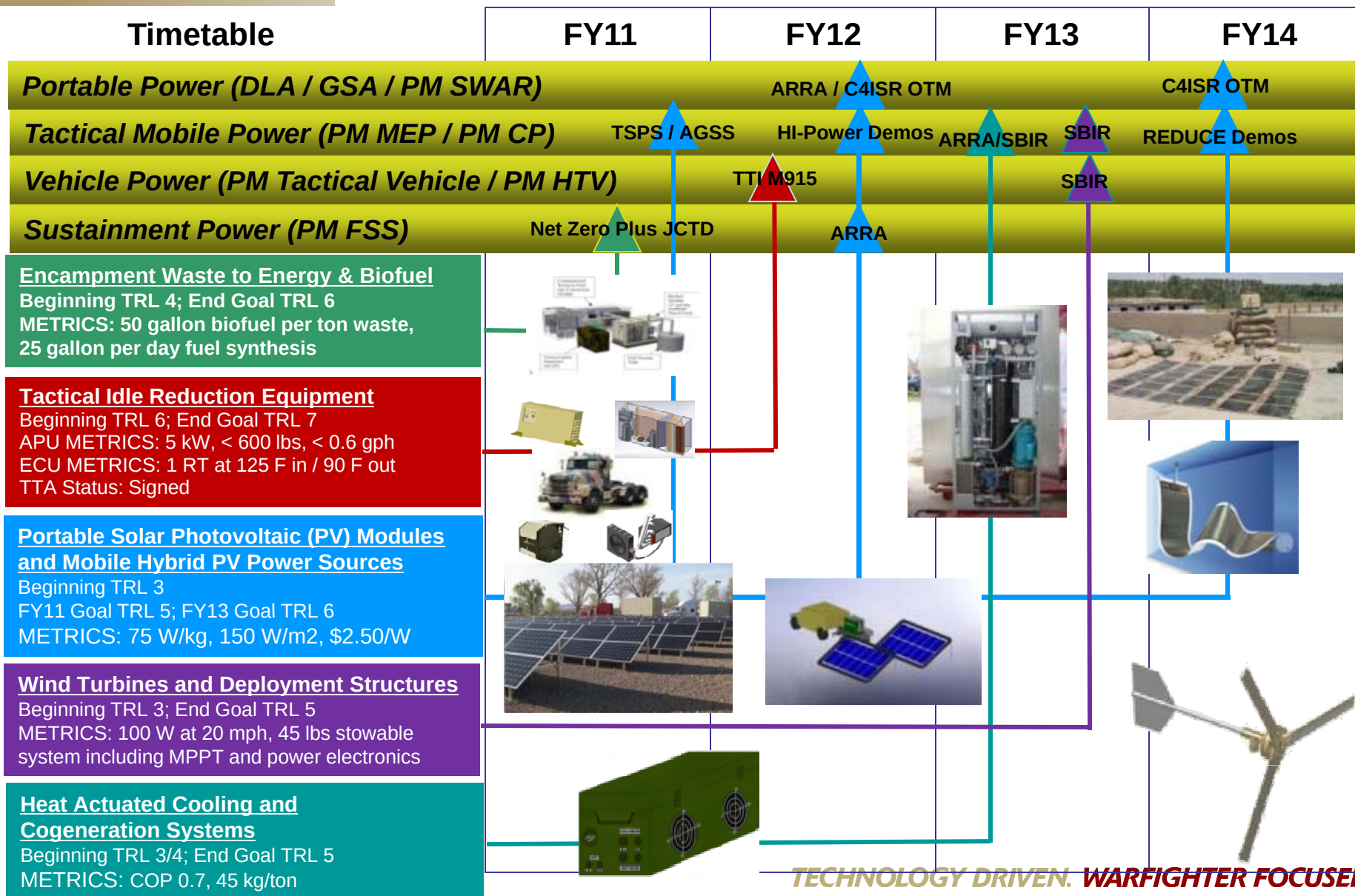
	Current	Threshold	Objective	Pacing Technology
Architecture	Stationary Semi-mobile	Semi-mobile, Containerized	Containerized (>15kW) Vehicle-mounted (50W-5kW) Man-portable (50W-500W) Trailer-mounted (500W-15kW)	Novel deployment structures, collapsible blades, telescoping tower
Power Density (Nominal at 25 mph Wind Speed)	Turbine: 30-40 W/kg Turbine / Pole: 7.5 W/kg	Turbine: 40-50 W/kg Turbine / Pole: 20 W/kg	Turbine: 80 W/kg Turbine / Pole: 40 W/kg	Novel HAWT and VAWT designs, production materials/processes, system assembly, improved generators/alternators
Cost (turbine, pole, electronics, batteries)	\$13.20/W	\$10/W	\$5/W	Low-cost turbine and deployment system production materials
Deployment / Retraction Time	>2 hours	30 minutes	15 minutes	Novel deployment structures

