

2011 DOE Hydrogen and Fuel Cells Program Review

Hawaii Hydrogen Power Park

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TV009

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Overview

Timeline

- ✓ **Start:** April 2009*
- ✓ **Finish:** Jan 2013
- ✓ **50% Complete**

Budget

- ✓ **FY09: Power Park - \$2.4 million**
 - \$1.2 million DOE
 - \$1.2 million State of Hawaii (SOH)
- ✓ **FY11: Power Park - \$0.6 million, SOH**
- ✓ **Related Funding**
 - **Vehicles at HAVO site**
 - \$1.0 million – National Park Service
 - \$0.6 million – SOH
 - **Vehicles at MCB Hawaii site**
 - \$1.8 million – Office of Naval Research
 - **Upgrade MCBH station to 700 bar**
 - \$1.5 million – Office of Naval Research

Barriers

- ✓ **Validation**
 - A. FCV Performance
 - C. H2 Refueling Infrastructure Data
 - H. Hydrogen from Renewables
- ✓ **Safety**
 - H. Hydrogen Knowledge by AHJ

Partners

- ✓ US DOE
- ✓ State of Hawaii
- ✓ Hawaii Volcanoes National Park (NPS)
- ✓ Kilauea Military Camp (DoD)
- ✓ Hawaii Ctr. Adv. Transp. Technology (HCATT)
- ✓ Hawaiian Electric Light Co (HELCO)
- ✓ Sandia National Lab
- ✓ Marine Corps Base Hawaii
- ✓ Office of Naval Research
- ✓ Puna Geothermal Ventures
- ✓ General Motors
- ✓ *NREL*

Objectives

Power Park project scope expanded in 2011 to support collaboration between USDOE and DOD which includes installation of higher capacity hydrogen infrastructure at the Puna Geothermal facility on island of Hawaii (see MT008) and ONR/GM fuel cell vehicle demonstration project at Marine Corps Base Hawaii on Oahu

