2011 DOE Hydrogen and Fuel Cells Program Review

Hydrogen Energy Systems as a Grid Management Tool

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May 10, 2011

Project: MT008

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Overview

Timeline

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

Barriers

✓**Hydrogen Production**

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

Budget

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

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**

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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.**

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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

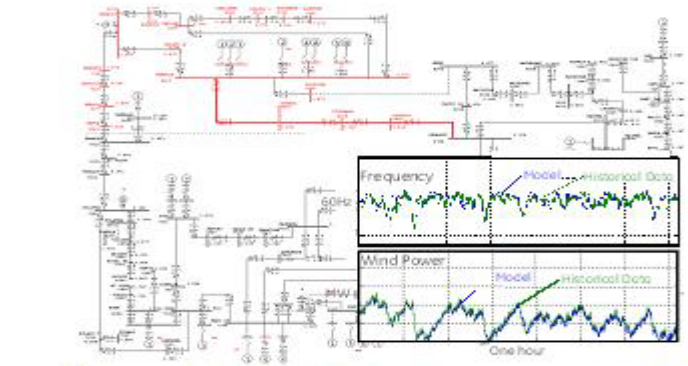
Step 3: Identify and analyze mitigating technologies (DSM, storage, Smart Grid, advanced controls, forecasting, future gen) to address systems integration (grid stability) and institutional issues.

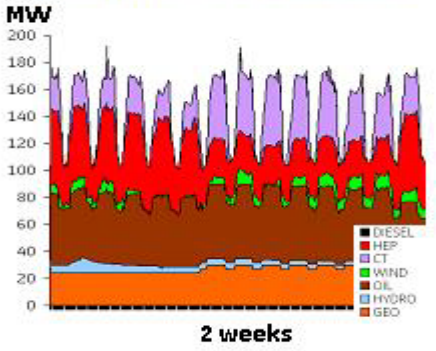
Step 4: Conduct testing and evaluation to validate potential solutions to facilitate utility acceptance

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.**





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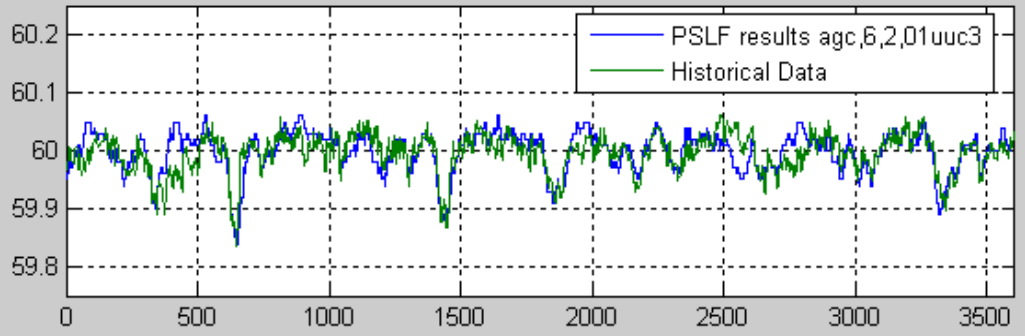
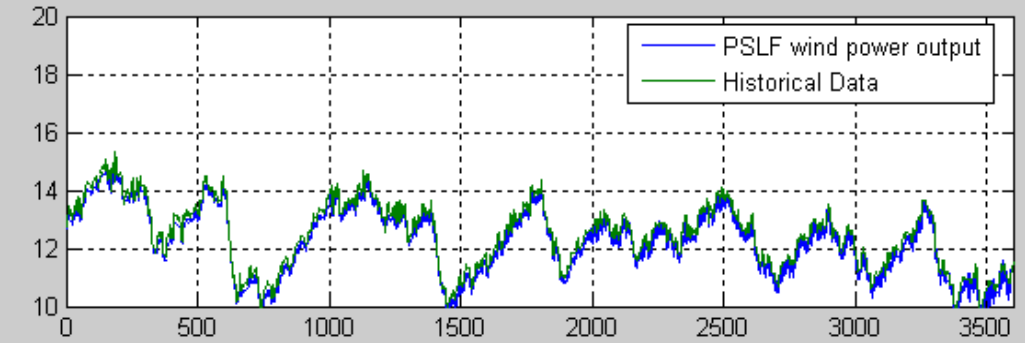
Frequency Variability due to Wind Fluctuation used as Initial Test of Model (Big Island)

- ✓ 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)



