Renewable Hydrogen Production at Hickam Air Force Base

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A PROGRAM OF THE HIGH TECHNOLOGY DEVELOPMENT CORPORATION

(808) 594-0100

Hawaii Center for Advanced Transportation Technologies

- Established by the High Technology Development Corporation (a Hawaii State Government Agency) in 1993 as Hawaii Electric Vehicle Demonstration Project.
- Mission: develop and demonstrate technologies for future military and commercial transportation systems.
- One of seven regional consortia that participated in the Defense Advanced Research Projects Agency (DARPA) Electric & Hybrid Vehicle Technology Program and the Department of Transportation (DOT) Advanced Vehicle Technologies Program.
- Began partnership with Air Force Advanced Power Technology Office (APTO), Robins AFB, GA in 2001.
- Expanded focus to include renewable energy applications.

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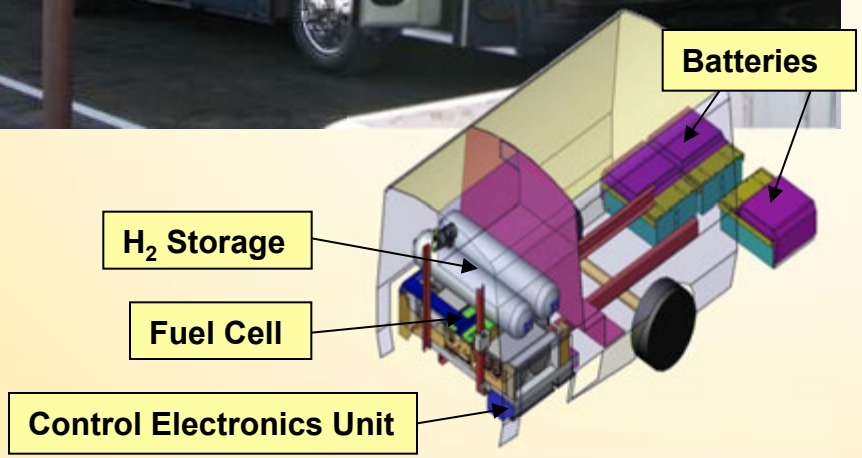
APTO Objective in Hawaii

- Air Force and State of Hawaii partnership established a National Demonstration Center at Hickam AFB to facilitate demonstration / validation of the latest fuel efficient and environmentally compliant technologies for use in Air Force ground vehicle fleets, support equipment, base infrastructure, and basic expeditionary airfield resources.
- Partner organizations:
  - Air Force Advanced Power Technology Office (APTO), Robins AFB, provides program direction and funding;
  - Hawaii Center for Advanced Transportation Technologies (HCATT), State government agency, develops technology through contracts with industry;
  - 15th Airlift Wing (15 AW), Hickam AFB, operates and evaluates technology for future procurement.

Battery Dominant Fuel Cell Hybrid Bus



- ElDorado National RE-29E
- L/W/H: 30ft/96in/116in Wheel base: 160in
- GVWR/Curb Weight: 29,000lb/ 22,240lb
- Seats: 23; Base shuttle service
- 120kW Enova Systems Electric Drive System
- 140Ahr Hawker Advanced Lead Acid Battery
- 20kW Hydrogenics Fuel Cell Power Module
- 2 Dynetek 5kg Hydrogen Storage Tanks (5000psi); total storage – 10kg

