Hawaii Center for Advanced Transportation Technologies

Plug-In Hybrid Electric Vehicles

Maui County Energy Expo 2007

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A PROGRAM OF THE HIGH TECHNOLOGY DEVELOPMENT CORPORATION

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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.
- All our vehicles, electric and hybrid, are plug-in.

Examples of Previous Projects

Hyundai Electric SUV Demo

Hybrid Electric Transit Bus

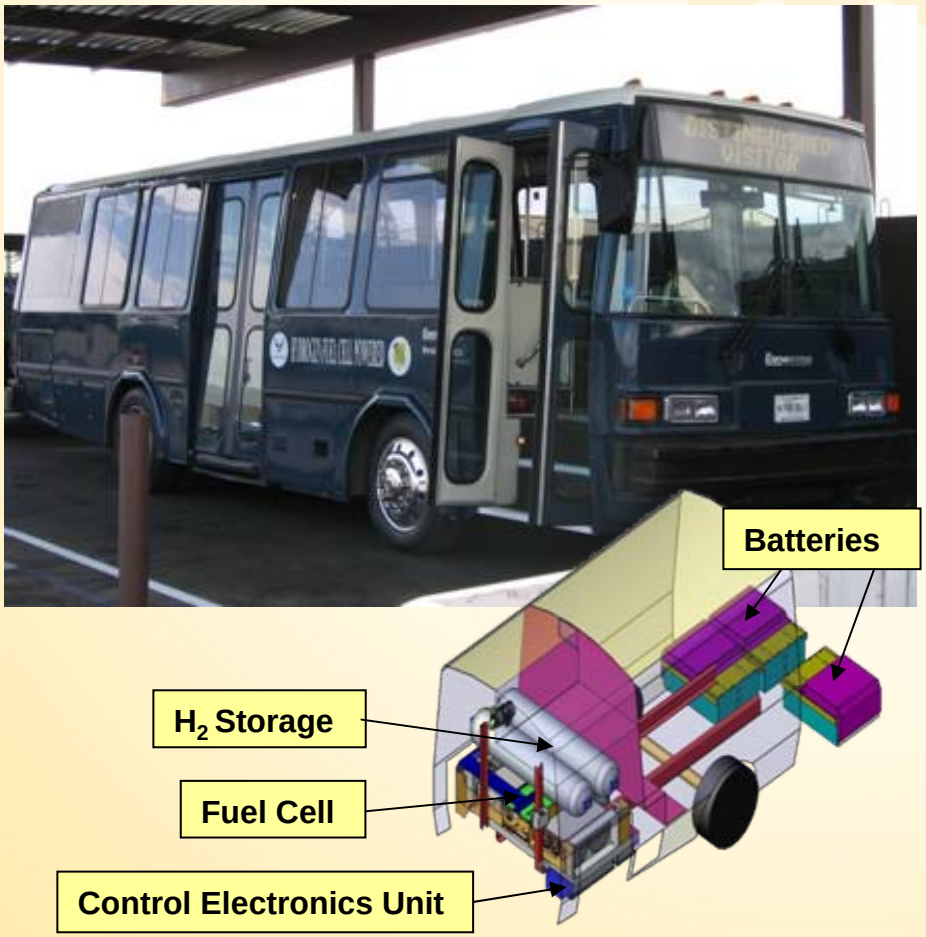
EV Rapid Charging Stations

Electric Shuttle Bus

APTO Objective in Hawaii

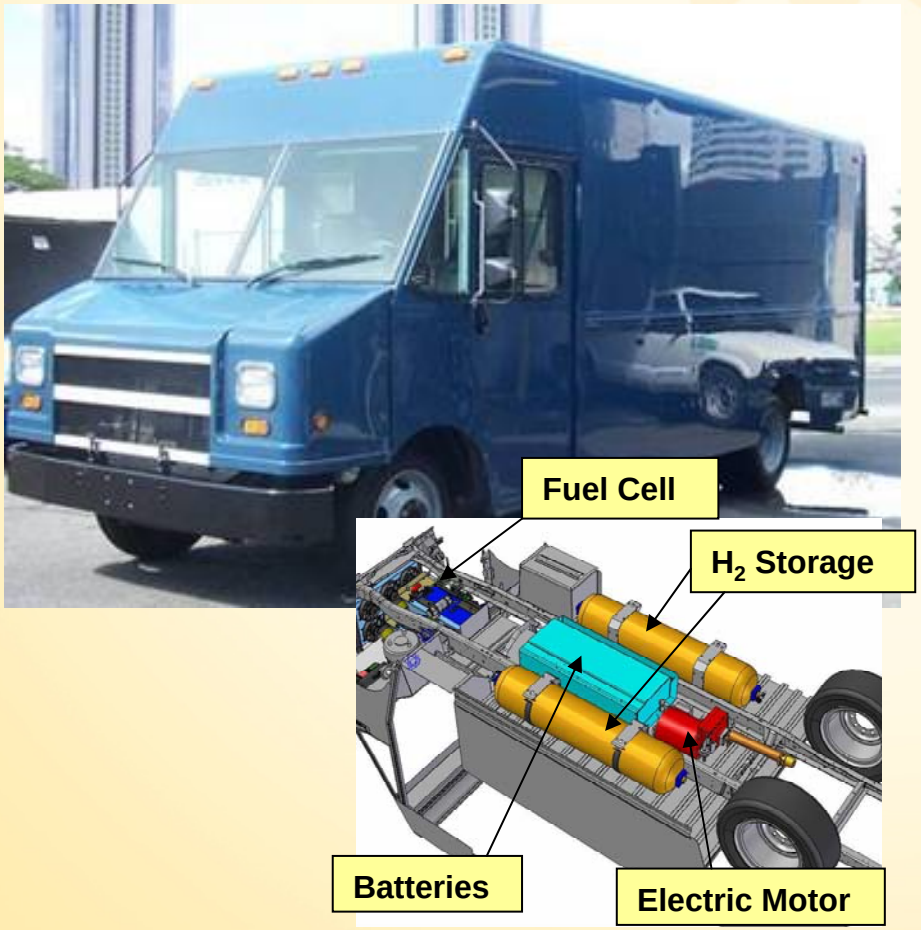
- Establish a National Demonstration Center at Hickam AFB to facilitate demonstration / validation of the latest fuel efficient and environmentally compliant technologies