

**2011 DOE Hydrogen and Fuel Cells  
Program Review**

**Hydrogen Energy Systems as a  
Grid Management Tool**

**Dr. Richard Rocheleau - Principal Investigator**

**Mitch Ewan - Presenter:**

**Hawaii Natural Energy Institute**

**May 10, 2011**

**Project: MT008**

# Overview

## Timeline

- ✓ **Project start date: 1 Sep 10**
- ✓ **Project end date: 30 Sep 12**
- ✓ **Percent complete: 25%**

## Budget

- ✓ **Total project funding:**
  - **DOE: \$1,833,015**
- ✓ **Funding received in FY10:**
  - **DOE: \$915,515**

## Barriers

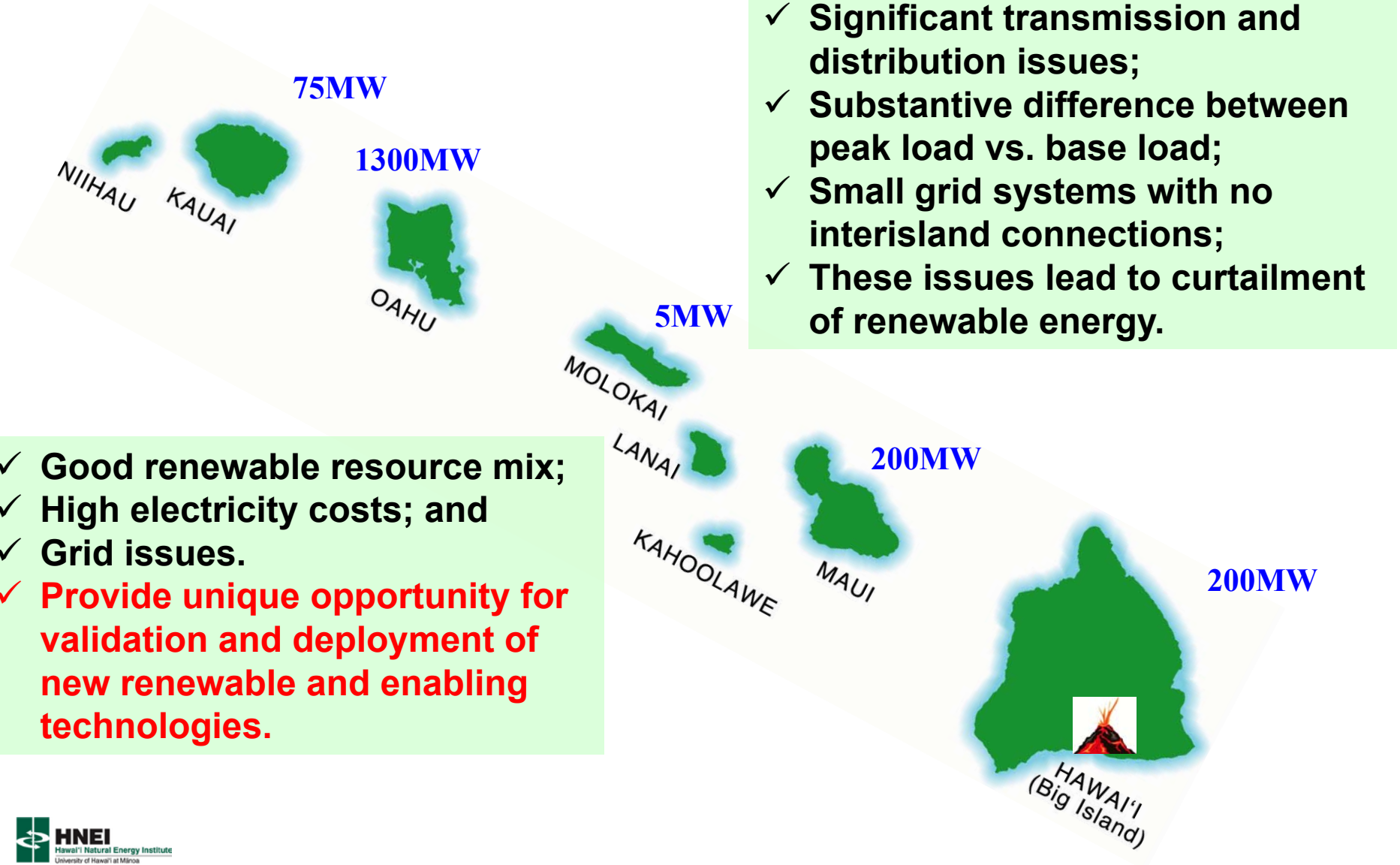
- ✓ **Hydrogen Production**
  - **J: Renewable electricity generation integration**
  - **Non-technical issues preventing full commercialization of hydrogen**

## Partners

- ✓ **US DOE:** Project Sponsor & Funding
- ✓ **Office of Naval Research:** Supplemental funding
- ✓ **Naval Research Laboratory:**
  - Federal Technical Program Manager
- ✓ **HNEI:** Implementing Partner, Technical Lead
- ✓ **Puna Geothermal Ventures:**
  - Host site, Power & Water Provider.
- ✓ **County of Hawaii Mass Transit Agency:**
  - Host Site, Bus Operator
- ✓ **HELCO:** Potential partner for expanded program

# Relevance

# High Percentages of As-Available Renewable Resources Creates Problems for Grid Systems



- ✓ Significant transmission and distribution issues;
- ✓ Substantive difference between peak load vs. base load;
- ✓ Small grid systems with no interisland connections;
- ✓ These issues lead to curtailment of renewable energy.