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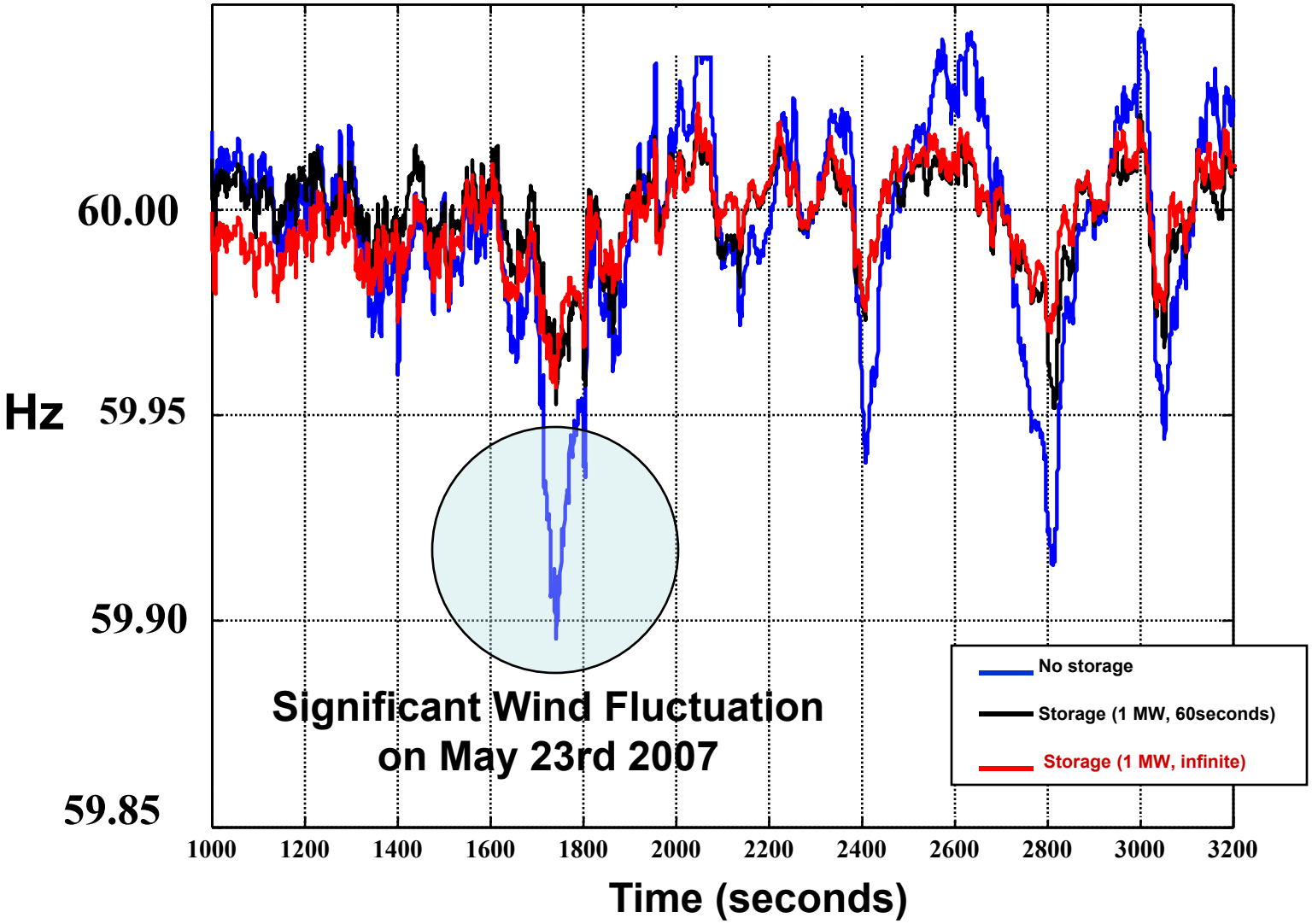
Models indicate that modest energy storage can mitigate negative effects of high wind penetration