for use in Air Force ground vehicle fleets, support equipment, Basic Expeditionary Airfield Resources (BEAR), and base infrastructure.
- Partner roles: APTO – funding agent; HCATT – technology developer; 15th Airlift Wing – operator/user.
- Present focus: fuel cell vehicles and hydrogen infrastructure, plug-in parallel hybrid electric van, lithium battery-powered van.

Battery Dominant Fuel Cell Hybrid Bus



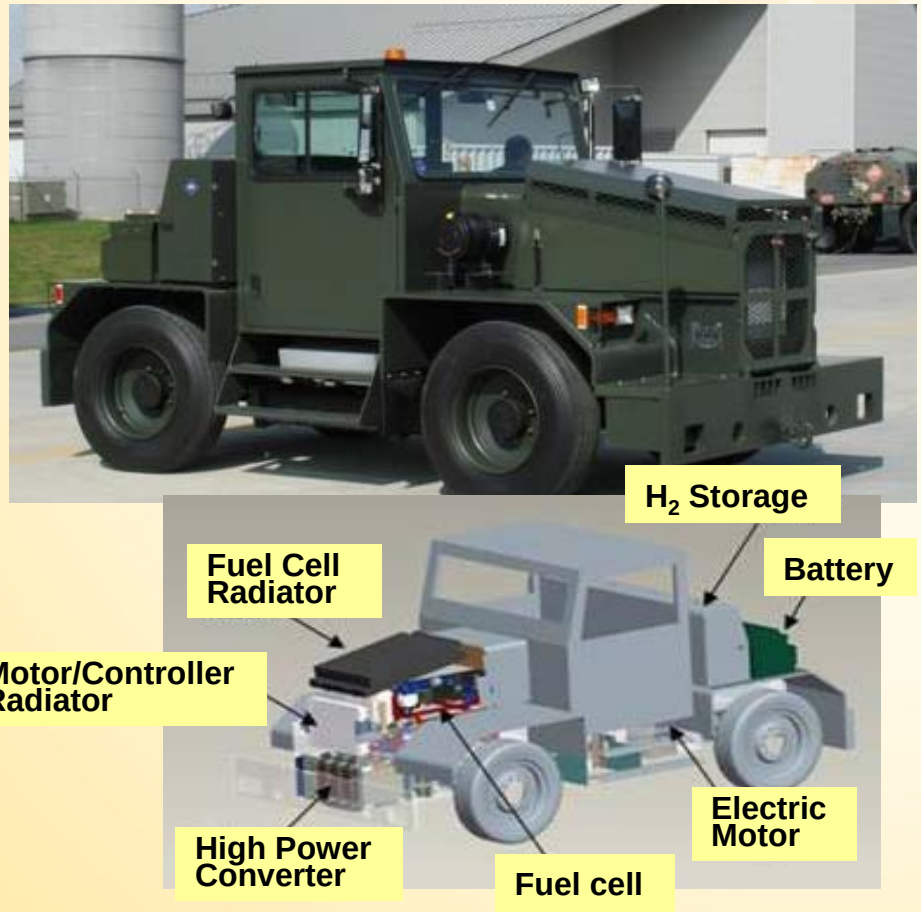
- ElDorado National RE-29E
- L/W/H: 30ft/96in/116in Wheel base: 160in
- GVWR/Curb Weight: 29,000lb/22,240lb
- Seats: 23; Base shuttle service
- 120kW Enova Systems Electric Drive System
- 140Ahr Hawker Advanced Lead Acid Battery
- 20kW Hydrogenics Fuel Cell Power Module
- 2 Dynetek 5kg Hydrogen Storage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