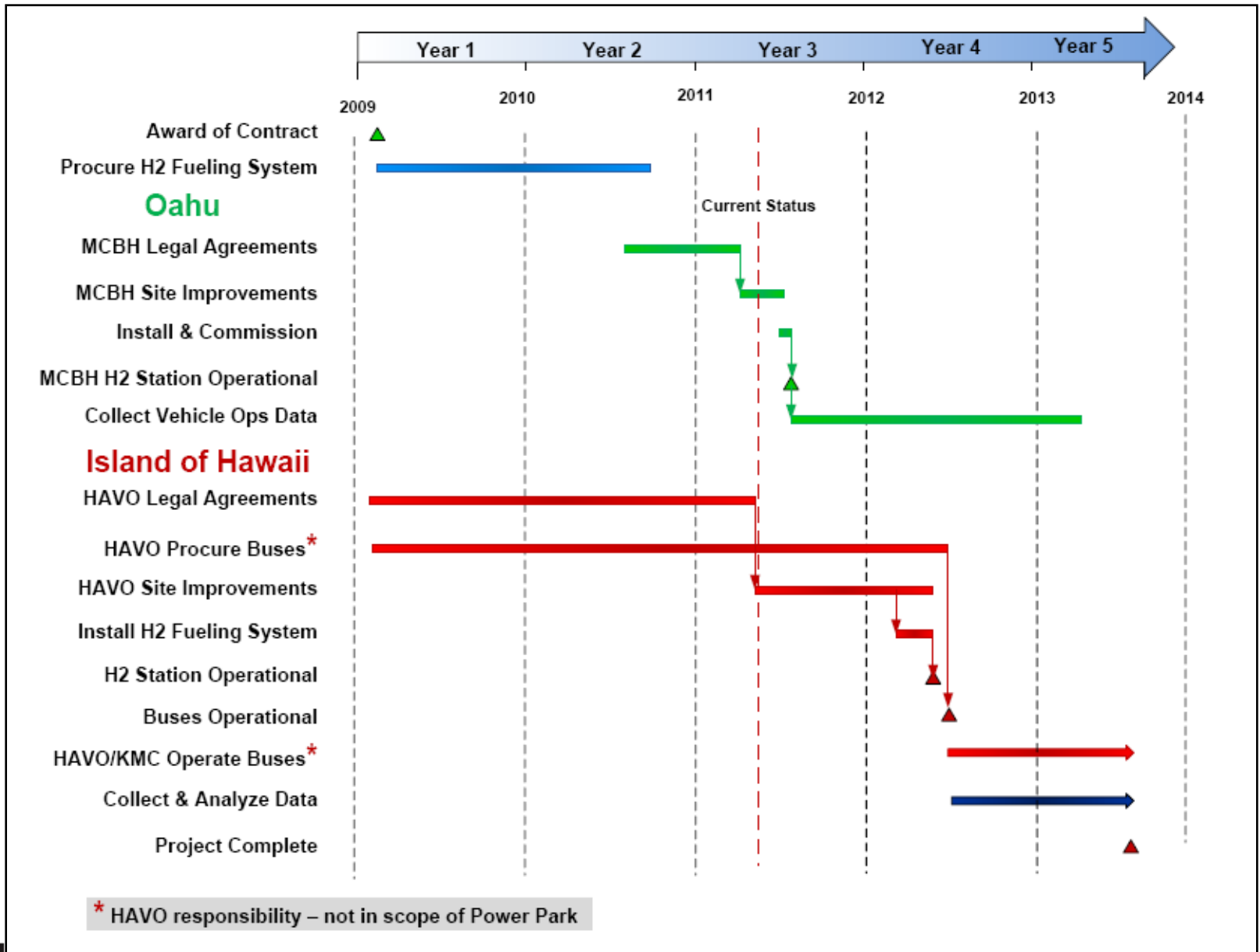
Hawaii Island

- ✓ Support the operations of Hawaii Volcanoes National Park (HAVO) hydrogen PHEV shuttle buses through to Jan 2013;
- ✓ Install hydrogen fueling infrastructure at HAVO;
- ✓ Conduct engineering and economic analysis of HAVO bus operations on different routes, grades, elevations & climatic conditions;
- ✓ Validate fuel cell system performance in harsh environment including high SO₂; and
- ✓ Attract new partners & applications for Big Island hydrogen infrastructure including back-up power applications

Oahu

- ✓ Support GM Equinox FCV demonstration project at Marine Corps Base Hawaii in partnership with Office of Naval Research.

Power Park Milestones

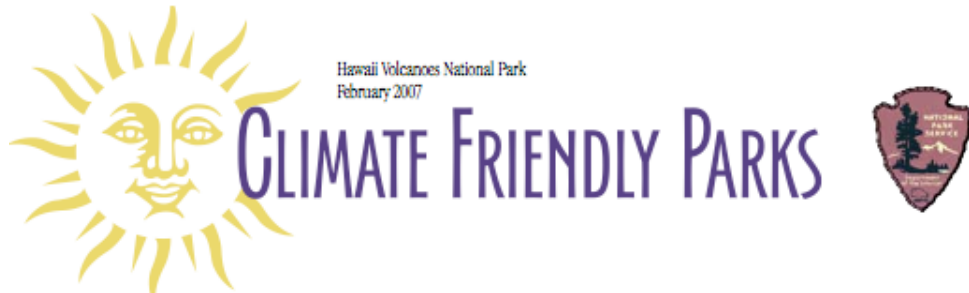


Approach

Reflects expanded scope of project to meet changed circumstances

- ✓ **Leverage DOE/NRL 60 kg/day geothermal to hydrogen grid management project to supply HAVO hydrogen requirements (see MT008);**
- ✓ **Leverage ONR investment (\$1.8 million) in GM vehicles to be operated from MCB Hawaii and other Navy sites on Oahu;**
- ✓ **Leverage National Park Service and State of Hawaii investment in FC-PHEV shuttle buses (NPS \$1 million + SOH \$600k) at HAVO;**
- ✓ **Relocate turnkey Powertech fueling station to MCB Hawaii on Oahu to support GM Equinox FCV program (original siting at HAVO);**
- ✓ **Use hydrogen produced at Puna Geothermal under DOE/NRL grid management program (MT008) to fuel HAVO buses using lightweight tube trailers and mobile compressor/fueling unit at HAVO;**
- ✓ **Collaborate with national lab data analysis groups to compare system data under different operating conditions (fueling stations & vehicles);**
- ✓ **Evaluate the effect of different grades, climatic zones, air quality conditions including SO₂ on vehicle performance;**
- ✓ **Transfer results to industry and government agencies.**