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



CERDEC Renewable Energy Team

A/RE Products, Metrics, Demos



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



US Army CERDEC Applications *Portable Power*



FUTURE

NOW



DAGR



LMR



P-Beacon



AN/PVS 14



Head Set



MBITR



Sure Fire Light



Mag Lite



PEQ-2A



Mark VII

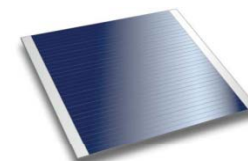


M68 CCO (Day)



HTWS (Night)

Army Rifleman



AN/PVS 14



Sure Fire Light



Mag Lite



M68 CCO (Day)



Head Set



PEQ-2A



MBITR



Mark VII



HTWS (Night)

7 Battery Types
72-hrs:
70 Batteries, 16 lbs

5 Battery Types
72-hr mission:
38 Batteries, 12.5 lbs

TECHNOL



US Army CERDEC Applications

Tactical Mobile Power



“During wartime, generators become the largest single fuel consumers on the battlefield... Gen-sets in Iraq [are] overwhelmingly used for space-cooling”

Category	Peacetime OPTEMPO	Wartime OPTEMPO
Combat Vehicles	30	162
Combat Aircraft	140	307
Tactical Vehicles	44	173
Generators	26	357
Non-Tactical	51	51
Total	291	1040

Army Fuel consumption in peacetime & wartime (million gallons per year)

Ref: USD(ATL) / Defense Science Board “More Fight Less Fuel” Feb 2006.

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



REQUIREMENTS

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



Soldier-Portable Power *Overview*



- Increase specific power and energy for Soldier-carried storage devices (Warfighter Outcome: 2 x power at ½ the weight);
- Reduce energy consumption by 50% by making end items more efficient and introducing power management algorithms;
- Reduce the quantity and variety of batteries (from typical 7-8) carried by the Soldier ;
- Identify locally available energy sources and Soldier power technologies;
- Provide interoperable interfaces between Soldier systems and infrastructure and vehicle-mounted energy systems.

Power & Energy Strategy White Paper, Army Capabilities Integration Center – Research Development and Engineering Command – Deputy Chief of Staff, G-4, US Army , 1 April 2010



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



Tactical Electric Power *Overview*



- Battlefield power generation and distribution provided via following **continuum**:
 - Tactical Electric Power (TEP) – Gov't owned/operated, Precise and utility grades, operation on JP-8 in all environments, **2 - 200 kW** (120/240 VAC single phase, 208 VAC three phase, 50/60/400 Hz)
 - Prime Power – Gov't owned/operated, Commercial grade, **0.2 - 10 MW** (2400/4160 VAC 60 Hz or 2200/3800 VAC 5 Hz)
 - Commercial Power – Not Gov't owned/operated, commercial grade, **>10 MW**, reliability/security risks in Iraq and Afghanistan
 - Contractor-Provided Power – Not Gov't owned/operated, commercial grade, **capacities vary**
- **Rules of thumb**:
 - 3 kW/person/day (bases with 5 to 3,500 population)
 - 4 kW/person/day (bases >3,500 population)



Tactical Electric Power *Basic Requirements*



- TEP systems must be designed to provide CONTINUOUS RATED POWER at these conditions:
 - 0.8 power factor (pf), lagging
 - Ambient temperatures up to 52°C (125°F) [-3% for each 10°C increment (18°F) above 52°C]
 - Altitudes up to 1,219 m (4,000 ft) [-3.5% for each 305 m increment (1,000 feet) above 305 m up to 3,048 m]
 - Operation on JP-8 as defined by MIL-DTL-83133E
- Two grades, four classes of TEP system power quality requirements: Prime and Utility Classes 2A, 2B, and 2C and as defined by MIL-STD-1332B



Tactical Environmental Control *Basic Requirements*



Military IECUs vs. Commercial A/Cs

Centralized ECU management will reduce the purchase and use of commercial equipment to replace standard military systems.