- ✓ Good renewable resource mix;
- ✓ High electricity costs; and
- ✓ Grid issues.
- ✓ Provide unique opportunity for validation and deployment of new renewable and enabling technologies.

# Energy Roadmapping/Technology Validation

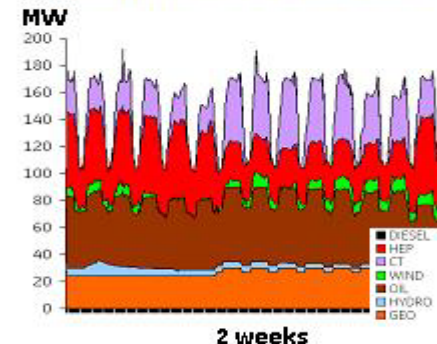
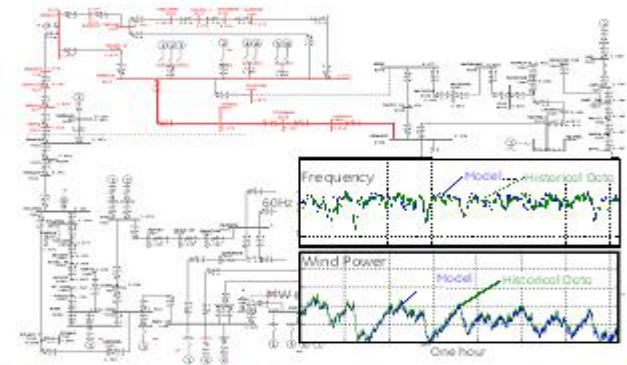
Ongoing DOE/Industry funded effort to identify economically viable technologies to transform island energy infrastructures.

## APPROACH: FOUR-STEP PROCESS TO EVOLVE ENERGY SYSTEMS

- Step 1:** Develop and validate rigorous analytic models for electricity and transportation
- Step 2:** Develop and model scenarios for deployment of new energy systems including additional renewables
- Step 3:** Identify and analyze mitigating technologies (**DSM, storage, Smart Grid, advanced controls, forecasting, future gen**) to address systems integration (grid stability) and institutional issues.
- Step 4:** Conduct testing and evaluation to validate potential solutions to facilitate utility acceptance

# HNEI & GE Modeled Electrical Infrastructure

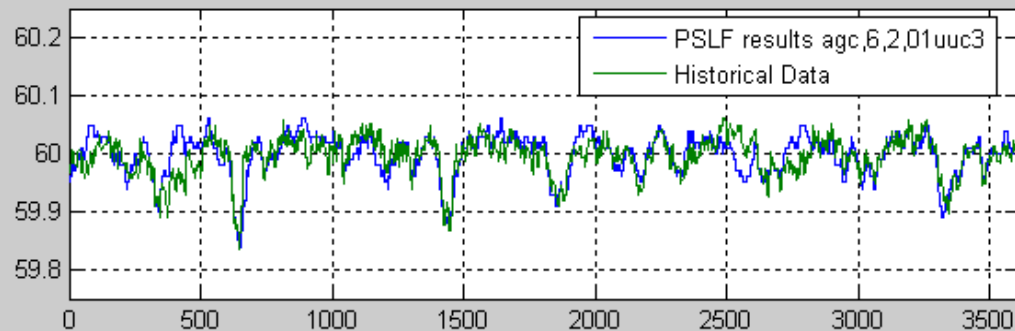
- ✓ **Transient Performance (PSLF™)**
  - Full network model, incorporating generator governors and AGC;
  - Transient Stability Simulation;
  - Long-Term Dynamic Simulation.
- ✓ **Production Cost (MAPS™)**
  - Representation of dispatch and unit commitment rules;
  - Hour-by-hour simulation of grid operations for a full year;
  - Yields cumulative fuel usage, emissions, variable cost.