Hawaii Volcanoes National Park



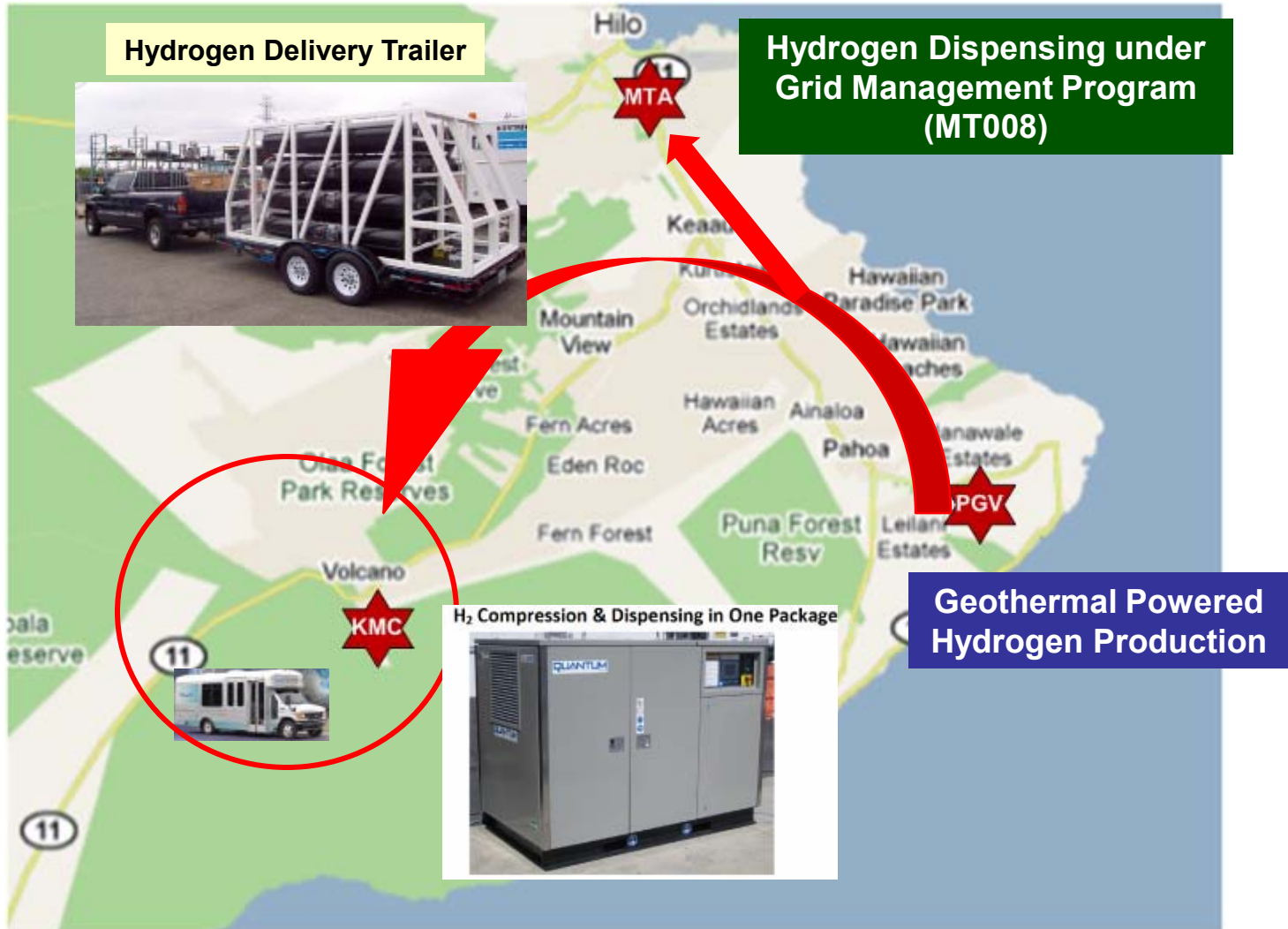
- ✓ **Power Park supports NPS “Climate Friendly Parks” program to reduce carbon footprint & improve visitor experience:**
 - **Reduce traffic congestion- cars and buses;**
 - **Reduce size of buses in the park;**
 - **Reduce emissions pollution; and**
 - **Reduce noise pollution.**