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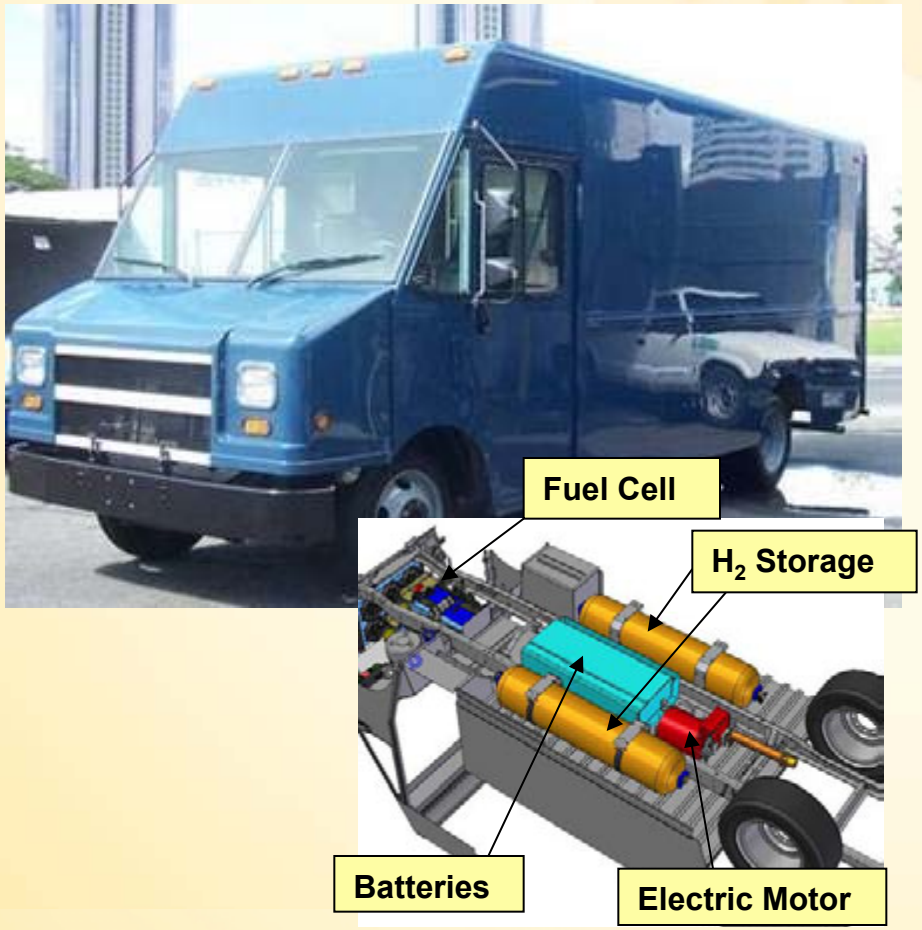
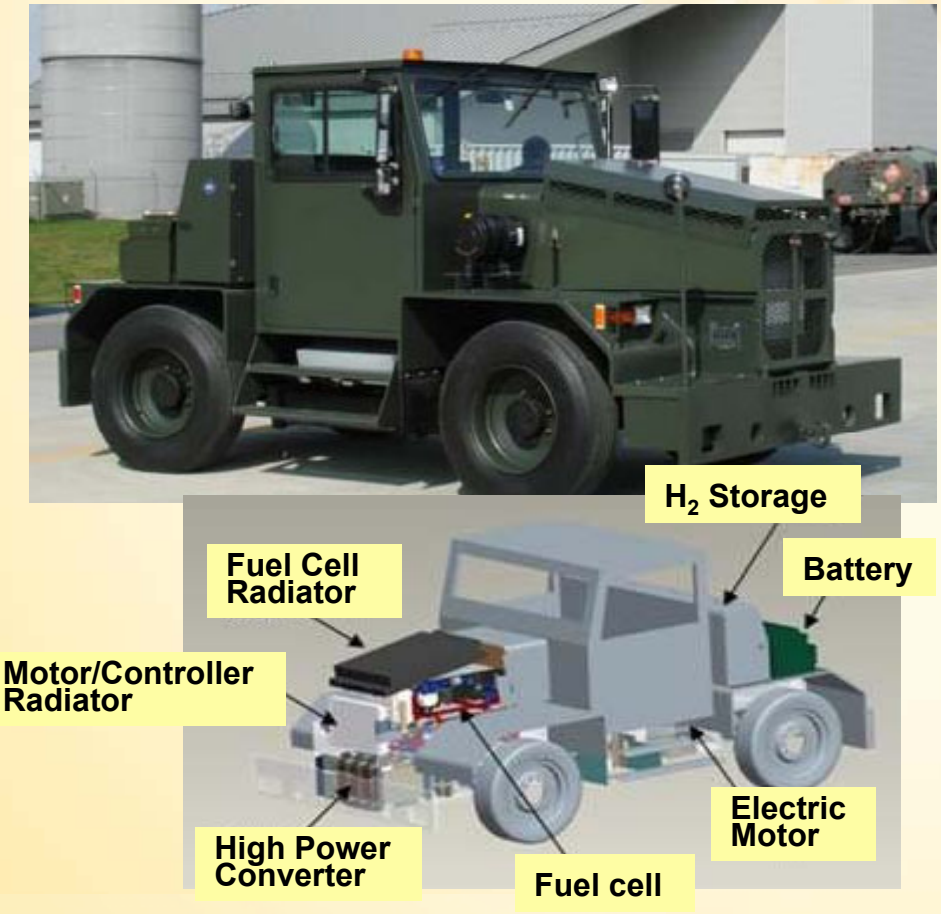
Fuel Cell Hybrid Step Van



