TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Vehicle-to-Grid and Grid-to-Vehicle Connectivity

Business of Plugging In

October 11, 2011

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Mission & Vision

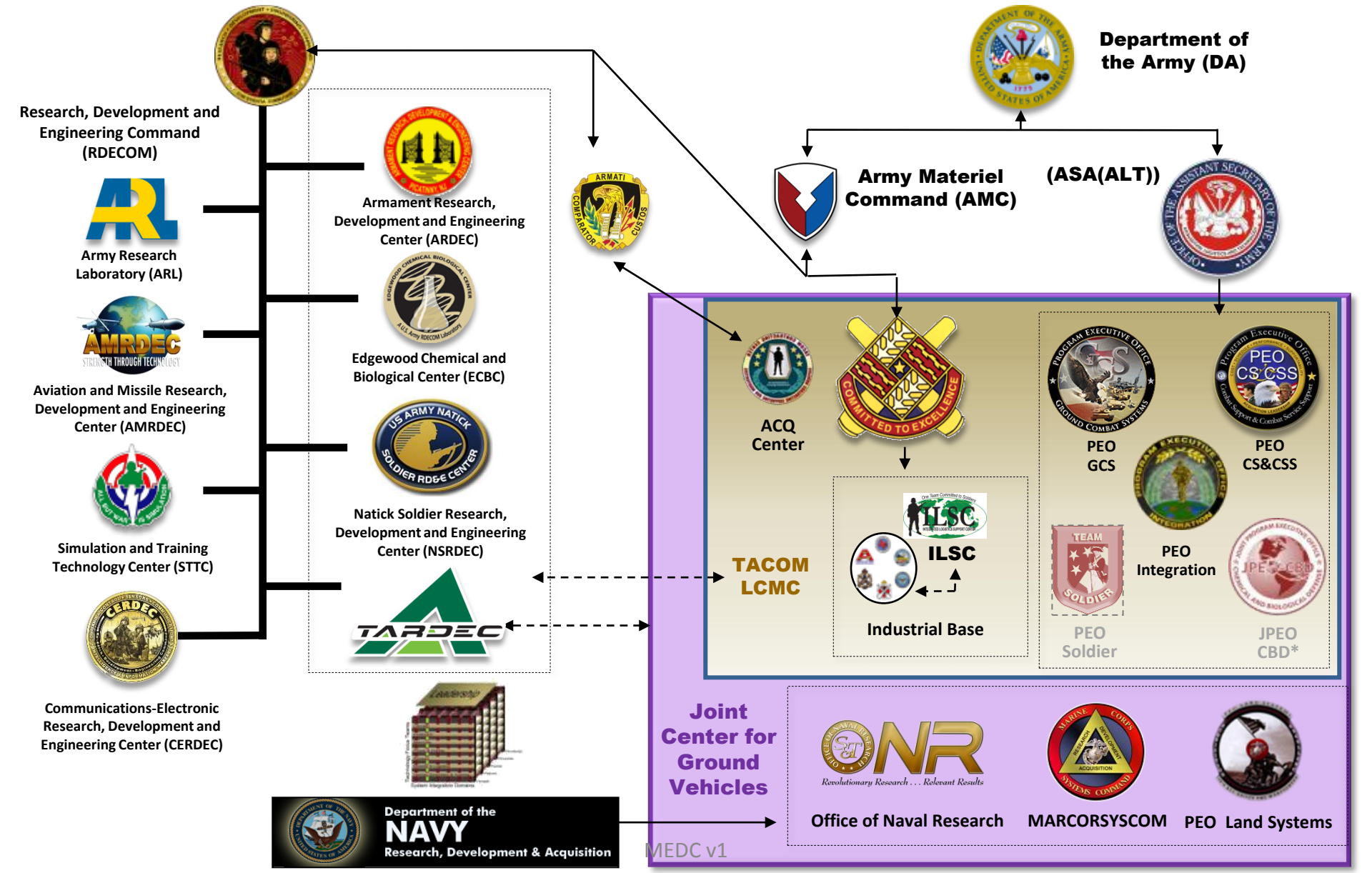
- TARDEC's mission is to develop, integrate and sustain the right technology solutions for all manned and unmanned Department of Defense (DOD) ground systems and combat support systems to improve Current Force effectiveness and provide superior capabilities for the Future Force.

- TARDEC's vision is to be the recognized DOD leader for ground systems and combat support systems technology integration and system-of-systems engineering across the U.S. Army TACOM Life Cycle Management Command.

Strategic Goal – Become world/national leader in Robotics, Energy and Underbody Blast

Lead. Innovate. Integrate. Deliver.