Improved Environmental Control Units

- ✓ Designed to operate to 125°F
- ✓ Cooling capacities rated at 125°F
- ✓ Organically supportable
- ✓ Improved NBC and EMP survivability, reduced aural and IR signatures
- ✓ Ruggedized for field use
- ✓ Soft start, limited inrush current
- ✓ High reliability in mission environments

Commercial A/C Equipment

- ✗ Designed to operate only to 100°F
- ✗ Cooling capacities rated at 90°F; performance degrades rapidly at temperature extremes
- ✗ Supportable only through contractor support
- ✗ No NBC or EMP survivability, or reduced aural or IR signatures
- ✗ Not ruggedized for field use
- ✗ High inrush current increases size of power generation equipment
- ✗ Reduced reliability in mission environments

Ref: Mr. Jeff Taylor, PM MEP, Presentation to JOCOTAS Technical Working Group dated November 2009

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



Tactical Hybrid A/RE *Emerging Requirements*



- Joint requirements community (with Army leadership from G4, ARCIC, and CASCOM) has drafted an initial capabilities document (ICD) for OE as of Nov 2010 and is currently working on Renewable Energy Power Sources Capabilities Development Document (REPS CDD)
- Gaps identified across power spectrum, DOTLPF can yield some operational energy reductions, but development of new materiel solutions (in the form of hybrid A/RE systems) is required

Characteristic	Threshold	Objective
Power Generation	The TSPV shall provide a 3kW average continuous electrical power output for 15-days under normal operating conditions and without requiring refueling or resupply.	The TSPV shall provide a 5kW average continuous electrical power output indefinitely under normal operating conditions and without requiring refueling or resupply.
Energy Storage Power Output	TSPV shall provide a 3kW continuous electrical power output for 12 consecutive hours without power input from the electrical generation or energy harvesting systems and without operator intervention.	TSPV shall provide a 5kW continuous electrical power output for 48 consecutive hours without power input from the electrical generation or energy harvesting systems and without operator intervention.
Trailer System	TSPV system shall use the Light Tactical Trailer-Heavy Chassis (LTT-HC). All trailer performance attributes remain in effect for the module as mounted, e.g., 4200 lb. gross weight (max), 420 lb. tongue weight and lateral stability on 40% slopes.	Threshold = Objective
Temperature	The TSPV shall be capable of sustained operation up to 95°F at 4000-ft. above sea level.	Threshold = Objective

Ref: T.E. Raney, PM MEP/CASCOM (BAE Systems, Inc.), White Paper "Tactical Solar-Photovoltaic Systems: Operational & Technical Insights", 21 Oct 2010.

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



DEMONSTRATIONS AND TRANSITIONS

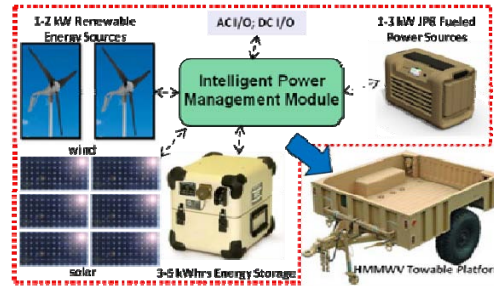
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



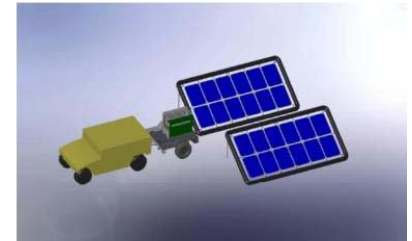
US Army CERDEC Hybrid A/RE Product/Application Spectrum



