HYDROGEN AS A MILITARY FUEL

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DOE-FCTO AMR Inter-Agency Activities Collaboration Panel
US Department of Energy Hydrogen and Fuel Cells Program
2018 Annual Merit Review

Operational Energy Capability Improvement Fund (OECIF): Background and Overview

- 2010 *Quadrennial Defense Review* originally identified the need for specific investments in operational energy technology
  - "…the creation of an innovation fund…to enable components to compete for funding on projects that advance integrated energy solutions."
  - DoD initiated OECIF funding in FY 2012

- OECIF mission is supporting innovation for energy dominance – today and tomorrow
  - Technical Goal: Develop operational energy technologies to improve military capabilities
  - Institutional Goal: Establish Service momentum to transition initiatives to funded programs

- OECIF funded over 50 programs through the Services and CCMDs
  - Typically provides four years of OECIF funding, then transition to Services
  - One year efforts for rapid transition and proof of concept
  - Completed programs have yielded consistent record of technical accomplishment and transition to Services

2016 Operational Energy Strategy: Requirement, Risk, and Response

Energy enables capability → **Energy distribution is at risk** → **Adapt energy use**

Capabilities

- Range
- Endurance
- Payload
- Speed
- Survivability

C-141 ⇨ C-17
F-16 ⇨ F-35
P-3 ⇨ P-8
FFG-7 ⇨ LCS
HMMWV ⇨ JLTV

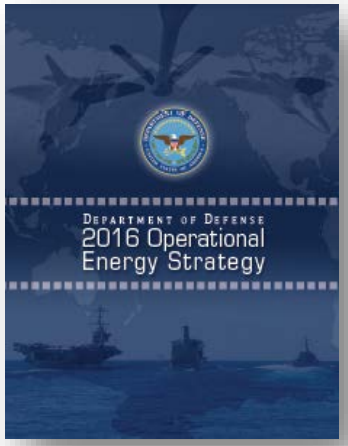
A2/AD

Geography

Distributed Ops

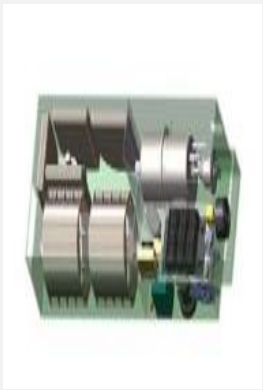
Irregular threats

Peer competitors



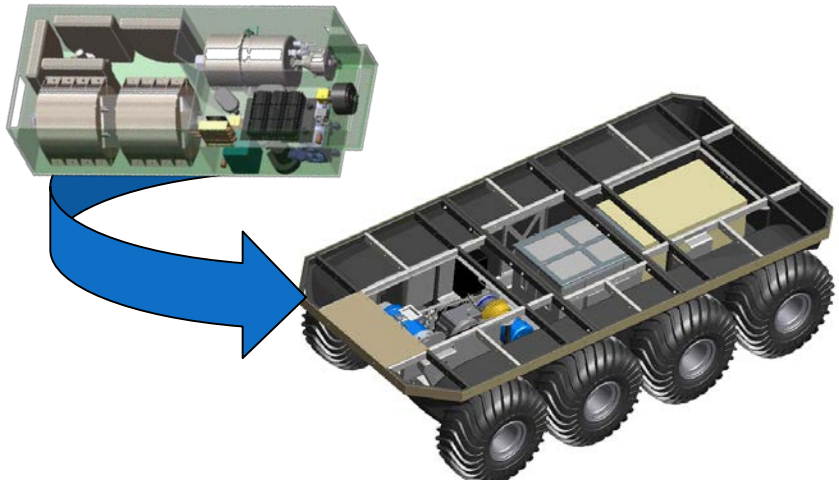
- Increase Future Capability
- Identify and Reduce Risks
- Enhance Current Mission Effectiveness

OECIF Hydrogen and Fuel Cell Initiatives

		Program	Description	Funding (M)
Army		**JP-8 Based Fuel Cell Power**	Develop a JP-8 based fuel cell power system that will meet the noise, range, and power requirements of Squad Multi-purpose Equipment Transport (SMET) unmanned vehicle. Current Status: Conducted JP-8 reformer maturation and began system level controls strategy and initial integration plan.	$8.5
Navy		**Hybrid Tiger** Multi-Day Endurance of Group 2 UAS using Pacific Energy Sources	Develop and demonstrate a multi-day, Group 2 UAS using Pacific energy sources - solar, hydrogen, and wind energy. Current Status: First flight complete with integrated wing solar arrays. Fuel cell and power management electronics in-hand undergoing hardware-in-loop benchtop verification before mounting in the aircraft. Custom large hydrogen tank under fabrication at vendor. Software production build undergoing hardware-in-loop simulations.	$6.3

JP-8 Based Fuel Cell Power

U.S. Army Tank Automotive Research, Development & Engineering Center (TARDEC)
Air Force Research Laboratory (AFRL)