Domain Systems



Vehicle-to-Grid and Grid-to-Vehicle activities follow two interrelated tracks:

Installation Energy

- Fixed bases throughout the world and non-tactical vehicles
    - Development and demonstration of modified commercial vehicles
    - Cooperative work on automotive standards
    - Integrated micro-grid demonstrations

Operational Energy

- “energy required for training, moving, and sustaining military forces and weapons platforms for military operations. The term includes energy used by tactical power systems and generators and weapons platforms.”
- Forward Operating Bases, tactical trucks and combat platforms
    - Development and demonstration of research vehicles
    - Support for requirement development

Policy Drivers

Army Energy Security Goals

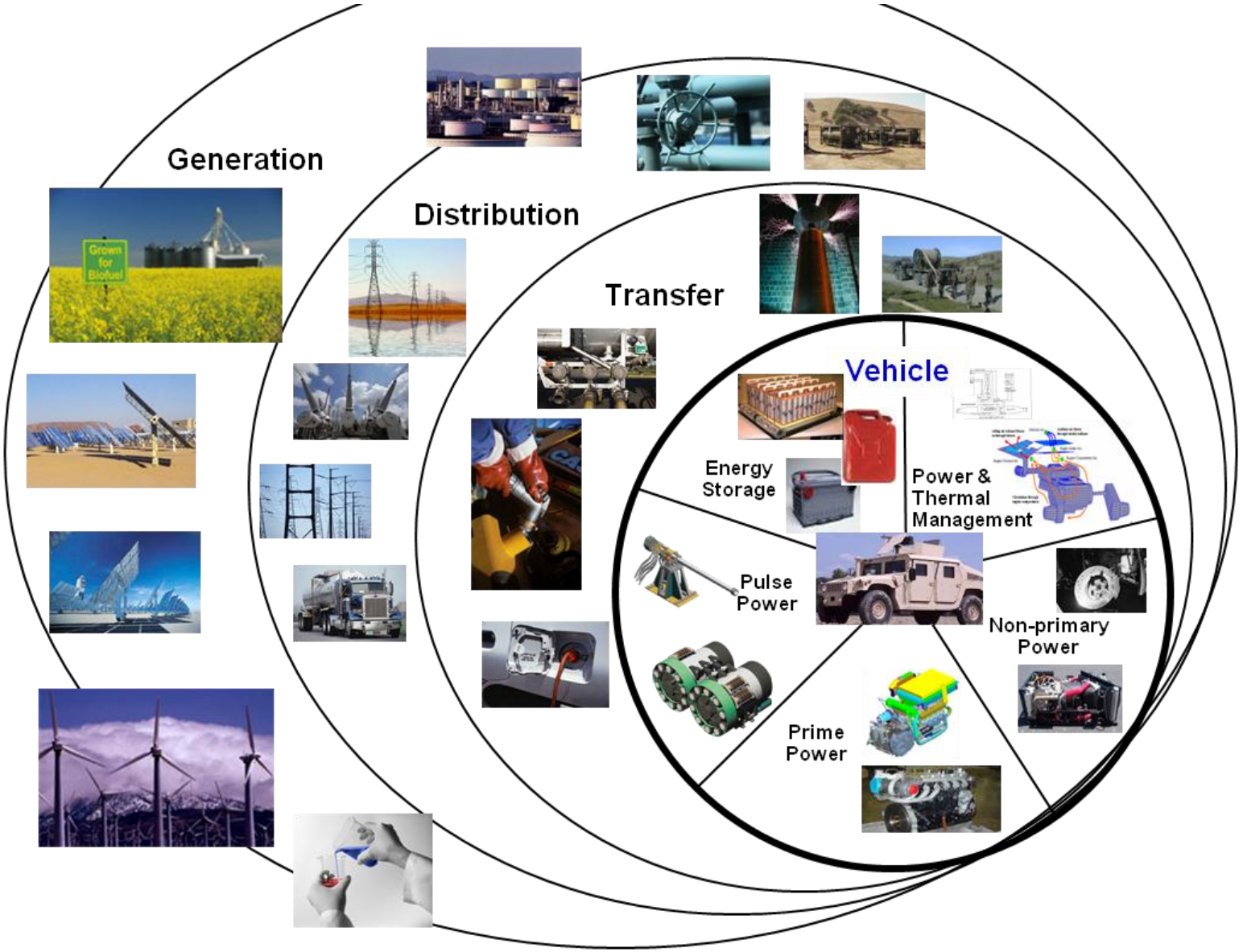
- Reduced energy consumption
- Increased energy efficiency across platforms and facilities
- Increased use of renewable / alternative energy

Installation & Contingency Base “Net Zero” electrical power production strategy (generation = consumption)