RENEWS



ASPS



TSPS



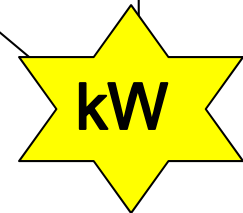
AGSS

REDUCE



Applications

REPPS



TECHNOLOGY DRIVEN. **WARFIGHTER FOCUSED.**



US Army CERDEC Hybrid A/RE *REPPS Kit*



Rucksack Enhanced Portable Power System (REPPS) Kit from Brentronics and Global Solar

- Connects to BB-2590 lithium ion rechargeable battery to allow for continuous operation of unattended ground sensors and surveillance cameras
- Flexible panels use copper indium gallium (di)selenide (CIGS) photovoltaic chemistry
- Over 100 of 725 deliverable systems have been free-issued by CERDEC under ARRA program
- Recharges BB-2590 lithium ion battery in 4 to 6 hours
- Output: 62 W at AM1.5 conditions



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



US Army CERDEC Hybrid A/RE *RENEWS Kit*



**Reusing Existing Natural Energy Wind and Solar (RENEWS) Kit
from Brentronics, Global Solar, Chinook**

EACH KIT CONTAINS:

- 400 W (at 25 mph) Wind turbine & 372 W (at AM1.5) Flexible Solar Panels
- 1.2 kWh (6 x BB-2590) "Six Pack" Battery Module
- 250 W Inverter, Power Conditioner, & Plugs/Connectors
- AC/DC Output: 120 VAC / 60 Hz at 250 W & 12/24 VDC at 720 W
- Contained within Two x Two-man-lift Transit Cases (260 lbs total)
- 125 systems to be delivered in late 2011 under ARRA program and free-issued to field units and training exercises

What it Includes



What it Powers

Up to Two AN/PRC-117 Manpack Radios



or

Up to Five ASIP Radios



or

Any Army Standard Charger



**One Kit
Powers**

What it Saves



**>80 x 5590 batteries
per month with 3
ASIP Radios
Weight /cost
payback within
3 winter months**

Eliminates

Remote Power for Combat Outposts (COPS) and Re-transmission Sites



US Army CERDEC Hybrid A/RE *Transportable Solar Power System*



- Customer: US SOCOM
- TSPS / SPS Contractor: SunDial
- Benefits: 1 gal/hour of fuel savings
- Approx. 10 kW continuous power
- Includes:
 - 38.6 kW glass mc-Si solar PV array
 - 192 kWh AGM energy storage
 - 7 kW diesel fueled power generator
 - Deployable in 24 man hours
- Initial TRL of 6, Current TRL 9
- Objective: Obtain Safety conf. report by 31 December 2010
- 2 x TSPS deployed to Afghanistan in January 2011
- Third improved “Smart Power System” in test/safety confirmation tested by ATC deployed Sep 2011



Image courtesy of Sundial



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



US Army CERDEC Hybrid A/RE *Western Hemis Info Exch*



- Customer: US SOUTHCOM
- WHIX Contractor: Florida International Univ. (FIU)
- Approx. 3 kW continuous power
- Includes:
 - 5 kW Ascent and Energy Tech Inc CIGS solar PV tent fly
 - 2 x 1 kW Bergey wind turbines w/ assembled foundation ARE wind towers
 - Energy storage of 36 kWhr using Li/FePO4 batt's, 4-man lift cases
 - 6 kW gas generator & 6 kW inverter
- Current TRL of 5/6
- Objective: RDECOM Consultant to SOUTHCOM and FIU
- Deployed to Dominican Republic in Apr 2011 for DR soldier training and used in dental exercise with US Army Reserves in May 2011



TECHNOLOGY DRI



US Army CERDEC Hybrid A/RE *Automatic Gen Start System*



- Customer: PM MEP / REF
- AGSS Contractor: Solar Stik
- Includes:
 - 1 kW BP Solar PV panels mounted on tripods
 - Energy storage of 10 kWh using AGM batteries, 2-man lift cases
 - 3 kW Tactical Quiet Generator modified for automatic start/stop
 - 1.8 kW inverter
- Current TRL of 6/7
- Obj: Obtain a safety confirmation by end of September 2011
- Testing and soldier demo completed by CERDEC
- 15 systems deployed in Oct 2011