- ✓ **Evaluate performance of plug-in hybrid electric vehicle (PHEV) shuttle buses using hydrogen;**
- ✓ **Test bed for range of NPS transportation solutions.**

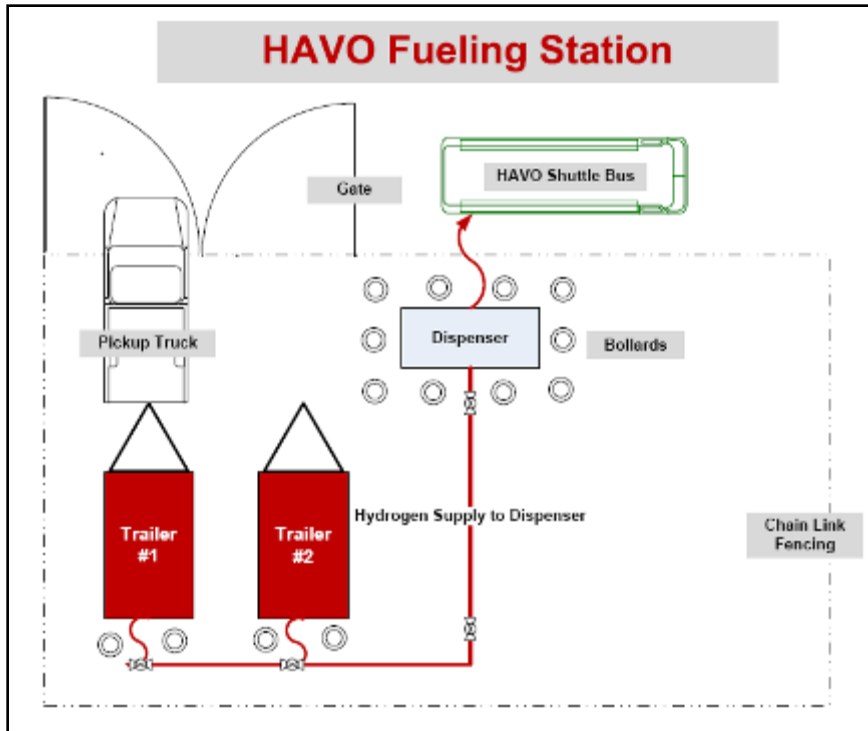
HAVO Hydrogen Fueling Station

- ✓ **Off-site electrolytic hydrogen production using geothermal electricity at the PGM power plant;**
- ✓ **Hydrogen delivered from PGM to HAVO by light-weight tube trailer;**
- ✓ **Fueling station sited at Kilauea Military Camp:**
 - **DOD recreational facility located within HAVO;**
 - **KMC to provide shuttle bus operators to support project.**
- ✓ **Investigate novel fueling systems including cascade non-compressor fill.**