Frequency Comparison

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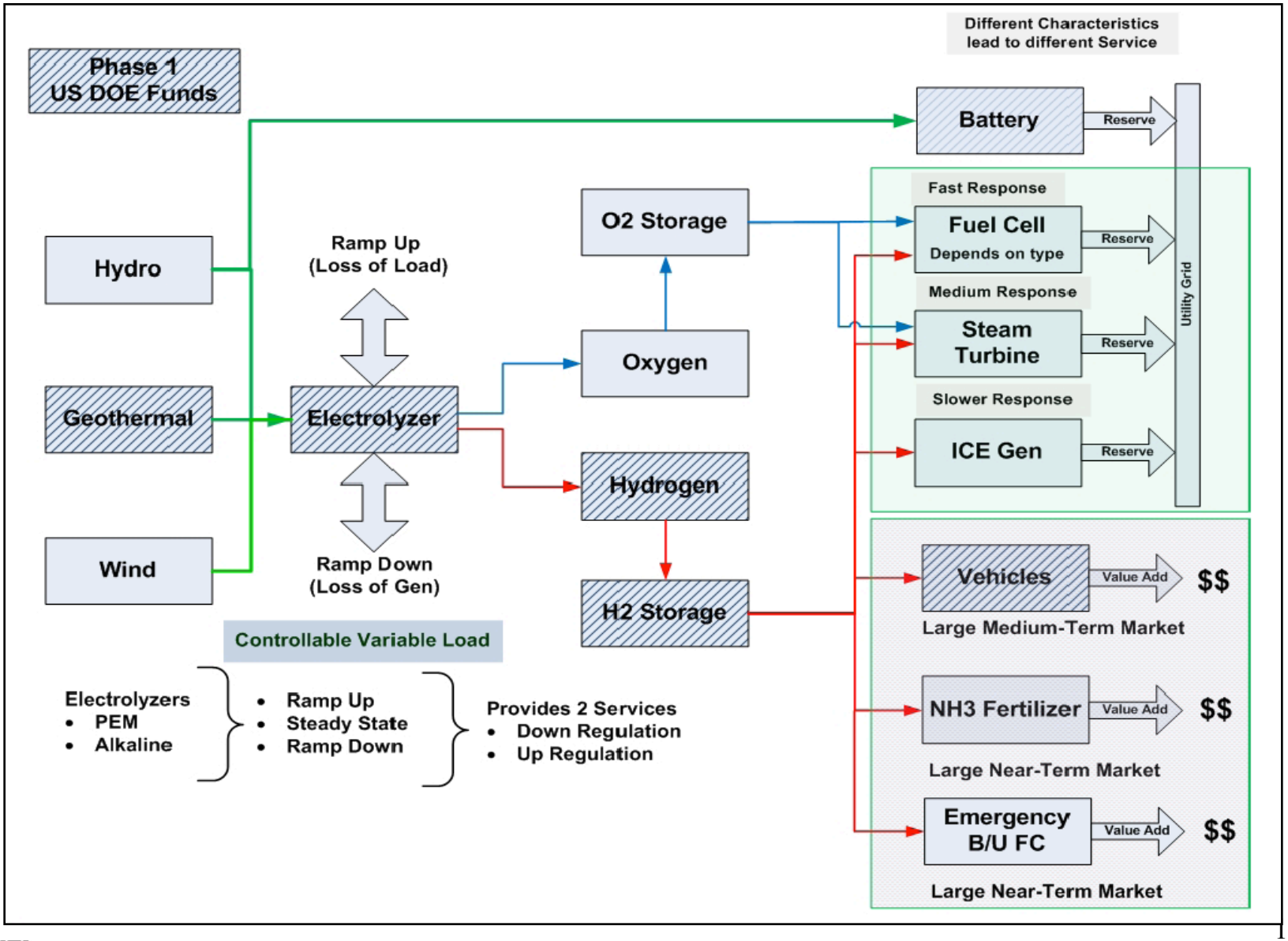
Approach