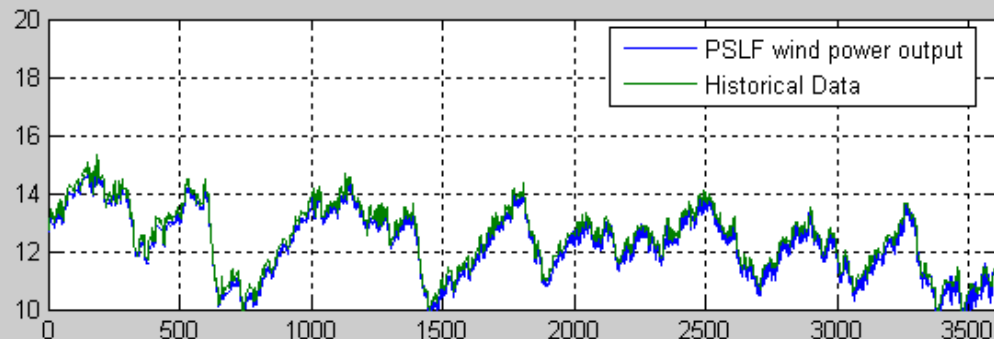
# Frequency Variability due to Wind Fluctuation used as Initial Test of Model (Big Island)

- ✓ 100 to 200 MW with early evening peak
- ✓ 30 MW wind
- ✓ 30 MW unregulated geothermal
- ✓ Significant and growing photovoltaics

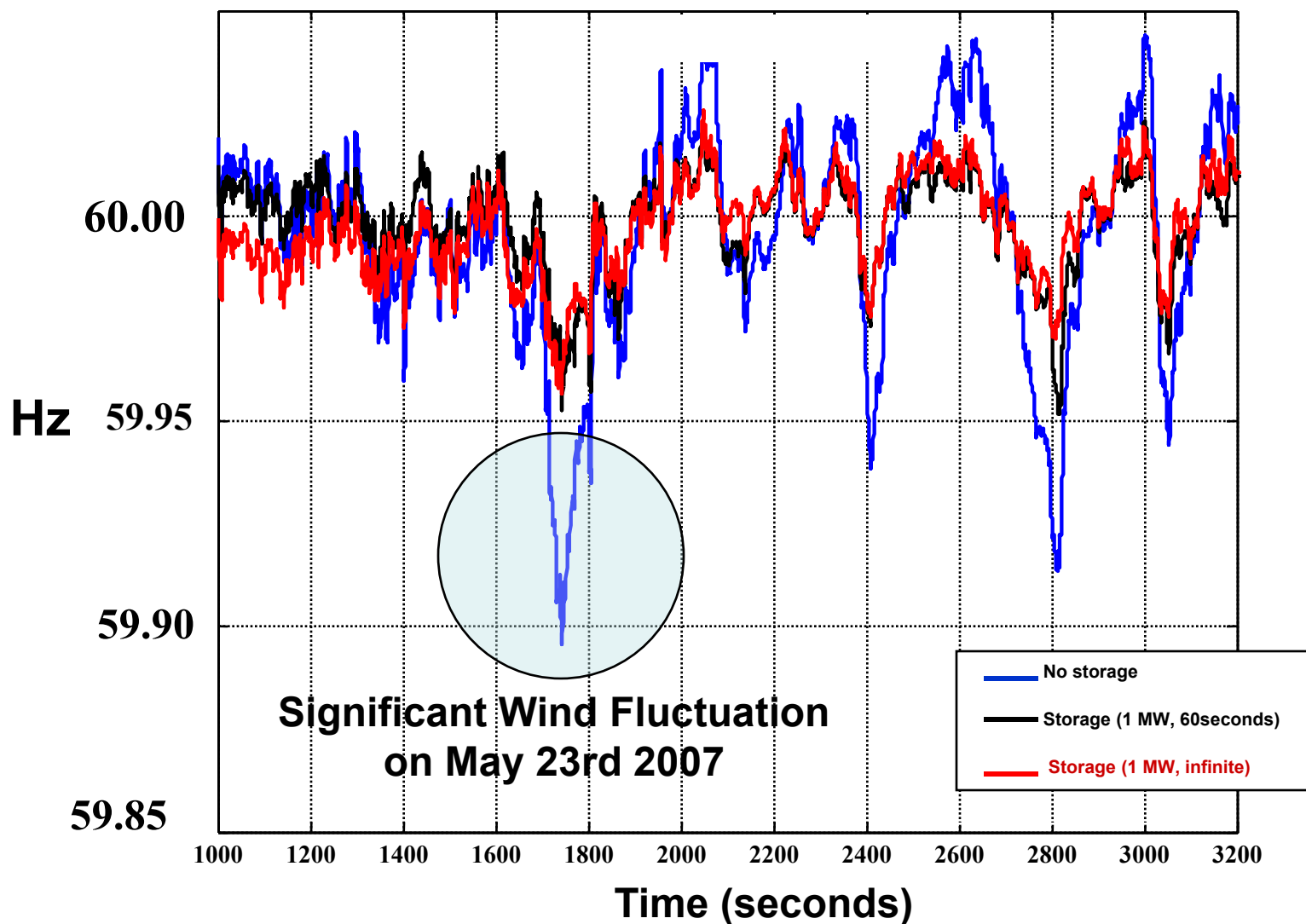
Frequency (Hz)



Apollo Wind Farm (MW)