Image courtesy of SolarStik

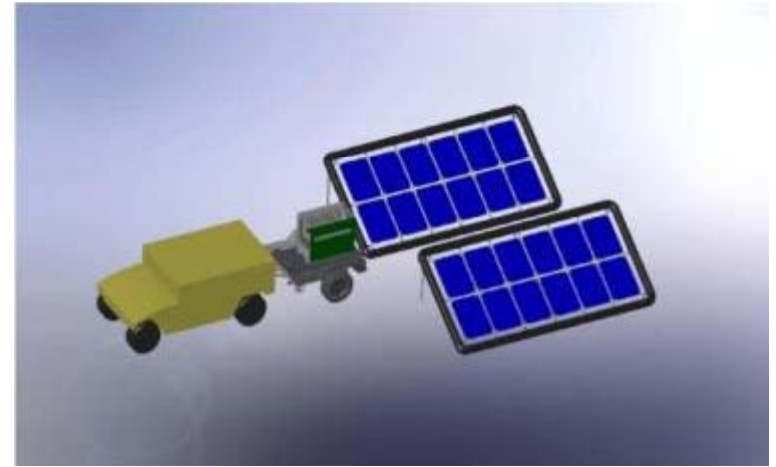
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



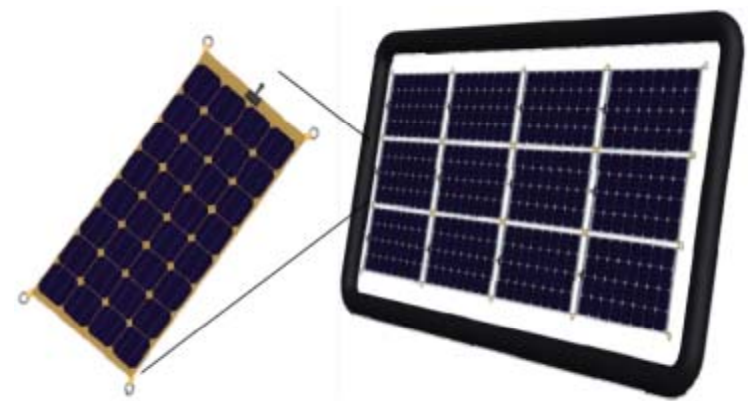
US Army CERDEC Hybrid A/RE *Advanced Solar Power Source*



- ASPS Contractors: Electricore, AeroVironment, VXE Inc
- Objective: TRL 5
15% eff. solar PV array (10% threshold)
- Includes:
 - 2.5 kW encapsulated mc-Si solar PV array
 - Energy storage of 12 kWh Li/CoO₂ (BB-2590) battery bank
 - 5 kW bidirectional inverter
 - Inflatable deployment structure
- Electricore reported 11.4% module efficiency and power dens. of >50 W/kg with exceptional bend radius
- Delivery in early FY12 to APG



