HYDROGEN AS A MILITARY FUEL

RuthAnne Darling
Director of Innovation
Office of the Deputy Assistant Secretary of Defense for Operational Energy

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

A2/AD

Geography
- Distributed Ops
- Irregular threats
- Peer competitors

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

- Increase Future Capability
- Identify and Reduce Risks
- Enhance Current Mission Effectiveness
# OECIF Hydrogen and Fuel Cell Initiatives

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<th>Program</th>
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<th>Funding (M)</th>
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| **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

<table>
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<tr>
<th>FY 2016</th>
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<th>FY 2018</th>
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<td>Concept Refinement, P&amp;ID</td>
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<td>JP-8 Reformer Maturation</td>
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<td>SOFC TRL Enhancement</td>
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<td>System Integration &amp; Controls</td>
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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 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 H₂ enables:
  - 24-7 uninterrupted air support: communications relay, ISR or other payloads
  - Long range (1000 nmi+) in a small tactical vehicle
- H₂ 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.)
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.