# Models indicate that modest energy storage can mitigate negative effects of high wind penetration



## Frequency Comparison

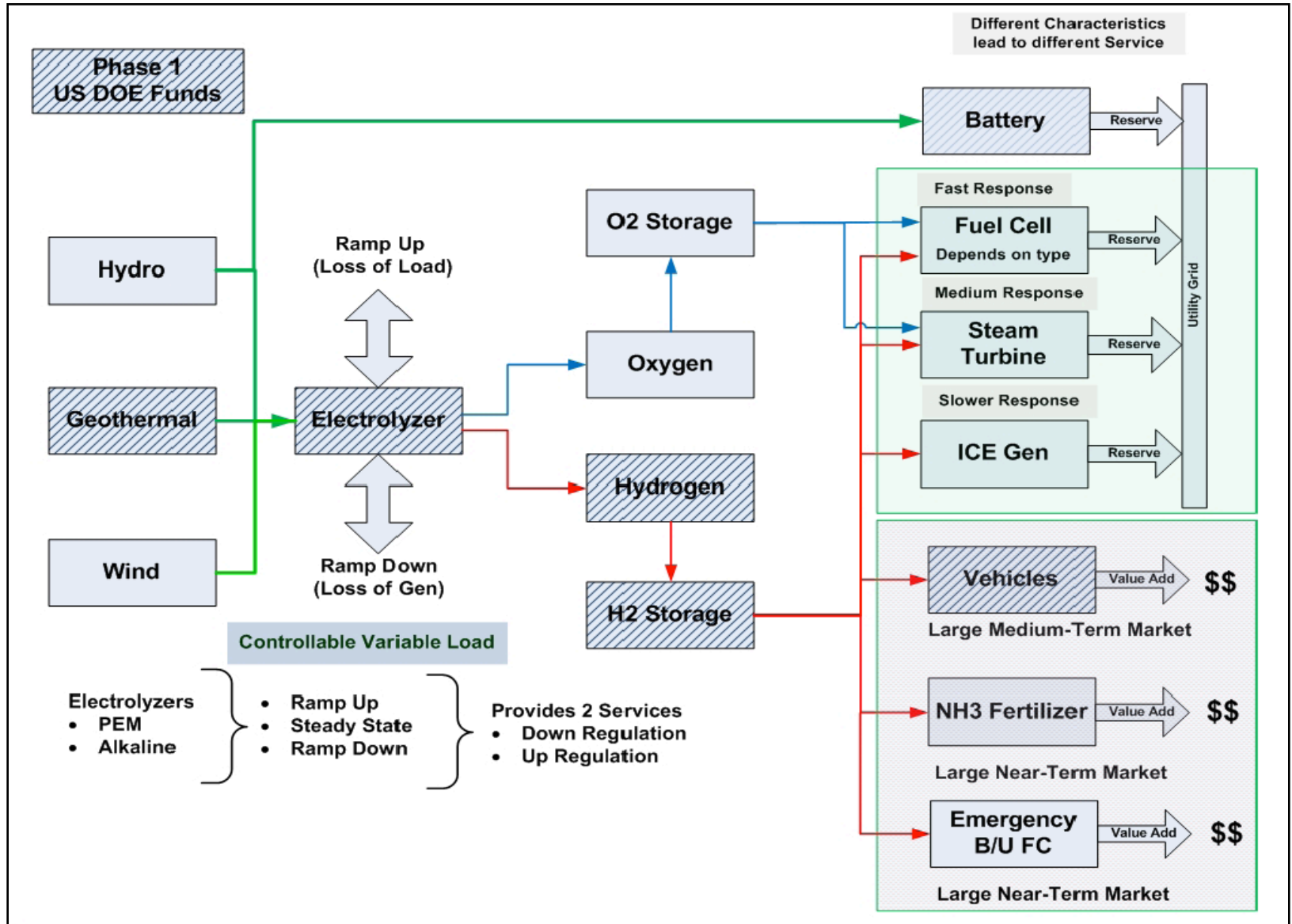


# Approach

# Utilize Hydrogen Energy Systems as a Grid Management Tool

- ✓ **Demonstrate the use of electrolyzers as a grid management tool to mitigate the impacts of intermittent renewable energy;**
- ✓ **Characterize performance/durability of commercially available electrolyzers under dynamic load conditions;**
- ✓ **Provide hydrogen to fuel 2 Ford E450 IC shuttle buses for local community bus service operated by County of Hawaii Mass Transit Agency; and**
- ✓ **Conduct performance/cost analysis to identify benefits of integrated system including grid services & off-grid revenue streams.**