DOD Operational Energy Strategy

- Need to decrease energy demands
- Need to provide more on platform power for non-propulsion needs
- Need for energy interoperation amongst platforms, Soldier systems and base camps

Meeting energy & power mandates, goals, and strategy requires understanding of the challenge


Generation
Distribution
Transfer
Vehicle
Energy Storage
Power & Thermal Management
Pulse Power
Non-primary Power
Prime Power

Infrastructure An Installation Energy Driver

Vehicle related goals of the Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) program

- Cyber Secure Grid-to-Vehicle (G2V) and Vehicle-to-grid (V2G) communications with the microgrid power flow.
- Demonstrate V2G capability to support power demands of the micro-grid/utility.
- Finish Development/Validate industry standards for vehicle communications with the micro-grid.
- Demonstrate coordinated vehicle energy system charging to level load micro-grid system level power demands.
- Capture data required to understand the effect on propulsion subsystems life when plug-in vehicle is used for peak shaving to lower utility costs.

Meeting energy & power mandates, goals, and strategy requires understanding of the challenge

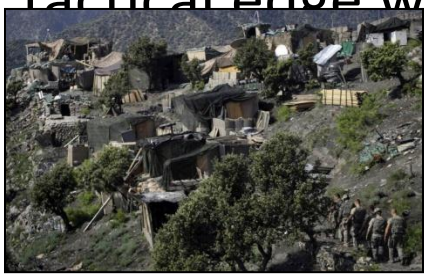
Contingency Basing

An Operational Energy Driver

Problem: Army S&T lacks an organized investment strategy for Contingency Basing

Issue:

- Tactical Small Units (TSU) (battalion & below) are forced to establish non-standardized base camps (contingency basing), limiting ability to efficiently employ full spectrum operations placing the TSU under duress with reduced capability
- Army faces increase logistical demand and operational costs due primarily to power and water with increased risk to supply lines
- RDECOM must develop a contingency basing strategy that will enable an enterprise approach to capability delivery for the tactical edge with total system integration aligned to Army s[illegible]n



Power in the Electric Infrastructure

Support of Army Energy Security Goals on domestic bases

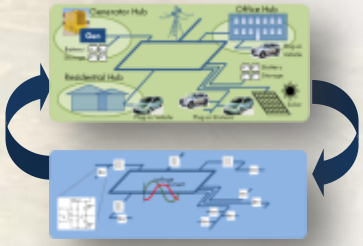
Utility and Distribution Network Impact

Standards Development

Power System Component Development and Vehicle Demonstrations

- Partnering in the development of Department of Defense electrified vehicle adoption plans
- Inter-agency demonstration of secure power infrastructure and renewable energy
- Development and operation of test beds on domestic bases

Early support of advanced power infrastructure for forward bases



Model Based Design and Control of Microgrids

- Apply lessons learned on domestic bases to development of future forward bases

Explore The Role of Vehicles in Installation Energy

Hydrogen Vehicles with Internal Combustion Engines(H2ICE)

H2 Station JBPHH

15 H2ICE-vehicles

= Hydrogen
= Electric

U.S. Army Aloha Microgrid 1

25 kW Solar Carport

Grid

4 Plug in, Bi-directional Electric Vehicles, 6kW/each

5 kW Mobile Solar

Two 150 kW Diesel Generators

AC DC

Building Loads

Hydrogen Fuel Cell Vehicles

Tri-service H2 Network

10 Hydrogen Fuel Cell Vehicle

U.S. Army Aloha Microgrid 2

Hybrid Hydrogen Vehicle

Fuel Cell Vehicle

Grid

H2 Station Schofield

Hydrogen Fuel Cell Electric Power Take Off vehicles (EPTO)