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



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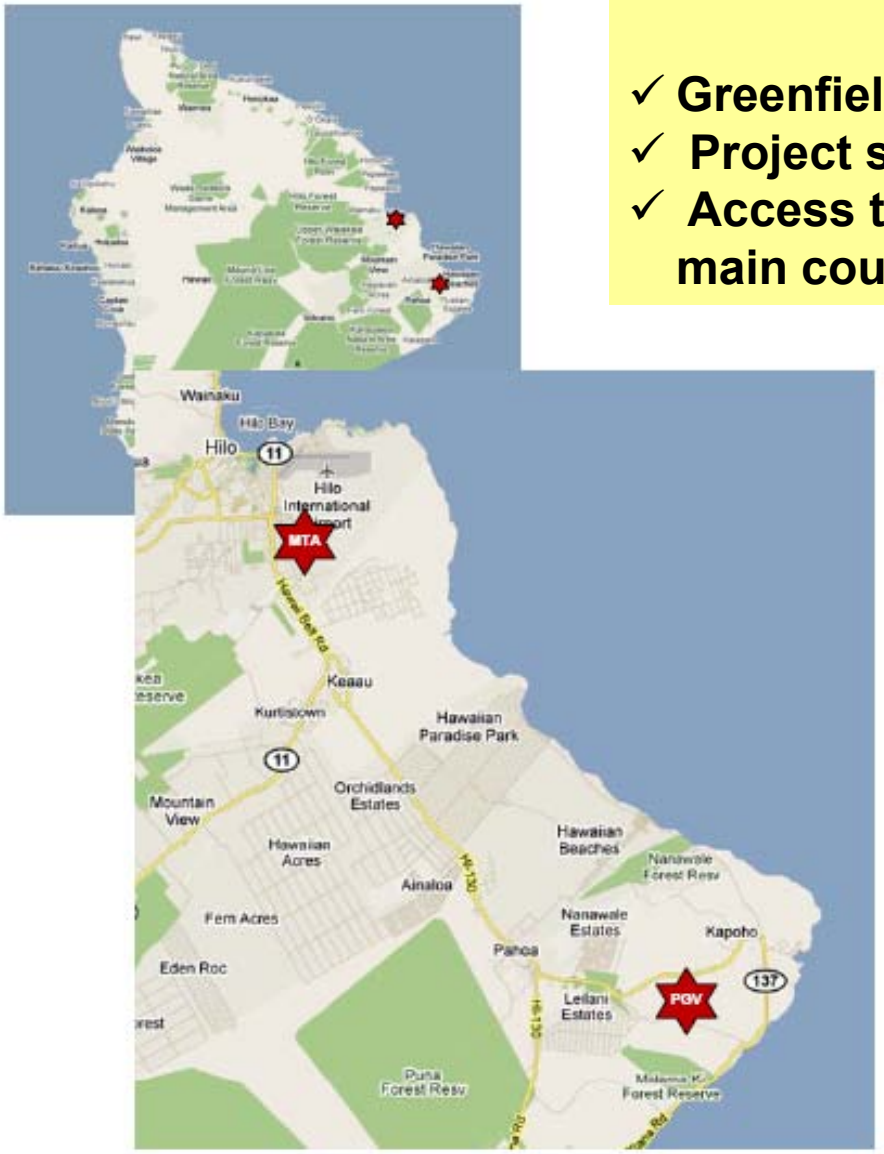
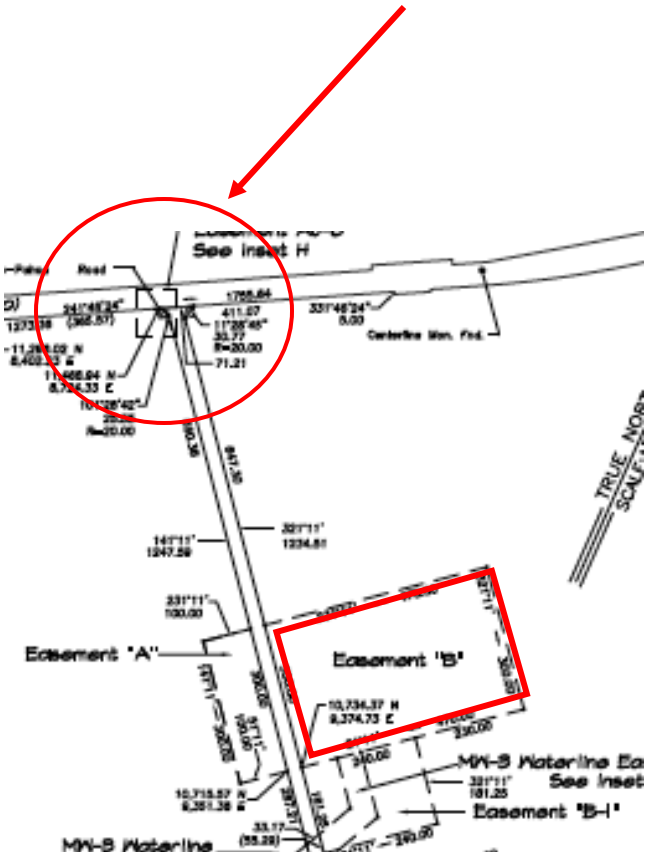
Project Site