# Approach



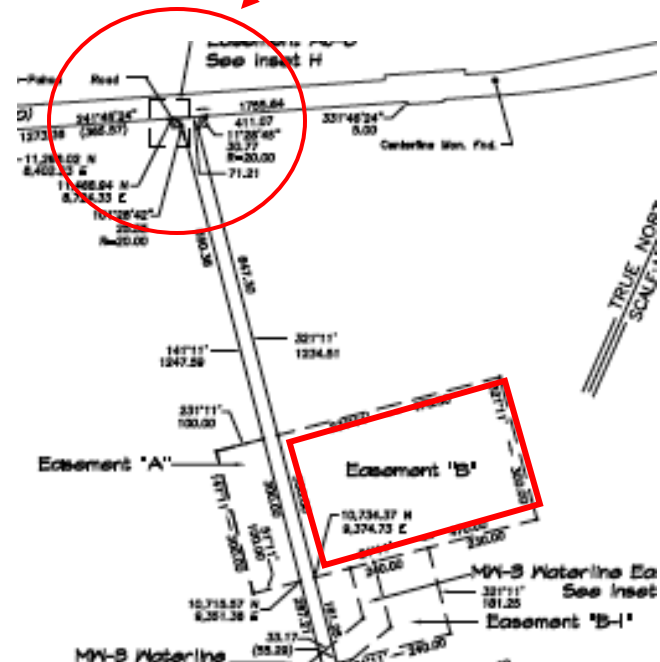
# Project Site

## PGV Site

- ✓ Greenfield with nearby access to critical utilities;
- ✓ Project site is rectangular, 43,000 sq ft;
- ✓ Access to the lot is via an asphalt road from the main county road shown at the top of the drawing.



Locations of PGV & MTA



# Project Schedule

**Task #1:** Develop Memorandum of Agreement & Contracts with Key partners (PGV, MTA, Ford): Feb 2011.

**Taking longer than planned.**

**Task #2:** Define System Requirements: Dec 2010. **Completed**

**Task #3:** Select Supplier for Hydrogen System for delivery August 2011: **Completed**

**Task #4:** Complete PGV and MTA Site Infrastructure, Sep 2011

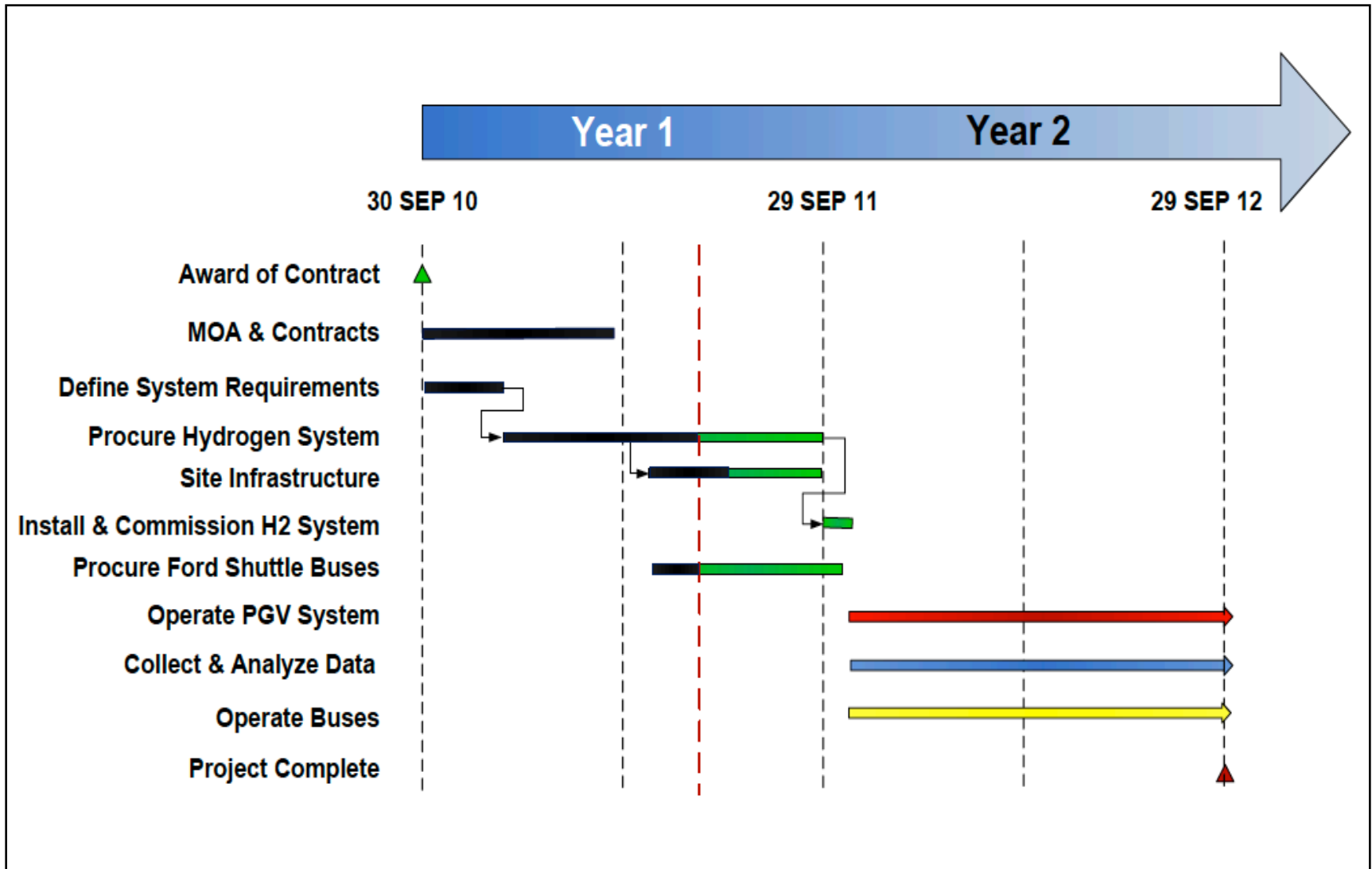
**Task #5:** Install & Commission Hydrogen System, Sep 2011