Fuel Cell Dominant 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 MB-4 Tow Vehicle

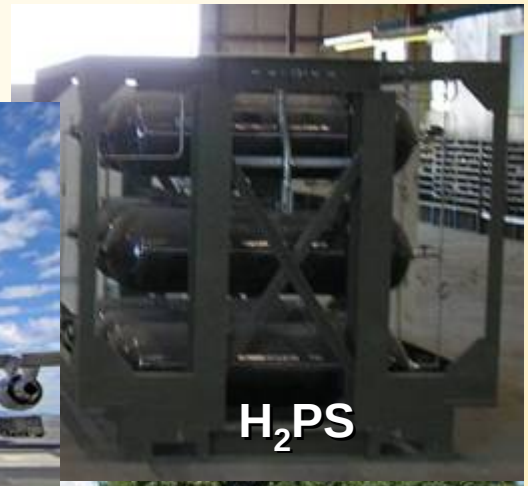


- Entwhistle MB-4 Aircraft Tow Vehicle
- 14,000lb Drawbar Pull
- Four Wheel Drive; Four Wheel Steer
- Curb Weight 19,800lb (stock)
- On-Board Power Generation
- Systems Integration by CTC
- 120kW Enova Systems Electric Drive System
- 65kW Hydrogenics Fuel Cell Power Module
- 70Ahr Hawker Advanced Lead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