Locations of PGV & MTA

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.**



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

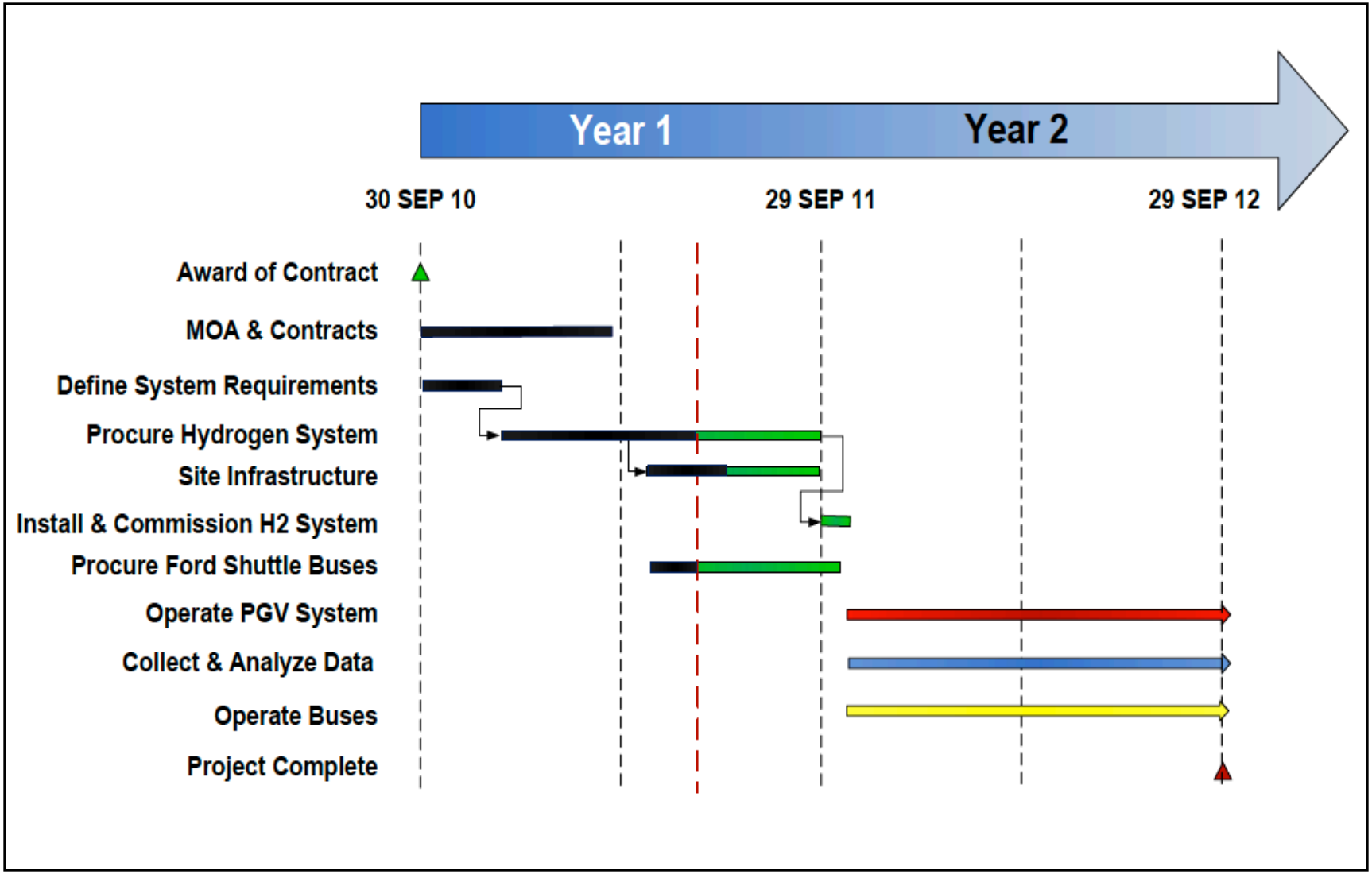
Task #5: Install & Commission Hydrogen System, Sep 2011

Task #6: Procure Ford Shuttle Buses, Sep 2011

Task #7: Operate Hydrogen System, through Sept 2012

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

Milestones


Year 1
Year 2
30 SEP 10
29 SEP 11
29 SEP 12
Award of Contract
MOA & Contracts
Define System Requirements
Procure Hydrogen System
Site Infrastructure
Install & Commission H2 System
Procure Ford Shuttle Buses
Operate PGV System
Collect & Analyze Data
Operate Buses
Project Complete