70 kW Solar

DC

Energy Storage

Two 75 kW Diesel Generators

2 Plug-in, Bi-directional Electric Vehicles;

Building Loads

2004

Created the H2ICE network and tested

2008

Existing CONUS vehicles arrive in Hawaii

2009

Hybrid Hydrogen Vehicles; In operation in Hawaii since February 2009

First Hawaii Advanced Vehicle Working Group Meeting Held

2010

Microgrid Planning Begins at Wheeler Army Airfield/Schofield Barracks

U.S. Army Aloha Microgrid 1; In Operation in November

2011

FCV deployed to Hawaii

General Motors Fuel Cell Vehicles; In Operation Starting August 2011

EPTO used by Marines in August 2011

2012

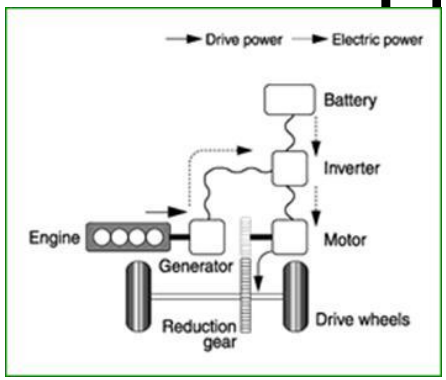
SPIDERS JCTD

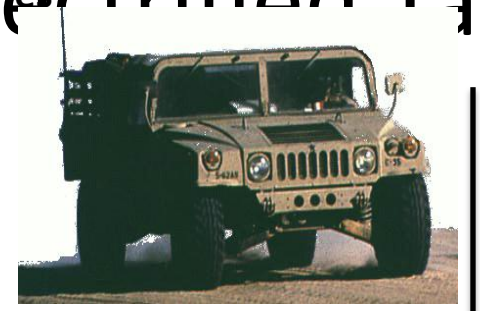
TARDEC Hydrogen Station; Planned operational for March 2012

U.S. Army Aloha Microgrid 2; Planned operational for January 2012

Demonstration Electrified Tactical Platform

Series

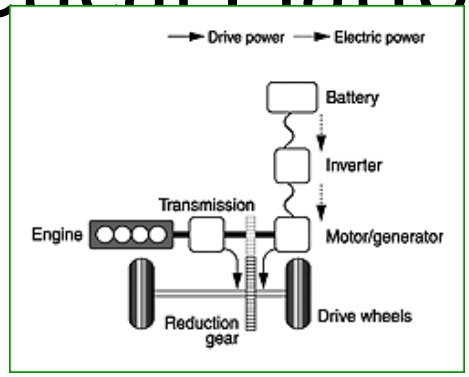




HMMWV Series HE

- Commercial Transit Buses
- All electric propulsion.
- Eliminates transmission, reduces mechanical linkages, thereby offering the greatest packaging flexibility.

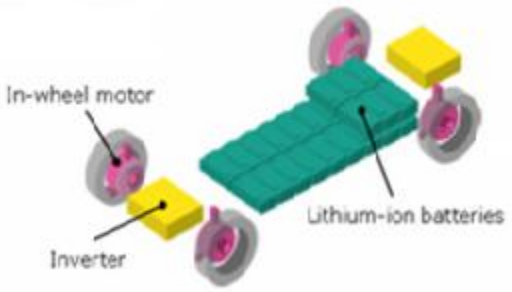
Parallel



Utility Vehicles

- Two paths from the prime mover to the wheels: One electric and one mechanical.
- Combined electric and mechanical propulsion.

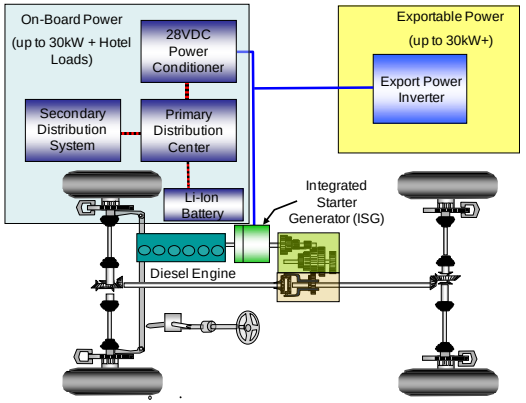
Electric



ROBOTS

- No combustion engine is present in this configuration; all power comes from onboard batteries which drive electric motors.

Integrated Starter Generator (ISG)



JLTV

- Bucket Trucks
- Propulsion of the vehicle is unchanged
- An inline generator provides onboard power

Fuel Economy varies with Architectures and Duty Cycles

Payback for Vehicle to Grid and Grid to Vehicle

User Profiles Considered		Yearly Fuel Consumption and Savings/vehicle: Hours/ Day	Relative frequency Days/yr	Convencional Fuel Consumad gal/veh.-year	Fuel Saved gal/veh.-year	Grouped Savings gal/yr	Payback = (Years)
Presence Patrol		9	156	2760	428	428	9
Afghanistan Convoy		15	156	8806	1194	1194	4
Drive Recon		7	84	2279	439	544	7
Helo Recon		7	20	575	105		
Mobile Radar	**Attack**	12	15	137	83	4194	2
	@ FOB	24	350	8988	4111		
	Host Nation Grid connected	24		8988	8988	9071	1

Payback covers recurring cost – not development cost

Excellent Cost-Benefit for Recurring Cost

Mission Input from :
3rd ID, based out of FOB Echo, Iraq , 656th Transportation Company, deployed to Afghanistan, USASOC, Cruise Missile Defense Systems Project Office, and Non lethal weapons