Images courtesy of Electricore



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



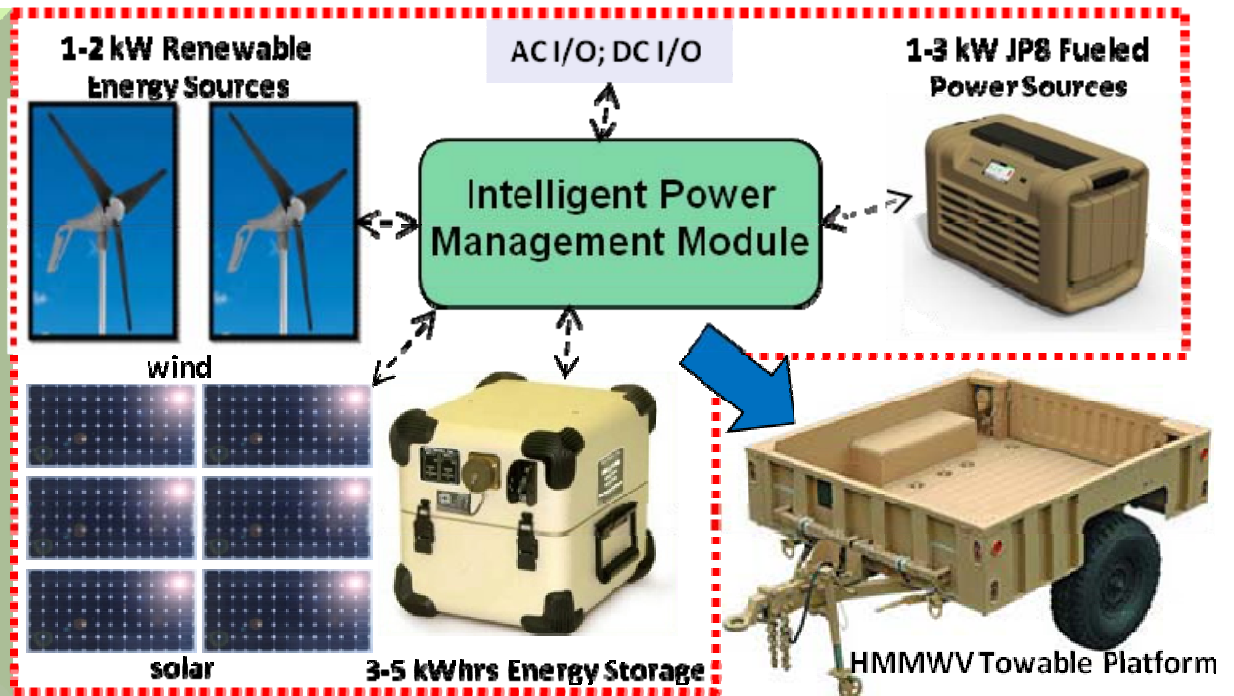
US Army CERDEC Hybrid A/RE *REDUCE Program FY12-14*



Renewable Energy for Distributed Under-supplied Command Environments (REDUCE)

EACH SYSTEM CONTAINS:

- 1-2 kW Renewable Energy Devices (Photovoltaic/Wind)
- 3-5 kWh Energy Storage Module
- Intelligent Power Management Module and Controls
- Optional 1-3 kW JP8 Fueled Power Source
- AC/DC Output- 115 VAC & 12/24 VDC
- HMMWV towable on M1101 Trailer
- Wt: ~200 kgs