- Workhorse Chassis P31842
- Utilimaster 16ft Walk-In Body
- GVWR: 14,100lb Wheel base: 178in
- On-Board Power Generation
- 120kW Enova Systems Electric Drive System
- 65kW Hydrogenics Fuel Cell Power Module
- 42Ahr Hawker Advanced Lead Acid Battery
- 2 Dynetek 5kg Hydrogen Storage Tanks (5000psi); total storage – 10kg

Fuel Cell Hybrid Aircraft Tow Vehicle



- Entwhistle MB-4 Aircraft Tow Vehicle
- 14,000lb Drawbar Pull
- Four Wheel Drive; Four Wheel Steer
- Curb Weight 19,800lb (stock)
- On-Board Power Generation
- Systems Integration by CTC
- 120kW Enova Systems Electric Drive System
- 65kW Hydrogenics Fuel Cell Power Module
- 70Ahr Hawker Advanced Lead Acid Battery
- 3 Dynetek Hydrogen Storage Tanks (5000psi); total storage - 7kg

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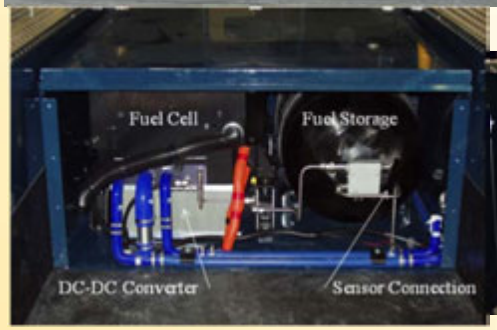
Flightline Maintenance Support Vehicle



- Ford Ranger Electric Pick-up
- Siemens AC Induction Motor
- 26kWh Panasonic NiMH Battery Pack
- 12kW Hydrogenics Fuel Cell Power Module (APU)
- 1 Dynetek Hydrogen Storage Tank (5000psi); 1.8kg
- 3hp J-Air Compressor for Pneumatic Tools & Light Mast
- 4 – 120VAC Circuits, plus Retractable Extension Cord
- 2 – 240VAC Circuits
- Pneumatic Light Mast Assembly

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Hydrogen Infrastructure Strategy

- Develop lowest cost, highest value infrastructure with multiple options for maturation.
- Fabricate modularized system, fully deployable by military or commercial transport.
- Ensure hydrogen source flexible, fully scalable for low and high volume fill with no modifications.
- Install complete refueling station at Hickam AFB - model for other air bases.
- Establish minimum requirements for fire safety and emergency response training.

Infrastructure Development Phases

- Interim solution: fabricate 3 DOT approved "12-packs" (36 total); transport packs from cylinder refilling site to Hickam AFB; add pressure management system to compress H_2 to 5000psi .
- Near-term: add on-site hydrogen production using electrolysis to eliminate over-the-road delivery; increase H_2 storage.
- Long-term: prepare technical site materials and design plans for a permanent station to accommodate any vehicle and reformation technology.

Interim H_2 Supply Component

- DOT approved Lift Packages for on-road transport; 2930psi.
- 10kg each; local industrial supplier compatible.
- Can be used as low pressure bank in completed system and retain capability for portable 10kg use.