Hydrogen Supply



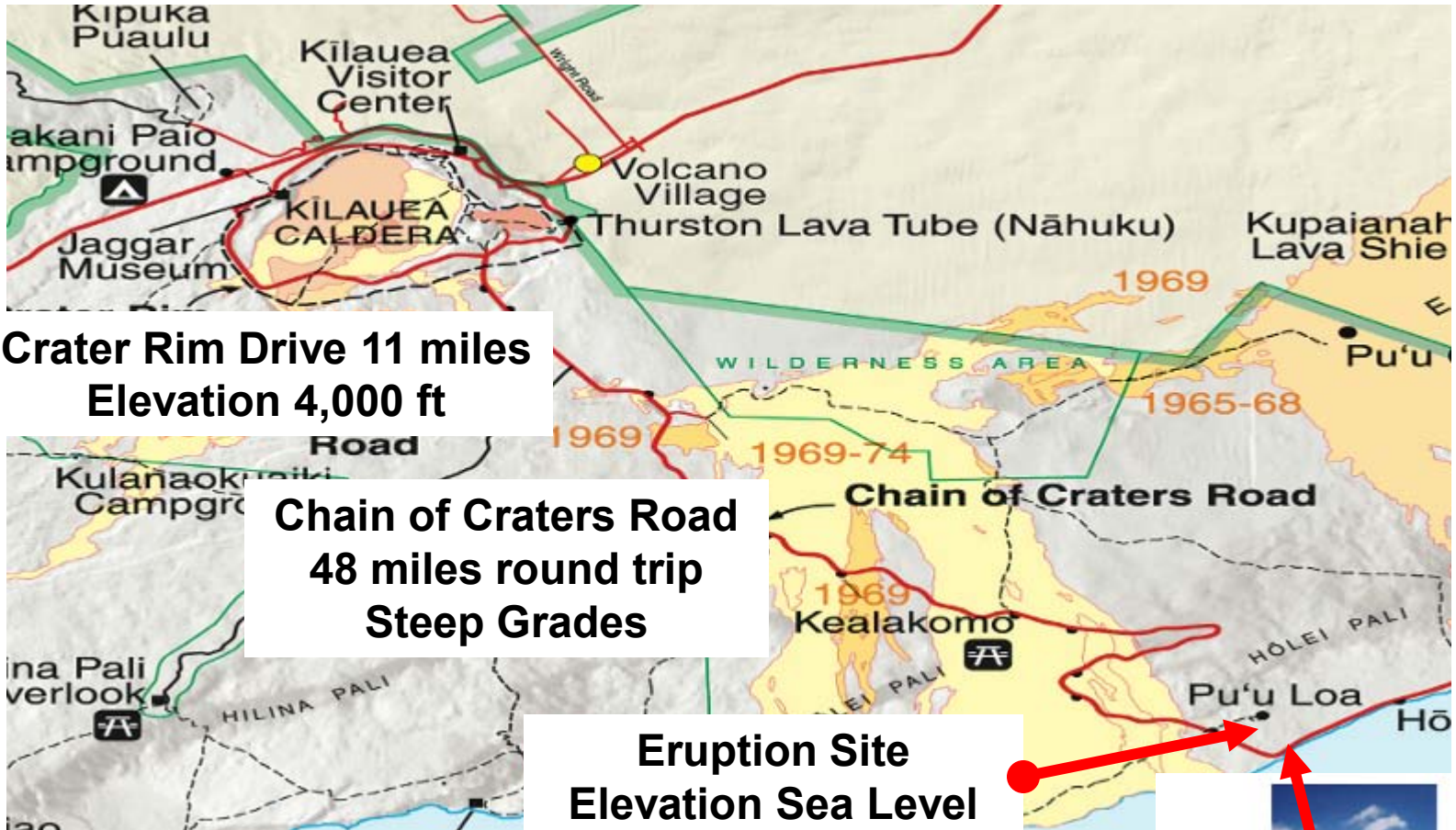
Station Layout



Hydrogen station acoustic level not to exceed 35 dba at 75 meters from closest sleeping quarters.