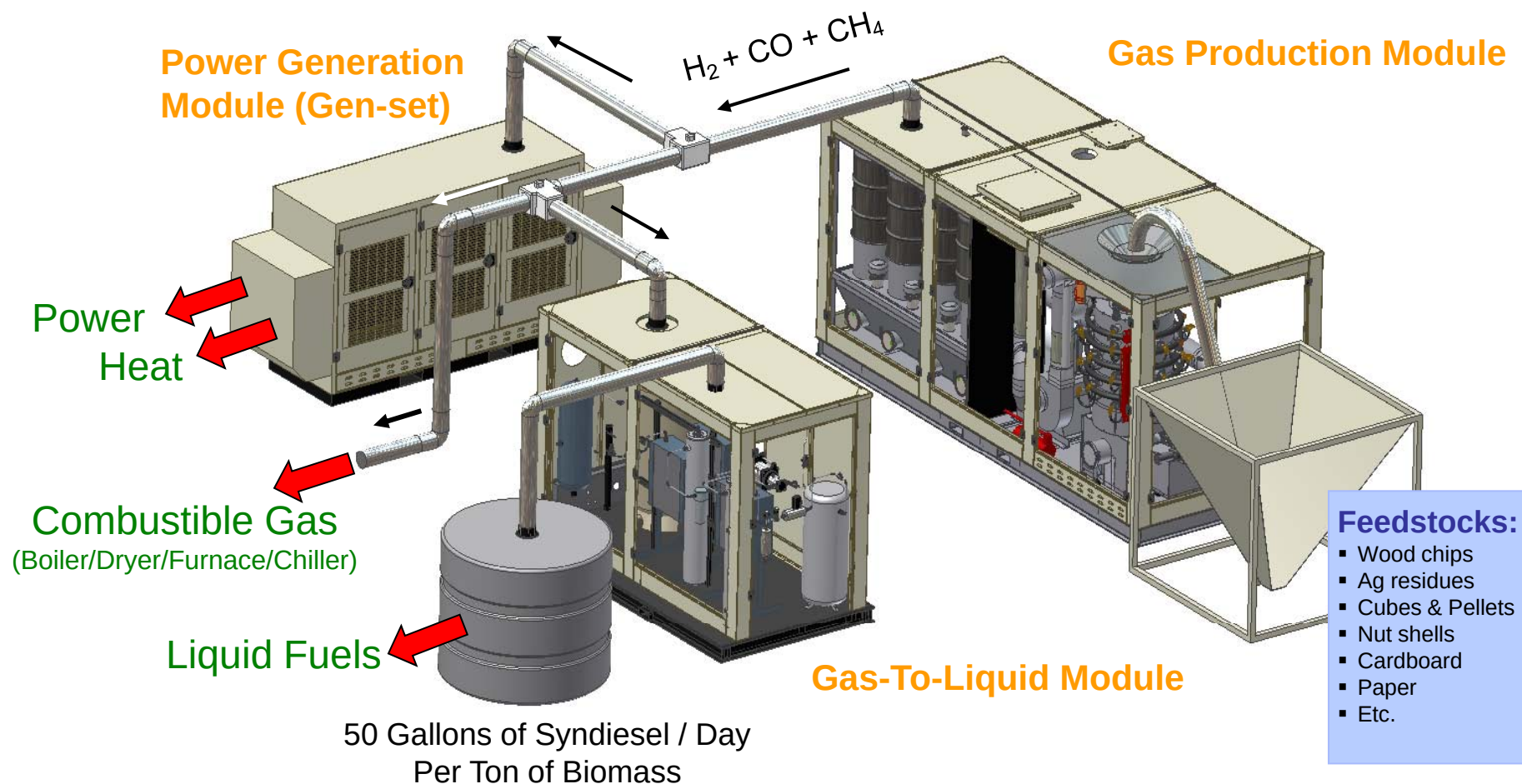


PLUG AND PLAY CAPABILITY for ease of use
Reliable Exportable Power Continuously under All Conditions
Modular System allows Component Selection based on
Mission Needs

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



US Army CERDEC W2E/GTL *Community Power Corp Demo*



Provided courtesy of Community Power Corp.

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



US Army CERDEC W2E/GTL *Community Power Corp Demo*



DRIVEN. WARFIGHTER FOCUSED.



US Army CERDEC Co-Gen ARRA for Co-gen Overview

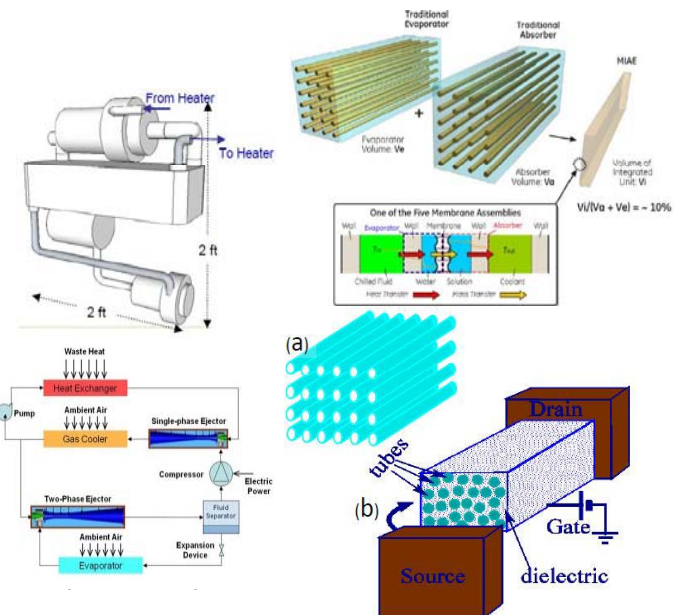
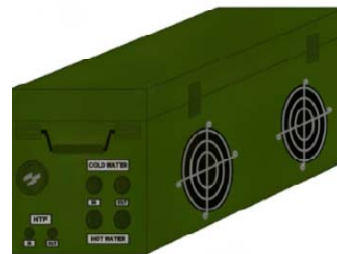


Project Objective:

The overall objective of this program is to demonstrate the co-generation of cooling, heating, and power from waste heat sources, which may include but are not limited to diesel engine exhaust gases, engine cooling fluids, and ambient airstreams.