MOTIVATION

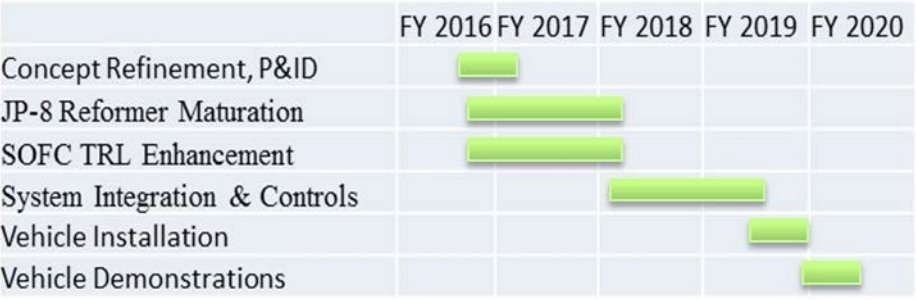
Logistical challenges in the PACOM AOR demand maximum energy density to minimize the logistical burden of supplying fuel in addition to great power density to integrate onto ground platforms. Large robotic vehicles, such as the Squad Multipurpose Equipment Transport (SMET), will travel with the dismounted infantry and require low noise signature, exportable power, and the ability to traverse difficult terrain over long distances without being refueled.

JP-8 based fuel cell systems can provide an SMET vehicle with the necessary power and energy to meet its requirements and perform as desired. On-board power means reduced need for generators, battery chargers and additional batteries, easing logistics.

PROGRAM PLAN /DESCRIPTION

Approach to overcome the technical barriers:

- Mature component hardware for JP-8 reformer and solid oxide fuel cell sized at 10-kW
- Design and integrate reformer and SOFC, optimize operation
- Integrate JP-8 fuel cell system on the SMET demonstration vehicle perform demonstration and performance testing
- Demonstrate silent mobility and export power capability



MILITARY BENEFIT

- A quiet Fuel cell (FC) based vehicle capable of using logistics fuels, transporting required equipment, conducting autonomous resupply missions, and silent watch
- Increased power & energy density for greater range and endurance
- Efficient power generation, especially at low electrical loads to reduce resupply
- Exportable power capable of replacing conventional 10kW
- Technology enabler for long range Intelligence, Surveillance, and Reconnaissance (ISR) payloads and mission scenarios
- Technology common across DoD - Working with Air Force, Navy, SOCOM, USMC, CERDEC
- Reduced thermal and acoustic signature operation

Hybrid Tiger

Hybrid Tiger leverages NRL's Ion Tiger long-endurance hydrogen fuel cell demonstrator:
26hr endurance on gaseous hydrogen, 2008
48hr endurance on liquid hydrogen, 2010

NRL / Industry hydrogen fuel cell, now a commercial product for UAS

Hybrid Tiger is Group 2 UAS with multi-day endurance

- 23 kg, 7.3 m wingspan autonomous air vehicle.
- Fuel cell and hydrogen fuel account for ~66% energy.
- Solar arrays in the wings account for ~33% energy.
- Environmental energy extraction via autonomous soaring capable of +50% endurance, depending on conditions.
- Energy-optimal guidance can reduce fuel consumption by up to ~30% depending on weather conditions.

Main technical challenges

- Power system integration: solar + fuel cell = endurance
- High specific energy fuel storage → endurance
- Automated energy guidance algorithms → endurance
- High efficiency electric propulsion → climb vs cruise

Mission Enhancement

- High specific energy of H_2 enables:
  - 24-7 uninterrupted air support: communications relay, ISR or other payloads
  - Long range (1000 nmi+) in a small tactical vehicle
- H_2 production from solar and water can reduce energy logistics burden

Other DoD Hydrogen Efforts (not sponsored by OECIF)

AFRL and the Hawaii CATT Technologies Hydrogen Powered Vehicle

Crew bus powered by a hydrogen fuel cell at JB Pearl Harbor-Hickam (U.S. Air force photo by J. Brian Garmon.

Other DoD Hydrogen Efforts (not sponsored by OECIF)

GM and TARDEC ZH2 Hydrogen Cell- Powered Vehicle

Technical Challenges and Advantages with Hydrogen

- **Challenges**
  - Lightweight storage tanks
  - Thermal management to shed waste heat

- **Advantages in Warfighting**
  - Provide more energy per weight unit
  - Produced locally from water
  - Leverage technology used in industry
  - Produce electricity directly

Collaborative Efforts

- OECIF invested over $250M in 60+ projects designed to increase capability for the warfighter partnering with industry, academia, and research laboratories.
- OECIF projects have produced consistent technical accomplishment and achieved an array of transition outcomes.
- STEM and intern efforts ensure we are growing and grooming the next generation of scientists and engineers.
- Use modeling and simulation/data analysis to make informed decisions.
- Agencies collaborate and share efforts to ensure adversarial match/over-match of near peers.