Location of station showing acoustic specification distance from nearest habitation

HAVO Bus Routes



**Crater Rim Drive 11 miles
Elevation 4,000 ft**

**Chain of Craters Road
48 miles round trip
Steep Grades**

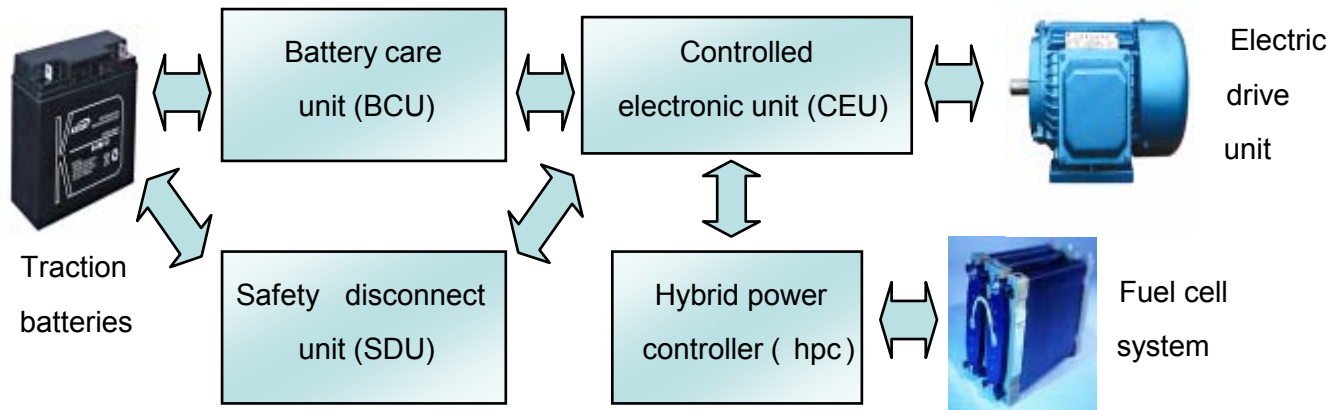
**Eruption Site
Elevation Sea Level**

FROG building at eruption site with PV panels to charge bus (pending)



FROG Unit

Vehicle Data Collection



Motor Data

- Motor Voltage (V),
- Requested power (kW),
- Motor speed (RPM),
- Temperature of the motor (°C),
- Operating mode (warming up, motoring),
- Temperature within the CEU box (°C).

Battery Data

- Voltage (V),
- Current (A),
- Power (kW),
- State of charge (%),
- Individual voltage of the modules (V),
- Temperature of sensors within the battery pack (°C)
- Fault status

Fuel Cell Data

- Current density (A),
- Allowed drawn current (A),
- Requested drawn current (A),
- Fuel cell stack voltage (V),
- Coolant temperature (°C).

Hybrid Power Controller Data

- HPC is active – Y/N
- HPC operating mode,
- Voltage of the batteries (V),
- Current delivered to the batteries (A),
- Voltage of the associated fuel cell stack (V),
- HPC fault status.

✓ Education & Outreach

- ✓ **Over 2 million park visitors annually. Hawaii's biggest tourist attraction;**
- ✓ **HAVO has facilities & team of tour guides dedicated to public outreach;**
- ✓ **Visitor Center theater and interpretation center will host static displays & movie;**
- ✓ **Theater to be powered by 5 kW stationary fuel cell; and**
- ✓ **Park interpreters on shuttle buses to incorporate hydrogen outreach into presentations.**



Vehicle Supply**

Hawaii

- ✓ Vehicle funding obtained by NPS from Advanced Transportation for Parks and Public Lands program (ATPPL);
- ✓ HCATT supporting conversion of shuttle buses - leverages Air Force Research Laboratory hydrogen vehicle programs

Status of Hawaii Vehicles

- ✓ HAVO has prepared specification for supply of 2 conventional shuttle buses;
- ✓ Delivery of retrofit vehicles not expected until late 2012 resulting in major impact to schedule;

Oahu

- ✓ GM supplied Equinox FCVs are onsite on Oahu;
- ✓ Full operation awaiting installation of fueling infrastructure;
- ✓ Supplemental funding (\$1.5 million) received from ONR Feb 2011 to upgrade to 700 bar to meet GM Equinox “fast-fill” requirements.