Approach:

Emphasis of the advanced hardware demonstrations will be on equipment mobility, compact and lightweight design, refrigerant safety (non-flammable, lower toxicity), and compatibility with military standard diesel generator systems as a source of waste heat for initial demonstration.



Benefits/Metrics:

It is well known that environmental control represents one of the most significant load requirements on the tactical battlefield today. These conditions present a unique opportunity for demonstration and transition of a smaller, lighter combined heating, cooling, and power system that provides energy efficiency and logistical benefits over the baseline stand-alone equipment. Threshold metrics at end of program: TRL 5, 45 kg/ton dry weight, COP=0.5

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



US Army CERDEC Co-Gen *ARRA for Co-gen Contracts*



Contractor	Purpose / Status
Creative Thermal Solutions	Development of a 10.5-kWt (3-ton) diesel-engine-waste-heat-driven ejector heat pump environmental control unit (ECU) that uses carbon dioxide refrigerant.
Stone Mountain Technologies Inc	Development of a 2-kWt (0.6-ton) diesel-engine-waste-heat-driven ammonia-water absorption environmental control unit (ECU) that uses micro-scale heat exchanger technology.
GE Global Research	Development of a hydrophobic porous membrane-based integrated absorber and evaporator heat exchange device for a target 5.3-kWt (1.5-ton) lithium bromide absorption cycle.
Northwestern University	Theoretical and experimental investigation of an advanced carbon nanotube based thermoelectric generation (TEG) technology for waste heat to electricity applications.
United Technologies Research Center	Design of a 10-kWe Organic Rankine Cycle (ORC) that uses low-global-warming-potential Novec fluid to be coupled with generator sets in the 60-kWe to 200-kWe range for waste heat to electricity applications.
United Technologies Research Center	Development of a 17.6-kWt (5-ton) hybrid vapor compression cycle with two-phase ejector heat pump using carbon dioxide refrigerant.

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



US Army CERDEC *Tactical Idle Reduction*



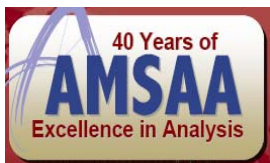
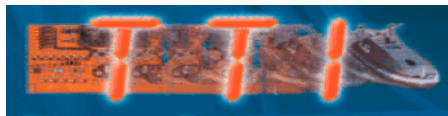
Objectives

- Transition idle reduction (TIR) equipment to Product Manager (PM) Heavy Tactical Vehicle (HTV) for M915A5 and Line Haul Replacement Tractor
- Assess power and energy requirements of current fleet of fielded HTV's: M915, M916, M917
- Adapt low-risk solutions to military requirements for power systems -- test, integrate, demonstrate, transition for procurement
- Accelerate availability of TIR equipment for procurement by 2 years from FY15 to FY13

Products

- Potential for 422 to 870 gal/yr per M915 fuel savings during wartime
- Fewer fuel convoys needed thereby increasing fleet force protection
- Significant cost savings over lifecycle through reduced prime engine use
- 5.3 kW tactical idle reduction auxiliary power unit (APU)
- Auxiliary 1 ton environmental control unit (ECU)

Team



Graphics



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



Closing



- CERDEC must leverage commercial marketplace to meet near-term operational energy reduction objectives and emerging requirements
- Developers of A/RE technologies must focus on system hybridization and dual-use applications to meet interoperability / cost requirements
- Solar PV and hybrid PV systems have greatest interest from CERDEC customers in both portable and mobile markets
- DoD procurement officials seem most interested in moderate PV conversion efficiency (15%) / low cost (<\$2.50/W) for large area power generation applications and high-eff (30%) / moderate cost (<\$10/W) for portable power and the burgeoning smart phone market
- Wind energy systems require substantial technology development in order to be tactically viable on size/weight basis
- Energy efficiency initiatives such as W2E/GTL, Co-generation, and Tactical Idle Reduction demonstrate demand-side reduction and waste utilization, which rival the criticality of source-side hybrid A/RE