**Task #6:** Procure Ford Shuttle Buses, Sep 2011

**Task #7:** Operate Hydrogen System, through Sept 2012

**Task #8:** Outreach & Education: **Ongoing**

# Milestones



# Task #1 Develop MOAs and Contracts

- ✓ **Develop legally binding agreements from all parties before making major financial commitments;**
- ✓ **Puna Geothermal Venture:**
  - **Confirm power free: Confirmed**
  - **Confirm host site availability: Confirmed**
- ✓ **Ford Motor Company:**
  - **Finalize terms & conditions for supply of buses including insurance & liability requirements: Underway**
- ✓ **County of Hawaii Mass Transit Agency:**
  - **Confirm MTA host site availability, agree upon bus operations, develop maintenance commitments: Confirmed**
- ✓ **Hydrogen Production System Operator – preliminary negotiations underway for third party operation of hydrogen/fueling plant.**

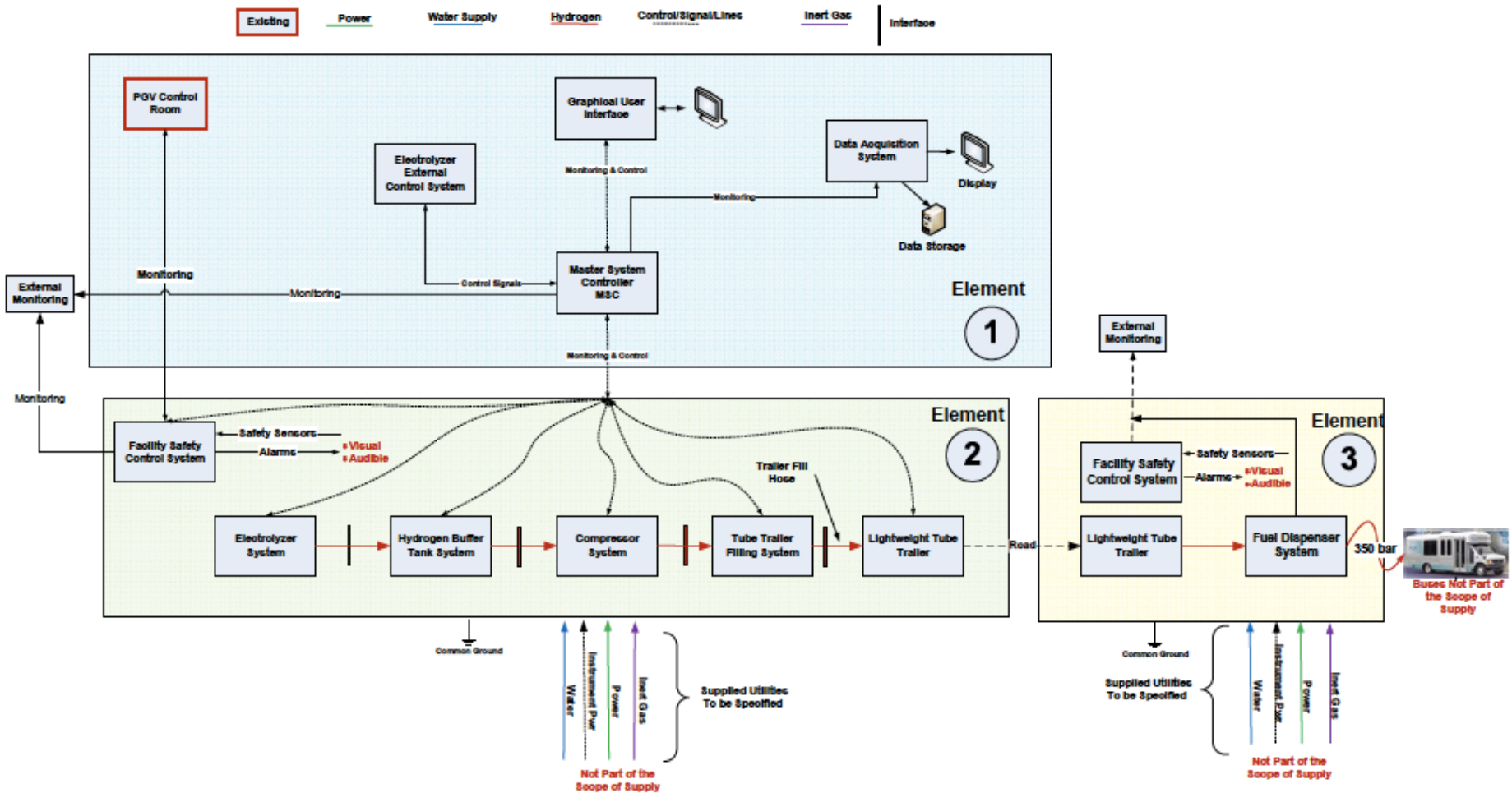
# Task #2: Hydrogen System Requirements

- ✓ Fully automated for remote monitoring, data acquisition, and control;
- ✓ Redundant fail-safe safety systems;
- ✓ Category 4 earthquake resistance;
- ✓ Highly corrosive salt air coastal environment;
- ✓ Hydrogen Production:
  - PEM or alkaline electrolysis with minimum 60 kg/day operated continuously at full capacity;
  - High purity hydrogen (SAE J2719) for engine and fuel cell use;
  - Dynamic Operation (frequent cycles up to 30% capacity, intermittent (2 per day) up to 80% capacity, one minute ramp rate);
  - Ability to control cycling directly or via grid frequency;
  - Lightweight hydrogen tube trailers for easy transport on narrow roads. Permanent on-site storage utilizing “spoolable” plastic pipe (subject to funding);
  - Compression consistent with maximum pressure of selected light-weight tube trailers (i.e. 350 bar or less).
- ✓ Mobile fueling station incorporating fueling dispenser & compressor.