H_2 Production & Fueling Station

- Modular, deployable hydrogen production and fueling station, designed and developed by HydraFLX Systems, composed of Packaged Operating moDules (PODs), which are crush proof-designed, DOT transportable, carbon steel packages for military or commercial transport.
- Three primary PODs:
  - Hydrogen Fuel Processor (H_2FP) using two Teledyne Energy Systems HMX 200 electrolyzers; production output 50kg/day.
  - Hydrogen Pressure Management (H_2PM) using HydraFLX compression system; pressurizes H_2 up to 5000psi.
  - Hydrogen Pressure Storage (H_2PS) using 9 Dynetek composite tanks; stores H_2 at 5000psi.
- Two additional PODs provide Power Control and Water for electrolysis; MEP 9 Generator used for deployment.

Modular & Deployable PODs

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Photovoltaic Array for H_2 Station

- H_2 is produced by solar power, deployable generator, or utility grid.
- Configuration efficiency based on NREL PV Watts website.
- 146kW PV array supports maximum load of station and provides capability to produce up to 12kg/day of renewable H_2; 207,445kWh/yr; annual savings - $43,563.
- Solar energy placed on grid when station is not operating.

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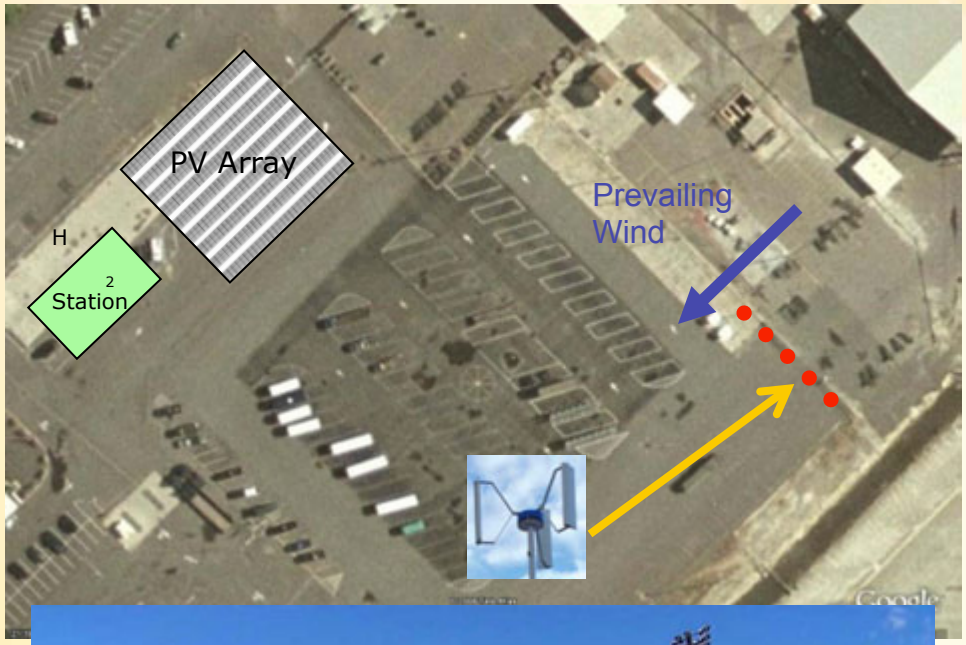
Accumulated Values

- PV array in operation for 5 months
- 96,765 kWh of energy produced to either make hydrogen or offset energy consumption on petroleum based power grid
- 472 kg of hydrogen produced
- $16,000 savings from grid offset (station not producing hydrogen)
- Rated 146 kW PV array actually produced 183 kW peak power

Wind Turbines for H_2 Station



- Five 10kW vertical axis wind turbines (vs. horizontal) due to proximity of runway
- Supplement PV for 24/7 renewable energy
- Installation underway; planned completion by 11/30/09
- Wind analysis required to calculate energy and cost savings
- When station is not operating, wind energy placed on grid.

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Future Fuel Cell Vehicles and Equipment

- Fuel cell powered light cart using hydride storage
- Fuel cell hybrid flight line sweeper
- Fuel cell hybrid R-12 refueler
- Fuel cell hybrid light duty shuttle bus
- Fuel cell hybrid towbarless aircraft towing vehicle
- Stationary fuels cell as back-up power

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