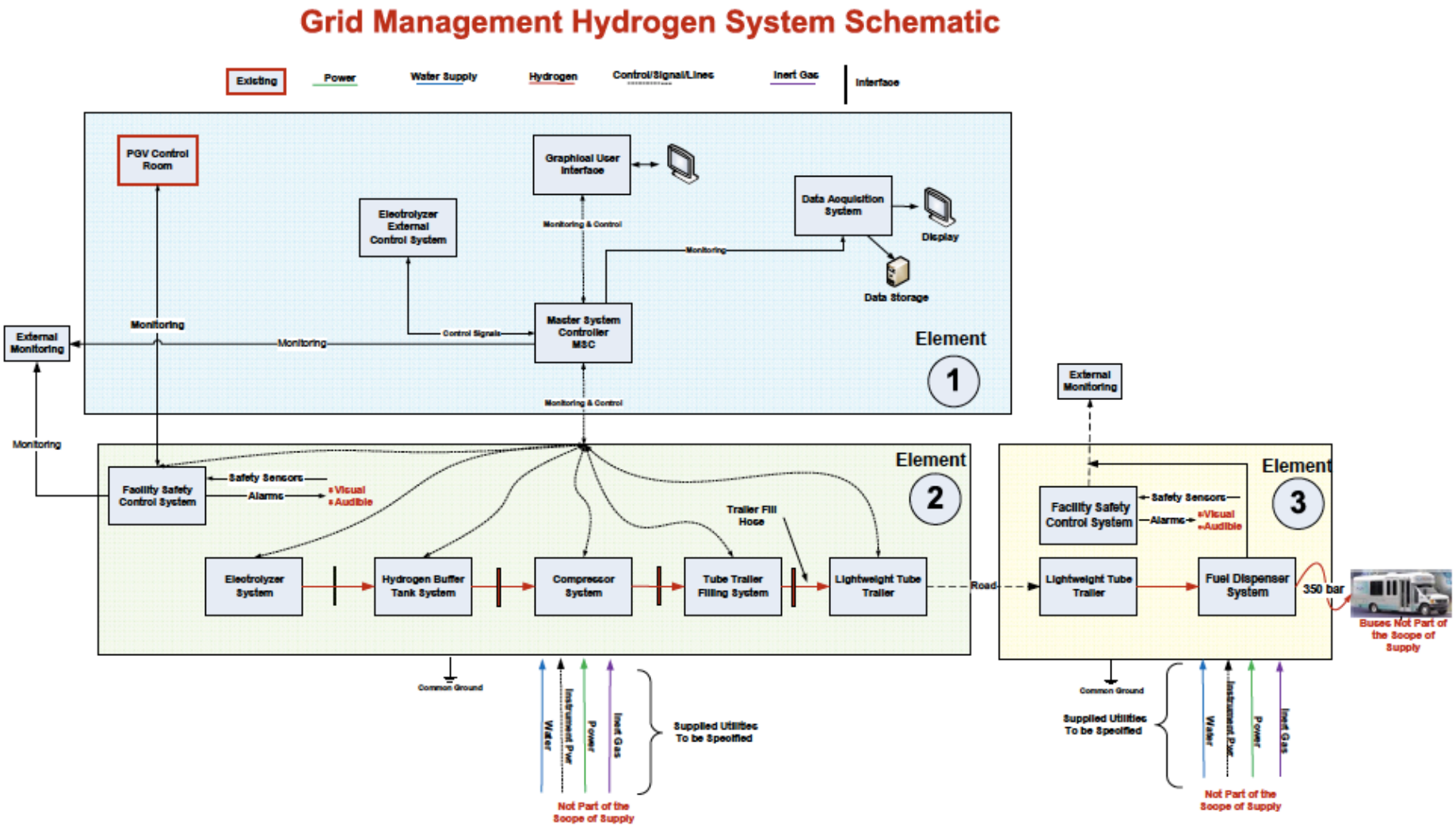
Task #1 Develop MOAs and Contracts

- ✓ 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



Hydrogen Supply

Hydrogen Dispensing under Grid Management Program (MT008)

Hydrogen Delivery Trailer

Geothermal Powered Hydrogen Production (MT008)

Hydrogen Dispensing under Power Park Program (TV009)

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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 PGV System

- ✓ **Prepare test protocols:**
  - ➢ **Dynamic response;**
  - ➢ **Liaise with project partners, DOE, and NRL;**
  - ➢ **Invite HELCO to participate.**
- ✓ **Operate PGV 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.

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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

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