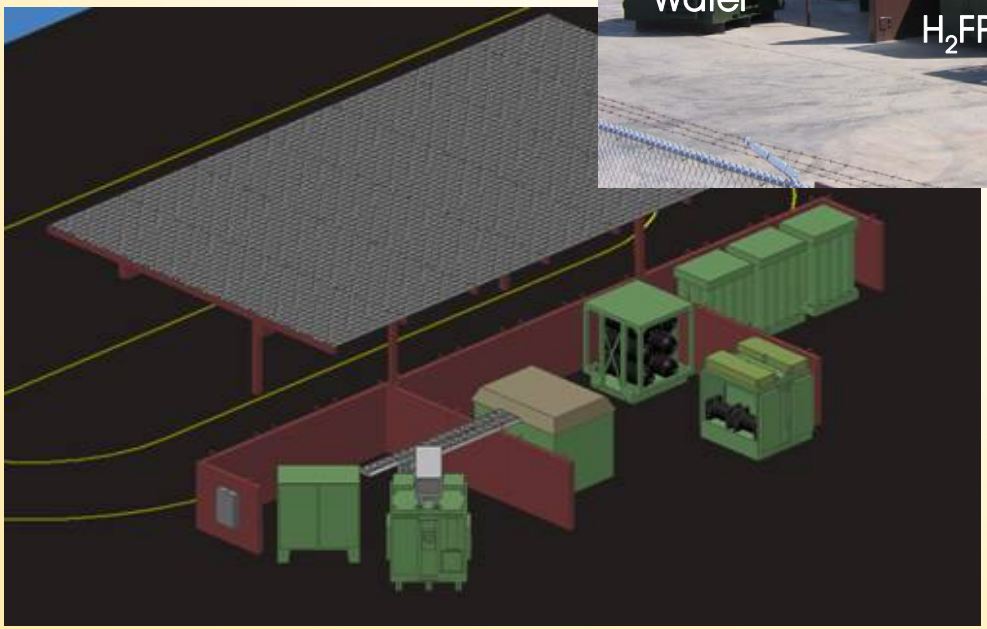
H_2 Production & Fueling Station

- 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



H_2 Production & Fueling Station Layout



Hybrid Electric Vehicles - today

- Manufacturers: Toyota, Honda, Ford, Lexus, transit buses, GM (2008); parallel hybrids.
- Relatively small battery packs.
- With few exceptions, engine runs whenever vehicle is moving.
- Marketed as “no plug required”, to distinguish from limitations associated with battery-only vehicles.

National Commission on Energy Policy

With a larger battery pack, it may be possible in the future to extend the all-electric range of hybrid-electric vehicles and provide consumers with the option of recharging the battery using the electric grid. "Plug-in" hybrid technology, because it could make use of grid-provided electricity, could help further diversify the energy mix used in the transportation sector.

Plug-in Hybrids

- Common names: plug-in hybrid, grid-connected hybrid, electric hybrid, gasoline-optional hybrid, PHEV; series and parallel hybrids.
- Larger battery pack, e.g. from existing 1.3kWh to 9kWh.
- Upgrade from NiMH to Li batteries.
- Increase battery-only range to 50 miles (78% of Americans drive <40 miles per day).
- On-board chargers plug into 110V or 220V outlets.

Paths to PHEV Commercialization

- Currently conversions; DOE and industry sponsored.
- Overcome advanced battery hurdle – price and maturity of technology.
- Production and promotion by automakers; create market demand – ease of refueling, less costly refueling (1/3).
- Focus on utility industry – PHEVs make good business sense for the utility that is focused on urban quality of life, economic development, and regional sustainability; sell importance of transportation emission reduction.

Plug-in Hybrid Projections

- Earliest introduction – 2010
- Production/sales ramp up similar to Prius sales:

Year	HI	US
2000	25	6,401
2001	92	15,556
2002	62	20,119
2003	99	24,627
2004	449	53,991
2005	662	107,897
	1,389	228,591

- Fuel cell hybrids ~ 2020

DOE's Pacific Northwest National Laboratory Power Estimates

- There is enough under-utilized, overnight electric power capacity to charge more than 80% of the United States automotive fleet if they were all plug-in hybrids or pure electric cars.
- Adopting plug-ins will not create a need for new base load electricity generation plants until plug-ins constitute over 84% of the country's 220 million passenger vehicles.

Environmental Impact

- Environmental and Energy Study Institute: with today's electricity grid, there would be a national average reduction in carbon emissions by about 60% per vehicle when a plug-in hybrid with 20-mile all-electric range replaces a conventional car.
- Electric Power Research Institute & Natural Resources Defense Council: scientists have confirmed that unlike gasoline vehicles, PHEVs will get cleaner as they get older because our power grid is getting cleaner.

Impact on Energy and Transportation Systems

- Reduce fossil fuel combustion/emissions at vehicle; increase at power plant with stricter emission controls.
- Reduce “pay at the pump”; refuel at home for 1/3 the cost.
- Reduce night time utility rates to incentivize off-peak charging.
- Transition to fuel cell hybrids; increase demand for hydrogen (non-carbon based fuel); produce hydrogen at home; vehicle to grid (V2G) power for residence.

Summary

- Spend less time at gas stations, get home back up power, lower maintenance costs, and benefit society by reducing oil imports, greenhouse gases, and pollution.
- It's an exciting vision, though one that isn't going to be easy to achieve. It will require breakthroughs in technology, manufacturing, public policy, and most importantly, political will.

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