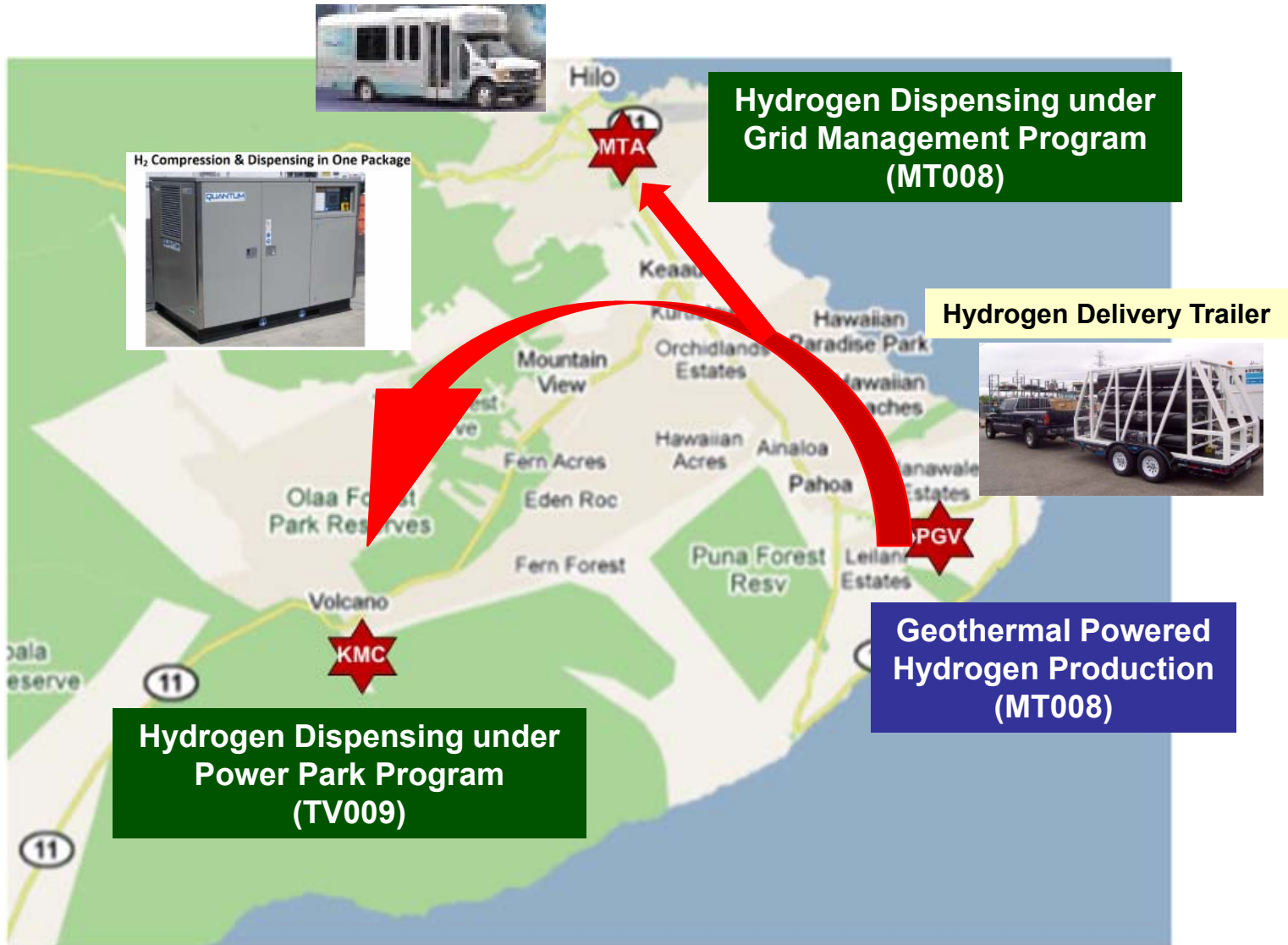


# Task #2: Hydrogen System Concept Design

## Grid Management Hydrogen System Schematic



# Hydrogen Supply



# Tasks 3 and 4

- **Task 3: Procure H2 Production/Delivery/Dispensing**
  - ✓ RFP for turn-key integrated system including dispenser to insure system compatibility: **Completed**
  - ✓ Select vendor for August delivery: **Selected**
  - ✓ Supplier to offer complete product liability and indemnification insurance coverage. **Completed**
- **Task 4: Install Site Infrastructure**
  - ✓ HNEI to issue contract for site infrastructure upon award of hydrogen system; and
  - ✓ Permitting not expected to be issue at site.

# Task #5: Install & Commission Hydrogen System

- ✓ **HNEI will provide coordination between infrastructure contractor and hydrogen system supplier;**
- ✓ **Hydrogen systems modular & containerized for ease of installation; and**
- ✓ **Acceptance testing included in hydrogen system award.**

# Task #6: Procure 2 Ford Buses

- ✓ **Ford and Hawaii County MTA execute MOA prior to ordering buses;**
  - **Ford insurance requirements;**
  - **MTA must take Ford training courses;**
  - **Need to ensure that MTA maintenance facility properly set up in accordance with Ford requirements.**
- ✓ **Develop a “wrap” (graphics package) in accordance with DOE guidance.**
  - **MTA, NRL & ONR need to be included to ensure recognition.**
- ✓ **Timing of lease - coordinate arrival of buses with commissioning of hydrogen system so 1-year lease coincides with on-site H2 production system acceptance.**

# Task #7: Operate PGM System

- ✓ **Prepare test protocols:**
  - **Dynamic response;**
  - **Liase with project partners, DOE, and NRL;**
  - **Invite HELCO to participate.**
- ✓ **Operate PGM system in accordance with protocols for 12 months.**
  - **Operation beyond 12 months depends on availability of funding and buses.**
- ✓ **Operate Ford buses**
  - **Meet bus requirements;**
  - **Conduct hydrogen delivery and fueling operations.**
- ✓ **Collect & analyze data;**
- ✓ **Develop alternate uses for hydrogen;**