****Vehicle procurement is outside the scope of Power Park Project**

Partner Roles

- ✓ **US DOE – program leadership & funding;**
- ✓ **HNEI – Program management & implementation;**
- ✓ **State of Hawaii – cost share & policy support;**
- ✓ **HAVO & National Park Service:**
 - **Host site;**
 - **PHEV vehicles;**
 - **Education & public outreach.**
- ✓ **Kilauea Military Camp (DOD):**
 - **Host fueling infrastructure;**
 - **Provide bus operators.**
- ✓ **HCATT – vehicle conversion & technical support;**
- ✓ **Puna Geothermal Venture – geothermal hydrogen;**
- ✓ **Office of Naval Research:**
 - **Lease of 5 GM Equinox vehicles for Marine Corps Base Hawaii;**
 - **Supplemental funding for 700 bar upgrade to Powertech fueling station.**
- ✓ **Marine Corps Base Hawaii:**
 - **Host site for Powertech fueling station;**
 - **Equinox FCV operator.**
- ✓ **GM – supplier of 5 Equinox vehicles for MCB Hawaii.**

Accomplishments/Progress/Results

- ✓ **Re-scoped project to support the GM Hawaii Equinox FCV rollout at MCB Hawaii;**
- ✓ **Completed factory acceptance of Powertech system and demonstrated compatibility with GM Equinox FCV;**
- ✓ **Developing several MOAs among project partners;**
 - **HAVO**
 - **KMC**
 - **MCB Hawaii**
- ✓ **Initiated actions to relocate Powertech integrated hydrogen production & dispensing system to MCB Hawaii on Oahu;**
- ✓ **NEPA submission approved for HAVO site**
- ✓ **CATEX approved for Marine Corps Base Hawaii site;**
- ✓ **Initiated actions to upgrade Powertech station to 700 bar fast fill;**
- ✓ **Developed infrastructure design for MCB Hawaii;**
- ✓ **Selected contractor to install infrastructure at MCB Hawaii;**
- ✓ **Secured additional \$600k in state funding for MCB Hawaii infrastructure.**
- ✓ **Purchased hydrogen delivery tube trailer for use on Oahu;**

Future Work

Oahu

- ✓ **Execute remaining MOAs with project partners (April 2011);**
- ✓ **Install Powertech system at MCB Hawaii (June 2011);**
- ✓ **Upgrade Powertech system to 700 bar “Fast-Fill” (Sept 2011).**

Hawaii (all 2012 due to vehicle delay outside control of project)

- ✓ **Install hydrogen 350 bar dispensing system at HAVO;**
- ✓ **Deliver geothermal hydrogen to HAVO with tube trailer;**
- ✓ **Support HAVO bus operations;**
- ✓ **Collect and analyze fueling station & vehicle data;**
- ✓ **Seek opportunities for expansion of fleets and/or additional hydrogen infrastructure.**

Overcoming Schedule Challenges

- ✓ **Legal issues & agreements are a serious roadblock to progress:**
 - **Legal issues concerning liability & indemnification are imposing serious delays and needs to be solved for all DOE hydrogen projects;**
 - **Need to work with insurance industry & legal profession to resolve;**
 - **Public & private sector, including equipment suppliers, need to take on and find solutions to risk issues;**
 - **Legal and insurance costs are significant components of projects and require many man-hours of project staff to resolve issues.**
- ✓ **HAVO & NPS have taken almost 3 years to approve bus procurement!**

Summary

- ✓ **Leveraging geothermal hydrogen grid-management project to increase scope of Power Park;**
- ✓ **Powertech fueling station being installed at MCB Hawaii & operational by July 2011;**
- ✓ **Providing critical support for GM Equinox FCV rollout in Hawaii;**
- ✓ **Power Park being supported by several agencies including DOE, DOD (Army and ONR), DOI, NPS, State of Hawaii;**
- ✓ **Power Park serves as the cornerstone for expansion of Hawaii “Renewables to Hydrogen” program;**
- ✓ **HAVO bus procurement continues to present a serious schedule challenge but Ford Shuttle buses under MT008 will provide vehicles for use on Big Island (Hawaii).**