- ✓ **Prepare reports.**

# Technical Accomplishments & Progress

- ✓ **Developed system requirements;**
- ✓ **Developed concept system design;**
- ✓ **Prepared & issued RFP for supply of the hydrogen system;**
- ✓ **Conducted bidders conference;**
- ✓ **Bids received and evaluated;**
- ✓ **Supplier selected; and**
- ✓ **Developing site design with infrastructure contractor.**

# Collaborations

- ✓ **US Department of Energy:** Project Sponsor & Funding;
- ✓ **Office of Naval Research:** Supplemental Funding;
- ✓ **State of Hawaii:** Cost Share;
- ✓ **Naval Research Laboratory:** Federal Technical Program Manager;
- ✓ **Hawaii Natural Energy Institute:** Implementing Partner, Technical Lead;
- ✓ **Puna Geothermal Venture:** Host Site, Provide Power and Water (Cost Shared);
- ✓ **County of Hawaii Mass Transit Agency:** Host Site, Bus Operator (Cost Shared);
- ✓ **HELCO:** Interested Observer, Potential Partner for Grid Analysis;
- ✓ **The Gas Company:** Interested system operator.



# Proposed Future Work

- ✓ **Install hydrogen production infrastructure at PGV site;**
- ✓ **Install fueling infrastructure at MTA site;**
- ✓ **Install & commission hydrogen systems at PGV & MTA sites;**
- ✓ **Procure 2 Ford buses E-450 shuttle buses;**
- ✓ **Operate systems;**
- ✓ **Collect & analyze data;**
- ✓ **Prepare performance reports;**
- ✓ **If results show promise, apply for a phase 2 follow-on project that increases the size of electrolyzers.**

# Summary

- ✓ **5MW of electrolysis would produce approximately 600,000 kg hydrogen per year, ~1% total Hawaii gasoline usage, ~ 10% Big Island gasoline usage;**
- ✓ **Electrolysis of water to produce hydrogen could contribute significantly to Hawaii fuel usage while providing significant support for renewable intermittency;**
- ✓ **Performance & durability of electrolyzer under sustained cyclic operation needs to be validated;**
- ✓ **Detailed grid behavior with significant electrolysis needs to be validated via models; and**
- ✓ **Costs required to justify large scale electrolysis for fuel need to be determined.**

# MAHALO

